VillageWaters

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The chemical and microbiological assessment of water and soil samples

Laima Cesoniene (Eds.)

FINDING THE BEST FITTING SOLUTIONS FOR WASTEWATER MANAGEMENT IN VILLAGES

VillageWaters Project
Research about Wastewater Treatment Systems

The chemical and microbiological assessment of water and soil samples

Report number 1

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Abstract

The aim of this work was to make an enviro-hygienic (chemical and microbiological) assessment for the waste water treatment systems In the VillageWaters-project partner countries. There are different pilots where the technological changes will be conducted during the project. There are two in two in Estonia (Kolgaküla and Valkla), two in Finland (Gennarby and Nurmijärvi), two in Latvia (Svētciems and Ainaži), one Lithuania (Leitgiriai) and two in Poland (Krynica-Zdrój and Sokoly).

The pollution of untreated wastewater flowing into the Gennarby, Finland wastewater treatment plant has been assessed by identifying the BOD7, pH value and concentrations of suspended materials, phosphorus and nitrogen. Accordingly, the present purification rates seem to meet reasonably the requirements set for the small communities of the scattered dwellings. Removal of organic matter (BOD) exceeds the requirement. Reduction of total nitrogen is slightly below the required level. Reduction of total phosphorus is significantly lower than the requirement. The second pilot plant is located in southern Finland, Nurmijärvi. The results show that treatment of the sewage yields to almost 97% reduction in total phosphorus and nearly 79% reduction in total nitrogen. This indicates the efficiency of soil filtration system in the removal of nutrients and reduction of eutrophic waste reduction in natural waters.

The pollution of untreated wastewater flowing into the Leitgiriai, Lithuania wastewater treatment plant has been assessed by identifying the BOD_7, pH value and concentrations of suspended materials, phosphorus and nitrogen. The results have shown that during the treatment process the wastewater is treated inefficiently and vary: submerged materials 29–47%, biochemical oxygen consumption in 7 days (BOD_7) - 88 -95%, it means that the BDS7 value in the released wastewater is higher than that in the inflowing wastewater; total nitrogen (N_t) –4 - 46%, total phosphorus (P_t) 2- 86 %. During the assessment it was found that the treatment of total nitrogen and ammonium nitrogen has changed the most (%). It was found that the values of nitrate nitrogen, total nitrogen, electrical conductivity were statistically significantly higher 500 m after the wastewater discharger than 100 m before the wastewater discharger. The differences between the ammonium nitrogen and total phosphorus concentrations were not significant.

The pollution of untreated wastewater flowing into the Idźki-Wykno village, Sokoly, Poland wastewater treatment plant has been assessed by identifying the BOD_7, pH value and concentrations of suspended materials, phosphorus and nitrogen. The suspended solids have been reduced by nearly 90%, the BOD_5 has been reduced by nearly 86% and the amount of wastewater was less than 5 m3/day, so all condition contained in the Polish "Regulation of the Minister of the Environment from 18 November 2014 on the conditions to be met for the discharge of sewage into water or soil and on substances particularly harmful for the water environment " have been met. The results have shown that during the treatment process the wastewater is treated efficiently. The efficiency of natural individual domestic wastewater treatment plant in Idźki-Wykno village in Poland is similar to efficiency of wastewater treatment plant in Gennarby in Finland.. The second pilot domestic wastewater treatment plants are located in the village of Słotwiny in the municipality of Krynica-Zdrój It is a mountain region in the south of Poland. Comparing the quality of untreated wastewater coming from household in Sokoły municipality and Krynica-Zdrój municipality you can notice that wastewater coming from household in Krynica-Zdrój is less polluted then wastewater coming from Sokoły municipality. Certainly, it depends on many factors. The wastewater is treated sufficiently ac-cording to BOD_5 and suspended solids. The requirements contained in Regulation of the Minister of the Environment from 18 November 2014 are fulfilled.

Keyewords: wastewater treatment, purification technologies, Enviro-hygienic assessment (EHA), nutrient, microbes

