# WASTE WATER TREATMENT FROM SMALL URBAN AREAS

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**Abstract.** This paper describes some actual specific problems by sewage systems in small urban centres. It is dilemma to find compliance with measures, which is following the strict requirements of EU by discharging of waste waters in receiving waters with lack of funds required for the construction of new sewage systems and WWTPs in small municipalities. In 2002 a new Water Act came into force in Slovakia. It is in line the requirements of Directive Nr. 91/271/EEC. The harmonisation of the waste water treatment in Slovakia with the requirements of this Directive will require substantial amount of funding for construction of new and reconstruction of existing WWTP's. This problem concerns especially municipalities with the equivalent population over 2,000 (EO). This paper discusses some possibilities to address this problem. There are some specific aspects and problems, as well as technical design of solutions for sewage systems in small municipalities. Under a small municipality we understand smaller urban units. In terms of water management Slovak Technical Norm (STN) 756402 Small Waste Water Treatment Plans, this group includes municipalities or urban centres, which produce up to 100 m³/day of waste water, assuming specific consumption of 200 litres/day per head of population. This concerns municipalities with population up to 500.

**Keywords:** sewage systems, waste water treatment, small urban areas, legislation in Slovakia

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## 1. Introduction

Since 1,174 out of a total of 2,891 municipalities in Slovakia belongs in the small municipality category and predominantly they are located in areas with less affected environment, the sewage solution needs to meet the technical and financial requirements, but also the aforementioned dilemma must be reduced to the acceptable degree and the sewage network must be integrated sensitively with the environment. Preferred approach is sewage network – Waste water treatment plant (WWTP), as well as sewage – natural environment – life environment. These links need to be given a priority not only in terms of design planning, execution and operation of the construction, but also in terms of contradiction waste water – surface water. Whereas the waste water, carried off via a sewage network represents progress for the society, mainly in terms of improved health and hygiene, the waste water is detrimental to the surface water and subsequently also to the natural environment.

## 2. Sewage, Division and Execution Status

Sewage is a set of equipment allowing harmless removal of waste water, including its treatment. It consists of two sub-systems – sewage network with construction objects and waste water treatment plant.

There are a number of municipalities, which have addressed waste water treatment partially, or not at all. In terms of the world standard in this area the municipalities can be split into the following categories:

- ideal status, municipality with sewage network with waste water treatment, located before the receiving water
- interim status, sewage system prior to expansion, reconstruction
- interim status, sewage network in place, insufficient effectiveness WWTP
- unsatisfactory status, sewage system without WWTP in place
- critical status, no sewage system.

### 2.1. SEWAGE SYSTEM IN PLACE

In this case the whole activity is focussed on operation and maintenance, or fixing of small breakdowns. In case of fully built sewage system we can encounter these problems: low quality construction (seepage, deficiencies in detail), insufficient and non-qualified operation, low effectiveness of WWTP, difficulties with sludge utilisation.

## 2.2. SEWAGE PRIOR TO RECONSTRUCTION

Each expansion or reconstruction even in small municipalities represents certain distinctiveness. In the first place we need to take into account the inspection of existing structure. Expansion can be delayed by application of new trends in sewage management and increased intensity of treatment processes.

## 2.3. SEWAGE SYSTEM IN PLACE, INSUFFICIENT EFFECTIVENESS OF WWTP

Solution to this situation is very similar to case no. 2, with the only difference being more focus on WWTP. Again, crucial factor is determining the amount and quality of waste water, hydraulic, technological and operational parameters of WWTP. Over the past decades the development of sewage systems has been the focus also in small municipalities. Considering that the financial and time requirements for the construction of WWTP are lower than the sewage network for the whole municipality, the waste water treatment plant was usually, and also due to legal reasons (waste water without treatment must not be drained in the river system), constructed as the first sewage system element. Following the launch of the operation, the WWTP has, as a result of incomplete sewage system, significant capacity reserves and it is a problem to maintain it in optimal operation regime.

## 2.4. SEWAGE SYSTEM IN PLACE, WITHOUT WWTP

When constructing a new WWTP, emphasis needs to be placed on establishing the volume and quality of waste water, treatment effectiveness, technological design, as well as proper operation. Of course, other factors are also important, such as costs, lifespan of materials and incorporation in the environment.

