Part 2: Consider before flush!

Contents

The advanced treatment of domestic sewage has led to beneficial effects on the quality of receiving Baltic Sea coastal waters

1 What is wastewater?

Wastewater is any water that has been affected by human use. "Used" water originates during domestic, industrial, commercial or agricultural activities, while stormwater originates as surface runoff from urban areas. The characteristics of wastewater – volume, physical state, chemical ingredients, and quantities of microorganisms – vary depending on the source of origin.

Pollutant – is any substance, as certain chemicals or waste products that makes environment harmful or unsuitable for a specific purpose.

Wastewater can contain physical, chemical and biological **pollutants**. According to origin, wastewater is classified as sewage or domestic wastewater, industrial wastewater and stormwater.

Figure 1. Types of wastewater produced during different human activities. Photo: L. Urtāne, Alephcomo | Depositphotos. Figure: L.Urtāne.

2 What is domestic wastewater?

Sewage or domestic wastewater is a type of wastewater that is produced by a community of people. It consists of **greywater** and **blackwater** that is combined with the human waste – soap and detergents, food particles, etc. – that is flushed away.

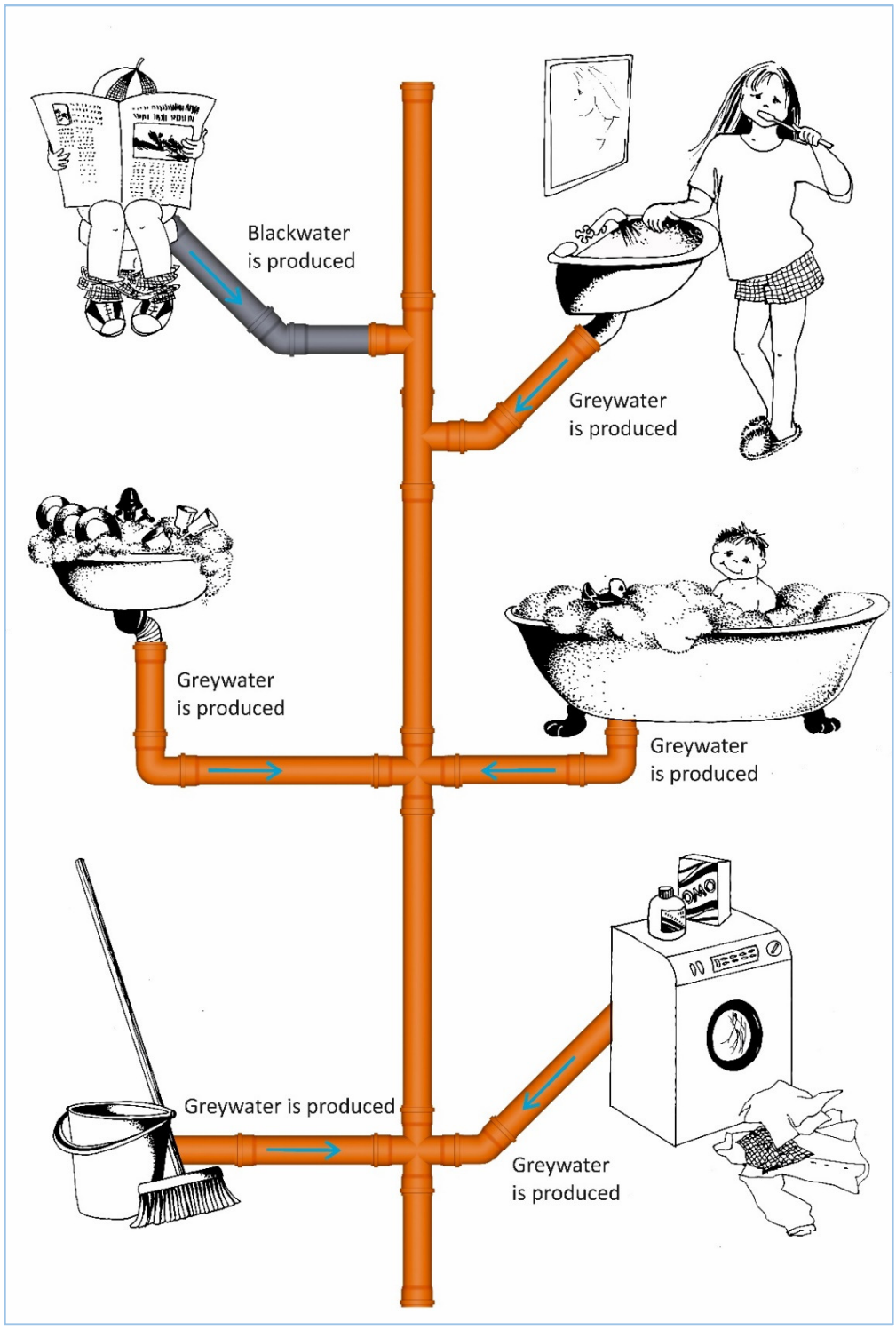

Figure 2. Origin of sewage. Drawing: Z. Rubene, Vantuz | Depositphotos. Figure: L. Urtāne.

According to source of origin, blackwater is produced in rather small volumes, but have high concentrations of organic pollutants, while greywater is substantially bigger in volume, but with low concentrations of pollutants.

If sewage systems, as it is more common in VillageWaters Project countries, is not split for greywater and blackwater collection systems, the mix of domestic wastewater is the subject of treatment.

In such cases untreated domestic wastewater contains high levels of organic material, numerous pathogenic microorganisms, as well as, nutrients and toxic compounds that can be harmful to human health and natural water if is discharged in environment without treatment.