Abbreviations

Agglomeration - an area where the population or economic activities are sufficiently concentrated for urban waste water to be collected and conducted to a waste water treatment plant or to a final discharge point
BAT – Best Avalible Technology
Black water - Waste water and excreta from water closets excluding waste water from baths, show-ers, handbasins and sinks
BOD - Mass concentration (mg/l) of dissolved oxygen consumed under specific conditions by the biological oxidation of organic and/or inorganic matter in water.
BOD_7- the amount of oxygen consumed over a 7-day period
BSAP – Baltic Sea Action Plan
Buried sand filter - A wastewater sand filter constructed below the surface of the ground and covered with earth to prevent annoyance to nearby dwellings. These filters are often used for disposing of septic tank effluent.
By-product - a result from a production process that was not the primary aim of that process. Unlike waste, it must be able to be used afterwards. The directive allows the European Commission to set criteria to be met by substances so as to differentiate by-products from waste.
Cesspool - Underground watertight tank without outflow used for collecting domestic wastewater.
Composting dry toilet - A toilet system without water flush used for disposal of and biological processing of human excrement into organic compost material.
Domestic waste water - waste water from residential settlements and services which originates predominantly from the human metabolism and from household activities.
EHA - Enviro-hygienic assessment
Eutrophication - enrichment of water by nutrients causing, among other things, an accelerated growth of algae which disturb the balance of water organisms and the water quality.
EU – European Union
Groundwater - all water below ground surface.
Grey water - Non-industrial wastewater generated in domestic processes, excluding human excrements, such as washing dishes, laundry and bathing
HELCOM - the Baltic Marine Environment Protection Commission, known as the Helsinki Commission
Industrial waste water - any waste water which is discharged from premises used for carrying on any trade or industry, other than domestic waste water and run-off rain water
Inland water - all standing or flowing water on the land's surface.
IPPC – Integrated Pollution Prevention and Control
Leaching field - A system of open pipes in covered trenches that permits effluent from a septic tank to enter surrounding soil.
MSFD - EU Marine Strategy Framework Directive
NH_4-N - Ammonium nitrogen is a measure for the amount of ammonia, a toxic pollutant often found in landfill leachate and in waste products, such as sewage, liquid manure and other liquid organic waste products. It can also be used as a measure of the health of water in natural bodies such as rivers or lakes, or in man-made water reservoirs. The term is used widely in waste treatment and water purification systems.
Nitrate nitrogen (NO_3-N)
NPK – Nitrogen, phosphorus, potasium fertilizers
NO_3-N - Nitrate nitrogen
N_{tot} - Total nitrogen
Oxygen (O_2)
PO_4-P - Phosphate-phosphorous

Population equivalent (p.e.) - means the load per day with a seven-day biochemical oxygen demand ***(BOD$_7$)*** of 70 g of oxygen (O_2); the population equivalent is calculated on the basis of the maximum average weekly load per day entering the treatment plant, excluding unusual situations.
P_{tot} - Total phosphorus
RBMP – River Basin Management Plan
Secondary treatment - a process generally involving biological treatment.
Sensitive areas - natural waters which are found to be or may become eutrophic in the near future if protective action is not taken, or those which need more advance treatment to reach compliance with other EU directives (e.g., the Bathing Water Directive)
Surface water - all inland water except groundwater, transitional or coastal waters.
Transitional waters - waters near river mouths, which are partly saline but contain substantial flows of freshwater.
Urban waste water - domestic waste water or the mixture of domestic waste water with industrial waste water or run-off rain water
WFD - EU Water Framework Directive

1. Introduction

Eutrophication of Baltic Sea has led to the serious environmental problems during the last century. One of the main contamination sources has been municipal wastewater, including wastewater from the small and scattered settlements. Sparsely populated areas are the third largest source of diffuse nutrient loads into the Baltic Sea.

The aim of this work was to make an enviro-hygienic (chemical and microbiological) assessment for the waste water treatment systems In the VillageWaters-project partner countries. There are different pilots where the technological changes will be conducted during the project. There are two in two in Estonia (Kolgaküla and Valkla), two in Finland (Gennarby and Nurmijärvi), two in Latvia (Svētciems and Ainaži), one Lithuania (Leitgiriai) and two in Poland (Krynica-Zdrój and Sokoly). More details in project webpage https://villagewaters.eu/Pilot_Villages_in_the_Project_769. Implementations in the pilots will be conducted in periods 3-4 of the project (=spring 2017-winter 2018). There wastewater, soil, sludge, soil, groundwater and surface water samples were taken to analyse some nutrients and microbial contamination from them. The aim was to find out a situation of waterborne emissions and other environmental impacts before and after the technological changes, respectively.

The main challenge of this VillageWaters -project (‘Water emissions and their reduction in village communities – villages in Baltic Sea Region as pilots’) is to find out the most sustainable technological wastewater treatment solutions to decrease wastewater emissions of sparsely populated areas locally but also into the Baltic Sea to the level set by ongoing implementation of the forthcoming EU water legislation. The main objective is to support the needs of households to avoid unnecessary investments and operating costs when shifting to improved waste water treatment and thus encourage them to implement new treatment systems. The work is conducted in 13 activities under four work packages in this project by 13 partners from Estonia, Finland, Latvia, Lithuania and Poland. The project’s schedule is 1st of March 2016 until 28th of February 2019, including 6 periods. The budget is about 3 million euros that is mainly funded by Interreg Baltic Sea Reagion (BSR).

This report 1 is part of the activity 2.4 ‘Functionality of the technological solutions by water and soil analyses’ of the project and was published on 31st of August 2017 (period 3 of the project). More analyses and results will be shown in the report number 2 that will be published in February 2019. The aim of this activity is to make an enviro-hygienic (chemical and microbiological) assessment for the waste water treatment systems by the pilot end-users, including the nutrient flows in and out of the systems. The concrete goal is to provide as comprehensive view as possible on the environmental hygiene in the neighborhood of the waste water treatment systems by the pilot end-users before and after the upgrading of the system.

