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Also, the **ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering, Tome XIV [2021], Fascicule 2 [April – June]**, includes scientific papers presented in the sections of:

— **ISB–INMA TEH' 2020 – International Symposium (Agricultural and Mechanical Engineering)**, organized by Politehnica University of Bucharest – Faculty of Biotechnical Systems Engineering (ISB), National Institute of Research–Development for Machines and Installations Designed to Agriculture and Food Industry (INMA

Bucharest), Romanian Agricultural Mechanical Engineers Society (SIMAR), National Research & Development Institute for Food Bioresources (IBA Bucharest), National Institute for Research and Development in Environmental Protection (INCDPM), Research-Development Institute for Plant Protection (ICDPP), Research and Development Institute for Processing and Marketing of the Horticultural Products (HORTING), Hydraulics and Pneumatics Research Institute (INOE 2000 IHP) and Food for Life Technological Platform, in Bucharest, ROMANIA, 30 October, 2020. The current identification numbers of the selected papers are the **#1, #4, #7, #11, #13, #16** and **#19**, according to the present contents list.

— **IIZS 2020 – X International Conference on Industrial Engineering and Environmental Protection**, organized by Department of Mechanical Engineering, Department of Environmental Protection and Department of Industrial Engineering in Exploitation of Oil and Gas, Technical Faculty Mihajlo Pupin Zrenjanin, University of Novi Sad (SERBIA), in cooperation with partners University Politehnica Timisoara, Faculty of Engineering, Hunedoara (ROMANIA), University St. Kliment Ohridski, Technical Faculty, Bitola (MACEDONIA), Aurel Vlaicu University of Arad, Faculty of Engineering, Arad (ROMANIA), University of East Sarajevo, Faculty of Mechanical Engineering East Sarajevo (BOSNIA & HERZEGOVINA) and University of Giresun, Faculty of Engineering, Giresun (TURKEY), in Zrenjanin, SERBIA, in 08–09 October, 2020. The current identification numbers of the selected papers are the **#3, #10, #14** and **#21,** according to the present contents list.

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[1.]Iulia GĂGEANU, [1.]Cătălin PERSU, [1.]Dan CUJBESCU, [1.]Gabriel GHEORGHE

RECOVERY OF LIGNOCELLULOSIC WASTE FROM HORTICULTURE BY TABLETING

[1.] The National Institute of Research – Development for Machines and Installations Designed for Agriculture and Food Industry – INMA Bucharest, ROMANIA

Abstract: The benefits of biofuels compared to traditional fuels include greater energy security, lower environmental impact, financial savings and socio-economic issues related to the rural sector. The concept of sustainable development embodies the idea of interconnectivity and balance between economic, social and environmental concerns. The use of renewable energy is an efficient way to ensure a cleaner energy supply. Romania has the capacity to produce energy from a multitude of sources, biomass being one of the most abundant and easy to use. Lignocellulosic waste represents an important biomass source that can be easily transformed in solid biofuels, thus eliminating losses and contributing to environmental protections. The paper presents a solution for lignocellulosic waste recovery, by transforming it into tablets using a specially designed equipment.
Keywords: biomass, lignocellulosic waste, tableting

INTRODUCTION

In all European countries, various lignocellulosic biomass have started to be used to produce renewable energy (Danciu et al, 2010; Ungureanu et al., 2016b; Vlăduţ et al., 2012; Voicea et al., 2014a). Of these, we can mention: agricultural residues (straw, straw containing manure) or fractions of solid municipal waste available in large quantities, but little of this potential is currently used. Not all wastes have an adequate content for their treatment using available techniques for transforming lignocellulosic biomass into renewable energy such as anaerobic digestion, ethanol production or heat recovery (European Commission – EUR 21350 – Biomass, 2005).

The most important categories of lignocellulosic materials are:

- wood and wood waste;
- stems of non-woody plants (annual or perennial); this includes agricultural cellulosic waste such as: cereal straw and stems from different crops as well as those from the processing of technical plants (textile plants, tobacco stems), spontaneously growing plant stems;
- fractions from municipal waste such as paper waste [td]. Lignocellulosic agricultural waste is a resource with high global availability and low price, resulting from the harvesting of cereals and some technical plants (quantities that can be collected depending on the type of crop: wheat straw: 1.4-2.5 t / ha; corn stalks: 4-6.5 t / ha; sunflower stems 1.9-5.0 t / ha; rapeseed stems 1.7-3.5 t / ha, (Marcu A., 2008).

Wood waste from the paper and woodworking industry is usually clean and can be used as fuel for various biomass-based energy systems. Forest waste includes unusable waste, dry trees, trees that do not meet commercial standards and other trees that cannot be traded and must be cut down to clear the forest.

Some species of energy plants are also part of the woody biomass category, such as fast-growing trees. The harvesting period of such plants varies between 3 and 10 years depending on the tree species.

Agricultural biomass is appreciably more abundant than woody biomass. Within it, the most commonly used types for energy purposes are: straw; corn stalks and cobs; grapevine canes; flax and hemp stalks; agricultural plants; sunflower and soybeans; biomass from fruits and seeds (Ungureanu et al., 2016a).

Straws have good energy characteristics, so they are acceptable for use in energy purposes. For example, corn can generate more than three times as much waste as all forms of wood waste. Sometimes large amounts of chlorine, especially in coastal areas grown with corn, can lead to corrosion of heat recovery plants (Ungureanu et al., 2018; Vlăduţ et al., 2011; Voicea et al., 2014b).

The paper presents a solution for the recovery of lignocellulosic waste, as an important part biomass, using a specially designed tableting equipment.

MATERIALS AND METHODS

Table 1 shows the energy potential by types of agricultural biomass available in Romania.

Table 1. Energy potential by types of agricultural biomass (https://ec.europa.eu/transparency/)

Biomass type	Available energy potential	
	TJ	toe*
Straws	30841	736580
Corn – stalks + cobs	177870	4248150
Sunflower – stalks, head, husks	55346	1321830
Flax and hemp stalks	92	2190
Grapevine canes	2688	64190
Total	266835	6372940

*tonne of oil equivalent

The main types of biomass conversion processes can be classified into four groups (Romania's 2018-2030 energy strategy, 2018):

- physical (grinding, separation, drying, briquetting, pelletizing, etc.);
- biological-biochemical (fermentation: anaerobic, aerobic, alcoholic);
- thermal (combustion, pyrolysis, gasification, hydrogenation);
- chemical (they initially use biological and biochemical processes which are then supplemented with chemical syntheses; for example, the synthesis of biodiesel).

Biofuels can be obtained in various forms, and they are beneficial for the environment, because they add much less harmful emissions into the atmosphere (they also contain oxygen in their chemical structure with beneficial effects for combustion and flue gas emissions) and uses various agricultural wastes as a resource.

Renewable energy technologies have the great advantage of using inexhaustible, low-polluting resources with an insignificant contribution to climate change. In addition, their use reduces dependence on conventional resources that will be depleted in the not too distant future. Used in the thermal energy system, biomass-type substances must meet the requirements of thermochemical conversion technologies (combustion or gasification), food and flow maintenance, in conditions of optimal energy efficiency with minimal impact on the environment. Biomass through its components (agricultural, forestry) varies in type, shape and presentation and does not does not meet the requirements of energy efficient installations. Thus, additional processing is required to improve the thermo-physical characteristics such as:

- increase of calorific value;
- increasing the specific mass;
- achieving optimal transport and supply dimensions.

In order to increase the density of solid fuels in biomass and to allow the automation of the combustion process, biomass is usually transformed into pellets, briquettes or tablets.

The specific characteristics of combustion products, briquettes, wood pellets are comparable in relation to thermal performance (calorific value), the differences in volume, density and final moisture being influenced by dimensional factors, moisture on pressing and compaction requirements of these combustible products (Table 2).

Mechanical, thermal and agglomeration processing of biomass, bringing it to the optimum particle size and moisture density, in solid combustion products – tablets, briquettes, pellets - has multiple advantages:

- the products obtained have superior energy properties, compared to biomass;
- tablets, briquettes and pellets produce, through combustion, reduced pollutant emissions and ash in smaller quantities, with a weight of 1 ÷ 2% of the amount of composite material subjected to combustion;
- widens the field of use, for private households, communal, urban and administrative thermal power plants;
- requires storage spaces under the storage requirements of natural biomass product (firewood, remains and sawdust from wood manufacturing);
- reduces the transport fleet, handling of the energy process;
- optimizes the combustion process;
- increases the calorific value of biomass.

a)

b)

c)

Figure 1 . Examples of solid biofuels from biomass [13, 14]; a – pellets; b – briquettes; c - tablets

Table 2. Calorific performance of briquettes, pellets compared to wood

Biomass products	Calorific value [kcal/kg]	Calorific ratio compared to wood [%]
Masive wood	4500 ÷ 5000	100
Wood tablets and briquettes	4000 ÷ 5000	100
Wood pellets	4000 ÷ 4800	96
Resinous bark	4500 ÷ 5250	105
Straw tablets and briquettes	4500 ÷ 4750	95
Reed tablets and briquettes	4300 ÷ 4500	90

The processing of biomass, which appeared to be necessary for energy, economic, ecological and social requirements, transforms products with low value and use into new products with high energy value.

RESULTS

Biomass tableting consists in subjecting biomass materials to high pressures in a closed die for a short period of time and then evacuating it by opening the closed end of the die.

The design of the tableting equipment for the recovery of lignocellulosic waste from horticulture involved the design of a system that would allow the recovery of lignocellulosic waste resulting mainly from orachards and viticulture, namely tree branches, vines resulting from spring pruning and falling leaves at the end of the vegetation period, thus transforming a series of waste into raw materials and finally obtaining a value-added product, which has no negative effects on the environment, and can be considered a "green" product.

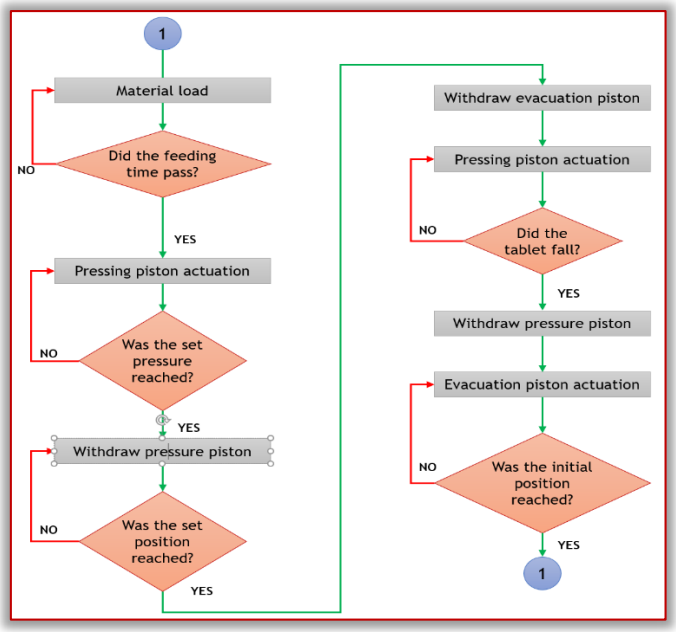

Figure 2. Operating diagram of the experimental model of lignocellulosic waste tableting equipment

The process can be controlled by using a programmable logic controller (PLC), through which the working parameters of the compression process can be programmed to obtain biomass tablets. The process of tableting biomass involves subjecting the crushed biomass to high pressures inside a mold and forcing it to significantly reduce its volume. To compress the biomass inside the mold, a pressing cylinder, driven by a hydraulic unit, is used. Emptying the mold of the resulting compressed product (tablet) is done by means of a second cylinder - emptying - which is connected by the locking plate (closing) of the mold and, by a pull-push movement, opens and closes the mold, at the same time evacuating the resulting tablet in a tableting cycle.

The functional scheme of the experimental model of lignocellulosic waste tableting equipment - TDL is presented in figure 2.

The experimental model of lignocellulosic waste tableting equipment – TDL (figure 3), is composed of compaction die 1, compaction assembly 2 with hydraulic compaction cylinder that presses the biomass, forcing it to reduce its volume, feed hopper 3 with auger 4 that feeds the die what material, the die closing plate 5, the hydraulic cylinder 6 for emptying by actuating the plate in the closed-open position, the hydraulic group 7 which feeds and actuates the 2 cylinders, the hydraulic distributors 8, proximity sensors 9, 10 and 11 which allow monitoring displacement of the cylinders during the compaction process, automation box 12.

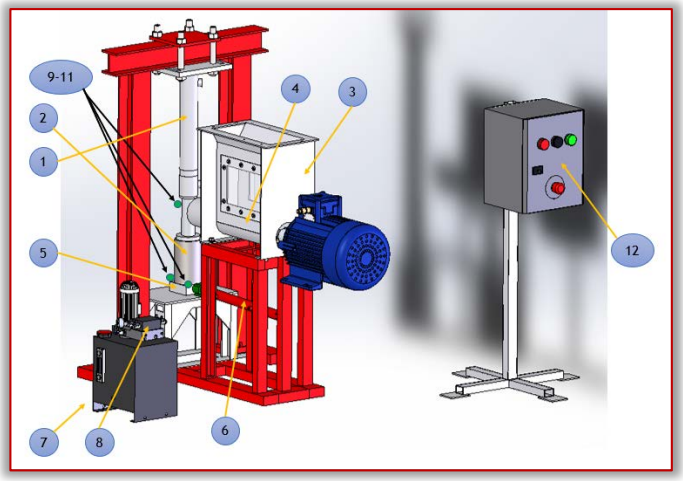

Figure 3. Experimental model of lignocellulosic waste tableting equipment

During operation, the feed hopper is loaded with the grinded biomass material in the dry state and the process starts automatically. The auger takes material from the hopper and feeds the die. The compaction piston descends inside the die and presses the material.

When the set parameters are reached, the piston of the compaction cylinder stops advancing, retracts to a set position, and the emptying cylinder acting on the counter plate pulls the latter until the die reaches the open position, at which point the piston descends again, removing the tablet from the mold.

When the tablet falls out of the die, the piston of the compaction cylinder is completely withdrawn from the die, and the emptying cylinder, by actuating the counterplate, pushes it into the closed position of the die, also performing the complete evacuation of the tablet.

CONCLUSIONS

Lignocellulosic biomass is considered one of the most promising resources for the future of bioenergy production. Lignocelluloses, such as timber resulting from maintenance pruning of orchards, have been identified as major sources of biofuels and other value-added products.

Tablets are an affordable way to compress biomass, the equipment has a much simpler construction than pelletizers or briquetting machines, and maintenance of this equipment is not expensive and has the advantage that the process results in solid biofuels that can be used in the same type of applications as in the case of pellets and lighters.

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[1.]Jelena VUKOVIĆ, [2.]Una MARČETA, [2.]Bogdana VUJIĆ

IDENTIFICATION OF THE CAUSES OF LOW RECYCLING RATE OF PAPER IN SERBIA AND ASSESSMENT OF CURRENT QUANTITIES USING MFA

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[2.]Technical faculty "Mihajlo Pupin" Zrenjanin, SERBIA

Abstract: The use of paper is widespread. It could be used in many purposes, starting from printing industry, over different type of packaging etc. At the same time significant amount of waste paper is generated. As material, paper has excellent recycling properties. Paper could be recycled several times, retaining its original quality. The main goal of this research is to present the current situation in the management of waste paper in the Republic of Serbia. It is evident that awareness of citizens is not satisfying in terms of paper disposal. This is also shown by surveys carried out in the cities Zrenjanin and Novi Sad, which can present the general situation in our country. The research presents the public opinion focused on potential causes of low recycling rate. Using STAN software and Material Flow Analysis (MFA), based on the available amount of waste paper, it is estimated which amount of paper is used as a secondary raw material, and which part of the waste paper ends on sanitary and unsanitary landfills. The results of the assessment may be the starting point for some further research.
Keywords: paper waste, secondary raw material, recycling, material flow analysis

INTRODUCTION

In developing countries, such as Serbia, the management of recyclable materials is pretty different from developed countries. If we look at the recyclable fractions, the largest share in the municipal waste category has the categories that belong to the group of plastic waste. Afterwards, a relatively large share have paper and paperboard, which together account for about 11% for most municipalities in Serbia (Vujić G., 2017).

Paper as a material can be widely used, for example: printing material, for packaging (packaging paper and cardboard), as stationery etc. Due to its composition and characteristics, the paper is very suitable for recycling (Šokman M., 2016).

In the municipal waste in Serbia, according to the established morphological composition, the following types of paper and cardboard can be found:

- old newspapers, advertisements, commercials on paper, envelopes, old books, notebooks etc;
- carton boxes, boxes of food and beverage, toys;
- cardboard with wax – tetra-pack for yoghurt, milk and juices;
- cardboard with aluminum - various types of tetrapacks depending on the manufacturer (Vujić et al., 2009).

Collection of paper in Serbia carries on three ways:

- individual collectors who collect directly from containers and small shops,
- organized collectors (public utility companies and other operators),
- the commercial and industrial sector who sells their waste to operators who take them directly at the place of production (Hempfling C., 2010).

Previous research in the field of recycling paper, which are associated with the analysis of the material flows (MFA - Material Flow Analysis), are mostly designed to monitor the amounts and flows of the waste paper, as well as the flows of the individual substances. One of the studies shows material flows of paper from households via containers and finally to the landfill as the final disposal site. This shows the different behavior of households in the consumption of paper products (Syeda Amber et al., 2015).

One of the essays, as an illustrative example of flows of contaminants in the recyclable material, displays paper quantities and flows. In this case the three selected chemicals were observed: bisphenol A (BPA), diethylhexyl phthalate (DEHP) and mineral hydrocarbonates (MOHs), and a combination of material flow analysis and flow modeling was performed, which determined the final disposition of these chemicals (Pivnenko et al., 2016).

Analysis of material flows in this area can be applied in combination with other research and analytical methods. An example of this is the Danish study, where analysis of material flows, ecological footprint and economic assessment of alternative waste collection and treatment in the region of Funen have been made, including recycled materials (Cimpal et al., 2015).

This paper aims to illustrate the situation in the management of waste paper and cardboard in Serbia, by examining the quantities and flows of this secondary raw material through the analysis of material flows at the goods level.

MATHERIALS AND METHODS

During the development of the essay, in addition to theoretical research, where appropriate data were found, a

survey was conducted as well as an analysis of material flows.

— **Survey**

In order to determine primary selection of the waste paper, we made the survey titled "The Waste Paper Recycling Questionnaire". It was made in "online" form and was actively shared for 10 days. Except for standard questions about sex, old and residence, the survey included next questions:

- Q1: Have you ever put the paper in the intended containers?
- Q2: If you never put paper in the intended containers, or rarely do it, reason is?
- Q3: Do you know how to sort waste paper?
- Q4: Indicate which type of paper should not be disposed of in the same container: offered answers - newsprint, tetra pack, office paper, old books;
- Q5: What do you think why waste in Serbia is not properly sorted?

— **Material flow analysis**

The material flow analysis is a systematic assessment of the flows and supplies of materials within a system that is defined in space and time (Brunner, 2004). The application of material flow analysis is wide, based on the principle of mass balance. It can be used on two levels – the level of goods and level of substances.

Using the MFA can be presented through the following steps (Brunner and Rechberger, 2004):

- definition of goals,
- description of the system and definition of time and spatial limits, relevant processes and materials and substances,
- data collection includes the flows and reserves of the materials of the observed system are determined by measurement and research, analysis of studies and projects, assessment, etc.
- development of the scenario and establishment of mass balance and modeling,
- interpretation of modeling results.

In this paper, the software STAN (substance flow analysis) was used. STAN is a free software that enables the analysis of material flows (Cencic and Rechberger, 2008). It is made according to Austrian standard ÖNorm S 2096 (Analysis of material flows - application in waste management).

The process consists of creating a graphic model with predefined components (processes, flows, system boundaries), after which you can enter known data (mass flows, concentrations, transfer coefficients) for different layers (layer of goods, substances) and calculate unknown quantities. Also, for more detailed analysis, there is a possibility to consider measurement uncertainty of data (Stanisavljević and Brunner, 2014).

RESULTS AND DISCUSSION

The results of the research will be analyzed as two different parts: the results of the questionnaire and the results of the MFA.

— **The results of the questionnaire**

In the survey participated 173 respondents (61.2% women, 38,8% men). The age structure is shown on Figure 1. The survey included respondents aged 15 to 65 years.

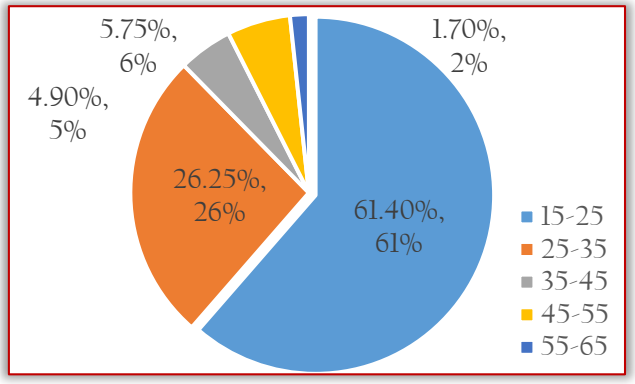

Figure 1. Distribution of ages of survey respondents

The highest number of the respondents were from the territory of the cities of Novi Sad (60 respondents) and Zrenjanin (78 respondents) , and 35 of the respondents were from the territory of Belgrade, Kikinda, Subotica, Pančevo and the other places in Serbia. The answer to Q1"Have you ever put the paper in the intended containers" is shown in Figure 2.

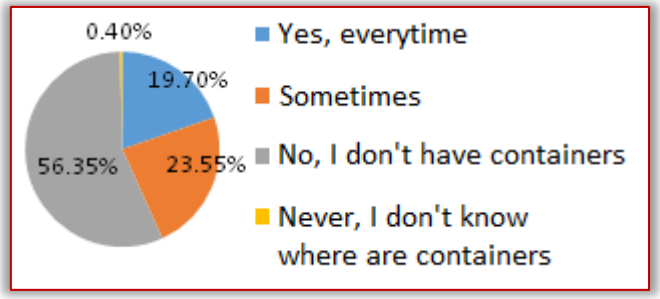

Figure 2. Answers to the survey question "Have you ever disposed old paper in the provided containers?

Most responders (53.35%) cite lack of containers as a reason of improperly deposition of the paper. In answers to Q2 most responders in their environment never saw dedicated paper container, even if it exists, it is very close from residence. Also, residents are not enough informed if there is organised collection of waste paper. Only in larger cities there is a small number of containers for recycling. The respondents almost equally answered the question of whether they know how to sort the waste paper (44.65% yes, 55.35% not).

However, on the question of which type of paper should not be deposited in the same container (with offered answers: newsprint, office paper, tetra-pack packaging and old books), 85.4% answered tetra-pack packaging, which is the correct answer. As the main reason on question "What do you think why waste in Serbia does not sort properly" respondents reports insufficient informations and lack of suitable recycling containers.

— **Results of the MFA**

For the needs of the MFA and modeling in the STAN software, in this case it is necessary to know the following data:

- the amount of total generated waste per year in the Republic of Serbia,
- percentage of the paper according to the morphological composition of waste,
- the quantity of primarily collected paper and paperboard,
- the amount of paper and paperboard collected through registered operators.

Based on the results of measurements in reference municipalities in 2008, about 2,374,374 tons of municipal waste was generated (Vujic et al., 2009). The results of the 2014 modeling, for the purpose of innovating the waste management strategy, show that the amount of generated municipal waste compared to 2008 increased by 0.5% annually. This means that 2.448.566 tons of municipal waste is currently generated in Serbia (Vujić G., 2017). The average composition of municipal waste in Serbia, according to the National Waste Management Strategy, shows that the percentage of paper and paperboard is around 9.60%.

The largest share in municipal waste has biodegradable waste (48.80%), plastic about 23.70%, and the rest is metal (1.5%), glass (4.10%) and other materials (NWMS, 2010). The Report of the Environmental Protection Agency for 2016 specifies the separately collected quantity of paper and cardboard in the amount of 2339.7 tons, which is the primary selection of this secondary raw material (SEPA, 2017). Compared to the previous three years, this amount is only 20% compared to 2013, which is a result of the extraordinary activity of the informal sector. In Serbia, a total of 5% of generated waste is recycled, and if extraordinary activity of the informal sector is added, this percentage is doubled and up to 10% of the recycling of PET and other plastics, paper and cardboard (Vujić G., 2017).

For the purposes of the MFA model, the information given on the informal sector activity will be taken into account and will be applied to the amount of primarily separated paper and cardboard, therefore this amount will be doubled by the informal sector activity.

The total collected quantity of packaging paper and cardboard for 2016 by the operator amounts to 93326.8 tons (SEPA, 2017).

Based on the available data on waste quantities, percentage of paper and cardboard in the total quantity of waste and the way of paper and cardboard disposal, a MFA diagram is shown, within which two processes are defined, namely: the separation of paper according to the morphological composition and the separation of paper and cardboard from the total quantities of waste (Figure 3). The following MFA system has been defined for the territory of the Republic of Serbia for a period of one year, quantities of paper and paperboard that are not considered are concerned with the import and export of this secondary raw material.

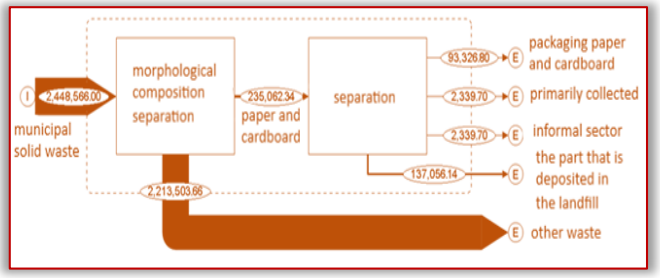

Figure 3. Flow chart for MFA

MFA results showed that, according to the morphological composition of waste, quantity of waste paper and cardboard in the total waste is about 235 062.34 tons. The next considered process is a separation of paper and cardboard from municipal waste. One part is collected by organized operators through packaging waste, the other part is primarily separated from waste, and the third part is the activity of the informal collectors of secondary raw materials. It should be noted that the results obtained should be taken with the reserve as there are no reliable data (or reporting) about the quantities collected within the informal sector.

The quantity of waste paper and recyclable cardboards (obtained by summation the primary amount of paper and cardboard, informal sector and packaging paper and cardboard) is about 98 006.2 tons, and the remaining 137 056.14 tons are deposited in the landfills in Serbia, which is shown in the output flows of the MFA diagram.

CONCLUSIONS

Identification of the causes of the low paper recycling rate shows that the main problem in correct waste paper deposition is insufficiency of the information about collection and the lack of the containers for specific waste types, such is the waste paper.

Comparing the results of survey research and material flow analysis, it is possible to notice their connection. The survey shows that citizens mostly do not opt for the separation of paper and paperboard, primarily because there is no adequate place to postpone it. From the other side, it is visible on the MFA diagram, if we look at the paper and cardboard quantities that are deposited at the landfills in Serbia. From this, it can be concluded that the respondents gave sincere answers when answering questionnaires.

Since the recycling in Serbia is in development, it is expected that in the coming period the situation in that area will improve, as it seeks to fulfill the legal obligations.

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SMART AND NETWORKED VILLAGES - INFORMATION SYSTEM FOR RURAL DEVELOPMENT

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Abstract: The aim of this paper is to contribute to the setting of an information model for the development of smart villages in the Republic of Croatia with special reference to villages in five counties of Eastern Croatia. It considers (a) EU rural development policies (2014-2020), as well as broadband networks in EU countries, especially in the new EU Member States, and (b) the concept and policies applied in these sectors in the Republic of Croatia, especially within the Slavonia program. The results of the project "Slavonian Network - Development of Broadband Access in Eastern Croatia" are presented. The "Slavonian Network" project was launched in 2012, and the Panon Institute for Strategic Studies proposed (in published papers from 2013 to 2017) broadband development models with intensive involvement of local communities in terms of social and economic development of Slavonia. Based on the results of these analyzes, the concept of the information system "Slavonian smart and networked village" was proposed.
Keywords: Territorial Development, Rural Innovation, Rural Services, Sustainability, Rural-Urban Linkages

INTRODUCTION

The Common Agricultural Policy (CAP) since the founding of the EEC and the Treaties of Rome (in 1957) has been one of the most important areas of activity of the institutions of the European Union, and rural development has subsequently been designated as the second pillar of the CAP. The objectives of this policy are: to promote the competitiveness of agriculture, to ensure the sustainable management of natural resources and climate change, and to achieve balanced territorial development in rural areas, including job creation and conservation. A new approach to rural development - dubbed 'smart villages' - appears in the Communication from the European Commission (EC) on the future of food and agriculture in November 2017 [1] with all elements of economic policy - from technology, communications, demographics, information systems and public relations to ecology and climate change. For complex consider of this topic more space/pages are needed to than is available here - therefore, the following considerations will only outline important factors - with reference to published papers explaining the details.

SMART VILLAGES AND EU RURAL DEVELOPMENT POLICY

— CAP implementation for the period 2014 - 2020

The basic regulations of the new CAP were published in December 2013. Subsequently, the EC drafted the delegated and implementing acts that were necessary to introduce the envisaged measures. During 2014, Member States had to make key decisions in view of the diversity of the way the new direct payments system is implemented and the space available for manoeuvre. All but one Member State (Germany) made use of the option of coupled payments at very different rates: eight decided to apply a redistribution of payments, while 15 Member States applied the small farmer's regime. When it came to green payment, five Member States gave farmers the opportunity to fulfil some of their obligations by applying the same practice. In addition, the choice of areas of ecological importance varies greatly within the EU. In addition, 15 countries have transferred amounts between the two pillars: for the whole period, the net amount of transfer between the two pillars, i.e. from the first pillar to the second, was approximately four billion €. For the second pillar, between December 2014 and December 2015, the EC approved all 118 rural development programs developed by 28 Member States. Twenty Member States have decided to implement only one national program and eight have opted for more than one program - in order to better take into account geographical or administrative structures. [2] Rural EU policy, now as a Smart Village macro project, covers almost all elements of economic policy - from technology, communications, demographics, information systems and public relations to ecology and climate change – so far more space/pages are required to consider this topic than is available here. Therefore, the following considerations will only outline important factors - with reference to published papers explaining the details.

In April 2017, the EC unveiled initiative for developing smart villages in the EU with the aim of achieving synergies with traditional agriculture, the Internet, local wireless networks and innovation, and through smart specialization to enable the development of new business models. The initiative also seeks to counteract negative demographic trends in rural areas. Public policies such as circular economy, energy union and digital economy need to achieve a EU energy transition to a low carbon society at reasonable cost to economy and greater citizen involvement in decision-making process in order to maximize social profit. Public sector policy-making requires coordination and collaboration of multiple sectors such as energy, transport, agriculture, economy and spatial planning. Development strategies, as a key document with policy objectives, must contain action plans for each sector in order to optimally achieve the policy objectives adopted.

Action plans should take into account regional and local specificities, strengthen the planning, financing and implementation of activities, and encourage involvement in EU initiatives such as the Smart Villages [3].

The Smart Villages concept has brought renewed attention to the development needs and natural potential of rural areas and to a much greater focus on empowering communities at the local level for rural areas to survive and thrive in the coming decades. But at the same time, it signalled the need to strengthen the processes in which local communities take an active role in shaping their own futures. The EU Smart Village Initiative seeks to achieve the synergy of traditional agriculture, the Internet, local wireless networks and innovation, and through smart specialization, enable the development of new business models. The initiative also seeks to counteract negative demographic trends in rural areas. The initiative came to life with the adoption of the EU Action Plan for EC Smart Villages, defined as rural communities based on existing strengths, available resources and the development of new opportunities, i.e. communities where traditional and new networks and services are enhanced by digital and telecommunications technologies, innovation and better use of knowledge. The pilot project "Smart Villages" is being implemented in nine countries of the EU, including Slovenia, which carries out activities in the three municipalities. "*Smart villages are about different policies working together to find better, smarter ways to promote holistic rural development. It is about using existing and new technologies and social innovation to add value to the lives of our citizens. It's about giving the village the tools to meet their own challenges, and at the same time contributing to the greater challenges facing society as a whole.*" [3] Therefore, concept of smart villages is one of solutions to prevent its dying out. Croatia is only just beginning in the concept of Smart villages, and the Croatian village is, more than ever, affected by emigration and depopulation today [4-14].

— The definition of smart villages

Smart Villages are communities in rural areas that use innovative solutions to improve their resilience, building on local strengths and opportunities. They rely on a participatory approach to develop and implement their strategy to improve their economic, social and/or environmental conditions, in particular by mobilising solutions offered by digital technologies. Smart Villages benefit from cooperation and alliances with other communities and actors in rural and urban areas. The initiation and the implementation of Smart Village strategies may build on existing initiatives and can be funded by a variety of public and private sources [15].

— European Network for Rural Development

The European Rural Development Network has been engaged in a 'smart village' for the third year, focusing on the production of materials that help interested rural stakeholders. Management structures should make materials the most of in rural areas. The aim of developing these materials is to support the concept of 'Smart Village' in the current programming period and in future Common Agronomic Policies. The "smart village" advice on this network recommended that Member States take the following steps when designing support for smart villages in the future CAP [3]:

1. Recognize the needs of rural communities that smart villages can address;
2. Map the existing policy support framework to identify opportunities and disadvantages;
3. Develop a targeted package of interventions that will provide rural communities with an initial idea for change to its sustainable scope.

It is useful to point out here that the scope of planned support for a 'smart village' in Finland is very broad and inclusive - to reflect the very diverse needs of villages in different parts of the country; there is no intention to develop a general national strategy. The aim is to be able to respond quickly and flexibly to the needs expressed by local communities in the following fields [16]:

- Economic investments and actions for business development of new value chains and local economic clusters (agricultural and non-agricultural) based on local assets and (potential) areas of comparative advantage (bio economy, smart tourism destinations, etc.), smart transport and logistics solutions, smart local services and service chains and smart food chains, digitization and collaboration between businesses.
- Connectivity (broadband) and different models for businesses (for example, social entrepreneurship).
- Social innovation to ensure sustainable and good quality social and cultural services. Also, investing in skills for the future, supporting urban-rural connectivity and sustainable well-being: preventing segregation and inequality among people, improved integration of immigrants, a sense of community, living conditions, culture, security, improving rural knowledge as well as access to "hidden" rural knowledge community.
- Environment - innovation to improve resources creates efficiency, create local energy communities, reduce carbon footprint, and improve biodiversity, both protecting and valorising environmental assets. Encouraging municipal authorities, business representatives, local people, research institutes and experts to work together to design and adapt new cost-effective emission reduction solutions, especially in the context of transport and mobility, housing and food. Low carbon villages: a circular economy, sustainable food production and local food.

RURAL DEVELOPMENT AND SMART VILLAGES IN THE REPUBLIC OF CROATIA

The concept of 'Smart village' is a new opportunity for Croatia to change its current direction and way of implementing agricultural policy, i.e. - rural development, by incorporating modern technological trends of internet technologies, energy efficiency, ecological agriculture (green economy), rural tourism, etc. into rural areas. This is fully in line with the priority areas set in the National Development Strategy 2030 [17,18]. In this way (by applying the concept of

'smart village') it can more effectively influence the trend of emigration from rural areas and encourage the arrival of young people into the country-side, that is, stimulate a balanced regional development using their potentials better and launching their (joint) development projects themselves. It is important here - as Euro-advocate Davor Škrlec points out - "*that the concept is recognized by the executive in defining the next operational program in national legislation, but the involvement of regional and local authorities is also required. This should remove local obstacles and encourage the development of projects. The concept of smart villages must be among the major initiatives in the next programming period for the modernization and demographic renewal of our rural areas.*"[19] One of the basic infrastructure platforms for realizing the concept of 'smart villages' is broadband access - fibber networks for high-speed Internet. Therefore, in order to consider the possibility of implementing this concept of rural development in Slavonia and Baranja, it is important to point out the state of play in this sector - that is, to point out experiences in implementing the project "Slavonian Network".

— "Slavonian Network" - a broadband project

Following adoption of the Broadband Development Strategy in the Republic of Croatia from 2012 to 2015, the Faculty of Electrical Engineering in Osijek (ETF), in February 2012, in cooperation with Croatian Network Agency (HAKOM), organized conference entitled "Development of telecommunications infrastructure – strengthening competitiveness and effective local self-government investment" which was also attended by the leaders of many municipalities, cities and five counties of the Slavonia-Baranja (SB) region. At the end of that year, the ETF launched project "Development of a Broadband Approach in the Five Counties of Slavonia and Baranja" [20-25]; (Figure 1 and 2)

Interdisciplinary project team of 'Slavonian Network' - composed of doctors, masters and graduated engineers of telecommunications, informatics and accounting, geodesy, economics, sociology and law from ETF and Panon Institute for Strategic Studies, Osijek and companies Geoprem doo Osijek and "Sokol" d.o.o. Vinkovci - created concept of the 'Slavonian Network' project and began to research and develop individual modules of this project. The project "Slavonian Network" (total amount of € 21.5 million) received three positive reviews from the Ministry, and by publishing papers at scientific conferences and journals, team members tested hypotheses and/or promoted the project. In this way, an effort was also made to carry out part of the mobilization and training preparations for involvement of other experts and LSGs from the region in its implementation. Results of one of the first studies (2012) on structure of costs in construction of municipal infrastructure (water supply, sewage, public lighting, hot water pipeline) and public infrastructure (electrical underground network, gas pipeline) were published in the Proceedings of the conference GAS 2013. [23]; the share of earth-works (construction) costs in the construction of fibber optic infrastructure is around 70%, and conclusion of the study - that an integrated approach can achieve a significant reduction in investment costs for construction of broadband infrastructure - is a proposal aimed at accelerating the realization of the "Slavonian network" and reducing costs; It is necessary to install plastic pipes at every construction (and before the start of construction within the framework of the "Slavonian Network") at each construction of the local public infrastructure.

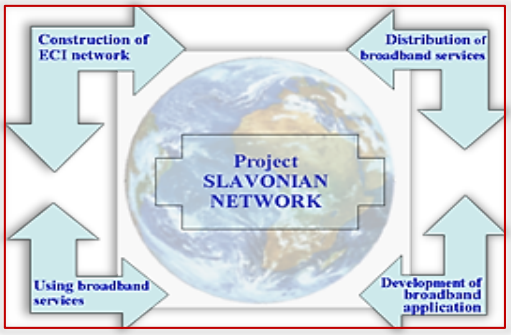

Figure 1. "Slavonian Network" project [23]

Figure 2. Area of "Slavonian Network [22]

However, this proposal - as well as several other organizational models (establishment of consortia, model of 'easement of rights' for electronic communications structure, model of concentration of available financial resources at the county level, and others) - unfortunately did not come to finalization - because in 2014 the project was transferred to level of the University, and all authors of the "Slavonian Network" project were excluded from further work on the project, and new team in the next five years did not realize the earlier proposals and are not initiate others models for implementation. He thus infamously finished the project, which was ranked 11th among the five hundred applications submitted to the Ministry's competition, and was the only broadband project and the only one covering more than one county (Figure 2). Finally - it should be emphasized that the existing broadband network in the five counties of the Slavonian region is not adequate for the needs of contemporary development, neither in capacity nor in speed; for the most part, this is based on copper conductors or over the air network - making it difficult to access high-speed Internet, especially when multiple users are involved at the same time. This means that for the development of 'smart villages' it is necessary to speed up the construction of a broadband network and make up for the lost seven years.

— **Social cohesion and knowledge society a prerequisite for smart village's development**

Experience from realization of this project has been discussed in several papers by Slavonian Network project team, from which it is important to state important issue of social cohesion - which is, otherwise, crucial for implementation of infrastructure project [26] - as the show Figure 3 and Figure 4.

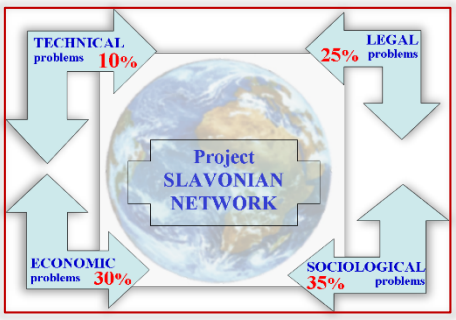

Figure 3. Elements of social cohesion [26]

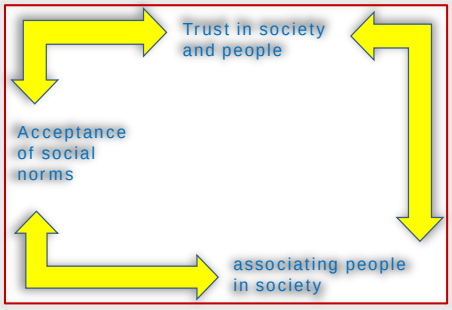

Figure 4. Problems of "Slavonian Network" [23]

In addition to the above - for the implementation of the concept of 'smart villages', the issue of understanding and application of the concept of 'Knowledge society' in Croatia is also important - on which concept EU projects are based. The know-ledge society (Figure 5.) is not yet a governing concept in Croatia and especially not in the element of 'lifelong learning', but also because of the fact that the practice is prevalent in which politicians of the 'general direction' make decisions often without effective public consultation, and without consulting independent experts.

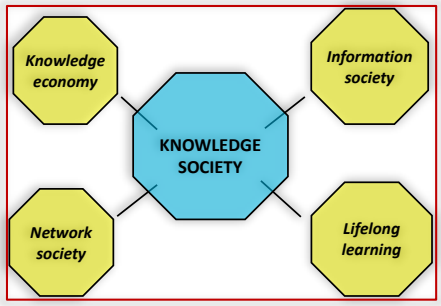

Figure 5. Elements of the Knowledge society concept [27]

INFORMATION SYSTEM FOR DEVELOPMENT OF SMART VILLAGES

Information system includes people, data, processes and information technology, which are together in the function of collecting and processing the data on the basis of which information is stored. Information can thus also be viewed as the output of an information system, since it is created to support the work of the organization. [28] [29] Each information system consists of:

- Hardware - the physical part of the information system (computers, modems, network equipment ...);
- Software - an invisible part of the information system in the form of software solutions, algorithms that drive hardware;
- Life ware - all those who use the information system;
- Data ware - the way and methods of organizing databases and data warehouses;
- Net ware - communication and networking solutions that bring all the elements together;
- Org ware - organizational procedures and methods for connecting all the above elements into one.

Today are in use:

- Classic or transactional information systems,
- Decision support systems,
- Expert systems,
- Communication and collaboration systems.

Decision support systems and communication and collaboration systems are important for our consideration.

An insight into the existing supply of structured knowledge and the broadcasting of important information in areas relevant to 'smart villages' shows that there are hundreds of information systems that produce the necessary information for use in the development of local 'smart village' projects. For example, at the national level, authorities issue daily important information on rural development (from the Ministry of Agriculture, Ministry of Regional Development, Ministry of Finance and other ministries and several national agencies), as well as regional (and local) institutions and EU institutions and/or networks. In this innumerable amount of information, local stakeholders of 'smart village' will not be able to read or read all that information daily, let alone act on it. Therefore, when designing implementation of 'smart village' concept and structural modelled of implementation units should be undertaken, as well as the identification of information needs and the construction of an appropriate information system.

a) **Smart Village implementation unit**

Each village has its own specificities - natural resources, tradition and human capital, and 'smart village' development programs will be developed on these bases. This means that each village will have its own development program. However, many villages in the regional structure, by territorial and geographical features, will have a number of common elements on which to build their development programs. Therefore, it is advisable to propose the creation of so-called smart village concept implementation units - Figure 6. - within which there would be one expert team for all villages in one implementation unit, in which, besides local experts (agronomists, etc.), there would be associate experts from surrounding cities (from related companies, associations, chambers, etc.) to ensure that all relevant areas of development are represented by a professional team structure.

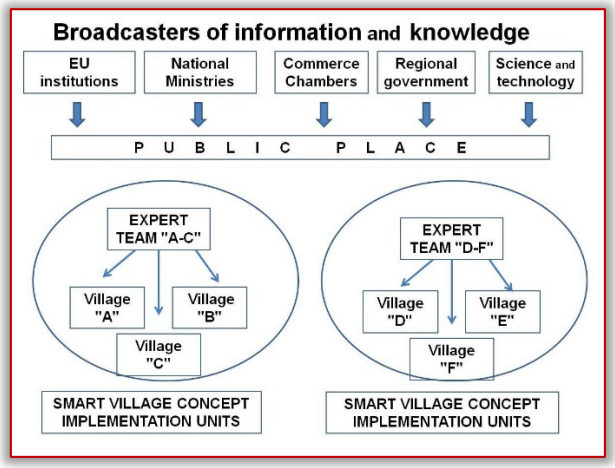

Figure 6. Model of receiving, selecting and sharing information/knowledge through units for implementation of the smart village concept

b) **Identifying information needs**

The said expert team should determine the information needs (area, frequency, manner of distribution and distribution) of its design and establishment of programs and methods of work - which should be documented in a separate act.

c) **Building an appropriate information system**

IT literacy of the average expert (of any profile) in Croatia is today at a reasonably satisfactory level so that building or setting up an information system that would suit the needs of the expert team in each implementation unit of the 'smart village' would not be a particular problem - especially if a staff member from a local software company involved in the process. After setting up the information flows set out in a separate act, the choice of hardware would be started - which should also not be a problem since the current supply of computer equipment in us is satisfactory. Software is also required to complete the 'smart village' implementation information system. It should be noted here that there are a number of ready-made applications (programs) on the Internet and networking applications that can be used for free (or at a small fee) - so it is not necessary to create special computer programs for this purpose. The education (training) of all stakeholders in the 'smart village' to use the selected program is also important element for the well-functioning information system of each unit implementation and each individual 'smart village'.

d) **Public relations policy**

At the end of these considerations, it is important to emphasize the need for transparency of the whole process and the importance of involving all stakeholders (experts, local government bodies and every household) in the implementation of this development project. That is why it is necessary to have a well-established and developed public relations model from the first step of setting up and implementing the 'smart village' concept. [30] This is important not only because of the mobilization of all stakeholders in the smart village on a joint development project - in order to optimally set up and implement the project, but it is also important in order to prevent potential corruption – it is also important to prevent potential corruption - which is not unknown in our region; even more - it domesticated.

CONCLUDING REMARKS

The EU's Common Agricultural Policy, and rural development as its second pillar, have been given a new dimension of action through the concept of 'smart villages'; In April 2017, the European Commission launched an initiative to develop "smart villages" in the EU with the aim of achieving synergies with traditional agriculture, the Internet, local wireless networks and innovation, and through smart specialization, enable the development of new business models.

- The Smart Villages pilot project is being implemented in nine EU countries - including Slovenia, but the Republic of Croatia is not included.
- The Croatian village is more than ever affected by emigration. Therefore, the concept of smart villages is one solution to prevent its dying out. The concept of 'smart village' is a new opportunity for Croatia to change its current direction and way of implementing agricultural policy, i.e. - rural development, by incorporating modern technological trends of internet technologies, energy efficiency, ecological agriculture (green economy), rural tourism, etc. into rural areas. . This is fully in line with the priority areas set out in the 2030 National Development Strategy.
- One of the cornerstones of successful implementation of the 'smart village' concept is the availability of broadband access. Although the Faculty of Electrical Engineering in Osijek initiated the project "Broadband Development in the Five Counties of Slavonia and Baranja" at the end of 2012, to date, this network in the five counties of the Slavonian region is not adequate either in capacity or in speed. This means that for the development of 'smart villages', it is necessary to speed up the construction of broadband and make up for the lost seven years.
- In addition to the above - for the implementation of the concept of 'smart village', the issue of understanding and applying the concept of 'Knowledge Society' in Croatia is also important - on which concept EU projects are based. Knowledge society is not yet a governing concept in our country, especially not in the element of 'lifelong learning', but also due to the fact that the practice is prevalent in which politicians of the 'general direction' make decisions, often without consulting independent experts.

After a framework analysis of the situation in the Slavonian region, a model of the so-called implementation unit of the "smart village" concept was proposed and basic frameworks for building (setting up) the "smart village" information system were proposed. In order for the whole process of setting up and implementing the concept of a smart village to be efficiently and quality implemented, it is important that the first step is to cultivate an objective public relation.

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THE PRODUCTION OF BIOHUMUS FOR A HEALTHY AND ORGANIC AGRICULTURE

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Abstract: One of the ways to solve the processing and transformation of organic household waste from agriculture and various branches of industry, turning them into precious organic fertilizers, like biohumus (biocompost, vermicompost) is vermiculture. The production and use of biohumus is addressed to those with livestock farms, but also to those who have vegetable, fruit, greenhouse, vegetable farms and have access to animal manure from other livestock farms. This paper aims to highlight the advantages of using biohumus for healthier and more natural agricultural production.
Keywords: vermiculture, biohumus, organic agriculture

INTRODUCTION

Vermicomposting is the process in which earthworms are used to convert organic materials (usually waste) into humus - a material known as vermicompost (Betz, 1999).

The processes of vermiculture and vermicomposting are similar, but different. A maximum density of earthworms is needed to produce vermicompost. If the goal is to produce earthworms, the density of earthworms must be kept low enough for the breeding rate to be optimal (Betz, 1999; Laza et al., 2019).

Vermicompost is generally superior to conventionally produced compost (Caba et al., 2019; Olan et al., 2020; Vlăduţ et al., 2019; Voicea et al., 2019) in several important ways, vermicompost is far superior to compost as an inoculant in the production of compost teas.

Figure 1- Biohumus

Biohumus contains in a balanced optimal form a lot of useful components:

- mineral elements;
- enzymes that ensure the transformation of organic residues into nutrient compounds;
- substances that prevent the spread of pathogens;
- phytohormones, which improve the growth and stress resistance of plants.

This type of organic fertilizer (biohumus) contains 4-8 times more humus than cow dung or compost derived from vegetable waste. Its advantages include good moisture capacity, friability, compatibility with other types of organic fertilizers, there is no need to use significant energy inputs in production and use.

The possibility to sell surplus products will allow to recover the costs and to obtain a certain income (Glenn,, 2009; Rink, 1992; PN 19.10.02 Contract no . 5N / 7.02.2019).

MATERIALS AND METHODS

Vermicomposting is a bit more variable, and this is due to the fact that there are several variations in how the process is performed. In composting, mixtures of materials rich in nitrogen and carbon are made at the beginning and then nothing is added. In vermicomposting or vermiculture operations, carbon-rich materials are used as a bed, while nitrogen-rich materials are generally food stocks.

Although similar processes take place in the bed (including conventional composting due to the action of microorganisms), some systems encourage the addition, during the process, of higher amounts of nitrogen compared to carbon than in the case of conventional composting. This is because the food is gradually added to the surface of the pile or string, and not mixed from the beginning (Gunadi B., Blount C., Clive A. E., 2002).

Since some nitrogen-rich materials (eg fresh food scraps) may have a higher water content than carbon-rich bedding, weight loss during the vermicomposting process may be higher (Rink, 1992).

For the production of biohumus the following things are required: earthworms, a hospitable living environment, usually called "bedding", a food source, adequate moisture (greater than 50% water content by weight), adequate aeration and protection from extreme temperatures. Bedding is any material that provides the worms with a relatively stable habitat. This habitat must have high absorbency because worms breathe through their skins and therefore must have a moist environment in which to live because if a worm's skin dries out, it dies. So the bedding must be able to absorb and retain water fairly well if the worms are to thrive, the beeding must have a good loosening potential, because if the material is too dense to begin with,

or packs too tightly, then the flow of air is reduced or eliminated. Different materials affect the overall porosity of the bedding through a variety of factors, including the range of particle size and shape, the texture, and the strength and rigidity of its structure. The overall effect is referred to in this document as the material's bulking potential, protein and nitrogen content (although the worms do consume their bedding as it breaks down, it is very important that this be a slow process. High proteinor nitrogen levels can result in rapid degradation and its associated with heating and creates inhospitable, often fatal, conditions. Heating can occur safely in the food layers of the vermiculture system, but not in the bedding (Short et all, 1999; Sudha et al, 2000).
Some materials make good beddings all by themselves, while others lack one or more of the above characteristics and need to be used in various combinations.
The vermicomposting system used to carry out the experiment is shown in the figure (Figure 2).

Figure 2 - Vermicomposting system

The vermicompost system Figure2 is a wooden construction provided at the bottom with a grate and vermicompost scraping system (compost subjected to the action of earthworms). This system consists of the following: Bracket, Geared motor transmission, Housing, Scraper knife.
On this system is also placed the wetting system that ensures the humidity (70% humidity) of the compost in which the earthworms move from the bottom up. The general technical characteristics of the vermicomposting system are the working capacity of1500 kg/h, installed power 1,5 kW, electric motor rotation frequency 1000 rot/m, sieve rotation frequency 35 rot / min, active sieve length 2000 mm, volume 3 m^3 installed power 1,1 kW.

RESULTS

In Table 1 is listed a number of materials along with their characteristics, absorption rate, loosening potential, carbon and nitrogen concentration, in order to highlight the efficiency of each material used.

Table 1. Materials used for bedding

Material	Absorption	Loosening Potential	Carbon/Nitrogen Report
Animal manure	medium-good	good	22-56
Domestic waste	good	medium	58
Silage corn	medium-good	medium	38-43
Hay - generally	low	medium	15-32
Straw - generally	low	medium-good	48-150
Paper from the municipal waste stream	medium-good	medium-good	127-178
Bark hard essence	low	good	116-436
Bark soft essence	low	good	131-1280
Corrugated cardboard	good	medium	563
Shredded sawmill waste	low	good	170
Waste paper fibers	medium-good	medium	250
Paper mill waste	good	medium	54
Sawdust	low-medium	low-medium	142-750
The chips from cleaning shrubs	good	low	53
Strong wood chips	low	low	451-819
Soft wood chips	low	low	212-1313
Leaves (dry, free)	low-medium	low-medium	40-80
Corn strains	low	good	60-123

Under ideal conditions, earthworms are able to consume in excess of their body weight each day, although the general rule-of-thumb is ½ of their body weight per day. They will eat almost anything organic (that is, of plant or animal origin), but they definitely prefer some foods to others. Manures are the most commonly used worm feedstock, with dairy and beef manures generally considered the best natural food for earfworms, with the possible exception of rabbit manure. The former, being more often available in large quantities, is the feed most often used (Clive and Lofty, 1972; Clive, 1998).

There are a number of other parameters of importance to vermiculture and biohumus production like pH, worms can survive in a pH range of 5 to 9 (Gaddie, R.E. and Donald E. D., 1975; Rink, Robert 1992). Most experts feel that the worms prefer a pH of 7 or slightly higher.

In general, the pH of worm beds tends to drop over time. If the food sources are alkaline, the effect is a moderating one, tending to neutral or slightly alkaline. If the food source or bedding is acidic (coffee grounds, peat moss) than the pH of the beds can drop well below 7.

This can be a problem in terms of the development of pests such as mites. The pH can be adjusted. Earthworms are very sensitive to salts, preferring salt contents less than 0.5% (Glenn, 2009). In case the manure is from animals raised or fed off in concrete lots, it will contain excessive urine because the urine cannot drain off into the ground. This manure should be leached before use to remove the urine. Excessive urine will build up dangerous gases in the bedding (Glenn, 2009).

The right mixtures used to create the bed are an essential element in meeting these needs. They provide protection in case of extreme temperatures, the required level and consistency of humidity and an adequate supply of oxygen. Fortunately, given their critical importance in the process, good mixtures are generally easy to find on farms.

The most difficult criterion to satisfy adequately is usually the absorption, because most of the straw and not even the hay are not too good at retaining moisture. This can be easily addressed by mixing manure or mature compost from cattle or sheep with straw.

The result is somewhat similar in characteristics to mature horse manure. The process of creating bed mixes does not have to be a burden, it can be done manually with a fork (small operations), with a bucket tractor (larger operations), or if available, with a mystery mixer. The latter would be suitable only for large commercial vermicomposting operations, where a high level of efficiency and constant product quality is required.

CONCLUSIONS

Biohumus contains the necessary set of macro and micro nutrients, enzymes, soil antibiotics, vitamins, growth hormones and humic substances, it contains on average a higher concentration of nitrogen, phosphorus, potassium, calcium and a number of beneficial microorganisms and bacteria than the ones we usually find in the upper layers of the soil.

The application of biohumus generates multiple benefits for farmers:

- by applying biohumus, significant production increases are obtained because the plants easily assimilate nutrients substances;
- increases the water retention in the soil (the amount of water needed for irrigation decreases by about 30%);
- the biohumus obtained can be used directly on the farm by distributing it on the area intended for fodder;
- fix soils affected by prolonged use of chemicals. By repeated application, the soil will be completely repopulated with microorganisms beneficial to plants destroyed by chemicals over the years.
- the application of biohumus improves the structure of the soil, aerates the soil and makes it easy to work, which leads to lower costs of providing fuel for agricultural machinery;
- it is non-toxic, does not burn plants, has no restrictions on use, can be used in any crop, greenhouse or field, with excellent results;
- it is compatible with any chemical preparation;
- it is excellent in the prevention of diseases (Alternaryosis, Gray mold, Fusariosis, Mana, Root rot, Bacterial burning in peas, Rhizoctoniosis, Septoriosis, Black tobacco rot, Apple rot).