Blackwater is wastewater from toilets, which likely contains pathogenic microorganisms. It can contain feces, urine, water and toilet paper from flush toilets. If food shredder is used, also sewage from kitchen sink is calsified as blackwater.

Greywater is all wastewater generated in households (or office buildings) except for the wastewater from toilets. Sources of greywater include, sinks, showers, baths, or dish washers. Comparing with sewage, which is not separated to blackwater and greywater, it contains small amount of pathogenic microorganisms and after simplified treatment can be reused for non–potable uses.

Figure 3. Origin of domestic wastewater and its content.

Without suitable treatment, the sewage we produce every day would damage the water environment and create public health problems

3 How does the sewage treatment is performed?

The sewage or domestic wastewater treatment is the quality improvement of household utilised water before its discharge to natural water.

Bacteria naturally presented in surface waters breaks down content of organic matter by using the oxygen dissolved in the water. If the content of organic matter in water is high, the use of dissolved oxygen is also high and it leads to insufficient oxygen level for life of fish and other aquatic organisms. Therefore, the first objective for wastewater treatment is to remove organic substances from sewage to keep high oxygen resources of natural water when sewage is discharged.

Sewage works, in practice, reproduce processes that occurs in the environment – sedimentation and degradation of organic substances. The settling down of the solid matter during **primary treatment** is similar to sedimentation processes into natural waters. Similarly, the degradation of organic matter that occurs during **secondary treatment,** repeat purification process of organic matter carried out in freshwater or in marine water by microorganisms.

In order to limit eutrophication processes and to protect natural water, which is recipient **of treated sewage, the** removal of nutrients is performed during the **tertiary treatment**.

The treatment allows water after its use to return to the environment. The requirements for sewage treatment depends on the nature and quality of recipient water. According to nature, natural waters are classified as **sensitive** and **less sensitive** waters. Sensitive to discharge of untreated or partly treated wastewater are waters, where rare species occurs – fast flowing rivers with salmons and oxygen-loving organisms, lakes with slow water exchange and coastal part of the Baltic Sea (refer – Part 1). The identification of sensitive waters, where discharge of sewage is allowed only after additional treatment and reduction of nutrients, is country specific (refer – Part 3).

Preliminary treatment of sewage or pre–treatment is the removal of coarse solids and other large materials often found in domestic wastewater. During this stage of WWT large materials – trash, tree limbs, leaves, branches, and other large objects – are collected to improve treatment process and to protect WWT plant from damage.

Primary treatment involves a physical and/or chemical settlement of suspended solids that is not removed by preliminary treatment. During these process 20 % of biochemical oxygen demand and 50 % of suspended solids are reduced.

Secondary treatment is the treatment provided after preliminary and primary treatment. During these processes a certain degree of effluent quality is achieved by physical separation of suspended solids and by biological reduction of dissolved and suspended

Tertiary treatment is provided after preliminary, primary and secondary treatment. It is a term applied to polishing methods used for nutrient removal to help prevent eutrophication, disinfection to reduce pathogenic bacterial and viral organisms, and removal of specific toxic