2. Methods and data sources

Enviro-hygienic assessment (EHA) is used as a method of this work. EHA covers initial and upgraded systems by the pilots, and, as far as possible, some of the present systems that potentially would need upgrading in each partner country. The EHA is carried out by taking water and soil samples before and after the upgrading of the wastewater treatment systems, and analyzing them for specific chemicals and microbes. EHA is applied 1) to the system itself, 2) to the immediate environments of the systems, and 3) on the surface waters directly affected by the systems in order to assess their actual hygienic states, and potential enviro-hygienic impacts of the systems and system upgrades on the surface waters.

The analysis of waste water system provides information for the assessment of the loading, nutrient and organic matter balances, purifying performance and results of the system, i.e. how well the treatment system is functioning and how well the general treatment requirements for BOD (=biochemical oxygen demand or dissolved oxygen), phosphorus and nitrogen are reached. Samples will be taken of wastewater flow into the treatment system from the use of WC, shower, dishwasher, washing machine and sauna, as well as of outflow wastewater, of sludge, and of soil. In the analyses, particular attention is paid on the soluble forms of phosphorus and nitrogen, because they have the fastest impact on the level of eutrophication of waters.

The analysis of the immediate environment of the treatment system provides information for the assessment of the actual state, and potential impacts of the systems and system upgrades on the hygienic state of the immediate environments of the system. Functionality of the waste water treatment systems has a crucial importance in ground water preservation, as purified wastewaters come to contact with natural ground waters, and thus have a direct impact on their hygiene. Samples taken of ground waters, of the waste water outflow from the treatment system, and of soil of the immediate environment of the treatment system will be analyzed for determination of the presence and persistence of potential hygienic risks.

The analysis of the surface waters provides information for the assessment of the nutrient levels, and the hygienic situation in the water body the waste water is led into. Water samples are taken from the waters concerned and analyzed for the electrical conductivity as an indicator for the total dissolved salts (TDS), and for enterobacteria, fecal Enterococci and coliformic bacteria (E. coli bacteria) as indicators of the hygienic state.

2.1.table. Detailed sampling and analysis program for this activity is given in the table below.

Sampled object	Analysed properties	Sampling position	Timing and amounts of sampling, e.g.
Inflow	pH, suspended solids, BOD_7ATU, total phosphorus, total nitrogen, total flow	-households outlet led to the wastewater treatment systems	-cumulative samplings -the samples will be taken four times per year in a year before and after the preparations are done when possible and appropriate.
Outflow	pH, alkalinity, suspended solids, BOD_7ATU, total phosphorus, soluble phosphorus, total nitrogen, ammonia nitrogen, sum of nitrite and nitrate nitrogen, total aluminium or total iron depending on precipitation chemical, enterobacteria coliformic bacteria, total flow	-input to the soil filter (outlet from the tank) if it exists -outlet from the treatment system if it exists	-normal, not cumulative, sampling -The samples will be taken four times per year in a year before and after the preparations are done when possible and appropriate.
Surface waters	Electrical conductivity, Fecal Enterococcus and Escherichia coli bacterial	-outlet to the sea/lake pond	-normal, not cumulative, sampling -The samples will be taken two times on summer season before and after the preparations are done when possible and appropriate.
Groundwater	enterobacteria, coliformic bacteria, Fecal Enterococcus	-well, groundwater basin/fountain, test hole	-normal, not cumulative, sampling -The samples will be taken once on summer season before and after the preparations are done when possible and appropriate.
Soil	Total phosphorus, soluble phosphorus, total nitrogen, soluble nitrogen, ammonia nitrogen, sum of nitrite and nitrate nitrogen, enterobacteria, coliformic bacteria, Escherichia coli	-every side of the absorption field (4 points, 2 depths: 25 cm and 1 m) -outskirts from the septic tank (2 points, 1 depth: bottom level of the well)	-normal, not cumulative, sampling -The samples will be taken once on summer season before and after the preparations are done when possible and appropriate.
Sludge	Total phosphorus, soluble phosphorus, total nitrogen, soluble nitrogen, ammonia nitrogen, sum of nitrite and nitrate nitrogen enterobacteria, coliformic bacteria, Escherichia coli	-sludge from the septic tank/bioreactor (5 cm from the bottom)	-normal, not cumulative, sampling -The samples will be taken once per year before and after upgrade the cleaning system when possible and appropriate.

2.1. The chemical and microbiological assessment

The assessment consists of sampling and laboratory analysis of the essential chemical, physical and microbiological characteristics of in- and outflows of wastewater and sludge as well as soil, ground water, and surface water immediately connected to the treatment systems. Cumulative sample will be taken of wastewater coming from each of the normal sources, including use of WC, shower, sinks, dishwasher, washing machine and sauna. The sample is taken from the septic tank (or a corresponding part of the system), at the point of incoming waste water, from a large enough volume and many enough points of it to ensure the cumulative nature for the sample. Other samples are one-off, non-cumulative samples. All analyses are made according to comparable standard methods.

