CURRENT STAGE OF DOMESTIC WASTEWATER TREATMENT IN SMALL PLANTS

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Abstract: The water, in its circuit, passing through various types of uses (industrial processes, domestic uses), is loaded with various materials and substances, turning into what can name by a general term "wastewater". Taking into consideration the problems Romania deals with regarding wastewater treatment, the present paper proposes to investigate the possibilities through which, municipal wastewater can be treated in small plant. In this sense, the infrastructure necessary for wastewater treatment systems must be made in the context of sustainable development by identifying the defining characteristics for each area, local and even individual households.

Keywords: municipal wastewater, small wastewater treatment plants.

1. INTRODUCTION

When water is used for domestic activities, it charges with various inorganic and organic compounds and becomes domestic wastewater. The disposal of municipal wastewater in natural emissaries, without treatment, causes negative effects on the environmental factors and human health.

The wastewater treatment can be realized using mechanical, biological and chemical processes which are part of the three general methods of wastewater treatment: primary, secondary and tertiary [1].

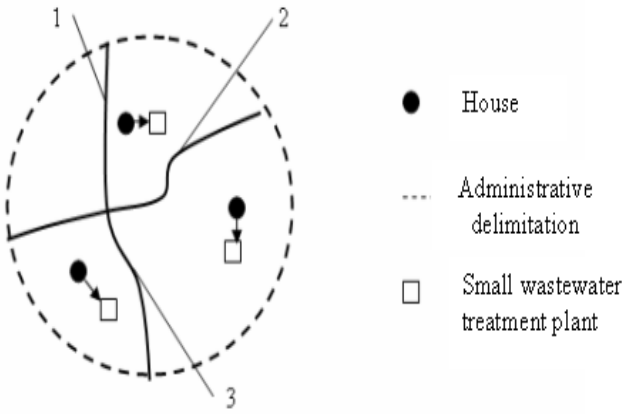

Fig. 1. The representing of the relation between isolated house and its wastewater treatment plant [2]: 1 - plateau relief form; 2 - hilly relief form; 3 - depressionary relief form.

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The municipal wastewater can be treat in: [3, 4, 5, 6]:
- decentralized system, used in wastewater treatment locally, individually, in areas where the implementation of a centralized wastewater collection and treatment is not justified technically and financially (Figure 1);
- centralized system used where population density is high and the introduction of centralized wastewater collection and treatment is justified technically and economically (Figure 2).