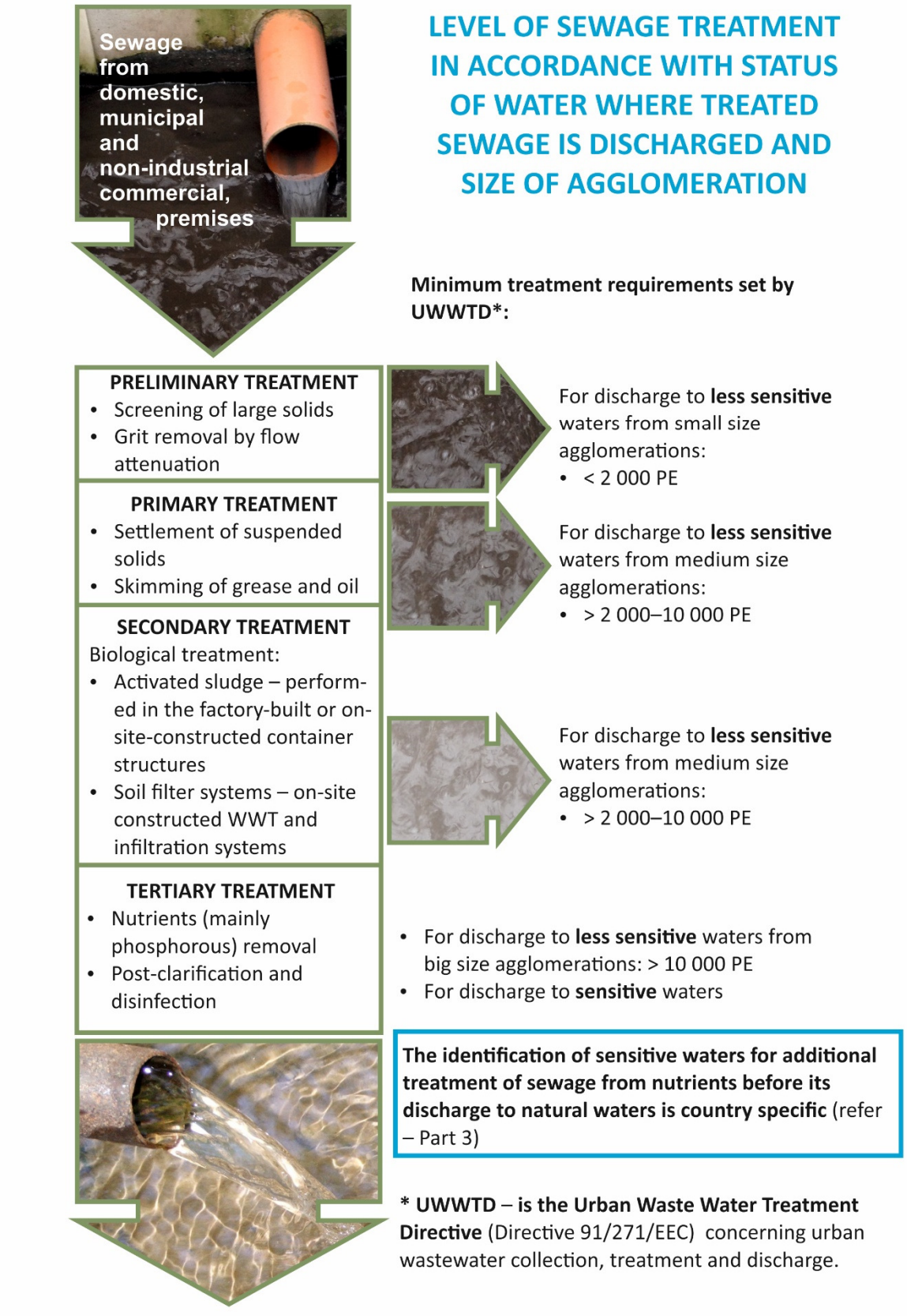

Figure 4. General requirements for sewage treatment set by EU legislation. Photo, figure: L. Urtāne.

According to size and structure of **agglomeration**, nature condition and availability of surface water body, two different approaches for domestic sewage treatment are used:

- WASTEWATER TREATMENT ON SITE – when sewage is treated within **small domestic wastewater treatment (WWT) systems** directly after it is transmitted from the household;
- POSTPONED WASTEWATER TREATMENT – when sewage is collected at household and later is evacuated to municipal WWT plant.

Agglomeration is a community of households, shops, hospitals and certain industries, which are sufficiently concentrated for the wastewater to be collected for treatment at a wastewater treatment (WWT) plants. An agglomeration most commonly is the community served by a single sewerage collection network and served by a single WWT plant.

Small domestic wastewater treatment (WWT) systems – according to EU standard EN 12566-3:2016 are WWT plants for up to 50 people equivalents (PE).

In the cases when sewage is evacuated for treatment on municipal WWT plants, at least secondary treatment (in some cases also reduction of nutrients) is conducted, while treatment efficiency within small domestic WWT systems depends on the type of WWT plant and WWT technology used.

In the VillageWaters Project countries, about 62 to 81 % of the population is connected to centralised wastewater collection and treatment systems. Small domestic WWT plants and wastewater holding tanks serve most of the remainder.

Table 1. Summary of the most popular types of wastewater treatment plants used in the VillageWaters Project countries as small domestic WWT systems

WASTEWATER TREATMENT ON SITE	POSTPONED WASTEWATER TREATMENT
Prefabricated factory-built WWT plants	Wastewater holding tank
Septic tank	
Packaged domestic WWT plant	
Site assembled domestic WWT plants	
Constructed wetland	
Soil filter	

In general, all types of WWT plants listed in the *Table 1* are applicable for areas with a limited number of people and small wastewater flows. Nevertheless, the treatment efficiency and corresponding impact to environment quality differs from WWT technology used. It concerns specially to reduction of nutrients, such as denitrification or phosphorus removal, in the majority of cases cannot be achieved without additional unit processes.

Only a part of organic matter and nutrients is reduced if WWT technology provides only primary treatment. For example, sedimentation and anaerobic processes take place within septic tank to reduce solids and organics. Therefore, the treatment efficiency is only moderate and only partly treated sewage is discharged to environment after its treatment. Comparing to oxygen-free anaerobic processes used in septic tanks, the more efficient reduction of polluting substances is achieved during biological treatment process conducted in oxygen-rich conditions.

Site assembled domestic WWT plant – is treatment systems constructed on site. It is plant composed of prefabricated components assembled on one site by one manufacturer, which accepts domestic wastewater and treats it to a declared quality.

Packaged domestic WWT plant – is prefabricated factory-built wastewater treatment installation, which accepts domestic wastewater and treats it to a declared quality

The content of **organic matter** is measured as biochemical oxygen demand in 5 days – BOD_5 and chemical oxygen demand – COD.

Table 2. Efficiency of the most popular small domestic WWT systems

POLLUTING SUBSTANCE	CONCENTRATION OF INCOMING SEWERAGE *	UNIT	REDUCTION OF POLLUTING SUBSTANCES (%)			
			Prefabricated factory-built WWT plants		Site assembled domestic WWTP	
			Septic tank	Packaged domestic WWT plant	Constructed wetland	Soil filters
BOD_5	150–450	mg/l	40–50 %	94–98%	94–96%	No data
COD	300–900	mg/l	60–70 %	90%	79–88%	23–79%
Suspended Solids	385–565	mg/l	40–80 %	88%	90–97%	55–90%
N_{total}	25–75	mg/l	0–50 %	57–87%	62–64%	24–99%
P_{total}	5–15	mg/l	15%	**	15–75 %***	94–99%

Notes: * - according to EN 12566-3:2005; ** - Most manufacturers do not guarantee certain reduction %; *** - depends on type – vertical subsurface flow system, horizontal subsurface flow system, free water surface systems or hybrid systems.