Water and sewage samples are taken in accordance with standards:

Water quality - Sampling - Part 2: Guidance on sampling techniques (ISO 5667-2:1991) - EN 25667-2:1993
Water quality - Sampling for microbiological analysis (ISO 19458:2006): EN ISO 19458:2006;
Water quality - Sampling - Part 13: Guidance on sampling of sludges (ISO 5667-13:2011) - EN ISO 5667-13:2011
Water quality. Sampling. Part 11: Guidance on sampling of ground waters - ISO 5667-11:1993
Water quality -- Sampling -- Part 6: Guidance on sampling of rivers and streams (ISO 5667-6:2014, identical) - ISO 5667-6:2014
Water quality - Sampling - Part 9: Guidance on sampling from marine waters (ISO 5667-9:1992, identical) - ISO 5667-9:1992

The assessment of wastewater, surface water, ground water, ground and sludge has been carried out in laboratories that have national or international accreditation or laboratories that perform internal quality control. Analyses have been carried out using national methods adapted to the European ISO standards. The methods are provided in the Appendix 1. Table a. The results of the analyses are assessed according to the limit values established by national assessment documents (Appendix 2. Table b).

The in- and outflows and balances for the chemicals and microbes analyzed are calculated based on the estimates of the gross flows (mass) entering and leaving the systems and the respective concentrations determined by the analyses. The purification efficiencies are calculated as differences between the entering and leaving N-, P- and BOD flows relative to the respective inflows.

2.2. Samples were taken from the pilots

Samples were taken from the pilots of partner countries: Estonia (Kolgaküla and Valkla), Finland (Gennarby and Nurmijärvi), Latvia (Svētciems and Ainaži), Lithuania (Leitgiriai) and Poland (Krynica-Zdrój and Sokoly). There wastewater, soil, sludge, soil, groundwater and surface water samples were taken to analyse some nutrients and microbial contamination from them. The aim was to find out a situation of waterborne emissions and other environmental impacts before and after the technological changes, respectively. The layout diagram of the pilot villages is provided in Figure 2.2.1.

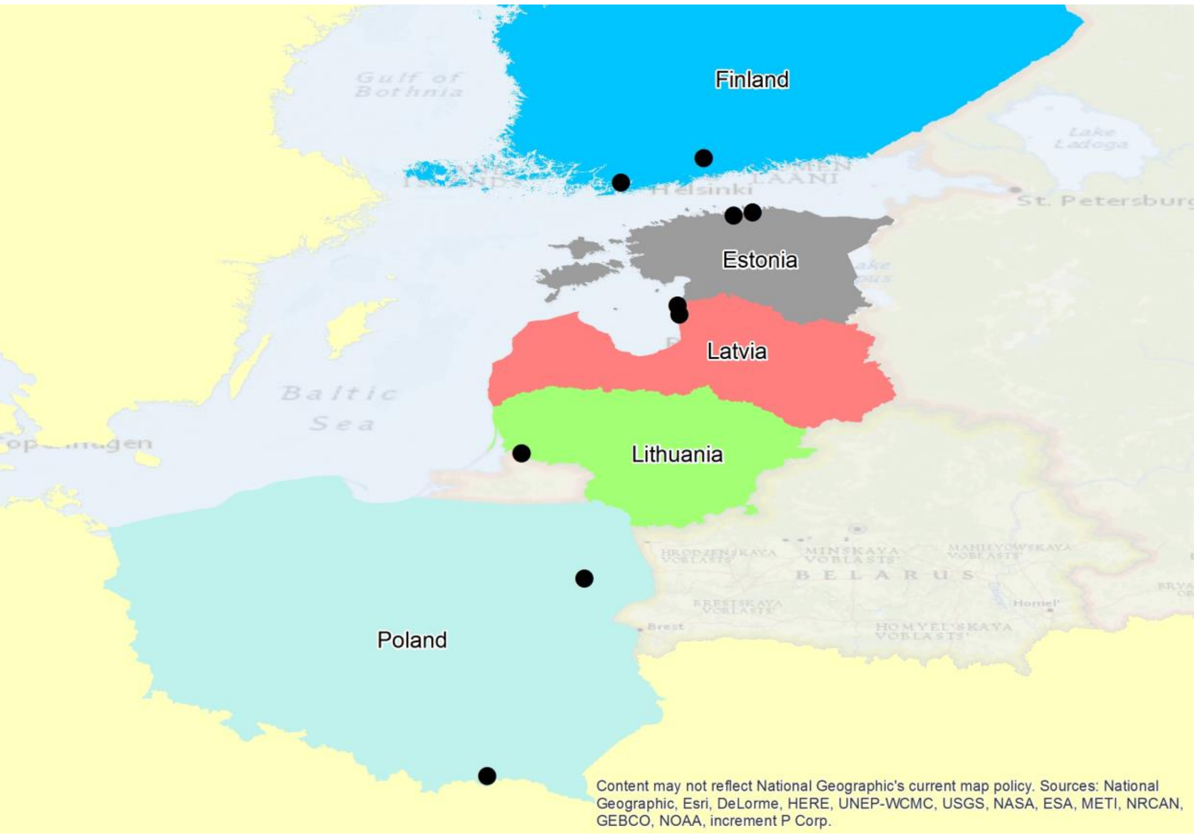


Figure 2.2.1. Layout diagram of the wastewater treatment plants in selected pilot villages