## 2.5. SEWAGE SYSTEM NOT EXISTING

Construction of sewage systems in small housing centres requires the preparation of warranted, prudent and forward looking concept. Formulation of such concept needs to be entrusted with experienced specialists with know-how on the subject. Considering the required distances, sewage cost per person in smaller estates are higher than average. Therefore a great care is necessary when deciding, which technical solution to apply. Two possible solutions for the treatment of household effluent are available:

- Central drainage and treatment of waste water
- Individual waste water treatment

## 3. Central Drainage and Treatment of Waste Water

This is a case of a construction of new municipal sewage network and its connection to the existing regional waste water treatment facility or a construction of a new local WWTP. From the technical and operational aspect, it is the optimal solution. Currently a Water Act has come into force in Slovakia, stating, that by the year 2015 every municipality with population over 2,000 will have to be connected to the public sewage system and waste water from this sewage must be subsequently treated in WWTP with biological treatment level effectiveness, which will be determined by the respective water management body according to the pollution degree of the receiving waters, which will be receiving the treated water. At the same time however it is necessary to consider the question of financial effectiveness of the given solution. The sewage system construction and its financing will be the responsibility of the municipalities, who find it increasingly difficult to raise the substantial amounts of funds required for such purposes. For example a construction of 1 metre of gravity-fed sewage system, outside the road, costs 100 Euro – 300 Euro, depending on the contractor. Considering the adverse financial position of our municipalities we are encountering more and more often individual solutions for household waste water storage and treatment.

## 4. Individual Waste Water Treatment

Household effluent can be drained from individual houses into drain-wells, septic tanks or into individual waste water treatment facilities.

## 5. Drain-wells

Drain-wells are used as storage tanks for household effluent. In majority of cases they are built as enclosed monolithic concrete tanks in the vicinity of the house. Disadvantage of the drain-wells is that they are used only for storage purposes and not as a separation or stabilisation tanks and therefore the content has to be removed and transported to the WWTP. Effluent removal truck operators are charging 10 – 15 Euro per 1 $m^3$ of household effluent.

## 6. Septic Tanks

These are flow-through tanks used for accumulation, sedimentation and partially stabilisation purposes. They were known and used already towards the end of the last century, when waste water from cities across England was

treated in this manner. They work as a small anaerobic filter. The sludge is separated from the water, which is then filtered through a filtration layer. Thus reducing substantially the amount of sludge, which needs to be removed from the septic tank. However this sludge is not sufficiently stabilised and therefore it needs to be further processed. In principle there are three solutions available: removal, stabilisation and final treatment at the municipal WWTP.

Removal – the sludge is taken to agricultural and other lands, sludge lagoons, possibly can be used for composting purposes.

Sludge stabilisation – carried out in the form of wet oxidisation or aerobic – thermal processing.

Final treatment in municipal WWTP – currently this is the only realistic method in case of high volume of sludge. However, WWTP must be suitable for sludge processing, since the sludge causes uneven peak loads for the treatment plant and therefore causing the run-off quality deterioration. It is accompanied by a strong odour and at the same time it has detrimental effects on the facility's equipment. When draining the sludge from septic tanks to WWTP, compliance with the following principles is recommended:

- max. distance, effective for sludge transportation to WWTP is 20–25 km,
- minimal size of WWTP, for sludge processing is 10,000 EP.

Sludge drainage represents a technical problem. If the sludge is drained directly, it can disrupt the treatment plant operation and reduce the quality of treated water. Current trend to combat this problem is by building as storage tank for sludge. The size of the tank depends on the number of EP, which the WWTP is capable of handling. From this tank the sludge is evenly fed, even prior to the mechanical treatment. The technology in the processing of sludge prior to treating in WWTP has been addressed also by several domestic companies. The approach adopted abroad was to bring the sludge directly to heated putrefaction tanks. However, the practice has shown that this sludge does not have sufficient sedimentation properties. Therefore it is simpler to introduce the sludge into the waste water feeder at the WWTP. Of course, construction of such tank requires additional funding required for reconstruction of the treatment plant, which needs to be secured by the operator, i.e., the municipality.

## 7. Household Waste Water Treatment Plants

As a last of the offered solutions are household waste water treatment plants. Over the past several years we have been witnessing their construction with increasing frequency also in Slovakia. In price terms they are comparable with quality septic tanks, without having to deal with the problem of residual sludge.

This sludge is aerobically stabilised, which means that it is hygienically harmless. It can be used in agriculture, thickened in concentration tanks or drained in sludge presses. Its thickening or drainage properties are comparable with properties of excess sludge produced in municipal WWPT.

## 8. Function of Household Waste Water Treatment Plants

Treatment plants are designed for treating normal household effluent. They are scaled to accommodate approximately 5–20 population equivalent. Waste water treatment takes place in two steps. In the first step, during the mechanical pre-treatment, mechanical debris is removed from the water. Second step represents biological treatment in the form of fine-bubble aeration activation. At the same time the treatment process is extended by removal of biological elements of nitrogen and phosphorus in the form of denitrification and nitrification, which makes the majority of household treatment plants compliant with the European requirements with respect to effluent treatment. Waste water treatment plant itself comprises of the delivery unit placed on the concrete plate. It is necessary to ensure that the whole unit is watertight, since often it is placed below the water-table level and also to prevent the waste water seepage.