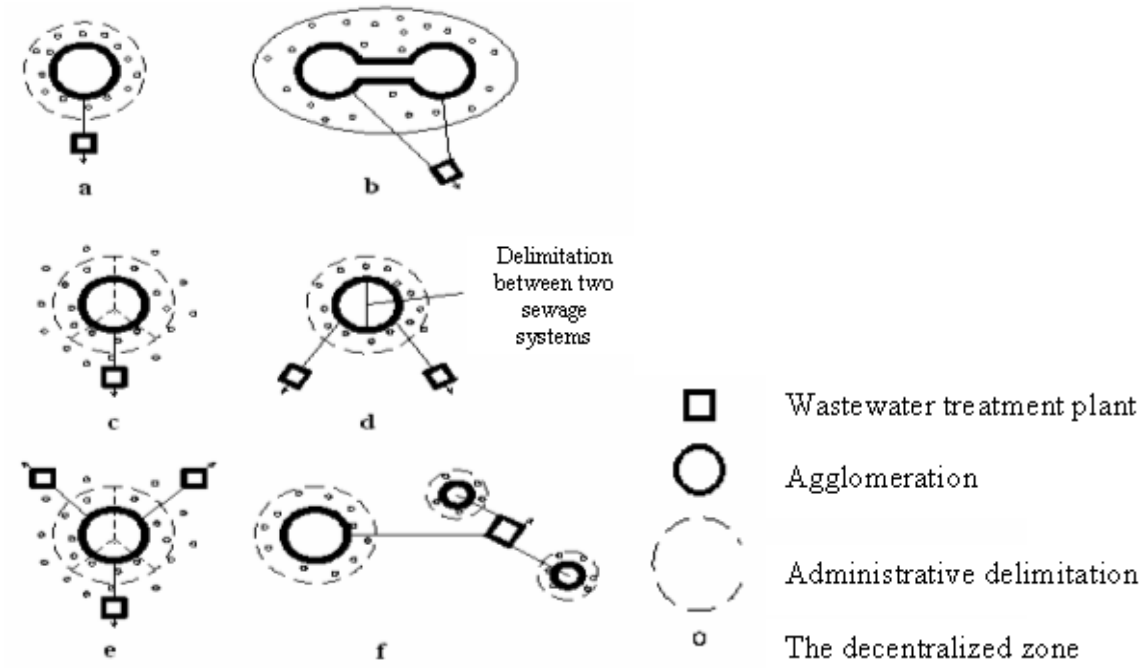

Fig. 2. Graphical representation of the connection between centralized region and its wastewater treatment plants [7, 8, 9, 10]:
a) agglomeration served by a sewerage system and a wastewater treatment plant; b) discontinuous agglomeration served by a sewage treatment plant; c) agglomeration constituted by three administrative entities, served by a sewerage system and a wastewater treatment plant; d) agglomeration served by two sewage systems, each connected to a wastewater treatment plant; e) agglomerations covering several administrative entities, served by two sewerage systems and two wastewater treatment plants; f) separate agglomerations, each with its own sewage system but with a wastewater treatment plant.

The statistical data of 2009 indicate that approximately 50 % of Romania's inhabitants are not connected to a wastewater treatment system. Taking into consideration this fact, the studies and the researches have been orientated to a small wastewater treatment plant that has sequential operation.

When is choice the treatment processes and techniques for wastewater treatment in a decentralized system must be taken into account the following aspects:
a) the number of residents;
b) construction destination;
b) domestic sewage flow and its variations (hourly, daily, weekly, monthly, yearly);
c) climatic conditions of the site;
d) wastewater characteristics.

The characterization of wastewater, including daily volumes, rates of flow, and associated pollutant load, is very important in choice of the treatment system design. Determination of the treatment system performance requirements, selecting appropriate treatment processes, designing the treatment system, and operating the system depends on an accurate assessment of the wastewater to be treated. A method to characterize the domestic wastewater is present in the Figure 3.