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SMART UNIVERSAL MULTIFUNCTIONAL DIGITAL TERMINAL/PORTAL DEVICES

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Abstract: This paper considers, proposes and describes possibilities and methods for design, implementation and usage of smart digital universal multifunctional terminal/portal devices in many practical applications. Using digital electronic technologies embedded in such devices it is possible to design and implement smart digital terminals/portals for very wide variety of purposes of teller/counter type operations, where such digital machines can replace human work. It is expected that this kind of digital devices will be in perspective widely used in all places where there is needed a certain form of teller/counter services. Such places are for example: banks, post offices, municipalities, companies providing services such as electricity and water distribution, hotels, schools, universities, parking places, theatres, cinemas, various types of transport, etc. Application of different types of such embedded smart digital universal devices enables increasing efficiency, speed and security and decreased costs for all such services. It gives many benefits and advantages to the providers and to the users of such services. Way of design and use of such digital devices and technologies to effectively increase functionality and efficiency of teller/counter services is proposed and described. It is also proposed and described one practically designed and implemented smart universal multifunctional digital terminal/portal device for banking purposes.
Keywords: digital electronic technologies; embedded systems; teller/counter type services; smart universal multifunctional digital terminal/portal devices; banking smart digital terminal/portal device

INTRODUCTION

Modernization of almost every kind of teller/counter type operations and services necessarily involves introduction and application of modern digital devices based on using different kinds of digital electronic technologies, automation and robotization and carefully designed software applications. It all increases efficiency, speed and security and decreases cost of such activities and services.

It also brings many other benefits and advantages for providers and for users/clients of teller/counter services. That all creates need for transformation of teller/counter services from classical way with using human work into modern digital organizational model [1,2,3,4]. It assumes creation and application of modern digital devices for performing all needed teller/counter and similar activities and services. One such device is smart universal multifunctional digital terminal or portal that is proposed and described here.

Possibility and way of application of modern digital electronic technologies for design and implementation of embedded devices such is smart universal multifunctional digital terminal/portal for effective transformation of classical to modern way of offering teller/counter type services are considered, proposed and described in the paper. Way of design of the smart universal multifunctional digital terminal/portal device was proposed and described.

The device was practically designed and implemented as banking digital terminal/portal. It could be easily adapted for many other similar applications in many other purposes and domains.

CLASSICAL AND MODERN WAY OF PROVIDING TELLER/COUNTER SERVICES

The classical way of providing teller/counter type services, using a human workforce, is a very well known and still is predominant way of organizing and offering of those services. The basic advantage of providing those services in this way is physical personal (human) contact of person providing the services and users of the services. Another advantage would be possibility to provide quality information to the customer about the services. Also, it enables provider to direct the client to correct place in case of need for additional services and other useful information for clients. However, as modern teller/counter services become more and more standardized (template based) the mentioned benefits are becoming less important.

The dominant user requirements in the use of teller/counter type services were, and are even more expressed now, speed and availability. Great efforts should be made in order to achieve this by the classical organization of teller/counter services. In some cases it is either impossible or totally unprofitable for the service providers. For example, it is very difficult to organize the work of bank tellers/counters on the basis 24/7. It is difficult because this requires not only work of teller/counter workers, but also additional number of workers in protection and security, maintenance, hygiene, etc. All that should be organized in at least 3 daily working

shifts. Similar situation is for teller/counter workers in many places like are for example banks, post offices, public, state and school institutions. Apart from the difficulties in engagement of the human workforce to organize such working time, there are also significant additional financial costs, additional heating, physical control and insurance costs, the need for larger premises and significant increase of their rent or purchase costs.

It is proposed and necessary to perform the following in order to adequately solve the problem of organization and quality providing of teller/counter services:

- Simplify and make easier and standardised as much as possible the way of organizing and providing teller/counter services,
- Perform and implement full automation of those services,
- Perform and implement robotization of those services using modern digital technologies.

When these three activities are fully implemented, then it is easy to organize providing of teller/counter services 24 hours a day and those services can be quick and efficient. An adequate algorithm and a flowchart should be created after successful simplifying of such services. On the basis of it a convenient and effective software application could be designed, developed, implemented and installed. That application should be installed on the special embedded hardware equipment, specially designed for this purpose. With this will be performed the final part of the modernization of those services, the part of service robotization.

The teller/counter type services are generally very similar in various institutions that provide such services. So, it is possible and proposed here to consider possibility to create and implement such devices that will be smart, universal and multifunctional and very easily adaptable to provide larger number of such services in different institutions and purposes. Looking generally, almost every teller/counter type service consists of a few basic elements [1]:

- Client authentication,
- Determination of the client right to use requested service,
- Providing needed service,
- Charge of the service if the service should be charged,
- Issuing adequate certificate that the service was provided,
- Issuing adequate confirmation (receipt) that the service was charged if it is such type of service.

These presented basic elements were used for a starting structure in creation, development, design and practical implementation of the smart universal multifunctional digital terminal/portal devices that are proposed and described here. Figure 1 shows model and design of proposed and implemented smart universal multifunctional digital terminal/portal device. The device can be used in many places and for many types of services of teller/counter nature (for example in banks, municipalities, other public institutions, hotels, transport companies, etc.).

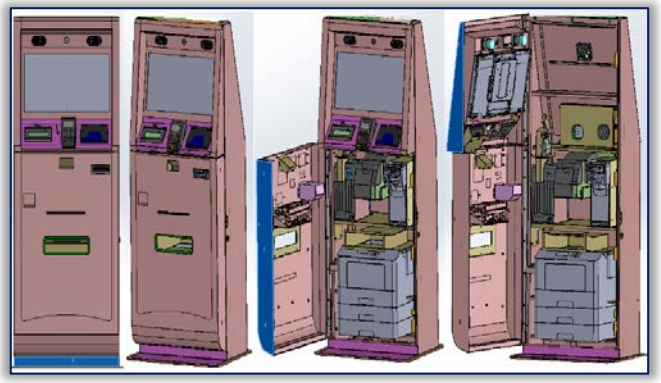

Figure 1. Model and design of smart universal multifunctional digital terminal/portal device

PROPOSED SERVICES USING MODERN WAY OF ORGANIZATION OF TELLER/COUNTER JOBS

The most of teller/counter type services could be automated and robotized in some way. It enables applying modern way of organization and providing of teller/counter type services using smart universal multifunctional digital terminal/portal devices. Some of the services and places where this could be implemented are:

— **Bank services and offices**

Activities of bank teller/counter workers could be automated and robotized with a high degree of success [2,3,4]. In transfer to robotization of this type of activities it is recommended to perform that process step by step. One of the suggestions is to first robotize activities related to the issuance of various certificates, statements and client reports for individuals and for legal entities. After that, it is necessary to robotize procedures of standard payments, such as are paying bills for electricity, utilities, state dues, etc. Then, it is needed to incorporate possibilities and functionalities of complete spectrum of providing of internal and external payment services. After that, it could be realized robotization of exchange transactions, of sale of certain banking services, of processes of signing contracts between banks and clients, and similar.

— **Municipalities and other public and government institutions services and offices**

In the municipalities and other similar institutions some types of teller/counter services could be automated and robotized. Such services are issuing of different types of certificates and some types of payments. It could be following services: issuing of birth certificate, children birth certificate, residence certificate, citizenship certificate, marriage certificate, payment of real estates and taxation, and etc.

— **Cadastre services and offices**

The following activities could be automated and robotized in the cadastre services and offices: issuance of property legal certificates for land and property holders.

— **Companies providing other standard services**

The following activities in other standard services could be automated and robotized: charging and paying bills of electricity and water consumption, communal utility bills, tickets for theatres, museums and cinemas, parking fees, etc.

— **Companies providing transport services**

The following activities in transport services could be automated and robotized: issuing of annual, monthly and daily tickets for various and almost all types of transport.

— **Hotel services**

The following activities in hotel services could be automated and robotized: organization of operation of hotel, hostel and motel reception and other similar hotel services.

PROPOSED DESIGN OF DIGITAL SMART MULTIFUNCTIONAL TERMINAL/PORTAL DEVICES

Proposed basic configuration of smart universal multifunctional digital terminal/portal device consists of:

- Housing,
- Power Supply,
- Industrial Desktop PC Type Computer,
- Touch Screen Display.

The following components were also used, individually or in combination, in order to achieve satisfactory user authentication:

- Webcam,
- Personal document ID and Passport Scanner with OCR Software,
- Barcode reader,
- Fingerprint scanner,
- Signature Pad.

This equipment can be used in combination for stronger user authentication where it is needed. Also, it can be used one method of authentication if it is enough for concrete purpose. POS (Point of Sale) device and electronic cards can be also useful for user authentication. Webcam is in most cases used in combination with Passport Scanner (with OCR Software), to use face recognition method for user authentication.

Service charges, where it is needed, can be performed using devices for the following ways of payment, individually or in combination:

- Payment with bank notes, top up and recycler,
- Payment with coins, top up and recycler,
- Payment with credit/debit bank cards via EFT POS.

The final service result of the performed service using the smart universal multifunctional digital terminal/portal, as well as printing receipts for payment of the service, could be achieved using the following devices:

- Printer device (usually of A4 format),
- POS printer for receipts printed on thermal paper.

Some other devices could be used like options for the terminal/portal device possibilities improvement:

- Device for instant issuing of mobile phone SIM cards (if intention is to establish 24/7 automated and robotized service for selling and filling SIM cards for mobile phones) and for issuing cards for many financial and other purposes (for example personalization of cards for entering in some special area),
- Plastic card colour printer (for similar purposes of cards issuing as it is previously described),
- Phone set (for offering Help Service, usually via Call Centre),
- Additional advertising 22“ monitor (for commercial and marketing reasons and activities),
- Dual iris camera.

Figure 2 shows proposed and practically designed and implemented smart teller/counter device used in a bank for purpose of automating and robotizing of the banking teller/counter services. All used equipment in the device implementation is shown and indicated in Figure 2.

Figure 2. Proposed design of implemented modern digital smart banking teller/counter service device

Figure 3 shows block diagram of proposed model of modern digital bank organization for teller/counter services using practically designed and implemented the smart banking digital terminal/portal, implemented for the needs of the bank, that is shown in Figure 2. The Figure 3 also shows a complete scheme of connecting of the terminal/portal device to the functional units of the bank information system.

Practically implemented way of selection of provided banking services on Touch Scream Display of the smart digital banking terminal/portal is shown in Figure 4. The Figure 4a shows menu of the device. Submenu in the “Certificate issuing” option of the menu is shown in Figure 4b.

Proposed, implemented and described digital smart teller/counter device for banking services and offices integrates offered services at device level with the real world. It was implemented integration with bank system that required a set of adapters to be implemented and certain security schemes to be applied. Unfortunately, there is no uniformity in all these when real systems for different practical applications are considered. That were and will be the challenges to overcome in the design and implementation of the devices.

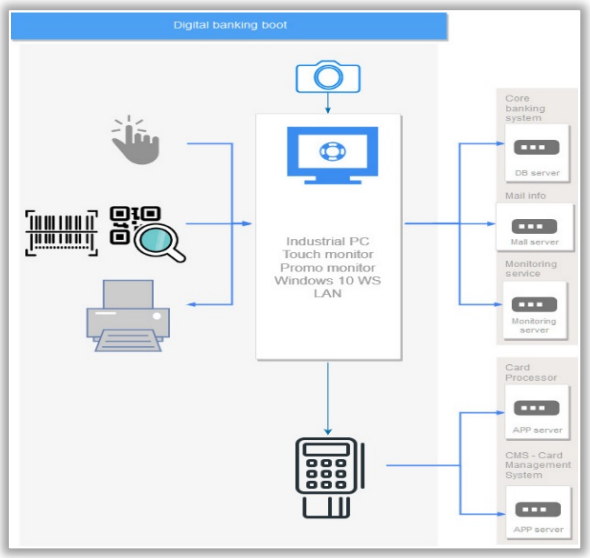

Figure 3. Block diagram of proposed model of modern digital bank organization for teller/counter services

a)

b)

Figure 4. Selection of needed services: menu (a) and submenu (b)

CONCLUSIONS

It is clear and secure that serious changes should be implemented in the teller/counter services in the future applying modern digital and mobile electronic technologies, systems and devices. The way how to performed it can vary in accordance with specific factors and needs of concrete application. One possible and expected way is proposed and described here. Speed of introduction of all mentioned activities and technologies will depend largely on speed of adoption of necessary legal regulation. It will also depend on differences in teller/counter service prices between using automatic devices and human work.

Initial discomfort of clients in use of automated self-service devices, as are ones proposed here, could be the best reduced by simplifying of operation with these devices and by providing well organized help desk support. However, greatest impact on popularization of these devices for customers could have significantly lower cost and much greater availability of services.

Proposed, implemented and described terminal/portal devices are smart, universal, multifunctional, modular, adaptable and could be easily used in many and almost all possible needs, purposes and applications where is necessary to realize teller/counter type services and activities. The devices are providing a set of services for citizens and are based on modern set of devices for user authentication, where applicable. Design and implementation was base on the involvement of modern ICT concepts and approaches and modern devices.

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THE METHODS OF SHOOTING EVALUATION

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Abstract: The Measurement Systems Analysis (MSA), unpaired t-test, factor analysis, normalized histogram, Z-score, and Mandel's statistics were used for estimation shooting accuracy capability of two spring air rifles, performed by two operators. The process of measuring the accuracy of the shooting, analysed by the MSA method, is not capable of the given measurement model (the value of %GRR is 96.32 for rifle V1 and 94.35 for V2).
Keywords: air rifle, capability, t-test, factor analysis, Z-score, Mandel's statistics

INTRODUCTION

Measurement in technical practice is affected by systematic, random, and possibly gross errors, which distort the measured value. To ensure accuracy and precision measurement results - the measured value must be measured in the system measurement management [1]. Standards ISO 5725-1 [2] and also ISO 3534-1 [3] define accuracy as describing a combination of both types of observational error above (random and systematic), so high accuracy requires both high precision and high trueness [1a].

Precision is the closeness of agreement between independent test results obtained under stipulated conditions. Less precision is reflected by a larger standard deviation. Precision is a description of random errors, a measure of statistical variability. Independent test results mean results obtained in a manner not influenced by any previous result on the same or similar test object. Quantitative measures of precision depend critically on the stipulated conditions. Repeatability and reproducibility conditions are particular sets of extreme conditions. Repeatability is the precision under repeatability conditions - the conditions where independent test results are obtained with the same method on identical test items in the same laboratory by the same operator using the same equipment within short intervals of time. [2][3].

The measurement management system requires that the measurement equipment must be confirmed and that the measurement process must be permanently controlled. An essential component of metrological confirmation is calibration. The calibrated measuring equipment is bound to the primary standard via an unbroken chain of comparisons with determined uncertainties. The requirement to control the measurement process stems from the fact that even the most accurate measuring equipment if used incorrectly, indicates incorrect results. The measurement process is performed in a system that includes, in addition to the measuring equipment of one or more operators performing the measurement, measurement conditions (e.g., temperature, humidity, pressure, vibration, noise, and lighting that may affect the operator), and properties of the measured samples.

The aim of the paper is the possibility of using some methods of evaluating the quality of measurement, commonly used in industrial and metrological practice to evaluate the accuracy of shooting. Due to the non-existence of relevant standards, in this case, we are limited only to the analysis of the control of the measurement process.

The first used method is based on the Measurement Systems Analysis (MSA), commonly used e.g. in the automotive industry [4]. It is based on the assumption that if the measuring process performs in a measurement system whose elements are capable, the process is also capable, i.e. of sufficient quality. This method has multiple approaches, the most used are repeatability and reproducibility analysis (GRR), and the analysis of variance (ANOVA). Due to the simpler approach, the GRR analysis will be used in the following. The results were confronted by t-test, factor analysis (ANOVA), and histogram of normalized values. The other two methods, Z-score and Mandel's statistics are used in practice to evaluate interlaboratory comparative measurements (round-robin tests), i.e. the quality of metrological, chemical, analytical work, etc. laboratories. The graphical output of both methods allows for quick orientation.

METHOD OF EXPERIMENTS

Two weapons were used - air rifles (pellet guns) type "Vostok" (IŽ-38), made in 1989 in the former USSR (in the following V1 and V2). Both have the original spring and seal, they have been used minimally. As the ammunition was used pellets Sport Diabolo caliber 4.5 mm (.177). It was verified according to the regulation of the Government of the Slovak Republic No. 397/1999 and its amendments (the last No. 269/2014). All pellets were from one package. The weight of 10 randomly selected pellets varied in the range of 0.5187 g - 0.5482 g (average 0.5328 g, standard deviation 0.0093 g). The measurement was performed in an enclosed space, the temperature fluctuated in the range of 25°C - 27°C, the illuminance of the target varied in the range of 94 lx - 253 lx. The "airgun" targets with a diameter of 120 mm (diameter of the outer circle of the scoring field with a hit value of 1, and were used hit value 1, and a diameter of 12 mm for an inner circle with a hit value of 10).

Two operators A (50 years) and B (36 years) shot at a distance of 10 m in a kneeling position. First, a rifle V1 and target No. 1 were used; both operators fired every five times in random order. It also fired at the targets No. 2 to No. 10. The same procedure was performed with the rifle V2.

As for the requirement for sufficient resolution (value of the smallest scale interval) of the measuring equipment, it is usually required to be able to read at least one-tenth from the variability of the monitored feature, which is represented by the standard deviation ST DEV. The target did not meet this condition, as the resolution was equal to 1 and the standard deviation of the measured values was 1.26 and 2.59. Fulfilling this requirement, i.e. dividing each scoring field of the target into tenth (to 1/10), would lead to the creation of a total of 100 scoring fields, separated by concentric circles. Such a target would be as confusing as possible.

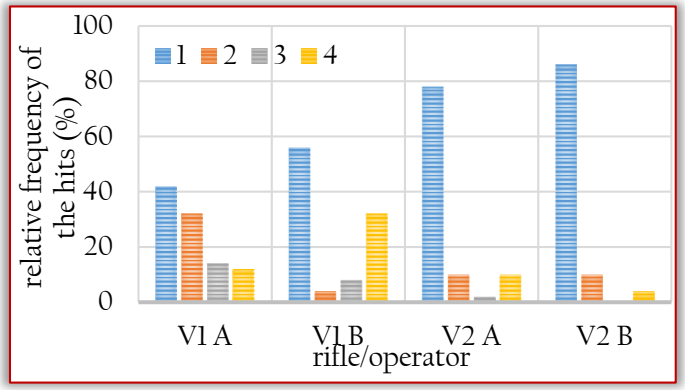

Figure 1 - Distribution (relative frequency of the hits) in individual sectors of the target

Outliers were determined using the Grubbs test at the significance level $\alpha = 0.05$, they did not occur. Normality was determined according to a normal probability plot using the Freeware Process Capability Calculator software. The normality of all files was confirmed (all hits of one operator with one weapon represented one file). If the measured results have a different distribution than normal, using standard methods for the calculation of capability results in an underestimation of the results. These usually seem worse than they are.

The repeatability and reproducibility analysis (GRR), the method used to evaluate the capability is described in more detail in the literature [4, 5]. Numerical calculations were performed at a 99% significance level with a 99% coverage interval (5.15) by the MSA module of the Palstat CAQ software. Ten targets represent ten samples with hits of both operators (model with 10 samples), the value of the hit represented the repetition of the measurement on the sample (model with 5 repetitions). The capability was evaluated separately for each of the rifles (V1 and V2).

RESULTS

As can be seen from Figure 1, both rifles, independent of the operator, takes to the top right (sector 1, Figure 2).

The parameter "ndc" - the number of separate classes (Wheeler's classification ratio) is related to the question of the resolution of measuring equipment. It indicates the number of different categories that can be reliably distinguished by the measuring system. The number "ndc" should be at least 5 (for rough estimates in it should be at least 2). The low value of the index (Table 1) corresponds to the above-mentioned low resolution.

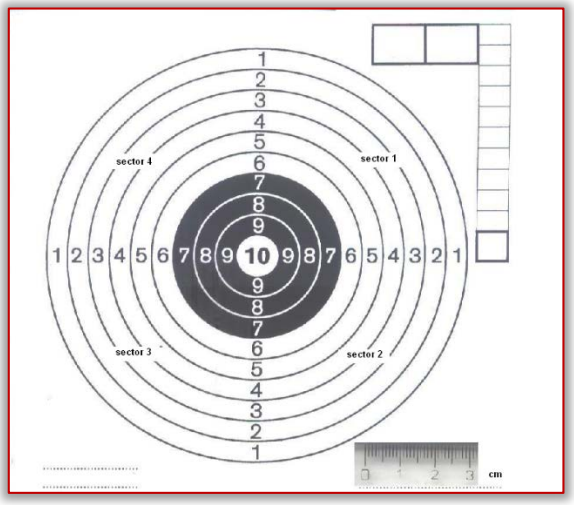

Figure 2 - The target and sectors

Table 1 - Basic statistics and competency indices

rifle	V1	V1	V2	V2
operator	A	B	A	B
average value of hits $\bar{x}$	7.44	7.4	6,46	6,88
standard deviation ST DEV	1.53	1.26	2,14	2,59
%EV	96.3		93.98	
%AV	0		8.252	
%PV	26.85		33.15	
%GRR	96.32		94.35	
ndc	0.333		0.435	

The% EV index is a function of the average variation range of repeated measurements - hits of all operators. Its high value is due to the low resolution of the target as measuring equipment, which practically represents the measuring means. The% AV index expresses the operator's influence on variability, e.g. his approach or abilities. It is a function of the variation range of arithmetic averages of hits of individual operators. For the V1 rifle, the influence of the operator on the capability was negligible. The increase in the value of the% AV index for the V2 rifle can be attributed to the different properties of both rifles. It proves, as follows from the Table 1, approximately the same decrease in the mean value of the hits $\bar{x}$ and an increase in the variance of STDEV in both operators. The % GRR index represents the ratio of the influence of the measuring equipment on the variability. Its value practically expresses the capability of the measuring process. If it is up to 10%, the process and also system are acceptable, up to 30% conditionally acceptable. The analyzed measurement process is unacceptable - ineligible, as the values of the% GRR index exceed 90%. The % PV index is a function of variation between individual targets - samples. Its low value indicates the low sensitivity of the measurement model used to capture these differences, but also the stability of the performance of both operators.

Table 2 - T-test and factor analysis

unpaired t-test			
together		P	difference betwen files
rifle	operator		
V1	A	0.1892	is not statistically significant
	B		
V2	A	0.2670	is not statistically significant
	B		
V1	A	0.0095	is statistically significant
V2			
V1	B	0.0719	is not statistically significant
V2			
one factor analysis			
1 – rifle and operator		0.0092	the influence of the factor is statistically significant
two factor analysis without repetition			
Factor 1 – rifle		0.5604	the influence of the factor is not statistically significant
Factor 2 – operator		0.1894	the influence of the factor is not statistically significant

The unpaired t - test of the assessment of the diameters of the two sets was compared to the sets of values of interventions of both operators from both weapons at the level of significance = 0.05%. As can be seen from Table 2, the difference between the operators when firing a weapon V1 or V2 is not statistically significant, on the other hand, the difference between the weapons is on the border of statistical significance for operator B, and statistically significant for operator A.

The Analysis of Variance – ANOVA, the part of the Microsoft Excel software package was used as another comparison method. Average values measured on individual targets were compared in one - or two-factor analysis with the first type error 0.05.

We assume that the variability of the values of the variable reaction Y is influenced by the factor 1 (rifle or operator) in the case of one-factor analysis or by factors 1 (rifle) and 2 (operator) in the case of two-factor analysis without repetition. We want to test whether the influence of factor 1 (or 1+2) on the variability of the hits values is statistically significant. If the p-value >0.05, the factor does not significantly affect the values of the hits [6]. The values of p for individual combinations are given in the Table 2. The cumulative influence of the rifle and the operator on the values of hits is statistically significant, although its share on the overall variability is relatively low - 5.6%. Separately, both components of the factor (as separate factors of the rifle and the operator) are not statistically significant.

The histogram of normalized values is a graph that shows the distribution of the frequency of measurement errors of individual operators. It makes it possible to obtain quick visual information on how the error, i.e. the difference between the observed and the normalized value, is divided. The ideal case is the maximum number at point 0 (on the x – axis). As can be seen from Figure 3, the error rate is higher for the rifle V2 and operator A.

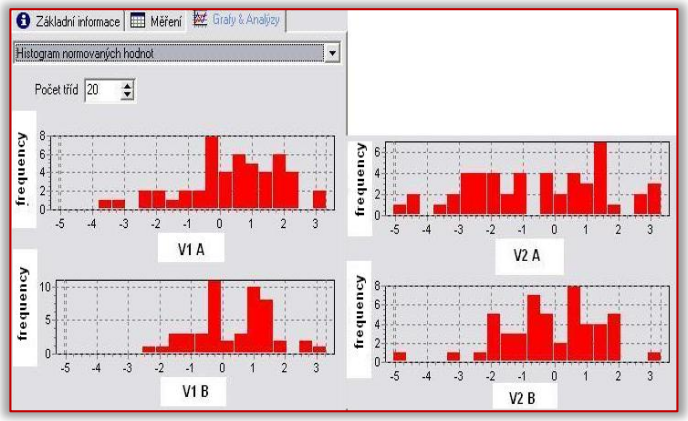

Figure 3 - Histogram of normalized values

When calculating the Z - score and Mandel's statistics, we used a simplification, the laboratory corresponds to the values of the hits of one operator with one rifle. For individual repetitions, the Z-score is calculated:

$$z_i = \frac{x_i - \bar{x}}{ST\ DEV} \quad (1)$$

where x_i the average of the values of the hits of one operator with one rifle on one target, $\bar{x}$ is the average of the values of all hits, and "s" is the standard deviation of the values of all hits. Z-scores whose absolute value $z_i \leq 2$ are satisfactory, whose absolute value exceeds 3 are unsatisfactory [6]. The Z-score values are shown in Figure 4.

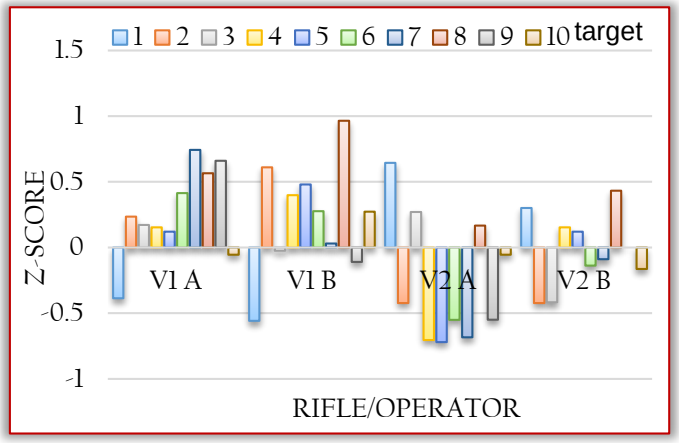

Figure 4 - Z - score

Mandel's statistic h is based on the mean, statistic k on the variance:

$$h_i = \frac{\bar{x}_i - \bar{\bar{x}}}{\sqrt{\frac{1}{p-1}\sum_{i=1}^{p}(\bar{x}_i - \bar{\bar{x}})^2}} \quad (2)$$

$$k_i = \frac{s_i\sqrt{p}}{\sqrt{\sum_{i=1}^{p} s_i^2}} \quad (3)$$

where $\bar{x}_i$ is the average of the values of one operator's hits with one rifle on one target, $\bar{\bar{x}}$ is the average of the values of all hits, s_i is the standard deviation of one operator's hits with one rifle on one target, and $p = 4$ (two rifles and two operators, i.e. four analysed files). Statistics k acquires only positive values. Lines corresponding to critical values are plotted in the graphs of Mandel statistics, at the significance level $\alpha = 0.05$ (strugglers) and at the significance level $\alpha = 0.01$ (outliers) [6].

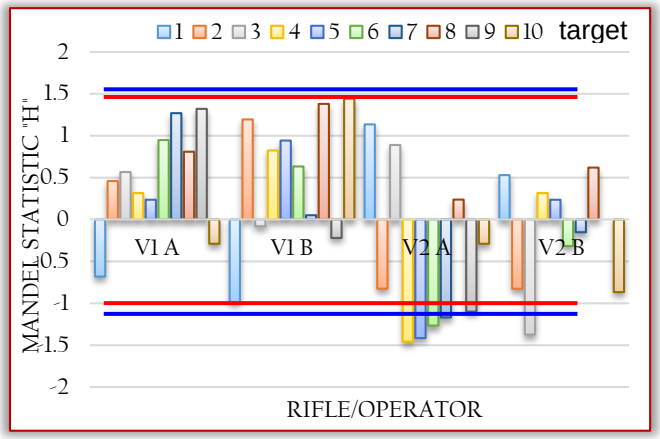

Figure 5 - Mandel's statistics „h"

In the analysis of Z - score and Mandel's statistic "h", Figure 5we notice outliers - these did not occur, but outside the set V1- A there are struggle values. Mandela's statistics are more sensitive in this respect than the Z - score. Symmetrical distribution of the values of individual samples - targets around the axis, which is approached only by the set V2-B, is suitable. As can be seen from Figure 6, this file shows the largest variance with the occurrence of an outliers. Operator A shows a larger variance on both rifles than operator B, this fact corresponds to the results of the histogram of normalized values.

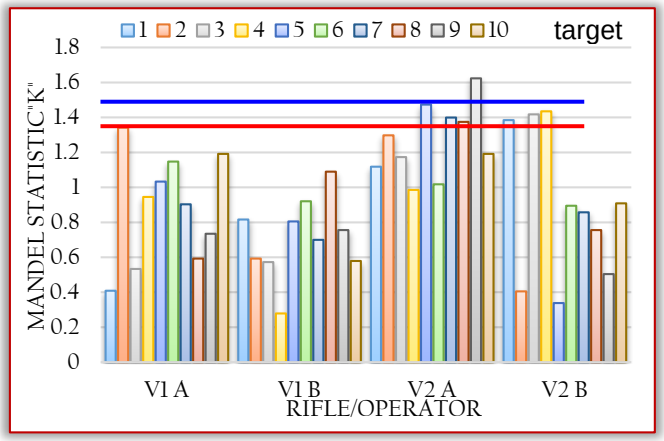

Figure 6 - Mandel's statistics „k"

DISCUSSION

The process analysed by the MSA method appears to be not capable, i.e. insufficiently sensitive to the evaluation of the quality of shooting. Insufficient resolution of the measuring equipment was identified as the cause. However, a finer division of the target would ultimately lead to a more complicated reading of the value of the hits. Likely, the MSA method is not suitable for evaluating the quality of shooting (similar to, for example, for measuring of the hardness [7] or the pressure of the blood [8]).

CONCLUSIONS

1. The process of measuring the accuracy of the shooting, analysed by the MSA method, is not capable of the given measurement model.
2. The statistical significance of the effect of the rifle used was confirmed by an unpaired t-test.
3. The statistical significance of the cumulative influence of the operator and the rifle on the accuracy of shooting was confirmed by one-factor analysis of variance.
4. The histogram of the normalized values and the Mandel statistic "k" confirmed a larger variance for operator A.
5. The results of MSA, t-test, and factor analysis show that the differences between the quality of the two operators are negligible. More sensitive graphical methods indicate that operator A is of lower quality than operator B.

Acknowledgment

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ENVIRONMENTAL POLLUTION CAUSED BY AGRICULTURAL ACTIVITIES

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Abstract: Environmental pollution is due to several factors such as: industry, agriculture, tourism, services, etc., and at first sight the industry is seen by all as the main polluter of the planet. On the other hand, agriculture also seems to play an important role in terms of environmental pollution. Among the factors in agriculture that have a high proportion in environmental pollution there are: animal husbandry and agricultural works, among which can be listed: works of establishment and maintenance of agricultural crops (soil pollution with chemical and organic fertilizers), works of plant protection (application of products used in plant protection). This paper presents some considerations regarding the main agricultural works that have a high impact on the environment in terms of pollution, respectively some measures that are required to combat this pollution.
Keywords: environment, pollution, agriculture, measures, impact

INTRODUCTION

Agriculture in general is largely polluting, and the phenomenon of pollution is largely known to environmentalists. It is true that pollution, as a process of degradation of the quality of environmental factors vital for human health, has not been recognized by political factors in the very recent past, as well as the fact that there were lacking and still lack the equipment needed to highlight all aspects involved in pollution. The main aspects of environmental pollution caused by agricultural activities can be summarized in (https://ro.ripleybelieves.com/what-is-environmental-impact-of-agriculture-7534):

- Discharge of several million cubic meters of wastewater, untreated or incompletely treated, from industrial complexes for growing of pig, poultry and cattle, into the surface water and the drainage system. To these is added the deep infiltration of wastewater, during the period of storage in ponds, battles and basins, affecting the quality of groundwater used as a source of drinking water in many rural localities.
- The use on agricultural land, for dual purposes of fertilization and irrigation, of sludge and wastewater from livestock farms, containing harmful salts and contaminating pathogens to the soil, plants, animals and humans.
- The administration on agricultural lands adjacent to the livestock complexes of exaggerated norms of manure (over 100 t/ha), at intervals of 2-3 years, which by far exceed the needs of plants and determine the accumulation of nitrates in feed, as well as the leaching of nitrates in groundwater.
- The use of chemical fertilizers (especially nitrogen) in too high doses and at times not related to consumption in different stages of development of the cultivated plants. Often, their application is made on frozen ground with a thick layer of snow, which is why due to sudden melting and favored by the slope of the land they reach, by washing, into the running water used as drinking water sources.
- Application of chemical products (pesticides), in order to control diseases, insects, rodents, nematodes and weeds in agricultural crops and fruit-wine orchards, by poorly trained people. Applying too large amounts and concentrations at inappropriate times and by using products with a high degree of toxicity and long shelf life has multiple negative effects on plants, animals and humans.
- Not to be neglected are the aspects related to the preparation of pesticide solutions, washing and dumping in illegal places of the remaining solutions from the agricultural apparatus and equipment used for their administration.
- Uncontrolled storage of manure and the lack of collection basins for liquid manure from animals belonging to many private households have as negative effects their runoff into running water, as well as nitrate infestation of groundwater.
- Aggravation of soil erosion on sloping lands, due to the practice of an inadequate agricultural system, respectively: poor organization of the territory, execution of soil works from hill to valley, crop rotations with a high share of weeding plants, lack of organic fertilization.
- Degradation of the physical state of the soils (structure, porosity, permeability, resistance to plowing) due to the decrease of the organic matter content and the exaggerated traffic with agricultural equipment on the field having an inadequate soil moisture.

In terms of animal husbandry, even some domestic animals irretrievably destroy the growing tree vegetation, preventing the regeneration of forests. Also, pet farms can also pose serious problems of environmental pollution with animal waste. The exodus of some animal populations can create

ecological catastrophes. In animal husbandry, in addition to insecticides, other chemicals are also used that give unwanted side effects, namely substances administered to influence the development of animal production. These substances are harmful because they are excreted in the urine and are found in the drinking water of other batches of animals (for which the substance is contraindicated) or they can reach to humans when administered until the last days before slaughter.

In the organization of modern agriculture, a very important role is played by landscaping works and especially by water management. Dams and irrigation canals not only change the hydrological regime in the area, but also the local ecological systems by changing soil factors. Both positive effects (territorial expansion of cultivated areas and increased productivity) and negative ones (salt pollution: salification, salting) can occur. Irrigation played a very important role in the development of the great ancient civilizations. Today, more than 500 million ha are irrigated, and this represents 50 times more than in 1800.

Agriculture is mainly responsible for water and soil contamination, this being caused by the increasing use of pesticides, as well as the intensive nature of agricultural production (Petre et al, 2019). Almost all pesticides are made from chemical substances that are designed to keep diseases and pests away from crops. However, in the long run, the whole environment suffers - a paradox that ultimately affects human health and therefore technical solutions are needed for a rational application of herbicides / chemicals (Bolintineanu et al, 2009; Bungescu et al, 2009; Matache et al, 2010; Niţu et al, 2012; Vlăduţ et al, 2010a; Vlăduţ et al, 2010b).

Moreover, as agriculture becomes more intensive, in order to feed the growing population, many ecosystems are destroyed to make room for crops. Entire forests are cut down to eventually get agricultural crops, but people forget that in the long run we are actually destroying the planet's lungs. Solutions consist in the recovery of degraded soils through different treatment / improvement methods (Pruteanu et al, 2019), treatment of wastewater from animal husbandry (Tociu et al, 2019; Ungureanu et al, 2019a; Popa et al, 2019), respectively the use of different methods and solutions for depollution of soils (Vanghele et al, 2019).

Organic farming is a viable alternative but it is still too expensive for many agricultural producers and also for potential buyers of products thus obtained. In the future, however, the adoption of cultivation techniques using agrochemical analysis of soil (Borland et al, 1981), organic and pest control equipment that does not involve the use of pesticides and other pollutants (Zhu et al, 2007), which uses advanced materials (Cârdei et al, 2012), will be a solution to prevent soil pollution.

MATERIALS AND METHODS

Paradoxically, the very branches of the human economy, which are mostly based on relations with the environment, are also sources of pollution. Agriculture can be a source of environmental pollution by: triggering and favoring soil degradation processes following the erosion processes (land clearing leads to soil erosion), salting, compaction (Ungureanu et al, 2019b); the use of pesticides (insecticides that destroy all insects, including the useful ones); excessive use of chemical fertilizers.

According to specialists, out of the total agricultural area of our country, only 30 % are soils with a high fertility potential, the rest having different states and stages of degradation. Of the 5 million ha of land affected by erosion only half were landscaped anti-erosion and thus led to increased productivity per hectare (compared to the previous period). Through the erosion process, 150 million tons of soil are lost annually, of which 1.5 million tons of humus.

Excessive deforestation in the upper part of most river basins, as well as the irrational use of agricultural land, have had a negative influence on the flow of water on the slopes, causing severe processes of soil erosion. The forest fund of our country is of 6.4 million ha, which represents a strong imbalance, predominating the young forest, and the one of over 80 years (exploitable) has a deficit of 500 thousand ha, causing an acute lack of wood for timber and veneer.

Due to intensive agriculture and to the use of pesticides and chemical fertilizers, the soil is the main environmental factor affected. Most soils lose their nutrients and organic matter to a greater extent than the process of supplementing them, which ultimately leads to their depletion.

Figure 1. Soil pollution (Borlan et al., 1981)

Soil pollution means any action that disrupts the normal functioning of the soil as a support and living environment in natural or man-made ecosystems. Soil disturbances can be:

a) physical: the phenomenon of compaction and damage to the structure generated by improper work;
b) chemical: generated by soil pollution with heavy metals, pesticides, fertilizers, changing the pH of soil solution;

c) biological: generated by soil pollution with germs of diseases transmissible to plants and animals;
d) radioactive: soils capture very easily radioactive pollution that they transmit to plants and animals for a long time (Borlan et al, 1981).

RESULTS

— **Soil pollution with chemical and organic fertilizers - works for the establishment and maintenance of agricultural crops**

Intensive agriculture, widely practiced in all countries of the world, involves the administration of chemical fertilizers in order to increase the productivity of crop plants. This process aims to return to the soil the equivalent of the amounts of nutrients extracted from it by plants. The most important and most used are nitrogen-based fertilizers (ammonium, calcium and potassium nitrates), sulfur (ammonium sulphate and superphosphate) and potassium. The polluting effect is mainly determined by the excessive amounts used, well above the necessary ones used repeatedly over the years and, secondarily, by the introduction into the soil of toxic impurities contained in fertilizers (Vlad et al, 2018; Vlăduţ et al, 2008).

The polluting effects are given by (Munteanu et al, 2011):

≡ impurities, residues from the manufacturing process;
≡ imbalances of certain biogeochemical cycles, which lead to soil degradation;
≡ contamination of groundwater;
≡ lack of purification and cleaning of industrial fertilizers due to production costs; they contain toxic metals and metalloids (arsenic, cadmium, chromium, copper, lead, zinc) with risks of soil and food contamination;
≡ excess of nitrates due to superfertilization with nitrogen fertilizers in the biosphere circuit, estimated at 9 million tons/year, which accumulates in the hydrosphere through leaching processes of soils degraded by superfertilization (misuse of nitrogen fertilizers).

Research shows that nitrates usually accumulate in green leaves, and in this sense, Rondest J. (1972) found that in spinach and lettuce leaves there were such large amounts of nitrates that consumers' health was endangered. Nitrates reaching the human intestine are converted to nitrosamines, which are powerful carcinogens. The misuse of chemical fertilizers has the following negative effects:

≡ modifies the biogeochemical circuit of nitrogen and phosphorus;
≡ inhibits or blocks the recycling of organic substances and humus, the process causing their decrease, manifested by the decline of the clay-humic absorbent complex;
≡ causes groundwater and surface water pollution and thereby induces a decrease in the biodiversity of aquatic ecosystems and their biological productivity.

Of the total amount of fertilizers applied on an agricultural area, a maximum of 50 % is found in the vegetable mass; the rest remains in the soil or is entrained in groundwater and surface water. Through links in the food chains, nitrogen from the plant mass is taken up by animals and humans. Through metabolic processes, nitrates are transformed into nitrites that have a high affinity for hemoglobin, together with which they form methemoglobin, a stable product that drastically reduces the oxygenation capacity of tissues. Nitrates usually reach the food chain through milk, the main food for children. In the '80s, in the areas of Galati, Braila and Ialomiţa, poisonings were reported because the concentration of nitrates in milk exceeded 850 ppm, compared to 75 ppm set as the maximum limit by the WHO and FAO (Tuomisto et al, 2017a).

Superfertilization with phosphate fertilizers causes the excess of phosphorus entrained yearly by inland waters into the lakes and seas to cause the phenomenon of eutrophication, which through its long-term action, makes the water increasingly poor in oxygen, finally destroying the aquatic fauna (fish, etc.).

Figure 2. Soil pollution with chemical and organic fertilizers (Tuomisto et al, 2017)

— **Pollution with pesticides and their residues - maintenance works of agricultural crops**

Soil pollution with pesticides is an important component of agricultural pollution of the environment in general. Unlike other pollutants, pesticides are deliberately dispersed in the wild to destroy certain parasites of humans, domestic animals or crops (Tuomisto et al, 2017b).

Modern pesticides are mostly synthetic organic substances intended for the destruction of harmful insects (insecticides), phytophagous fungi (fungicides), weeds in crops (herbicides), rodents (rodenticides) or nematodes (nematocides). Current synthetic insecticides are divided into three main groups: organochlorines, esters and carbonates. Contamination of soils and vegetation with pesticides has important consequences for species and biocenoses (Pisante et al, 2012).

Despite the important advantages of using pesticides in the agriculture (increased production, reduced labor, etc.), their use on a large scale and in large and repeated doses causes many ecological disadvantages. Their application leads to a

number of changes in the ecosystems in which they were introduced, among which are mentioned:

- has a very intense spectrum of toxicity for both animal and plant organisms;
- have a fairly low degree of selectivity and are often used against populations and not against individuals;
- their effect does not depend on the density although their application takes into account the density;
- many of them have a high degree of persistence in the soil which can be of the order of months or even years;
- some pesticides are dispersed over very long distances and are incorporated into biomass, ocean waters or soil;
- through their biological action, they destroy not only the target organisms, but also some useful ones;
- persistence in the environment, accumulation of some of them and their penetration into food chains.

These effects can be of demoecological nature (those that affect the populations and especially their density), respectively of biocenotic nature (those that cause disruptions of biocenotic balances). Being toxic to weeds, diseases and pests, pesticides pose a risk of harm to humans, pets, venison and birds. For this purpose, various procedures are used, such as:

- incorporation of activated carbon in the soil;
- administration in the soil of adjuvants, products that retain or degrade the pesticides;
- cultivation of plants (corn, sorghum) that have the ability to depollute the soil of atrazine by organic absorption into the soil in large quantities;
- integrated control of diseases and pests as a measure to prevent soil pollution with pesticides.

Due to the high risks, it is recommended to use those pesticides that comply with the following rules: to use the least toxic products; to avoid the introduction into the ecosystem of biologically degradable pesticides, those with high residuality; to avoid the use of easily leachable products, which reach the groundwater faster; products that due to their persistence easily enter the food chain plants - animals - humans are no longer accepted. A safe way to achieve this goal is the introduction of integrated protection (integrated management), which is based on:

- combining methods: agrotechnical, physical, biological, chemical;
- the application of control measures only when they are economically justified.

If in the not too distant past it was expected to liquidate, eradicate pests to the last specimen, in integrated management the concept is combated and abandoned. In reality, pathogenic pests and weeds produce crop losses only when they have a certain density. It is therefore recommended to use the economic damage threshold before using pesticides to determine exactly how much pesticide is needed (https://ec.europa.eu/agriculture/envir_en).

Figure 3. Pesticide pollution
(https://ec.europa.eu/agriculture/envir_en)

— **Plant protection**

Plant protection is the science that deals with the study of harmful organisms (phytopathogens, phytophagous arthropods, weeds, rodents, etc.), in order to establish the most effective measures to combat the damage / economic losses caused by them. It is estimated that about a third of the potential crop yield is destroyed ("tithed") by harmful organisms, so plant protection, as an applied biological discipline, contributes to increasing crop yields and improving crop quality.

Pest control of agricultural crops is achieved by several methods: chemical (using pesticides), biological (using antagonistic organisms and natural products), genetic (by improving the resistance of plants to harmful organisms), agrotechnical (by soil work, including weeding) and physical-mechanical (thermal disinfection of seeds, plant surgery, seed clearing, etc.).

Pesticides are either mobile or highly absorbed by soil organic matter. They can be volatile, persistent or rapidly degradable. Pesticides are chemical means of plant protection, obtained by formulating and conditioning of biologically active ingredient(s). With very few exceptions (such as plant growth regulators, used to control plant growth, or products that act by activating systemically manifested resistance in plants, and which are a kind of "vaccines" for plants) biologically active ingredients are toxic ingredients. This toxicity actually requires the existence of a code of good practice for the distribution and use of pesticides. The following categories of substances are also included in the category of pesticides: growth regulators, defoliants, desiccants, systemically activated resistance activators, vegetable and fruit cleaners, substances applied to prevent fruit falling, as well as substances applied before or after harvest to control pests acting during storage and transportation of the crop (http://www.farmer.com.cn/wlb/nmrb/nb8/).

Biopreparations are biological means made on the basis of microorganisms useful to crop plants or on the basis of natural compounds (plant extracts, suggestively called in English "botanicals"). The use of biopreparations is an important orientation in today's agriculture due to its advantages:

≡ reducing environmental and food pollution;
≡ avoiding the occurrence of pest populations resistant to control treatments;
≡ the possibility of using unqualified personnel in conditions of total security (both for crops and for the user);
≡ sustainable use of a useful resource from the agricultural systems unexplited so far.

There is a widespread but wrong practice on farms to voluntarily dispose of waste and pesticide residues in ditches, canals, surface waters or on agricultural land. They come from:

≡ excess spray liquid;
≡ washing of the machines;
≡ losses of spray liquids during their supply or during technological operations;
≡ losses due to uneven distribution;
≡ packaging and containers which still contain pesticides and which are disposed of or stored improperly;
≡ residual liquids from immersion baths or sheep bathing;
≡ waters that were used to wash the agricultural products;
≡ leakage from broken or cracked packaging or containers;
≡ pesticides eliminated due to expiry date.

The cultivation of vegetables and ornamental plants in greenhouses and solariums is an important source of complex local pollution, with pesticides and fertilizers. Pollutants reach the surface waters through other circuits than in the case of agricultural crops, namely:

a) eaves spills (condensation water or artificial rain) that carry the fertilizers and pesticides deposited on the windows inside;
b) irrigation that is used concomitantly with fertilization and for the administration of pesticides;
c) waters of glazing washes on both sides;
d) wastewater from special flower treatments.

All this water must be recovered in watertight concrete ponds and followed by a closed circuit by recirculation, without being discharged outside.

Pesticide depots will not be located near water bodies or in areas where groundwater is present at shallow depths. The location will be at least 200 m from homes, water sources, fodder, fields and agricultural land, farms and animal depots. Warehouses will be constructed of durable, non-flammable materials with sufficient and adequate storage capacity.

The pesticide depot must be able to keep the products safe in the event of spills or spills. The floor must be impermeable and located below the ground surface to form a retention basin or there must be sills on doors and walls that prevent liquids from passing through them and that retain the scattered material. (Zhu Liya et al, 2007).

— **Application of products used in plant protection, and water and soil protection measures**

The strategies to reduce the impact on the environment through the intake of pesticides can be addressed in various ways, from prevention at source to treatment of symptoms related to the adverse environmental effects. Next are some of them (https://www.ncbi.nlm.nih.gov/pmc/):

a) reducing the basic needs of crop protection by chemical means by using practices and methods that reduce crop diseases (judicious crop rotation, cultivation of varieties resistant to diseases and pests, seeds, seedlings, disease-free and pest-free cuttings, adequate measures of hygiene to limit the spread of disease and pest attacks) as well as by the strict use of chemicals to the minimum in order to combat crop diseases;
b) choosing with great discernment of only authorized pesticides that do not harm the environment, such as selective ones;
c) personnel using these products must be trained, certified and authorized;
d) strict supervision of the regime and use of pesticides;
e) interdiction of using air treatments, especially when the treated agricultural land is close to water bodies;
f) limiting the administration of fertilizers because there is a situation that certain diseases and pests are favored by increasing the yield and productivity of crops;
g) reduction of the preventive use of pesticides taking into account the fact that the presence of parasitic organisms is a normal situation, their problem being reconsidered only when there is an estimated danger or a certain degree of harm is exceeded;
h) partial replacement of the use of pesticides by ecologically clean means and methods, other than chemical ones (biological methods, preventive methods, traps, manual removal of pest nests, etc.).

The following complementary measures are recommended to reduce the amount of pesticides dispersed in the environment:

≡ equipping the spray devices with anti-dispersion screens that limit the spread of pesticides outside the strictly targeted areas;
≡ sprayers and especially their most important component - the nozzle must be maintained in the best operating condition at optimal parameters; for this purpose, periodic checks will be carried out with the immediate replacement of defective, worn or improper parts; strict correlation between the capacity and efficiency of the spraying equipment and the load of pesticides supported by the environment;
≡ prohibition of the establishment of orchards in the immediate vicinity of water bodies;
≡ the establishment of forest curtains against the predominant winds;
≡ the establishment of pesticide-free areas 10 m wide in the immediate vicinity of a body of water.

Chemical control treatments are applied curatively or preventively, either in vegetation, or by seed treatment, or by

soil treatment. Pesticides are usually applied by wet treatments, in the form of spraying, pulverization or aerosols (toxic mist).

Many widely used pesticides (bentazone, atrazine, simazine, dinoseb, etc.) are included in the category of substances with a high risk of pollution of surface water and groundwater. When such pesticides are identified in the groundwater, it can be assumed that there will be an increase in their concentration given that the movement through the pedological columns can take place in a relatively long time.

Seed treatment is done either by wet or dry methods (depending on the type of product) using special seed treatment machines. The most dangerous products for the environment and human health are dust powders. In Romania there are practically no products formulated in this way, with the notable exception of sulfur, which is a product with ecological consonance, being natural, biodegradable and with low toxicity for non-target organisms.

Usually, all pesticides are biologically active substances that have side effects on the environment and human health. When there is a choice, the product that has the least impact on the environment and presents the lowest risk to human health will always be chosen.

Pesticides should only be applied on warning. Treatment warning is done when a pest tends to grow above the economic damage threshold (EDT), which is the level of the pest population that causes a higher damage to the total costs (ecological and economic) of the treatment with plant protection means (pesticides, biopreparations). In general, the treatment warnings are made by the County Plant Protection Inspectorates, having a weighted value at county level. However, the most accurate and advantageous are the computerized forecasting and warning systems used locally.

Pesticide treatments must be notified in advance (in writing) to local authorities, specifying: type of treatment; crops to be protected; the plots on which treatments will be applied; the period of application;the type(s) of pesticide(s) used.

In areas with surface water, good agricultural practices require the limiting of using aero means of treatment (helicopters, gliders, planes, etc.), because these means of treatment are too widespread. A similar situation is the case of the use of strongly blowing mechanical means such as those used in vineyards and orchards.

In areas with surface water, treatments with toxic insecticides for fish (e.g. synthetic pyrethroid insecticides) should be avoided as much as possible. If it is not possible to give up these pesticides, appropriate risk management measures will be taken (precise delimitation of the treatment perimeter with a minimum distance of 10 m to the waterfront, equipping the spraying machines with anti-dispersion screens, strict correlation between machine capacity spraying and the surface to be treated, application of treatments at a maximum wind speed of 4 m/s, complete prohibition of discharges of water polluted with pesticides from washing machines, etc.).

The application of pesticides will be done in meteorological conditions provided by the technologies in force. Treatments will not be made at very high temperatures and during the afternoon, and for products with inverse temperature coefficient the maximum indicated temperature will be observed. Do not apply to rain (or before and after) and do not apply pesticides when the humidity is high. In case of strong wind, the treatments will be performed in the morning or in the evening.

In Romania, however, the practice of using illegally traded pesticides is quite common. These illegal pesticides are:

- brought by the small border traffic from the neighboring countries;
- from expired pesticide stocks (including DDT stocks!);
- extracted from the waste dumps of chemical factories.

In order to ensure a proper operation, the sprayers will be regularly tested and certified. Each of the dispensing devices (spray nozzles, rotary sprinklers, etc.) will have to discharge similar amounts of solution / suspension, in a constant and reproducible manner. The fastening system of these spraying devices must allow strict adjustment of the distance to the treated plants. Worn parts must be replaced immediately with new parts. Spraying systems must ensure a strictly localized distribution on the row of plants and not on the entire field. Untreated and / or double-treated areas should be avoided. This is done by marking the area to be treated, and the equipment to be applied pesticides must allow compliance with the markings.

The dose of pesticide applied per ha must be strictly correlated with the watering norm established by the Interministerial Commission for the Approval of Phytosanitary Products. Watering norms are established according to the type and age of the crop and vary between 330 - 1100 l/ha. To facilitate the compliance with the pesticide dose, the recommendations for use usually include both the recommended dose and concentration at the appropriate watering rate.

The user has the obligation to choose the appropriate nozzle to the specifics of the work to be performed. The user must also avoid the use of worn, dirty, clogged nozzles, because they, even if they were initially very good, cause disturbances in the work process, leading to the formation of asymmetrical jets, with large drops and uneven distribution. These also increase the risk of high concentrations of solution reaching certain areas on the plant and in the soil, which leads to increased pollution.

The sprayer with ramps for the application of treatments to field crops must be checked, making sure that all nozzles show the same amount of solution in the unit of time.

The water from washing the packages will be transferred to the spraying solution, in compliance with the watering norm. The equipment will be washed with pressure jet, in specially arranged areas, provided with inactivation bases for the pesticides from the washing waters. The bases for inactivating the washing waters will be delimited and marked accordingly "Danger, poisoned area!". The location of the inactivation bases will be set at a suitable distance from houses, wells, animal shelters, and agricultural crops (https://www.girisudecris.ro/).

Figure 4. Application of products used in plant protection (https://www.girisudecris.ro)

CONCLUSIONS

Intensive agriculture, which uses large amounts of pesticides and fertilizers, affects the environment, the irrational exploitation of land leading, in addition to the effect of soil degradation, to the losses of agricultural land, soil pollution, water and thus the environmental pollution. One solution is to promote organic but mechanized agriculture.

The European Union, through the Common Agricultural Policy, promotes the sustainable agriculture but due to population growth, implicitly increasing the need for food, the agriculture will face in the coming years a great challenge: to provide food for the population but without polluting the environment. Unfortunately, the green revolution has only solved one problem, that of food.

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COMPARISON OF A TRIPLE INVERTED PENDULUM STABILIZATION USING OPTIMAL CONTROL TECHNIQUE

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Abstract: In this paper, modelling design and analysis of a triple inverted pendulum have been done using Matlab/Script toolbox. Since a triple inverted pendulum is highly nonlinear, strongly unstable without using feedback control system. In this paper an optimal control method means a linear quadratic regulator and pole placement controllers are used to stabilize the triple inverted pendulum upside. The impulse response simulation of the open loop system shows us that the pendulum is unstable. The comparison of the closed loop impulse response simulation of the pendulum with LQR and pole placement controllers results that both controllers have stabilized the system but the pendulum with LQR controllers have a high overshoot with long settling time than the pendulum with pole placement controller. Finally the comparison results prove that the pendulum with pole placement controller improve the stability of the system.
Keywords: inverted pendulum, linear quadratic regulator, pole placement

INTRODUCTION

An inverted pendulum is a pendulum that has its center of mass above its pivot point. It is unstable and without additional assist will fall over. It may be suspended stably in this inverted position by means of the usage of a feedback control system to reveal the angle of the pole and flow the pivot factor horizontally returned beneath the center of mass while it begins to fall over, retaining it balanced.

The inverted pendulum is a classic problem in dynamics and manage idea and is used as a benchmark for testing control techniques. An inverted pendulum is inherently unstable, and have to be actively balanced with a view to stay upright; this could be accomplished either by applying a torque at the pivot factor, with the aid of transferring the pivot point horizontally as a part of a feedback system, changing the state of rotation of a mass installed at the pendulum on an axis parallel to the pivot axis and thereby generating an internal torque at the pendulum, or with the aid of oscillating the pivot factor vertically.

