ACTA TECHNICA CORVINIENSIS
– Bulletin of Engineering
Tome IX [2016], Fascicule 3 [July – September]
ISSN: 2067 – 3809

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BASIC EQUIPMENT FOR THE MECHANICAL TREATMENT OF WASTEWATER

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Abstract: In a continuously developing world, where many activities are high consumers of natural resources, including water, it has become absolutely necessary to apply methods of wastewater treatment. The purpose of wastewater treatment is to improve water quality, in order to be discharged into the environment, without being harmful for different environmental factors. In this paper are presented the equipment used in the mechanical stage of a wastewater treatment plant, and also the status of wastewater treatment plants in Romania.
Keywords: wastewater, mechanical water treatment, treatment plant

INTRODUCTION

In the current state of economic and social development, is becoming more difficult to achieve the satisfaction of water needs for household, industrial, energy and agricultural use, given that each of these activities entail the pollution of groundwater and surface waters. Water pollution is mostly due to industrial development, growth of urban population and discharge into rivers and lakes of sewage, more or less treated [10].

In recent years increasing attention has been directed toward the discharge, presence and potential effects of persistent pollutants in the environment. While many of these pollutants break down relatively quickly in the environment, many others are highly resistant to degradation [6].

European Council Directive 91/271/2002 is the legal basis regarding the legislation on wastewater. This Directive, transposed by G.D. 188/2002, defines water treatment as the process of "removal from wastewater of toxic substances, microorganisms, etc., aiming to protect the environment, the envoy first, and also soil and air." Hence, water treatment is a complex process of withholding and neutralizing harmful dissolved substances, in colloidal state or in suspension, present in industrial and municipal wastewater, that are not supported in the aquatic environment into which is discharged the treated water and that allow restoring the physicochemical properties of water before use [10].

Given the differences in location, economic resources, living standards of different countries, and also the characteristics of water and its pollutants, many nations adopt diverse techniques for wastewater treatment [1]. Wastewater treatment processes include:

a. Mechanical treatment (primary) - the wastewater treatment processes are of physical-mechanical type, and consists of: withholding of coarse bodies and suspension of wastewater, sedimentation (settling) of the solids in suspension, floating of impurities with lower density than that of water or which are brought by aggregating to this status, filtration and centrifugation, methods generally used in the sludge treatment and ultraviolet disinfection. European Council Directive 91/271/2002 stipulates that, following the processes of mechanical treatment, the biochemical oxygen demand of the incoming waste water is reduced by at least 20 % before discharge and the total suspended solids of the incoming waste water are reduced by at least 50 % [15].
b. Chemical treatment - the wastewater treatment processes are of physico-chemical nature. Chemical processes are applicable in wastewater holding large quantities of fine matter in suspension, colloid, or even dissolved substances that are very difficult to separate by classical mechanical methods. In this case, after the classical the chemical step, into which are placed a number of substances that favor the accumulation of large flocks colloidal substances, or which react with compounds in the water, forming compounds that are easier to separate. Also as chemical process is water

disinfection at the end of the treatment process, using chemical substances.

c. Biological treatment - the treatment processes are both physical, and biochemical. Biological processes involved in the treatment of wastewater refers to the decomposition of organic materials by bacteria and are of two types, depending on the nature of the bacteria:
   - *aerobic processes* of decomposition of organic substances in the presence of oxygen, a process carried out by aerobic bacteria, which feed on these substances;
   - *anaerobic processes* of decomposition of organic oxygen scavengers that organic compounds by anaerobic bacteria, in terms of lack of oxygen.

In figure 1 is presented the technological flow in the mechanical stage of a wastewater treatment plant.

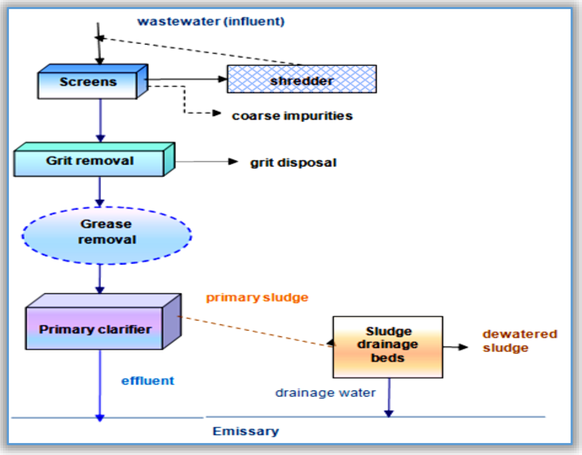

Figure 1. Diagram of a mechanical wastewater treatment plant

Some treatment plants are equipped with tertiary treatment step, which aims to remove excess compounds (e.g. nutrients - nitrogen and phosphorus) and to ensure water disinfection (e.g. by chlorination). This step may be biological, mechanical, chemical or combined, using conventional technologies (filtration) and special processes (adsorption on activated carbon, chemical precipitation, etc.).