## 9. Technological Treatment Line Design

Household waste water treatment plants are offered on our market by several companies in various technological modifications. They use either bio-filtration or a long-term activation with aerobic sludge activation. In our paper we will focus on the description of household WWTP technology and operation, which was used also by residents of a new housing estate in Bernolákovo. Since it is a new development within the boundaries of municipality, which does not have a public sewage system, it was necessary to conduct a study of effluent management for the area. Following the assessment of investments required for the construction of effluent sewage and related connection to the municipal WWTP, a decision on behalf of about 25 households was made, to construct individual household waste water treatment units to address the household effluent issue. Waste water treatment takes place in a circular tank, in the form of long-term activation with aerobic sludge activation. The principle of comprehensive waste water treatment in the proposed technological solution is based on biological treatment by heterogeneous biological sludge, maintained in the deposit, with prior denitrification, where the source of carbon for denitrification processes is the introduced organic contamination of waste water. In order to oxidise the biological treatment process and to maintain the

concentrate in the deposit, an aerating system of fine-bubble aeration is applied. Air is delivered through fan powered by electric motor. Treated waste water is lead to the collection tank, where tertiary treatment, using disinfectant agent is introduced. Excess, aerobically stabilised sludge, is removed from the treatment process by effluent truck once or twice per year, depending on the sludge production.

## 10. Operation of Household WWTP

It is very important to know that well functioning WWTPs, not requiring regular maintenance and audit do not exist. Therefore it is necessary to look after your WWTP and to follow the supplier instructions for maintenance and operation. Biological treatment is based on the biomass growth, which needs for its existence regular supply of nourishment in the form of organic contamination in waste water and also sufficient amount of oxygen, which is supplied to the system through fine-bubble aeration. Any disruption of this system can lead to deterioration of treatment effectiveness. Long-term incorrect operation of WWTP results in dying of the biomass, followed by total disruption of the treatment process. Although the treatment plant operation is automated, it still requires supervision. At least once a week the fan needs to be checked and the treatment process in the reactor, as well as the quality of treated water in the accumulation tank, need to be checked visually.

Household waste water treatment unit is designed for treating normal household effluent, therefore it can be disabled by the introduction of excess amounts of substances, which should not be present in municipal waste water. These are mainly the following:

- greases in higher concentration (frying oil)
- household softener solutions
- paints, varnishes and solvents
- powerful disinfectants and acids
- low degradability materials (plastics, rubber, textiles).

Reliable treatment requires daily supply of effluent, in order to facilitate biological processes in the treatment unit. In case of absence over a period of 2 to 4 weeks, without new effluent for the WWTP, the micro-organisms start slowly to die. However, following the re-introduction of regular effluent supply they have the capacity to adapt and recommence their reproduction. However the air supply must be maintained also during the absence of waste water supply, otherwise organisms could start to decompose and rot. Only in case of absence from home for several months it is recommended to shut down the whole unit and remove the content.

## 11. Handling of Treated Water

Treated water can be used for watering of lawns and fruit trees. However it is not to be used for watering of plants for direct consumption, since it can contain substances harmful to human digestive tract.

## 12. Handling of Excess Sludge

When the separation tank is filled with sludge, it needs to be removed in order to prevent the sludge entering the treated water, hence reducing the quality at the exit point from WWTP. Excess sludge is sufficiently stabilised, i.e., hygienically harmful and it can be used in agriculture or used for further treatment in the municipal WWTP.

In closing, we would like to present several price comparisons, which can assist the consumers in selecting the most suitable solution for the treatment of their household effluent. These are for reference purposes only, since there is a number of suppliers and operators of sewage systems and waste water treatment plants.

## 13. Conclusions

Currently the trend is the preference for individual solution and each home owner has the freedom to select the most suitable equipment. Be it a drain-well, which is more affordable, but the operation requires regular emptying the full content, hence increased cost of removal or more costly septic tank, where only thickened sludge is being removed. However it is not stabilised and therefore a hygienic treatment at the municipal WWTP is necessary. Available is also a third solution, being highly promoted in the past few years – household waste water treatment unit. Although it is more demanding in terms of operation, there are however no problems with excess sludge and treated water.

TABLE 1. Price comparison for various treatment methods of waste water from small sources

| Building, facility | Cost (Euro) |
|---|---|
| construction of 1 m of sewage system in green belt (except road) | 100 – 300 |
| drain-well capacity – 20 $m^3$ | 1000 without foundations |
| septic tank capacity – 10 $m^3$ | 1000 – 1400 |
| WWTP for 5 – 10 PE | 1800 – 2500 |
| effluent removal per $m^3$ | 1 – 2 |

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