In order to stabilize a pendulum in this inverted position, a feedback control system may be used, which monitors the pendulum's attitude and actions the position of the pivot point sideways while the pendulum starts off evolved to fall over, to hold it balanced.

MATHEMATICAL MODELING

The pendulum consists of three arms that are hinged by ball bearings and can rotate in the vertical plane. The torques T1 and T2 are the inputs to the pendulum with the middle hinge made free for rotation.

By controlling the angles of the arms around specified values, the pendulum can be stabilized inversely with the desired angle attitudes. The triple inverted pendulum is shown in Figure 1 below.

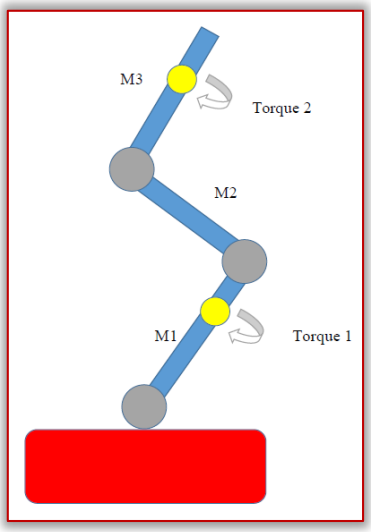

Figure 1. The triple pendulum

Let Θi denote the angle of the ith arm measured from the vertical axis as shown in Figure 2 below.

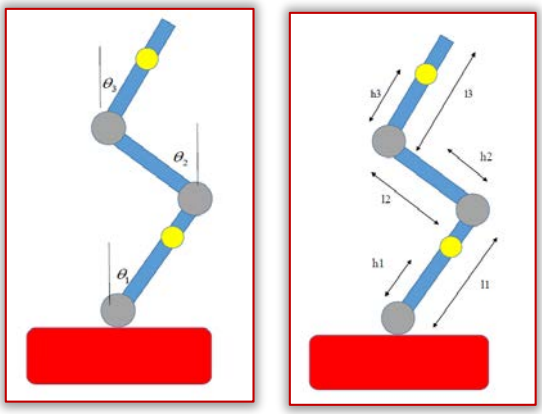

Figure 2. System Configuration

The mathematical modelling of the triple inverted pendulum is derived under the assumption that each arm is a rigid body

Lagrange differential equations is the method used to construct the triple pendulum with a nonlinear vector-matrix differential equation of the form:

$$M(\theta)\ddot{\theta}_i + N\dot{\theta}_i + q_i = GT_j \qquad (1)$$
$$i = 1,2,3$$
$$j = 1,2$$

where

$$M(\theta) = \begin{pmatrix} J_1 & l_1M_2\cos(\theta_1-\theta_2) & l_1M_3\cos(\theta_1-\theta_3) \\ l_1M_2\cos(\theta_1-\theta_2) & J_2 & l_2M_3\cos(\theta_2-\theta_3) \\ l_1M_3\cos(\theta_1-\theta_3) & l_2M_3\cos(\theta_2-\theta_3) & J_3 \end{pmatrix} \qquad (2)$$

where

$$M_1 = m_1h_1 + m_2l_1 + m_3l_1 \quad \text{and} \quad J_1 = I_1 + m_1h_1^2 + m_2l_1^2 + m_3l_1^2$$
$$M_2 = m_2h_2 + m_3l_2 \quad J_2 = I_2 + m_2h_2^2 + m_3l_2^2$$
$$M_3 = m_3h_3 \quad J_3 = I_3 + m_3h_3^2$$

The N matrix become:

$$N = \begin{pmatrix} C_1+C_2 & -C_2 & 0 \\ -C_2 & C_2+C_3 & -C_3 \\ 0 & -C_3 & C_3 \end{pmatrix} \qquad (3)$$

and the q matrix and G matrix are

$$q_1 = l_1M_2\sin(\theta_1-\theta_2)\dot{\theta}_2^2 + l_1M_3\sin(\theta_1-\theta_3)\dot{\theta}_3^2 - M_1g\sin(\theta_1)$$
$$q_2 = l_1M_2\sin(\theta_1-\theta_2)\dot{\theta}_1^2 + l_2M_3\sin(\theta_2-\theta_3)\dot{\theta}_3^2 - M_2g\sin(\theta_2)$$
$$q_3 = l_1M_3\sin(\theta_1-\theta_3)\left(\dot{\theta}_1^2 - 2\dot{\theta}_1\dot{\theta}_3\right) + l_2M_3\sin(\theta_2-\theta_3)\left(\dot{\theta}_2^2 - 2\dot{\theta}_2\dot{\theta}_3\right) - M_3g\sin(\theta_3)$$

$$G = \begin{pmatrix} 1 & 0 \\ -1 & 1 \\ 0 & -1 \end{pmatrix}$$

Table 1. The description of the system

No	Symbol	Description
1	l_i	length of the ith arm
2	h_i	the distance from the bottom to the centre of gravity of the ith arm
3	m_i	mass of the ith arm
4	θ_i	angle of the ith arm from vertical line
5	C_i	coefficient of viscous friction of the ith hinge
6	I_i	moment of inertia of the i-th arm around the centre of gravity
7	T_j	control torque of the jth hinge

After linearization of Equation (2) under the assumptions of small deviations of the pendulum from the vertical position and of small velocities, one obtains the following equation

$$M\ddot{\theta}_i + N\dot{\theta}_i + P\theta_i = GT_{m_j} \qquad (4)$$
$$i = 1,2,3$$
$$j = 1,2$$

where

$$M = \begin{pmatrix} J_1 & l_1M_2 & l_1M_3 \\ l_1M_2 & J_2 & l_2M_3 \\ l_1M_3 & l_2M_3 & J_3 \end{pmatrix} \qquad (5)$$

and

$$P = \begin{pmatrix} M_1g & 0 & 0 \\ 0 & -M_2g & 0 \\ 0 & 0 & -M_3g \end{pmatrix} \qquad (6)$$

The block-diagram of the pendulum system is shown in Figure 3 and the nominal values of the parameters are given in Table 2.

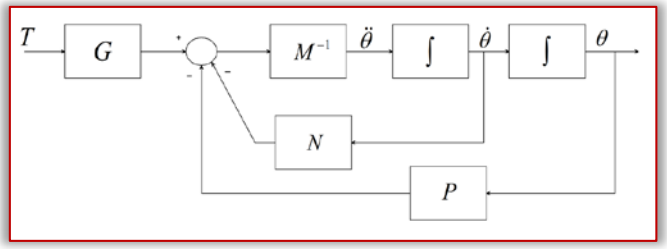

Figure 3. Block-diagram of the pendulum system

Table 2. Nominal values of the parameters

No	Symbol	Value
1	h_1	$0.45\,m$
2	h_2	$0.2\,m$
3	h_3	$0.3\,m$
4	l_1	$0.5\,m$
5	l_2	$0.4\,m$
6	m_1	$3.5\,Kg$
7	m_2	$2\,Kg$
8	m_3	$2.25\,Kg$
9	I_1	$0.55\,Kg\,m^2$
10	I_2	$0.12\,Kg\,m^2$
11	I_3	$0.65\,Kg\,m^2$
12	C_1	$0.07\,N\,m\,s$
13	C_2	$0.03\,N\,m\,s$
14	C_3	$0.009\,N\,m\,s$

The state space representation of the triple inverted pendulum becomes

$$\begin{pmatrix} \dot{\theta}_1 \\ \dot{\theta}_2 \\ \dot{\theta}_3 \\ \ddot{\theta}_1 \\ \ddot{\theta}_2 \\ \ddot{\theta}_3 \end{pmatrix} = \begin{pmatrix} -57.75 & -14.42 & -15.82 & -16.26 & -5.5 & -7 \\ -25.3 & -43 & -12.7 & -11 & -13.6 & -5 \\ 178 & 88.6 & 55.6 & 57.3 & 30.2 & 25 \\ 22.9 & -10 & -0.14 & -0.08 & 0.04 & -0.008 \\ -26 & 37.5 & -3.6 & 0.15 & -0.13 & 0.033 \\ -0.83 & -8.2 & 9.25 & -0.01 & 0.04 & -0.02 \end{pmatrix} \begin{pmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \\ \dot{\theta}_1 \\ \dot{\theta}_2 \\ \dot{\theta}_3 \end{pmatrix} + \begin{pmatrix} 1.559 & -0.8 \\ -4 & 3.8 \\ 0.65 & -2.4 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \end{pmatrix} \begin{pmatrix} T_1 \\ T_2 \end{pmatrix}$$

$$y = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \\ \dot{\theta}_1 \\ \dot{\theta}_2 \\ \dot{\theta}_3 \end{pmatrix}$$

THE PROPOSED CONTROLLERS DESIGN

— LQR Controller Design

The principle of most reliable optimal control is involved with working a dynamic system at minimum cost. The case

wherein the system dynamics are described via a fixed of linear differential equations and the cost is defined through a quadratic function is referred to as the LQ problem. One of the primary outcomes within the theory is that the solution is furnished with the aid of the linear quadratic regulator (LQR). The block diagram of the triple inverted pendulum with LQR controller is shown below in Figure 4.

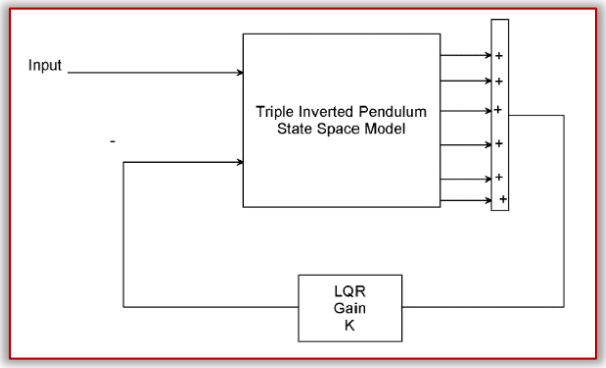

Figure 4. Block diagram of the triple inverted pendulum with LQR controller

In this paper, the value of Q and R is chosen as

$$Q = 10\begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \text{ and } R = \begin{pmatrix} 5 & 0 \\ 0 & 5 \end{pmatrix}$$

The value of obtained feedback gain matrix K of LQR is given by

$$K = \begin{pmatrix} 87.4053 & 32.8355 & 25.6454 & 27.1508 & 11.2981 & 11.1817 \\ 97.7657 & 45.7910 & 30.0834 & 31.2118 & 15.6479 & 12.9896 \end{pmatrix}$$

— Pole Placement Controller Design

Pole placement, is a way employed in feedback control system principle to region the closed-loop poles of a plant in pre-decided locations in the s-plane. Placing poles is proper because the region of the poles corresponds immediately to the eigenvalues of the system, which control the traits of the reaction of the system. The system ought to be considered controllable on the way to put into effect this technique. The block diagram of the triple inverted pendulum with pole placement controller is shown in Figure 5.

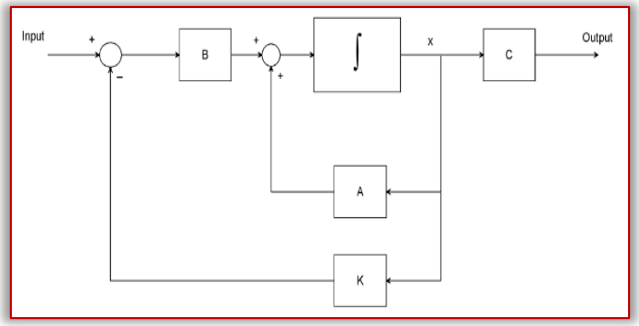

Figure 5. Block diagram of the triple inverted pendulum with pole placement controller

The state equations for the closed-loop system of Figure 5 can be written by inspection as

$$\dot{x} = Ax + Bu = Ax + B(-Kx) = (A - BK)x \qquad (7)$$

$$y = Cx$$

The poles for this system is chosen as

$$P = [-1, -2, -3, -4, -5, -6]$$

Solving using Matlab the robust pole placement algorithm gain will be

$$K = \begin{bmatrix} 19329 & 8885 & 7472 & 11601 & 5861 & 6699 \\ 23483 & 10820 & 9086 & 14362 & 7268 & 8307 \end{bmatrix}$$

RESULT AND DISCUSSION

— Controllability and Observability of the Pendulum

A system (state space representation) is controllable iff the controllable matrix C = [B AB A2B....An-1B] has rank n where n is the number of degrees of freedom of the system.

In our system, the controllable matrix C = [B AB A2B A3B A4B A5B] has rank 6 which the degree of freedom of the system. So, the system is controllable.

A system (state space representation) is Observable if the Observable matrix D = [C CA CA2....CAn-1] T has a full rank n.

In our system, the Observable matrix D = [C CA CA2 CA3 CA4 CA5] T has a full rank of 6. So, the system is Observable.

— Open Loop Impulse Response of the Triple Inverted Pendulum

The open loop simulation for a 1 Nm impulse input of torque 1 for angular displacement 1, 2 and 3 and for angular velocity 1, 2 and 3 is shown in Figure 6, 7, 8, 9, 10 and 11 and for torque 2 input the angular displacement 1, 2 and 3 and for angular velocity 1, 2 and 3 is shown in Figure 12, 13, 14, 15, 16 and 17 respectively.

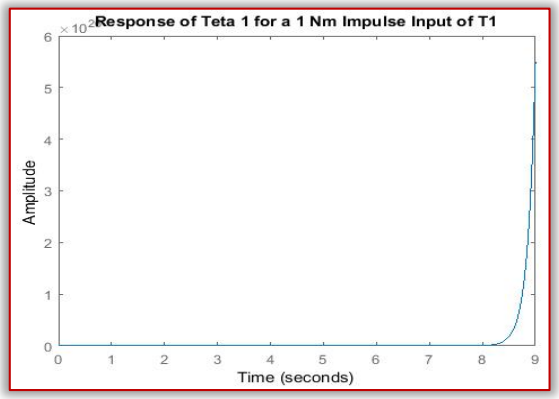

Figure 6. Response of Teta 1

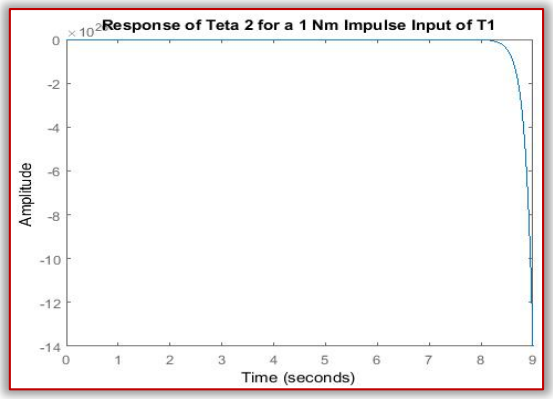

Figure 7. Response of Teta 2

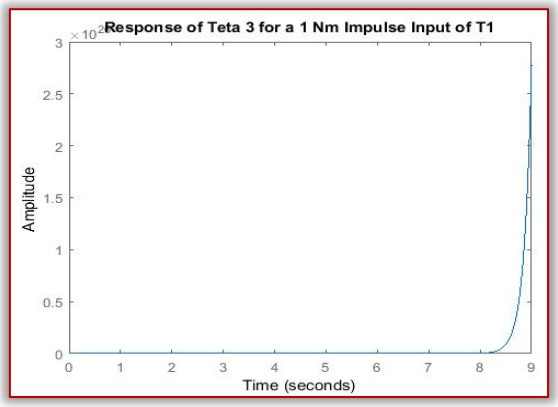

Figure 8 Response of Teta 3

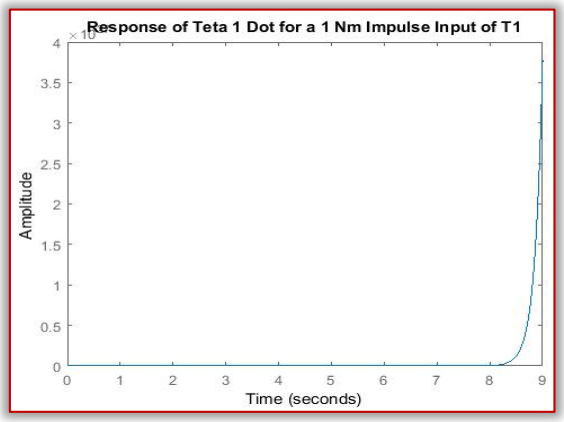

Figure 9. Response of Teta 1 Dot

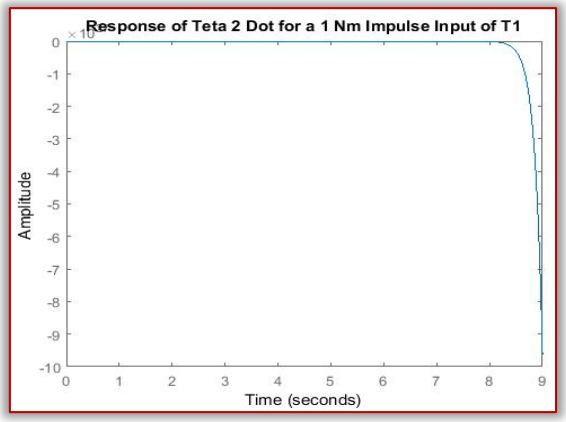

Figure 10. Response of Teta 2 Dot

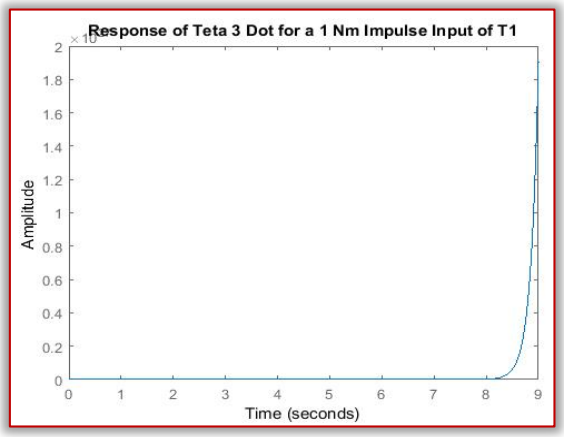

Figure 11. Response of Teta 3 Dot

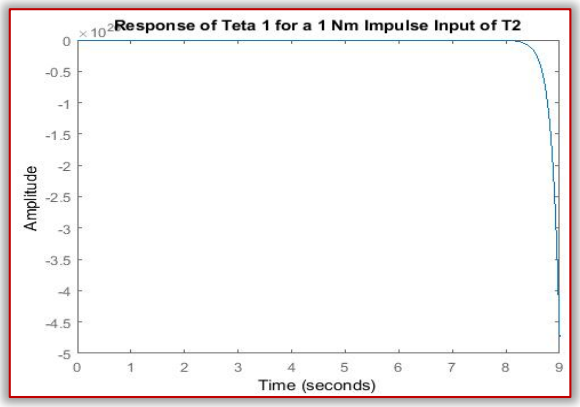

Figure 12. Response of Teta 1

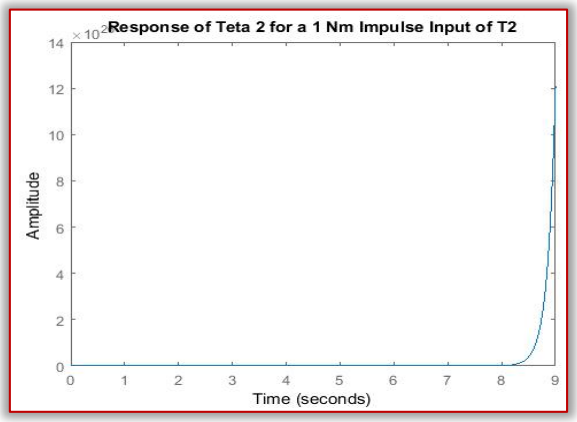

Figure 13. Response of Teta 2

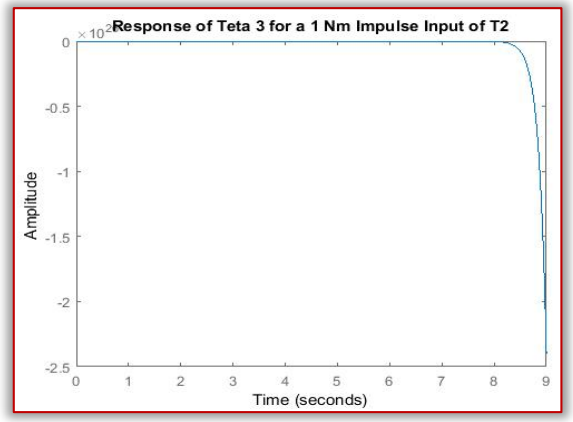

Figure 14. Response of Teta 3

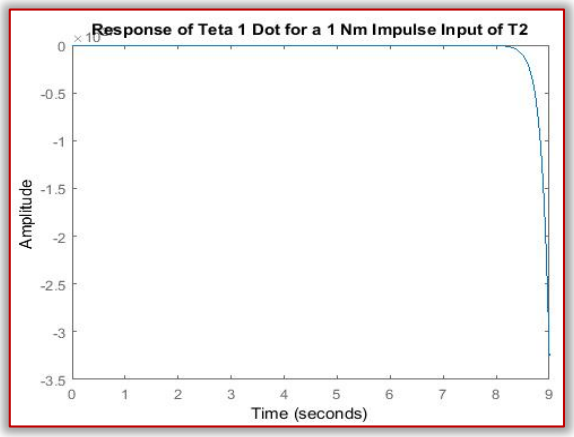

Figure 15. Response of Teta 1 Dot

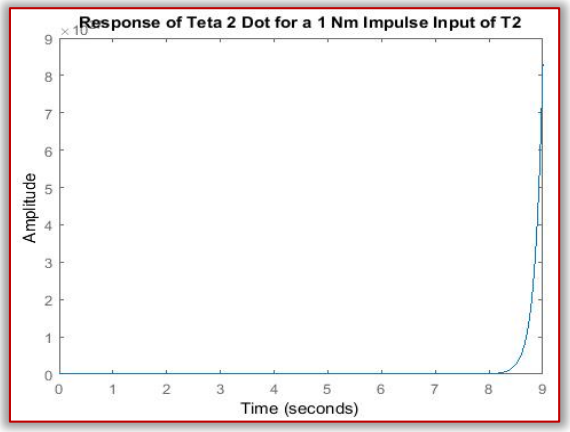

Figure 16. Response of Teta 2 Dot

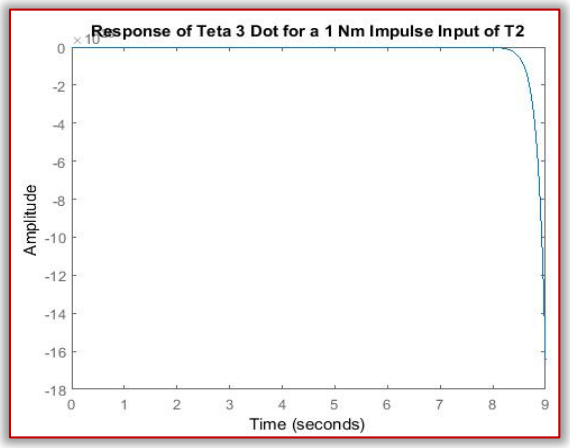

Figure 17. Response of Teta 3 Dot

As we seen from the Figures above the angular displacements and the angular velocities are unstable.

— **Comparison of the Triple Inverted Pendulum with LQR and Pole Placement Controllers for Impulse Input Signal**

The comparison of the triple inverted pendulum with LQR and pole placement controller for a 1 Nm impulse input of torque 1 for angular displacement 1, 2 and 3 and for angular velocity 1, 2 and 3 is shown in Figure 18, 19, 20, 21, 22 and 23 and for torque 2 input the angular displacement 1, 2 and 3 and for angular velocity 1, 2 and 3 is shown in Figure 24, 25, 26, 27, 28 and 29 respectively.

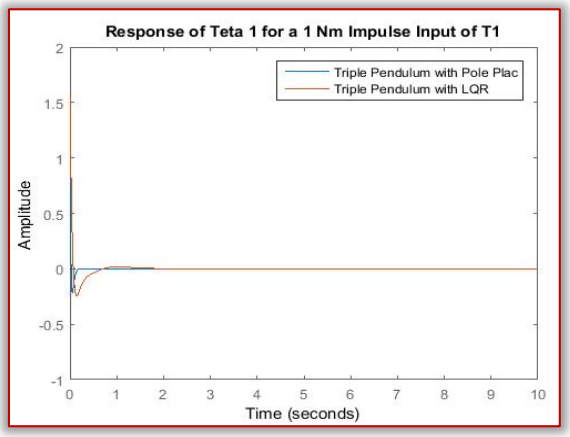

Figure 18. Response of Teta 1

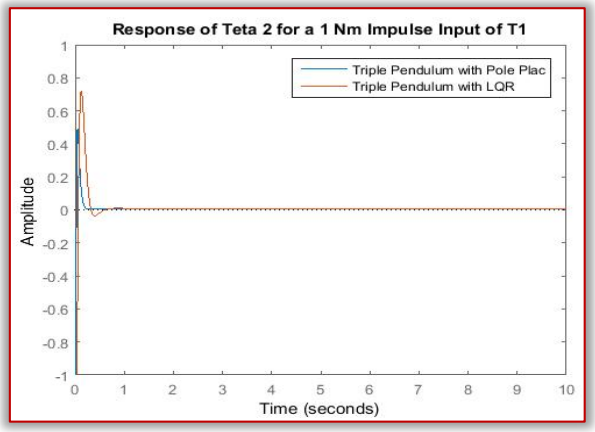

Figure 19. Response of Teta 2

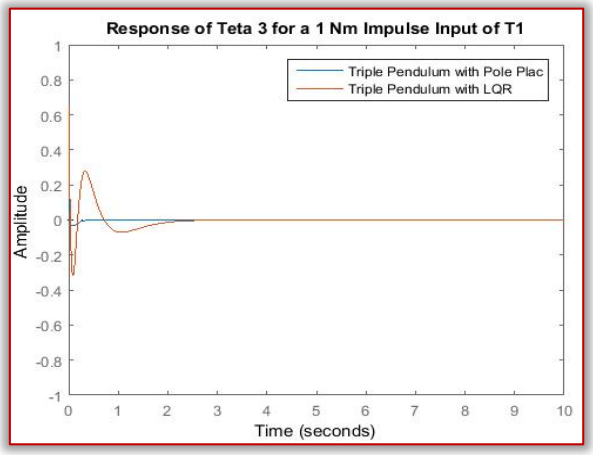

Figure 20. Response of Teta 3

As we seen from Figure 18, 19 and 20, for the impulse signal the angles starts to increase and returns to zero degree for the two controllers but the pendulum with LQR controller has a high overshoot with more settling time than the pendulum with pole placement controller.

As we seen from Figure 21, 22 and 23, for the impulse signal the angular velocities starts to increase and returns to zero for the two controllers but the pendulum with LQR controller has a high overshoot with more settling time than the pendulum with pole placement controller.

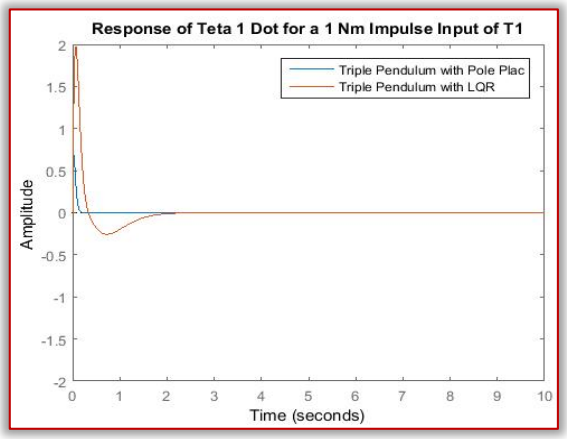

Figure 21. Response of Teta 1 Dot

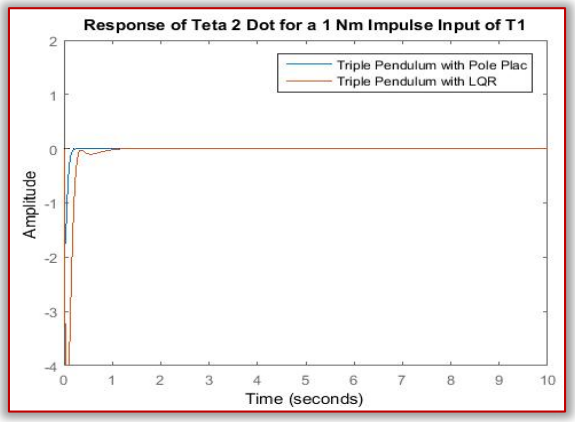

Figure 22. Response of Teta 2 Dot

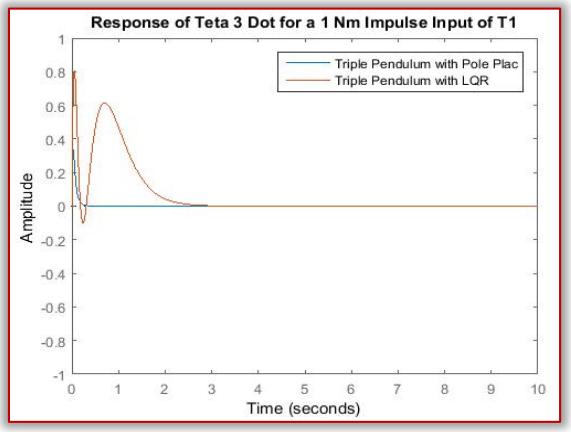

Figure 23. Response of Teta 3 Dot

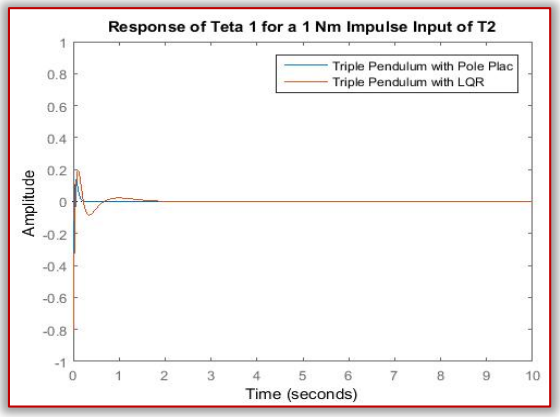

Figure 24. Response of Teta 1

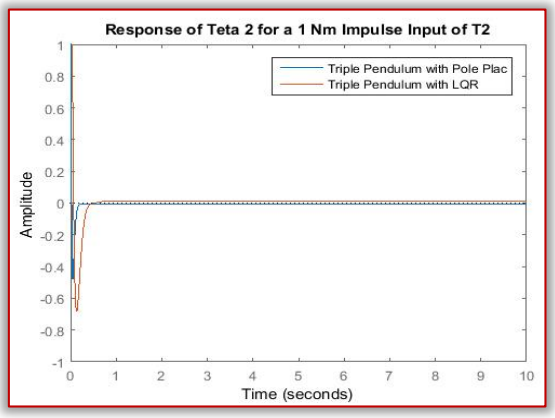

Figure 25. Response of Teta 2

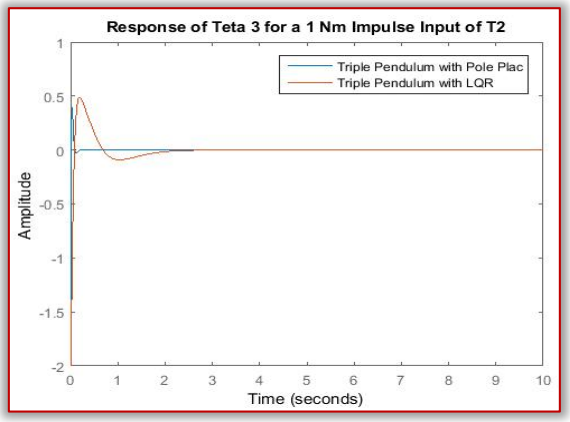

Figure 26. Response of Teta 3

As we seen from Figure 24, 25 and 26, for the impulse signal the angles starts to increase and returns to zero degree for the two controllers but the pendulum with LQR controller has a high overshoot with more settling time than the pendulum with pole placement controller.

As we seen from Figure 27, 28 and 29, for the impulse signal the angular velocities starts to increase and returns to zero for the two controllers but the pendulum with LQR controller has a high overshoot with more settling time than the pendulum with pole placement controller.

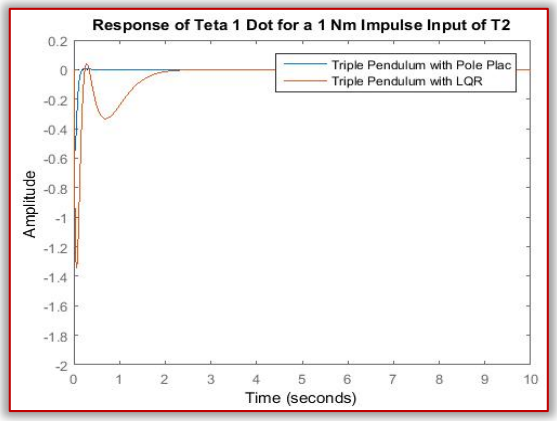

Figure 27. Response of Teta 1 Dot

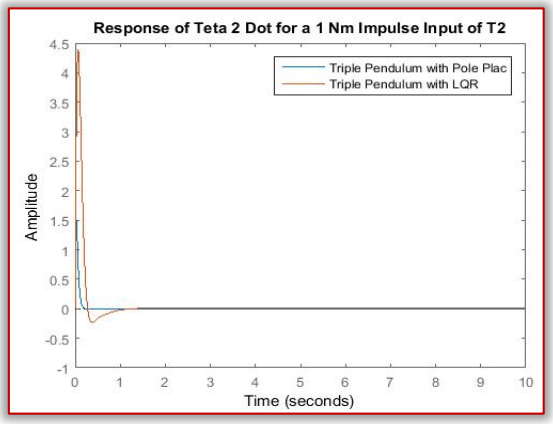

Figure 28. Response of Teta 2 Dot

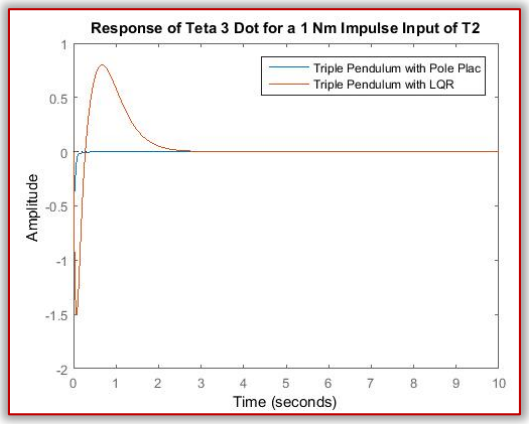

Figure 29. Response of Teta 3 Dot

CONCLUSION

In this paper, stabilization of the triple inverted pendulum with LQR and pole placement controller have been analyzed simulated and compared suceesfully. The open loop simulation prove that the system is not stable without feedback control system. Comparison of the proposed controllers for an impulse input have been done and the system with pole placement controller improves the stability of the system.

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REVIEW OF EXISTING FORMS OF ENTREPRENEURIAL INFRASTRUCTURE IN THE REPUBLIC OF SRPSKA

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Abstract: The paper presents the characteristics of entrepreneurial infrastructure. One of the modern ways to support small newly established enterprises, which are in a developmental life phase, and entrepreneurs is the system of technological infrastructure comprising: entrepreneurial incubators, technology centres, science parks and business zones. Those are the different organizations that help entrepreneurs to develop their business ideas and to overcome more easily the initial problems in business, for which, in a wider context, the term business incubators is used, and also the clusters related to entrepreneurs who are in an advanced phase of entrepreneurship. The paper presents the general characteristics of entrepreneurial infrastructure - clusters. In this paper, we present in the tables existing organizational forms of business infrastructure (clusters and entrepreneurs – business centers: free zones, industrial and business zones, science and technology parks, business incubators), their activities, and numerical strength in the territory of the Republic of Srpska.
Keywords: SMEs, Entrepreneurial infrastructure, Clusters, Entrepreneurship

INTRODUCTION

Infrastructure is important for entrepreneurial activities [4] and may have various forms and functions. As first, the development of trade and industrial growth require physical infrastructure, road and railway traffic and transportation etc.

In all developed Western countries and in many developing countries, entrepreneurship and small enterprises as a whole are supported by the state, state institutions and nongovernmental organizations in many ways [7,9,10].

Orientation of a market-developed countries has deep roots, regarding the fact that the capitalism has tried many development models as opposed to one-dimensional models of economic flows control which have been practiced more-less for decades in the countries of socialist and similar socio-economic systems.

The support to the development of small and medium-sized enterprises in the Republic of Srpska had gained in importance in 2002, with the adoption of the Program of Small Business Development, and after that the Law on Stimulating the Development of Small and Medium-sized Companies was adopted. The adopting of the Law has created the basis for legislative, institutional and financial help to this area.

On the basis of the Law, during 2004, there were formed: Department for SMEs and Production Craftsmanship at the Ministry of Economy, Energy and Development of the Republic of Srpska and the Republic Agency for the Development of Small and Medium-sized Enterprises. At the same time, on a local level, local agencies for the development of SMEs were being established. The support to the development of SMEs at a local level is also given by municipal development departments which, together with the above mentioned institutions, make support network for the development of SMEs.

Similarly to the leading countries of the West, many small countries which started with the implementation of market-capitalistic principles in the development of economy three to five decades ago, have reached an enviable level of development today[7] exactly due to the development of small enterprises.

The determinations of Bosnia and Herzegovina [2] related to the SMEs development sector rely on the recommendations of the European Charter and the Act on Small Business. The Law on Ministries and Other Control Bodies of Bosnia and Herzegovina has also defined the institutional framework in the field of issues in the sector of SMEs whose difficulties reflect, above all, in: approaches in defining policies, development strategies and goals in the sector of SMEs, competences, way of work a harmonized monitoring of the results in this area, mutual cooperation and profitability and excessive administration.

At the level of the Republic of Srpska, within the Ministry of Economy, Energy and Development, there is a department for small and medium-sized enterprises, the head of which is an assistant minister with the responsibilities in the work fields: development of entrepreneurship and craftsmanship, making of medium-term and long-term development plans and making of the development strategies of SMEs and entrepreneurial activity.

Pursuant to the [12], an enterprise is a legal person which performs the activity to gain profit, and an entrepreneur is a physical person who performs the activity to get profit and the activity of free profession, while an individual agriculturist is not an entrepreneur. The Law does not know the notion of small and medium-sized enterprise, and because of that the same provisions apply to them as to the other enterprises.

The new [13] is a modern regulation, greatly harmonizes with the directives of the European Union company law and as such should contribute to the creation of a legal framework complementary the internal market of the EU.

The Law on Business Companies of the Republic of Srpska is based on the best solutions of modern national law of the

surrounding countries, and also of some countries from Europe and the USA (Illinois), the Statute of the European Company from 2001, OECD Principles of Corporate Governance from 1998 etc. Entrepreneurship, in the sense of the [14], is an innovative process of creation and development of business ventures or activities and of creation of business success at market. Entrepreneurial infrastructure presents spatial-technical forms for toe support of entrepreneurship development, with a special emphasis on establishing and development of SMEs.

Entrepreneurship, in the sense of The Law on Development of SMEs of the RS, is an innovative process of creation and development of business ventures or activities and of creation of business success in the market. Entrepreneurial infrastructure presents spatial-technical forms to support entrepreneurship development, with a special emphasis on establishing and developing SMEs.

In recent time [3], there is a greater emphasis in the commercialization of university research, especially through the creation of spin-off enterprises. They emphasize inhomogeneity of the concept of university spin-off enterprises and point out their heterogeneous properties.

CHARACTERISTICS OF CLUSTERS

A cluster is a network organization or a group of enterprises coordinated by market mechanisms [7,9] rather than by chains of commands. A cluster consists of enterprises that are mutually connected, vertically (buyer – supplier) or horizontally (same buyers, technologies, distribution etc.). Competitive branches are grouped into clusters most often.

A cluster [14] is a form of entrepreneurial infrastructure consisting, in a geographical area, of mutually related business entities that do their business in the same, similar and various activities and, related to them, specializes suppliers, service providers, educational and scientific-research institutions, agencies and other.

In the practice of small-enterprise development, the cluster model deserves special attention. It has proven to be practical, especially in countries that have a tradition of supporting the development of small enterprises. The immediate predecessor to the development of clusters was incubators and, actually, clusters developed quickly in the areas that have had experiences with incubators. The connecting of entrepreneurs, their cooperation, sharing of services and equipment, or their networking into the most common clusters is also, as stated by [1], the influence of the work of most incubators. The connecting of business incubators with the academic and research community is also of great significance.

Clusters are presented by [11] as the basis of the new competitive economy, emphasizing their importance in increasing the competitiveness of enterprises on local and international markets. He defined them as geographic concentrations of mutually related enterprises, specialised suppliers, service providers, enterprises with similar activities and relevant institutions related to them (universities, agencies for standardisation and vocational associations), which mutually compete in some areas but also earn money. A cluster, as a concentration with critical mass [11] and extraordinary competitive success in a certain activity, represents a significant characteristic of every country, regional and local economy, especially in economically developed countries.

In countries in transition, clusters have their real future perspectives. It must be kept in mind that the experiences gained in the development of clusters in the European Union can be transferred to local practice without modifications, which would be unavoidable in an uncontrolled development.

The system of clusters [6] is a global model for the development of small enterprises. They prosper where the development of small business has already reached a significant level and where systematic measures of the country contribute to it. They assist enterprises to develop quickly, to apply modern methods of work and gain the maximum from their market environment under modern management; at the same time, the regional economy achieves competitive advantages in relation to others. Thus clusters connect technologies, industries and, generally, the economies of two regions or even a few regions from a few countries.

It can occur within branches (metal, wood, textile, food etc.) in which SMEs develop by using communications, technologies and foreign investments from other regions.

The aim of clusters is to achieve a competitive advantage. One of the relevant factors promoting competitiveness is also the geographic concentration. Finally, besides the geographic (local) factors, legislation, organization and development of financial market have great significance for the development of clusters. The use of knowledge [8] about sound strategies for the development of clusters in the world and on the overall results from their realization contributes so that, in all new cases (either specific or not), good solutions for their creation and development are established. However, besides the similarities, there are also differences in the development of clusters. They mostly occur due to different degrees of development of regions, levels of governmental inclusion in this model of small enterprises development, strengths of the industrial basis, critical masses of people with entrepreneurial spirit and the general interest of environment factor carriers in general. In developed countries, local and regional government initiate the development of clusters and have had success in that, because of good knowledge of economic processes and of exactly where they are in control, consistent with finding productive measures of support for the realization of the goals[10]. In underdeveloped countries and in small countries, ventures of this type are taken at the national level, especially when it is known that local and regional authorities are not ready to support the development of clusters.

REVIEW OF EXISTING FORMS OF ENTREPRENEURIAL INFRASTRUCTURE IN THE REPUBLIC OF SRPSKA

At At the beginning of the 1990s, characterized by the breakdown of the former state, the outbreak of civil war, especially in the territory of B&H (The Republic of Srpska),

events stopped not only the development of entrepreneurship but also fundamental economic activities. The support for development of small and medium-sized enterprises in the Republic of Srpska gained in importance in 2002, with the adoption of the Program of Small Business Development, and, after that, the Law on Stimulating the Development of Small and Medium-sized Companies was adopted. The adopting of the law created the basis for legislative, institutional and financial help in this area. On the basis of the law, during 2004, there were formed two key agencies: the Department for SMEs and Production Craftsmanship at the Ministry of Economy, Energy and Development of the Republic of Srpska and the Republic Agency for the Development of Small and Medium-sized Enterprises. At the same time, on for local level, local agencies for the development of SMEs were being established. The support the development of SMEs at the local level is also now given by municipal development departments which, together with the above mentioned institutions, maintain support network for the development of SMEs.

Besides the state institutions, the institutes for small business at universities and colleges have a significant role in the support of the SME sector in the USA [7]. In the European Union, state institutions also support the work of SMEs, creating a favourable setting for their business. The development of SMEs in the EU occurs at various levels, although the measures are not harmonised and the same for all members, which implies that a successful practice cannot be copied because of the existence of differences in cultures, economic structures and economic potentials.

Every local community or a set of local communities that are connected geographically engages in various activities to improve the conditions of work for SMEs so as to attract a larger number of enterprises to their territory or their region [7]. Local communities plays a very significant role, while the task of the country, or the government, is to activate the internal resources, as additional developmental sparks.

A prudent activity of a local community aiming to develop its own infrastructure and entrepreneurial potential and to attract investments can be to adopt a concept for regional development. Local communities must develop attractive environments for capital and enterprises. The establishment of business zones accelerates and simplifies the placement of spatial resources in the function of economic development, investments, growth and employment. Everywhere in the world, business zones present a significant instrument for the stimulation and development of entrepreneurship and general economic growth of an area. They are established on the basis of a clearly expressed interest among the businessman and bodies of local and regional government, with the support of higher levels of government and research-educational organizations, universities and institutes.

Regarding the business incubators, their location is also important, and it is recommended that an incubator serve as an entrepreneurial environment, so it is desirable that they be networked with the university or science sector. Incubators accept [7] primarily firms based on new technologies (hi-tech firms) or production firms based on tested technologies.

The emphasis should be put on human factor as the generator of success. Business incubators, as well as business zones, can have a significant, positive impact on the development of the national and local or regional economy.

The entrepreneurial infrastructure [14] can be organized in the form of business zones, technology parks, entrepreneurial incubators and clusters. Exceptionally, they can be organized and other forms of infrastructure for the development, promotion and research in this area in accordance with the regulations and requirements of the economy.

Table 1 provides an overview of the entrepreneurial infrastructure in the Republic of Srpska. This overview contains the forms of organization of entrepreneurial infrastructure clusters and entrepreneurs-business centers: free zones, industrial and business zones, science and technology Parks, and business incubators, as well as their activities and the number of existing forms of entrepreneurship infrastructure.

As regards cooperation with scientific institutions and universities in the Republic of Serbian, there exists several business incubators and one cluster; they are:

1. Business Incubators—Innovation Centre Banja Luka operates as a foundation, which has the following stakeholder's structure: Ministry of Science and Technology of the Republic of Srpska, Atene Prosjekledlse on behalf of Ministry of Foreign Affairs of Government of Norway, City of Banja Luka, University of Banja Luka, University of East Sarajevo and RARS—Republic Agency for the Development of Small and Medium Enterprises. The Innovation Centre Banja Luka contains enterprises: Business Incubator, Training and Conferences.
2. Business incubator NGO "Krajina" Banja Luka, located on an area of ten hectares of land planted with perennial medicinal herbs (seedlings garden formed in partnership with the city). The business incubators are agriculture and forestry activities, and owned by City of Banjaluka. Project leaders: NGO Krajina"—Business Incubator, City of Banjaluka, City of East Sarajevo, RS municipalities, RS Government, RS Institute of Agriculture and Banjaluka and Centre for Rural Development and Improvements. A business incubator has been implementing a programme of organized support for the development of agriculture—production of organic food, fattening of breeding cattle and initiation of small farms (interviews conducted with 1734 households in the city territory, education, advisory groups and establishment of agro-exchange – electronic supply and demand bids for agricultural products).
3. Business Incubators university business incubator—in creation phase. It will be cited in the municipality East Ilidža.
4. Existing clusters, Solar Energy Cluster, whose is activities Energy, gas and water production and supply.

Leader cluster is Faculty of Mechanical Engineering Banja Luka with members "Topling Factory" Prnjavor, "Energomont-Bemind" Banja Luka and "Koming pro" Gradiska.

Table 1. Review of existing forms of entrepreneurship infrastructure in the Republic of Srpska

Entrepreneurial infrastructure		Activities	Numerical strength
Cluster	Existing clusters	Agriculture and forestry	5
		Processing and products of wood and cork, cellulose paper and paper products	6
		Energy, gas and water production and supply	1
		Food and beverage industry	1
		Other	2
	Planned	Food and beverage industry	1
		Agriculture and forestry, food and beverage industry	1
	Cooperatives	Food and beverage industry	4
		Agriculture and forestry, food and beverage industry	6
	Cooperatives	Food and beverage industry	4
		Agriculture and forestry, food and beverage industry	6
Entrepreneurs-business centers	Free zones		3
	Industrial and business zones		96
	Science and technology parks		1
	Business incubators	Agriculture and forestry	1
		Construction, furniture production, production of metal products, excluding machinery, production of rubber and plastic products	1
		Other, processing and products of wood and cork, cellulose paper and paper products, production of leather and leather products	1
		Other	6

CONCLUSION

Every local community or a set of local communities which are connected geographically, to attract a larger number of enterprises to their territory, the territory of the Region, takes various activities to improve the conditions of work of SMEs.

Local community plays a very significant role, while the task of the country, or the government, is to activate the inner resources, as additional development impulses. A prudent activity of local communities with the aim of developing own infrastructure and entrepreneurial potential and attracting of investments can be a concept of regional development. Local community must develop an attractive environment for capital and enterprises.

The current determination are to harmonize the legal framework, which is being built with the EU and the Act on Small Business, providing the conditions for the SMEs sector to be at the top of economic development priorities.

It is very important to make efforts in understanding particular notions of different forms of entrepreneurial infrastructure. There are no precise and unified definitions, so the matching is not compulsory among the notions in the various countries.

General characteristics of entrepreneurial infrastructure (clusters) are presented, as well as their role and importance in terms of providing conditions for the creation and development of small and medium enterprises.

The paper presents the existing state of entrepreneurial infrastructure in the Republic of Srpska, with the numerical strength, as well as their activities.

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AUTOMATION AND INDUSTRY 4.0

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Abstract: For many years, Industry 4.0 has been a popular topic related to the application of digital technologies in various manufacturing processes. The basis of this concept is the acquisition and analysis of data from propulsion equipment, which enables the realization of faster, more flexible and more efficient production. The result is high quality products, cost reduction, increased production, changing labor profile, increasing the competitiveness of the country's economy. The fourth industrial revolution is characterized by smart factories and plants that are adaptable and efficiently integrate customers and business partners, with an emphasis on full automation. This is possible due to the increasing reduction of barriers between the elements of automation and communication and information technologies. Modern process automation means optimizing the quality of products, increasing safety at work, reducing unplanned downtime in production, efficient use of available resources, meeting strict environmental requirements. Improving technology consists of mass production, which saves energy, resources and labor. The following technical and technological elements essentially represent Industry 4.0: big data, autonomous robots, software for the development of simulation models, universal system integration, industrial internet, cyber security, cloud computing, additive production and augmented reality.
Keywords: process control, internet of things, cloud computing, additive technologies, digitization of processes

INTRODUCTION

Increasing production and reducing costs are the driving force in the development of industry and various technical - technological disciplines. Every revolutionary innovation in industry makes a great contribution to increasing the quality and production capacity of industrial enterprises on a global level. Nowadays, the global industry is in the process of intensive transition to *Industry 4.0*, a standard that implies a fully automated industry, in which the Internet of Things (*IoT*) platform enables more precise management of production and process activities, reduces production costs, minimizes errors and failures, thanks to systems for predictive maintenance, management and analysis.

Modern automation systems basically have a six-step model of industrial automation architecture, which is defined at Purdue University: level 5 - business system automation; level 4 - automation of production plant automation of production plant, enterprise resource planning (*ERP*) [1], production planning strategy (*MRP*) [2] and production process management (Manufacturing execution systems - *MES*); level 3 - automation of various branches of enterprises automation of various branches of the enterprisies; level 2 - automation of machines and technological processes automation of machines and technological processes; level 1 - supervisory control systems; level 0 - sensors and actuators. In the general case, the software is installed on PCs connected to levels 2, 3, 4 and 5. Levels 2, 3 and 4 usually have communication interfaces and databases in which data is buffered and information of individual levels and user interfaces is synchronized. This model of computer data processing is relatively complex, increases operating costs and complicates the administration process. This is also the reason for the tendencies that lead to the simplification of architecture.

The new controller models and devices in the field are in direct communication with all levels - from levels 0 and 1 to 4 and 5 levels, using appropriate communication protocols and especially WEB services based on Open Platform Communications Unified Architecture (*OPC UA*).

This tendency develops naturally and dynamically, since each new element of automation, as a rule, possesses a certain intelligence and richer functionality. This applies both to devices and equipment that are installed in the field - more intelligent sensors and controllers, and to equipment in operation - more powerful computer systems. The *Industry 4.0* initiative, *OPC UA* and the Industrial Internet of Things *(IIoT)* consortium also make a significant contribution to this direction of development [3]. The tight integration of field devices and corporate-level business systems is becoming increasingly important in increasing production efficiency - the next big step in the evolution of industrial automation.

Business production management systems such as those for enterprise resource planning - *ERP* or materials - *MRP* traditionally use a package architecture, which does not reflect the situation in real time [4]. This way naturally affects the quality of products, services and supply chains, and ultimately reduces the level of profit. Full automation of the company enables processing and monitoring of transactions in real time, which enables synchronized and timely operation. There are controllers that are in direct communication with the company's business systems using the *OLE* architecture - Object Linking and Embedding for Process Control. To achieve the set goals, we are also working on adapting existing industry standards such as *OPC*, *OPC UA*, *B2MML* (Business To Manufacturing Markup Language), *ERP* interfaces as well as those with *IT* (Information technology) databases.

Digitization of products and services has a horizontal and vertical effect on the value chain, which means that the

company must integrate processes and data flows from the procurement of raw materials and product development to technology, production and transport. In this process, it is necessary to network with suppliers, customers and other partners in a complex value chain. After the steam engine, conveyor belt, electronics and the Internet, there is now talk of 6 "Industry 4.0" - the fourth generation of industry characterized by the networking of smart digital devices. The characteristics of industrial revolutions are shown in Figure 1 [5. 6].

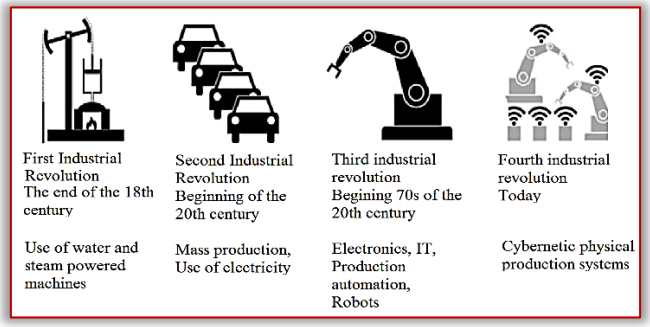

Figure 1. Basic characteristics of industrial revolutions

Condition maintenance (maintenance based on the forecast or predictive maintenance) is a way of anticipating possible problems in the plant and undertaking activities in order to neutralize those problems. Developed analysis systems can drastically improve the finding of solutions that will contribute to the precise conduct of the production process. Related to this are modern business models based on newly promoted services and new technologies. Countries differ in terms of digitalization goals, although companies around the world are largely in the vortex of *Industry 4.0*, with regionalization of their goals being observed: corporations in Japan and Germany use digitalization mainly to increase production efficiency and product quality.

In the USA, there is a trend of developing new business models with the maximum acceleration of digital offers and services. Enterprises in China place emphasis on strengthening their position in relation to international competitors through cost reduction. Some research predicts that most regions will be at almost the same level of digital integration within five years, and that some countries such as Japan, Germany and the United States will still be at the forefront [6, 7].

LARGE VOLUME OF DATAV EXCHANGE, ANALYSIS, OPTIMIZATION, CLOUD COMPUTING SERVICES

The development of automation is accompanied by a constant increase in the set of data used in the analysis and optimization of automated processes in order to increase productivity and production efficiency. The amount of information is constantly increasing due to the installed devices that generate real-time data. *The Cloud Computing* platform enables companies to access the *IT* infrastructure (servers, data storage equipment, etc.) and various fully developed software business applications via the Internet. An important feature of cloud architecture is flexibility in relation to users, which allows small and medium enterprises to keep pace with the constant change of technologies with their relatively limited *IT* resources [8].

OPC UA is the only open communication protocol so far, created on the basis of standards adopted in computer technology, which connect industrial software, controllers and sensors with corporate business systems, which enables increased productivity and creates conditions for the realization of a digital factory. *OPC UA* creates the possibility of efficient and reliable communication infrastructure - from sensors to corporate management system at all levels of production automation, *SCADA* system and process management. *PLC* (programmable logic controller) open *OPC UA* functional blocks are extensions of the IEC 61131-3 standard that traces the path to the IEC 61131-3 software model and the *UA* information model [9].

GSM devices are increasingly being used instead of remote monitoring systems. The implementation of techniques for connection to cellular networks, which are constantly being improved, and the sending of short texts (*SMS*) to controllers have been increased. The development of this area also includes technologies such as the Internet, cloud computing, software with various functions as well as *IP* (Internet Protocol) video and audio communications

APPLICATION OF COLABORATIVE ROBOTS

Robotics is the basis of the 4th industrial revolution. The question arises as to why these robots are different from those that have been used for ten years or more in various branches of industry (automotive industry, shipbuilding, military industry, pharmaceutical industry, etc.). The difference is that today robots and humans have become equal partners - robots now have a higher degree of artificial intelligence in a networked factory and can communicate with machines and workers via smart devices. Machines communicate with semi-finished products, and individual parts of machines with each other.