Several modifications of the activated sludge processes are used within package plants, which are industrially produced treatment systems operated in the oxygen-rich conditions. Also the modified natural self-purification processes conducted in soil filters and constructed wetlands take place in the soil or water in oxygen-rich conditions. Therefore high treatment efficiency of organic matter is achieved during WWT processes, while the same status of phosphorus removal can be achieved only when additional unit processes are introduced.

Knowing that phosphates are used in automatic dish detergents and laundry detergents we can improve quality of produced sewage before it's flush by using nature friendly products in our household.

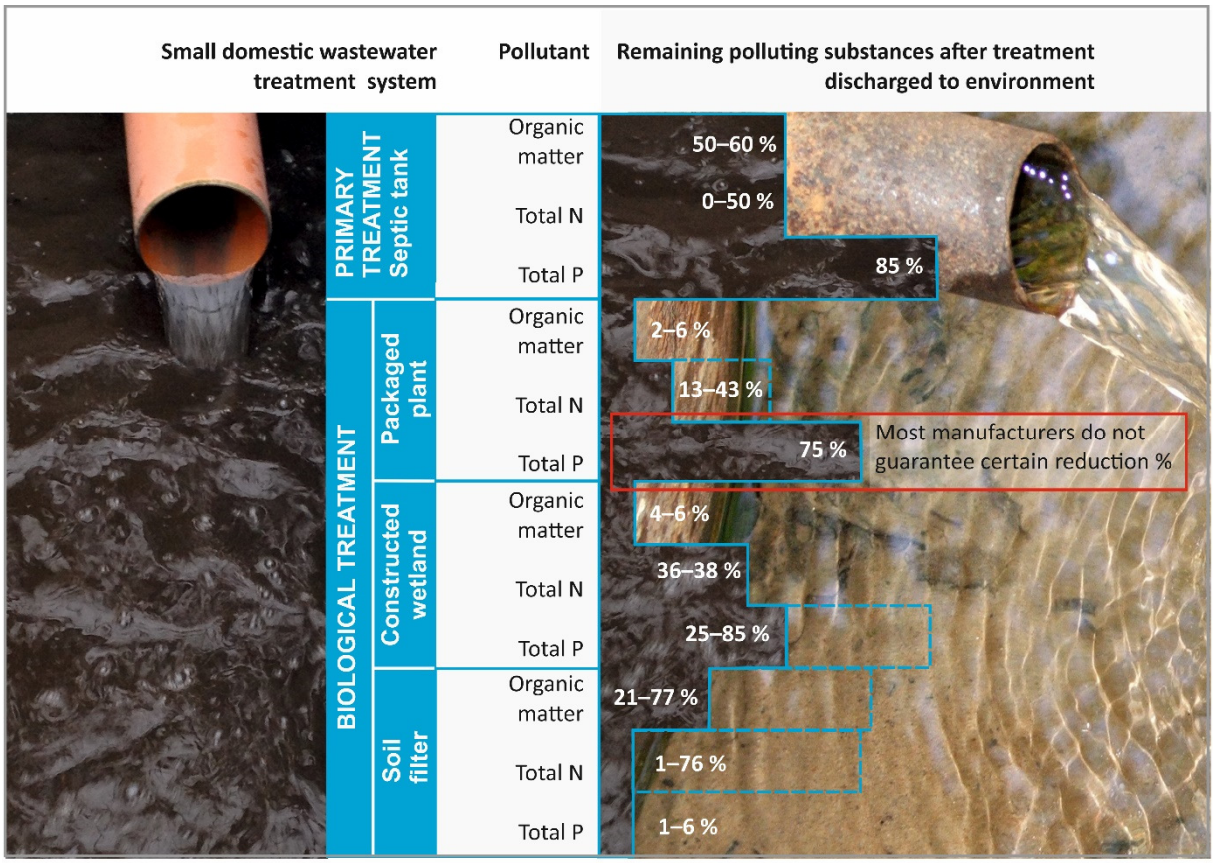

Figure 5. Comparison of treatment efficiency of different wastewater treatment solutions. Photo and figure: L. Urtāne

We all contribute to the pollution of the water environment, so protecting and improving it depends on each of us trying to reduce our part of pollution in sewage

4 Wastewater Treatment Systems used for domestic sewerage treatment

4.1 Pre-fabricated factory-built wastewater treatment plants

4.1.1 WASTEWATER HOLDING TANK

Wastewater holding tank is an enclosed container designed to collect and temporarily store wastewater in places where the use of wastewater treatment systems is limited or impossible. Within the frameworks of VillageWaters Project chemical toilets (Portaloo, TOITOI, Honey Bucket etc.) are considered as storage tanks too, since they do not have output to environment.

MAIN CHARACTERISTICS

Holding tanks are used to collect and temporarily store sewage from a facility or dwelling for later removal and transport to municipal WWT plant for treatment. These WWT solution is postponed wastewater treatment solution.

BASIC PRINCIPLES OF OPERATION

Wide variety of holding tanks are available on market. The storage capacity of a holding tank depends on daily sewage flow and emptying frequency. The operation of small holding tanks is manual. Bigger tanks are usually equipped with filling alarm system.

The difference between holding tank and cesspool, which externally seems similar, is the insulation level. According to its construction cesspool is not watertight and allow liquid to leach out from pit. Therefore cesspools could be considered as the older version of holding tanks and used only in cases when such impact to environment is allowed and acceptable.

Figure 6. Wastewater holding tank with filling alarm. Photo: Scan-Plast Latvia LSEZ SIA

ADVANTAGES	DISADVANTAGES
Low installation cost	More frequent content evacuation comparing with septic tanks and active sludge plants
No power consumption	
No reagents used	Is possible contamination of close environment
No output to close environment	

4.1.2 SEPTIC TANK

MAIN CHARACTERISTICS

The septic tank is an enclosed container designed to:

- collect wastewater,
- segregate settleable (sand and grit) solids and floatable (scum, fats and oils) fractions,
- accumulate, consolidate, and store solids, digest organic matter,
- discharge treated sewage.

