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Small Wastewater Treatment Plants a solution for isolated households

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Abstract: In the first part of the paper are presented the main problems specific to the rural area related to the collection, transport and treatment of waste water. If compared to those presented in [11] at the present time are made large investments for the development of sewerage systems in small localities. But there are still situations for which the small wastewater treatment plants are an efficient solution. Further are presented the main purification technologies that are suitable for small capacity installations and the requirements to which such installations must respond. Finally is presented a proposal for organizing and controlling the implementation of local wastewater treatment technologies for isolated households.

1. THE IMPORTANCE OF SMALL WASTEWATER TREATMENT PLANTS

The collection, transport and treatment of waste water presents a wide range of problems in rural conditions. The present village is in a continuous transformation, following the blurring of the great differences between the comfort of city life and municipal facilities in the village.

Occurrence in our country of a new branch of the tourism industry, agro-tourism, requires the lifting of the municipal and hydro-edilitary facilities to a new standard, namely to the current standard of the technique. This means the hydropower supply to a level that allows the supply of quality drinking water and the evacuation and treatment of waste water for absolutely all the village households as well as the management of the sludge resulting from wastewater treatment.

We can assimilate the rural environment the consumers of tourist resorts, sanatoriums, parking equipped with motel and restaurant, monasteries, etc.

It is taken into account that, compared to other European countries, especially highly industrialized with a highly developed infrastructure, the Romanian rural area does not yet have a unitary concept related to water supply, a situation that is valid even for some small cities. For financial reasons, water supply almost always goes before sewage and sewage treatment. This idea must disappear in the future and propose sewage and treatment solutions that will run in parallel with the water supply even in the case of isolated households. The situation of water supply and sewage in the localities in Romania is presented in table 1, (2008).

Table 1

Localities equipped with hydro-edilitary installations of the in Romania

Number of urban localities	From which		**Number of rural localities**	From which			
	with drinking water supply facilities	with public sewerage facilities		with drinking water supply facilities	%	with public sewerage facilities	%
262	262	261	13461	2391	17.7	346	2.57

The rural area presents problems in the collection, evacuation and transport of wastewater, especially in the hill areas, with the displaced households, (low density of inhabitants). The topography of the place is also sometimes completely unfavorable to the network achievements. Possibilities to solve are: public channel and central wastewater treatment plant, wastewater collection in septic tanks, (seals), and local wastewater treatment in low and very low capacity wastewater treatment plants.

The public channel and the central treatment plant represent a very advantageous solution, but it is expensive to execute in the classic version. It can intervene by designing and executing the network in an economical version, which means: small diameters, large distances between manhole, reduced installation depth, simple manhole, curvilinear trails. This network will be served by pumping or vacuuming stations. In extreme cases, this solution may not be applicable.

The collection and transport of waste water to the treatment plant through the vacuum channel or the pressure channel, represents an economical and technically efficient solution for isolated households. Problems in the operation and maintenance of these channels appear in the cases of long and winding routes.

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The system for collecting waste in tanks, involves perfectly sealed septic tanks, (with a volume of 3-5m^3 / place served), and an organized drainage and transport service, analogous to that of household waste collection. The solution is favorable in terms of compliance with environmental conditions, but very expensive. The transport distances of the tank to the point of unloading can be very large.

Small and very small capacity treatment plants are also a solution for extreme situations, such as isolated communities with access roads that are not always practicable. The solution has been imposed in recent years at European level, there are a lot of constructive solutions for these stations, (light synthetic materials, monobloc type container construction, etc.). The legislation of some European countries, for example Austria, provides for grants to be applied to this solution. The disadvantage of the small and very small capacity treatment plants is that they incorporate in their construction a complex technique, usually not accessible to the beneficiary, sometimes maintaining maintenance and adjustment problems that may affect the purification performance. This disadvantage can only be considered temporary because the large-scale application of this solution also develops and improves the maintenance and control services, [4], [7], [10], [11], [13], [14]. The estimated costs related to the execution of the collection, transport and wastewater treatment plants are shown in table 2, [9].