The robots have built-in sensors - each individual joint of the robot has a sensor and responds to the slightest touch. If a glass of water is suddenly placed in front of the robot's hand, it will slowly slow down its movement so that not a drop is spilled. With that collision hazard recognition, human-robot collaboration is now possible. Until now, people and robots in the halls have always been separated by fences. Modern robots now work closely with humans. The development of robots goes in the same direction as with PCs - the goal is to produce at the lowest possible cost during operation, with at the same time greater power and functionality, which makes robots suitable for performing a number of tasks in the industry.

Colaborative robots safely and efficiently assist workers in the production process, with no need for experts to program, install and maintain them. Installing and configuring these robots is intuitive and does not require much time. Robots can be switched off during idling while waiting for processing materials, which can save up to 15% of the energy now consumed in the production process. In addition, their price is several tens of thousands of euros, and the efficiency and time of exploitation enable a quick return on

investment. These robots provide optimal speed, high precision and safety at work. Nowadays, new generations of robots are appearing on the market, which are more compact and work in a working environment with workers. Their prices are significantly lower compared to the prices of conventional industrial robots and are very interesting for relatively small production plants [10, 11].

INTEGRATED DESIGN

Recently, the design of various products, machines and production processes has been intensively and dynamically developed. At the same time, we are working on the development of efficient management systems. A key component of this concept is simulation software, which is becoming increasingly accessible and easy to use. The goal is to create software that will enable the design of products, production processes and automation platforms, with the idea of enabling the verification of these projects through simulation before physical realization. The simulation enables the cooperation of designers of production processes and automation, which contributes to the relatively easy adoption of new technologies, while improving product quality, increasing the level of production and ultimately the profit of the plant.

Control and supervisory systems can be developed in the direction of software and system-oriented architectures, which are based on devices for analysis, modeling, design and evaluation of human-machine interaction, including methods that enable modeling of human behavior, real and virtual environments for simulations, complex methodologies design, task assignment, etc. Advances in modern human-machine systems in process automation include intelligent *HMI* (Human-Machine Interfaces) devices for operator navigation, automatic generation of machine control programs, various trends and graphics, as well as training programs based on ready-made functional modules and blocks. The global transformation of industrial automation is in full swing. An increasing number of connected devices, unlimited Internet access, permanently growing *IT* infrastructure are prerequisites for the development of new business potentials [12, 13, 14].

ADDITIVE TECHNOLOGIES AND 3D PRINTING

Advances in the field of additive methods have enabled the development of *3D* printing - modern technology in the production of three-dimensional objects. *3D* printers are widely used to make prototypes and even regular products, which allows production at far less cost compared to conventional technologies. Another advantage of additive technologies is reflected in the fact that a single machine can produce a large number of different products, which is practically impossible with traditional production lines. At the same time, *3D* printing enables the creation of very complex shapes and structures that would not be profitable in classic production. This is likely to lead to radical changes in the way a wide range of industrial products are designed, developed and manufactured.

The technique of *3D* printing has found application in the military industry. The US military printed a spare part for the *F-16*, and the British for the *Tornado* [15].

The principle of operation of *3D* printers is similar to the operation of ordinary printers - printing takes place in a plane, except that not one layer is printed but the appropriate number of layers to get the third dimension. Graphic *3D* software packages are used to design the element to be created as the final product. The printer driver converts this model into layers. A simple presentation does not reflect all the complexity of this procedure. One of the first materials used for these purposes (along with liquid photopolymers that harden) is ceramics. Various powders are used as raw material *for 3D* processes. Since materials have different properties, certain technologies cannot be used for certain types of materials. It should be expected that with the further advancement of *3D* technology and printers, as well as the materials used in the production of samples, there will be improvements and even greater efficiency and applicability of this technology [16].

INTERNET OF THING (IoT) PLATFORM IN INDUSTRIAL AUTOMATION

The integration of IoT functionality in industrial automation has significantly reduced operating costs, contributed to the optimization of production process time, energy and resource use. In this context, the *Internet of Thing* is a set of physical objects or devices that connect to the Internet using embedded technologies and have the ability to observe, measure and interact with other things around them.

The realization of an intelligent production infrastructure, based on the IoT platform, provides owners and managers of industrial plants with information related to production and business at any time and at any point. Data on the operation and functionality of equipment are the starting point in optimizing productivity, developing process control, increasing energy efficiency, safety at work, reliability and flexibility of industrial production.

The *IoT* platform basically has sensors and devices with a relatively low price and low energy consumption, which contributes to a significant reduction in costs in modern industrial production. This technology enables direct communication between sensors, devices and infrastructure in the plant, which provides servers, operators and management with the necessary information about the operation and efficiency of the system [17, 18].

Cloud platforms, intelligent buildings, the current development of automation in construction and industry, the possibility of acquisition, processing and storage of extremely large amounts of data (big data) and other technological innovations in this area have accelerated the development of the concept of industrial Internet elements - *IIoT*.

NEW STRATEGIES AND TECHNOLOGIES

According to *Berg Insight*, the number of automation systems is constantly increasing globally. At the same time, the number of interconnected devices and the amount of collected data to be processed is increasing. This results in

the need for new, more powerful management systems to fully exploit the potential of the data collected. About ten years ago, there was a significant difference in the price of technical means (especially controllers and accompanying equipment) of various manufacturers.

Recently, there are differences in the price of processors, memory, *embedded* software, communication components, etc. they become minor. Conventional processes and technologies, which have had a satisfactory performance in the industry for a relatively long period of time, are already becoming inefficient. The transition to *Industry 4.0* requires new strategies and technologies, which will reduce the time and effort to perform industrial operations. Renowned experts believe that in addition to technological innovations, work will have to be done on improving the system for data acquisition, processing and analysis, and that the problems related to that will be solved in the *IoT* environment.

The growing role of automation in the realization of industrial production and the "transfer" of increasing human rights and tasks to automated equipment and robotic systems represents a huge potential for more precise control and increased production efficiency. For the application of *IoT* in industrial automation, a new generation of controllers and sensors has been developed, with advanced capabilities and increased intelligence, which enables more precise management and efficient operation with a minimum of downtime. The main challenge of today's development of process automation is the design of complex and global decentralized systems. This requires new methods and techniques of modeling, improving the design and functionality of control - monitoring systems, the ability to manage complex networks with a large number of interconnected control systems and the coordination of many autonomous network elements.

DEVELOPMENT OF COMUNICATION TECHNOLOGIES AND PROTOCOLS

The evolution of communication technologies has a decisive role in the transformation of the structure of industrial automation systems. Until recently, plant automation was based on the concept of Computer Integrated Manufacturing (*CIM*). In such a hierarchical structure, certain devices are designed for specific tasks and use specific network connections.

With the development of technology in this area, devices are becoming multifunctional, the intelligence of devices and equipment is increasing, and there is a need for modular devices. For example sensors, which are traditionally used to measure certain process variables, are increasingly being integral parts of monitoring and predictive maintenance systems in modern process automation. It is noticed that the traditional hierarchical concept of process management is becoming insufficiently functional, and its place is taken by decentralized distributed architecture.

Industry 4.0 integrates modern information technologies with conventional physical production and processes, enabling the development of new markets and business models. *Industry 4.0* is thus oriented towards integration and the provision of services that the individual customer is willing to pay for [19]. *Industry 4.0* is projected to transform the industrial workforce by 2025. According to research in ermany, the introduction of digital industrial technologies will create more jobs than jobs that will cease to be needed, with new jobs requiring significantly different workers. Detailed modeling predicts an increase of about 350 000 jobs in Germany by 2025.

Namely, the increased use of robotics and information technologies will reduce the number of jobs by about 610.000 in assembly and production, which will be compensated by the creation of about 960.000 new jobs, especially in the *IT* sector and data science. For this country, Fig. 2 illustrates the gross revenues of certain industries for 2013 and forecasts for 2025 [20].

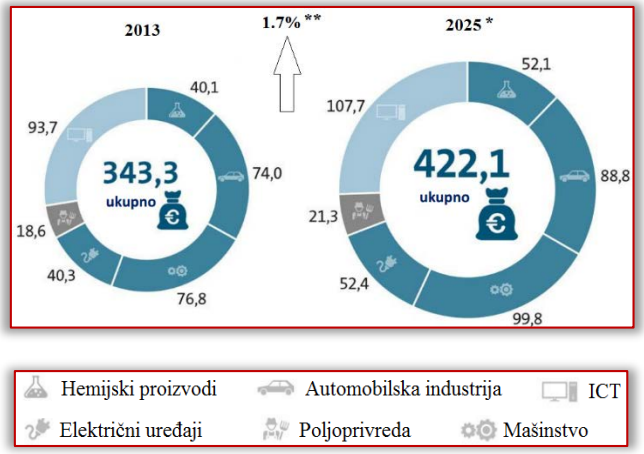

Figure 2. Gross revenues (in billions of €) in individual sectors in Germany

DATA TRANSFER

The increasing speed of data exchange has imposed the need for mass use of Ethernet technologies in industrial networks. This also applies to wireless architectures that are increasingly present in the process industry. They can integrate remote, geographically remote measuring elements and devices in the field, have flexibility, are easy to install and operate, enable visualization, remote configuration, diagnostics and control. Another leading trend, in terms of communication in process automation, is the integration of interfaces that support the transfer and exchange of various types of device data - data from process measurements, control signals, various diagnostic data, monitoring data, hierarchical information and more. In order to respond to the needs and challenges of the modern process industry, it is necessary to implement horizontal and vertical integration of information and communication technologies as well as automation systems in the entire structure of the industrial enterprise. This can be achieved by efficiently integrating various processes into a single platform and connecting all individual subsystems.

CONTROL WITH THE USE OF PREDICTIVE MODELS

Model predictive control - *MPC* is already a standard solution in process control in the industry. There are mainly two models of predictive control - linear and nonlinear. The

main advantage of this control method is the possibility of regulating multivariable systems, which have numerous limitations of input and output values. Solutions in the field of process control and automation of fourth generation *MPC* technologies are available on the market, which enable parallel optimization of a number of levels, priority realization of control tasks, improvement of product quality and efficient use of resources. There are also various advanced identification devices based on error and fault prediction methods. This concept is used in various fields including the chemical industry, food, oil and gas processing plants, the pharmaceutical industry, the rubber industry and a number of other sectors.

The development of optimal control of nonlinear systems, estimation of status and parameters, as well as stability analysis and synthesis of nonlinear systems are also part of the field of predictive control. Modern solutions of predictive control systems enable decentralized control and horizontal integration of global nonlinear processes that can be connected by a network, as well as the application of hybrid discrete - continuous control systems.

In process automation the application of artificial intelligence is increasing, especially in the field of product quality control, where slight improvements in process management can lead to significant advantages over the competition. The most important thing of technologies based on artificial intelligence in the industry is real-time process control and resource planning and management where their further development and mass application is yet to come. Monitoring of the production process, the possibility of forecasting failures, unplanned downtimes and accidents, are key elements for increasing efficiency. The basic task of the management system is to enable product quality, safety and security of people and equipment. The consequences of unplanned and unwanted events due to various causes lead to a drastic increase in costs, to the interruption of the production process in a certain period with significant negative effects on the reliability and economy of the company, as well as on its image. The more complex the control process, the more complex the monitoring and diagnostics that will prevent the occurrence of failures and breakdowns. In modern process automation, based on knowledge of the nature of the controlled process, there are two methods: one is based on previous process modeling, which includes various quantitative and qualitative simulation methods and predictive calculation of values of certain variables of systems over time; the second method is based on the experience and historical data of the managed process with the application of quantitative, qualitative and statistical methods. The development of automation and information technologies in the process industry and the increase of its complexity and intelligence have resulted in the generation of a huge amount of data and the need for their processing and analysis. At the same time, the need for the number of executors engaged in management processes has decreased. Today, operators are faced with very responsible tasks in terms of taking action in certain critical or crisis situations, when it is necessary affect quickly and energetically.

For these reasons, they need processed and easily accessible relevant data. Therefore, the basic tendency in process control is the integrated connection of management, knowledge and information. This development is based on in-depth research into the interrelationships that exist between humans and machines in the production process, covering all possible technical and social aspects of that communication, as well as all activities in which people control or supervise machines, equipment or complete technological processes.

DIGITAZION OF PRODUCT AND SERVICE PORTFOLIOS

Industry 4.0 goes far beyond process digitization. This revolution is leading to a greater degree of digitization of product and service portfolios. The perfect mechanical properties of one product are no longer enough to compete on the world market. The advantage is on the side of digitized products with built-in sensors, software, the ability to generate data and network. Digital products are phenomena that can be found in all branches of industry. For example in the automotive industry, instead of classic braking systems, *ABS* (Anti-lock braking system) devices with implemented modern control systems are installed. It is an electro-hydraulic system that prevents the wheels from locking when braking, which usually happens when braking very hard or when driving on slippery sur the risk of blocking the wheels. In production and engineering, the use and connection of appropriate sensors enables optimal maintenance of machines and provides efficient operational control. It is understandable that the percentage of digital products is the highest in the information and communication technology sector. In the manufacturing industry, the degree of digitization is currently between 22 % and 27 %. The general tendency of all sectors is an intensive increase in the level of digital products and services in the coming years. At the core of *Industry 4.0* is the complete digitization of processes, products and services and integration into digital ecosystems with value chain partners.

CONCLUSIONS

The perspective of automation is considered with special reference to *Industry 4.0*. Various corporations around the world are projected to invest more than $ 1000 billion a year by 2022 in the conquest of *Industry 4.0*, which will lead to a significant reduction in costs, increased efficiency and profits, and it is predicted that the investment will pay off in two years, with the need for *IT* experts to increase permanently. In the countries of the developed world, it is estimated that one third of their companies have a high level of digitalization, and it is expected that this percentage will reach the value of 75 % in the next five years. Worldwide, large companies are investing 5 % of their digital sales revenue annually, or approximately $ 907 billion, which will be further invested in digital technologies such as sensors and various devices, and in the development of software and

applications such as production management systems. It is believed that in the next five years, data analysis will have a major impact on decision-making processes. *Industry 4.0* is based on the smart factory model that integrates the knowledge and skills of participants at all levels (scientific corps, managers, engineers, workers). The basic features of a smart smart enterprise are: smart personalized product, unified role of manufacturers and service providers (offer of extended products - integration of products and services), high level of cooperation at the level of business system and environment. The essence of the vision of *Industry 4.0* and *IoT* is a versatile connection of people, products, machines and equipment in the production plant in order to realize new products and services.

Products, transport system and devices will be able to "negotiates" within the virtual market regarding the most efficient steps that would allow maximum efficiency of the production process. This would provide a connection between the virtual world and the physical objects of the real system. In the last 15 years, progress has been evident in the development of additive technologies (*3D printing*), which has significantly increased the potential for design, development, production and distribution of certain products. This progress is e.g. in the automotive industry opened the door to innovative technical solutions that have contributed to cleaner, easier and safer production, shorter delivery times and reduced costs. It is a question of the near future when *3D printing* will begin to be used not only for prototyping but also for innovative elements in mass serial production.

Note:

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NUTRIENT REMOVAL FROM WASTEWATER BY MICROALGAE CHLORELLA VULGARIS

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Abstract: In Europe, 2.52 kg nitrogen and 0.51 kg phosphorous / inhabitant / year are discharged in wastewater. Conventional biological and chemical methods for wastewater treatment are costly and not fully efficient in removing nutrients, and the discharge of effluents in rivers and lakes enhances the eutrophication. The use of microalgae species to remove nutrients available in wastewater, as a sustainable and low-cost treatment option, and also the use of different systems for algal cultivation in wastewater, aiming to obtain biomass and bio-products, is a growing field of research. Green microalgae, especially Chlorella species, play an important role in wastewater treatment while producing algal biomass, with numerous studies proving the high potential of Chlorella to consume nutrients from different categories of wastewater: municipal wastewater, wastewater from agriculture, wastewater from zootechnics, industrial wastewater. Cultivated in autotrophic, heterotrophic or mixotrophic conditions, in open or closed systems, microalgae have an important role in reducing greenhouse gases, consuming 1.83 kg CO_2 / kg dry algal biomass. Algal biomass can be capitalized to obtain many value-added products, including biofuels. The aim of this study is to review the advances in the utilization of microalgae Chlorella vulgaris in the treatment of municipal and zootechnical wastewater, emphasizing the removal of nutrients (nitrogen and phosphorus).
Keywords: wastewater, nutrients, biomass, microalgae, Chlorella

INTRODUCTION

Depending on their origin, municipal, agricultural, and industrial wastewaters contain variable amounts of organic matter, nutrients, heavy metals, pharmaceuticals and other emerging contaminants, detergents, greases, oils, microplastics, insecticides, fungicides, herbicides, sulfates, phosphates, fluorides, chlorides and a variety of pathogens.

Nutrients (nitrogen, phosphorus and other minerals) are the main elements for eutrophication of natural water bodies (lakes), which manifests by oxygen depletion, harmful microalgal blooms and disturbances in the balance of the ecosystem. Nutrients discharged from wastewater are getting increased attention and have been strictly regulated worldwide. Even if it has low concentrations, the ammonia in wastewater effluents can be toxic to aquatic organisms and fish. Furthermore, the phosphate and ammonia may cause serious health issues in humans, such as methaemoglobinaemia in new-borns (Yamashita et al., 2014).

The nitrogen in wastewater is primarily due to the metabolic interconversions of extra derived compounds, and over 50 % of phosphorus comes from synthetic detergents (Abdel-Raouf et al., 2012) used in households and different industrial activities. Nutrient concentrations and availability vary across the wide types of wastewater. For example, total nitrogen and phosphorous concentrations can reach values of 10–100 mg/L in municipal wastewater, more than 1000 mg/L in agricultural wastewater and 500–600 mg/L in zootechnical wastewater (Cheunbarn and Peerapornpisal, 2010). In Europe, on average, 2.52 kg nitrogen and 0.51 kg phosphorous / inhabitant / year are discharged in wastewater (EU-EEA, 2015). The European Directive 6498/15/EC establishes a limit of 10 mg/L for total nitrogen and 1 mg/L total phosphorous contained in effluents before discharge in natural waters. However, the effluents from wastewater treatment plants have much higher values: 20–70 mg/L nitrogen and 4–12 mg/L phosphorous (Rinna et al., 2017). Hence, wastewater should not be discharged unless proper treatment. If not recycled, the nitrogen in wastewater is lost as N_2 or as important greenhouse gases such as N_2O, which can contribute up to 78 % of the carbon footprint of a conventional wastewater treatment plant (Vasilaki et al., 2018).

The main forms in which they occur in wastewater are NH_4^+ (ammonia), NH_2^- (nitrite), NO_3^- (nitrate) and PO_4^{3-} (orthophosphate). In the secondary effluent, the concentration of ammonia is between 40-48 mg NH_4^+ - N/L, and the concentration of phosphorous is 9–12 mg PO_4^- - P/L (Martinez et al., 2000).

Nitrogen is conventionally removed through biological nitrification and denitrification using aerobic and anoxic reactors, or by the application of dual sludge treatment, while phosphorus is removed by coupling anaerobic and aerobic reactors. The disadvantages of biological methods are the need of aeration, high energy demand and carbon footprint. Chemical methods like chemical precipitation, ion exchange and adsorbtion, or electrochemical methods like electrooxidation, are also used in wastewater treatment plants to remove the nutrients, but these methods have the disadvantage of generating high amounts of sludge from chemical reactions and precipitates. Conventional treatment of municipal wastewater (primary settling and biological

treatment) could remove 40 % of total nitrogen and 12% of total phosphorus (Rinna et al., 2017). Overall, regardless their category, the conventional methods for nutrients removal include many steps, with complicated operation for which are required skilled personnel, are energy intensive, produce large quantities of sludge and have high costs.

With the new construction and upgrade of wastewater treatment plants and stricter disposal policies, alternative and sustainable approaches are needed for treating the ever increasing volumes of wastewater.

MATERIALS AND METHODS

Bio-treatment, bioremediation or phycoremediation of domestic, agricultural and industrial wastewater involves the use of microalgae and has attracted increasing attention in recent years.

Microalgae have the ability to adjust in adverse conditions; they grow naturally in many types of wastewater thriving on nutrients and forming an abundant resource of biomass. Microalgae have a rapid growth-rate (12 days), their doubling time during exponential growth are only 3.5 hours (Ungureanu et al., 2020) and can double their biomass within 24 hours. During their growth, algal cells might accumulate high amount of lipids and carbohydrates, which makes them an important feedstock for biofuel production.

Because of their photosynthetic capabilities, they convert the solar energy into abundant useful biomass. Microalgae also play an important role in CO_2 sequestration, because the CO_2 needed for their photosynthetic metabolism can be provided from industrial flue gases. When CO_2 from flue gases is consumed during microalgae growth, this leads to a decrease of greenhouse gas emission to the atmosphere simultaneously with carbon fixation. It was estimated that 1 kg of dry algal biomass consumes about 1.83 kg of CO_2 (Rosenberg et al., 2011). Microalgae have carbon fixation rates much higher than those of land-based plants by one order of magnitude (Kumar et al., 2011).

In addition to CO_2 mitigation, microalgae produce oxygen as a byproduct of photosynthesis, which can be used by aerobic bacteria to decompose biologically the organic matter in the wastewater. Thus, microalgae can help to reduce the need for mechanical aeration during wastewater treatment (Otondo et al., 2018).

Microalgae cultivation can take place in photoautotrophic, mixotrophic, or heterotrophic conditions (Figure 1). As an emerging wastewater treatment method, microalgae treatment provides an alternative and sustainable pathway for the removal (uptake) of the inorganic nitrogen and phosphorous from wastewater. Sunlight or UV light, pH, temperature, conductivity and water salinity are parameters for controlling and adjusting the process of microalgae cultivation (Nedelcu et al., 2019). Many other factors including nutrients, the concentration of organics and metal ions, or trace elements such as Mn, Fe, Zn and Cu, can influence the microalgal growth in wastewater.

Microalgae either grow naturally or are cultivated in open systems like wastewater lagoons, shallow algal ponds, high rate algal ponds, raceway ponds, constructed wetlands, and these require large areas with considerable light exposition. About 90 % of the global algae production is conducted in the open systems (Placzek et al., 2017).

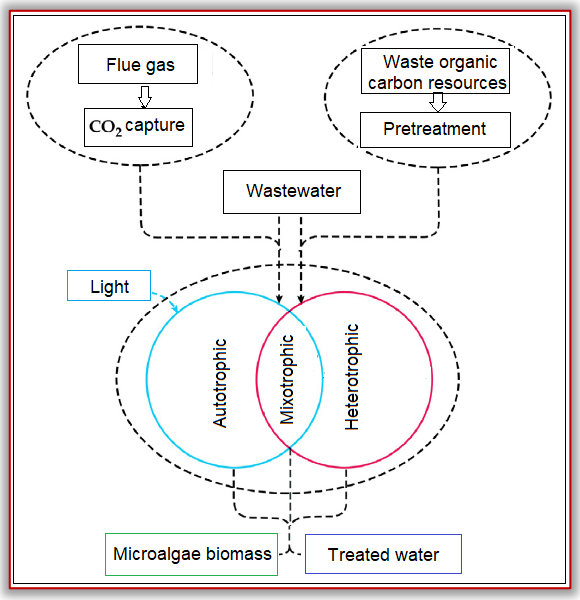


Figure 1 – Microalgae cultivation methods for wastewater treatment (Sundar Rajan et al., 2019)

In recent years, a large variety of closed systems (photobioreactors) were developed. This equipment must be supplied with CO_2 and light and represent a possible economically viable alternative to conventional aerobic biological methods for wastewater treatment due to their potential of resource recovery and recycling (Christenson and Sims, 2011). The cultivation costs in closed systems are high and this limits their commercial applications to high-valued compounds, but the costs can be reduced by efficient design of photobioreactors, which are able to achieve high areal biomass productivities (Placzek et al., 2017).

To some extent, in addition to the uptake by microalgae, some of the nutrient removal might be due to physical and chemical processes like volatilization, precipitation or adsorption (AlMomania and Örmeci, 2016). Algae uptakes the phosphorus as inorganic orthophosphate, preferably as $H_2PO_4^-$, PO_4^- or HPO_4^{2-} (AlMomania and Örmeci, 2016).

Besided wastewater, there are other possible culture medium for microalgae growth. Centrate is a stream generated from dewatering of sludge from primary and secondary settling, and mainly contains phosphorus, ammonia, and nitrogen. According to Wang et al. (2010), centrate is the best among all municipal wastewater streams for algal cultivation with high biomass accumulation and high efficiency wastewater nutrient removal. In addition to different types of wastewater, activated sludge contains 90–95 % organic matter and nutrients and there are some studies that have shown that activated sludge might be an alternative medium that could provide the necessary nutrients for microalgae cultivation. Digestate from anaerobic digesters can also be used as suitable medium for microalgae cultivation, preferably after dilution with synthetic culture medium, secondary/tertiary wastewater or seawater (Dickinson et al., 2015).

Microalgae can improve the quality of the final effluent through natural disinfection because they reduce the pathogenic organisms, viruses, protozoa and coliform bacteria such as Salmonella, Shigella found in municipal and livestock wastewater (Ungureanu et al., 2020).

Wastewater treatment by microalgae can be achieved in the form of suspended free-cells culture and immobilized cells.

The suspended free-cells culture is the condition of microalgae living cells to move independently within the flasks containing a medium under the condition to ensure uniform cells distribution (Katarzyna et al., 2015). The use of suspended free-microalgae cells culture involves the removal of nitrogen and phosphorus from wastewater whilst simultaneously providing oxygen (O_2) for aerobic bacteria coexisting in the culture. The immobilized cells culture is the condition of microalgae living cells to be prevented from flow freely from their original location to all parts of the medium (Emparan et al., 2019). Several residual polymeric materials like alginate and chitosan are currently used for microalgae immobilization. Biofilms also provide a medium for immobilization of microalgae, because they are slimy, green layers consisting of large numbers of microalgae entrapped in a gel-like matrix (Ungureanu et al., 2019).

Research on algae-based wastewater treatment has focused mostly on the conventional microalgae and cyanobacteria, including Arthrospira sp., Botryococcus sp., Chlorella sp., Chlamydomonas sp., Haematococcus sp., Nannochloropsis sp., Scenedesmus sp. and Spirulina sp.

Unicellular green microalgae Chlorella sp. is spherical shaped, flagellate organism with a diameter of about 2-10 µm (Figure 2). Chlorella sp. is mostly used in the tertiary treatment of wastewater, but it has high removal efficiency (› 80%) of nutrients (nitrogen and phosphorus) in primary and second treatment effluents.

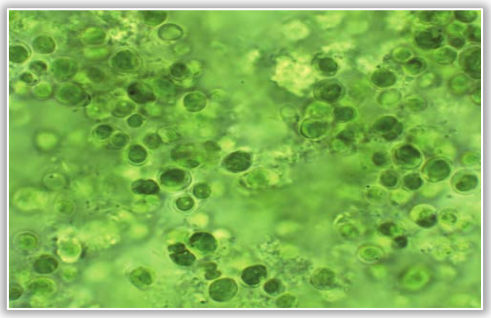


Figure 2 – Microalgae Chlorella vulgaris (Brzychczyk et al., 2016)

Under certain conditions, Chlorella sp. can completely remove ammonia nitrogen, nitrate nitrogen and total phosphorous, hence it has wide application in the treatment of agricultural and fecal wastewater (Wang et al., 2010). Its photoautotrophic growth is usually limited by lack of nutrients (particularly nitrogen), weak light, carbon limitation, changes in wastewater pH, and accumulation of photosynthetic oxygen (Yuvraj and Singh, 2016). Chlorella vulgaris produces more oxygen than all other plants in the world (Malothu R., 2020).

In the context of a circular and bio-based economy and the development of biorefinery concepts, after wastewater treatment, the harvested microalgal biomass can be processed to obtain high-value products, including: cosmetics, pharmaceutical products (with antiviral, antibacterial, anticancer, antihistamine role), steroids, algal toxins, pigments, organic fertilizers rich in N, P and K minerals, protein sources, animal feed, food products (juices, sauce, cheese, noodles, beverages), preservatives in food industry, bioplastics, biosorbents (ion exchangers that can bind toxic heavy metals), bioenergy (biofuels including biogas, biodiesel, bioethanol, biobutanol, biohydrogen, biochar etc), and digester residues (compost and vermicompost).

RESULTS

— Microalgae Chlorella in the treatment of municipal wastewater

As reported by Wang et al. (2010), Chlorella sp. cultivated in wastewater from a local municipal wastewater treatment plant achieved removal rates of NH_4-N, phosphorus and COD of 74.7%, 90.6% respectively 56.5%, before the primary settling stage. It was also reported a high removal efficiency of NH_4-N and phosphorus from secondary wastewater.

Feng et al. (2010) cultivated Chlorella vulgaris in synthetic wastewater containing 78 mg/L N- NH_4^+ and 400 mg/L COD was provided by glucose. Cultivation was done at 30°C, under 3000 lx light emission and 0.5 vvm of air bubbling. The microalgae grew for 7 days, and the removal efficiency of nitrogen, phosphate and COD were 96%, 97% and 85%, respectively. In another study, Chlorella sp. grown in a highly concentrated municipal wastewater (centrate) achieved approximately 90 % of total nitrogen removal (Li et al., 2011).

Choi and Lee (2012) investigated the effect of optimal concentration of Chlorella vulgaris (FC-16) with cell diameter between 3–8 µm, for the removal of nutrients in real wastewater obtained from preliminary sedimentation of a wastewater treatment plant, using batch reactor operation. They observed that increasing the concentration of Chlorella vulgaris from 1 to 10 g/L produced an increase of removal rates thus: total nitrogen from 81.04% to 84.81%; total phosphorous from 32.26% to 36.12%; NH_3-N from 96.90% to 97.26%, PO_4-P from 44.76% to 48.71%, COD from 78.33% to 82.30%, respectively BOD from 80.41% to 82.92%.

In a study conducted by Ebrahimian et al. (2014), Chlorella vulgaris was cultivated in batch system and mixotrophic conditions supplied with CO_2 using a mixture of primary and secondary wastewater with 25, 50 and 75 volume percent of the primary wastewater. As presented in Figure 3, the removal rates using 25% of the primary wastewater were 100% for ammonium, 82% for nitrate and 100% for organic matter (COD).

AlMomania and Örmeci (2016) tested the efficiency of Chlorella vulgaris, Neochloris oleoabundans and mixed indigenous microalgae collected from a wastewater treatment plant, for the removal of nitrogen, phosphorus and organic carbon from primary effluent, secondary effluent, and centrate. The indigenous microalgae culture has proven to be more effective than Chlorella vulgaris and Neochloris oleoabundans in removing inorganic nitrogen (63.2–80.8%),

phosphorus (30.8–70%) and chemical oxygen demand (64.9–70.4%). Zhou et al. (2014) obtained removals of 76.7–92.3% of total nitrogen and 67.5–82.2% of total phosphorus by Chlorella vulgaris, Chlorella pyrenoidosa, Chlamydomonas reinhardtii and Scenedesmus obliquus, during wastewater treatment.

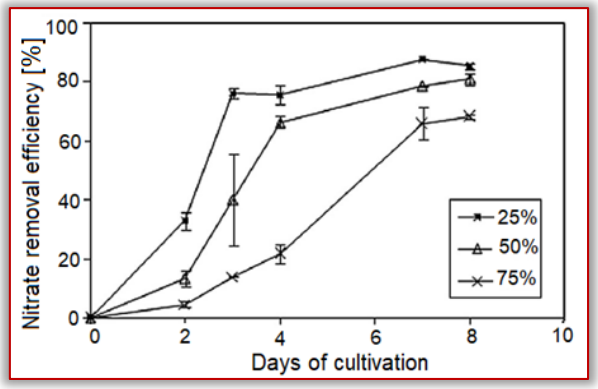


Figure 3 - Removal of nitrate in a mixture of primary and secondary wastewater (Ebrahimian et al., 2014)

Caporgno et al. (2015) tested freshwater microalgae species Chlorella vulgaris and Chlorella kessleri and the marine microalgae species Nannochloropsis oculata cultivated in urban wastewater, in batch mode using a flat-panel airlift photobioreactor. Both freshwater microalgae species achieved reductions of nitrogen concentration around 96% and 95%, and of phosphorous concentration around 99% and 98%. Nannochloropsis oculata was able to uptake nutrients from wastewater to grow but with less efficiency, indicating the need of microalgae acclimation or process optimization to achieve high nutrient removal.

Bacteria are inevitably present in the wastewater and they interact with the microalgae, on the one hand potentially restricting their growth and on the other hand potentially enhancing the efficiency of wastewater treatment due to stimulation of microalgae growth. Some bacteria could kill the algae by releasing enzymes to break down the microalgae cell wall, and extracellular substances produced by bacteria could cause algae lysis (Ma et al., 2014).

In this regard, He et al. (2013) studied the effect of Chlorella vulgaris with or without co-existing bacteria on the removal of nitrogen, phosphorus and organic matter from wastewater. In the algae–bacteria system Chlorella vulgaris had a dominant role in the removal of nitrogen and phosphorus, while bacteria removed most of the organic matter from the wastewater. Using the algae–bacteria consortium resulted in the removal of 97% ammonium, 98% phosphorus and 26% dissolved organic carbon at a total nitrogen level of 29–174 mg/L. A study conducted by de-Bashan et al. (2002) proved that the co-immobilization of microalgae Chlorella vulgaris in alginate beads with bacteria Azospirillum brasilense was superior to a stand-alone microalgae system, obtaining removal rates of up to 100% ammonium, 15% nitrate and 36% phosphorus.

Kube et al. (2019) also proved that algae immobilization in alginate was more efficient and stable for synthetically-made municipal wastewater treatment, achieving a maximum nitrogen removal efficiency of 95% after 84 h of treatment.

Ma et al. (2016) cultivated Chlorella vulgaris in wastewater with waste glycerol generated from biodiesel production, to improve nutrients removal and enhance lipid production.

The tested concentrations of glycerol were 0, 1, 5 and 10 g/L. The optimal concentration of the pretreated glycerol for Chlorella vulgaris was 10 g/L with biomass concentration of 2.92 g/L, lipid productivity of 163 mg/L·day. Under these conditions, it was obtained the removal of 100% ammonia and 95% of total nitrogen (Figure 4).

The highest COD removal efficiency of the culture with the pretreated glycerol was 98%, possibly because some organic compounds in the crude glycerol, which were not removed by pretreatment, were not fully absorbed by Chlorella vulgaris.

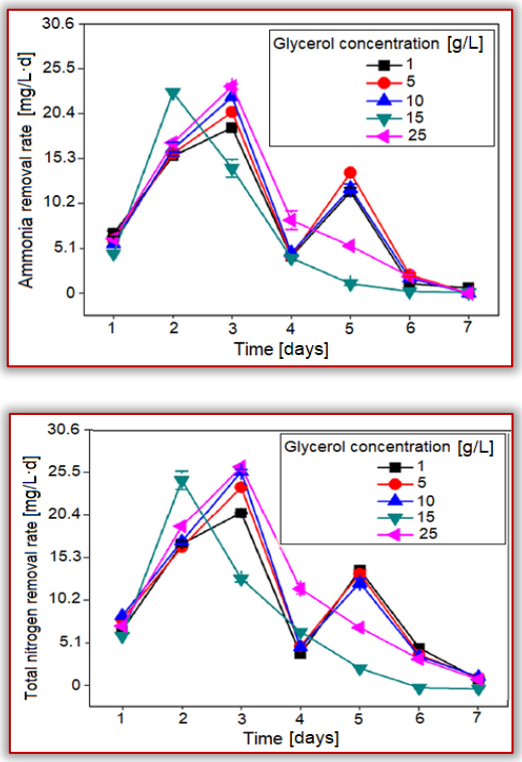


Figure 4 - Effect of concentration of pretreated glycerol on nutrients removal by C. vulgaris (Ma et al., 2016)

In a recent study, iron-magnetic nanocomposite particles (Fe_3O_4@EPS) synthesized by co-precipitation of iron (III) chloride and iron (II) sulfate (Fe_3O_4 nanoparticles) with exopolysaccharides (EPS) derived from the microalga Chlorella vulgaris were tested for the removal of nutrients from wastewater. Under optimum conditions (3.5 g/L of Fe_3O_4@EPS, pH 7.0 and 13 hours of incubation) 91 % PO_4^{3-} and 85 % of NH_4^+ were effectively eliminated, showing the potential of Fe_3O_4@EPS application in removing nutrients in wastewater treatment plants (Govarthanan et al., 2020).

— **Microalgae Chlorella in the treatment of zootechnical wastewater**

Piggery wastewater contains high concentration of suspended solids and nutrients, small amounts of heavy metals and organic matter, antibiotics and hormones, so its insufficient treatment can cause serious environmental pollution and risks to human health. The typical composition of piggery wastewater exhibits the following

concentrations: nitrogen 800–2300 mg/L, phosphorous 50–230 mg/L, biochemical oxygen demand 2000–30000 mg/L, and N/P ratio is about 12–17 (Chen et al., 2020).

A common feature of piggery wastewater is the high-strength ammonium, which is toxic for microalgae and therefore it should be mitigated during piggery wastewater treatment by microalgae, by the addition of glucose to adjust C/N ratio of the wastewater (Lu et al., 2018). Recognizing the potential benefits of microalgae cultivation incorporated into the piggery sewage systems, studies into the use of microalgae as a treatment for piggery wastewater have been ongoing for the last decades.

Lv et al. (2018) used Chlorella vulgaris selected from five freshwater microalgal strains of Chlorophyta for nutrients removal from undiluted cattle farm wastewater by two-stage processes of microalgae-based wastewater treatment. By the end of treatment, 62.30%, 81.16% and 85.29% of chemical oxygen demand, ammonium and total phosphorus were removed.

The two two-stage processes included a setup of double biological treatment by Chlorella vulgaris, respectively a setup of biological treatment by Chlorella vulgaris followed by activated carbon adsorption. After 3–5 days of wastewater treatment by the two processes, the nutrients removal efficiency of chemical oxygen demand, ammonium and total phosphorus ranged between 91.24–92.17%, 83.16–94.27% and 90.98–94.41%.

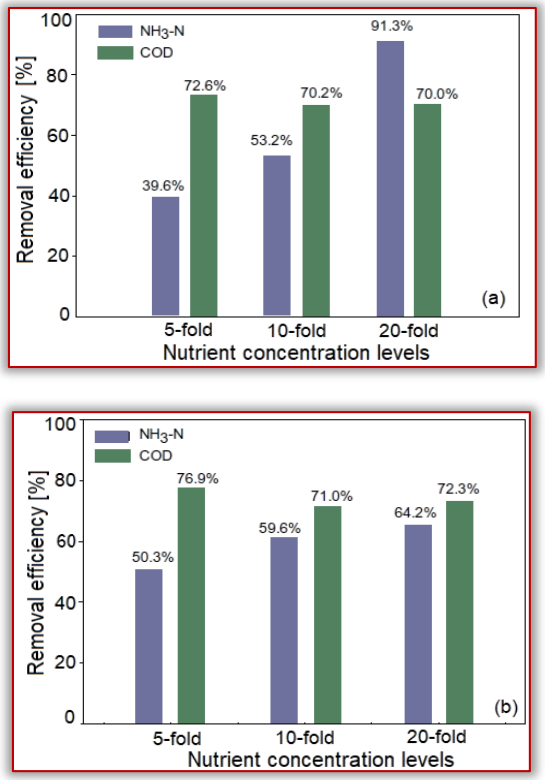
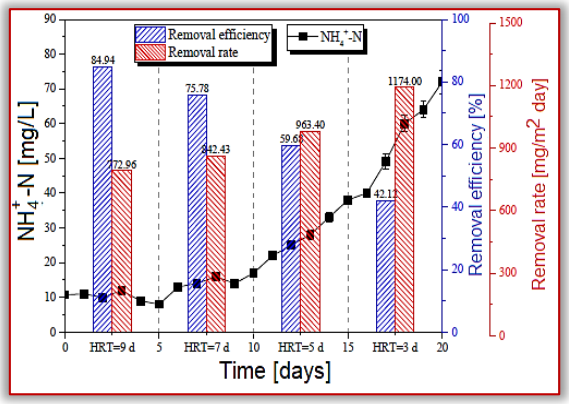


Figure 5 – Removal efficiency of NH_3-N and COD at different nutrient concentration by Chlorella vulgaris JSC-6 grown mixotrophically (a), respectively heterotrophically (b) in piggery wastewater (Whang et al., 2015)

Whang et al. (2015) tested an isolated carbohydrate-rich microalga Chlorella vulgaris JSC-6 to treat piggery wastewater. They obtained between 70–77% COD removal and 40–90% NH_3-N removal in mixotrophic and heterotrophic conditions, depending on wastewater dilution ratio, with the highest removal percentage obtained for 20-fold diluted wastewater (Figure 5).

Chlorella vulgaris can grow well in pretreated fresh pig urine (at 8-fold dilution, pH=6, $MgSO_4 \cdot 7H_2O$ dosage of 0.1 mg/L). About 1.72 g/m^2·day of microalgal biomass could be produced, and 98.20% of NH_4^+-N and 68.48% of total phosphopous could be removed in the batch mode at cultivation in light-receiving-plate enhanced raceway pond. A hydraulic retention time of 7-9 days is optimal for the efficient removal of nutrients and microalgae biomass production in continuous regime (Zou et al., 2020).



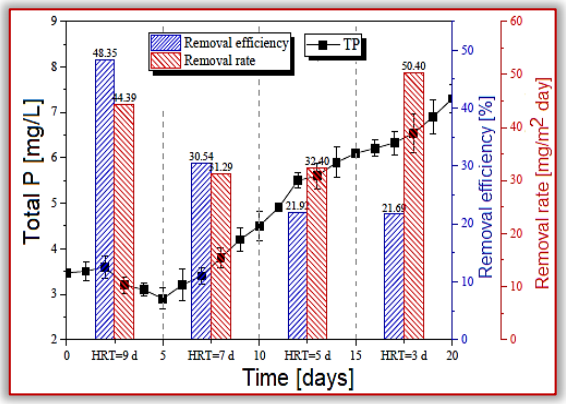


Figure 6 - Removal efficiencies and removal rates of NH_4^+-N and total phosphorous (Zou et al., 2020)

Zhou et al., (2018) cultivated Chlorella zofingiensis in municipal wastewater and also in municipal wastewater mixed with 8 % pig biogas slurry. The latter contains abundant mineral nutrients after anaerobic treatment; hence it had a significant effect on microalgal growth (2.5 g/L biomass).

Figure 7 illustrates that in municipal wastewater (MW), nitrogen and phosphorous concentrations decreased continuously in the first 24 hours, and then remained stable, with Chlorella zofingiensis showing a good removal efficiency of nutrients. Nitrogen decreased continuously within the first 60 hours then remained stable, whereas phosphorus concentrations decreased rapidly in the first 36 hours.

Overall, the removal rates for nitrogen and phosphorus in MW were 21 mg/L·day, respectively 4.6 mg/L·day, achieving

90 % total phosphorus removal and 93 % total nitrogen removal.

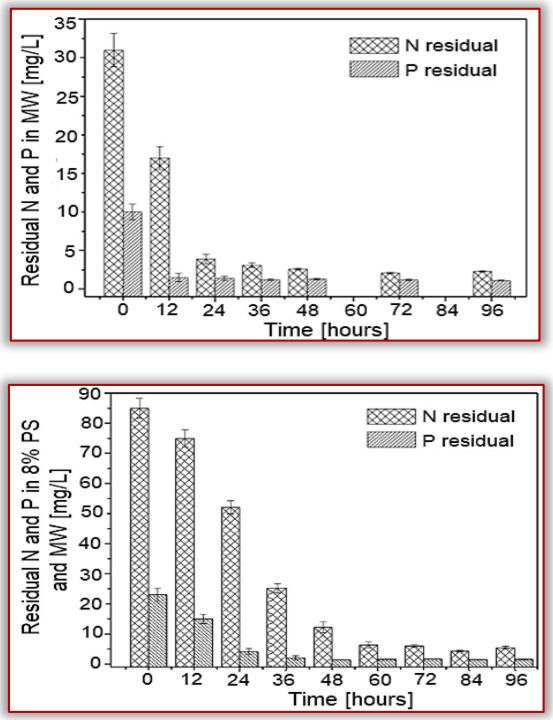


Figure 7 – Removal of nutrients by Chlorella zofingiensis in municipal wastewater and in 8 % pig biogas slurry in municipal wastewater (Zhou et al., 2018)

Zhu et al., (2013) treated piggery wastewater by the freshwater microalgae Chlorella zofingiensis, a protein-rich algae, and obtained removal rates of 68–81 % for nitrogen, 90–100 % for phosphorous, respectively 65–76 % for COD.

CONCLUSIONS

Conventional methods are widely employed for the treatment of municipal and zootechnical wastewater, which is based on biological and chemical systems and is costly. Hence, the use of microalgae for wastewater treatment got increased attention in recent years. In the past few decades, tremendous advances have been made in the field of algal technologies for combating numerous disadvantages of techno-economic order and improving biomass production, and the research is ongoing worldwide.

Chlorella vulgaris is widely cultivated in different types of wastewater and it proved its efficiency in the removal of nutrients (nitrogen and phosphorous) that would otherwise cause eutrophication, and in the removal of chemical oxygen demand, biochemical oxygen demand, heavy metals, and even pathogens.

Besides their important role in the sustainable treatment of wastewater and in the reduction of greenhouse gases, microalgae represent an abundant biomass with potential to be capitalized in obtaining biofuels of real interest in the current climatic conditions.

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APPLICATION OF NANOTECHNOLOGY IN LEACHATE TREATMENT (A CRITICAL REVIEW)

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Abstract: Over the years, new tools and techniques for treating hazardous leachate water. From biological treatment methods to physical/chemical techniques for treating leachate to acceptable standards. The fast and rapid growth of the nanotechnological sector has shown promise in its application for environmental remediation and by extension leachate treatment. Regardless of these met progress in technological approaches to treating leachate, there still remains the need for universal and economically scalable methods for leachate treatment. This paper covers the various leachate treatment methods with emphasis on the application of nanotechnology/nanomaterials in past research in this regard as well as some setbacks the leachate treating method has seen.
Keywords: Nanomaterials, leachate; biological; physical; and chemical treatment

INTRODUCTION

Owing to population growth, lifestyle preferences, consum ption and technological advances, the rate of waste generati on hascontinued to increase, which has intensified the need to address this environmental concern (Nnamdi I. 2014). As a result of agricultural and industrial revolution, industries are found of producing wastes which may not be recycled again. Nigeria as a case study produces over 32 million tons of solid waste every year, only 20-30% of this stated volume is properly collected. Also, from the United Nations Habitat Watch reports, the populations of African cities will more than triple over the next 40 years, translating in even much higher volume of waste produced. Hence, the need for disposal. This illustrates the vulnerability of the African or Nigerian environment to the toxic hazards that can be caused by improper waste disposal.

Sadly, for many developing countries across the world including Nigeria, waste management remains a major challenge due to lack of standard engineered landfills. Even so, for densely populated countries with high volume of waste produced daily combined with poor waste management infrastructure (Aluko et. al. 2003). Open dumping systems and landfill are the primary means or system of waste disposal in many developing countries around the world including Nigeria since they infer low economical consequences and are capable to storing large volumes of solid waste contrasted with other methods such as incineration. The absence of properly constructed landfills for waste disposal by the governments has led to the rise of even more open dumps that are scattered around the country (Asibor G. & Edjere O., 2016). Over time, these develop into valleys, excavations and mountain heaps of illegal dumping sites without the consideration of the waste synthesis (Ugwoha E. & Emete K.C., 2015).

Open dumps and landfills have been identified as one of the key threats to groundwater sources. Waste disposed of at these sites are often prone to be infiltrated by precipitation. In the Nigerian context where local rivers have also become avenue for dumping refuse and sewage (Sabejeje, *et al*., 2014). As the precipitated water seeps through the waste, it collects various organic and inorganic compounds flowing out of the waste and settles at the bottom of the waste pile. With such contamination of groundwater sources, the quality of life of the local groundwater users can adversely be affected with threats of substantial health risks, including waterborne illnesses such as typhoid, cholera and dysentery, since the contaminated water source ends up createing breeding space for flies, rodents and mosquitoes (Ugwoha E. & Emete K.C., 2015) and in other worst case scenarios, the effects of these contaminated groundwater have been linked with several symptoms and diseases associated with biometal poisoning such as asthma, vomiting and convulsion, anemia, depression, ataxia, diarrhea, cancer, hypertension, pneumonitis. Other biometal poisoning related diseases also include neurological diseases, cardiovascular and renal diseases, skeletal deformities, and gastrointestinal disorders (Boateng et al., 2019).

As these poorly disposed wastes encounter and make interactions with water that percolates the landfill sites, a complex liquid containing disproportionate amounts of biodegradable and nonbiodegradable materials is formed and is known as Leachate (Kamaruddin et al. 2014). This undesirable fluid, which is a source of environmental pollutants is generally heavily contaminated (with high levels of dissolved carbon, inorganic constituents, heavy metals, humic acids, ammonia, salts and other toxic substances) and consists of complex waste water that is very difficult to deal with and would usually contain even more complex contaminants depending on the nature of the age and other factors. The research of Tairu (1998) on the concentrations of pollutants present in leachate, lead to a report of high rate of mortality among domestic animals, low farm produce, production of unpleasant and unwanted gases and contamination of the domestic water sources which were reported and traced to direct discharge of raw leachates into nearby environment at the landfill site

As leachate pollutes the groundwater, its components and constituents are dissolved in it too. For example, cancerous heavy metals seep faster into groundwater. Heavy metals

present in leachates from waste disposal sites have been studied to have hazardous effect to public health. Boateng et. al. 2019 multivariate study on the possible sources of heavy metals in the poor condition water media of sites in the Kumasi metropolis of Ghana using the IBM's SPSS was able to reveal that high levels of heavy metal suggests significant contamination of groundwater due to percolated leachate from the landfill site. Also, individually, Lead has been involved in numerous diseases such as anaemia, anorexia, brain damage, mental deficiency, vomiting and even death in human. Cadmium also has been reported to cause agonistic and hostile effects on hormones and enzymes resulting in several malfunctions like kidney failures. These two metals have affinity for sulfhydryl groups in proteins, haemoglobin, enzymes/ hormones. Likewise, Pb and Cd are classified as carcinogens. Other metals examined in the study were Nickel(Ni), Chromium(Cr), Zinc(Zn) and Copper(Cu), each of which were stated to be linked to various health problems due to being non-biodegradable and with the risk of accumulation in the food cycle (Ogundiran O. & Afolabi T., 2008). Hence there is an ever-increasing need for global awareness of the hazardous role these emissions play on human health and also on the environment as well as technological means for the remediation of these damages.

LEACHATE TREATMENT

Leachate needs to be pre-treated on site in order to meet the standards for its drainage into the sewer or its subsequent discharge into surface water (Abbas A. et. al., 2009). Virtually, various types of treatments methods have been explored for treating leachates for some time now. In fact, traditional treatment methods have proved no longer sufficient anymore to achieve the degree of purification needed to completely mitigate the negative impact of landfill leachates on the ecosystem. Therefore, there exists a need for a universal, adaptable and transferable method of leachate treatment (Aluko O. et. al., 2003). This would owe to the fact that leachates vary greatly in composition/ characteristics from site to site. Some of these factors or differing characteristics that would affect the treatment technique to be used for treating leachate includes COD/TOC and BOD/COD ratios, absolute COD concentration and age of the landfill (Gao et. al., 2014).

Loosely, Leachate treatment techniques can be characterized into two basic types, biological and physical/chemical methods.

— **Biological Treatment:**

These systems are divided into aerobic (with oxygen) and anaerobic (without oxygen) conditions. In particular, the use of microorganisms or bacteria to remove pollutants in the leachate is achieved by an assimilation pro cess. It is widely considered one of the most popular and cost-effective technique of leachate treatment and is best used with other techniques to achieve the best required result. It is energy conservative too. They are best used for younger leachate (1-2 years old).

— **Physical-Chemical treatment techniques:**

These systems utilizes non-biological changes in the leachate whereby only physical or chemical phenomenon are used to improve the quality of the leachate. Examples of physical-chemical treatment methods includes adsorption, coagulation/flocculation and chemical oxidation, activated carbon adsorption, membrane filtration processes (microfiltration, ultrafiltration, nanofiltration and reverse osmosis), ion exchange, electrochemical treatment and flotation. These techniques are, however, disadvantaged due to factors such as membrane fouling, permeation flow, and minimal recovery rate.

— **Recycling:**

On the other hand, involves regulating and enhancing of landfill biological, chemical and physical processes by the addition of leachate into the landfill. This technique, however, would usually lead to an increase in the moisture content in the landfill.

It is worthy to note however that each treatment method has its own advantages and disadvantages and the implementation of a specific method is not always be effective because of the complex characteristics of municipal solid waste leachate and low biological to chemical oxygen demand ratio, resulting in insignificant treatment efficacies (Abbas A. et. al., 2009).

NANOTECHNOLOGY AND ITS RESEARCH APPLICATION TO THE TREATMENT OF LEACHATE

The word "nanotechnology" was first used at the end of the 19th century (1867) when James Clerk Maxwell published his first studies on this technology and proposed possibilities for the manipulation of individual molecules (Zelić E., Vuković Ž., Halkijević I., 2018). In general, nanotechnology would imply the management or manipulation of materials or articles with particle size of 1-100nm. Over the century, however, nanotechnology has shown great potential in advancing environmental remediation. Most of the environmental applications of nanotechnology fall into three categories: (i) environmentally friendly and/or sustainable products (e.g. green chemistry or pollution prevention), (ii) remediation of materials contaminated with hazardous substances, and (iii) sensors for environmental agents (Tratnyek P. & Johnson R., 2006). By extension, nanotechnology has also shown the same magnitude of potential in water and wastewater treatment to enhance treatment efficiency as well as to increase water availability through safe use of unconventional sources of water (Qu et. al., 2013).

Nanomaterials in principle, are materials with dimensions of less than 100 nanometers. Owing to numerous specific unique properties, including high surface to volume ratio and high catalytic activity, nanomaterials finds myriad pharmaceutical, cosmetic, electronic, energy-related and ultimately environmental applications. Currently, the most recent applications of nanomaterial in environmental nanotechnology continues to rapidly gain traction in environmental remediation studies with water purification possibly being among the most advanced environmental applications of nanomaterials. Some of the considered properties that have makes nanomaterials suitable for leachate treatment includes their large surface to volume ratio, behaviour and motion of electrons (quantum effects),

their reaction with polluting atoms, faster chemical processes, etc. (Zelić E., Vuković Ž., Halkijević I., 2018). Some of the techniques in which nanomaterials or nanotechnology have been employed in its treatment include the following:

— **Nanofiltration**:

Is a high-pressure membrane filtration-based treatment process which requires a much lower drive pressure (5 to 20 bar), and so allows lower energy consumption. While there exist several controversies regarding the use of the term 'nanofiltration' in connection with nanotechnology, the vast role it plays in leachate treatment and heavy metal removal can be hardly pushed aside.

When used for treating wastewater, nanofiltration produces water that meets very strict criteria for the reuse of water. Currently, the advancement of nano-filtration technologies has been adopted into many processes i.e., demineralization in the dairy industry, pulp-bleaching of textile industry effluents, virus removal and metal recovery from wastewater, and extraction of biopharmaceuticals from fermentation broths. Nano-filtration shows notable promise as a technique for the treatment of inorganic pollutants and natural organic matter in leachates (M. Rafique et al., 2019).

— **Nanomaterials for catalysis and Photocatalysis:**

Nanocatalysts have seen wide applications in the oxidation of organic and inorganic pollutants in leachates in advanced oxidation processes as it increases the catalytic activity at the surface due its high surface area with shape dependent properties (Deepa Madathil et al, 2013.). Researches has shown that iron nanoparticles can act as effective catalysts in detoxifying a large variety environmental contaminant, such as agricultural pesticides, trinitrotoluene (TNT), heavy metals, nitrates, polychlorinated biphenyls (Kashitarash Z. et al, 2012.).

Photocatalysis is known to be a more effective method for detoxifying waste water, which also affects our environmental pollution and suppresses energy crises (M. Rafique et al., 2019). In this treatment, the nanocatalyst is illuminated by activated visible light resulting in the formation of highly reactive hydroxyl radical which can then react easily with pollutant molecules and degrade it (Zelić E., Vuković Ž., Halkijević I., 2018).

Metal nanoparticles and metal oxides have shown promise for environmental pollution remediation as regards their use as nanocatalysts and in photocatalysis. Titanium nanomaterials, for example, are at large considered efficient and favourable nanocatalysts and photocatalysts for use in research due to their relatively low cost, stability and environmental friendliness. Results obtained from the use of these nanomaterials can further be tuned by doping them with metallic ions to affect their surface and structural morphology (M. Rafique et al., 2019).