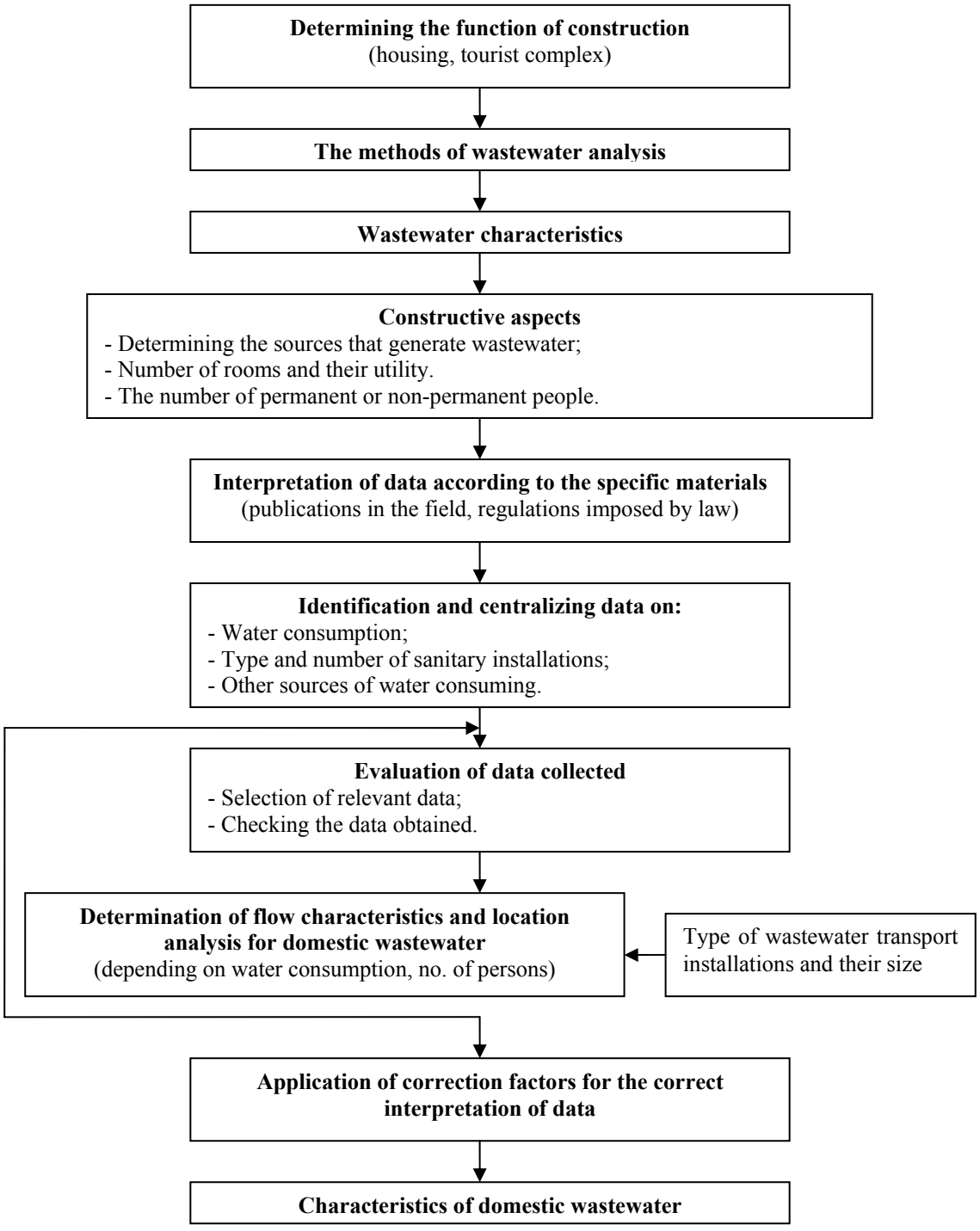

Fig. 3. Method for determining the characteristics of domestic wastewater in isolated areas [8].

2. METHODS OF DOMESTIC WASTEWATER TREATMENT IN SMALL PLANTS

2.1. Methods and techniques used for primary treatment of domestic wastewater in decentralized systems

Collection basins (Figure 4), are impermeable underground tanks used for drainage and storage of wastewater in a small period if time [10].

Legislative regulations (Government Decision 352/2005) allow use of collecting basins only as a temporary solution for wastewater treatment.

Using the collection basins for wastewater treatment has the following disadvantages:
- have a limited volume, is only a temporary measure;
- require regular emptying;
- give off an unpleasant odor;
- can cause sewage leaks into the soil;
- must be located in areas with road access.

The septic tanks are anaerobic treatment systems that use anaerobic bacteria to decompose the organic matter from wastewater in salts and gases. Also, the septic tanks are used for separating the grease from domestic wastewater. There are several technological options to achieve septic tanks, depending on the variant differentiated design and the retention time of wastewater. Thus septic tanks are divided into three categories [7]:
a) Simple septic tanks, with a compartment (Figure 5) have the lowest efficiency of organic matter expressed as BOD_5 reduction of only 15-20 %. Effectiveness in reducing of suspended matter is about. 30 % and can be used up to 5 to 10 equivalent inhabitants [3, 10];

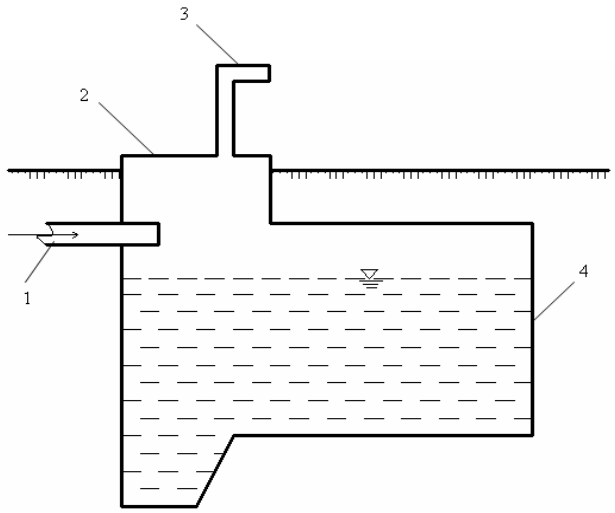

Fig. 4. The scheme of a basin for wastewater collection [7]:
1 - influent; 2 - inspection access; 3 - ventilation tube; 4 - sealed basin.