By withholding or neutralization of toxic or recoverable substances from wastewater are obtained treated waters, in various degrees (which are either discharged into an emissary or are used as water for irrigation or in other purposes), and sludges that can be processed, stored, decomposed or recovered [4]. After going through these steps of treatment, the water must hane an acceptable quality, in accordance to the standards for treated wastewater.

MATERIAL AND METHOD

Bar screens are designed to withhold large bodies representing 3-5% of the total materials transported by the wastewater. Usually, bar screens are made from profiled bars, parallel and equally spaced, rigidly fixed on ransverse bearings, leaving between interspaces named gap. After interspace size, bar screens can be classified as rare and dense, and by the plan shape, the bar screens can be: plane, radial, curved etc. [2].

Bar screens are made of stainless steal to prevent the corrosion. The retaining of coarse suspensions can be done manually or automated. Automation is preferred if the bar screens are subjected to high flow rates of wastewater or if the wastewater contains large amounts of solid debris. With the help of mechanical rakes, the screens are constantly scrapped off to remove material deposited, which is then dumped into a container [7]. In figure 2 is presented a continuous bar screen. Usually, continuous screens are often being installed in channel sewery where the screen moves through the sewage and takes with it the coarse waste; the waste can also be removed from the sewage by a slow combined movement of the screen components. These types of screens have very scant gaps (3-8 mm) [13].

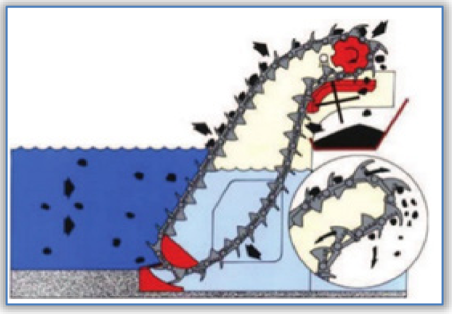

Figure 2. Continous bar screen [13]

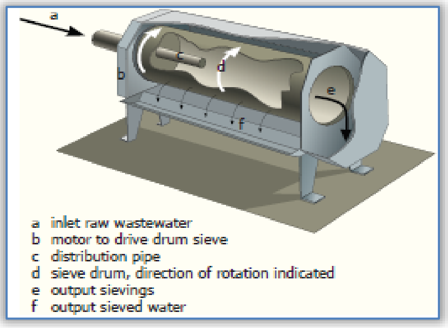

Figure 3. Drum sieve [13]

Sieves have the same role as bar screens, but they have denser holes, retaining solid particles of smaller diameter. A constructive solution is the drum sieve (figure 3) presents a drum sieve that can be used for chicken slaughterhouses to remove feathers and their organs. A drum sieve consists of a slow rotating drum that is equipped with small perforations. The drum is driven through a gear box by an electric motor [13]. The wastewater enters the drum axially and leaves radially, trapping the screenings inside the drum [7].

The sieved particles stay in the drum and through both the revolving movement of the drum and the internal screw are placed at the end of the sieve screen and then cast out [13]. Water jets periodically clear the screenings from the drum [7].
More small particles from industrial wastewater can be removed from wastewater by sieves than by bar screens [13].
Grit chambers are devices used for retaining granular mineral suspensions, characterized by lack of putrefaction and higher sedimentation rate of solid matter organic, putrescible in suspension. The role of grit chambers is to protect moving mechanical equipment against the abrasive action of sand, to reduce the possibilities of clogging of pipes, caused by deposition of sand and to reduce the frequency of cleaning of digesting tanks and clarifiers of excessive accumulation of sand.
The vortex grit removal unit (figure 4) removes large particles of gravel and sand from the wastewater. The flow of wastewater enters into each grit unit and is directed to create a circular vortexing current. This current creates an area of low velocity in the center of the chamber. The heavier grit and sand falls down to the bottom while the water and other solids stay moving in a circular flow pattern. The grit is collected on the bottom of the unit, and is discharged and sent to the landfill for disposal [12].