Many studies have shown that doping TiO_2 NPs with metal ions (with transition and earth metals seeing more applications in this case) is one of the most effective methods used to enhance the photoelectrochemical properties of TiO_2 under ultraviolet radiation and sunlight. Heterogeneous photocatalysis with TiO_2 nanomaterials have been established to adsorb heavy metals such as Pb, Cd, Cu, Zn, and Ni at pH of 8 (Ghasemzadeh G. et al, 2014). A study by Azadi et al. (2017) on the efficiency of the photocatalytic treatment process of landfill using TiO_2 and W-doped TiO_2 showed that using W-doped TiO_2 as a photocatalyst is more efficient than using a TiO_2 catalyst and that a 46% rate of Chemical Oxygen Demand (COD) removal was achieved under optimal operating conditions. Elleuch et al. (2020) also found in his research that the removal efficiencies of TiO_2 doped with silver (Ag) were found to be 90, 100, 96, and 75%, for TOC, Cd, Ni, and COD

— **NanoZerovalent Iron Injections:**

Zerovalent metals are typically prepared through the borohydride reduction of metal salts. Due to their large surface area, reactivity and environmental reactivity, zerovalent metals are considered ideal compounds for effectively detoxifying organic and inorganic contaminants in aqueous solutions. Nanoscale zero-valent iron has found different applications in wastewater remediation, sediments or soils for nitrates reduction and removal (Ghasemzadeh G. et al, 2014). It also has been shown to be effective for removing chemical pollutants such as heavy transition metals including chromium, cobalt, copper, lead, silver, nickel; post-transition metals, actinides, azo dyes etc.

Kashitarash Z. et al. (2012) investigated the effect of Nanosized Zero Valent Iron (NZVI) for treatment of Hamadan landfill leachate. It was observed that this procedure attained a fast removal efficiency of 47.94% for COD in 10 min at optimal conditions of pH value of about 6.5, temperature of 18 ± 1°C and 2500 mg/L concentration of iron nanoparticles. It is to be noted that the optimal condition will differ for different leachate samples due to differing properties and characteristics of the leachate earlier mentioned in this paper.

CONCLUSIONS

With the volume of waste produced being on a rise and some country looking to run out of landfill space over time, there arises the need for better waste management systems and also for providing universal, cost-effective and sustainable method for treating the resulting leachate produced thereof. Over the past years, however, different techniques for treating landfill leachate has been developed and tested in a bid to find economically scalable and transferrable method. Nanotechnology has shown rapid growth in its application in leachate and wastewater treatment. While, some of the techniques have been argued to be more cost-effective, durable and eco-friendly, more research still needs to be done to be able to provide a commercial based system of application of nanotechnology to the treatment of leachate and wastewater and to provide a sound basis on which the adverse effects of these advanced treatment techniques might have on the environment and human health can be determined.

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AGRICULTURAL SOILS EVALUATION, AFTER USE OF DIATOMITE AS AN ECOLOGICAL INSECTICIDE

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Abstract: Soil quality is best defined in relation to the functions that soils perform in natural systems and agroecosystems. The quality of soil resources has historically been closely related to soil productivity. Indeed, in many cases the terms soil quality and soil productivity have been nearly synonymous. Soils have important direct and indirect impacts on agricultural productivity, water quality and the global climate. Soils make plant growth possible by mediating biological, chemical and physical processes that provides plants with nutrients, water and other elements. Limited availability and quality of water resources are important aspects of natural resource management, and the protection and conservation of water resources is a key requirement in the principles of sustainable development. Climate change is just one of the responsible factors for the emergence and spread of diseases and pests in vegetable crops. Plant pests continue to be one of the biggest constraints on food and agricultural production. In order to protect the soil, and implicitly the environment, it is necessary to choose ecological methods to combat them. Thus, a model of eco-sustainable technology for reducing and preventing diseases and pests was developed, in which diatomite was selected as an ecological insecticide. The main chemical indicators were analyzed, both in the year of application and in the next year, in order to establish the long-term effect.
Keywords: Climate change, diatomite, ecological, agriculture

INTRODUCTION

The soil is an essential resource for all cultivated plants, being not only a support for plant roots, but also a reservoir of essential nutrients needed for plant growth. Because the soil is a complex system that interacts with other systems, participates in phytomass production, influences the ecosystems production capacity, having an essential contribution to recirculation of chemical elements in nature and regulates the atmosphere and hydrosphere composition. The soil is a living and quality system and must be preserved accordingly. This is the result of several interactions between biological components, including microbial communities that are essential for physico-chemical functioning. It is composed of mineral particles, organic matter, water, air and living organisms, in fact it is an extremely complex, variable, and living environment (EC, 2020 (a)).

Soil not only makes life on Earth possible, but also helps fight climate change. About 70 billion tonnes of organic carbon - almost 50 times more than the EU's annual emissions - are kept safe under our feet. Soil is the second largest carbon sink on the planet after the oceans and this is another reason why is so important to maintain a healthy soil (EC, 2020(b)).

Soil quality is best defined in relation to the functions that soils perform in natural systems and agroecosystems. The quality of soil resources has historically been closely related to soil productivity. Indeed, in many cases the terms soil quality and soil productivity have been nearly synonymous (NRC, 1993).

The objective of the agricultural production sector, which takes place mainly on the ground, is no longer simply to maximize productivity, but to optimize, in the conditions of a more complex agricultural landscape, a rural development under urban pressure. (Godfray et. Al, 2010). Obtaining a good soils quality condition of soils is a complex process, which depends on several factors (Oara, 2015).

The method of assessing soil quality is based on quantifying certain indicators that refer to stable or intermediate properties, determining the functional capacity of the soil (ICPA).

Soils have important direct and indirect impacts on agricultural productivity, water quality and the global climate. Soils make plant growth possible by mediating biological, chemical and physical processes that provides plants with nutrients, water and other elements (NRC, 1993). Limited availability and quality of water resources are important aspects of natural resource management, and the protection and conservation of water resources is a key requirement in the principles of sustainable development (Tociu et. al, 2020).

Crops are threatened by soil-borne diseases, which makes them difficult to control due to the "hidden" nature of pathogens and the low effectiveness of conventional treatments. In this context, the interest of agricultural practices that use these ecological changes needs to be rethought. These practices significantly affect soil quality, which in turn affects the plants quality (Oara, 2015). According to studies, although there is clear evidence that climate change is altering the distribution of diseases and plant pests and animals, the full effects are difficult to predict and quantify. The changes in temperature, humidity and greenhouse gases can increase the growth and growth rate of fungi and insects, as well as altering the interactions between pests and their hosts. While new pests and diseases have regularly emerged throughout history, climate change

is responsible for many diseases and pests. (FAO, 2016). Plant pests, including insects, pathogens, and weeds, continue to be one of the biggest constraints on food and agricultural production.

For example, fruit flies cause extensive damage to fruit and vegetable production, and as global temperatures continue to increase, they are finding more areas to adapt and develop. Control of these pests often requires the use of pesticides, which can have serious side effects on human health and the environment, which is why environmentally friendly methods are recommended. Climate change is only one of several "global change" driving the emergence and spread of plant pests and animal diseases (FAO, 2016).

MATERIALS AND METHODS

During the period of 2019 agricultural year, in the study area at SCDL Buzău, three varieties of vegetables were planted, namely Rubiniu onions, Menuet dwarf garden beans and bell peppers from Buzău 10. They were grown on different surfaces as follows: onion variety on 3000 m^2, peppers on 2000 m2 and beans on 5000 m2. In 2020, the cultures succeeded as follows: on the area cultivated in 2019 with onions, were planted peppers in 2020, on the area cultivated in 2019 with beans, were planted onions in 2020, respectively on the field cultivated in 2019 with peppers were planted beans in 2020.

They are part of the varieties vulnerable to diseases and pests, so for an ecological agriculture and environmental protection it was chosen to develop an experimental model of eco-sustainable technology to prevent and reduce the aggression of diseases and pests in vegetable crops, where as an ecological variant of insecticides was used diatomite (Deák et al., 2018).

Diatomite was applied on the soil in the powder and liquid form, being used the one from Pătârlagele quarry, Buzău County, due to the high insecticidal effect (ICDPP, 2014, Laslo et al., 2019). Each culture was customized according to the amount of diatomaceous earth powder administered (Laslo et al., 2019) -Table 1. The liquid diatomite was administered in an amount of 5l / 7sqm.

Table 1. Content of solid diatomite administered

V1	control sample
V2	52.5 g diatomite /7 sqm (administered grams / repetition)
V3	105 g diatomite /7 sqm (administered grams / repetition)
V4	210 g diatomite /7 sqm (administered grams / repetition)

Soil samples were taken from a depth of 0-30 cm, shortly after application in 2019, and one year after the application of diatomaceous earth in 2020, in order to verify the effect of its long-term application

RESULTS

In order to determine the degree of soil quality impairment, following the application of eco-sustainable technology for the prevention and reduction of diseases and pests, where diatomaceous earth was used as an insecticide, the main chemical indicators of the soil were analyzed.

In order to establish the effect of diatomite was chosen the version (V1), which is the control sample, and where the diatomite was not administered, and the version (V4) where the maximum amount was applied, respectively 210 g /7 sqm. The following table presents the results of the main chemical indicators analyzed (Table 2).

Table 2. Chemical analysis

	2020		2019		Chemical indicators
ONION	V1(R3)	V4(R3)	V1(R4)	V4(R4)	Version
	8,59/24,5	8,55/24,1	7,98	8,00	pH (units pH/°C)
	233	192,8	154	150	Conductivity (µS/cm)
	0,094	0,093	0,100	0,102	Total phosphorus (%)
	0,14	0,14	0,18	0,16	Total nitrogen (%)
	2,37	2,45	2,69	2,57	Humus (%)
	1,38	1,42	1,56	1,49	Organic carbon (%)
PEPPER	V1(R4)	V4(R4)	V1(R4)	V4(R4)	Version
	8,52/24,3	8,31/24,1	7,9	7,96	pH (units pH/°C)
	223	299	164	183	Conductivity (µS/cm)
	0,106	0,102	0,101	0,092	Total phosphorus (%)
	0,15	0,15	0,17	0,13	Total nitrogen (%)
	2,46	2,51	2,41	2,47	Humus (%)
	1,40	1,46	1,40	1,43	Organic carbon (%)
BEANS	V1(R2)	V4(R2)	V1(R4)	V4(R4)	Version
	8,44/24,4	8,49/24,9	7,99	7,90	pH (units pH/°C)
	212	227	168	140	Conductivity (µS/cm)
	0,096	0,094	0,102	0,108	Total phosphorus (%)
	0,14	0,14	0,17	0,17	Total nitrogen (%)
	2,25	2,52	2,77	2,97	Humus (%)
	1,30	1,46	1,61	1,72	Organic carbon (%)

In the case of these three crops, can be observed an increase in the soil reaction value (pH), in both versions from 2020, but it falls into the same category, namely alkaline pH. This

cannot be considered to be due to the application of diatomite, as the increase was recorded in both versions.

Analyzing the total nitrogen content, a decrease can be observed, except for the pepper culture, where diatomite was administered, and the phosphorus level increased from a small range (0.10 - 0.14 N%) to a medium one (0.14 - 0.27 N%).

In the case of the onion field, the amount of nitrogen in the soil has decreased from a medium to a small content. The phosphorus content is present in appropriate amount for crops grown in field, the differences between 2019 and 2020, consisted in small decreases, but not significant, to affect soil quality. An imported element can be observed in the case of onion and bean cultivation in 2019, when the amount of phosphorus in the soil was higher on the crop where diatomite was applied, and in 2020 in the same soil the phosphorus content decreased, thus we can conclude that diatomite brings a benefit to the soil, being rich in nutrients and phosphorus.

The proportion of humus in the soil is an average one, with over 2% content. In the case of this indicator, also has been a decrease from one year to another, except for pepper cultivation where there has been a slight increase. In this case, the application of diatomite to the onion and bean crop contributed to the.

In 2020, the results indicated a significant electrical conductivity increase for all three crops, but these values are within the normal values for agricultural soil, the value of salts falling within the "non-salty" category (Malik et al., 2018).

For the 2019 soil samples, physical analyzes were performed, and the density and particle size distribution were determined with standard laboratory tests (Dumitru et. Al, 2019). From a physical point of view, the soil from SCDL Buzau has a medium to sandy texture (Laslo et al., 2019). By analyzing the values of the organic carbon content, it falls into the category of soil with an average carbon content (1.17-2.32%) (Rus, 2013).

Analyzing the eco-sustainable technology for the prevention and reduction of diseases and pests, using diatomite as an ecological insecticide, it was found that it does not affect soil quality, and in some situations contributes to improve it, from a chemical point of view.

CONCLUSIONS

Eco-technology for reducing and preventing diseases and pests in vegetable crops, uses diatomite as an ecological insecticide. Within the scope of this research, has been used diatomite from the Pătârlagele quarry, due to the high insecticidal effect.

The main soil chemical indicators were analyzed (pH, humus, organic carbon, conductivity, total nitrogen, total phosphorus), in order to highlight the effect of applying diatomite on the soil, both shortly after application and for a long period, more precisely about a year. The results of the analyses showed that solid diatomite used in the maximum amount of 210 g / 7 sqm, does not affect soil quality, and in some situations contributes to improve it, from a chemical point of view.

Acknowledgement

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FORGE WELDING OF BIMETALIC AXE

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Abstract: Today, we used to say that bimetalic products belong to the new era, produced only by a high- tech procedure. Here will be shown one product manufactured on a really primitive but successful way, made from one structural and tool steel. Joining of two different steels here is explained by forge welding. For the body of an axe commonly is used a kind of softer structural steel, about 0,30%C, while for a cutting edge must be used an insert from high carbon tool steel with more than 0,70%C. The practice of this kind of welding needs very skill forgers. Another disadvantages of this technology is in very low productivity. But, instead of these, the forging and forge welding were applied over centuries ago in producing very qualitative tools and arms (*cold weapons*). The skills and technical demands from this kind of producing are not fully known to the contemporary welders or engineers, especially the benefits from a protective atmosphere that charcoal could provide. In fact, forge welding does not need an electrical current (direct or alternate), induction heating up, laser beam, shielding atmosphere (argon or vacuum), etc., but only a wood charcoal, coke or gas fuel, and many practical experiences in temperature determination during heating up, handy strikes and speedy movements. The using of an appropriate flux also is needed. At the end, some knowledge and experience are desired in heat treating of tool or an axe, it means in quenching and tempering. After forge welding is done, very qualitative joint is achieved, first of all it means the fusion and interface lines, which here are approved by metallographic view.

Keywords: tool, axe, low- and high carbon steel, forge welding

INTRODUCTION - HISTORICAL BACKGROUND ON FORGING

Forging is undoubtedly the oldest deformation process. At the beginning, the noble metals as silver and gold were deformed, firstly by forging and further by drawing and/or rolling. Very few works were dedicated to the forge welding on the engineering manner, even today.

Forging welding was used in past for producing the wheels for vagons: the steel strip is heated up, bended and forge welded into ring shape, then is mounted on a circular wooden wheel structure. The heat affected zone is present in almost of contemporary welding techniques, but it could be said to be unknown term in forge welding.

Forging and generally fire have taken a very important role in almost civilizations all over the world. One of the most known gods is Hephestus, from ancient Greek, Figure 1a).

Figure 1. Hephestus - ancient Greek's god of forging & fire a) and forging fire b)

The principle of forging in its nature is very simple: the shaping of metal is provided by using localized forces, almost. Traditionally, forging is performing by using hammer and anvil, earlier is provided by hand strikes. The most valuable pieces from industry and elsewhere (hand tools, jewelry, etc.) still are producing by forging, because they are stronger than casted and machined piece.

FORGING FIRE

Forging fire has a pretty long history. Small number of steels may be forged in the cold state; it means that almost of steels should be forged in the warm or hot state. Heating up was provided by using a forging fire by using a charcoal. In nowadays the heating up is rather provided by using a coke or gas fuel (propane or propane mix) for easier achieving the high temperatures. The most important advantage of forging fire lies in ability for producing much desired reduction atmosphere, for preventing the decarburization of steel.

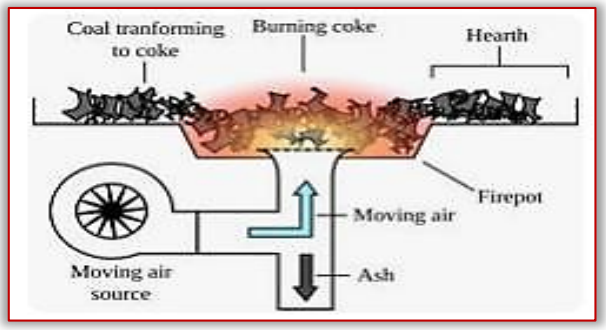

Figure 2. Partially heated up end of a part to be forged a) and air supplying into forging fire b)

The disadvantages of using a forging fire are in limited length (or volume) of heated part, Figure 2a), and at low productivity for the contemporary sense of production. The equipment for forging fire is pretty simple, Figure 2b).
The vertical cross section through the forging fire is given in Figure 2b). Charcoal was used over millennia but now the coke and or propane/butane gas mixture are more desired for heating up for forging. Water power was introduced into iron production in the XII century, allowing the use of large hammers in forging processes.
Pretty long time the forging process (—drop forging) is provided when hammer (raised and dropped by hand) strikes and deforms the workpiece – it is so called open-die forging. For these operations is needed a well skillful operator. It also valids for forge welding.

PRINCIPLE OF FORGE WELDING

In forge welding the pressure and temperature have play crucial role. By using only a pressure many welding methods were developed, from those the most important are:

- friction welding,
- ultrasound welding,
- explosion welding and
- stir welding.

Today, the pressure welding is applying in producing some of avio- and auto pieces, thanks to the high quality of those technologies. The real problem in forge welding is limited dimensions.
If the forging force is great than is needed the lower temperature for heating up. In past, the temperature of heating up of a piece is determined only by naked eye, as bright yellow or white. Those temperatures are about 0,9Ts, (between 1200-1300^{0}C), as approved by contemporary methods of temperature measurement. Sketch of three principal stages during forge welding of an axe is shown in Figure 3.

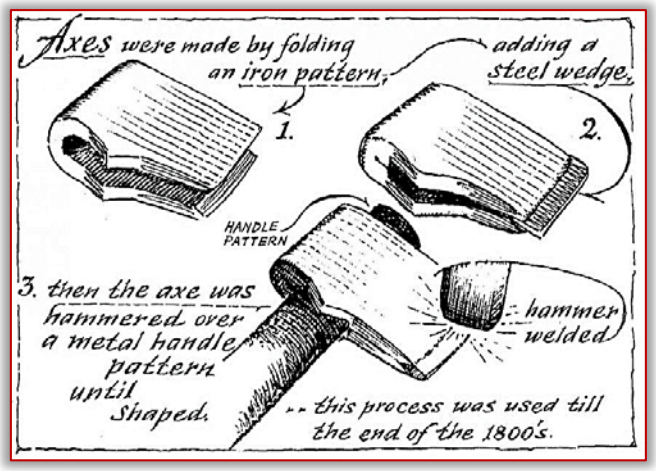

Figure 3. Principal operations in forge welding of an axe with insert

After the piece, from a moderate carbon steel (≈0,30%C), is heated up to desired temperature, next operation is the folding (1) at Figure 3. The second operation (2) is adding the insert from high carbon steel (≥0,70%C), position (2). Then, the juncture is ready to forge (3).
In industrial practice is well known the impossibility of welding when the high carbon steel is used. The critical moment in producing the axe with an insert is the moment of welding, two views are shown in Figure 4. The forge welding starts when the pieces are heated up near to white color, it means to the pretty high temperature, say about 1300^{0}C, Figure 4a). Overheating is not allowed, from the metallurgical reasons. After few strikes the pieces are going to cooling down, as could be see from Figure 4b). In that case, it means that the forging procedure must be stopped and reheating is needed. The number of reheatings is not determined in advance, it depends from the kind of used steels, dimensions of forged parts (here an axe), further from the used energent (fuel), and however from the skillfull of blacksmith.
The process of forge welding must be stopped after pieces are cooled, it could be noticed by changing the color, say at orange color, Figure 4b).

Figure 4. Critical moments in hand forge welding:
a) beginning (bright color) and b) at the end (pieces were cooled to orange color)

In situation as in Figure 4b) the reheating of cooled pieces bust be provide.

RESULTS AND DISCUSSION

— Microstructure of forge welded joint

The microstructural review is one reliable method for observation the state at the weld zone. Many thin cracks in metallic materials could not be registered by ultrasound or gamma-ray techniques, but are available by microscopic monitoring. The presence of eventually imperfections or nonmetallic inclusions will be seen in metallographic view. Microstructures of both materials, low and high carbon steel after forge welding is done, are shown in Figure 5.

Figure 5. Microstructures of two steels obtained in forge welding: left – low carbon and right – high carbon steel [11]

The existence of two different materiaal clearly is visible. The binding zone is homogenous and free of microcracks, those were the aim of welding.

Figure 6. Some steps in hand forging/forge welding of an axe with insert of high carbon steel

After the forge welding is finished, the axe further is heat treated (quenched and tempered) and at the end of processing the edge is sharpened by grinding, sometimes polishing. Picture of some steps in producing an axe is shown in Figure 6.

Forging and forge welding require really simple tools: hammer, anvil and forge fire, it means without electrical current, plasma, laser, shielding gas/mixture, etc. Forge welding is available by hand strikes, but in last centuries for this purpose are used hydraulic or air hammers.

Forge welding is, however, based on forging technology. The pieces to be joined must be heated up to the higher temperatures than for ordinary forging. For successful forge welding the pieces must be heated up to $0,9T_s$. The strong strikes lowering the temperature. The forge welding must be done by pretty fast strikes, sometimes with two blacksmiths if needed, with synchronized moves. Even though the high temperature is applied; the strong strikes enable obtaining the fine grain structure of deformed metal.

For the body of an axe commonly is used a kind of softer structural steel, about 0,30%C, while for the cutting edge must be used an insert from high carbon tool, steel with more than 0,70%C. The greater content of carbon is needed for achieving the great hardness and strength at the cutting edge after quenching and tempering.

Today, the handy forging is rarely in using, because for its providing are needed both great skillfull and fast moves, so the production periode becomes long. It is clear that many welding methods with using an electric current (on different ways) are faster than handy forging techniques, but the forging usually gives better properties of finished product, also in aesthetic appearance, than mentioned welded products.

CONCLUSION

The axe from the ancient times was an useful tool for man. Pretty early, such man achieved to produce this very qualitative product, even from two different materials/steels. The welding of diversed steels, if one is low and another high carbon steel, represents the problem even today. On the empirical way, the man discovered the production schedule of forging and forge welding, which are approved by contemporary methods of investigations. However, this principle is also available for production of very qualitative goods, as for chains, etc. Handy forging does not require expenses for machinery, tooling and high-temperature furnaces, but the workers must be very skilled. By inserting a high carbon steel at the cutting edge, in a body of an axe from a low carbon steel, is achieved very good connection between these different materials, as could be seen from metallographic view. The microstructures of this forge weld shows pretty good adhesion of two kinds of steels in the fusion zone.

Note:

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POSITION CONTROL OF A SOLENOID BASED LINEARLY MOVABLE ARMATURE SYSTEM USING ROBUST CONTROL TECHNIQUE

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Abstract: In this paper, a solenoid based linearly movable armature system is designed using robust control theory in order to improve the performance of the system. Reference track method is the best performance analysis for position control systems. Among the robust controllers, H infinity mixed-sensitivity and Mixed H 2 /H∞ with Regional Pole Placement Controllers are used to improve the performance of the system. Comparison of the proposed controllers for tracking a reference displacement signals (step and sine wave) and a promising simulation result have been obtained.
Keywords: Solenoid, Robust control theory, H infinity mixed-sensitivity, Mixed H 2 /H∞

INTRODUCTION

A solenoid valve is an electromechanically operated valve. Solenoid valves fluctuate within the traits of the electric contemporary they use, the energy of the magnetic area they generate, the mechanism they use to alter the fluid, and the kind and traits of fluid they control. The mechanism varies from linear action, plunger-kind actuators to pivoted-armature actuators and rocker actuators. The valve can use a -port layout to regulate a glide or use a 3 or more port design to switch flows between ports.

Multiple solenoid valves may be positioned collectively on a manifold. Solenoid valves are the most frequently used manipulate factors in fluidics. Their duties are to close off, launch, dose, distribute or mix fluids. They are discovered in many utility areas. Solenoids offer fast and safe switching, excessive reliability, lengthy carrier life, desirable medium compatibility of the substances used, low manipulate strength and compact design. In a few solenoid valves the solenoid acts at once on the fundamental valve. Others use a small, complete solenoid valve, called a pilot, to actuate a larger valve. While the 2d type is genuinely a solenoid valve mixed with a pneumatically actuated valve, they may be offered and packaged as a unmarried unit referred to as a solenoid valve.

Piloted valves require a lot less energy to control, however they are highly slower. Piloted solenoids normally want full power always to open and live open, wherein a direct acting solenoid may also simplest want full energy for a quick period of time to open it, and handiest low power to maintain it. In this paper, solenoid based linearly movable armature system is designed and controlled using robust control technique and the performance of the system is analyzed based on track a reference approach.

MATHEMATICAL MODEL

The dynamics of the solenoid based linearly movable armature system is shown in Figure 1.

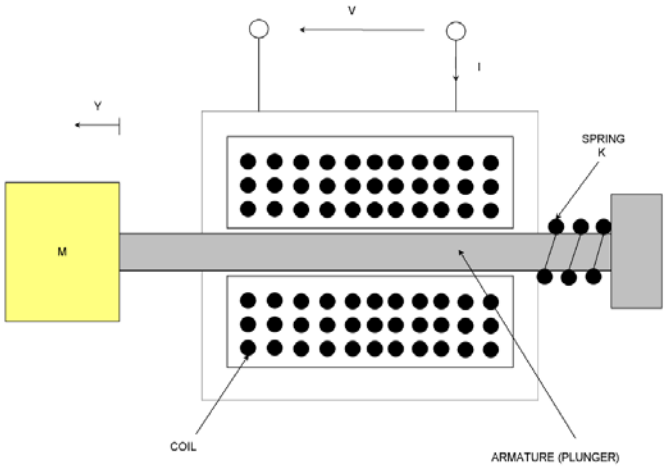

Figure 1. Solenoid based linearly movable armature system

The magnetic flux linkage can be described by

$$\Psi = \Psi_0 + L_d I + L_C Y \qquad (1)$$

where

Ψ_0 Initial magnetic flux linkage

L_d Differential inductance

L_C Coil inductance

The magnet circuit equation will be

$$V(t) = RI(t) + L_d \frac{dI(t)}{dt} + L_C \frac{dY}{dt} \qquad (2)$$

The force exerted by the magnetic circuit to the mass become

$$F_m(t) = L_C I(t) \qquad (3)$$

The spring-mass system model equation is given by

$$F_m(t) = M\ddot{Y}(t) + b\dot{Y}(t) + KY(t) \qquad (4)$$

Upon selecting the voltage $V(t)$ as the variable to be manipulated and the linear displacement as the variable to be controlled, substituting Equation (3) in to Equation (4) and in to Equation (2) and taking the Laplace transform results the transfer function

$$G(s)=\frac{Y(s)}{V(s)}=\frac{\frac{L_C}{KR}}{\frac{ML_d}{KR}s^3+\left(\frac{M}{K}+\frac{bL_d}{KR}\right)s^2+\left(\frac{b}{K}+\frac{L_d}{R}+\frac{L_C^{\,2}}{KR}\right)s+1} \quad (5)$$

The system parameters are shown in Table 1 below.

Table 1. System parameters

No	Parameters	Symbols	Value
1	Mass of the body	M	3 Kg
2	Resistance of the coil	R	10 ohm
3	Differential inductance	L_d	5 H
4	Coil inductance	L_C	10 H
5	Damping friction	b	3 N-s/m
6	Spring stiffness	K	6 N/m

The transfer function of the system numerically become

$$G(s)=\frac{Y(s)}{V(s)}=\frac{0.1667}{0.25s^3+0.75s^2+2.667s+1}$$

The state space model become

$$\dot{x}=\begin{pmatrix}-3 & -10.667 & -4\\ 1 & 0 & 0\\ 0 & 1 & 0\end{pmatrix}x+\begin{pmatrix}1\\0\\0\end{pmatrix}u$$

$$y=\begin{pmatrix}0 & 0 & 0.6667\end{pmatrix}$$

PROPOSED CONTROLLERS DESIGN

— H infinity Mixed-Sensitivity Controller Design

H infinity mixed-sensitivity evaluates a controller K that minimizes the H infinity norm of the closed-loop transfer function the mixed weighted sensitivity

$$T_{y1u1}\triangleq\begin{bmatrix}W_1S\\W_2R\\W_3T\end{bmatrix} \quad (6)$$

where S and T are referred to as the sensitivity and complementary sensitivity, respectively. R measures the manipulate effort. The again controller K is such that S, R, and T fulfill the following loop-shaping inequalities:

$$\bar{\sigma}(S(j\omega))\le\gamma\underline{\sigma}(W_1^{-1}(j\omega))$$

$$\bar{\sigma}(R(j\omega))\le\gamma\underline{\sigma}(W_2^{-1}(j\omega))$$

$$\bar{\sigma}(T(j\omega))\le\gamma\underline{\sigma}(W_3^{-1}(j\omega))$$

where γ = GAM. Thus, the inverses of W1 and W3 determine the shapes of sensitivity S and complementary sensitivity T. Typically, you choose a W1 this is large within the desired manipulate bandwidth to acquire accurate disturbance attenuation (i.e., performance). Similarly, you commonly pick a W3 that is large outside the manage bandwidth, which facilitates to make sure precise stability margin. The solenoid based linearly movable armature system with H infinity mixed sensitivity controller block diagram is shown in Figure 2 below.

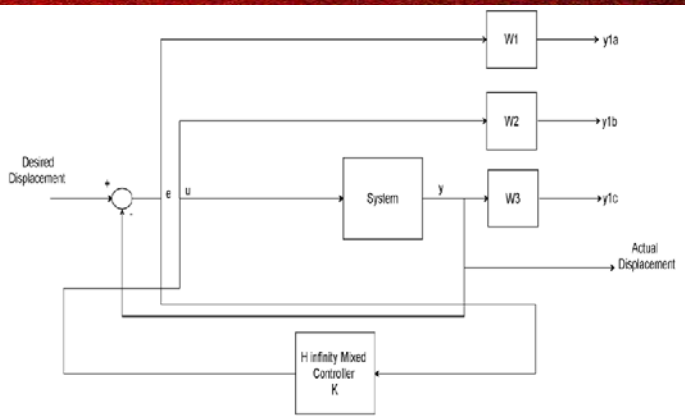

Figure 2. Solenoid based linearly movable armature system with H infinity mixed sensitivity controller block diagram

Here in this system we choose the three weighting functions W1, W2 and W3 as

$$W_1=\frac{1}{s+12}$$

$$W_2=\frac{1}{s+11}$$

$$W_3=\frac{1}{s+8}$$

The Controller transfer function is

$$K_{mixed}=10\frac{s^2+107s+70.5}{s^2+95s+1}$$

— Mixed H 2 /H∞ with Regional Pole Placement Controller design

The mixed H 2 /H∞ control hassle is to reduce the H 2 norm of overall state remarks gains K such that what also satisfies the H∞ norm constraint. Mixed H 2 /H ∞ synthesis with regional pole placement is one example of multi-objective layout addressed by means of the LMI. The manipulate problem is sketched in Figure 3. The output channel z is associated with the H ∞ overall performance at the same time as the channel z 2 is associated with the H 2 overall performance.

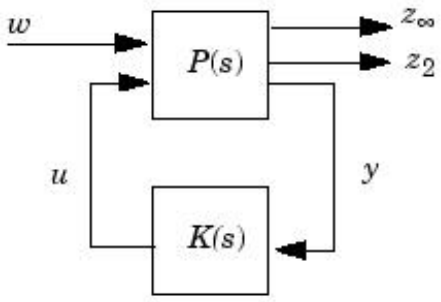

Figure 3. Mixed H 2 /H∞ configuration

The LMI region for the pole placement is determined the use of the command lmireg and we select the 1/2 plane region and the output region is

$$2.0000+1.0000i \text{ and } 1.0000+0.0000i$$

And we use this region for the mixed H 2 /H∞ controller synthesis.

The transfer function of the controller is

$$K_{mixed}=12\frac{s^2+118s+100}{s^2+100s+1}$$

RESULT AND DISCUSSION

In this section, the Simulink model design and simulation of the solenoid based linearly movable armature system using H infinity mixed-sensitivity and Mixed H 2 /H∞ with regional pole placement controllers by comparing the two proposed controllers for tracking the step and sine wave references displacement signals.

— **Comparison of the proposed controllers for tracking the step reference displacement**

The Simulink model of the solenoid based linearly movable armature system using H infinity mixed-sensitivity and mixed H 2 /H∞ with regional pole placement controllers for tracking the step references displacement signal is shown in Figure 4 below.

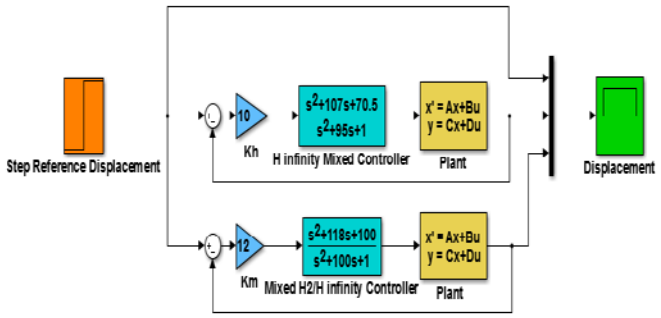

Figure 4. Simulink model of the solenoid based linearly movable armature system using H infinity mixed-sensitivity and mixed H 2 /H∞ with regional pole placement controllers for tracking the step references displacement signal

The solenoid based linearly movable armature system performance for the proposed controllers using a step reference (step change from 0 to 6 m) of the displacement output simulation is shown in Figure 5 below.

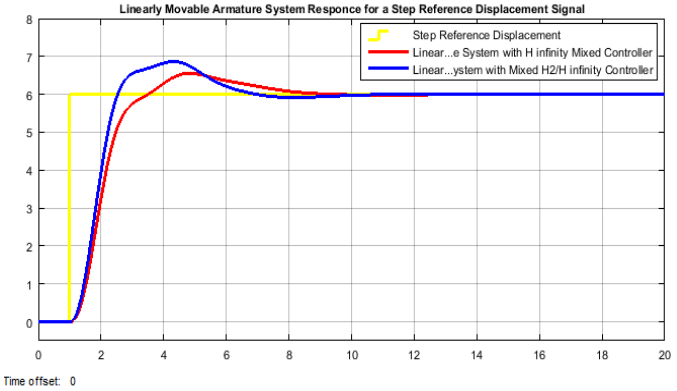

Figure 5. Simulation result for a step reference input

The data of the rise time, percentage overshoot, settling time and peak value is shown in Table 1.

Table 1. Step response data

No	Performance Data	H infinity mixed-sensitivity	Mixed H 2 /H∞
1	Rise time	2 sec	1.9 sec
2	Per. overshoot	8.33 %	15 %
3	Settling time	10 sec	13 sec
4	Peak value	6.9 m	65 m

— **Comparison of the proposed controllers for tracking the Sine Wave speed reference**

The Simulink model of the solenoid based linearly movable armature system using H infinity mixed-sensitivity and mixed H 2 /H∞ with regional pole placement controllers for tracking the sine wave references displacement signal is shown in Figure 6 below.

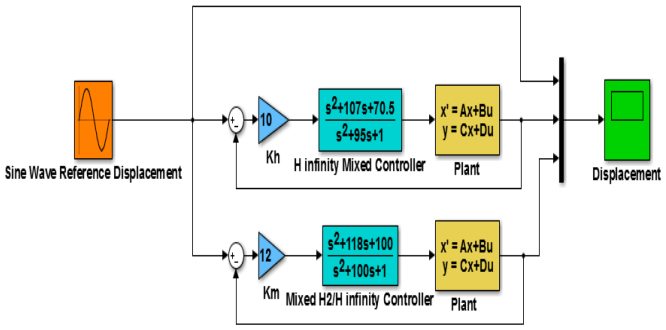

Figure 6. Simulink model of the solenoid based linearly movable armature system using H infinity mixed-sensitivity and mixed H 2 /H∞ with regional pole placement controllers for tracking the sine wave references displacement signal

The solenoid based linearly movable armature system performance for the proposed controllers using a sine wave reference (displacement moving in the forward and reverse with 6 m) of the displacement output simulation is shown in Figure 7 below.

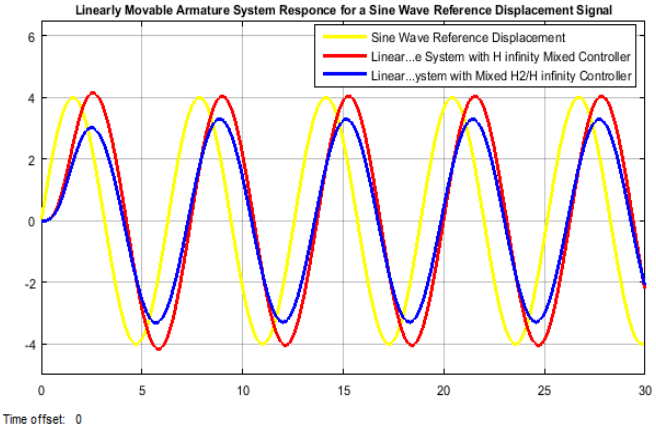

Figure 7. Simulation result for a sine wave reference input

The simulation result shows that the solenoid based linearly movable armature system with H infinity mixed-sensitivity controller track the reference speed better than the solenoid based linearly movable armature system with mixed H 2 /H∞ with regional pole placement controller.

CONCLUSIONS

In this paper, modelling, design and control of the solenoid based linearly movable armature system using H infinity mixed-sensitivity and mixed H 2 /H∞ with regional pole placement controllers have been successfully done with the aid of Matlab/Simulink Toolbox. The proposed controllers improved the performance of the position controlling mechanism and comparison of the system with the two controllers for tracking a reference displacement signals (step and sine wave) is done. The solenoid based linearly movable armature system using H infinity mixed-sensitivity

controller has better percentage overshoot and settling time in the step reference displacement signal and better tracking the input signal in the sine wave reference displacement signal than the solenoid based linearly movable armature system with mixed H 2 /H∞ with regional pole placement controller.

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CONTRIBUTIONS TO THE GENERATION OF PRECESSIONAL GEAR TEETH BY PLASTIC DEFORMATION

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Abstract: Gears are machine parts that occupy an essential place in the operation of various mechanical constructions. The execution of the gears at a high quality level and at a low cost, puts in front of the specialist multiple problems. From the design stage onwards, the specialist must take certain measures to achieve a high reliability of the designed gears. Starting from the correct choice of materials, the designer must adopt constructive solutions of the gears that can be made in the most economical conditions. The cost of manufacturing gears decreases significantly when combining the operations of generating teeth and changing the properties of the surface layer of the teeth. One of these new methods of manufacturing the gears of the precessional gear, in which the formation of the profile of the teeth is not done by cutting, is to obtain the teeth by plastic deformation by rolling.
Keywords: plastic deformation, precessional gear, precessional multiplier, satellite

INTRODUCTION

The gear material is chosen according to the conditions in which the gear works. From this point of view, it is necessary to know well the forces that require the gear, the peripheral speed, the character of the demands (constant or with shocks), the operating conditions without noise, the environmental conditions, etc.

For the processing of gears, very different materials are used, such as: steels, cast iron, bronzes, brass, plastics, etc.

Depending on requests, it is recommended:

- for gears with low loads and peripheral speeds, between 0.5 and 2 m / s, it is recommended to use non-ferrous alloys based on zinc or copper, thermoplastic materials and ferrous alloys: steel and cast iron;
- for gears with loads and average peripheral speeds, between 2 and 8 m / s, non-alloy or low-alloy semi-hard steels are recommended, as well as cast iron. These wheels are found in large gearboxes, in some lifting and transporting machines, in agricultural machines, mining combines, etc.
- for heavy-duty gears with high peripheral speeds, between 8 and 16 m/s, with high loads on the tooth, with shocks in operation, alloy and non-alloy steels are recommended. In cases of particularly high stresses, it is recommended to use high alloy steels, cementation, Cr-Ni, Cr-Ni-Mn, Cr-Ni-W, etc.

These wheels are found in gearboxes from machine tools, ships, vehicles, airplanes, turbines, etc.

Table 1 shows the recommended steel brands for gears. In order to replace the expensive and deficient materials, metallic powders of cheaper materials are used, the semi-finished products being obtained through powder metallurgy.

Powders of pure metals, chemical compounds of metals or metal mixtures are used, which by pressing and sintering ensure the formation of workpiece products for gears (Bostan I, 2019; Bostan I, 2018; Bostan I, 2016; Grămescu T., et all, 2000; Grămescu T., et all, 1993).

Table (1). Materials used in the construction of gears and their mechanical properties

The kind of material	Mark	Recommendations for use
General purpose steels for construction	OL 50 OL 60 OL 70	Very low load gears at low peripheral speeds. Very low load gears at moderate peripheral speeds
Alloy steels for heat treatment, intended for machine building	20 MoNi 35 21 TiMnCr 12 TiMnCr 12	Heavy-duty gears at high peripheral speeds and shock loads
Cast steel in pieces	OT 40-3 OT 50-3 OT 60-3	Large gears, very little required

ARGUMENTATION FOR CHOOSING THE DIMENSIONS OF THE WORKPIECE PRODUCT

The profile of the teeth of the central wheels of the precessional gear is variable depending on the values of the angle of the bevel axoid δ, the taper angle of the rollers β, the nutation angle θ, the number of teeth of the gears Z_1 and the number of rollers of the satellite Z_2, and the correlation between them. Depending on these parameters, the height of the teeth will be different, which will influence the height of the workpiece product that will be subjected to plastic deformation (Irani M., et al, 2014; Malcoci I. et al, 2019; Trifan N., 2014; Trifan N., 2016).

The correct choice of the dimensions of the semi-finished product is one of the main problems, the solution of which depends on the reduction of material and energy consumption, as well as the quality of the wheels obtained by plastic deformation. Referring to the manufacture of conical wheels with convex-concave profile of the teeth by knurling, the height of the tooth of the workpiece product is determined by the condition of equal volume of metal moving from the gaps between the teeth to their tip during plastic deformation by rolling (figure 1).

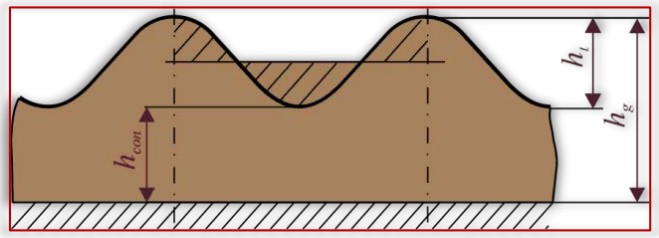


Figure 1. Schematic for determining the height of the gear

$$h_g = h_t + h_{con} \quad (1)$$

were h_{con} is the constructive height of the gear, [mm]; h_t - tooth height in normal section, [mm]; h_g - gear height, [mm].

If the workpiece product has been previously deformed and has no porosity, being further subjected to cold deformation, by the accumulation of dislocations, vacancies and microcracks, its volume increases. If the semi-finished product of the gear has been previously deformed hot and another hot deformation follows, the variation of its volume is negligible. In this case it can be said that the volume of the workpiece product in the deformation process remains constant.

In this case it can be said that the volume of the workpiece product in the deformation process remains constant.

Thus, based on the constancy of the volume, for the annular cylindrical workpiece product the volume of material can be written:

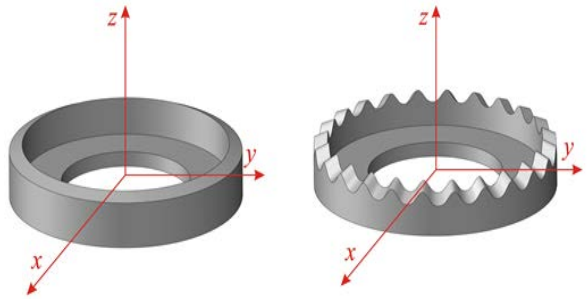
$$V_{wp} = \pi h_{hw} \cdot [(R_{out})^2 - (R_{ins})^2] \quad (2)$$

were: h_{hw} is height of the workpiece product subjected to plastic deformation, [mm];

R_{out} - the outer conical radius of the workpiece, [mm];

R_{ins} - inside conical radius of the workpiece, [mm].

It is necessary to specify that according to relation (3) the volume of material necessary to form Z teeth of the gear from the precession gear is determined (figure 2 (a)).



a) b)

Figure 2. Observance of the law of constant volume at plastic deformation of the teeth in the precessional gear by plastic deformation: a) initial workpiece product; b) plastic deformed gear

The volume of material for forming a gear tooth from the precessional gear (figure 2 (b)) will be determined from the relation:

$$V_t = \frac{1}{3} \cdot b_w \cdot (S_{ins} + \sqrt{S_{out} \cdot S_{ins}} + S_{ins}) \quad (3)$$

where: b_w is the width of the tooth, [mm];

S_{out} – the area of the outer surface of the tooth, [mm^2];

S_{ins} – the area of the inside surface of the tooth, [mm^2].

Based on the computer model of the plastic deformation device of the gears, the working strokes (vertical feedrate of the table), the speed of the main shaft of the machine tool were analyzed to ensure the deformation speed prescribed by the specialized literature.

The increase of the tooth height depending on the vertical advance of the plastic deformation node, in which the plastic deformation rollers are fixed, was determined according to the relation:

$$\Delta h_{pc} = s_{pc} \cdot \cos(\delta + \beta + \theta) \quad (4)$$

where: s_{pc} is the advance of the plastic deformation node to a precession cycle, mm;

δ - the angle of the conical axoid, [º];

β - angle of conicity of the rollers, [º];

θ - the angle of nutation, [º].

CHOOSING THE OPTIMAL PROFILE OF THE TEETH

Certain kinematic structures of precessional planetary transmissions at the correct choice of the basic geometric parameters of the gear can operate efficiently in multiplication mode- figure 3 (Bostan I., 2019; Bostan I., 2019; Ciobanu R., 2014).

Kinematically, the precessional gear represents a Hooke joint. This imposes some conditions on the generation of non-standard profile teeth of the central wheel. From the kinematic analysis performed, some conditions regarding the optimal design of the precessional multipliers are highlighted.

They can be divided into two distinct groups:

- conditions related to the reasoned choice of the tooth profile;
- conditions related to the reasoned choice of the structural scheme of the multiplier and of the type of the connection mechanism (coupling).

The choice of the optimal profile of the teeth in the precessional gear of the multiplier must comply with the following conditions:

- maximum resistance condition - the ability to transmit maximum loads in small dimensions;
- the condition of avoiding self-locking;
- the efficiency condition in terms of minimizing energy losses in the gear;
- the condition of observing the uniformity of the rotational movement of the driven element $\omega_{const.}$ by compensating for the schema error.

The maximum resistance condition is based on self-excluding aspects. The tooth must be as massive as possible to be able to transmit large loads, but at the same time, to have a minimum height and extended profile to ensure a maximum engagement angle, which creates optimal

conditions for the transformation of the rotational movement of the the precession moving element of the satellite in multiplication mode. In this case, the designer must ensure the optimization of the choice of the profile of the teeth in order to consider to the maximum the two conditions that self-exclude.

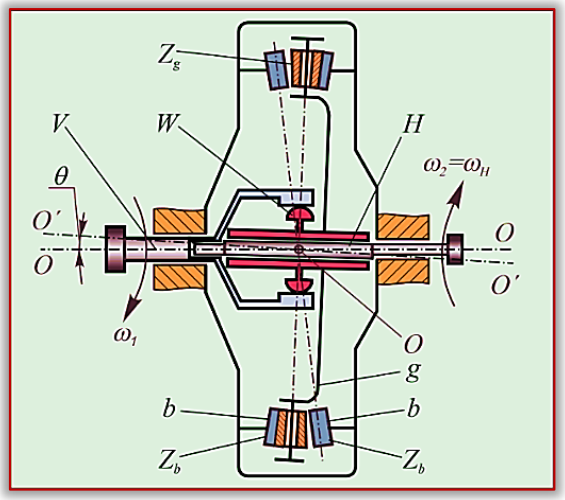


Figure 3. K-H-V type kinematic structure with two central wheels

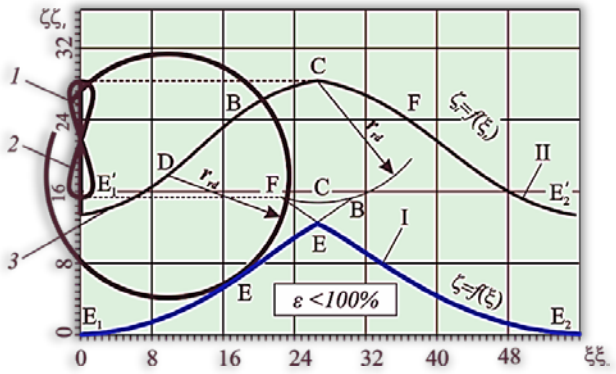


Figure 4. Curves of the trajectory of the movement of the "tooth-roller" contact point

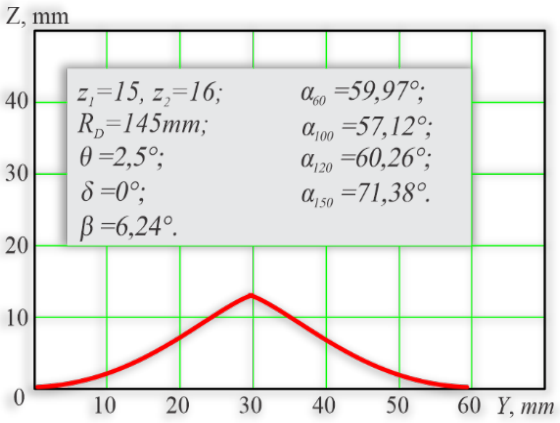
The angle of nutation angle θ (inclination of the crank H) must be as large as possible to ensure a higher load-bearing capacity (a torque applied to the larger conductive element T_{hi}) and, at the same time, as small as possible to ensure minimum height and extended profile of the teeth.

Since the precessional gear is a Hooke joint, which generates the so-called schematic error, this error must be compensated. In the case of the articulated connection of the satellite with the housing, the trajectory of the movement of the contact point E "tooth-roller" should represent a straight line (line I, figure 4). In reality, due to the existence of the scheme error, the trajectory of the movement of the contact point represents a closed octoidal curve (curve 2, figure 4).

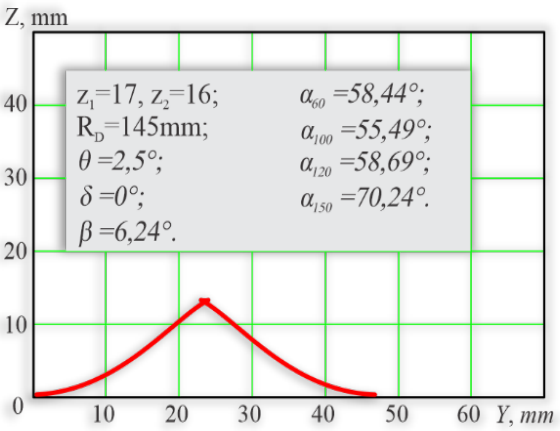
In the case of the articulated connection of the satellite with the driving element, the trajectory of the contact point represents a curve, on which the octoidal curve of the scheme error is superimposed (curve 3, figure 4). This speaks to the need to change the profile of the center wheel teeth at the stage of their generation to compensate for this schematic error.

Obtaining the optimal operating parameters of the precessional multipliers in addition to the basic parameters of the precessional gear is also influenced by another group of conditions related to the reasoned choice of the structural scheme of the multiplier and the type of connection mechanism (coupling)

Based on the resistance calculations performed of the chosen tooth profile, using the computerized principle of creating the toothed solid based on the parametric equations describing the tooth profile [6, 7, 8], the profiles of the teeth of the central wheels were obtained (figure 5 (a, b)) and generated the toothed crown of the wheel and subsequently created the 3D model of the gear (figure 6).



(a)



(b)

Figure 5. Profiles of central wheel teeth with number of teeth: a) z_1=15, z_2=16; b) z_1=17, z_2=16

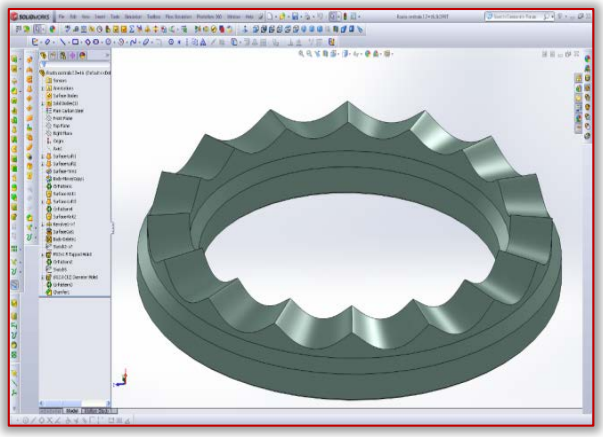


Figure 6. Computerised model of the sun gear

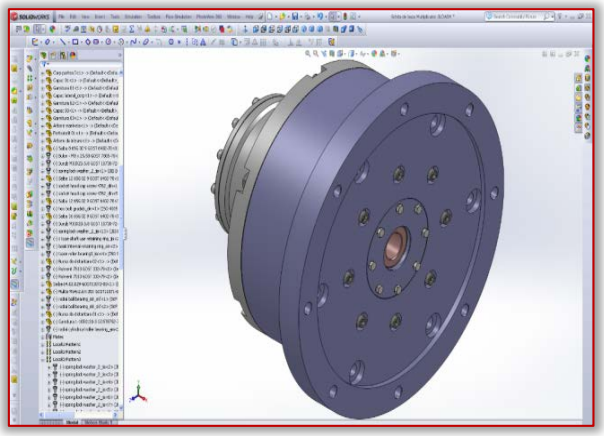


Figure 7. 3D model of the multiplier

DESIGN OF THE EXPERIMENTAL PROTOTYPE OF THE PRECESSIONAL PLANETARY MULTIPLIER K – H – V WITH THE TRANSMISSION RATIO I =-16

When designing any transmission, the designer must ensure to the maximum the satisfaction of the ever-increasing requirements regarding the bearing capacity, compactness, mass and dimensions, low production cost, etc. and, in particular, with respect to the kinematic characteristics, structural compatibility with other aggregates of the machine, etc. Precessional planetary transmissions correspond to these ever-increasing requirements of manufacturers and consumers of reducers and multipliers due to the constructive-kinematic peculiarities presented in the previous chapters.

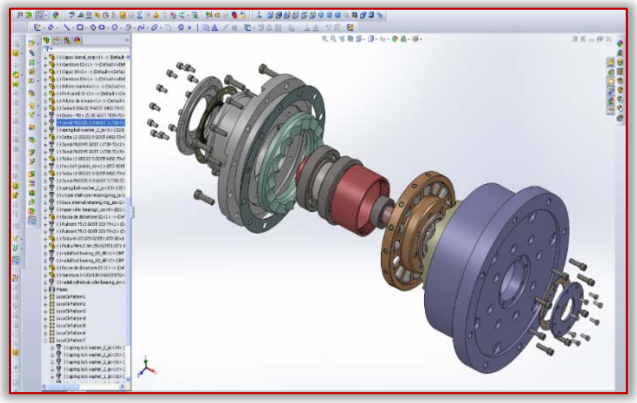


Figure 8. 3D model of the multiplier in assembly perspective

Based on the kinematic structure (figure 3), the 3D model of the processional planetary multiplier presented in general view (figure 7), and in assembly perspective (figure 8) was elaborated. The 3D model of the processional multiplier in the developed state is informative both in terms of structure and assembly process (succession of assembly phases).

RESEARCH OF THE MECHANICAL EFFICIENCY OF THE PRECESSIONAL MULTIPLIER

Experimental research has the primary role of validating theoretical results. The basic energy parameters of a multiplier are the mechanical efficiency, which determines the power losses in the kinematic torques of the multiplier and the starting moment, which in some cases establishes the functionality of the working machine. For example, in the case of the wind turbine, the starting moment of the multiplier determines the operation of the wind turbine at low wind speeds (Bostan I., 2019; Bostan I., 2019; Bostan I., et al, 2019; Ciobanu R., 2014).

The test method comprises the whole complex of operations on the multiplier, in order to assess its efficiency in operation. The tests are performed under normal environmental conditions. For the test of the precessional transmission with reducer and multiplier operation, the open flow test stand of the power flow from the Mechanical Transmission Testing Laboratory of the "Basics of Machine Design" department was used (figure 9, 10).

The mechanical efficiency of the multiplier is determined according to the formula:

$$\eta = \frac{T_2}{T_1 \cdot i}, \qquad (5)$$

where T_1-the torque on the output shaft of the multiplier, [Nm]; T_2 - torque on the multiplier input shaft, [Nm]; i - the transmission ratio of the multiplier.