3. The pilots and results

3.1. ESTONIA

3.1.1. Kolgaküla

There is no WWTP for the village. Household sewage is mainly collected in cesspools and gully emptier trucks transport it to a WWTP elsewhere. The only WWTP that Kolgakũla had for its apartment houses is no longer working properly, and thus currently not used. These wastewater treatment systems were constructed at the end of the 1970s and were mainly designed for organic matter removal. In Kolgaküla, groundwater is unprotected or weakly protected in most of the local municipality’s territory. As for surface water, eutrophication is also a problem, as in Estonia overall. Small watercourses are especially vulnerable to wastewater. As the 1970s sewage treatment system is outdated, the wastewater goes to oxidation ponds that were only designed for post-treatment. The diagram of wastewater inflow into the Punsu river is provided in Figure 3.1.1.1.

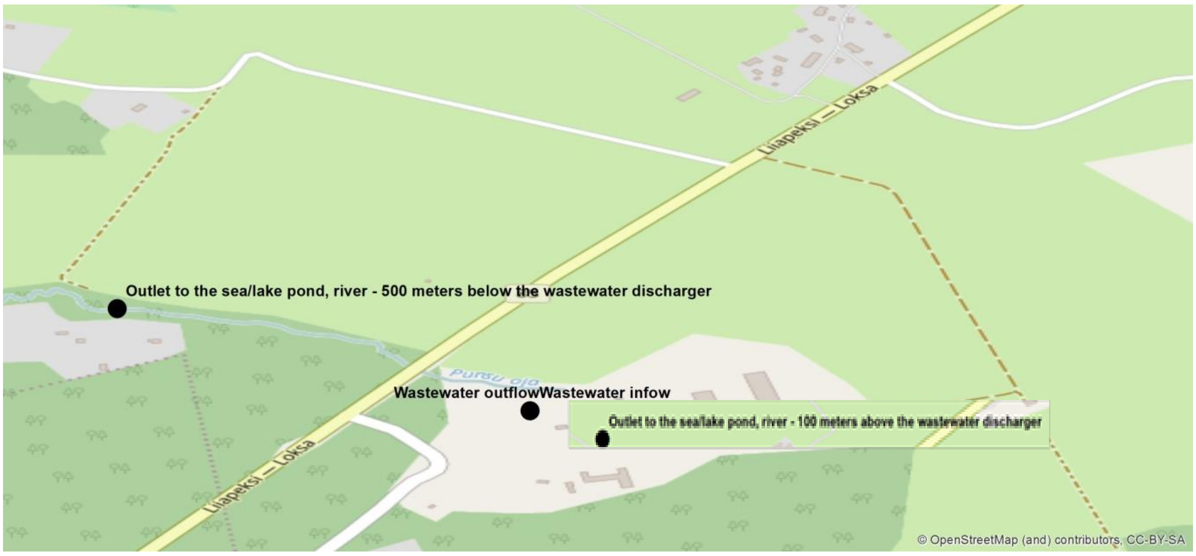


Figure 3.1.1.1. Diagram of wastewater inflow into the Punsu river

The Punsu river's condition was assessed by taking samples in July, October and December of 2016, March and June of 2017, 100 meters before and 500 after the wastewater discharger. The results are provided in Tables 3.1.1.1 and 3.1.1.2.

Table 3.1.1.1. Assessment results for the surface water in the Punsu river 100 meters before the wastewater discharger

Data	Limit value	2016 12	2017 03	2017 06
Eletrical conductivity, µS/cm	Not regulated	345	324	300
Fecal Enterococcus	Not regulated		9	
Escerichia coli bacterial	Not regulated		91	
O_2, mg/l	Not regulated	13.2	13.,8	9.9
O_2, %	>60	94	98	90
pH	6-9	7.8	7.6	7.5
SS, mg/l	Not regulated	2	12	4.0
BOD_7, mgO_2/l	3	1.0	3.5	2.0
NH_4, mgN/l	0.3	0.026		
NO_2, mgN/l	Not regulated	0.003	0.004	0.008
NO_3, mgN/l	Not regulated	0.46	0.20	0.21
TN, mg/l	3	0.59	1.14	0.29
PO_4, mgP/l	Not regulated	0.051		
TP, mg/l	0.08	0.074		

Table 3.1.1.2. Assessment results for the surface water in the Punsu river 500 meters after the wastewater discharger

Data	Limit value	2016 12	2017 03	2017 06
Eletrical conductivity, µS/cm	Not regulated	340	332	319
Fecal Enterococcus	Not regulated		9	
Escerichia coli bacterial	Not regulated		120	
O_2, mg/l	Not regulated	12.7	13.6	9.1
O_2, %	>60	91	96	82
pH	6-9	7.85	7.65	7.5
SS, mg/l	Not regulated	3	7	5
BOD_7, mgO_2/l	3	1.2	2.6	2.5
NH_4, mgN/l	0.3	0.055		
NO_2, mgN/l	Not regulated	0.03	0.06	
NO_3, mgN/l	Not regulated	0.47	0.28	
TN, mg/l	3	0.92	1.03	
PO_4, mgP/l	Not regulated	0.045		
TP, mg/l	0.08	0.059		

Electrical conductivity measurement results are provided in Figure 3.2.1.2.