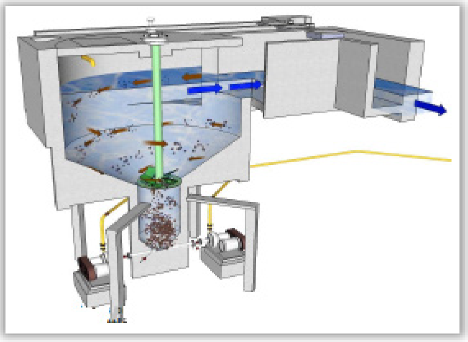

Figure 4. Vortex Grit chamber [12]

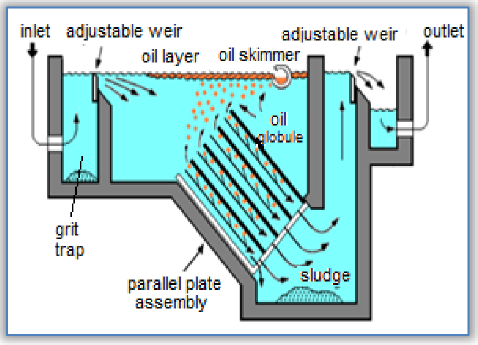

Figure 5. Grease removal [20]

Grease removal (figure 5) are equipment in which the separation of grease and oil residues under tack at the surface of domestic wastewaters and are placed between grit chambers and primary clarifiers.
Free fats, which tend to rise to the water surface are separated into rectangular tanks, and the method is based on lowering the flow rate of the water. Fats are separated from the basin surface in a specially designed space, from which are discharged manually and the water is discharged by siphoning. Fats found in colloidal state or as emulsions do not have a natural tendency to rise to the surface, and their separation is done by blowing air at low pressure in divided tanks [3].
Primary clarifier (or settling tank) has the role to withold most of the suspensions in wastewater, respectively raw water, by sedimentation – gravity deposit. They are constructions made of concrete; they generally have very large sizes, at about 30 m long and 9 m wide and can have various geometric shapes (rectangular, round).
Rectangular primary clarifier (figure 6) is a tank into which the water stays for 1.5-2 hours. Collection of deposits in the upstream hopper is done several times per day, with the help of a scraper mounted on the bridge, to prevent their fermentation [5].

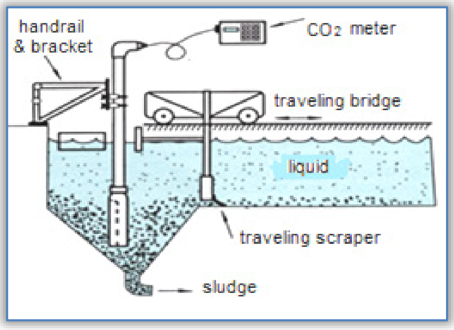

Figure 6. Rectangular primary clarifier [20]

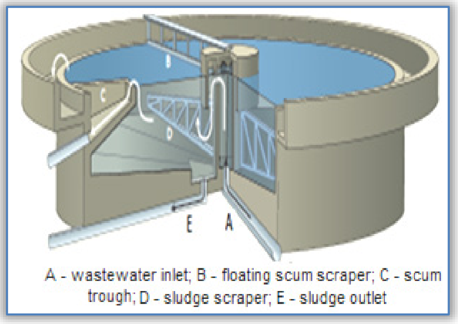

Figure 7. Round primary clarifier [13]

Round primary clarifier (figure 7) is an installation into which the wastewater is fed into the middle and is discharged through a trough on the outer periphery. Above the tank there is a bridge that slowly rotates with sludge scrapers attached. These scrapers move the sludge on the bottom slowly towards the central sludge funnel, where it is removed. The bottom is built with a slight slope. For the effluent trough there is a scumboard or baffle for holding back the floating solids. The floating solids (fat) are pushed into a scum trough by the floating scum scrapers that are attached to the bridge [13].

Processes in the primary treatment generate primary sludge. The sludge is removed and pumped to the solids treatment process for ultimate removal [9].

RESULTS

In Romania, a major problem is the lack of sewerage network in certain areas and the inadequate treatment system. According to the National Administration of Romanian Waters, the water used by 90% of romanians from the village and 50% from the city does not get into a sewer system, but is thrown directly near the house [11]. Also, in Romania, the degree of connection to the sewerage network and sewage treatment plants is 57% and respectively 46%. In Romania, physically, there are 983 sewers, of which only 631 are functional, the rest being still in various stages of implementation [17].