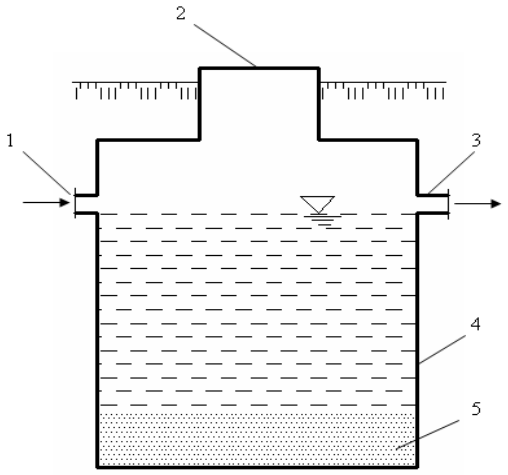

Fig. 5. The scheme of a simple septic tank [2, 7, 11]:
1 - influent, 2 - inspection access; 3 - discharge of treated water, 4 - basin; 5 - sediment.

b) Septic tank with two compartments (Figure 6) is used for more than 50 equivalent inhabitants. A septic tank with two compartments can provide effective treatment (reduction) of organic matter from wastewater by 25-40 % and the suspension of approx. 50 % [14, 15];

c) Septic tanks extended (Figure 7), with differ by the rest of septic tanks by a special division of the sedimentation compartment. In the first compartment the water is settled, and in the second compartment is for anaerobic sludge thickening and digestion. By using this method is obtained treatment efficiency of organic compounds and total solids of 30-50 % [2, 13].

Use of septic tanks for wastewater treatment has the following disadvantages:
- provide only retention of suspended matter and grease;
- requires regular vacuum;
- release odors during improper operation;
- may occur sewage leaks into the soil and groundwater;
- risk of flooding.

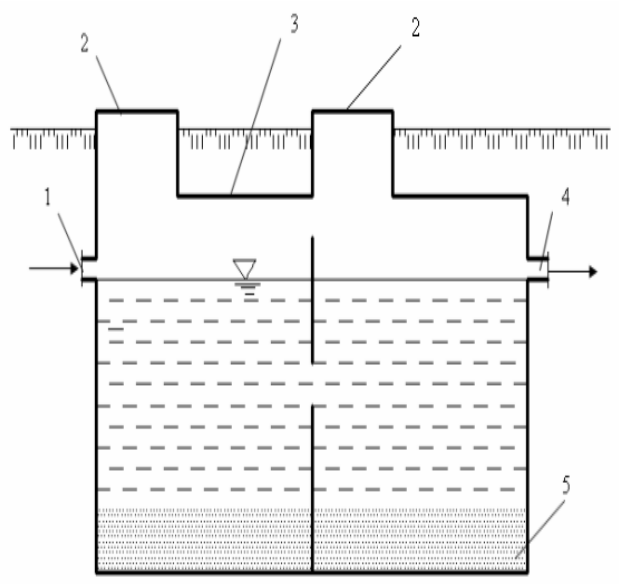

Fig. 6. Operation scheme of a septic tank with two compartments [3, 12, 13]:
1 -influent; 2 - inspection access, 3 - basin compartment; 4 - discharge of treated water, 5 - sediment.

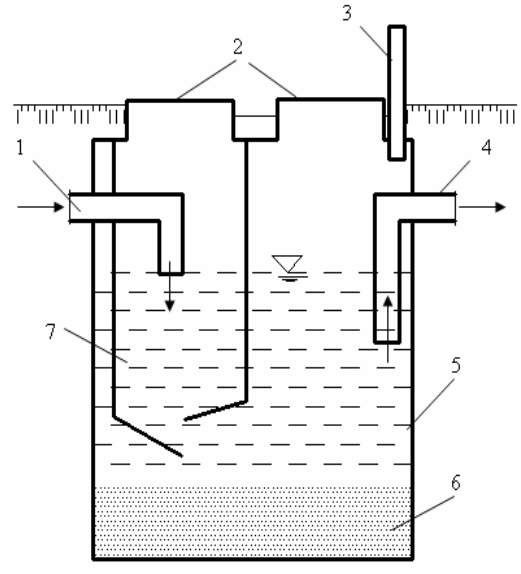

Fig. 7. The scheme of a Imhoff septic tank [3]:
1 - the influent; 2 - inlet in the tank; 3 - biogases evacuation; 4 - evacuation of the treat wastewater; 5 - the compartment for anaerobic treat; 6 -sludge; 7 - settling compartment.