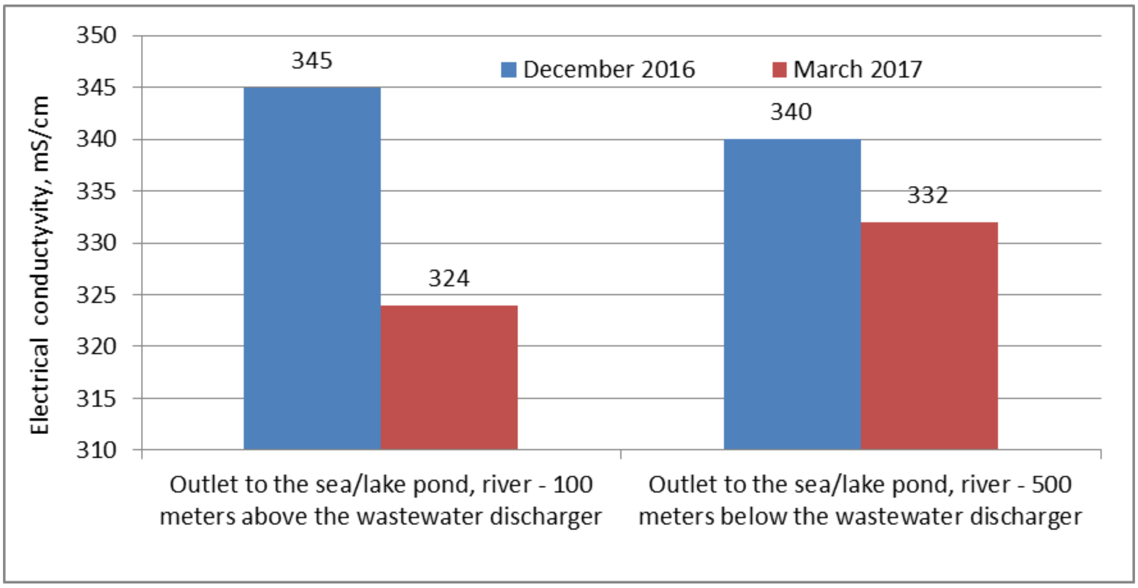


Figure 3.1.1.2. Electrical conductivity measurement results

The electrical conductivity value in December was higher than that in March. The electrical conductivity value in the Punsu river in December was higher 100 meters before the wastewater discharger, while in March it was higher 500 meters after the wastewater discharger. This shows that released wastewater can affect the Punsu river's water quality during the warm period of the year.

Fecal Enterococcus measurement results are provided in Figure 3.1.1.3.

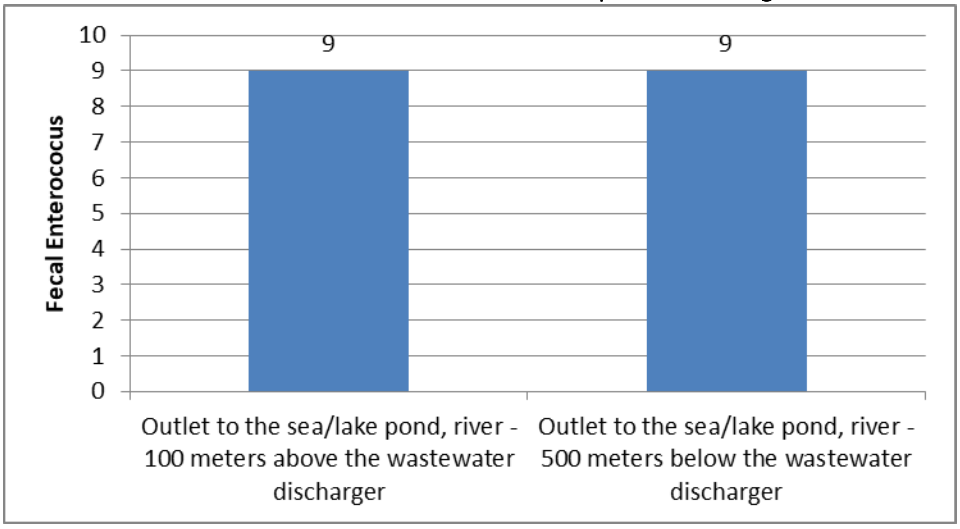


Figure 3.1.1.3. Fecal Enterococcus measurement results

The Fecal Enterococcus value in the Punsu river both 100 meters before and 500 meters after the wastewater discharger was the same. Escerichia coli bacterial measurement results are provided in Figure 3.2.1.4.