The values of the torques on the input and output shafts of the multiplier T_1 and T_2 are determined according to the indications of the indicators of the dynamometers 5, 8 using the pricing graphs). The measuring devices of the stand ensure the measurement of the torques T_1 and T_2 with the corresponding accuracy 0,5 ÷ 1%. The stability of the T_1 and T_2 torques at each of their values was investigated within 1-2 hours of uninterrupted tests.

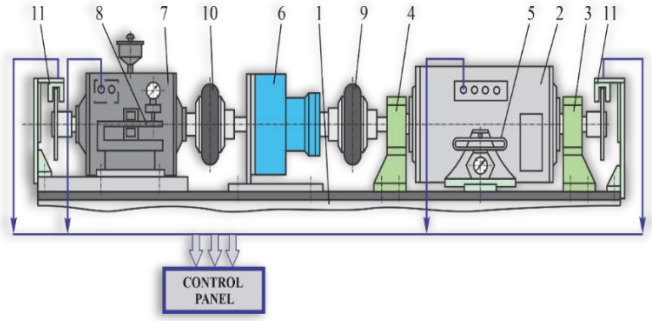


Figure 9. Scheme of the experimental stand for the test of the precessional multiplier:
1 - Rigid stand; 2 - DC electric motor with a power of 8.0 kW; 3, 4 - support; 5 - force dynamometer with indicator; 6 - the precessional reducer; 7 - electromagnetic brake with metal powders; 8 - force dynamometer with indicator; 9,10 - compensating couplings with elastic elements; 11 - speed measuring transducer

Figure 10. Experimental stand for testing the precessional multiplier

The research of the mechanical efficiency depending on the load and the number of revolutions took place from a methodical point of view similar to the case of operation of the transmission in reducer mode, with the modification of the load regime imposed by the stand possibilities: 2 Tn; 0.4 Tn; 0.6 Tn) and 3 speed regimes which represent the speed accepted at the reducer load divided by the transmission ratio.

To ensure the same kinematic regimes, the multiplier was tested at 40min-1 speeds; 50min^{-1}; 60min^{-1}. The gearbox was charged gradually, the load being increased from 0.2 of the nominal torque value to 0.6 Tn, as allowed by the electric motor. Based on the obtained results, the graphs of the mechanical efficiency were constructed depending on the torque for the speeds n = 40min^{-1}; n = 50min^{-1}; n = 60min^{-1} (Figure 11).

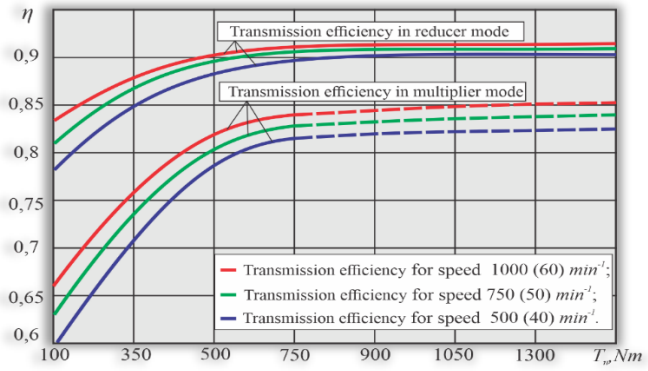


Figure 11. Mechanical efficiency depending on the torque in reducer and multiplier mode

Because the graphs for reducer operation show that from the load of 0.6 Tn the efficiency of the reducer stabilizes, the graphs of the efficiency of the multiplier were continued until the moment of loading 1.0 Tn by similarity. The comparative analysis of the yield graphs in reducer and multiplier mode shows that at low values of the charging moment the multiplier efficiency is much lower than the reducer efficiency. This is explained by the fact that in multiplier mode the starting moment is higher than in reducer mode, measurable with the charging moment at low loads. Then the initial total charging moment is equal to the sum of the charging moment and the starting moment (Bostan I., et al, 2019; Ciobanu R., 2014).

CONCLUSIONS

Based on the optimized conceptual schemes of the precessional gear and the connection mechanisms, the structure of the precessional multiplier K – H – V with two central wheels was developed with a connection mechanism in the form of coupling with teeth or tapered rollers, which ensures high load capacity and total compensation. of the axial force generated in the precessional gear.

It has been established that the mechanical efficiency of the multiplier is determined by the power losses in the tooth-roller gear, in the coupling and the bearings. To reduce the power loss in the coupling, the coupling with tapered rollers has been proposed, in which the sliding friction is replaced by rolling friction.

Experimental research of the precessional multiplier has shown that the mechanical efficiency of the multiplier is relatively high about 85%, but at low loads the yield is low, explained by the fact that at low values the load is commensurable with the starting moment, which in multipliers is higher.

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TECHNO-ECONOMIC CHALLENGES IN IMPLEMENTATION OF SOLAR EQUIPMENT BASED ON A STAND-ALONE MICROGRID IN HILLY TERRAINS OF RURAL INDIA

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Abstract: Rural electrification is an essential requirement for improving the lives of people and improving their image among the international community. To install photovoltaic (PV) panels in isolated regions according to the government plans and regulations, solar-based microgrids are the best solution. However, there are several components required for installing and operating the microgrid, including its location of the microgrid. The present paper made an effort to explore the challenges encountered in installing solar-based microgrids, especially in hilly terrains of rural India. The review highlighted the varied technical difficulties including the stability, reliability, power imbalance, control and operation. Besides, the discussion on the stand-alone models of a microgrid along with its advantages, also been highlighted. Further, government initiatives like subsidies and funding for rural electrification also been presented. As a case study, two microgrids in India, one at Ladakh and one at west Bengal are presented. These case studies bring out the challenges faced during the rural electrification, and strategies adopted to overcome are given for the future scope.
Keywords: rural electrification, solar power, microgrid, hilly terrain, Indian solar power scenario, stand-alone model of microgrid

INTRODUCTION

India has a large population and with third-largest electricity producer in the world. Nonetheless, about 300 million people remain un-electrified especially in the rural regions (Ritchie & Roser. 2019). On the other hand, there is an exorbitant gap between electricity production and the demand for electricity. The use of coal and fossil fuels for electric energy is not only depleting them but also keeps a challenge on environmental concern. Therefore, the use of renewable energy is the only solution to make pollution free(The World Bank. 2019). Although there are several electric energy producing sources, the heart of rural electrification is having the sustainable, non-pollutant environment-friendly and reliable energy. One such prominent and viable sources, especially in the tropical region is the solar energy (Verma et al. 2014).

Solar energy, which is produced by using the techniques of concentrated solar power (CSP) or solar photovoltaic (SPV). The solar energy has the highest capacity to provide electricity, but it has not been utilized to the highest potential. Solar energy-based microgrids are found to be a promising solution to terrain electrification particularly in rural, remote villages and for poor communities. In remote villages of India, there are many constraints in electrifying as these isolated regions are presented with deep forest, deserts, islands, hills and therefore there is a lack of clear approachability and less populated. Besides, laying live conductors in such terrains is challenging due to their topography and distance from the grid (Diesendorf & Elliston. 2018). Providing electricity, with a new grid structure, or through the expansion of existing grid is highly expensive, especially considering the quantity of consumption. Most of the loads would be used for lighting; hence the power demand would be low and transmitting such low power over long distances from the grid will incur high losses for power transaction and distribution. The return on investment would become non-existent and might be negative in most cases, and hence would not be affordable (Sastry. 2003). Rather than expanding the central grid, using a stand-alone model of microgrid would be a promising solution for isolated hilly terrains (Hubble & Ustun. 2018). This paves the way for distributed generation or for the concept of a microgrid which is suitable for both stand-alone and interactive structures (Mothilal Bhagavathy & Pillai. 2018). Although the government has initiated several rural electrification programs at village levels (e.g., Deendayal Upadhyay Gram Jyoti Yojana (DDUGJY), the Rajiv Gandhi Grameen Vidyutikaran Yojana) [9], but these programs have largely created impact [4] and still, the aspiration for rural electrification is self-limited.

The paper is structured as follows: First section of the paper overviews the rural electrification in India while section 2 details about the microgrid and distributed generation, and gives a historical overview, solar grid working, and the key challenges of implementing microgrid. The next section describes the different types of site analysis, design analysis, and economic analysis performed during the microgrid installation. Two case studies are discussed in terms of challenges faced during the rural electrification, and strategies adopted to overcome. Finally, the summary and recommendations were given for future scope.

RURAL ELECTRIFICATION IN INDIA: AN OVERVIEW

Rural electrification involves transmitting electric power to rural and inaccessible regions (Alliance for Rural Electrification. 2019). Electricity is an important service for financial operations in rural areas. For rural communities, the beneficial and optimistic results of supplying energy for essential needs such as drinking and irrigation pumping, street lighting, house lighting are significant. House illumination would enable students to learn during night and night hours. Small-scale factories can be started here with energy to create livelihood prospects for the local community. Condensed operating periods for electrically pumped and disinfected drinking water could reduce time and could be used efficiently to raise income for women, who could, in turn, be supported by electrical power inputs. (Cecelski. 2003).

A few decades earlier, when linking the towns with grid was the primary priority, few villages near that grid were benefited, i.e. rural electrification was just the by-product of urban electrification. The main occupation in India was its agricultural sector, hence electrical pumping systems were used to irrigate the fields of a larger region, for which electricity was required. Therefore, rural electrification was mainly powered by agricultural electrification. Household electrification was only brought to the fore by the Rural Electricity Supply Technology Mission (2002). The scope of rural electrification needed specific basic agenda to be followed, which includes:

- The construction of substations and transmission lines, wherever required.
- Electrification of possible villages with grid enabling facilities and habitations with a population 100 and more, by providing distribution transformers in newly electrified villages/habitations.
- Situating small generators and distribution net in villages where grid extensions are very costly as well as not enclosed by the remote village electrification program offered by the Ministry of New and Renewable Energy (MNRE); and
- The households of Below Poverty Line (BPL) are to be equipped with free connection while the households of the Above Poverty Line (APL) are to be given provision for approaching distribution companies for connection (Mothilal Bhagavathy & Pillai. 2018).

Electricity is a crucial input to make people's choices and opportunities very clear. It is suggested that the qualitative approach towards the electrification of villages should improve the settings for politics and society in terms of valued capabilities (Malakar. 2018). There is a strong mandate for the State Electricity Boards (SEBs) to supply electricity to all regions, including urban and non-urban areas. In a nutshell, the significance of providing electricity in rural areas had been accentuated through the Electricity Act (2003) and the other policies of a nation like National Electrification Policy (The Gazette of India. 2005) and Rural Electrification Policy (Authority & Power. 2006). Therefore, at the household level, in October 2017, the government launched the Saubhagya Programmes alongside DDUGJY [12]. Implementation of these programs had reached 30 million households with some degree of electrification [13]

There is still a significant shortage in the quantity and standard of electricity supply in India. Grid outages are common along with transmission and distribution (T&D) losses, which clearly call for an expanded and improved system and for non-rural electrification. Owing to the unreliable existence of transmission and distribution and power theft, a considerable amount of produced power is lost. India also wants improved facilities to boost its power transmission and reduce its waste of electricity. Moreover, India is a land of farmers who have spread through all fields, and hence electrifying rural villages is a primary task, and in the present era it is considered a necessity along with food, water, and shelter. Thus, the government agreed to provide electricity to all villages, initially to provide power for cultivation, and then also to add power to household connections. Recently, the Indian Government. has introduced a major program of grid expansion and strengthening of the infrastructure for rural electricity under the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY)(Data.gov. 2020)

The Indian government has sketched a striving plan for electrification through solar energy to 400 million people who do not have access to the grid. In 2015, India's Government started a dedicated Rural electrification programme called Deen Dayal Upadhyaya Gram Jyothi Yojana (DDUGJY) for electrifying the villages that are still in darkness and allocated a budget of about 11 billion US dollars. By the end of April 2018, the villages were given electricity, but only public places like schools, health centers, panchayat buildings, medical dispensaries, and 10% of the households have been electrified, leaving 90% of households with no electric connection Wouters, C. (2015). To address this and ensure electrification to 100% households in the villages, the government introduced another scheme called Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya) budget of 2.5 billion US dollars in 2017. This scheme would cover around four crore households in rural and urban areas just by paying INR 500 to distribution companies, as easy monthly installments for ten months' period in total, costing INR 50 every month. To date, about 50% of the targeted households got an electric connection and still work is in place. The Key challenges/difficulties faced during the implementation of these kinds of schemes are summarized as:

There are many logical issues in constructing/situating power transmission network/infrastructure due to a big topographical extent. Also, these areas are mostly uneven terrains. Hence, the grid structure with transmission lines may not be similar to that in the cases of urban and metro regions. This requires intricate calculation, design and manpower. Seamlessly, implementing a government scheme with huge cores involved requires strong and deep coordination between various levels of government, which is not so easy. 100% electrification is essential for the

economic growth of the country. Carrying electric power from the central grid to villages involves massive loss because of the distance (remoteness) involved and the topology existing. Since new grid connections and expansion of the available grid are not cost-effective concerning rural electrification, the concept of Distributed Generation (DG) can be utilized for village electrification. On-site generation/DG based on non-conventional alternate energy sources is an economical choice to allow village electrification faster (Mothilal Bhagavathy & Pillai. 2018).

MICRO-GRID AND DISTRIBUTED GENERATION (DG)

The DG can be designed as grid-interactive (Grid connected/on-Grid) or decentralized (Off-Grid/Stand-alone) types. The type of DG is mainly dependent on the type of consumers and locality. The DG is frequently used as a backup source of electricity. It is used as a means of delayed investment in the building of new transmission and distribution infrastructure. The network charges are thus avoided, line losses are decreased, facilities for huge generators are adjourned with the use of DG. In addition, an alternative source of electric power is available in the electricity market that replaces the conventional and costlier grid power supply. This also helps in reducing environmental pollution because of the clean sources associated with DG (S. Singh et al. 2009).

There are typically two models available for decentralized generation. Generating electricity by the use of location-specific sources of energy at a local level, establishes a Microgrid, serving a restricted number of consumers in the form of generators grouped. This can either be interconnected with the main grid at one point, or it may be a totally independent unit. In the second model, the same machinery with minor scales are used, and they are installed by the individual consumer of power, which is then referred to as Distributed Generation. They can be linked to the grid individually, and they can supply grid power as, and when required, thus, every consumer can be a potential power producer, with a new terminology prosumer (India Smart Grid Knowledge Portal. 2019). The structural differences between the centralized and distributed generation is depicted in Figure 1.

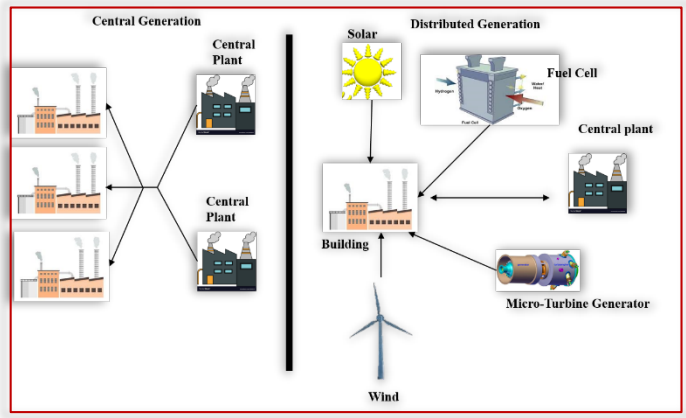

Figure 1. Structure of Distributed Generation (2019)

The microgrid can detach from the normal grid and can function autonomously. The microgrid has control capacities and is a local energy/power grid. This grid can disconnect and operate on its own by means of local power generation during the power crisis or outages. It is powered by Diesel generators, batteries, and/or renewable sources like solar panels (Hirsch et al. 2018).

Many renewable sources of power can be compatible with generators including small hydro, micro-hydro, wind turbine, geothermal, and biomass. Apart from those mentioned, currently, solar photovoltaic (PV) plants are mainly emphasized. The similarity between all the quoted plants, including PV is that they are supplying the local loads as isolated sources of power without a link to the central grid. During the year 2017, solar PVs were used to illuminate a famous monastery of 2,500-year-old, situated in the Ladakh region of Himalayas. This was achieved by a team of global Himalayan to fulfill the needs of about 150 monks, who had never experienced night lighting so far (Suryad et al. 2017).

— Historical overview

The USA's first electric commercial power plant was erected by Thomas Edison in the Manhattan Pearl Street Station, in the year 1882. It was a coal-based station, serving about 82 customers for electrifying 400 lamps. After two years, the customers grew to 508, and the lighting loads were 10,164 in number. In 1886, the firm of Edison installed 58 microgrids with direct current. The first industrial microgrid equipped with modern technologies was constructed in Whitling refinery in Indiana with 64 MW capacity, in 1955 (Pike Resarch. 2009)

The microgrid encompasses a range of services, from the illumination of homes to entertainment, refrigeration, and other efficient industrial uses. Microgrids' operation depends on the volume of load to be handled, the type of renewable source used, and the type of service to be offered. This can vary from a single kW to a few hundred kW. Microgrid solar PV systems have been highly important owing to their decreased retail rates worldwide in the recent timeframe and their lower costs. Even the storage battery solution is a requirement for solar PV cells.

The microgrid has a varied capital cost and generally spans tens of thousands to hundreds of thousands of US dollars. The factors governing the billing charges are capital, operational and maintenance cost, government subsidies, the degree at which the manufacturer recovers these expenditures. Almost in all cases, the bill paid for microgrid power is lesser than that of candles and kerosene (Energy Sector Management Assistance Program, (ESMAP. 2000).

The main demerit of distributed power generation is that there is no broad improvement in the rural economy due to minimal power loads. However, expenditure for the traditional method of lighting are reduced (Aklin et al. 2017).

The stand-alone microgrid structure with a connection to the main grid is depicted in Figure 2 (Energy Networks. 2019).

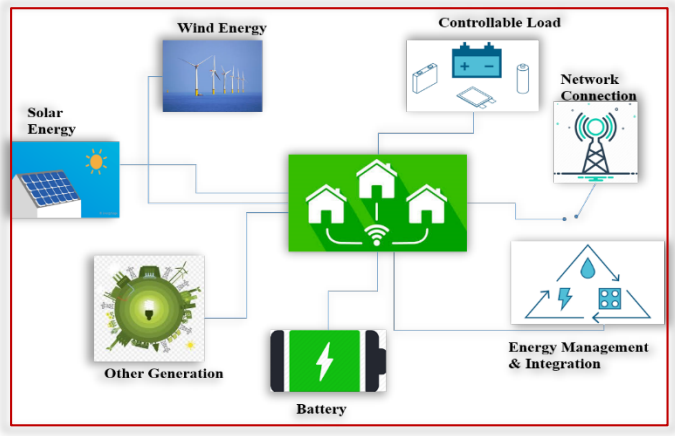

Figure 2. Microgrid system

The foremost discriminating aspect between off-grid/stand-alone and grid-connected models is that the load demand and solar energy output is matched, in off-grid models. When a PV microgrid is linked with the central grid, it may transport surplus power to the grid or utilize the main grid as a backup system, in case of inadequate generation from PV. Stand-alone systems are generally used in the cases of rural electrification (Saulo & Omondi. 2015).

The microgrids are broadly classified as DC, AC and Hybrid microgrids. The DC microgrid incorporates a DC bus and hence avoids many conversion stages as opposed to AC microgrid. Thus, energy efficiency is enhanced along with healthier economic operation. One of the main sources that offer DC output is solar energy. Solar PV cells integrated with DC microgrid is otherwise referred to as Solar microgrid. The following merits can be observed with DC microgrid.

- Many distributed PV units can be employed
- Energy dissipation is reduced, and facility cost (cost involved in AC/DC conversion) is lessened.
- Even at the time of blackout of central grids, power is continued to load through normal distribution lines.

— The status quo of Renewable energy and microgrid in India

Decentralized stand-alone/off-grid Solar Home Systems (SHS) is majorly utilized in almost all PV projects for the purpose of rural electrification in India. The specification of these systems ranges from 35 to 100 Wp (Watt Peak Capacity). As per MNRE report, July 2009, about 450,000 solar home systems had been installed. Even 1500 kWp off-grid PV plants with self-governing distribution capability (micro-grid) had been well thought-out for electrifying India's villages. Based on the report of MNRE, 2009, around 5 MWP of collective micro-grid volumes are available in India, most of these being situated in the Sundarbans section of West Bengal. The domestic consumers who majorly use lighting are supplied with DC, that is obtained from SHS and in fact, the household consumers are the owners. The Energy Service Company (ESCO), who generally setup microgrids, supplies the electricity in AC mode to various load points through a distribution network of low voltage capacity. It is a paid service; the power users pay for the consumed electricity (Arun et al. 2007).

SHS are premeditated and deployed for usage through individual establishment/household. The setup for SHS comprises PV modules, which charge a bank of batteries, that store power as DC electricity. This stored power is used to supply the consumers that use DC appliances like fan, TV, and Compact Fluorescent Lightbulbs (CFL). The battery bank's energy flow and the bank are governed/paneled by the charge controller, an essential SHS fragment. The traditional power sources such as candle, torch, kerosene, recycled battery for operating TV are replaced with SHS. They are being utilized to serve the necessary household facilities which are not associated with the central grid. Small power applications and home lighting are best suited through SHS, but the scope of generating income and the entire community's development is very much limited with SHS. The community development here refers to the establishment of harmless drinking water, road light provision, and refrigerating the essential vaccine (Kamalapur & Udaykumar. 2011).

Microgrids are meant for central electricity production, and the generated power is supplied to the applications spanned inside a nominated geographical zone. It usually is generated as 3-phase and 1-phase power with a power capacity of 220 V and 50 Hz. The electricity is distributed through a low voltage distribution network for residential, commercial, and community purposes. The commercial activities here include shops and offices. The major sections of a microgrid contain a PV array for electricity generation, battery banks for storing the electricity, a Power Conditioning Unit (PCU) distribution boards, junction boxes, inverters, and necessary cables /wires. The Distribution Network contains various materials like conductors, poles, insulators, cables, and wires, to individual households. A well-designed PV/Solar based microgrid could supply sufficient power for at least 24 hours effectively when combined with other power sources like wind, electric generator, diesel generator, or biomass gasifier (Alzola et al. 2009).

Indian renewable energy is administered by the Ministry of New and Renewable Energy (MNRE). It is focused on developing innovative and non-traditional sources, especially wind and solar energy, at a significantly faster leap. Being the forerunners of alternate energy use, India would be among the Global Solar Alliance plan promoting solar power expansion amongst 120 nations. India was the first country to have a dedicated ministry for renewable energy sources. This ministry was started in the 1980s and is intended to monitor alternate energy resources. As of 14 June 2017, India's full installed capacity has touched 329.4 GW, the renewable sources of energy are contributing a major of 57.472 GW. A more significant share of 61% is contributed by wind energy, and a considerable share of 19% is by solar energy out of the entire renewable energy (Government Of India Ministry of Power Central Electricity Authority. 2018). The total installed capacity of grid-connected renewable energy sources in India up to March 2017 is shown in Figure 3.

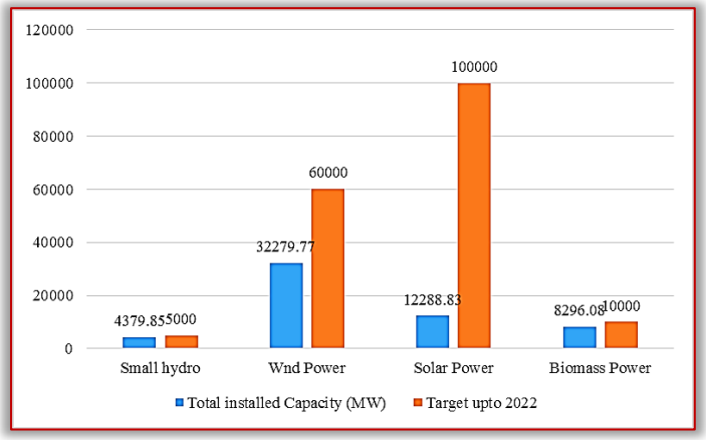

Figure 3. The total installed capacity of grid-connected renewable energy sources in India up to March 2017 (Ministry of New & Renewable Energy. 2019).

India is gifted with a massive solar energy capacity. India's land area receives around 5x103 trillion-kilowatt hour every day, and most of the parts get 4-7 kilowatt-hour per m2 each day. So, solar irradiance can effectively be transformed into both heat and electricity, leading to solar thermal and solar photovoltaic technologies. These powers can be effectually harnessed and thus offering vast scalability in India for solar power. The major advantages associated with solar power are that it can generate power on distributed mode, and it is possible within a short period to add additional capacities very quickly. Applications with Stand-alone, decentralized, and low temperatures are beneficial from a rural electrification viewpoint and serve additional energy requirements for power, heating, and cooling in rural and urban zones. From a secured energy standpoint, solar is the utmost protected of all sources, because it is plentily available. Wouters, C. (2015). Supposedly, a minor fraction of the whole incident solar energy (if captured successfully) can meet the entire country's energy requirements. It is further understood that provided the massive percentage of underprivileged and electric power un-served inhabitants. All efforts must be made to exploit the comparatively ample energy sources existing to the nation (MNRE).

— **Key Challenges**

There are quite a few challenges/issues with a microgrid. They generally depend on the location/site, technical, policy, economic and social aspects (Chauhan. 2016; Sabzehgar. 2017). In addition, the storage of energy in batteries is yet another problem that is to be effectively managed (Faisal et al. 2018). A few of these challenges are discussed in this section.

Technical Challenges: The microgrid must function securely either coupled to the main grid or in an 'islanded/decentralized' manner (Sandhu & Thakur. 2014). In the case of decentralized, stand-alone mode, it must dynamically manage power production and electricity utilization (Hossain et al. 2018). The crucial technical challenges on microgrid would be the frequency and voltage control, islanding/disconnecting from the primary grid, and microgrid protectionmicrogrid protection in terms of guaranteeing the distributed generations, loads, and the lines (Salam et al. 2008). In addition, noteworthy participation by loads is mandatory, and it is necessary to have durable interaction between real and reactive power. The control regulatory and marketplace consequences, new technologies, assessment of the microgrid boundaries are the other technical factors that influence the operation of microgrid (Hatziargyriou. 2004)

Regulatory Challenges: The microgrid majorly coexists with the central grid. Hence, the microgrid consumers/customers are supposed to share some of the charges allied with the central grid's operation (Kharul. 2013). There should also be an ownership and liability while offering safe operation and security of electric power supply; responsibilities that are presently accepted by the utility in the prevailing arrangement (Wouters. 2015). It is concentrated on distributed renewable energy (DRE) specifically, as renewables motivate the development of distributed power generation (Williams et al. 2015). A set of data containing the variables describing the country's important issues and policies is considered to comprehend the role of DG in national electrification plans (Ma & Urpelainen. 2018). The concerns and vital variables are shown in Table 1.

Table 1. The concerns and vital variables considered to comprehend the role of DG in national electrification plans (Ma & Urpelainen. 2018).

Sl. No.	Concern	Vital Variables
1	Current Condition of Electrification	—Rate of National, urban, and rural electrification (People, in %) —The non-electrified populace of National, urban, and rural (in millions)
2	Electrification Plan for National and Rural Areas	—Document title of national and rural electrification plan —Short-term and long-term energy access target (in %)
3	Current State of Distributed Renewable Energy (DRE) Production	—DRE generation capacity (in MW) —DRE electricity consumption (in GWh/yr) —National and rural population electrified by DRE technologies (in millions)
4	DRE's Role: Plan/ Policy for National Electrification	—Document title of national DRE plan —Responsible institution —Short-term and long-term DRE generation target (in %) —Investment plan (in million USD) —DRE technologies —Policy instrument

— Economic Challenges: The installation cost would be higher for the utility companies. As costs for important microgrid components like renewable energy sources, Energy storage, cutting-edge load generation controls,

and intelligent switches continue to reduce, the finances for microgrids for explicit applications may become inexpensive in comparison with the regular power sources (Carey & Miller. 2012).

— Energy Storage System: One of the decisive components that aids in the proper functioning of a microgrid is the storage device, for instance, the battery bank. The Energy Storage System (ESS) matches the consumer's energy demand with the generated energy of the power producer. From the prevailing techniques for ESS, batteries, and supercapacitors are better choices for microgrid functioning (R. Singh et al. 2018).

MICRO-GRID ANALYSIS

A detailed analysis is needed for effectively implementing the system. This will lead to a proper feedback and corrective measure. The design analysis and economic analysis is done on the site.

— Proposed Site Analysis

Several aspects are necessary to decide the location of the site. The primary factors are the land's topography, nearness to load demand, approachability, and the type of land use (Charabi & Gastli. 2011). The temperature and dust, which are referred to as negative environmental elements, had a great influence over the plant's efficiency, which in turn affect the economic profits in the case of PV farms and were also accounted for the site analysis (Mani & Pillai. 2010). Research on location identification focuses on the illumination of the region. It is identified that it is very tough to get flat terrains in urban zones, and it is not cost-effective. As per the studies by Gastli and Charabi (2010), the utmost appropriate area for PV plant is the flat area, and for successful operation, it must face south direction with an angle of slope lesser than 10 degrees. The apt terrains for PV plant setting up were abstracted using a multi-criteria evaluation model, which combines the Digital Evaluation Model (DEM) in GIS platform and other spatial information (Arangarajan et al. 2015). Large terrains are essential for the execution and expansion of PV farms. A master design for deploying solar energy and planning the optimization of the electric transmission grid to ascertain the future solar energy market lies in identifying the appropriate land. Almost in all developed/urbanized nations, the highest percentage of residents live in an urban atmosphere, leading to difficulty in getting lands near the city areas and getting even a minimum land area is very costly. This pushes the location of PV plants in remote/distant areas, which are far away from the core loads. The assessment of solar irradiance necessitates a denser network of PV plants in the case of composite terrains as opposed to flat terrain (Chrysoulakis et al. 2004). The surface elevation, gradient, alignment, and positioning, the surface position of adjacent terrains are the deciding factors of solar irradiance in mixed terrains. The larger usage of solar energy is affected by the climatic and geographic elements that influence the spatial and temporal variations. An inclined terrain will be a very good option to eliminate the power consumption areas through solar PV. The unexploited inclined nearby lands were used to evaluate solar PV's capacity (Charabi et al. 2016; Chimtavee & Ketjoy. 2012; Hamza et al. 2017).

— Design Analysis

The Isolated/stand-alone power systems should be modeled based on constraints related to technical and economic aspects and probable consistency to satisfy the location-specific demands (Markvart et al. 2006). Also, the design should accommodate the effect of fluctuating PV resources. The design of the battery's size is decided by the number of self-sufficient days in case of simple methodologies (Khatib et al. 2016). These kinds of methods are not accurate and complete, while the design space method is useful because the entire viable configurations of the system are mapped (Hontoria et al. 2005). The sizing of a PV system is meant for the design of a PV array and includes the design storage battery capacity. CA, the capacity of PV array, is defined as the ratio of mean values of produced energy of PV array and the load demand. CS, the storage battery capacity, is the ratio of the capacity of battery to load demand. There are 3 types of sizing methods, namely, intuitive or empirical, analytical and simulation methods (Egido & Lorenzo. 1992). The requirements of battery storage capacity and rating of islanded PV generator were linked for the given pattern of electric power demand and the efficiency of power conversion from solar irradiance to electricity. In this method, a sizing curve was created to find the rating of PV generator and associated least capacity of storage batteries. The maximum and minimum values of ratings of the generator as well as batteries, could be found. This method was demonstrated on DG-battery and PV-battery Systems (Arun. 2018). The effect of the village's projected load factor that has to be solar-powered on the microgrid design was tested, and the energy cost had been investigated by Mellit (Mellit. 2010). In addition, there are many technical studies available in the literature for resolving the technical issues related to microgrid (Balijepalli et al. 1967; Del Carpio Huayllas et al. 2010).

A disparity in the microgrid shits from on-grid to off-grid mode, primarily when disconnect occurs while supplying or absorbing power by the microgrid. Few micro resources, maybe with less inertia, and the dynamic response of these sources would be slow. Hence, to maintain the balance of power, energy storage units are used. When the microgrid is about to restore to grid-connected mode, it may be synchronized after verifying the voltage magnitude and phase angle. This issue may be resolved by using an automated, sensitive static switch of high-speed capacity before the disconnection (Xiao et al. 2010).

— Economic Analysis

Most of the studies related to the analysis of energy cost in microgrids omitted the grid cost because of the main grids' minor contribution, which are just less than 10% (Moreno et al. 2012). Rural electrification with designed microgrid needs to encompass industrial, commercial and residential loads at the preparation stage itself to improve the intended village and are to be encouraged by the government, microgrid investors and NGOs (Robert et al. 2017). Currently, solar panels are offered at subsidized costs by the

government of India, which would help in developing the microgrid. Even though the grids are not available directly for purchase, individual components can be purchased. Most of the microgrids installed in rural regions have been done with financial assistance from NGOs (Fowlie et al. 2018). Any technical challenges, resolved by placing any new tool/gadget and the energy storage system, would increase the microgrid cost. Any other challenges considered as critical challenges will include the economic aspect also (Mao et al. 2014)

CASE STUDIES

The benefits and intricacies involved in microgrid pertaining to rural electrification are well perceived by analysing the case studies. A few case studies have been discussed in this section.

≡ **1MW Solar Microgrids – Ladakh, India**

Ladakh village, famous for "Kargil war of the year 1999", is in Jammu and Kashmir, India. It is "the land of high passes" and lies between the Himalayas and the Kunlun mountain range at more than 3,000 meters above sea level. The temperature may go up to -20°C from December to February and the average temperature being 2°C. During March and April, the night temperature floats between 6°C to -5°C and the average day temperature is 12°C. From May to August, the temperature shifts from 16°C to 3°C between day and night respectively. September to November, this region receives high sunlight, and the average temperature in the day is 21°C and 7°C at night (Climate Data website. 2019). The entire inhabitants of this region are equally split in Leh and Kargil districts. The total population in Leh is 1,17,637 and in Kargil is 1,15, 287. The public of stunning Leh valley has struggled for epochs to have complete access to energy for their rudimentary needs, for example, light, hot water or electricity.

The home-grown renewable energy agencies and MNRE recognized the villages of Ladakh that were lacking any supportable source of energy, united with Tata Power Solar to design solar power venture that solar-powered more than 100 villages where grid connectivity was not possible (TATA Power Solar Website. 2019).

≡ **Challenges:**

- Transportation of components: Mules and yaks carried solar panels across the mountains' high passes through altitudes close to 18,000 ft. and the average temperatures at -20°C during winter. To counter these issues, Tata Power Solar customized the solar power plant components so that they are compact and easy to transport. For instance, the battery dimensions were reduced to permit transportation via mules and yaks on the uneven and bumpy terrain. The number of batteries had been increased to get the required power output.
- Temperature: The climatic situations in Leh and Kargil region are such that there is no access to these regions for 6 months in a year. Hence maintenance of the projects was a big challenge. This unruly weather was taken into consideration, and an adequate stock of standbys was maintained at the site.

≡ **Impact:**

More than 3.5 million units of power have been created in the past 2 years, which has illuminated about 35 villages with lights and offsetting approximately 3000 tons of carbon dioxide every year. The uninterrupted power supply for more than 8 hours is offered to the public of this region.

≡ **110 kW Solar Microgrid – Sundarbans, West Bengal, India**

The village Indrapur is situated in Patharpratima Tehsil in West Bengal, India. It is located 22km away from sub-district headquarter Ramganga and 117km away from district headquarter Alipore (Indian Village Directory. 2019). It has a total population of 200,000 people and 2000 families. The nearest town is Diamond Harbour, which is roughly 100 km away. From Howrah to Patharpratima, the distance is 81 km, and it takes close to one and half an hour to reach this village through a ferry boat. Tata Solar Power custom-built 110 kW solar plant and it was commissioned in March 2011. The village climate is such that it alternately gets a bright and cloudy day (TATA Power Solar Website. 2019).

≡ Challenges: Accessibility to site location: The only way to get to the project site was via a 90-minute boat trip from Patharpratima, the nearby ferry port, 81 km from the adjacent railway station. The shipment of parts and the work process should be fully prepared and well-coordinated. If not, the total project may have been impacted.

≡ Absence of continuous sunlight: Due to the nonexistence of continuous exposure to the sun, there was a problem of getting consistent electricity powered by solar. An exclusive solar power scheme was premeditated on a two-day autonomy (self-sufficiency) mechanism, where the battery bank was changed to release/ discharge only 25 – 30% of stored power per day irrespective of a cloudy or sunny day. Thus, the battery can store up to 70-75% of energy to be used on subsequent days.

≡ Impact: The designed microgrid was well matched to the fragile ecosystem, including small islands, deserts, mountains, semi-arid lands, wetlands and few coastal areas of the region (ENVIS Centre on Floral Diversity, West Bengal, India). The fishing community of 10,000 people got accessibility to electric power and hygienic water. About 2000 families had received electricity, and children were privileged to get a good light quality for doing their homework after dark. The literacy rate had been improved, and the island's economy had been enhanced by stretched working hours, particularly the periodically held village markets in India.

FUTURE RECOMMENDATIONS AND LESSONS FOR TRANSITION

Rural electrification decides the nation's economy and the welfare of the people. The microgrid is the best choice for electrifying the villages. Out of the available resources, solar PV aptly suits the rural climate. However, the microgrid placing depending on the terrain and designing microgrid concerning rural loads and maintaining and controlling the

microgrid requires careful planning and execution. The Government of India has a clear vision of improving electrification in all the villages across the nation and provides subsidy in various forms under various schemes. Awareness about these schemes should be created amongst the rural population to achieve real success. This work's contribution lies in the fact that the Indian perspective of rural electrification is covered. There are very few studies on rural microgrids from the Indian perspective. India's rural mountainous regions have very less population density; hence, the government does not find it feasible to electrify these isolated pockets of villages.

CONCLUDING REMARKS

Electricity has a large variety of uses like domestic, agricultural, commercial, and irrigation. While people in cities and towns enjoy the fullest benefits of electricity, the rural population still does not have wide access to it, and there are many reasons for it. Electricity is a resource that needs a strong infrastructure, starting from power plants, substations, transmission and distribution networks, central grids, e, etc. Transporting electricity often includes lines which will increase over longer distances. According to the topology, the rural population living in remote areas is from power-producing centres and substations. The grid system consists of the building of poles and towers. The terrain in which rural people live is usually complicated and requires more planning and design.

Moreover, there is more demand for loads or power in urban areas and thus the cost of energy can be easily recovered. On the other hand, there is less demand for load in rural villages, and most of them use lighting loads. The energy system's cost is not justified in comparison to the grid-connected electricity supply of the rural population. Hence, microgrid have come into place as an alternative and cost-effective system. In a microgrid, excess power is generated or the power that was not used during day time can be supplied to the grid, if the microgrid designed is interactive to the main grid. A microgrid can be islanded whenever required, and it can supply loads even during a blackout. This paves the way for "prosumers" which enhances the livelihood of village dwellers (Wouters. 2015). Though, methods have been devised for electrifying villages, there are many complications in creating a microgrid. A detailed literature survey was made to understand the challenges involved in a solar microgrid, including site analysis, technical difficulties, storage of power, number of batteries, cost optimization, and regulatory issues. The probable solution to a particular challenge was discussed in the previous section. Few case studies were discussed to analyze the problems which are location specific. The reliability of solar microgrid is mainly based on the intensity of sunlight and the availability of sunlight. Also, to extract maximum power, proper power tracking technology should be used. So, in the future, to fully harvest the benefits of electricity in rural areas, a hybrid system involving many renewable sources will evolve. These systems are already in place, but solar and wind would be used as hybrid energy sources in a rural community. In the future, many sources that are potential in that particular region can be examined. When combined with proper algorithm and technology, the quality of microgrid would improve, and in the future, the design and control of microgrid should be integrated with economy optimization. It is concluded that more challenges are faced while placing the microgrid in hilly terrain, and an entirely different approach is needed for transportation of components, improving the sustainability of the grid and the economy.

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SYNTHESIS AND CHARACTERIZATION OF ZEOLITE Y FROM UKPOR CLAY FROM ANAMBRA STATE, NIGERIA

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Abstract: The present study involved the processing of raw Ukpor clay from Anambra State, Nigeria to kaolin as a precursor for the development of Y-type zeolite. The clay was first subjected to pretreatment by separating the foreign bodies from it using deflocculant (Sodium hexametaphosphate and Sodium hydrogen carbonate). Subsequently, the pretreated clay was calcined at 850^0C for 6 hours at atmospheric pressure. The calcined clay was formulated by adding sodium hydroxide and sodium metasilicate to produce a gel aged at room temperature for 12 hours. The gel was subsequently heated in a laboratory oven at 100^0C for 9*hrs* to produce the Y-type zeolite in a process called crystallization and a product with Si/Al molar ratio of 4.07 was achieved which is suiting for a typical Zeolite Y. The formulated samples were characterized using X-ray Fluorescence (XRF), Fourier Transform Infrared Spectroscopy (FTIR), and Scanning Electron Microscope (SEM). The results showed possible synthesis of Y-type zeolite from Ukpor kaolinite having a molar ratio of $15Na_2O:Al_2O_3:15SiO_2:450H_2O$. The synthesized product with Si/Al ratio of 4.07, an agglomerated euhedral morphology, and FTIR spectra peak at wavelengths of $719cm^{-1}$ and $3424cm^{-1}$, are the basis upon which the conclusion of possible development of Y-type zeolite is drawn.
Keywords: XRF, FTIR, SEM, y-type zeolite, deflocculant

INTRODUCTION

Currently, there is need to improve hydrocarbon fuels both qualitatively and quantitatively, and to effectively use them. Hydrocarbon fuels have been essential to the growth of transportation, industry, and the agricultural sector [1], and also of immense importance in domestic lightening and heating. Energy consumption growth is projected at 28% between 2015 and 2040 worldwide. And petroleum consumption to take 31% of this cumulative increase [2]. The rising energy demand have instigated the need for the further processing of heavy petroleum feedstock. Residue content of heavier petroleum feedstock is about 40% and needs to be further processed into more valuable product to find use. This requires new catalytic systems, and improvement of already existing ones [1].

Catalytic cracking of heavy molecular weight hydrocarbon is required to meet the increased demand of energy consumption [1]. Catalytic cracking in petroleum refining is a process of converting or breaking large hydrocarbon molecules into smaller molecules by the action of catalyst [3]. Zeolite catalyst ensures higher yield of desired product in catalytic cracking compared to other catalyst systems such as acidified clay, alumina, silica, etc. They have high stability to thermal shocks, loading and physical impact, and have strong resistance to poisoning caused by carbon dioxide, nitrogen compounds, air and steam [4]. Zeolites are hydrated aluminosilicate minerals made from interlinked tetrahedral of alumina (AlO_4) and silica (SiO_4). Zeolite X and Y are known as faujasites and serve as catalysts in catalytic cracking [5]. The use of natural materials for the production of zeolite has economic advantage over conventional commercial chemicals [6]. Previously, only zeolites from natural sources were used, but presently tangible achievements have been made to synthesize them on industrial scale which have aided replication [7]. Kaolin is a well-placed material and is regarded as the next generation material because it is more abundant and environmentally friendly than precursors used in zeolite production, hence their application in the synthesis of zeolite has continued to receive tremendous research interest [8].

Several studies indicating development of faujasite type zeolite has been carried out. These works includes; that of Adeoje, J.B *et al.*, titled "Synthesis of Zeolite Y from Kaolin using Novel Dealumination Method". In the study Zeolite Y of silica/alumina molar ratio of 3.46was successfully synthesized and modified to its hydrogen form through the process of ion exchange with ammonium chloride (NH_4Cl) from local kaolin from Ado-odo Ota, Ogun State [9], The work of Atta, A. Y. *et al.*, titled "Synthesis of Faujasite Zeolites from Kankara Kaolin Clay", where X type faujasite zeolite was developed. The X-ray diffraction analysis revealed a composite crystalline phase consisting zeolite X (32-36%) and zeolite Y (21-25%), unnamed zeolite (<1%), quartz (2-5%) and anatase (2-5%). In addition an amorphous phase (>20%) was found in the synthesized zeolite. He attributed the formation of zeolite X and Y in the same reaction to lack of proper mixing, and the presence of high level of quartz (4%) and anatase (4%) are speculated to be as a result of lower number of days in which aging was done. Previous attempts to produce Y zeolite from Kankara resulted in D-type zeolite being formed predominantly, and this was attributed to presence of potassium ion in the clay, reagents and leaching of glass wares used which hindered successful synthesis of the targeted zeolite[10], and the work of Ajayi, A. O *et al.* on *Novel Method of Metakaolin Dealumination-Preliminary Investigation.* He indicated that the silica-alumina ratio using the novel method increased with increase in

strength of sulfuric acid and was found to be good enough for the synthesis of faujasite type of zeolites. Although, the quantity of heat released by the heat of sulphonation was found to be sufficient to effect the dealumination reaction, it was not determined [11].

The current study employs an additional silica source, sodium metasilicate to develop Y-type faujasite zeolite rather than the process of dealumination, since much leaching of the alumina from the metakaolin precursor was not necessary. The work highlights the possible development of Y-type zeolite from Ukpor kaolinite from Anambra State, Nigeria to create a more sustainable supply of catalysts for fluid catalytic cracking, and to serve as substitute to their alternative synthesized from uneconomical commercial chemicals which serve as sources of silica and alumina [1].

MATERIALS AND METHODS

— Beneficiation of raw clay

The raw clay mined from Nnewi Local Government Area of Anambra State was beneficiated by deflocculation in order to purify it from physically and chemically combined impurities such as metallic oxide, soluble salts and grits. The raw clay was crushed and ground. 2.75*kg* of crushed clay sample weighing out and poured into a plastic bucket. Then 220*g* of sodium hydrogen carbonate and 880*g* of sodium hexametaphosphate were mixed and 11 liters of distilled water was added to the sample for deflocculation purposes. It was allowed to stand for 8hrs whence three distinct layers were observed namely the supernatant layer, fine and coarse layer after which the supernatant fluid was decanted and thoroughly washed with distilled water to remove excess deflocculant subsequently, the mixture was passed through a 70*μm* sieve to obtain the fine particles, and was allowed to settle and the water decanted before centrifugation. The centrifuge machine was operated at 1500 rpm (revolution per minute) for 10 minutes per run. After 10 minutes, the tubes were removed and the wet lumped clay was scooped out and was collected into a tray. The removed tray was dried overnight in an oven at 120°C to liberate completely the physical water content and to obtain beneficiated clay (cake). The cake formed was crushed and milled to +70 *μm* particle size using a micro sieve.

— Calcination of refined clay

Calcination was done in a programmable electric furnace (Model no: BF51794C-1) from 25°C to the calcination temperature (T_{cal}). The sample was held at T_{cal} (850°C) for 6*hrs* [12]. Calcination was achieved by evenly placing beneficiated kaolin into crucibles to allow for a relative good heat distribution since the specific heat capacity and latent heat of the kaolin is poor. The metakaolin obtained was then cooled in a desiccator before characterization and usage.

— Gelation and synthesis of Y-type zeolite

Synthesis of zeolite Y was carried out according to the method reported by Kovo [13]. In the synthesis of zeolite Y from Ukpor kaolin, the use of external silica source was adopted. [14] The aluminosilicate gel used to synthesize zeolite Y was produced based on the following molar ratio:

$$15Na_2O: Al_2O_3: 15SiO_2: 450H_2O \quad (1)$$

Sodium hydroxide pellets (97.9% w/w) and anhydrous sodium metasilcate which served as a source of additional silica source were used for gel formation. The Ukpor metakaolin served as a combined source of alumina and silica.

One hundred and fifty nine point nine two decimeter cube (159.92dm^3) of distilled water was measured and was divided into two equal parts in separate beakers. One point six five grams (1.65*g*) of sodium hydroxide pellets were measured and were added into the first half of the distilled water and the mixture was stirred until it dissolved completely. Four point four grams (4.4*g*) of Ukpor metakaolin was measured and was also dissolved in the first half of the distilled water. Thirty three grams (33*g*) of sodium metasilicate was measured and dissolved in the second half of the distilled water. After properly stirring and mixing of the two sets of precursors, they were then mixed together to form a homogeneous aluminosilicate gel. The gel was then aged at room temperature at varying ageing time of 12 hours with intermittent stirring. The aged gel was then crystallized using the oven at crystallization temperature and crystallization time of 100°C and 9 hours respectively. Upon crystallization and/or hydrothermal treatment, the sample was retrieved from oven, allowed to cool and was washed using the distilled water until the pH of the sample was between 7 and 9. This was followed with drying of the sample at 70°C using the oven for 5 hours.

The instrumental analysis of all the samples were carried out using modern equipment/analyzers to study the XRF, SEM and FTIR.

INSTRUMENTAL ANALYSIS

— X-ray fluorescence (XRF) analysis of samples

The XRF of the various samples were carried out using Energy Dispersive X-Ray Fluorescence (EDXRF) spectrometer analyzer of model "Minipal 4". The analyzer was set at the following conditions;

- Elemental composition determination.
- Nature of the samples to analyzed as press powder (pellet)
- The current used as 14*kv* for major oxides
- Selected filters were "kapton" for major oxides

The samples were pulverized (grind to fine powder) using arget pulverizing machine (planetary micro mill pulverisette 7). The ground samples were ensured to pass 150 micro mesh sieves. This was to ensure homogeneity of the samples.

5g of the pulverized sample was weighed into a beaker, 1g of binding aid (Starch soluble) added. The mixture was thoroughly mixed to ensure homogeneity, which was pressed under high pressure (6 "tone") to produced pellets; labeled and package ready for the analysis.

Time of measurement for each sample was 100 seconds and the medium used was air throughout. The machine was then celebrated by the machines gain control, after which the respective samples were measured by clicking the respective positions of the sample changer.

— **Scanning Electron Microscopy (SEM) analysis of the samples**

The SEM of the various samples were carried out using SEM analyzer. Samples were coated with an ultrathin coating of electrically conducting material (carbon), which was deposited on the sample by low-vacuum sputter coating. Samples were then mounted rigidly to the sample holder or stub using a conductive adhesive called double sided carbon tape.

The pump icon on the software machine was clicked and the pump attached to machine started automatically and draws out air completely from the Chambal.

The light showed green and the beam icon was clicked. The machine then scans the surface of the sample in the SEM analyzer at set magnifications of x150, x500 and x1000.

— **FT-IR analysis of samples**

The FT-IR of the various samples were carried out using FT-IR analyzer of model "Bulk scientific M530 FTIR USA". Analysis was done using 0.4g of KBr, weighed and ground to powder. 0.001g of the samples were weighed and poured into the ground KBr and both were thoroughly mixed together and moulded into a disc. The disc was inserted into the sample compartment of the analyzer. The scan button was pressed.

RESULTS AND DISCUSSION

— **Elemental Analysis**

Table 1 presents the elemental composition of raw Ukpor kaolin, beneficiated kaolin, calcined kaolin, and synthesized zeolite obtained using XRF.

Table 1: composition of raw Ukpor kaolin, beneficiated kaolin, calcined kaolin, and synthesized zeolite

Component	Weight %			
	Raw Kaolin	Beneficiated Kaolin	Calcined Kaolin	Synthesized Zeolite
SiO2	88.70	56.20	58.80	55.60
Al2O3	4.16	20.00	22.70	23.20
K2O	0.24	ND	ND	
Na2O	0.046	ND	ND	
CuO	0.033	0.047	0.019	0.026
Fe2O3	2.08	3.53	1.50	3.32
TiO2	3.63	3.76	2.54	3.32
BaO	0.15	0.10	ND	0.08
CaO	0.14	0.01	0.027	0.05
ZnO	0.002	0.013	0.005	0.003
MnO	0.021	ND	0.005	0.025
LOI	0.48	10.04	12.81	13.0

ND = Not Detected

The results indicate Ukpor kaolinite contained impurities of oxides of potassium, iron, titanium, magnesium etc. The results also indicate the effect of refinement using deflocculant on the raw kaolinite, as value of SiO_2 declined from 88.70% to 56.20% owing to expulsion of free silica (quartz) from raw kaolinite.

The Table also highlight that Ukpor kaolinite is ferric in nature owing to the high iron oxide (Fe_2O_3) content of (2.08) when compared with that of potassium K_2O (0.24). Similarly, the white colour of the raw and beneficiated Ukpor kaolin can be attributed to the significant content of TiO_2.

Pure raw kaolinite clay is expected to have silica/alumina ratio of between 1 to 2 [15]. Table 1 indicate that SiO_2/AlO_2 ratio of 21.32 and 2.81 for the raw and refined kaolinite respectively do not fall within the theoretical value, This shows that Ukpor clay contained so much mineral impurities. It is also observed that Ukpor clay has high silica content making it a good source from which silica can be produced and development of high silica zeolites.

The compositional analysis of the refined kaolininite clay indicates a reduction in the amount of its free silica, potassium and other impurities, were as there was record increase in both alumina and iron content. All of these follow a proportionate decline in the content of silica. It is expected that the refining of raw kaolin will help improve kaolinite content.

The XRF analysis indicated little or no difference in chemical composition of samples of both the beneficiated and metakaolinized Ukpor kaolin. The obvious variation is captured in the values of the loss on ignition (LOI) which had increase from 10.04% to 12.81% for beneficiated and metakaolinized samples respectively. This may be attributed to the combustion of impurities such as the iron content during calcination.

The compositional analysis of the final synthesized material indicates a silica to alumina molar ratio of 4.07, hence suggesting successful synthesis of Y-type zeolite. The silica to alumina ratio is between 2 and 3 for X-type zeolites, while it is 3 or higher for Y-type zeolites [16].

— **Shape Analysis**

≡ **SEM analysis of Raw Clay**

The platelet structure of kaolinite clay reported in the literature [17-19] which normally portrays pseudo-hexagonal platelet morphology could be clearly observed. Each of the images showed a pseudo-hexagonal morphology consisting of platelet sheets of kaolinite mineral as reported in the literature, the pseudo-hexagonal morphology became clearer as the magnification increased.

≡ **SEM analysis of calcined Ukpor clay**

From Figure 2, it can be observed that the pseudo-hexagonal platelet morphology that was earlier obvious in the SEM image of the raw and beneficiated kaolin samples has been lost. Even though the metakaolin SEM image still possessed some relatively low platelet morphology, the morphology of the metakaolin was lump-like.

The lump-like morphology could be attributed to the highly amorphous nature of the material as a result of the crumbling of the kaolinite structure. The relatively low platelet morphology observed in the material could be as a result of the crystalline silica contained in the clay even after the metakaolinization.

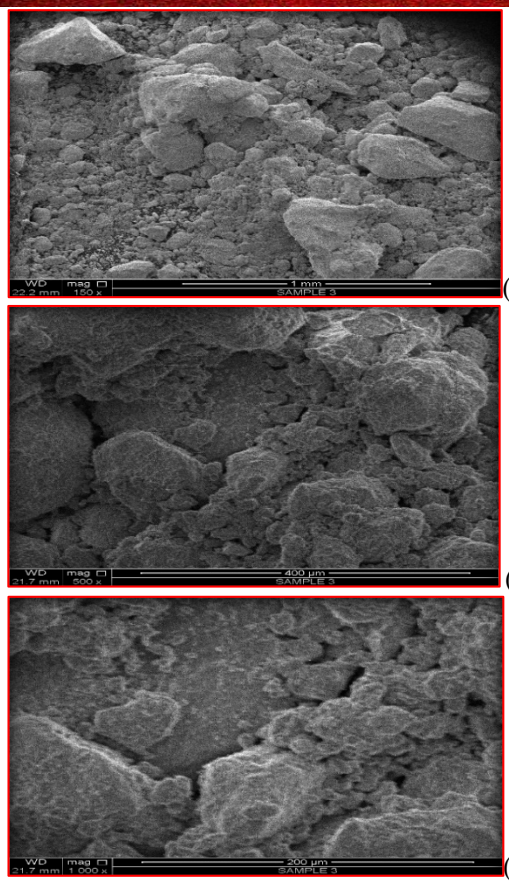

Figure 1: SEM Analysis of Beneficiation Kaolin with magnification of 150x(X), 500x(Y), 1000x (Z)

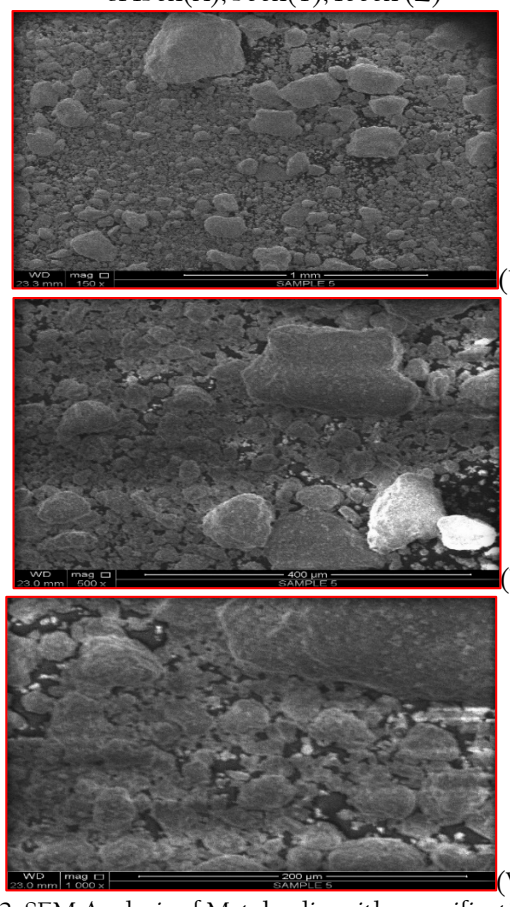

Figure 2: SEM Analysis of Metakaolin with magnification of 150x (U), 500x (V), 1000x (W)

≡ **SEM analysis of attributed synthesized zeolite Y**

Figure 3 Shows the SEM micrograph scanned at various magnifications. The SEM micrograph scan of Zeolite Y shows images at magnification of 150 (I), 500 (J) and 1000(K). Irrespective of the various magnification, the zeolite Y particles appeared densely agglomerated. At the high magnification, the micrograph appeared densely agglomerated revealing the definite shape of the particles, although the micrograph was not clear enough to show the actual shape clearly. It could be obtained from the images therefore that the Zeolite Y has an agglomerated euhedral morphology. This is similar to that reported by Salahudeen N. in his work "Development of Zeolite Y and ZSM5 composite catalyst from Kankara kaolin".