Table 2

Estimated costs of execution and operation of the small capacity treatment plants

Capacity (inhabitants)	Building-costs Euro / inhabitant	Operating costs Euro / inhabitant * year
5	2123	92
10	1465	77
25	965	63
50	765	53
100	643	45
150	593	40
200	572	38

The general classification of the treatment plants according to [13], according to the influent flow is:

- very small treatment plants $Q_{u.zi.max} \leq 5l/s$;
- small wastewater treatment plants $5l/s \leq Q_{u.zi.max} \leq 50l/s$;
- medium treatment plants $50l/s \leq Q_{u.zi.max} \leq 250l/s$;
- large wastewater treatment plants $Q_{u.zi.max} \geq 250l/s$.

However, this classification is difficult to use in the current context of the continuous decrease of the water requirement due to its rational use and metering.

The general classification of the treatment plants according to the number of equivalent inhabitants served, according to ATV and ONORM, is:
very small treatment plants ,5-50 inhabitants;
small wastewater treatment plants, 50-500 inhabitants; medium treatment plants,500-5000 inhabitants; large wastewater treatment plants 5000-50000 inhabitants; - very large treatment plants >50000 inhabitants.

Requirements related to the efficiency of the low capacity treatment plants are also in line with their scope, thus [1], [2], [3], [7], [10], [11], [13] , [14]:

- minimum investment and operating expenses;
- have robust, reliable and simple to operate machinery, equipment and installations;
- have a complex automation, remote data transmission systems;
- have a low power consumption and a reliable system of electricity supply, (for a greater safety a generator set can be provided);
- the materials used in the construction must be resistant and anti-corrosive;
- be able to pick up any debit shocks;
- be compact and occupy a smaller surface area;
- if a physical-chemical step is required, it should be designed in such a way that the consumption of reagents is minimal;
- be so located in relation to the community served so as not to create shortcomings through the production of odor, noise or vibration, generally not being a source of pollution for water, air and soil;
- to avoid the shocks of flow and of loading with pollutants, providing the necessary means for a continuous functioning of the biological treatment step, with a flow as constant as possible, (basin of uniformization and equalization).

2. WASTEWATER TREATMENT TECHNOLOGIES AND PERFORMANCE OF SMALL WASTEWATER TREATMENT PLANTS

A comparison between the discharge limits of the effluent from the wastewater treatment plants and the minimum treatment rates provided by European, Austrian and Romanian legislation is shown in table 3. It should be noted that compared to NTPA 001, these discharge limits are based on the number of serviced inhabitants, namely the waste water flow, [12], [13], [15].

Table 3

Comparison between the limit values of the waste water charges according to RL 91/271 / EWG, 1.AEVkA and NTPA 001/2002.

Parameter	RL 91/271/EWG**		1.AEVkA***				NTPA 001
	normal areas	sensitive areas	50-500	500-5000	5000-50000	>50000	all areas
CBO_5 (mg/l)	25	25	25	20	20	15	20-25*
CCO (mg/l)	125	125	90	75	75	75	70-125*
NH_4-N (mg/l)	-	-	10	5	5	5	2(3)
N_{total}	-	15mg/l 1) 10mg/l 2) 70-80% 3)	-	-	70% (>12ºC)	70% (>12ºC)	10(15)
P_{total} (mg/l)	-	2 1) 1 2)	-	2 (>1000 loc.echiv)	-	-	1(2)

1) ......for installations with 10000 - 100,000 equivalent residents served.

2) …. For > 100,000 equivalent residents served,

3) …. the arithmetic mean of the minimum degrees of reduction over a year,

* ... .. for new stations, extensions or refurbishments,

** .... Normative regarding the limits of the communal waste water loading, Austria,

*** ... Directive of the Council of the European Union on the limits of communal waste water loading.

Treatment plants with aeration tank and pre-treatment (primary clarifier)

These installations are the most used, representing a miniature wastewater treatment plant. The mechanical stage consists of a grill and a clarifier. In the activation plant, aeration of the mixture of waste water and active sludge takes place, Figure 1. The amount of oxygen required is blown through an aeration system, performing blowing and stirring the mixture in the tank. The secondary clarifier retains the active sludge, [2], [6], [10], [11].