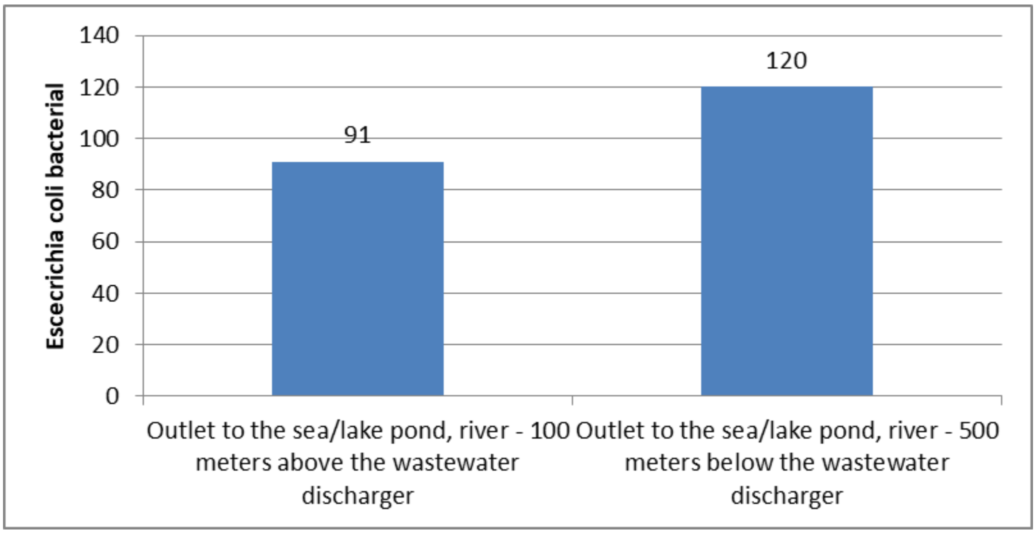


Figure 3.1.1.4. Escerichia coli bacterial measurement results

The found Escerichia coli bacterial value in the Punsu river was higher 500 meters after the wastewater discharger than 100 meters before the wastewater discharger. This shows that released wastewater can affect the Punsu river's water quality.

3.1.2. Valkla

There is no WWTP for the village. Household sewage is collected in cesspools and gully-emptier trucks transport it to the nearest WWTP. There are two apartment building areas in village. The existing (not used) wastewater treatment systems were constructed in the end of the 1970s and were mainly designed for organic matter removal. In Valkla village, groundwater is unprotected or weakly protected in most of locality. Valkla creek is a salmonid waterbody and the mouth of the creek is a protected area.

The problem is the sewage treatment of two apartment buildings (40 inhabitants in total). After construction of the new wastewater treatment facility, the effluent will be treated effectively and discharged into Valkla creek. The diagram of wastewater inflow into the Valkla river is provided in Figure 3.1.2.1.

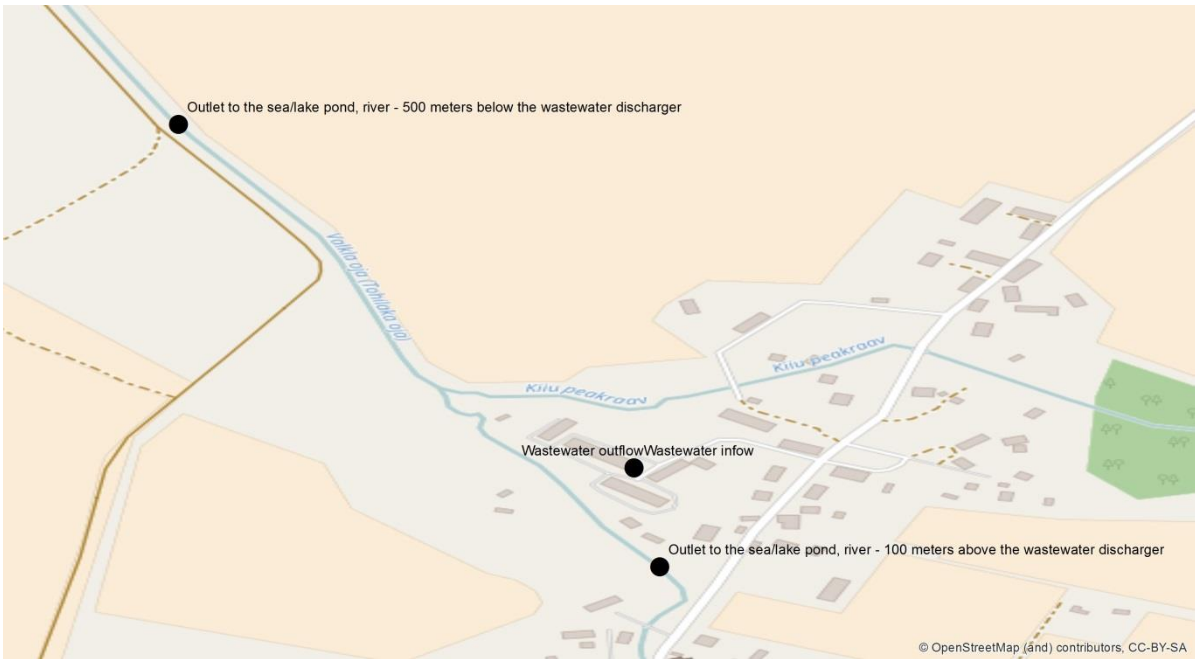


Figure 3.1.2.1. Diagram of wastewater inflow into the Valkla river

The Valkla river's condition was assessed by taking samples in July, October and December of 2016, March and June of 2017, 100 meters before and 500 meters after the wastewater discharger. The results are provided in Tables 3.1.2.1 and 3.1.2.2.