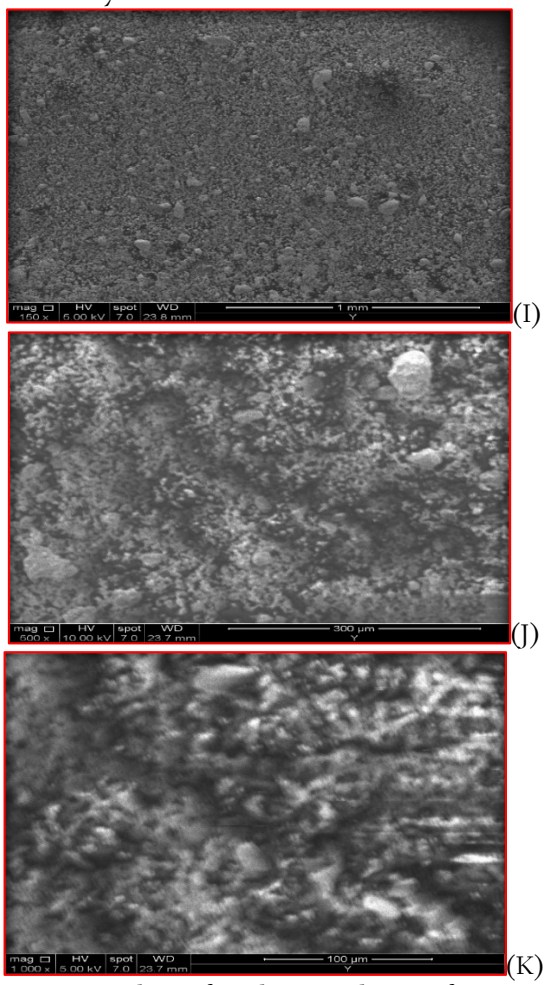

Figure 3. SEM Analysis of Zeolite Y with magnification of 150x (I), 500x (J), 1000x (K)

— Absorbance Analysis

≡ **FTIR analysis of raw and calcined Ukpor clay**

Figure 4 shows FTIR spectra of raw Ukpor kaolin (A) and calcined kaolin (B).For a kaolinite clay mineral, the –OH hydroxyl group is identified at wave number (cm^{-1}) of either 3696, 3671 or 3650 [21]. Therefor the peak at 3696.034818 cm^{-1} for Fig. 4 (A) shows the presence of an –OH group. Also in Fig. 4.4(A), the peak at 2729.8723 cm^{-1} shows the presence of an –OH cabonyl group confirmed by the peak which it overlaps at 2987.863 cm^{-1} representing a C-H single bond. The peak at 3530.21736 cm^{-1} in Fig. 4 (A) signifies an alcohol –OH which is confirmed by the peak at 1054.27961 cm^{-1}

signifying a C-O single bond. In Fig. 4 (B) due to metakaolinization which involves removal of hydrogen and framework oxygen, the FTIR spectra reveals dissapearance of the various –OH peaks indentifed in the raw clay.

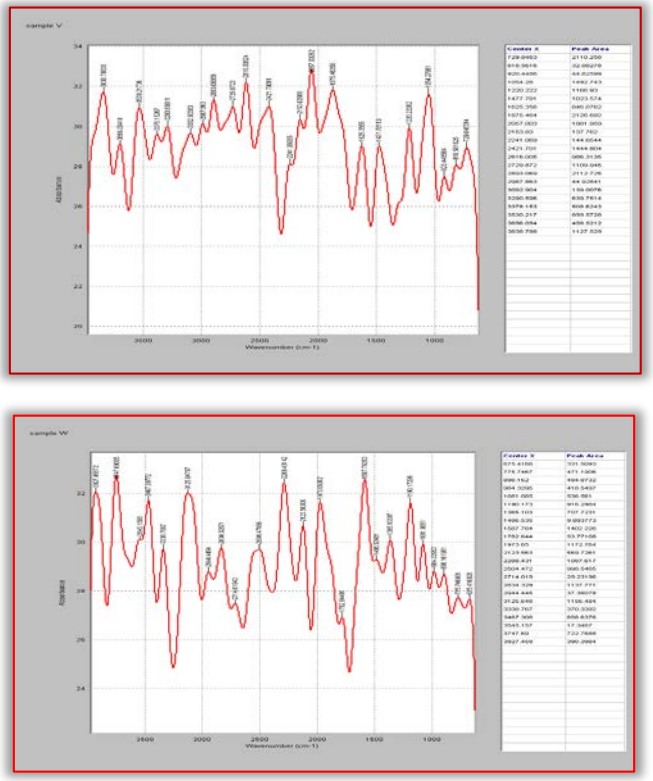

Figure 4: FTIR spectra of raw (A) and calcined Ukpor clay (B)

≡ **FTIR result for attributed synthesized Y-type zeolite**

Figure 5 shows FTIR spectra of attributed synthesized Y-type zeolite. Prior studies reported that the characteristic FTIR bands for zeolitic lattice are in the wavelength range of 460–1200 cm^{-1} [22] and the bands in these range of wavelength indicate the crystallinity of the material [23]. Particularly the characteristic FTIR bands for zeolite Y are located around 1025, 790 and 715 cm^{-1} [24].

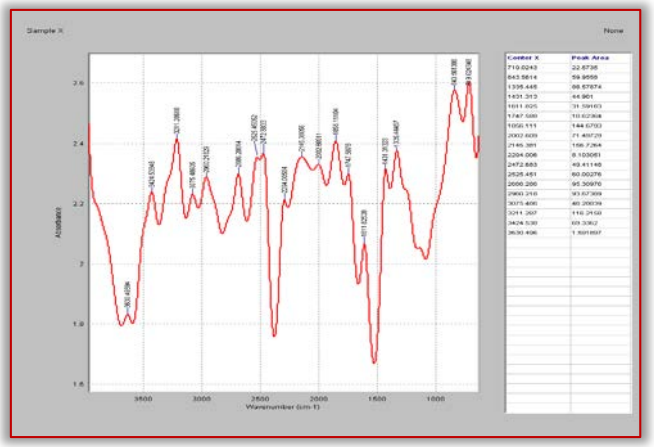

Figure 5: FTIR Spectra of Attributed Synthesized Zeolite Y

The vibrational bands at 760–710 cm^{-1} correspond to the vibration of Al-O fragment. The band at 719.024348 cm^{-1} was attributed to Si–O–Al in-plane bending. The band at 3500 - 3200 cm^{-1} was attributed to O-H bond stretching vibration [20]. These observations confirm the possible formation of zeolite Y.

CONCLUSION

The authors concludes that the various analysis; XRF, SEM and FTIR conducted in the study affirms successful synthesis of Y-type zeolite. Hence, Y-type zeolite was successfully synthesized from kaolinite deposit located in Ukpor in Anambra State. The synthesis involved beneficiation by deffloculantion, calcinations at 850^0C, ageing for 12 hours, crystallization at temperature of 100^0C for 9 hours and drying for 9 hours. This will go a long way to ensure an economical and sustainable supply of Y-type zeolites in addition to those synthesized from different kaolin deposits in Nigeria. In the current study XRD analysis is recommended to ascertain the purity of the synthesized y-type zeolite. Also, each process should be subjected to varying conditions to obtain optimum process parameters.

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RESEARCH ON THE INFLUENCE OF BIOLOGICAL TREATMENT WITH MIXED BACTERIAL PREPARATION APPLIED TO SEEDS, ON THE GROWTH AND DEVELOPMENT OF ORGANICALLY GROWN TOMATO PLANTS

[1.]Vegetable Research Vegetable Research and Development Station Buzau, ROMANIA

Abstract: Biological fertilization techniques are pertinent strategies for an efficient and rational use of agricultural resources with minimal generation of adverse environmental impacts that may affect water resources, ecosystems or the quality of human life. In addition, biological fertilizers provide a wide range of possibilities for the development of conservative agriculture (CA) in different geographic, economic, and cultural backgrounds. Treatments with mixed bacterial preparations or with *Trichoderma* spp., applied to seeds, can have a beneficial influence on the growth and development of organically grown vegetable species. In 2019, the VRDS Buzau, within the Complex Project PN-III-P1-1.2-PCCDI-2017-0301/Contract 28PCCDI/2018-"SEDMAGRO", carried out research activity with 4 variants: V1-control; V2-mixed bacterial preparation applied: A-for seeds; B-at planting, 2.5g granules at the base of the plant; V3-fungal preparation based on *Trichoderma sp.* applied to the seed; V4-with seedlings obtained from bacterialized seeds (V2), and no treatment at the time of planting. The experiment was carried out in the ecological polygon, on an area of 350m^2. The applied culture technology was unitary, also the treatments applied for the prevention and control of phytopathogens. The tomato variety used was BUZAU 1600 cultivar.

Keywords: bacterialized seeds, mixed bacterial granules, tomato growth&development, *Trichoderma sp.*

INTRODUCTION

Treatments with mixed bacterial preparations or with *Trichoderma* spp., applied to seeds, can have a beneficial influence on the growth and development of organically grown vegetable species, according to studies conducted over time, "all strains of *Trichoderma* spp. have been able to stimulate the growth parameters of the plants, in different degrees", (*Paica A., 2020*) both in the country and abroad, "the growth potential of the plants induced by the species of *Trichoderma* spp. can be 20% higher than the control" *(Baker R., 1988)*.

Trichoderma spp. is a saprophytic (non-pathogenic) fungus, among the strongest in the category of antagonistic microorganisms, characterized by a great capacity for adaptation and rapid growth *(Ceausescu et al, 1979; Jitareanu G., 1999)*. *Trichoderma* spp. introduced into the soil improves the health of plants and increases disease resistance without eliminating other beneficial microorganisms. *Trichoderma* also stimulates plant growth and the production of phytohormones. *(Sbîrciog, 2017)*.

Council of Agriculture (COA) held various seminars as well as workshops on the application of biofertilizers, so that farmers would have the opportunity to understand the effects of biofertilizers and are willing to use them *(Levandovschi at al., 2017)*.

Farmers were invited to inspect the growth of AMF, Rhizobial or PSB inoculated crops in the fields and were encouraged to participate in workshops after viewing the successful outcomes of using biofertilizers.

The application of inorganic chemical fertilizers was thus significantly reduced to 30-50% *(Aggani S. L., 2013; Raja, 2013)*.

Biological fertilization techniques are pertinent strategies for an efficient and rational use of agricultural resources with minimal generation of adverse environmental impacts that may affect water resources, ecosystems or the quality of human life. In addition, biological fertilizers provide a wide range of possibilities for the development of conservative agriculture (CA) in different geographic, economic, and cultural backgrounds *(Carvajal-Muñoz&Carmona-Garcia, 2016)*.

In order to support farmers in these fields, new organic products have appeared on the Romanian market meant to be used in the agro-zoo-veterinary field: biofertilizers, silage agents, probiotics and immunomodulators *(Toader G. et al, 2019)*.

MATERIALS AND METHODS

During the second stage of the SIMPLANT project, the biological material used for the establishment of the experimental plot was represented by the tomato variety BUZAU 1600.

Characterization of the biological material: The BUZAU 1600 tomato variety was approved in 1977, being one of the most important creations of the Vegetable Research and Development Station Buzau. It is a semi-late variety (120-130 days), with undetermined growth, high vigor, tolerant to the attack of the main pathogens of tomatoes. The fruits are spherical, weighing 180-200 g, the average height of the fruit is 6.6 cm, the average diameter of the fruit is 7.7 cm, the number of seminal lodges is 5-6 and the color of the fruit is uniformly red at maturity (without green cover). The tomato

variety BUZAU 1600 can be grown in the open field (in a palisade system), in all areas of the country favorable for tomato cultivation.

The batch of tomatoes established on 20.05.2019 was organized in four experimental variants and the arrangement of the experiment was in randomized blocks, with 4 variants and 3 repetitions each. The surface of a rehearsal was 7.5 m^2:

- Variant 1 - was the control variant, tomato variety BUZAU 1600, without biostimulation;
- Variant 2 - was the variant in which biological treatment with mixed bacterial preparation was applied, created and inoculated by ICDPP Bucharest, applied in two stages (seed and planting), to the BUZAU 1600 tomato variety;
- Variant 3 - was the variant in which biological treatment was applied to the seed with fungal preparation based on *Trichoderma* spp., created and inoculated by ICDPP Bucharest, for the tomato variety BUZAU 1600;
- Variant 4 - was established with seedlings obtained from bacterialized seeds (V2), but to which the mixed bacterial biopreparation was not applied at the time of planting.

The land preparation started in the autumn of 2018 when the works for the chopping of the previous culture and the leveling of the land were executed. In the spring of 2019, the land was prepared with the cultivator and modeled on 140 cm (94 cm at the canopy) furrows.

The production of the seedling was done in the greenhouse multiplier. The seedling was produced by sowing in a germination bed. The sowing was performed on 01.04.2019 in 3 (three) variants. The culture started to emerge on 09.04.2019. The seedling was transplanted on April 22, 2019, in alveolar pallets, using sterile peat as substrate.

The care works applied to the seedling were: directing the vegetation factors at the optimal level for the growth and development of the seedlings. The ventilation of the space plays a very important role in the prevention of diseases, knowing that high atmospheric humidity favors the appearance of diseases in this culture environment, rational irrigation and the application of treatments to prevent and combat diseases and pests with ecological substances.

Before ten days planting the seedling in the field, it was hardened by gradually lowering the humidity, temperature and progressive aeration of the seedling production space.

RESULTS

Biometric measurements were performed on the seedling before the culture was established. As can be seen in table no. 1, following the measurements, differences were found between the 3 variants in terms of seedling height and root development:

- V2 - tall seedling, with well-developed root, with an average number of leaves;
- V3 - seedling with a more vigorous growth, lower seedling height, very well developed root, and an average number of leaves.

Tabel 1. Differences were found between the 3 variants in terms of seedling

No. Var.	Height plant cm	Root length /cm	G.M.V. Root /g	G.M.U Root /g	Height stem /g
V1	28,6	8,63	1,11	0,07	18,3
V2	35,5	13,1	0,55	0,04	24,1
V3	25,5	12,4	0,87	0,06	15,7
No. Var.	**G.M.V Stem / g**	**G.M.U Stem/ /g**	**No. leaves**	**G.M.V leaves /g**	**G.M.U leaves /g**
V1	2,4	0,1	6,4	2,9	0,2
V2	2,9	0,1	6,1	2,9	0,2
V3	2,0	0,1	5,6	2,5	0,2

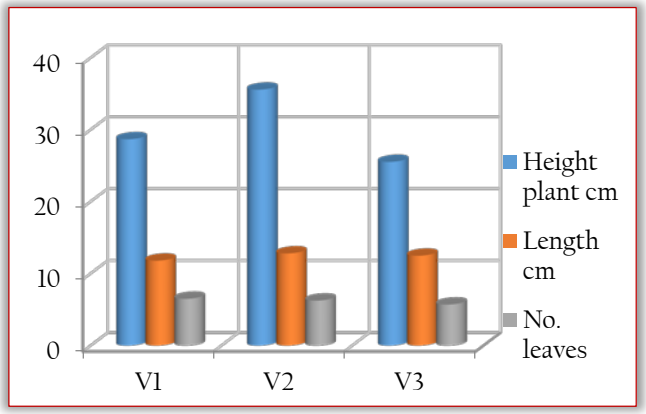

Figure 1. Differences between biometric determinations to V1, V2, V3

Figure 2. Trichoderma spp., created and inoculated by ICDPP Bucharest

Establishment of the culture: the planting of the seedling was done manually, on 20.05.2019, the planting distances were 70 cm between rows and 35 cm between plants / row, setting up 1,500 plants / solarium, the experimental variants were placed and the mixed bacterial preparation was applied to the base of the plant (2.5 g granules / plant) at V2 (photo no. 1)

Immediately after planting, the crop was irrigated by the installed drip system (photo no. 2). After 3 days from planting, the gaps were filled, manually, with seedlings of the same variants and of the same age as the one initially used. During this stage of the project were followed the growth and development of plants, under the influence of seed treatment as well as tolerance to the appearance of phytopathogens and the evolution of pathogens in tomato culture BUZAU 1600.

The experiment took place against natural infections. After the establishment of the culture and the filling of the gaps, the care works applied to the tomato culture were the general works, the irrigation of the culture being carried out whenever it was necessary (Figure 3).

Figure 3. Detail of the infinite culture

After 14 days from planting, the palisade and shoots removal were carried out. Manual weeding was done 4-5 times to destroy weeds and loosen the soil. Shoot removal was repeated periodically at about 14 days. Given the location of the experiment (in the ecological polygon), the treatments for preventing and combating phytopathogens and pests were also ecological. After 7 days from planting, the first pest that appeared in the tomato crop Buzau 1600 was the common red mite (*Tetranichus urticae*), which has a very aggressive attack on plants.

The treatments administered at its signalling were Laser, applied in a dose of 0.05% and Metab, in a dose of 0.25% (it was microactivated with the Nutryaction product). These products have managed to reduce the degree of attack of this pest until it is completely stopped. The treatment based on Bordeaux Juice was applied on 05.07.2019 in a dose of 0.5%, when signalling the appearance of the phytopathogenic agent *Phytophthora infestans* (tomato blight).

On 17.07.2019, the biological insecticide based on *Beauveria bassiana* was applied in a dose of 15 ml/m^2, when signalling the occurrence of the pest *Tuta absoluta* (tomato moth). On the same day, an organic fertilizer based on NPK (from SIRIO ORGANIC) was incorporated.

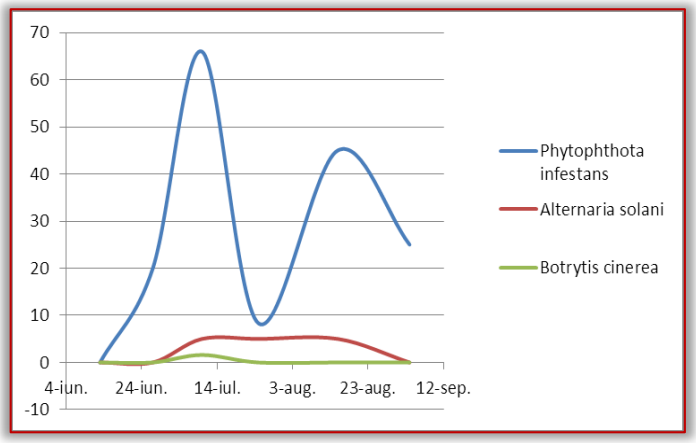

Figure 4. Evolution of phytopathogenic agents in the Buzau 1600 tomato crop in the ecological crop (%)

During the vegetation period, ecological products based on microorganisms, biological insecticide based on *Beauveria bassiana* from the project leader, the Research and Development Institute for Plant Protection Bucharest, Bordeaux Juice and Laser were administered.

The determination and monitoring of the attack of pathogens and pests was performed by means of indicators of frequency, intensity and degree of attack. For this purpose, dynamic observations were made, every 10 days, on the frequency of the attack (F%) and the intensity of the attack (I%), on the background of natural infestation. The degree of attack (GA%) was calculated with the obtained data. Biometric determinations were performed at 15 days, on each repetition being retained for observations and determinations 5 (five) plants.

In figure no.4 shows the evolution of the three phytopathogenic agents, *Phytophthora infestans* having a stronger degree of attack than the other pathogens. By administering Actiseed and Clonotri organic products, this disease has been greatly diminished, until it is completely stopped. The highest number of pests were *Tuta absoluta* and *Aphys gossypii*. Under the action of applied bioinsecticides, they were reduced to total cessation (Figure 5).

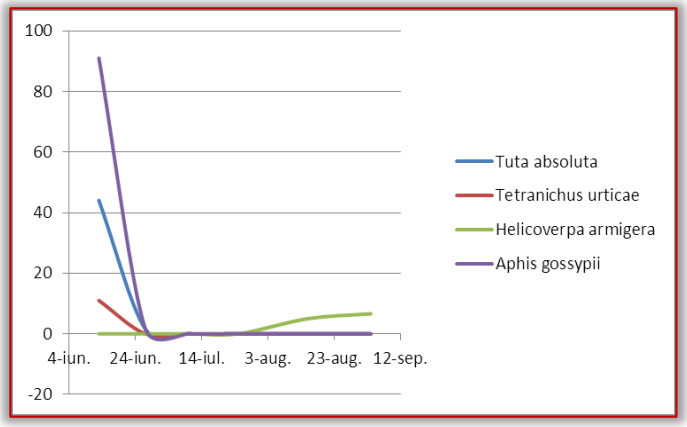

Figure 5. Evolution of pests in tomato crop Buzau 1600 planted in the ecological polygon (%)

Regarding the growth and development of plants, based on the results of biometric measurements and phenological observations, the following conclusions were reached: After the establishment of the culture, the plants developed normally, with small differences between the experimental variants in terms of average plant height, noting V3 (which used seeds with biological treatment based on *Trichoderma* sp).

Regarding the number of leaves per plant, it is found that V2 (the variant with bacterized seeds to which the mixed bacterial preparation was applied at the time of planting) had a richer foliar growth compared to the other variants. Regarding the number of inflorescences on the plant, it is observed that V4 (without the application of the mixed bacterial preparation at planting) has better results, but due to the high temperatures in July and August, the 3rd and 4th order inflorescences aborted in 75%, the 5th order inflorescences aborted in 50%, which greatly influenced the production (Figure 5).

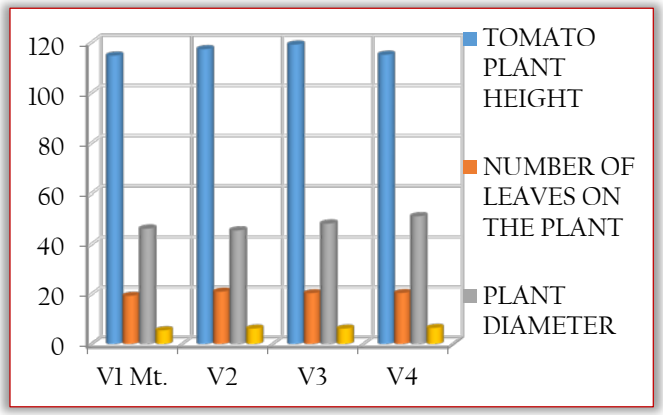

Figure 6. Growth and development of tomato plants Buzau 1600, SIMPLANT project

The fruit productions obtained on each variant following the harvests performed are presented in Figure 6.

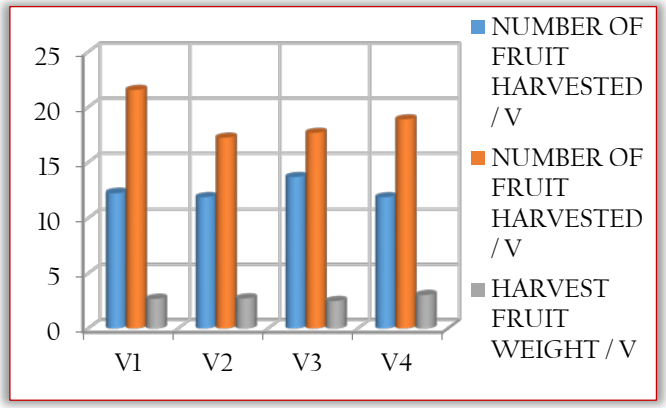

Figure 7. Productions obtained for the Buzau 1600 tomato variety

The harvests were carried out on 12.08.2019 (first harvest), 29.08.2019 (second harvest) and on 12.09.2019 the last harvest was made in the tomato crop, Buzau 1600 variety. The production was much diminished due to abortion of flowers formed between June 20 and August 30. Very high temperatures and atmospheric drought resulted in a 45% loss of production. The first 2 (two) inflorescences normally bore fruit on average 3 fruits / inflorescence, on the third inflorescence the abortion phenomenon occurred and on average 1 fruit / inflorescence was harvested (Figure 7).

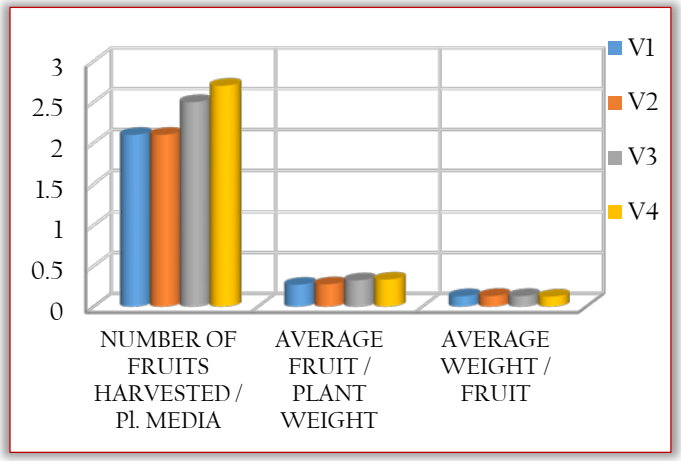

Figure 8. Presentation of the variation of the number of fruits / plant and of the average weight of the tomato fruits, Buzau 1600 variety

CONCLUSIONS

The fourth and fifth floors were 70% aborted, and the fruits formed were small, uncharacteristic of the variety. In the sixth floor the formed fruits reached the consumption maturity on average 3 fruits/inflorescence, but the average weight of the fruit was 85 g. In these conditions the variant with the most fruits harvested on the plant was V4. Regarding the average weight of the fruits, there were no significant differences between the 4 experimental variants, the main reason being the stressful climatic conditions in the summer months.

So, based on the main growth, development and productivity indices followed in the experiment, the degree of utility of the bacterial biopreparation applied to both seed and planting (V2) and of the fungal preparation based on *Trichoderma* sp. (V3) compared to the control (V1) without applied biostimulation treatment, the conclusions of the experience are the following:

- In the seedling phase the experimental variant V3 was distinguished by strong plant vigor, short internodes, strongly developed root, compared to V2 where the seedling was tall, with long internodes;
- After the establishment of the culture in the ecological polygon, the plants had a uniform growth and development, without big differences between the 4 experimental variants.
- Climatic factors, especially high temperature and atmospheric drought have caused significant losses in fruit production. In these conditions, regarding the production obtained on the plant and the number of harvested fruits, Variant V4 was highlighted.
- The applied culture technology was of unitary and general character, the treatments applied for the prevention and control of phytopathogenic agents also had a general and unitary character (it was not necessary to apply different treatments on variants).

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Note:

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Life Technological Platform", in Bucharest, ROMANIA, 30 October, 2020

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GENDER MAINSTREAMING INTO DISASTER RESPONSE AND RECOVERY

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Abstract: Although women are considered the most vulnerable group in the society; but very little attention has been made to take into consideration the issue of gender sensitivity during the phase of response and recovery in both natural and manmade disaster. In Pakistan, a very limited number of organizations are working to address the issue gender based Violence in disaster response and recovery. The goal of this paper is to synthesize and review the issue of disaster and gender mainstreaming. This paper highlight the gap areas in terms of disaster preparedness, response and recovery; and also critically analyzes the importance of the mainstreaming the element of gender in the phase of disaster response and recovery overall in general and specific in the context of Pakistan. Recommendations and suggestions of the paper can be used to design and implement comprehensive response and recovery plan by mainstreaming the element of gender sensitivity.
Keywords: Disaster, response, gender issues, recovery plan

INTRODUCTION

Disasters, both natural and manmade, strike all over the world equally in one form or another. Disaster are not specific to any geography, ethnicity or religion; Disaster don't discriminate as it is evident from Sandy hit the America, Flood-2010 hit Pakistan, Fire-2011 hit Australia, Earthquake in Japan, Droughts in Africa and lots of other examples. Disasters don't discriminate and its impacts are similar to all but it is the man response which diversifies and diverts the impacts of disasters. Disasters are the 21st century core issue men are facing. Since, 1990 after the declaration of International Decade of Natural Disasters significant work has been done to counter effect the impact of disasters [1]. But most of the steps taken are scientific in nature and don't take into account the social impacts of disaster, and gender biasness is one the core issue in disaster response and recovery that miss the shot.

Women and girls, who account for over half of the 200 million people affected annually by natural disasters, are typically at greater risk from natural hazards than men, particularly in low-income countries and among the poor. Natural disasters and climate change often exacerbate existing inequalities and discrimination, including those that are gender-based, and can lead to new forms of discrimination [2,3]. The term "gender" refers to the socially-constructed roles, behaviors, activities and attributes that a society considers appropriate for a person based on his or her assigned sex at birth.

It is obvious; if we look into the goals and objectives of International bodies and key stakeholders and local agencies that no or very little attention has been made to tackle the issue of gender biasness. Very limited number of organization are working address the issue gender based violence in disaster response and recovery, this clearly highlight the gap areas in terms of disaster preparedness, response and recovery [4]. International awareness of the importance of gender in humanitarian and development programs dates back some three decades, and national governments and international organizations have taken important steps to incorporate gender into disaster risk management policies and programs. And yet, in almost every major disaster of the past three decades, there are reports of women facing discrimination or neglect in assistance or recovery planning [5].

Women are typically more vulnerable than men to the effects of natural disasters and climate change, not only because of biological and physiological differences, but also, notably, because of socioeconomic differences and inequitable power relations. After natural disasters strike, pre-existing vulnerabilities and patterns of discrimination are usually exacerbated and women face protection risks including unequal access to assistance, discrimination in aid provision, loss of documentation, and inequitable access to property restitution Inter-Agency Standing Committee (IASC) operational guidelines on the protection of persons in situations of natural disasters [6,7,8]. The natural disasters and climate change often exacerbate existing inequalities and discrimination, including those that are gender-based, and can lead to new forms of discrimination. Although men and women's livelihoods were equally disrupted by the tsunami itself, women had a more difficult time recovering from this loss for many reasons including neglect from NGOs, lack of women's ability to engage in micro-credit program schemes, and lack of capacity building activities for women [9,10]. Prior to the tsunami women's income generating activities remained less substantial and after the tsunami, the international NGOs focused the majority of their development projects on the head of household, typically men, neglecting the widowed women. Women were overburdened with an increase of unpaid work, continuing to take on the responsibility of domestic duties

including caring for the sick, the elderly and children further limiting their ability to recover.

The main purpose of this paper is to evaluate the issue of disaster and gender mainstreaming, in terms of disaster scenarios, and to suggest recommendation for streaming the gender sensitivity. The methodology of "Meta-Analysis" is used for this study.

DISCUSSION

Disasters both natural and manmade whenever hit an area women are the ones who suffered a lot in every aspect i.e.in terms of social loss, economic loss, loss of livelihood and lives losses. This is not due to that disaster discriminate among different group but it is the human response that led to such discrimination in loss. Gender relations as well as natural disasters are socially constructed under different political, economic, social, cultural, geographic conditions and have complex social consequences for women and men. If we critically look into the phenomenon and various aspects of disaster we will realized the facts that why women carry the major weightage of loss in one form or another during disaster. In most of the disaster literature and research gender has been consider as demographic variable instead in the context of social and dynamic sets of relation.

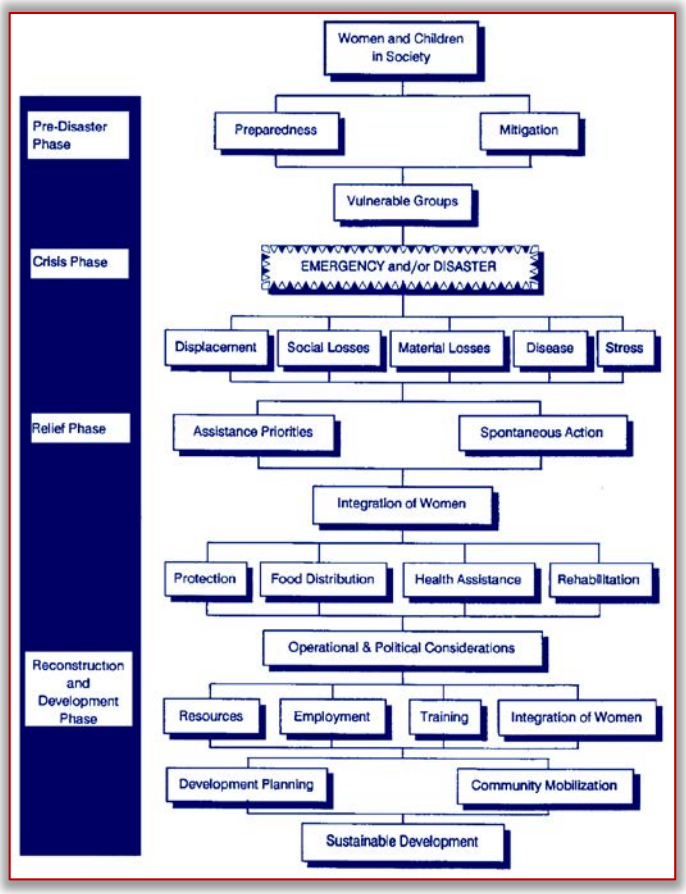

Figure 1. Temporal model of women and children in response to emergencies and disasters

Generally it is being consider that women are the victims of disaster because of their low economic status; and no significant steps have been take the analyze mainstream the element of gender in any stage of disaster neither pre-disaster nor post-disaster. Till neither now, neither the NGOs nor the governmental agencies have fully incorporated gender relations as a factor in disaster vulnerability and response, nor have they engaged women as stakeholder in disaster response and recovery [11]. The model in Figure 1, illustrates the scenario and identify the areas where gender streaming need to be done.

Although no specific data has been made available to categorize the economic, social, live and livelihood losses on the basis of gender; but it is estimated that more women loss their lives during earthquake 2005, more women loss their live during tsunami 2004, women are the most sexually abused in floods in Bangladesh. All these are not just a natural phenomenon that women are the most vulnerable but it is the human approach that exposed women to such situation and make women more susceptible. Keeping in view the model in Figure 1.0, this paper analyze the areas where there in shortcoming in terms of response and recovery and need to be done gender mainstreaming. These are protection, food distribution, health assistance and rehabilitation

In both natural and manmade disasters social and physiological differences as well as society norms and values disadvantage women. We have also observed that the evidence is ambiguous on whether these differences will affect women more adversely to a large extent or little. But it is evident that the prominent disadvantage that is got by women due to its physiological and social differences when we look into the practices of food distribution during the response and recovery phase of disasters, it is observed that usually food packets are drop by air operation or it is distributed at some points. In both these ways women are unable to get their due share, because of their physical nature and social constraints [12,13]. Women can't reach to food packages drop by air nor they get their place in queue at food distribution point and it is the women suffered at the end.

Protection is one the core issue that need gender mainstreaming. Disaster whether natural or manmade always induce displacement and during displacement women and children need to be taken care of as they are highly vulnerable in terms of gender based violence, especially in camps, where they risk higher levels of human trafficking and sexual abuse. During response and recovery phase the condition unintentionally made in such way that it creates a favorable environment for one to abuse women and children; all this happen because of not involving women in planning for disaster response and recovery.

Settlement of camps of food distribution point needs special attention to reduce the risk of sexual abuse and equal distribution. If food is not provided to women on separate distribution point and when they are excluded while management for camps from the phase of preparedness to response and recovery phase, women's vulnerability to sexual exploitation and abuse increases will be the end result . If women are to be involved in response and recovery planning they will better communicate about their need like showing concern about separate food distribution point, separate washrooms / latrines and special health needs.

Like other developing countries in Pakistan there is patriarchal hierarchy and women are ignored in the policies and procedures. Usually when disaster hit any area along with economic and social loss; there also occurs loss of livelihood. In most of disasters usually compensation is being made for the rehabilitation and uplifts of the community. In past like Earthquake 2005, and Flood 2010, 2011 all these compensation were made to the family head and as discussed earlier that Pakistan running a patriarchal hierarchy system this mode of compensation ignored women and mostly compensation were made to male as they were the family heads; in this way women were become more less empowered [14]. As we experience that disaster create set back development but disasters also create opportunity for development. Same is in the case of gender sensitivity; women can be empowered and their resilience can be build be gender is to be mainstream in disaster response and recovery; Like instead of making the compensation to be made to family male head; this compensation to be made to family female head, this will led to herd effect, and will improve the overall status of women.

The vulnerability resulting from predominantly female poverty is not confined to developing countries. A study by the Japanese government that showed that during the Kobe Earthquake in 1995 1.5 times as many women as men died. In Kobe, many elderly single women died because they lived in poor residential areas, which were more heavily damaged and more likely to catch fire; similarly studies identified that more women drowned in tsunami 2004 than men. In Indonesia, in the four villages in the Aceh Besar district surveyed by Oxfam for this report, only 189 of 676 survivors were female. Male survivors outnumbered female survivors by a ratio of almost 3:1. In four villages in North Aceh district, out of 366 deaths, 284 were females: females accounted for 77 per cent (more than three-quarters) of deaths in these villages. In the worst affected village, Kuala Cangkoy, for every male who died four females died or in other words, 80 per cent of deaths were female [15].

Now the question arises why women trapped inside the collapsed structures or engulfed by the waves of tsunami. This need an in-depth research but when we search the literature for emergency preparedness and response intervention one element common in all activities and that is; in all these activities women were not considered as stakeholder of these activities. Women generally take the role of house wife and bound to boundary wall of house, whenever capacity building or mock and drill exercise carried out in communities these major chunk of communities were ignored and that's why women don't know how to trap a collapsed structure or how to evacuate if there struck an earth quake; similarly in the case of floods and tsunami women don't know swimming as they don't get any trainings and that's why they are the one who suffered more than men. Figure 2, summarizes the area that need gender mainstreaming during disaster.

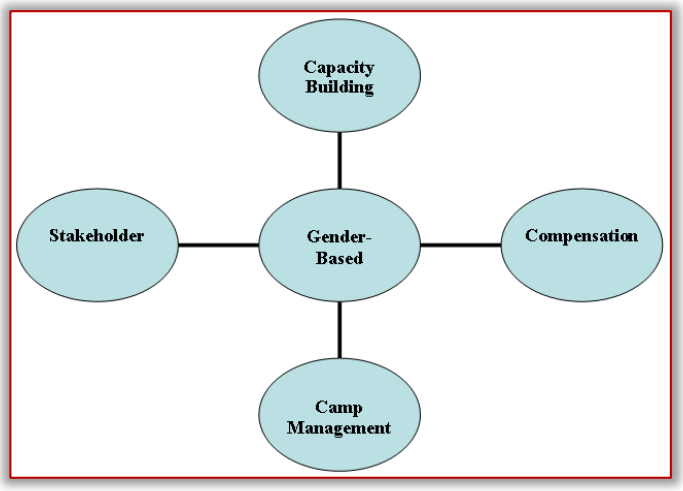

Figure 2. Gender mainstreaming during disaster

CONCLUSION AND RECOMMENDATION

To effectively respond to disaster and recover from disaster gender mainstreaming should be fully incorporated into disaster response and recovery planning. The data on disaster related to morbidity, mortality or other should be sex-disaggregated. If women are to be involved in response and recovery planning they will better communicate about their need like showing concern about separate food distribution point, separate washrooms / latrines and special health needs. Improve disaster preparedness, response and contingency planning from a gender perspective and make them respond to the specific needs and concerns. There is a need to increase awareness of disaster management practitioner and policy maker about gender bias in disaster practice, planning guidelines, and training. Recruitment and retention of gender-aware staff, and ways for professional accountability to gender issues;

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A BRIEF REVIEW OF THE APPLICATION OF THE SPM METHOD IN ORDER TO IMPROVE PREVENTIVE MAINTENANCE OF BEARINGS

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Abstract: One of the most important aspects of preventive maintenance is reducing the cost of maintaining and extending machines' service life. Any downtime of a particular machine entails the costs caused by the machine's inactivity as well as the costs of corrective maintenance, which are often many times more expensive than the application of some of the methods of preventive maintenance. By applying diagnostics as a preventive method, it is possible to predict the future failure of a particular element or assembly before a machine downtime/failure, which significantly simplifies maintenance, both on organizing maintenance and on the economic side. Today's tendency of diagnostics is the use of methods that do not require stopping the induction motor, and one of those methods is the shock pulse method - SPM method. This paper gives a brief review of the SPM method's use to diagnose the bearing failure and its advantages.
Keywords: SPM method, bearing, preventive maintenance, vibrations

INTRODUCTION

Maintenance policies are categorised into two main strategic streams: corrective and preventive. Condition Based Maintenance (CBM) is a subdivision of preventive methodology and is based on the belief that 99 per cent of equipment will evidence some sort of indicators prior to a fault develops. Through the utilisation of science and technology, CBM exploits the operating condition of assets to diagnose faults at early stages of occurrence, thus triggering proactive maintenance based on the need, [1].

One of the benefits of preventive maintenance is planning the moment of maintenance. By correctly choosing the method of testing the condition of an element, we can predict the replacement of an element that is currently operating within the allowable limits but is approaching the critical condition. This prevents the occurrence of major machine failures, reduces the cost of corrective maintenance as well as the cost of machine downtime due to the fault.

Proactive technical maintenance aims reducing the total volume of technique required servicing and maximizing service life equipment (i.e. the ideal creation of a "perpetual" machine that do not require technical services), systematic elimination of the source of the defect [2]. Diagnostics of asynchronous motors is an area that is developing very intensively in world technical practice. The literature mentions various methods by which it is possible to establish a whole range of failures of asynchronous motors. Today's tendency of diagnostics is the use of methods that do not require stopping the induction motor, and one of those methods is the shock pulse method - SPM method [3,4].

BASIC CONCEPTS IN SPM METHOD

— Vibrations

Vibrations are mechanical oscillations relative to the reference position. Vibrations occur as a result of dynamic forces in the moving parts of an asynchronous motor. The basic parameters of vibration are amplitude, speed and acceleration of vibration.

Vibrations in asynchronous motors are generally undesirable because [4,5]:

- intensify the process of wear of all moving elements,
- cause breakage of mechanical components,
- lead to the weakening of separable ties,
- lead to the failure of electronic components and systems,
- damage the insulation of the cables being touched,
- cause noise and
- cause damage and disease in humans.

— Diagnostic

The basis of diagnostics is the comparison of actual and desired behaviors, i.e. engine parameters. Diagnostic parameters help us in that, and that is why it is crucial to choose the right ones. The diagnostic parameter is a measurable physical quantity (vibration, noise, temperature, etc.) present in the process of engine operation.

The parameter must meet the following requirements [3,6]:

- unambiguity of change,
- sufficient sensitivity to change and
- accessibility and ease of measurement.

The main benefit of diagnostics is reflected in [3, 6]:

- transition from corrective to proactive
- maintenance,
- reduction of the risk of material damage,
- increasing operational reliability,
- increasing the mean time between failures and
- minimizing unplanned downtime.

— Bearings

Ball and roller bearings are among the most common and important elements in rotating machinery. Every rolling

element or anti-friction bearing has a limited life which is strongly influenced by installation, operating condition and the maintenance it receives. Machine reliability, efficiency and safety depend on bearings functioning correctly [7].
Great attention is paid to the study of bearings and their improvement. Furthermore, if in production the dimensions of the bearings deviate minimally from the ideal dimensions, due to the action of forces acting on the bearing, over time there are deformations in the bearing which leads to an increase in vibration.
The service life of roller bearings is limited. Even if the loads they are exposed to are within the projected limits, sooner or later there will be material fatigue and bearing failure. The time period until the appearance of the first signs of fatigue is a function of the number of cycles and the magnitude of the load. The life of roller bearings is defined by the total number of cycles that the bearing can perform before the first signs of damage appear. This does not mean that the bearing is unusable after that moment. As a rule, from the onset of the first signs of damage to the final stop, there is a sufficiently long period of time to plan and prepare for bearing replacement [8].
Moreover, if it is expendable, it is rare for the bearing to perform its intended service life. Other factors often cause bearing failures. An overview of the reasons for bearing failure is given in Figure 1:

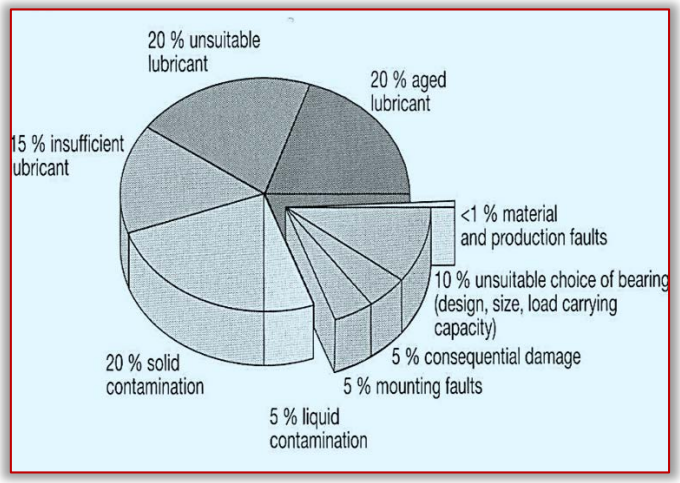

Figure 1. Causes of failure in rolling bearing [9]

SPM Method

The SPM Method (S-Shock, P-Pulse, M-Method / Measurement) or shock pulse method is one of the methods used to monitor the condition of bearings. As it rotates, the bearing acts as a pulse generator. This method is based on extracting these impulses and monitoring their behavior.
In practice, this method has proven to be reliable. After years of testing through this method, the results obtained on all types of bearings and regardless of the age of the bearings were of the same quality [10].
In the shortest terms, the SPM method, i.e. the device (SPM meter), is used to detect the development of mechanical shock waves caused by the collision of two masses. The SPM method is based on phenomena in the material that occurs in a brief period of time immediately after the first contact of body particles [8, 7].
Figure 2 shows one of the SPM meters.

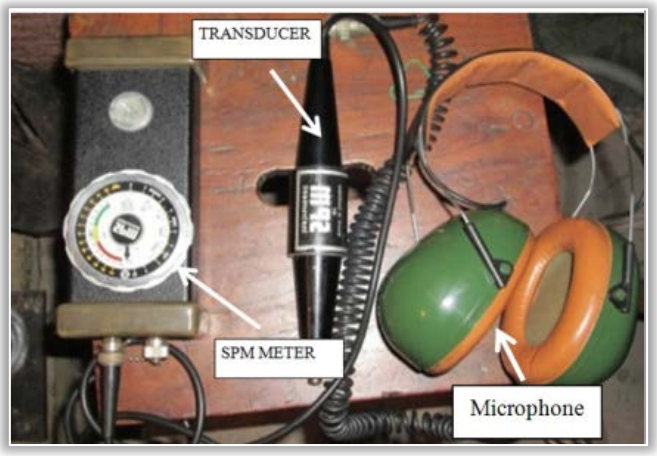

Figure 2. Shock pulse meter 43A with transducer and microphone [11].

ANALYSIS OF PREVIOUS RESEARCH

In the Automobile factory "Zastava" in Kragujevac, 180 asynchronous motors were repaired in 2005. More than a quarter of the share in these failures was bearing failure. Table 1 shows the percentage of failures in asynchronous motors [3]:

Table 1. Percentage of asynchronous motor failures in the Automobile Factory, 2005

Failure	% of failures
Stator winding	12,94
Rotor winding	29,65
Stator assembly	11,34
Rotor assembly	13,25
Bearing	26,5
Other	6,32

Failures of asynchronous motors used in industry have a 40 to 90% share in failures and downtime due to bearing failures. The percentage of failures depends, of course, on the size of the machine [12].
In order to prevent machine downtime, it is necessary to react on time and to determine the condition of the bearings in an easy and tested way before the machine malfunctions/downtime. The SPM method can easily, and without interruption in engine operation, give the result of the bearing condition.
By applying the SPM method and obtaining results that show the values of bearing malfunctions or bearing failure, the cause of bearing failure should be discovered and analyzed. Not infrequently, even if the obtained values show poor bearing performance, the reason does not have to be the failure of the bearing itself.
Bearing damage is just one of the possible causes of poor operating condition. Therefore, when inspecting the bearings, generally speaking, the following basic elements should be kept in mind [3]:

- Carry out a detailed visual inspection of the bearing itself, with control of the clearance (wear of the bearing elements). Inspect other elements of the bearing assembly, ie. whether the connections of the parts are loose, whether there is a contact of the rotating parts on the housing or the bearing cover, whether there is damage to the parts and the like.
- Imbalance of rotational masses, work in the area of critical speed, preload or high load of the rolling bearing leads to poor operating condition. It is needed on the basis
- information on the existing vibration levels on the bearing housing, which are inspected, eliminate the cause of any increased vibrations (imbalance, mismatch, loosening of mechanical connection, etc.).
- Contamination of lubricants also leads to high values of the shock impulse. In any case, the lubricant should be replaced before the final decision on bearing replacement is made.

Less than 1% (0.35%) of all bearings perform their intended service life, and as many as 55% of the causes of premature bearing failure are inadequate lubrication. From this, we conclude that premature bearing failure could have been avoided by proper preventive maintenance [9]. Damages of bearings indicate most often downtimes of the production cycles and cause the high costs and losses, especially in the more expensive equipment [13]. Timely detection of a bearing defect can avoid unwanted conditions, primarily due to operative delays of machine systems and direct and indirect costs in this regard [14].

After obtaining results that indicate poor bearing performance, it is not necessary to replace the bearing immediately. We conclude from the above that we should first check other aspects that may affect obtaining this type of result.

After the checks, a new measurement must be performed. Depending on the obtained values, three cases can occur [3]:

- The measured value decreases to an acceptable level and no longer increases. The cause was not the bearing,
- The measured value decreases, but after a few hours it increases again. The cause is damage to the bearing,
- The measured value does not decrease. The causes are greater bearing damage.

CONCLUSION

The prevalence of bearings in the industry is enormous. There is almost no machine that does not have a bearing in it. Therefore, maintenance, and especially preventive maintenance, is an essential thing in extending the service life of the bearing and thus the part or machine in which it is located. Proper preventive maintenance entails savings by avoiding corrective maintenance, machine downtime, or major machine failure caused by bearing failure.

With little investment in a preventive maintenance system, verified bearing condition results can be obtained quickly and safely by applying the SPM method. Also, we must keep in mind the reasons for the failure of bearings, which in most cases can be removed very easily as a precaution.

The training and expertise of the person using the SPM method must be at a high level because early bearing replacement does not solve the specific problem of high impulse results, which will lead to a repeated replacement of the newly installed bearing in a short time, and thus unnecessary maintenance costs.

Note:

This paper is based on the paper presented at IIZS 2020 – The X International Conference on Industrial Engineering and Environmental Protection, organized by Technical Faculty "Mihajlo Pupin" Zrenjanin, University of Novi Sad, in Zrenjanin, SERBIA, in 08–09 October, 2020

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SYSTEM APPROACH OF ASSET VALUATION MOULDING MACHINES

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Abstract: The system approach is one of the possible human approaches to the implementation of various activities, especially those that are associated with various types of analysis of objects and processes that take place on them, with cognitive processes, solving common and professional problems, but also activities such as thinking or acting. The contribution addresses the problem of the systemic concept of asset valuation. The main challenge is to present the systemic concept in practice. The issue is analyzed in the form of a case study on moulding machines. The paper contributes to the objectification of approaches to the valuation of moulding machines allowing experts to base their subjective assessments on objectified valuation material and thereby create the conditions to further develop methods for valuing machines based on clarified and generalised approaches.
Keywords: system approach, system of essential quantities, valuation, usefulness

INTRODUCTION

The value of moulding machine, as well as other movable property, depends on its usefulness. In valuation, it is generally true that the higher the usefulness of the valued object, the higher the possible utility of the entity with the right to the object, the higher the value of the object for the eligible entity, and the higher the achievable price at its eventual sale [1].

Usefulness expresses the satisfaction of the needs brought to the consumer by the consumption of goods and services. Usefulness depends on the quantity of goods and services consumed, their characteristics, their quality, as well as the subjective feelings of the consumer. Usefulness in economics is expressed in monetary units [2].

The usefulness thus depends on the characteristics of the valued moulding machine (its design and condition), the characteristics of its surroundings (its design and condition) and the possibilities and method of handling the valued moulding machine. The most common method of valuing machines is market-based. The value of the machine is determined by comparison with identical or comparable machines for which price information is available.

As reported by International Valuation Standards [3], the market approach is applied in the case of a sufficiently large market and executed transactions. The subject of the transaction should be substantially similar assets. These criteria are often not met. A market-based approach can be applied even when those criteria are not met, for example assets are not sufficiently similar, the differences between them are significant. However, in this case, a comparative analysis of the qualitative and quantitative similarities and differences between comparable assets and the asset being measured needs to be made and the necessary adjustments made.

Approaches to the valuation of moulding machines are known. But solving these problems is not easy. These are always complex problems where the level of solution is very significantly influenced by the expert's level of expertise, subjectively. One method for solving complex problems is a system approach.

The system approach is one of the possible human approaches to the implementation of various activities, especially those that are associated with various types of analysis of objects and processes that take place on them, with cognitive processes, solving common and professional problems, but also activities such as thinking or acting. It is a tool of scientific and practical knowledge, contributing to the effective implementation of cognitive processes and thus to the solution of problem situations on structurally and procedurally complex entities, regardless of their sectoral nature. The system process is then a generalized problem-solving algorithm, respecting the system approach, requiring system thinking and using system methods [4].

When solving problems using system theory, it is necessary to distinguish between a real system and an abstract system. The real system is [5]: „at some level of resolution, a structured real or abstract entity with system properties.“ We understand the abstract system as [5]: „abstract entity, purpose-built on entity Ω (real system) from the point of view of the solved problem.” It is usually a system of essential quantities and includes those characteristics that are essential for solving the problem. In solving the problem, it is then necessary to apply those system approach attributes that describe the material facts in relation to the analysis of the assessed object.

The essence of the scenario for solving causal situations [5] lies in this consideration: „an entity with certain properties is influenced by the environment and subsequently influences this environment“. In the context of this definition: „It is characteristic of each entity Ω that it has a certain environment, shape (geometry), and that in the surrounding area, it occupies a certain position (topology). It has certain ties with the environment, through which interactions are realized that activate and influence the entity. The entity manifests itself in its environment in a

certain way, which has certain consequences. If an individual of the above characteristics of an entity, that is from the surroundings, topology, geometry, bonds, activation, influence, processes, conditions, expressions and consequences, thus, from the set of characteristics $\chi(\Omega)$, selects those, that are essential for solving a specific situation, receives a set of essential parameters $\Pi(\Omega)$ and of which the system of essential quantities $\Sigma(\Omega)$.

CREATING A SYSTEM OF ESSENTIAL QUANTITIES

In accordance with the system approach, it is appropriate at the beginning of the solution of any problem, hence the valuation, create a system of essential quantities $\Sigma(\Omega)$, whose completeness and level significantly influence not only the approach and choice of method to solve the problem, but also the credibility of the results of its solution. This system is divided into seven subsets of quantities, that comprehensively describe all the essentials, what is related to solving the problém (Figure 1).

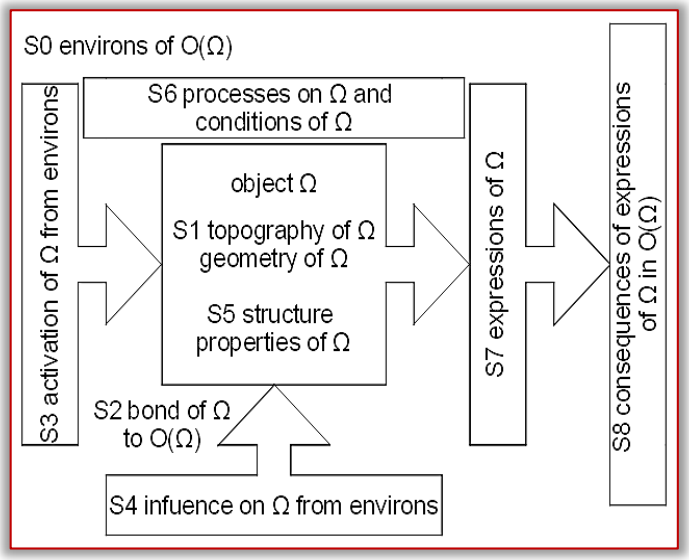

Figure 1. Subsets of quantities of the substantial quantities system Σ(Ω); modified [5]

Technical-economic expertise deals with property valuation, solves problems based on knowledge of structure, activation and influence, assesses the conditions and quantifies expressions (i.e. the potential benefit from the point of view of the entity from whose point of view the valuation is made) *[6].*

The case study is focused on the technical object of the moulding machine. Based on the above facts, the valuation problem can be formulated as follows:

„Analyze usefulness of the moulding machine."