Septic tank is an underground container made of concrete, fiberglass or plastic, through which sewage (domestic wastewater) flows for primary treatment – settling and anaerobic reduction of solids and organics.

Septic tank provides primary wastewater treatment. It may be the important component used for treatment within small domestic WWT systems. Septic tanks can be both factory manufactured or assembled with concrete details on site. Traditional septic tank contains only one section. The newest models of septic tanks consist of two sections to avoid sludge flushing to output pipe.

During operation, the sludge layer consisting of various insoluble matters accumulates on the bottom of a septic tank. This layer should be periodically removed to make in use total volume of septic tank.

BASIC PRINCIPLES OF OPERATION

Septic tank is container with their own ecosystem of microorganisms, which take in place complex biochemical processes to reduce content of polluting substances of sewage put in.

The microorganisms found in domestic sewage are bacteria, which use wastewater containing solubilized nutrients for cell growth and energy. The main part of septic tank is oxygen-free or anaerobic. Only in the clear zone of septic tank oxygen is available.

The treatment processes what are going on in those parts are different. The bacteria inhabited both oxygen-rich and oxygen-free parts of septic tank, solubilize complex organic material to **volatile organic acids.** Within oxygen-free parts of septic tank, where scum or sludge is performed, bacteria ferment the volatile organic acids to acetic acid, which further is next converted to methane and carbon dioxide gases.

Volatile organic compounds are organic chemicals that have a high vapour pressure (an indication of a liquid's evaporation rate) at ordinary room temperature.

The growth of bacteria population is dependent on the characteristics of the wastewater – temperature, concentration of organic matter, toxic chemicals or cleaners. On the other hand, larger quantity of bacteria ensures more efficient treatment of sewage.

EFFICIENCY

The treatment efficiency of septic tank strongly depends not only on characteristics of influent wastewater, but also on the size of septic tank, because optimal retention time gives more viability to the process of treatment.

The level of pollutants reduction provided by septic tanks usually do not allow to use them as the only step of wastewater treatment. In practice WWT solution with septic tank often is combined with secondary treatment alternatives – filtration fields, constructed wetlands and biological ponds – and is used also as pre-treatment for packaged activated sludge processes.

PARAMETER	EFFLUENT CONCENTRATION"	UNITS	REDUCTION OF POLLUTING SUBSTANCES
BOD_5	150–450	mg/l	40–50 %
COD	300–900	mg/l	60–70 %
Suspended Solids	385–565	mg/l	40–80 %
N_{total}	25–75	mg/l	0–50 %
P_{total}	5–15	mg/l	15 %

Notes: * - according to EN 12566-3:2005

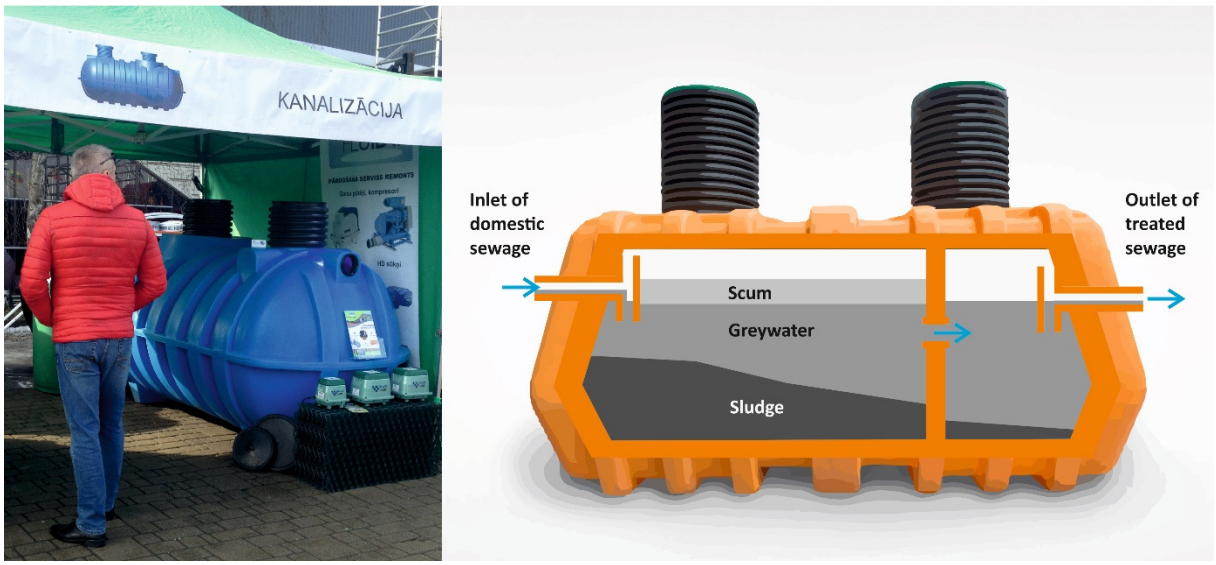

Figure 7. Factory manufactured septic tank. Photo and drawing: L. Urtāne

ADVANTAGES	DISADVANTAGES
Low investment costs	Insufficient treatment efficiency
No power supply	Methane evaporation to atmosphere
Comparably rare sludge evacuation	
Methane produced can be used for heating	

4.1.3 PACKAGED DOMESTIC WASTEWATER TREATMENT PLANT

MAIN CHARACTERISTICS

Packaged domestic wastewater treatment plant (simplifying the term ”package plant” is used) is an enclosed container designed to:

- collect wastewater,
- segregate settleable (sludge) and floatable (scum) solids,
- accumulate, consolidate, and store solids, digest organic matter on aerated sludge,
- discharge treated effluent.