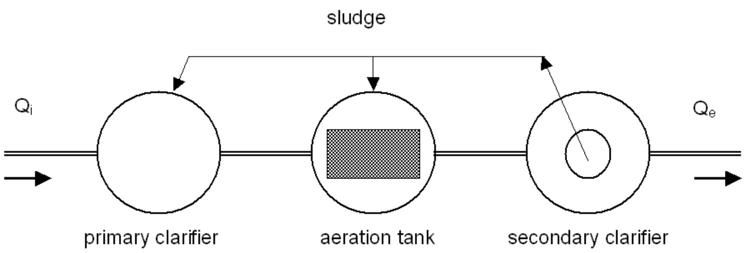

Figure 1. Schematic of an installation with an activation tank and mechanical stage

Treatment plants with aeration tank and accumulation

At the accumulation activation treatment plants, alternate working phases, inlet, aeration, activated sludge decantation and purified water sampling, (by pumping or free drainage), once or several times a day, figure 2. A secondary clarifier for sludge retention therefore active is not necessary.

The chronological sequence of the cycles can be controlled according to quantities or time. The adjustment of the individual phases will be adjusted until the maximum purification performances are obtained, [2], [6].

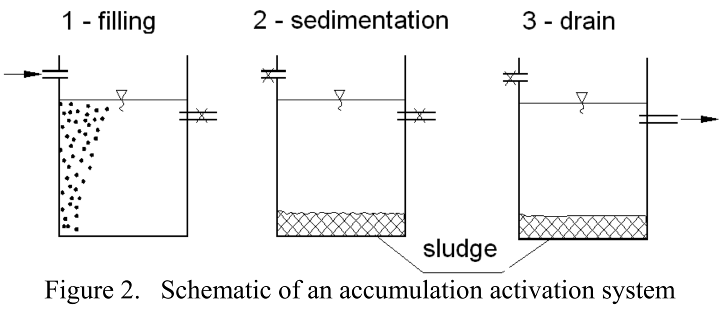

Figure 2. Schematic of an accumulation activation system

Treatment plants with biological filter

At the facilities with biological filter the clarified water is dripped over a large surface of filling material, on whose particles a biological film is fixed, figure 3. The oxygen supply is done by natural or artificial aeration. To keep the filter active, a recirculation of water, [2], [6] is required.

Biological filters are optimally exploited by recirculating water. The height of the filler material in the filter shall be at least 3 m for a recirculation ratio r = 1, (in relation to the maximum influential hourly flow), and at least 2 m for a recirculation ratio r = 3, [2], [6], [10], [11].

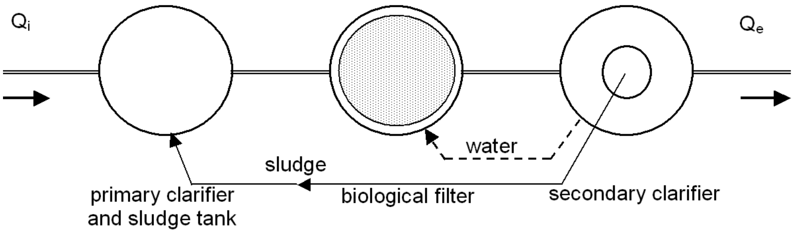

Figure 3. Diagram of a biological filter treatment plant

3. RECOMMENDATIONS REGARDING THE LOCATION OF A SMALL WASTEWATER TREATMENT PLANT

The location of the small capacity treatment plants will be done taking into account the following aspects, [5], [7], [9], [10], [11], [13], [14]:

- to allow, if possible, the gravitational reception of the influencer in the station;
- to allow the gravitational evacuation of waste water from the station;
- be respected protection distance between the station and the nearest populated area is respected, so that princes, noise or vibrations can be tried for people;
- to reduce, if appropriate, the risk of floods by carrying out embankments;
- to avoid as far as possible the choice of sites with an inadequate geological texture;
- there is the possibility to easily connect the treatment plant to the utility networks, such as electricity, water, gas and telephone;
- easy connection of the access road to the main road;
- the possibility of extension;
- limiting the retention time in certain technological objects, such as the receiving tank of the pumping station or the basin of equalization of the flows and concentrations, in order to avoid sedimentation and septicity;
- the conditions for the discharge of the effluent purified;
- the aesthetic aspect of the constructions and installations;
- access to the waste dump of the locality;
- safety of constructions and installations.