2.2. Wastewater treatment plant, used in decentralized systems, which use mechanical-biological processes and biomass on a fixed support

The anaerobic filter (Figure 8) is used in treatment plants that use for the decomposition of organic substances in wastewater, anaerobic microorganisms activity. Microbiological culture grows as on the surface and inside the filter.

The main disadvantage of these filters is given by the high retention capacity of biomass for a long time, which may cause the phenomenon of excessive biomass growth and silting of the filter [16].

In a complex system of wastewater treatment with low flow, anaerobic filters are used as secondary treatment method, which are most cases proceeded by septic treatment processes (Figure 9).

Percolation filters, can be used as a secondary treatment processes in small wastewater treatment systems.

The main component of this system is the filter layer can be formed of natural granular material (gravel, volcanic rock) or artificial (plastic). On the surface and inside the filter layer is developing microorganisms that decompose organic substances dissolved or colloidal in domestic wastewater [17].

Figure 10 is represented a method of using a trickling filter treatment system to treat wastewater from an individual house.

Rotating biological contactor (Figure 11), is constructed from one or more tanks are installed rotating disc, a short walk from each other on the horizontal bars which rotate through the wastewater with low speed. The microorganisms grow of on the surface of the rotating contactor and form a thin film with biomass. By rotation of the contactor, the biomass developed is putted in contact with the organic substances from wastewater and oxygen from the air [3, 17].

The contactor disc rotation speed can be varied to control the intensity of biochemical reactions given by the ratio of organic substances and oxygen [17].

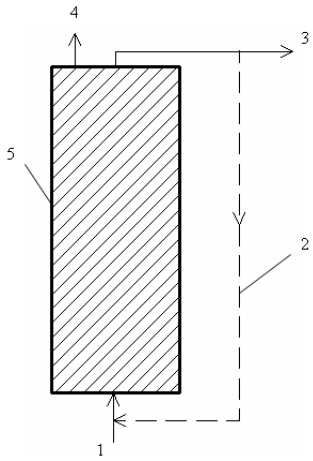

Fig. 8. Scheme of anaerobic filter [10, 18, 19]:
1 -influent; 2 - flow recirculation;
3 - discharge of treated water;
4 - biogas evacuation; 5 - filter media.

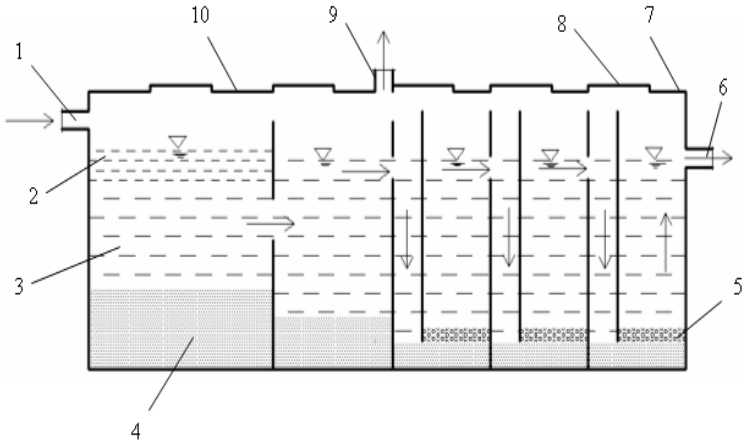

Fig. 9. Scheme of using anaerobic filter small plants wastewater treatment [12]:
1 - the inlet of wastewater; 2 - wastewater; 3 - settle wastewater;
4 - sludge; 5 -the filter material;
6 - evacuation of the treat wastewater; 7 - the compartment for filter; 8 - inlet in the tank; 9 - biogases evacuation;
10 - septic tank.