The formulated problem is solved on the real system's moulding machine - the press brake. The moulding machine is a system of engineering (has the ability to realize production). Is an open system (the target behavior is influenced by the properties of the environment), fully structured, dynamic (properties are variable with time) and stochastic (quantities describing the quality of the moulding machine have a random character). From the above characteristics, it can be concluded that it is a hard system. The moulding machine has its usefulness, for which it generally applies, that the greater the usefulness, the greater the value of the machine and the greater its achievable price in the event of a sale. The usefulness of the moulding machine depends on the time, for which it maintains an acceptable level of properties (quality). Primarily, the quality of the moulding machine is based on functional characteristics, further safety, durability, economy, ecology, etc.

Subsets of systems of essential quantities $\Sigma(\Omega)$ contain these quantities:

- Subset S0 – Environmental quantities describe the environment in which the moulding machine is operated, temperature conditions in the workplace, etc.
- Subset S1 – Object quantities express the location of the moulding machine in the workplace, the distance from other machines.
- Subset S2 – Binding quantities describe substantial bonds with the environment and the interactions that take place there (moulding machine-subject).
- Subset S3 – Activation quantities are design, quality of production, operation or disposal of the moulding machine.
- Subset S4 – Influential quantities may describe, for example, the setting of the moulding machine, maintenance, repairs and service.
- Subset S5 – Field quantities express the properties of the moulding machine. The properties depend on the design of the moulding machine, resp. its structure and condition. Structures can be analysed due to structure groups (Figure 2). The structure of the moulding machine allows its function.

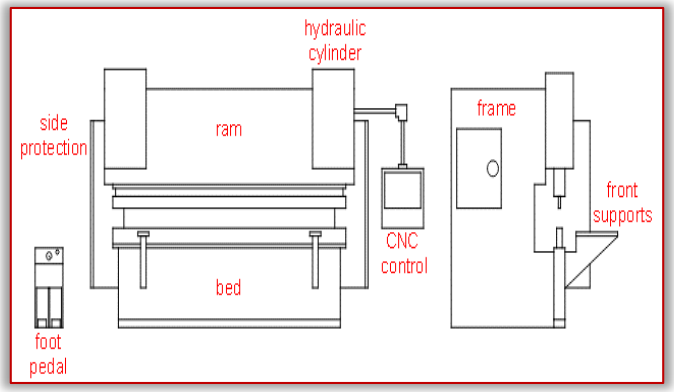

Figure 2. Some elements of a typical CNC hydraulic press brake; author

The properties of the moulding machine are described by many parameters and due to technical progress and developing new technologies and functions. It is a dynamic parameter system (e. g. compression force, bending lenght, stroke).

- Subset S6 – Process quantities describe the processes taking place on the structure of the moulding machine. These quantities put the moulding machine in a different technical condition. The technical condition of the moulding machine is described by condition variables, that describe its properties at a particular time. Technical state of the moulding machine may take values from the interval < excellent; unsuitable>.

— Subset S7 – Expression quantities is benefit to the subject. This depends, for example, on the quality of the products, the operability of the moulding machine, the profitability of repairs of the moulding machine.
— Subset S8 – As a result of the decrease in the level of properties of the moulding machine, its usefulness also decreases (the value decreases).

For this type of problem (valuation problem), the inputs to the solution algorithm are quantities from the subset S0, S1, S2, S3, S4 and S5. The output is then the quantities from subsets S6, S7 and S8. Of the subsets of all characteristics, only essential characteristics need to be considered. It is important to take these quantities into account when quantifying the usefulness of the moulding machine and expressing its value.

CONCLUSION

To solve valuation problems in expert activities, it is appropriate to apply a system approach. A system approach is a tool of scientific and practical knowledge, contributing to the effective implementation of cognitive processes and thus to the solution of problem situations on structurally and procedurally complex entities, regardless of their sectoral merits. The system $\Sigma(\Omega)$ is an abstract entity, purposefully created by the subject on the entity Ω (system) from the point of view of the solved problem. The formulated problem is solved on the system of the moulding machine and its usefulness is analysed. Following the detection of significant quantities related to the problem, the standard method of calculating the value of the moulding machine is chosen. From the above the author concludes that the presented procedure is an important step that can lead to the right conclusion and verification of results in the valuation reports.

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HOUSING DEVELOPMENT AND OWNERSHIP BY WOMEN: A REVIEW

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Abstract: This paper presented a review on African on housing ownership, women and development, women as decision makers in housing choice, barrier to women participation in housing production and management, ways women have contributed in housing production and management and gender issues in housing and planning. Studies on gender and housing have focused on various issues relating to several areas such as roles of women in housing development and their involvement in decision making. In development of housing, women face challenges as cultural factor affect their involvement in housing developments processes. Also, socio-cultural and traditional practices, norms and beliefs inhibit women's engagement in housing developments processes. Government policies should be enacted to encourage female participants in housing development processes in order to bring a change process as women are leading actors in this area of decision making. Patience is needed to achieve the desired goals in order to make urban housing development acceptable for both men and women.
Keywords: housing, ownership, women, development, management

INTRODUCTION ON HOUSING DEVELOPMENT

A series of studies have been conducted on the factors influencing participation in housing development in general and urban housing development in particular (Larson 1991; Macaloo, 1990 & 1994; Ntege 1992; Obbo 1976; Republic of Uganda 1992a; Rondinelli 1990). With regard to the social aspects of housing development, Sengendo (1992) describes housing as an expression of ways of life; a process by which people express themselves, their status, aspirations and social relations. House ownership in most African society is largely constructed as a male preserve (Obbo, 1976). Agbola (1990) pointed out that the decision to own housing is usually apportioned to men as heads of households according to the patriarchal system. For instance, among the Konjo ethnic group of western Uganda, the norms and beliefs against women's ownership of land is so high that landowners may refuse to sell land to a female even if she has ready cash (Mariye, 1993). It is argued among the Konjo that selling land to a female amounts to encouraging "prostitution", which sets a bad precedent for their (Konjo) girls and women. Ntege (1992) similarly notes that young women are often threatened that if they "go too far" in education, owned property or accumulated "too much' money, they will jeopardize their chances of marriage. As far as women are concerned, house ownership is for the hopeless, those who will never marry, i.e. widows, prostitutes, senior spinsters, the frustrated and the divorced. Ntege (1992) adds that these social tactics not only prevent women from purchasing land or pursuing their inheritance rights where they existed, but also discourage them from optimally utilizing these resources. It is probably in this context that Berry (1989), states that people's ability to increase their assets depends not only on their access to productive resources, but also on their ability to control and use them effectively. Berry (1989), cautions that this ability depends on participation in a variety of social institutions. In the case of women's engagement in urban housing development, the social institutions discourage women's utilisation of resources to develop their own houses. Some women, especially second wives, leave their husbands when they acquire land as they consider it unnecessary to work on someone else's land at the same time being responsible for dressing and feeding themselves and their children. Quoting Bujra (1976), Lee Smith (1997) cites a woman who was heard saying, *"My house is my husband"*. Implicitly, the marital contract entails men providing property. Hence, if a woman could acquire her own property, the acquisition through the husband (marital bond) may become nullified thereby reducing the necessity of having a resident, full-time husband. In his submission, Okewole (1997) opined that there are prejudices and conceptions about women accounted for by cultural norms in Africa, especially the south west zone and few other areas in Nigeria. For example, the Yoruba tradition does not see the need for a woman, single or married, to have any other residential accommodation other than her parent's and her husband's house. In addition to this, the customary land tenure system gives authority only for household heads, usually male, to be allocated the communal land. Any land owning propensity by a woman is believed to be a constraint and bound to have a negative effect. Another cultural belief is in the inheritance system, where the male child is considered more important and willed all the family possession and property. This is because of the belief that the male child will develop the ancestral home while the female child will only get married and allow family properties pass to strangers or non-members of the family. Hence, decision to own housing is usually reserved for men as head of households according to the patriarchal system (Agbola, 1990). Female attempts to gain access to housing are often frustrated and met with resistance in a male-dominated structure. She is often looked at as being too ambitious if she aspires to own a house.

Although the United Nations Charter of 1945 and the 1948 Universal Declaration of Human Rights have enshrined the principle of equity, little progress has been achieved in the area of equality between men and women in Africa. The contradictory situation in Africa today places women as important producers and reproducers on the one hand, and as political, social and economic subordinates on the other. Resolving this paradox is the most challenging need facing African women today.

GENDER ISSUES IN HOUSING DESIGN & PLANNING

Housing development is conceptualized in its broad aim and objectives, and actualized in its eventual ability to enhance livability. This depends on a hub of information needed, which are best provided by women who are best users of shelter and infrastructures. Unfortunately, they are never consulted and their opinions are usually treated with levity. At micro level of housing construction and delivery, it is common to notice that woman's wishes have not been integrated into set standards. They are often expected to adapt themselves to the finished products as regular maintainers of those properties. However, most women often nurse this quest, especially if circumstance does not allow them to express such over time. But in situation where they have the opportunity to voice out their desire, they often criticize the plan and male engineers. According to them, the design of the toilets creates room for spaces which exposed their feet while using the toilets. This design violated their notion of privacy (Agbola, 1990). In everyday life, women seem to lay emphasis on the space provided for kitchen and its attendant utilities and not necessarily on spacious living rooms nor exotic bedroom. It is very conventional to see women requesting spaces to store extra water, extra fuel (e.g. firewood) to plan for days when normal supply seems to disappoint. In view of this, women idea and concept should be incorporated in planning and designing buildings. But rather, this has been dominated by men whose perception, thought and designs have resulted in today architecture and city designs. This trend, according to Agbola (1990) tends to have forgotten the historic role of women in housing participation and involvement. In this wise, men principles of design tend to run parallel to women conceptions. While women have a tendency to design from inside to outside with a view to make housing area function as a social and cultural unit, men tend to go entirely in opposite direction.

There are at least three points of entry to apply a gender perspective to housing and planning Larsson (2001). They are women's access to housing, women's participation in the planning; and Women's needs and priorities in the design of dwellings and spatial planning. Women's access to housing can be discussed in terms of constraints based in laws, in prevailing ideologies and financial rules. Women's participation in various processes is a key issue in both housing and planning projects and crucial for identifying women's needs and priorities in the design of housing, and in spatial planning. A number of common situations, mainly from Southern Africa, illustrate the constraints in women's legal of financial access to housing. Professionals in housing must be aware of these constraints in order to avoid unnecessary and unintentional discrimination against women in the design of housing projects. After that, women's participation in housing and planning processes will be considered, with arguments for using a bottom – up rather than a top – down approach. After a comment on some general perceptions of domestic and public spheres, some design issues that have emerged recently are presented.

WOMEN AND DEVELOPMENT

Women over time have always contributed to development through home management, environment management, agriculture, income generation etc. such contributions have been made as individuals and as group through organizations. According to Akinola (1999), the amounts of hours women devote to economic activities are very enormous. The maintenance of existing stock of shelter and infrastructures in any community is an important aspect of providing such infrastructure and facilities. In this process, women because of their domestic locus have traditionally played a major role. In many societies, the day-to-day maintenance of the immediate environment is regarded as the women's duty. The involvement of women in maintenance is for three main benefits namely: To achieve better results and prevent the settlement from degenerating into a slum; cut down cost of renovations and repairs and servicing of infrastructures.

— Women, Housing, Poverty and the Domestic Space

Women generally are endangered by poverty and a times failure because of the challenges around them. A Nigerian woman is dissatisfied and poor because she can neither afford nor make use of the abundant opportunities available to her, particularly in the housing industry. These opportunities range from ownership and accessibility of housing, land acquisition to building construction. The few that have been able to grasp this opportunity had obtained it through a man by the process of marriage (Agbola, 1989). Housing problem affects women mostly not only because up to half of the households in many low-income areas are headed by women but also because women are the primary users of housing through their responsibility for the welfare of the household (UNCHS, Habitat, 1986). In his submission, Okewole (1997) opined that there are prejudices and conceptions about women and that for example, the Yoruba tradition does not see the need for a woman, single or married, to have any other residential accommodation other than her parent's and her husband's house. Another cultural belief is in the inheritance system, where the male child is considered more important and willed all the family possession and property. This is because of the belief that the male child will develop the ancestral home while the female child will only get married and allow family properties passed to strangers or non-members of the family. Hence, decision to own housing is usually reserved for men as head of households according to the patriarchal system (Agbola, 1990). Her attempts to gain access to housing are often frustrated and met with resistance in a male-dominated structure. She is often looked at as being too ambitious if she aspires to own house. Due to high rate of urbanization in

many urban centers in Nigeria; most of the houses provided are with exorbitant prices of rent thereby subjecting the low-income earners to live in majorly poor quality houses with inadequate or no infrastructural environments and amenities.

— Women's Role in Housing Construction

Women are very active as men in building the family house, particularly in area of manual labour and efforts to get adequate supply of materials like water, mud and sand as well as preparing food for the workers at sites. A study conducted in Dares-Salam (Tanzanian) by Mascarenhas (1999) on division of labour during housing construction process corroborates the above assertion with some findings and discoveries as shown in Table 1. The statistical data reveal that involvement in building process is affected by gender division of labour as women get involved in most of the unskilled works and activities more than men.

Table 1: Role played by women compared to Men in Construction processes

Construction Tasks	Women		Men	
Drawing house plan	19	15.8	52	43.3
Fetching of water	76	63.8	22	18.7
Collecting of mud	37	30.8	24	20.0
Collecting of grass	19	15.8	14	11.7
Pulling up of thatch	13	10.8	16	13.3
Total	120	100.0	120	100.00

Source: Mascarenhen (1999)

However, training of women in construction-related skill such as carpentry, masonry, bricklaying, electrical fitting and steel works have been carried out in many countries under various projects and programmes to enhance women improved participation in actual building construction. Notable examples are the Western Kingston Women Collective Construction (WKWCC) and the Women Self-Help Construction Project (WSHCP) in Panama (Agbola, 1990).

— Women as Decision Makers in Choice of Housing Units

In recent times, there has been a wide – spread proliferation of squatter and shanty settlements where the majority of the population of many cities in Nigeria has taken responsibility for their own housing provision. The conventions intervention of public projects by the government have also failed to satisfy low income housing demand, thus there has been pyramid shift in government housing policy to a diversity of assisted alternative "self-help" solution such as "sites and services" and 'upgrading' scheme as observed by Keonigsberger (1986). Agbola (1990); Moser (1992) and Asiyanbola (2000) observed that such self-help programmes involving the participation of beneficiary in all aspects of the project are recognized by international agencies and national governments as offering cheap alternatives housing to a large proportion of the urban population without major increases in the proportion of investment allocated to housing. In devising new housing solutions and policies, Agbola (1990); Moser (1992, 1993) Wood (1994); Young (1995) and Pascal (1997) observed that there have been age-long assumptions which do not fit the reality of women's live in the developing countries. The first assumption holds that the household consists of a nuclear family of husband, wife and two or three children. This assumption fails to recognize that low-income households are not homogenous in terms of family structure. Although nuclear families may be the dominant type, a diversity of other structure may occur. For instance, the changing social conditions, which disrupt traditional patterns of family and kinship, have brought about a rise in the number of female-headed households. Here, the male partner is absent, either temporarily because of migratory or permanently because of abandonment, divorce or death. Moser (1992) and Chant (1997) observed that an estimate of one third of the households is now headed by women. With the frequent retrenchment, collapse of financial institution and brain-drain syndrome, there are strong indications that such households have increased in Nigeria (Siyanbola, 2000). In such households, women shoulder almost all, if not all, the responsibilities of a male household head. Secondly, it is assumed that in the family there is a clear division of labour in which the man of the family, as the breadwinner, is primarily involved in productive work outside the home while the woman, as the housewife, takes overall responsibility for the reproductive and domestic work involved. This second assumption fails to recognize that women in low-income households perform "triple roles" (Moser 1992, 1993, Brett, 1991 and Young 1995). First, women works include reproductive works, childbearing and rearing responsibilities. Second, it includes productive works, often as secondary income earners, located within the home or in informal sector enterprise. Third, women works increasingly include community- managing work, the organizational jobs undertaken by women at the neighbourhood level unlike men; women are severally constrained by the burden of simultaneously balancing these three roles. Their reproductive and community-managing works are often seen as naturally or non- productive and are not valued as work. This role of women is individualized and is erroneously assumed that women have free time. This is why planners wonder why women fail to participate fully in self-help housing projects which rely particularly on their contributing work. This is particularly true in the case of female-headed household where the problem of the triple burden can be severe (Moser 1999, Young 1995 and Chant 1997). Implicit among these assumptions is the fact that within the household, there is equal control over resources and decision-making between men and women in matters affecting the household livelihood. However, recent studies by Olatubara (2003) shows that the husband takes a disproportionately higher fraction of decision in the choice of residential district a household lives in and the choice of house in such selected residential district. In both cases, the husband solely takes these decisions in more than 30% household surveyed in Ibadan while the wife takes decision in an average of 9% of all respondents. However, a good fraction of these decisions in an average of household (about

40%) jointly take decision between husband and wife. Discrimination against women in matters of housing has shown that the end products do not reach and /or substantially benefit the target groups (Kaushahu, 2000), especially the poor, majority of who are women.

BARRIER TO WOMEN PARTICIPATION IN HOUSING PRODUCTION AND MANAGEMENT

The lesser participation of women in the housing industry would be understood in terms of their (women) difficult position as compared to men with respect to their access to the needed resource for housing production and management. As highlighted by Ajayi (2000), the major constraint to participation in housing production is due to their socio-economic status. According to her, the 1999 constitution of the federal republic of Nigeria on fundamental objectives and directives, Principle of state policy, section 17, paragraph 3a and e; maintained that:

(a) All citizens, without discrimination on any group whatsoever, have the opportunity for securing adequate means of livelihood as well as adequate opportunity to secure suitable employment.
(b) There is equal pay for equal work without discrimination on account of sex, or any other ground whatsoever.

Despite the above national policy statement, the stereotyped images of the role of women in our society hinder their participation as contributors to housing development in the state. Until recently, the gender professional stereotypes streamed women into such professions as teaching, nursing, catering, secretariat activities and the like as observed by Etim and Awah, (1996). Therefore, few women are seen in technical-related professional because they are considered more masculine. This confirms the findings of Olurin (1996) that in Nigeria, physical planning has essentially been male-dominated profession with limited contribution from women. Few other works by other researchers, especially Anikpo (2000) and Agbola (1996) assessed the contribution of women beyond farm and household chores (subsistence). They noted that the narrow perception of women duties may be attributed to the late arrival of women in the colonial system or administrative works. Other barriers to women participation in housing delivery include education, cultural barrier and site constrains conditions.

— Ways Women to Participation in Housing Production and Management

Women are invaluable in housing and this has been observed over the ages (Olatubara 2007). They have also been noted as being the original home builders in the early civilization days. The major contribution of women in housing production could be highlighted as labour (Olatubara 2003) on construction sites, in production of building materials and fittings which include bricks, concrete blocks, tiles, roofing sheets, wash-hand basins and water pumps (Agbola 1988; 1990; and 1993). Other roles of women include: serving as crisis managers (Schmink,1985), playing monitoring role during construction against theft(UNCHS,1985,Agbola 1990); being actively involved in housing finance especially if the man has offspring for the man (Agbola, 1990) and being physically involved in actual constructions as observed in professional women in the built environment.

— Women as Beneficiaries of Housing

The international community is beginning to recognize that women lack of right in having access to and control over land, housing and property constitutes violation of human rights and contributes significantly to women increasing poverty. The United Nations Center for Human Settlement (UNCHS, 1985) affirmed that developing countries are seriously facing financial difficulties in allocating resources to housing, so that focusing on administrative and financial resources on the specific housing need of women is a secondary priority. A large proportion of world population is either homeless or live in extremely inadequate housing conditions. High proportion of this population constitutes of women who, though contribute immensely to development, seem to form part of the poorest population. This is quite obvious because they lag behind in their access to resources. Thus, they are vulnerable group, particularly in area of land/housing resources. They include poor female heads of household who are divorced, widowed, single working mothers or separated. It also includes elderly ones, the physically and mentally challenged, the battered, refugee and destitute women (UNCHS, 1993). Although, provision of housing for the battered women are given some considerable attention in developed counties like England where about 11,400 women and 20,850 children were accommodated in one year in about 150 refugees homes, similar programs are being experimented in some parts of Nigeria and many other developing countries. For instance, in Ebonyi state, several self – contained bungalows were constructed to house widows in 2004, which was undertaken by the First Lady, Mrs. Eunice Ukamaka Egwu. These widows were predominantly those maltreated by the cruel hands of obnoxious traditions. There is need for improvement on this few examples as these efforts seem to be infinitesimal compared to the backlog of challenges in housing demand by this group of people. Meanwhile, single-parent, separated and divorced women are yet to receive any attention from any quarters. Concrete measure however seems difficult to formulate for now. They are either too costly or require a broad- based scheme whose main target is female population in urban and rural areas for housing programs consideration. In some traditional societies, housing was part of women's domestic sphere rather than men's public sphere. Women were, for instance, in charge of the various houses within a traditional dwelling. They might even, as was the case in Tswana society, be the builders of traditional houses (Larsson and Larsson, 1984). There is need to develop gender awareness among the professional men and women in order to make them be aware of gender issues within their professional field, and women at grassroots in order to create networks among them and support them to act as watch dogs in development processes.

CONCLUSIONS

A review on housing ownership as it pertains to women involvements as women as decision makers; barrier to women participation and ways women they contributed in

housing production were discussed in this paper. Studies on gender and housing have focused on various issues relating to several areas such as roles of women in housing development and their involvement in decision making as attested to by findings from the studies of Agbola, (1990, 1993); and Olatubara, (2003). These studies offered different ideas for the development of housing and the challenges being faced by women in housing production. Cultural factor is depicted as a major predictor of female involvement in housing developments processes thus policy guidelines for adequate women involvement in urban housing development in especially in Southwest Nigeria. Women should be encouraged via the societal and community system within the family and through broad and specific policies and initiatives within the urban sector. Women should be freed psychologically from men's oppression and from socio-cultural and traditional practices, norms and beliefs that inhibit women's engagement in urban housing development. Gendered social structures and relations should be addressed by embedding it in housing development by bringing those female participants who had already successfully engaged in housing development processes to bring a change process as leading actors. However, most of these recommendations may meet resistance at the initial stage of their implementation as against the cultural 'norm' and 'beliefs' which appear 'natural' and somehow 'right;' persistence and patience is needed to achieve the desired goals and to make urban housing development acceptable for both men and women.

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DISASTER RESPONSE AND RECOVERY IN CONTEXT OF PUBLIC HEALTH

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Abstract: From the last several decades the number of natural disaster are occurring at regular interval, and they hit the communities very hard leaving devastating impacts. This paper reviews the impacts of disasters events on public health and the importance of incorporating public health intervention a part disaster response and recovery. The area of public health is an important and demanding one, any ignorance in this area super imposed the devastating impacts of disasters. One of the key components of disaster response and recovery should be the priority to prevent the outbreaks of epidemics and prevent further deterioration of affected population. By incorporating public health intervention in response and recovery phase morbidity and mortality can be reduced to a great extent. This paper overview the major issues in line with Pakistan disaster response and recovery plan in terms of public health for natural as well as manmade disaster.
Keywords: public health, epidemics, disaster, recovery plan

INTRODUCTION

Generally it is believed that natural disasters always accompanied by communicable diseases. It is believe that the risk for outbreaks is certain and usually presumed to be very high in the aftermath of natural disasters. In fact the risk factors for outbreaks of epidemics after disasters are primarily associated with displacement of population, the degree of crowding, presence of water and sanitation services, clean drinking water accessibility, the availability of healthcare services, the underlying health status of the population, all interact within the context of the local disease ecology to influence the risk for transmission of diseases and death in the affected population.

Disaster results in social loss, economic loss and loss of livelihood. All these losses are superimposed by secondary hazards. Because when disasters strike it led to both structural and non-structural damage. Structure damage includes loss of power supply, water supply, blockage of sewerage system and contamination of drinking water. All these damage point towards one end result that is high risk public health. Disasters all over the world are occurring at regular interval leaving devastating impacts. Previously disasters were not taking into serious consideration and post-disaster intervention remains the priority intervention to mitigate the impacts of disaster; because these disasters were considered as act of God. But with the advancement of science and technology man realize that disaster are the outcomes of hazards and that, that its impact could be mitigate to a great extent [1,2]. For this purpose certain guidelines and standard operating procedures were set in with the passage of time. But unfortunately Pakistan couldn't get much benefit with guidelines of HFA (Hyogo Framework Action), as there are so many issue lie within the response plan i.e. National Disaster Response Plan - 2010.

Pakistan has design its response plan i.e. National Disaster Response Plan 2010 (Pak NDRP-2010) and approved since March 2010 with built-in strategies, measures and standard operating procedures to deals with the disaster s and counter-effects the impacts of disaster to maximum possible level, but still Pakistan couldn't improve the quality of life of public and couldn't prevent epidemics and out breaks. Epidemics of Measles, dengue, malaria, cholera etc. break at regular interval, this indicate that there is something lack in the response and recovery planning [3,4,5].

The overall purpose of this paper is to critically analyse the Pak NDRP-2010 and to critically review the element of public health in the context of response and recovery. To outlines the requirements for effective emergency medical and public health response to the events of both natural and manmade disasters.

A LITERATURE REVIEW

Previously immediate impact of disasters were believed to cause not only massive social disruption, widespread death, but also led to outbreaks of epidemic disease, making community completely paralyze and made the survivors completely dependent on aid from outside. If we systematically observed the impacts of natural disasters on human health it will led to different conclusions, both about the most effective ways of providing humanitarian assistance and about the effects of disaster on health. Due to its geographical and strategic location Pakistan always remain highly exposed to both natural and man-made disaster.

After natural disaster the risk for outbreaks of epidemics low, especially when the disaster does not led to substantial displacement of population. When displaced population have poor access to clean drinking water and proper sanitation, primary health care and adequate shelter then communicable disease is common [6]. All these are favorable condition for the transmission of disease, and must be immediately addressed with the rapid reinstatement of basic services. Assuring access to safe water and primary healthcare services is crucial, as are surveillance and early warning to detect epidemic-prone diseases known to occur in the disaster-affected area. A comprehensive

communicable disease risk assessment can determine priority diseases for inclusion in the surveillance system and prioritize the need for immunization and vector-control campaigns.

To determine the local, state and federal resources that are necessary to respond to disasters, Jonathan L. Burstein has suggested a model defining the preparedness and response problem in terms of systems, supplies, staff, and space. The systems component of the model seeks to address the communications and logistics needed to prepare for and respond to crises [7,8]. The supply variable addresses the drugs, vaccines, and basic necessities; housing, food, and water that victims need, and how to best distribute those resources among affected communities. Staff considerations include training and credentialing adequate numbers of volunteers and ensuring their safety throughout the response effort. The final component of the model, space, takes into account the physical space needed for patient care, isolation, if necessary, and the distribution of community prophylaxis [9]. Upgrading the public health and health care systems by strengthening systems, supplies, staff, and space, will allow local, state, and federal governments to better respond to disasters [10,11].

If the public is given honest information, inappropriate behavior will be less likely and many people may even be comforted by the message. In addition, noted the value of refraining from delivering completely negative messages. As a result of the emotional component of disasters, if the spokesperson needs to deliver one negative message, it should be balanced with at least three positive messages [12]. Negative words are very difficult to overcome in the context of a crisis; therefore, honest messages should be delivered using positive or neutral words. At the same time, emphasizing the value of not over-reassuring the public because, if the crisis situation intensifies, the spokesperson and the organization will lose their credibility. Instead, the communicator should acknowledge the uncertainty surrounding the disaster, express that a process is in place to learn more about it, acknowledge the public's fear and misery, and ask that the public work with responders to find a solution [13,14].

It includes creating awareness in communities about the natural signs of disaster, identifying and developing escape routes and elevated ground and training volunteers on how to manage disasters. Disaster management includes three key components: risk-reduction, preparedness and response [15]. In Pakistan the first point hardly receives any serious attention, the second component is inadequate and the third is in shambles.

DISCUSSION

In past Pakistan was hit by major disasters that lift devastating impacts in every aspect of life whether that is social, economic, physical or political. Previously some major accident of natural disaster that occurred in Pakistan are floods of 1950, 1976, 1977, 1978, 1988, 1992, 1998, 2010, 2011 and 2011; Earthquakes of 1935 Quetta, Huns 1974, Kashmir 2005, Drought 2000, 2010 and Sakrdu Avalanche. The 2010 Pakistan floods directly affected an estimated 14-20 million people, and killed over 1,700. Nearly 1.1 million homes were damaged or destroyed, and at least 436 health care facilities were destroyed. The flooding lasted almost six months in some areas and caused $9.7 billion in damage in forty-six of the country's 135 districts. The impact on the rural economy, including agriculture crops, livestock, animal sheds, personal seed stocks, fertilizers, agricultural machinery, fisheries and forestry, was unprecedented [16]. Infrastructure losses were widespread including 2.9 million damaged households, of which 1.9 were severely affected or completely destroyed, and 80% of food reserves lost.

As a result of the irregularity and increasing frequency of both natural and manmade disasters, public health and medical systems throughout the world often find their resources beyond their capabilities. While the events of disaster occur locally this place immediate effect upon local means and preparedness, therefore, response and recovery and preparedness must be multidimensional. First, preparedness requires horizontal integration between public health, health care, emergency management, agricultural, and private sector assets to support the response setup at each level. Second, it needs a vertical integration of federal, state, local and other government resources. While state and federal resources are not instantly available to local responders, within 4 to 24 hours they can be equipped and greatly enhance the capabilities of the response to an event of any nature. Preparedness and response are principally government roles; therefore, federal, state, and local elected administrators must work in partnership to better understand the possible risks of disasters and how to best safeguard society from them.

If the present gaps in public health and health care are considered in the context of natural disaster, response and recovery capabilities take on even greater importance. In developing country like Pakistan floods and earthquake could destroy much of the mankind and physical infrastructure depending upon for a response effort; therefore, at local level to provide even a minimal level of care for mass casualties, federal and state governments must provide additional resources. While Pakistan is undoubtedly vulnerable to such hazard like earthquake and floods, some officials, not understanding the seriousness of the threat therefore do not believe that the risk of public health could result in devastating impact.

During the disasters of Earthquake 2005 in Pakistan and AJK (Azad Jammu and Kashmir), emergency worker encountered numbers of problems, including confusion over the authority responsible for coordinating the response effort; an inability to link the vulnerabilities and risks before, during, and after the disaster; difficulties in getting rescue worker to the disaster site while moving victims away from it; and problems distributing essential resources among those who need it most. To overcome these problems during future disaster, steps are to be taken although services has made improvements in state and local preparedness by providing funding and guidelines for all District and Tehsil level hopes to improve the response capabilities for natural and other disasters, while overcoming decades of neglect in

the public health arrangement with respect to containing infectious disease outbreaks.

Disaster-related deaths are overwhelmingly caused by the initial traumatic impact of the event. Disaster-preparedness plans, appropriately focused on trauma and mass casualty management, should also take into account the health needs of the surviving disaster-affected populations. The health effects associated with the sudden crowding of large numbers of survivors, often with inadequate access to safe water and sanitation facilities, will require planning for both therapeutic and preventive interventions, such as the rapid delivery of safe water and the provision of rehydration materials, antimicrobial agents, and measles vaccination materials.

One of the ignored areas in response and recovery phase of disaster management in Pakistan is the area of surveillance. Surveillance in area affected by disasters is important, to comprehend the impact of disasters on communicable disease illness and death. Obtaining significant surveillance information in these situations, however, is often challenging. The destruction of the established public health infrastructure can exaggerate or eliminate what may have been weak pre-disaster systems of surveillance and response. Surveillance personnel and other public health workers may be killed or missing, as in Earthquake 2005. On the other hand population displacement can misrepresent census information, which makes the deviousness of rates for comparison more difficult.

Healthcare during the response and recovery phase is often delivered by a wide range of national and international actors, which creates coordination challenges. Also, a lack of pre-disaster baseline surveillance information can lead to difficulties in accurately differentiating epidemic from background endemic disease transmission. Although post-disaster surveillance systems are designed to rapidly detect cases of epidemic-prone diseases, interpreting this information can be hampered by the absence of standard surveillance data and accurate denominator values. Detecting cases of diseases that occur endemically may be interpreted as an early epidemic.

The priority in these settings, however, is rapid application of control measures when cases of epidemic-prone diseases are identified. Despite these challenges, persistent finding of and response to communicable diseases are crucial to monitor the incidence of diseases, to document their effect, to respond with control measures when needed, and to enhanced quantify the risk for outbreaks after disasters.

The media is the fastest, and, in some cases, the only means to circulate important public health information to the public during a crisis; therefore, working with the media is critical to successful communication. While the media is expedient as an emergency broadcast system, members of the media may not have the background knowledge to immediately understand the scientific or technical issues surrounding many disasters. Thus, it is important for spokespersons to speak plainly in order to avoid miscommunication and misinformation.

CONCLUSION

The only way to reduce the impacts of disasters upon affected individual is to have a well and integrated preparedness and response system. Effective communication before, during, and after disasters, to socially assorted public of wide-ranging level of education, is a critical component of any preparedness and response efforts. It is essential to communicate with to provide affected communities, the public, the scientific community, and other stakeholders, the information they need to make the best possible decisions concerning their wellbeing within nearly impossible time constraints.

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REVIEW OF THE USE OF BIOETHANOL AS ALTERNATIVE FUEL FOR INTERNAL COMBUSTION ENGINES

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Abstract: The discovery of fossil fuels revolutionised the world, it caused rapid industrialisation and geometrical growth in transportation system globally. This growth however, is not without its disadvantages, chief among which is the change in global climate which is as a result of the increase in anthropogenic emission of greenhouse gases into the atmosphere. The need to stop the accelerated warming of the globe and its attendant consequences has led to the consideration of alternative sources to fossil fuels. Bioethanol is perceived as one of the viable alternative sources to fossil fuels, especially since it is renewable and is less contaminating. This study reviewed the suitability of bioethanol as alternative to fossil fuels for use in internal combustion engines. It was found that bioethanol is more suitable for use in spark ignition engines than in compression ignition engines. It was also found that the renewable nature of bioethanol and its low emission properties is its most outstanding advantage. It was however noted that despite the numerous literatures on biofuels and bioethanol, there is very limited literature on the nonautomotive use of biofuels in general and bioethanol in specific. There is also limited literature on properties of bioethanol obtained from different sources.

Keywords: bioethanol; spark ignition engine; compression ignition engine; greenhouse gas emissions; particulate matter

INTRODUCTION

Since the onset of the industrial age, fossil fuels have been the force driving the global economic growth and the consequential improvement in general standards of living. The high energy density of fossil fuels has been a major factor for its popularity and high demand for usage as fuel for domestic, industrial and transportation needs. This high demand for fossil fuels has not been without its impact on the environment. It is no longer news that climate change is as a result of anthropogenic emission of greenhouse gases (GHGs) into the atmosphere mainly from the burning of fossil fuels [1]. The attendant effects and consequences of climate change which include floods, accelerated desertification, drought, loss of biodiversity, reduction in soil fertility and a host of others have forced the hands of policymakers and governments to rethink the way and manner fossil fuels are used. This has made the idea of sustainable energy sources more appealing and a serious contender for replacement of fossil fuels. In recent years, the adoption and usage of electric vehicles has significantly improved globally [2], [3], this has encouraged vehicle manufacturers to give serious considerations to vehicles that run on alternative fuels.

Bioenergy has been among the sources of energy that has gained serious traction as an alternative to fossil fuels. In recent times, bioenergy and notably liquid biofuels have emerged as a suitable, renewable alternative to co-exist with fossil fuels as their quality constituents match petroleum-based products while less polluting (at combustion) and, if managed correctly, can contribute to rural development and economic growth [4].

Ethanol has been explored as a potential fuel since the creation of the internal combustion engines at the end of the 19th century. It is on record that in the early 19th century, Henry Ford designed a car that would run completely on ethanol [5]. Thus far, ethanol is one of the fuels that has shown promise as a substitute for gasoline, this has led to some countries choosing the path of less dependence on petroleum by developing their ethanol fuel technology. Brazil is a classic example of one of these countries where ethanol as an alternative fuel is a success story. This was encouraged by policies which encourage the usage of ethanol by making it cheaper than petrol [6].

Currently, ethanol is being used as a transportation fuel typically not in pure form but blended with gasoline in different proportions. A mixture of 90% gasoline, 10% ethanol is referred to as E10 and is the most common form since it can be used interchangeably with gasoline by vehicles without any special arrangement or modification of the fuel/air system on the vehicle. Even though bioethanol has proven to be a suitable replacement for petrol for use in vehicles, it has its inherent disadvantages, the major one among them being the corrosion of engine and auxiliary parts [7]–[9].

Bioethanol seems to be recognized as the best alternative to petroleum-derived transportation fuels and cooking fuels. This is justified by its ability of reducing air pollution, improving rural economies by creating job opportunities and raising farm income and diversifying energy portfolios. In this review paper on bioethanol as an alternative to petrol for internal combustion engines, a review of existing literature will be carried out so as to enumerate the advantages and possible problems associated with the uses of the bio ethanol in the internal combustion engine.

INTERNAL COMBUSTION ENGINES

Internal combustion engines (ICE) are heat engines that convert chemical energy in a fuel into mechanical energy. The mechanical energy is usually made available for use in the forms of a rotating output shaft which is connected to the engine. The sequence of activities that occur within the ICE involves first conversion of the chemical energy of the fuel into thermal energy by means of combustion or

oxidation with air inside the engine. This thermal energy raises the temperature and pressure of the gases within the engine and the high-pressure gas then expands against the mechanical mechanisms of the engine. This expansion is converted by the mechanical linkages of the engine to a rotating crankshaft, which is the output of the engine. The crankshaft, in turn, is connected to a transmission and/or powertrain to transmit the rotating mechanical energy to the desired final use. For engines this will often be the propulsion of a vehicle (i.e., automobile, truck, locomotive, marine vessel, or airplane). Other applications include stationary engines to drive generators or pumps, and portable engines for things like chainsaws and lawn mowers [10], [11].

BIOFUELS

Biofuels by definition are fuels that are generated from biological material, a concept that has recently been narrowed down to renewable sources of carbon [12]. They can complement and/or replace fossil fuels and reduce carbon emissions in the transport sector with only modest changes to vehicle technology (i.e. engines) and to existing infrastructure for fuel distribution. The difference between fossil fuels and biofuels is that fossil fuels were produced millions of years ago when plants and other organisms died, became buried and were subjected to high temperatures and pressures forming coal, oil or natural gas. Biofuels, on the other hand, are produced from biological material that has been living recently. There are a number of ways in which biofuels can be produced, some biofuels can be produced from waste material, such as recycled plant oils, whilst others can be produced from plants specially grown for the purpose. Both liquid and gaseous forms of biofuels can be produced from crops that either have a high sugar content, such as sugar cane or sugar beet, or contain starch that can be converted into sugars, such as maize. Plants containing high levels of plant oils, such as oil palm or soybean, can also be used. Wood and its by-products can be converted into a variety of biofuels. Depending on the feedstock type and the maturity and sustainability of the production process, biofuels can be classified as conventional (1st generation) or advanced (2nd and 3rd generation) biofuels.

Conventional biofuels are biofuels produced from commercial feedstock (such as corn, sugar cane and other sucrose and starchy crops) using the well-known processes currently in use in many countries. They include liquid fuels, such as bioethanol from sugar- and starchy crops, biodiesel from oil crops and waste oil, and biogas for anaerobic digestion and other processes. The main disadvantage of first-generation biofuels is the food-versus-fuel debate, which may cause rise in food prices. There are concerns about environmental impacts and carbon balances, which sets limits in the increasing production of biofuels of first generation [13].

Second-generation biofuels are defined as fuels produced from a wide array of different feedstocks, especially but not limited to non-edible lignocellulosic biomass. Biomass used for production of second-generation biofuels is usually separated in three main categories: homogeneous, such as white wood chips; quasi-homogeneous, such as agricultural and forest residues; and non-homogeneous, including low value feedstock as municipal solid wastes as reported [14]. The price for 2nd generation biofuels is significantly less than the price for vegetable oil, corn, and sugarcane, which is an incentive. On the other hand, such biomass is generally more complex to convert and its production is dependent on new technologies.

Third generation biofuels are biofuels that are produced from algal biomass, which have a very distinctive growth yield as compared with classical lignocellulosic biomass [15]. Production of biofuels from algae usually relies on the lipid content of the microorganisms. Usually, species such as Chlorella are targeted because of their high lipid content and high productivity [16], [17]. There are many challenges associated with algal biomass, this includes the need for large volumes of water.

BIOETHANOL

Ethanol (C_2H_5OH) is a high performance, biomass fuel. It is considered the most suitable alcohol to be used as a fuel for spark ignition engines. Ethanol is a biodegradable, high-octane motor fuel derived from renewable energy sources such as sugars, starches, and cellulosic matter found in plants. It has been used as a fuel or additive since the days of Henry Ford's Model T. Ethanol is used as transportation fuel typically not in pure form but blended with gasoline in different proportions. The term, "Exx", is used to describe ethanol-gasoline blends, also known as gasohol, where xx indicates the fraction of ethanol present in the fuels. For instance, E15 means blends of ethanol and gasoline that contain 15% ethanol. It is considered the most suitable alcohol to be used as a fuel for spark ignition engines, it is the most widely used fuel among biofuels in the world. More than 95% of bioethanol production is obtained by processing agricultural products. In many countries of the world, the use of bioethanol in vehicles has become compulsory and the rate of this has been diversified in each country according to their own production sizes. There is also a requirement to use biofuels in EU countries, the minimum bioethanol addition was increased from 2% to 5.75% in 2010, it is expected to increase to 10% in 2020 and 25% in 2030 [18].

Bioethanol is obtained by transforming organic substances, whose origin is sugar, by microorganisms in the fermentation medium. The content properties of the raw material used and the sugar content it contains significantly affects the bioethanol yield to be obtained at the end of fermentation. Bioethanol production steps are carried out from three different raw materials, mainly sugar compounds, starchy compounds and cellulosic materials. While sugar and starch containing products are generally handled in the common area, cellulosic raw materials are kept separate as they require longer and more complex processes as pretreatment. Since the basic structure of starchy substances is based on sugar, the sugar they contain can be easily revealed with several different pre-treatments. Examples of these are corn, which is used in many parts of the world. Apart from this, grains such as wheat and barley

also contain high levels of sugar. Sugar is directly released in agricultural products such as sugar cane and sugar beet [19]. A major advantage of bio-ethanol is that the feedstock (agricultural materials) is varied, renewable and can be produced in many places. Feasibility of growing lignocellulosic material for ethanol production has been explored around the world depending upon availability (including Nigeria). According to Abdullahi *et al* [20], switch grass could be cultivated under irrigation both in lowland and upland conditions in Sokoto state of Nigeria with manure and nitrogen fertilizer supplementation.

Even though bioethanol is receiving more attention as a potential transportation fuel of the future, its cost is still proving to be the major hindrance to its success as the next petrol is its cost. Its cost is still high due to the manufacturing and processing required. The conversion of lignocellulosic feedstock into bioethanol is based on two main processes: biochemical and thermochemical processes. The biochemical process relies on enzymatic or acidic hydrolysis to convert cellulose and hemicellulose into sugars, followed by fermentation and distillation to extract the ethanol. The thermochemical processing involves the conversion of biomass into a range of products, by thermal decay and chemical reformation, this essentially involves heating biomass in the presence of different concentrations of oxygen which generates synthesis gas or syngas. This syngas can be directly burned or further processed for other gaseous or liquid products. In this sense, thermal or chemical conversion of biomass is very similar to that of coal. The clear advantage of thermochemical processing is that it can essentially convert all the organic components of the biomass compared with biochemical processing which focuses mostly on the polysaccharides [21].

ETHANOL AS ALTERNATIVE FUEL FOR INTERNAL COMBUSTION ENGINES

Bioethanol is currently the most commonly used biofuel for spark ignition (gasoline) engine applications due to similar auto-ignitability properties to those of gasoline fuel. Ethanol can also be used as an additive in diesel engines to enhance combustion and reduce some emissions in spite of differences in auto-ignitability as compared to diesel fuels. Since most small engines are spark ignition, the future of bioethanol in small engine applications appears to be very promising [22]. Ethanol contains 35% oxygen, which results in a complete combustion of fuel and thus lowers the emission of harmful gases. Bioethanol when blended with gasoline, increases the octane number, decreases the Reid vapour pressure and produces fuel with clean burning characteristics. Ethanol also reduces smog formation because of low volatility; its photochemical reactivity and low production of combustion products. In addition, bioethanol possesses a property of low flame temperature that results in good engine performance and durability [23]. Bioethanol in spark ignition engine applications is currently the most practical and widely used biofuel and is potentially the most feasible renewable replacement for small gasoline engine applications. Using bioethanol in spark ignition engines with higher values of the compression ratio becomes possible due to its higher octane number which can go as high as 106. Also, the higher combustion rate of bio-ethanol is directly related to engine efficiency improvement.

ENGINE PERFORMANCE

The properties of bioethanol which makes it suitable for use as replacement for gasoline in spark ignition engines are numerous, these properties are intricately linked to the performance of a spark ignition engine. Table 1 shows a comparison of the fuel properties of bioethanol as compared to gasoline [24], [25]:

Table1: Comparison of Physical and Chemical Properties of Bioethanol and Gasoline

The fuel properties	Gasoline	Bio-ethanol
Density at 15 °C [kg/m3]	735...760	792
Boiling point (at 1.013 bar) [°C]	30...190	78
Specific heat (at 20 °C, 1.013 bar) [kJ/kgK]	2.01	2.369
Dynamic viscosity at 0°C [mPa s]	0.42	1.20
Heat of combustion [kJ/kg]	43500	26800
Theoretical combustion air quantity [kg/kg]	14.9	9
Heat of vaporization [kJ/kg]	290...380	904
Autoignition temperature [°C]	257...327	420
Octane number, MON/RON	90/98	87/106
Flame temperature (λ =1) [°C]	2290	1930
Lower Heating Value (MJ/kg)	`44	26.9
Ignitability range (°C, 1.013 bar): Φs....Φi	0.4...1.4	0.3...1.56
Composition: C/H/O [%mass]	85/15/0	52/13/35
Flame velocity (λ =1, at 20 °C, 1.013 bar) [m/s]	0.41	0.56
Ignitability point [°C]	<20	12.5
Reid vapor pressure [daN/cm^2]	0.8...0.9	0.14
Temperature reduce at vaporization (λ =1) [°C]	28	96.5
Heat of combustion for stoichiometric mixture [kJ/kg]	0.8...0.9	0.14
Temperature decrease when vaporizing a theoretical mixture [°C]	28...31	96.5
Molecular weight [kg/kmol]	98	46.070
Melting point at 1.013 bar [°C]	<-30	-114.6

From the properties shown in Table 1 above, the higher heat of vaporization of ethanol indicates that the volumetric efficiency of ethanol blends is higher than that of pure gasoline, improving power output [26]–[28]. It was determined that a 5% increase in the portion of ethanol in the mixtures can enhance the octane number of fuels by 10% [29]. This allows ethanol blends to operate in engines with higher compression ratios than gasoline. The higher laminar flame speed of ethanol makes ethanol blends combust quicker than gasoline, improving efficiency and power [25]. Jankowski and Sandel [30] found that the use of bioethanol can influence a spark ignition engine's performance thus:

a. Evaporative cooling of the charge in the inlet manifold and during the intake stroke, increasing charge density, and thus increasing the effective volumetric efficiency and power output.
b. The combined effect of the stoichiometric air/fuel ratio and the heat of combustion enable alcohols to release

more heat of combustion for a given air charge, thus increasing power output.

c. Changes in the timing, rate, and duration of combustion thus influencing the cycle efficiency, which influences the power output and specific fuel consumption.

EMISSIONS

An important engineering aspect of the internal combustion engine involves decreasing the quantity of undesirable emissions created by the combustion process. Exhaust emissions are dependent on fuel composition, air/fuel equivalence ratio, operating conditions, oxygen content, and the chemical structure of additives power [25]. The increased water contents results in an increase in the specific heat of the combustion products. The increased charge mass and specific heat can significantly reduce temperatures throughout the cycle, which would tend to reduce NO_x emissions. Using bioethanol in SI engines can reduce emissions through the following thus [30]:

a. Reduced stoichiometric air/fuel ratio, thus leaning out unless closed loop air/fuel ratio control is used.
b. Differences in the actual chemical reactions related to the combustion of alcohols, influencing the composition and reactivity or toxicity of the exhaust gasses
c. Changes in fuel distribution owing to the different evaporative characteristics of alcohols.
d. Changes in charge temperature owing to evaporative cooling properties of alcohols.
e. Increased gas specific heat and increased charge mass when closed loop air/fuel ratio control is used, leading to reduce combustion temperatures

ADVANTAGES OF USING BIOETHANOL AS ALTERNATIVE FUEL IN SI ENGINES

The advantages of using bioethanol as alternative fuel for SI engines are numerous, chief among them includes the emission of lower quantities of GHGs when compared to gasoline [31,32]. Still on emissions, bioethanol as fuel for SI engines instead of gasoline have been proven to have lower particulate emission [33,34]. Also, as ethanol content increases, benzene levels in the emissions from bioethanol reduces. Still on emissions from combustion of bioethanol laced fuels, emissions from such fuels contain less ozone damaging substances compared to pure gasoline or diesel. In addition to these, bioethanol has no sulphur content and is wholly biodegradable. When compared to other biofuels like biomethanol, bioethanol is less toxic [35].

Since bioethanol has a higher octane number compared to gasoline, this feature allows SI engines to run more efficiently. Also, its high-octane performance makes operating SI engines that run on bioethanol relatively cheaper than SI engines that run on gasoline. Likewise, SI engine vehicles retrofitted to run on bioethanol have been found to have higher energy efficiency than their equivalent gasoline run vehicles.

DISADVANTAGES OF USING BIOETHANOL AS ALTERNATIVE FUEL IN SI ENGINES

The nature of bioethanol having low vapour pressure and high latent heat of vapourization makes cold starting in cooler climates more difficult. This makes the use of ethanol exclusively in place of gasoline as fuel for SI engines unsuitable, especially in cold climates [13,30]. When bioethanol is burnt as fuel in SI engines, it leads to increased formation of acetaldehyde but lower emissions of formaldehyde compared to the combustion of gasoline in SI engines.

The low lubricity of bioethanol means higher friction among engine parts as such wearing and corrosion of engine parts are more common when SI engines use bioethanol as their preferred fuel. Another problem encountered when vehicles use ethanol as fuel is that of phase stability especially when water is present in the mixture. On the safety aspect, whenever neat ethanol is burnt, an invisible flame is given off, this can cause serious safety concerns since the flame cannot be spotted in good time.

BIOETHANOL AS ALTERNATIVE FUEL IN COMPRESSION IGNITION (CI) ENGINES

The Compression Ignition engine is currently considered the most fuel-efficient engine for industrial and transport applications, but it has the major disadvantage of being a significant contributor to air pollution caused by the combustion of diesel. Therefore, using bioethanol fuels in CI engines reduces emissions of particulate matter and GHGs. Ethanol use in CI engines represents a more efficient ethanol application because of the higher efficiency of the combustion, which on average is about 30% higher than in SI engines.

One of the major reasons why ethanol is added to diesel is to enhance combustion efficiency and reduce emissions of particulate matter and GHGs. The ethanol-diesel blend is also referred to as e-diesel. The main drawback is that ethanol is immiscible with diesel fuel over a wide range of temperatures, leading to phase separation. Consequently, in many cases the presence of a surfactant and cosolvent additive in the e-diesel blend becomes necessary [36,37].

EFFECTS OF BIOETHANOL FUEL IN COMPRESSION IGNITION ENGINES

Diesel oil has an energy content of about 36MJ/litre, whereas that of ethanol is 21 MJ/litre, this means that the engine needs injection of relatively larger volumes of fuel, compared to diesel oil, in order to have the same power output. Therefore, if bioethanol is to be used in compression ignition engines, then larger injectors, pumps, and fuel tanks are required [36].

Auto-ignition property of diesel fuel is designated by its cetane rating, diesel engines at the moment are designed to run on fuel that has cetane numbers of 40 and 51. Unfortunately, the cetane rating of ethanol is quite low, it ranges 5 to 15. This means that the fuel will likely not auto-ignite under the conditions existing in standard diesel engines. This problem can be remedied by the addition of certain ignition improvers, applying an ethanol fuel with too low cetane number in CI engines can among other things, result in poor cold starting, rough idling, and excessive NOx emissions [36].

The fuel system of the diesel engine is such that the fuel injectors and fuel pump rely on the lubricating properties of diesel to reduce friction and wear. Ethanol is considered a

low lubricity fluid, and this effect may cause failure of some parts of the fuel system. These lubrication problems can be overcome by using additives or improving the properties of these parts such that they become more resistant to wear and tear.

FINDINGS AND DISCUSSION OF FINDINGS

Several researches have been carried out in order to identify the effects of bioethanol as alternative fuel for internal combustion engines and many of the literature have shown the advantages of bioethanol as well as the problems associated with its production, marketing and usage (among others) from different perspectives. However, gaps in knowledge still exist, as some aspects need to be investigated to be able to draw proper conclusions about the use of the bioethanol in internal combustion engines.

These gaps in knowledge includes (but not limited to) the followings:

- Analysis of the composition of ethanol (according to the type of processing and the source). The composition of ethanol produced from different sources and processing methods is significant because the ethanol produced from biomass may be different from the one obtained from grains. So also, the ethanol processed using the thermochemical process may differ from the one processed using the biochemical process. This factor may affect the proper mixing and blending the ethanol and other fuels
- The impact of mixing of bioethanol from different sources is unknown, this makes the possibility of phase separation occurring when bioethanol from different sources is mixed and used as fuel. Such possible phase separation may affect the emission and the performance characteristics of the engine.
- The impacts of neat bioethanol and bioethanol blends used in non-automotive applications is unknown. There is very limited data available with regards to the usage of bioethanol non-automotive engines such as power generators, lawn mowers etc.
- Corrosion test is regarded as vital for any successful engineering design, ethanol blends with different ethanol concentrations may have different corrosion properties on materials, and these properties are unknown. There is a need to study these properties in order to find out which of the blends has the highest corrosion property.
- It was found that there are no proper specifications by manufacturers on the type of ethanol blend to be used in different automotive engines. It is expected that internal combustion engines from different manufacturers should specify the of gasoline/diesel-ethanol blends to be use in their respective products

CONCLUSIONS

This study which is a review of the use of bioethanol as alternative fuel for internal combustion engines considered the suitability of bioethanol as alternative fuel by reviewing data available in literature. It was found that a number of qualities makes it suitable, among which are renewable nature and emission characteristics. However, there are also problems associated with its usage such as relatively higher cost of production and corrosive effect on engine parts. In summary, the following conclusions can be drawn based on the literature reviewed in this paper.

- Bioethanol is more suitable to be used in spark ignition engines than in compression ignition engines considering its wider differences with diesel than with gasoline.
- Bioethanol can deliver more power output (due to higher volumetric efficiency) but has lower volumetric fuel economy when compared with gasoline.
- Bioethanol can be produced virtually everywhere due to wide ranges of its raw materials
- Bioethanol is less toxic than gasoline as it is considered to be bio friendly, but it is corrosive to several materials. Extra measures need to be taken when selecting materials for engines with bioethanol compatibility.
- When bioethanol is to be used in conventional diesel engines, some modifications are needed such as larger injectors etc.
- There is a greater reduction in the emission of greenhouse gases when ethanol is used compared to gasoline and diesel.

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FIGURES AND TABLES

Figures (diagrams and photographs) should be numbered consecutively using Arabic numbers. They should be placed in the text soon after the point where they are referenced. Figures should be centered in a column and should have a figure caption placed underneath. Captions should be centered in the column, in the format "Figure 1" and are in upper and lower case letters.

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Place equations on separate lines, centered, and numbered in parentheses at the right margin. Equation numbers should appear in parentheses and be numbered consecutively. All equation numbers must appear on the right-hand side of the equation and should be referred to within the text.

CONCLUSIONS

A conclusion section must be included and should indicate clearly the advantages, limitations and possible applications of the paper. Discuss about future work.

Acknowledgements

An acknowledgement section may be presented after the conclusion, if desired. Individuals or units other than authors who were of direct help in the work could be acknowledged by a brief statement following the text. The acknowledgment should give essential credits, but its length should be kept to a minimum; word count should be ‹100 words.

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In a very short period the ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering has acquired global presence and scholars from all over the world have taken it with great enthusiasm.
We are extremely grateful and heartily acknowledge the kind of support and encouragement from all contributors and all collaborators!

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