4. ORGANIZING THE DESIGN, APPROVAL, ACQUISITION, CONSTRUCTION, OPERATION, MAINTENANCE AND CONTROL OF A SMALL WASTEWATER TREATMENT PLANT

Starting an investment for a purification microstation means, first of all, a technically economically based analysis, carried out by the local (or zonal) operator of water and sewerage. The investment is justified only when there is no other possibility of providing the sewerage service.

The wastewater operator has both the task of advising the beneficiary and the pursuit of investment during the construction and its proper maintenance and operation, [10], [11], figure 4.

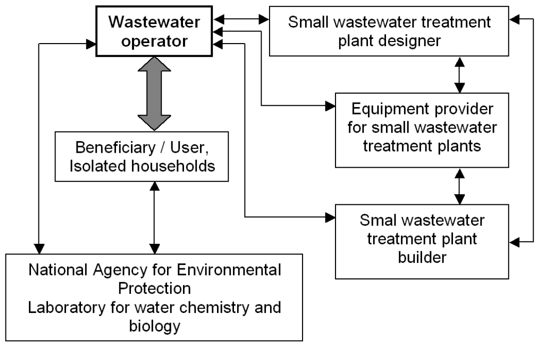

Figure 4. Organizational chart

The presented organizational chart, designed for the implementation of these technologies for isolated communities or households, proposes an optimal way of working between the beneficiary (user), wastewater operator, designer, equipment provider and the National Agency for Environmental Protection in order to make a justified investment by the beneficiary but also to ensure an exploitation and maintenance corresponding to it.

The beneficiary (User)

- will contact the local operator for advice;
- will make available to the local wastewater operator all the necessary data for the study of the solution;
- will conclude an assistance contract with the wastewater operator;
- will approve the operating instructions of the station;
- will announce and cooperate with the wastewater operator whenever a failure is detected;
- will allow the wastewater operator and the National Agency for Environmental Protection access to the manhole for the purpose of taking samples;

- will invest, if appropriate, in the modernization and refurbishment of the microstation.

The wastewater operator

- will propose to the beneficiary-user the optimum solution from the technical economic point of view for the solution of the treatment and disposal of the domestic waste water and of the resulting sludge, as the case will propose several variants;
- will contact the specialist designer to carry out the necessary documentation;
- will be responsible for obtaining the necessary permits for the construction and operation;
- will train the beneficiary (user) to proper operation and maintenance of wastewater treatment plant;
- will start up the treatment plant;
- will supervise its proper functioning, by periodically analyzing the main quality parameters and by the verification and maintenance works;
- it will intervene whenever the faults of the installation are signaled;
- keep in touch with independent laboratory surveillance and with the Local Environmental Protection Agency;
- propose to the beneficiary (user) the possible works of modernization and / or extension of the existing installation;
- will collect and remove excess sludge accumulated in the microstation.

Equipment provider for small wastewater treatment plants

- will keep it updated the local wasterewater operator informed about the technical parameters of the installations that he can supply;
- will provide the operator with operating and service instructions for the provided facilities, will provide the spare parts, in a timely manner, for the installations delivered for a period of at least 10 years;
- will deliver approved and quality installations to the beneficiary (user);
- will collect from the operator all the necessary data related to the delivered installation, in order to assess its reliability and operating performance. The operational monitoring of the provided facilities must be an integral part of the quality management program. The provider will make modernization and refurbishment proposals for the delivered installations.

5. FINAL CONCLUSIONS

Small capacity treatment plants represent an interesting alternative for solving the problem of collecting, transporting and purifying waste water isolated consumers, who cannot have a public sewerage network.

At present, in our country, these technologies are still very expensive, sometimes even difficult to access, with retention, even from experienced designers, in their application. However, the purification/treatment modules used in recent years gave good and very good results.

The choice of biological treatment technology is based on technical - economic criteria. The most popular wastewater treatment systems, including those already in use in our country, are those with activation basin. This is explained by the experience gained in the operation of the activation basins of the large stations.

A proposal would be to carry out pilot projects to promote these technologies among beneficiaries, designers and wastewater operators.

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