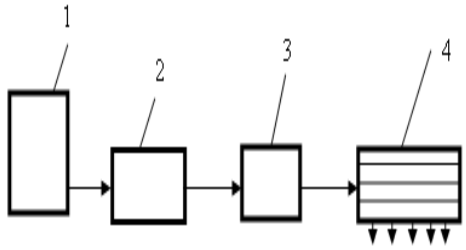

Fig. 10. Graphical representation of using a trickling filter treatment system to treat wastewater from a household [20, 21]:
1 - house; 2 - septic tank;
3 - trickling filter, 4 - soil infiltration system.

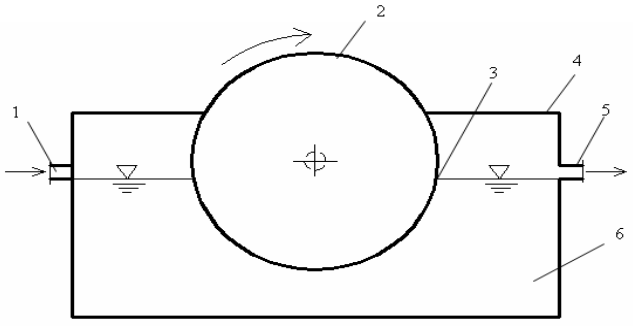

Fig. 11. Schematic representation of rotating biological contactor [14, 21, 22, 23, 24]:
1 - enter wastewater; 2 - contactor surface; 3 - limit of immersion; 4 - basin;
5 - discharge of treated water;
6 - wastewater.

Membrane bioreactor (Figure 12), used for decomposition of organic matter from domestic wastewater, the activated sludge is formed suspended and attached to the membrane [14, 25].

Ascending flow anaerobic reactor sludge (Figure 13), works on the principle of forming a layer of biological sludge in the filter medium and in suspension. Wastewater enters in the reactor at the bottom of it, and anaerobic sludge transforms organic material. Anaerobic biomass is distributed over the stratum of sludge [2].

Ascending flow anaerobic reactor sludge has some advantages in wastewater treatment:
- the process can be relatively easily controlled;
- can work with small volumes of wastewater;
- is a mechanically simple.

The disadvantages of this type of filter are:
- insufficient retention time of attainment of optimal treatment;
- operation of the reactor depends on the development of dense suspension solids.

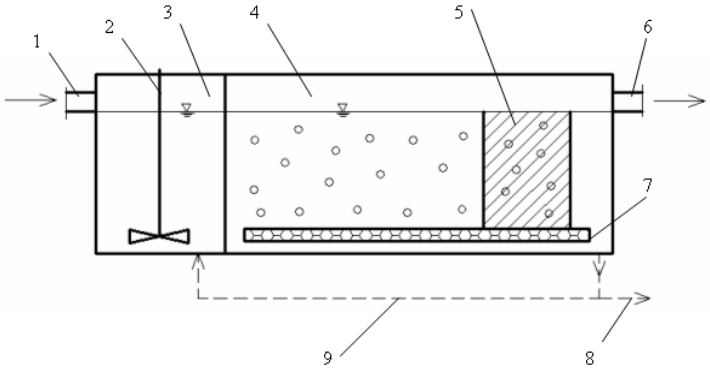

Fig. 12. Graphical representation of a system of wastewater treatment are used biomembrane [20, 26]:
1 - enter wastewater, 2 - mixed;
3 - anaerobic basin, 4 - zone of aeration,
5 - biomembrane, 6 - discharge of treated water,
7 - aeration, 8 - disposal of excess sludge,
9 - sludge recirculation.

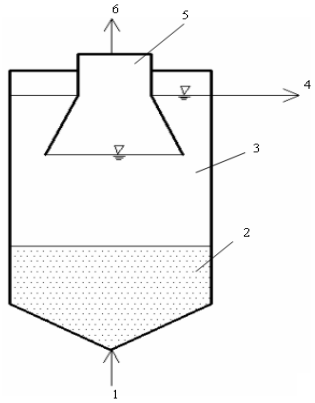

Fig. 13. Scheme of a reactor with ascending flow of sludge [7, 19, 27]:
1 - enter wastewater, 2 - zone with sludge,
3 - settling area, 4 - discharge of treated water; 5 - gas-liquid separator, 6 - biogas evacuation.