Packaged domestic wastewater treatment plant – is pre-manufactured treatment plant used to treat wastewater in small communities or single dwellings.

Packaged domestic WWT plant usually provides primary, secondary and tertiary stages of WWT and can be used as the only WWT system for a household. The variety of packaged WWT plants are available in market. Part of them provide only primary and secondary treatment stages, or even only secondary WWT stages.

BASIC PRINCIPLES OF OPERATION

Very different technological processes are used for secondary treatment. The most common of them is activated sludge process with its modifications – extended aeration, sequencing batch reactors and oxidation ditches, contact stabilization plants – and additional physical/chemical processes. It explains the large number of packaged domestic WWT plants available on the market for small domestic WWT solutions.

ACTIVATED–SLUDGE PROCESS

Activated sludge is one of WWT process known since 1912–1914. There is a large variety of packaged WWT plants available, based on activated sludge process. In principle all of such plants consist of 3 main components:

- Aeration tank – serves as bio–reactor;
- Settling tank – "final clarifier" for separation of activated sludge solids and treated waste water;
- Equipment for recirculation of activated sludge – to transfer settled activated sludge from the clarifier to the influent of the aeration tank.

Activated sludge process – is a type of WWT process used for treating sewage or industrial wastewaters using aeration and a biological floc.

Biological floc – is a flocculent mass formed from aggregation of suspended particles and small water organisms – bacteria and protozoa.

Figure 8. Solution for small domestic wastewater treatment in Leitgiriai village (Lithuania). Photo and figure: L. Urtāne

The modifications of activated sludge process used for small domestic WWT solutions:

Extended aeration

Diffused air is introduced into the aeration tank. This provides the proper environment for the development of aerobic bacteria. In comparison to traditional activated sludge process, longer mixing time with aged sludge offers a stable biological ecosystem better adapted for effectively treating waste load fluctuations from variable occupancy situations.

This type of small domestic WWT plant is preferred for relatively small waste loads, where lower operating efficiency is offset by mechanical simplicity. Extended aeration is typically used in pre-fabricated "package plants" intended to minimize design costs for sewage disposal from single households or small communities.

Contact stabilization

The main advantage of this process is the short hydraulic retention time in the contact reactor, allowing treatment volumes significantly lower than in conventional activated sludge processes. With contact stabilization, the same amount of mass sludge can be retained in the system with almost 30% volume reduction compared to conventional activated sludge plants.

Process typically achieves the same treatment efficiency in a smaller volume than conventional activated sludge plants. Therefore this process is suited for small to mid–scale plants where influent wastewater contains a high concentrations of COD.

Oxidation ditch

The typical oxidation ditch is equipped with aeration rotors or brushes that provide aeration and circulation. This process uses long solids retention times to remove biodegradable organics. The wastewater moves through the ditch at 0,3 to 0,6 m/s. The ditch may be designed for continuous or intermittent operation.

The system may be used not only for the purification of domestic sewage, but also for the treatment of wastes from dairies and other industrial activities, even when these contain phenols, thiocyanides or peak loads of cyanides.

Sequencing batch reactor

The arearation tank is a “flow through” system, with sewage (influent) coming in at one end and treated water (effluent) flowing out at the other end. During the WWT process oxygen is bubbled through the mixture of wastewater and activated sludge to reduce the organic matter. The plant combines all of the WWT steps and processes into a single tank. Therefore this type of small domestic WWT plant is preferred when area is limited.

The treatment cycle can be adjusted to undergo aerobic, anaerobic, and anoxic conditions in order to achieve efficient biological nutrient removal, including nitrification, denitrification, and some phosphorus removal – BOD_5 <5 mg/l, N_{tot} <5/mg/l, P_{tot} <2 mg/l. The use of effective decanters lets achieve high efficiency of reduction of suspended solids (<10 mg/l) (Metcalf & Eddy, Inc., 1991).

Figure 9. Secondary treatment within packaged domestic wastewater treatment plants conduced as activated–sludge process. Photo: L. Urtāne

EFFICIENCY

PARAMETER	EFFLUENT CONCENTRATION*	UNITS	REDUCTION OF POLLUTING SUBSTANCES
BOD_5	150–450	mg/l	94–98 %
COD	300–900	mg/l	90 %
Suspended Solids	385–565	mg/l	88 %
N_{total}	25–75	mg/l	57–87 %
P_{total}	5–15	mg/l	25 %

Notes: * - according to EN 12566-3:2005

ADVANTAGES	DISADVANTAGES
High efficiency of removal for organic matter, suspended solids and total nitrogen.	Operation is power supply dependant.
The sequencing batch reactor (a modification of activated sludge process) can consistently perform nitrification, denitrification and phosphorous removal.	Not all modifications of activated sludge process achieve denitrification or phosphorus removal without additional unit processes.
Plants are easy to operate, as many are manned for a maximum of two or three hours per day.	Sludge must be disposed frequently.
Systems are easy to install, as they are shipped in one or two pieces.	Oxidation ditches (a modification of activated sludge process) can be noisy due to mixer/aeration equipment.
Most of systems (except oxidation ditches) are odor free.	Oxidation ditches (a modification of activated sludge process tend to produce odors when not operated correctly.
WWT systems require less space than constructed wetland or soil filter.	