In 2011 were identified 511 sewage treatment plants, of which only 16 treatment plants comply with the requirements of Directive 91/271 / EEC, for the second stage of treatment. The poorly equipped treatment plants are those in Muntenia and Oltenia (Dolj, Gorj, Giurgiu, Călărași), central and southern Moldova (Galaţi and Vaslui) and best equipped treatment plants are in the center and west of the country (Brașov, Cluj Napoca, Mureș) [16]. Figure 8 shows the map of localities provided with wastewater treatment plants in our country, according to estimates made in 2011.

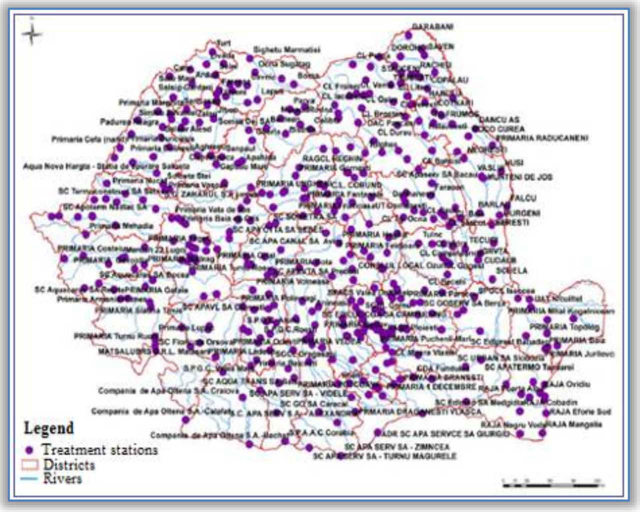

Figure 8. Wastewater treatment plants in Romania in 2011 [19]

Bucharest is served by a mixed system of sewage, spread over about 2400 km, that takes wastewater from approximately 80% of the population of 1.92 million people from the city, but also from most of the industrial units and institutions. The wastewater collected is transported to the treatment plant in Glina, in the south-east of Bucharest [18].

In the wastewater treatment plant from Glina, technological and biological processes occur in three stages of wastewater treatment (figure 9).

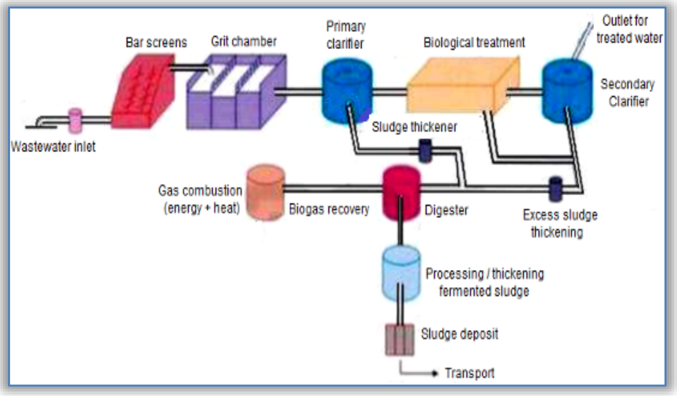

Figure 9. Technological flow at Glina wastewater treatment plant, near Bucharest

In the first stage, larger bodies floating in the waters of Dâmboviţa river are retained by bar screens and sieves. Cleaning of water of these bodies is made in a similar manner to household waste management, being sent to landfill or to sludge incinerator. Then, the separation of sand takes place into grit chambers and the sedimentation of suspensions in the primary clarifier. After decanting, substances collected to surface (grease, hydrocarbons) are removed, and primary sludge deposited on the bottom of the primary clarifier is thickened and sent to digesters [14].

Mechanically treated water reaches the biological stage, where acts microorganisms that break down organic matter. From the secondary clarifier, secondary sludge is obtained, which is thickened (dried) and sent to the digester.

By anaerobic digestion of sludge is obtained the biogas, which is converted by co-generation into heat and electricity. The digestate, namely the remaining solid after fermentation, is dehydrated and can be used as fertilizer on agricultural fields.

Currently, Glina wastewater treatment plant removes mechanically only 85% of the wastewater entering the plant, with a flow of 10 m^3/s, but only half of this quantity is fully treated, according to the European environmental standards.

CONCLUSIONS

Wastewater includes water resulting from residential, industrial and commercial activities.

A wastewater treatment plant consists of various equipment and processes that have the role to remove or destroy harmful materials, chemical compounds, and microorganisms found in the wastewater.

In order to protect the environment, especially the emissary, and also the soil and air, a proper treatment process of wastewater should provide favorable conditions for further possible use of such water for domestic, industrial or agricultural activities.

Raw untreated wastewater, discharged into rivers, have a devastating impact.

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ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING

ISSN:2067-3809