2.3. Installations with biomass in suspension used in decentralized systems for mechanical-biological wastewater treatment

Activated sludge treatment systems can operate continuously or discontinuously and use aerobic or anaerobic microorganisms. All methods of activated sludge use microorganisms for the decomposition of organic matter from wastewater.

2.3.1. Mechano-biological treatment plant with biomass in suspension and continuous operation

Figure 14 shows the operation a scheme of a total oxidation treatment plants that can be used for 800-100 person and a flow of 1.6 to 20 m^3/day.

The most efficient systems used for wastewater treatment with low flow rates are those that use alternative denitrification and nitrification processes of organic compounds from wastewater. This type of system is shown in Figure 15.

2.3.2. Mechano-biological treatment plant with biomass in suspension and sequencing batch operation

The most common activated sludge treatment systems with batch operation are using the process type Sequencing Batch Reactor (SBR). Unlike conventional biological mechanical systems, in which the treatment process is divided by space in more basins, in a SBR system de treatment process is divided by operation time. So, the treatment systems that use the SBR process type represent the most effective alternative to the conventional wastewater treatment with low flow [6, 17, 26, 29, 30].

This method, unlike the continuous treatment can be adapted to the quantitative and qualitative variations of the influent and the purification process can be easier controlled [31, 32].

There are several variants of using SBR process in a mechanical-biological wastewater treatment system, depending on the influent characteristics and flow (Figure 16) [11, 12, 32].

Mechanical-biological treatment process in a SBR system is conducted in a single basin, the operation sequence, a complete cycle is comprised of the following phases: filling, reaction, settling, discharge treated water and sludge disposal.

For treat municipal wastewater with low flow, most often is used hybrid, modular type of installation, where the SBR process forms the second stage of treatment. Such a system is shown in Figure 17. This type of installation can be used for individual homes and for small localities. The main elements of the system of treatment they are:

- septic tank;
- SBR tank (dual role);
- air aeration system;
- flow control system.

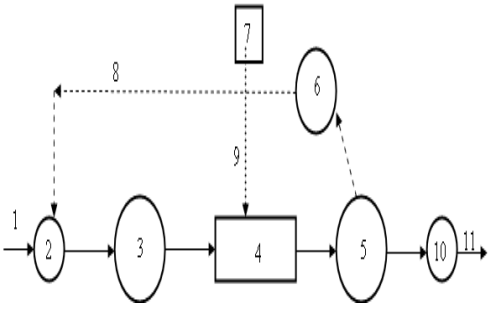

Fig. 14. Operating scheme of a wastewater treatment plants with small capacity, full oxidation and continuous operation [28]:
1 - the inlet of wastewater; 2 - mixing tank and pumping stations; 3 - primary clarifier; 4 - aeration basin; 5 - secondary clarifier; 6 - sludge thickener; 7 - air pump station; 8 - recirculated sludge; 9 - introduction of air; 10 - disinfection basin; 11 - evacuation of the treat wastewater.

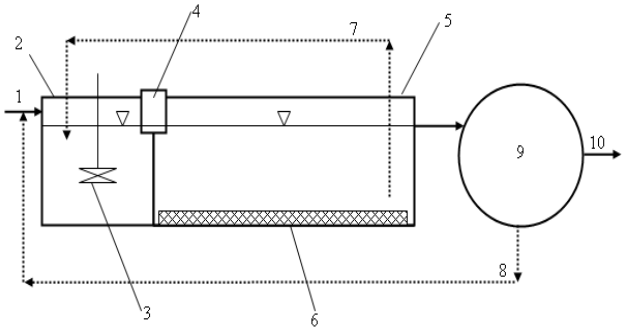

Fig. 15. Graphical representation of a system with a sequential denitrification and nitrification treatment [7]:
1 - influent, 2 - denitrification tank; 3 - mixed; 4 - filter sludge; 5 - nitrification tank (aeration); 6 - diffusers; 7 - recirculation of the sludge from nitrification tank; 8 - sludge recycling from basin; 9 - sedimentation basin; 10 - effluent.

Among the most important advantages of the SBR process include the possibility of modifying the operating cycle, elimination of secondary clarifiers and a better control of operations that form the treatment process [5, 23, 31, 33, 34].

