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

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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.

MATERIALS 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.

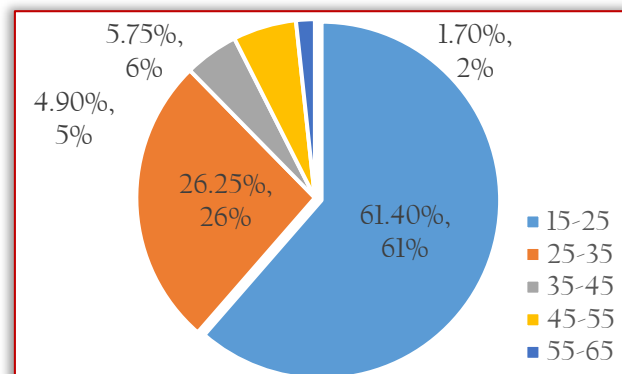


Figure 1. Distribution of ages of survey respondents

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.

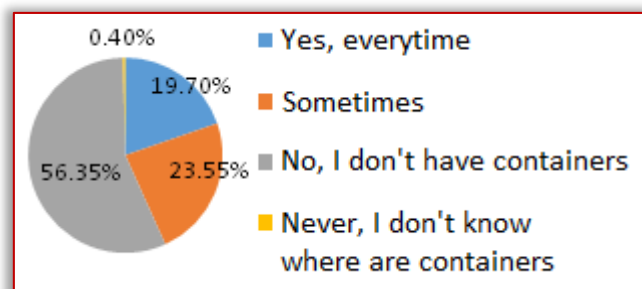


Figure 2. Answers to the survey question "Have you ever disposed old paper in the provided containers?"

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.

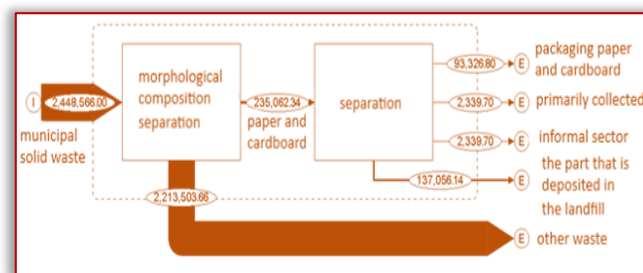


Figure 3. Flow chart for MFA

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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