Figure 10. Main advantages of packaged domestic wastewater treatment plants. Photo: L.Urtāne, A. Percovs, K. Küngas, T. Drabavičius.

4.1.4 CHEMICAL TREATMENT OF NUTRIENTS

MAIN CHARACTERISTICS

PHOSPHORUS

The phosphorus (P) load in the inflow of a wastewater is measured as total phosphorus (P_{tot}) and is presented in a form of orthophosphate–phosphorus (PO_4–P), polyphosphates and organic phosphorus compounds.

During biological wastewater treatment, polyphosphates and organically bonded phosphorus are converted to orthophosphate. During the biological treatment process only part of the phosphorus in wastewater is eliminated biologically. Therefore in order to limit eutrophication the rest of phosphorus have to be removed by chemico-physical phosphate precipitation.

NITROGEN

The nitrogen (N) load in the inflow of wastewater is measured as total nitrogen (N_{tot}) and is presented in organically bonded form (organic N) and as ammonium nitrogen (NH_4–N). During the biological wastewater treatment conducted as activated sludge process, organic N is converted to NH_4–N by the bacteria. Further both the converted NH_4–N and N of the same form originally contained in the inflow of wastewater during the nitrification process is converted to nitrite (NO_2), which in turn is converted to nitrate (NO_3).

The nitrogen compounds that are not biodegraded in the activated sludge are converted during denitrification process. The denitrification is ongoing in anoxic (absence of dissolved oxygen) conditions and during this process the oxidized forms of nitrogen are transformed to N_2 and is emitted to the atmosphere.

BASIC PRINCIPLES OF OPERATION

PHOSPHORUS

Depending on the composition of the wastewater, the chemical and physical treatment of P often take place as an individual step of wastewater treatment. In order to provide additional removal of phosphorus, the method of chemical removal is used. The chemical removal of inorganic phosphorous from domestic wastewater consists of two stages:

- incorporation of phosphorous into floccules and further sedimentation;
- removal of phosphorous together with other sediments.

Lime, ferric chloride or sulphate and aluminium sulphate are the most commonly used coagulants for inorganic phosphorous coagulation. The main process is formation of calcium, iron or aluminium phosphates, which can be easily settled and mechanically removed from reaction tank. Dosing of reagent is performed by peristaltic or membrane dosing pump to the last part of aeration chamber of package plant.

NITROGEN

In order to provide additional removal of nitrogen the nutrient ratios approach is used. It means that ratio between C, N and P should be balanced to correspond the need of the bacteria performing the activated sludge process. Taking in to account that content of nutrients in wastewater depends of its origin, it is practiced to add additionally phosphorus, if

ratio C:N:P is not the range between 100:10:1 and 100:5:1 (Optimal nutrient ratios for wastewater treatment, 2018).

4.2 Natural treatment systems

Natural technologies of wastewater treatment use modified natural self-treatment processes that take place in the ground soil and water environment. Wastewater with high organic content and high load of fats, oils, oil derivatives, are without pre-treatment (treatment) inappropriate to unusable for natural technologies of treatment.

Natural treatment methods are used either as only WWT solutions for dwelling, hotels, recreational facilities, restaurants and summer camps, or for polishing after septic tank or packaged WWT plant discharge or for infiltration of treated wastewater (refer Table 3).

*Table 3. Use of Natural Treatment Systems for sewage treatment**

Possibilities of the use in small domestic WWT systems	**Type**
Constructed wetland	
Treatment of domestic wastewater	Sub-surface flow wetland, hybrid systems
Polishing after septic tank discharge	Surface flow wetland, sub-surface flow wetland, hybrid systems
Soil filters	
Polishing after septic tank discharge	Vertical or horizontal flow without vegetation
Infiltration fields	
Infiltration of treated wastewater	

Notes: Only technologies suitable for climate of VillageWaters counties are mentioned

4.2.1 CONSTRUCTED WETLANDS

MAIN CHARACTERISTICS

Constructed wetlands are one of natural wastewater treatment systems. These are engineered systems that use natural functions of vegetation, soil, and organisms to treat wastewater. Similarly to natural wetlands, constructed wetlands act as a biofilter and remove a range of pollutants – organic matter, nutrients, pathogens, heavy metals – from the wastewater. Constructed wetlands are also a sanitation technology. All types of pathogens – bacteria, viruses, protozoan and helminths – are removed to some extent in a constructed wetland (Regelsberger M. et al., 2005).

Many terms are used to name these WWT technology – reed beds, soil infiltration beds, treatment wetlands, engineered wetlands, man-made or artificial wetlands.

BASIC PRINCIPLES OF OPERATION

Constructed treatment wetlands represent a biological treatment stage – secondary and/or tertiary. It is based on slow filtration of pre-treated wastewater. It may also be used for tertiary treatment of effluent from WWT plants with activated sludge process.

Constructed wetlands are constructed filtration systems planted with vegetation (most often reed) with defined filter material and direction of wastewater flow. The basic principle of this method for sewage treatment is the flow of wastewater through the filtration system, which is planted with vegetation. The planted vegetation plays an important role in sewage treatment. There are three types of constructed wetlands used – sub-surface flow constructed wetland, surface flow constructed wetland, hybrid system – a combination of subsurface flow and surface flow systems (Öövel M., 2006).