Mechanical-biological treatment process - Sequencing Batch Reactor (SBR) is one of the most used for wastewater treatment, especially those with variable flow [5, 30, 31, 33, 34, 35].

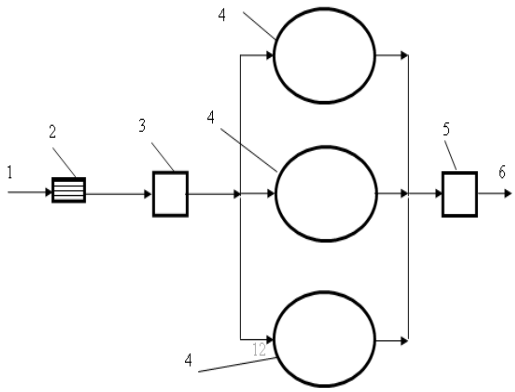

Fig. 16. Graphical representation of a complex wastewater treatment system that works by SBR process:
1 - the inlet of wastewater; 2 - grids; 3 - collection basin; 4 - SBR basin; 5 - legalization basin; 6 - evacuation of the treat wastewater.

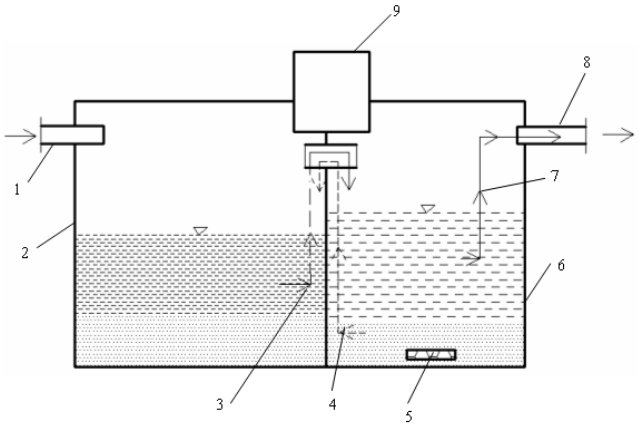

Fig. 17. The scheme a compact plant with activated sludge treatment and operation sequence:
1 -influent; 2 - septic tank; 3 - alimentation of the SBR compartment; 4 - recirculation sludge; 5 - diffuser; 6 - SBR basin, 7 - treated water; 8 - treated water outlet connection; 9 - inspection opening.

3. CONCLUSIONS

Domestic wastewater treatment technology used methods: mechanical, biological and chemical. Often these procedures are used to increase efficiency in the combined treatment.

Mechanical processes in wastewater treatment, underpinning the other two processes: biological and chemical.

Successive treatment methods applied, even for the same wastewater can be achieved by different types of construction and installation. Choosing the optimal solution depends on several factors, of particular importance with technical and economic criteria.

Procedures and techniques of intensive treatment of domestic wastewater in decentralized system, ensures the treat of wastewater from individual homes or small communities, local and/or individually.

Differentiation of processes and techniques of intensive treatment of domestic wastewater in decentralized system is based on:
- degree of treatment required;
- influent flow;
- influent properties;
- climatic conditions of the location.

For domestic wastewater from individual houses and/or small localities often is used mechanical biological treatment process.

Domestic wastewaters from individual households and/or small localities have considerable flow variations. This leads to the need of identify the best methods and treatment techniques that can operate in a variable wastewater flow conditions.

Municipal wastewater with variable flow can be treated using sequential treatment plants.

In choosing the type of installation used for wastewater treatment, resulting from the activities of individual houses sanitary and/or small localities, need to take into account the possibilities of automation of its operation.

Identify the opportunities for automation the operation of municipal wastewater treatment plants with small capacity creates the possibility of reducing the operating costs by eliminating the operators.

The municipal wastewater treatment plants with small capacity usually operating without operator intervention.

From all mechanical-biological wastewater treatment processes from plants with variable flow, the SBR process has great flexibility assuring a high degree of purification.

The wastewater treatment plants that operating by SBR principle are those suitable to be used mainly for small flow of wastewater.

In most cases, installation of wastewater treatment plants with SBR principle has automated operation.

Systems used to automate the operation of SBR-type treatment plants must be customized according to:
- number of people using treatment plant;
- domestic waste water flow;
- domestic waste water characteristics;
- operating conditions of the treatment plant.

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