SUB-SURFACE FLOW CONSTRUCTED WETLAND

Subsurface flow constructed wetlands are designed to have either horizontal flow or vertical flow of wastewater through the gravel and sand bed. In subsurface flow constructed wetlands the flow of wastewater occurs between the roots of the plants and there is no water surfacing. Therefore, the system is more efficient, does not attract mosquitoes, is less odorous and less sensitive to winter conditions. Vertical flow systems have a smaller space requirement than horizontal flow systems.

SURFACE FLOW CONSTRUCTED WETLAND

Surface flow constructed wetlands, also known as free water surface constructed wetlands, can be used only for tertiary treatment or polishing of effluent from WWT plants and for collection and treatment of stormwater drainage.

Surface flow constructed wetlands have only horizontal flow. These systems have a bigger space requirements than subsurface constructed wetlands to purify wastewater, may attract mosquitoes, may have increased smell and lower performance in winter (Rozkošný M. et al., 2014).

EFFICIENCY

PARAMETER	EFFLUENT CONCENTRATION*	UNITS	REDUCTION OF POLLUTING SUBSTANCES
BOD_5	150–450	mg/l	94–96%
COD	300–900	mg/l	79–88%
Suspended Solids	385–565	mg/l	90–97%
N_{total}	25–75	mg/l	62–64%
P_{total}	5–15	mg/l	15–75 %**

Notes: * - according to EN 12566-3:2005; ** - depends on type – vertical subsurface flow system, horizontal subsurface flow system, free water surface systems or hybrid systems.

Figure 11. Solution for small domestic wastewater treatment in Stare Racibory (Sokoły.Minicipality, Poland). Photo and figure: L. Urtāne

4.2.2 SOIL FILTERS

MAIN CHARACTERISTICS

Soil filters are one of natural wastewater treatment systems. These are engineered systems that use natural functions of soil to treat wastewater. Similarly to constructed wetlands also soil filters act as a biofilter, but is without plants.

Soil filters treat wastewater using naturally occurring physical, biological, and chemical processes. Soil filters usually are used as the second step in WWT after solids in raw wastewater have been separated out in a septic tank or during other sedimentation process. Their performance is relatively consistent and they have low operation and maintenance requirements. The overall treatment costs also are low in comparison with other WWT systems.

BASIC PRINCIPLES OF OPERATION

Soil filters are constructed beds of sand or other suitable granular material. The filter materials are contained in a liner made of concrete, plastic, or other impermeable material to avoid contamination of surrounding environment. Depending on the design, the filter may be situated above ground, partially above ground, or below ground, and the filter surface may be single pass or covered. If covered, it should be vented to maintain aerobic conditions.

To prevent the soil filter from clogging, the wastewater at first is pre-treated to remove solids and scum. Pre-treatment usually takes place in a septic tank. After septic tank the partially treated wastewater is applied to the filter surface in small doses where it is slowly trickles through the filter. Combination of natural physical, biological, and chemical processes provides the treatment process. Sand filters are habitat for variety of organisms – bacteria, protozoa and worms –, which consumes organic matter that are found in the wastewater (Rozkošný M. et al., 2014).

Most treatment occurs in the first centimetres of the filter surface and this layer becomes clogged. Therefore, the top layer of soil needs to be removed as part of regular filter maintenance.

EFFICIENCY

PARAMETER	EFFLUENT CONCENTRATION*	UNITS	REDUCTION OF POLLUTING SUBSTANCES
BOD_5	150–450	mg/l	No data
COD	300–900	mg/l	23–79%
Suspended Solids	385–565	mg/l	55–90%
N_{total}	25–75	mg/l	24–99%
P_{total}	5–15	mg/l	94–99%

4.2.3 INFILTRATION FIELD

MAIN CHARACTERISTICS

The traditional infiltration field, also known as leach field, is a system of perforated pipes, laid within a gravel layer under soil frost zone. In order to reduce installation and earth works in the newest infiltration fields the perforated pipes are replaced with infiltration tunnels.

Since the sewage treatment result is not easy to control, the infiltration field is not used for wastewater treatment, but only for treated wastewater discharge after pre-fabricated WWT plants or septic tanks. Infiltration fields are not suitable for the regions with high level of groundwater.

BASIC PRINCIPLES OF OPERATION

Effluent after its treatment in the pre-fabricated WWT plant or septic tank trickles out of the pipes, through the gravel layer, and into the soil where additional treatment occurs. The filtering, which is characterised with suction velocity, is strongly dependant on the type of soil. Therefore, the area of infiltration field should be designed individually in the each particular case.

Figure 12. Infiltration fields consisting of infiltration tunnels under construction. Photo: A. Percovs. Figure: L. Urtāne

Table 4. Summary of advantages and disadvantages of Natural Treatment Systems used for only wastewater treatment solution.

ADVANTAGES	DISADVANTAGES
The natural character of the sewage facility provide better possibilities to integrate in landscape.	WWT systems require more space than packaged WWT plants.
Investment costs are comparable with packaged WWT, but operational and maintenance costs are low.	Low efficiency of ammonia nitrogen removal.
Simple maintenance due to simple technology.	Since most of the technologies are based on wastewater distribution though rather thin pipes, proper mechanical pre-treatment should be provided.
The possibility of short-term and long-term shutdown.	
Relatively rapid incorporation of the treatment process and achievement of the performance efficiency quality target in a short period of time after the start of operation.	Longer time for technical project preparation, because the dimensions of plant have to be calculated on the bases of hydraulic and pollution loads.
Treatment of wastewater with low concentrations of organic matter that cannot be treated by activated sludge processes.	
Possibilities to operate with enlarged hydraulic loads.	
High efficiency of removal for organic matter, suspended solids and phosphorus.	
Systems are easy to install, owner can engage in the installation, thus reducing investment costs.	