Table 3.1.2.1. Assessment results for the surface water in the Valkla river 100 meters before the wastewater discharger

Data	Limit value	2016 12	2017 03	2017 06
Eletrical conductivity, µS/cm	Not regulated	358	387	211
Fecal Enterococcus	Not regulated		6	
Escerichia coli bacterial	Not regulated		34	
O_2, mg/l	Not regulated	12	12.4	9.5
O_2, %	>60	86	90	92
pH	6-9	7.7	7.75	7.9
SS, mg/l	Not regulated	3	14	6
BOD_5, mgO_2/l	3	1.3	2.2	1.5
NH_4, mgN/l	0.3	0.042		
NO_2, mgN/l	Not regulated	0.006	0.005	< 0.003
NO_3, mgN/l	Not regulated	1.49	3.37	0.17
TN, mg/l	3	2.68	3.75	1.34
PO_4, mgP/l	Not regulated	0.036		
TP	0.08	0.056		

Table 3.1.2.2. Assessment results for the surface water in the Valkla river 500 meters after the wastewater discharger

Data	Limit value	2016 12	2017 03	2017 06
Eletrical conductivity, µS/cm	Not regulated	377	404	258
Fecal Enterococcus	Not regulated		3	
Escerichia coli bacterial	Not regulated		17	
O_2, mg/l	Not regulated	12.1	12.7	9.9
O_2, %	>60	88	92	96
pH	6-9	7.7	7.85	9
SS, mg/l	Not regulated	7	12	3
BOD_5, mgO_2/l	3	1.2	2.4	1.4
NH_4, mgN/l	0,3			
NO_2, mgN/l	Not regulated	0.004	0.007	0.005
NO_3, mgN/l	Not regulated	2.06	4.13	0.55
TN	3	3.42	3.82	1.26
PO_4, mgP/l	Not regulated			
TP	0.08			

Electrical conductivity measurement results are provided in Figure 3.1.2.2.

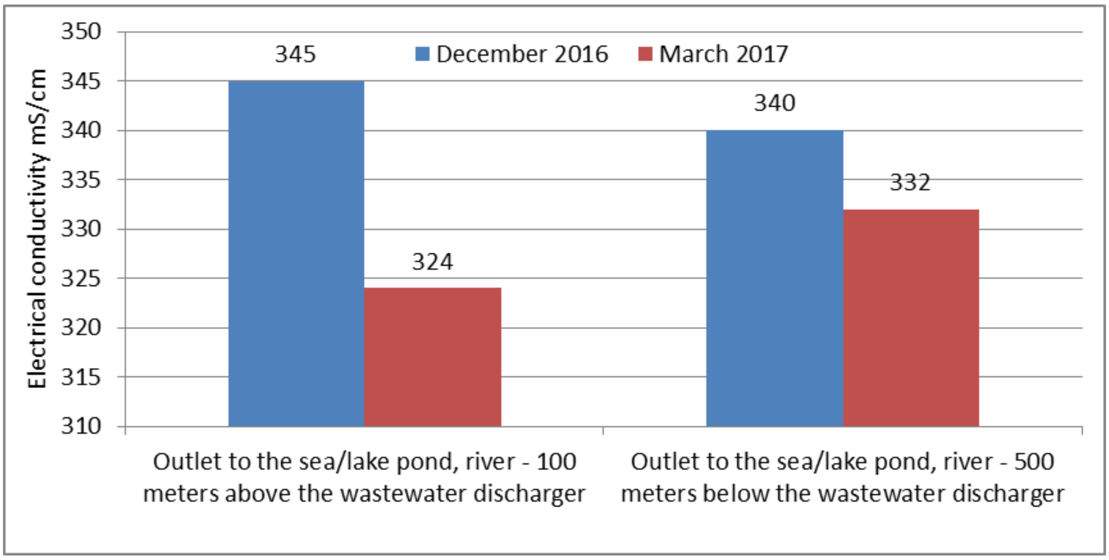


Figure 3.1.2.2. Electrical conductivity measurement results

The electrical conductivity value in December was higher than that in March. The electrical conductivity value in the Punsu river in December was higher 100 meters before the wastewater discharger, while in March it was higher 500 meters after the wastewater discharger. This shows that released wastewater can affect the Punsu river's water quality during the warm period of the year. Fecal Enterococcus measurement results are provided in Figure 3.1.2.3.

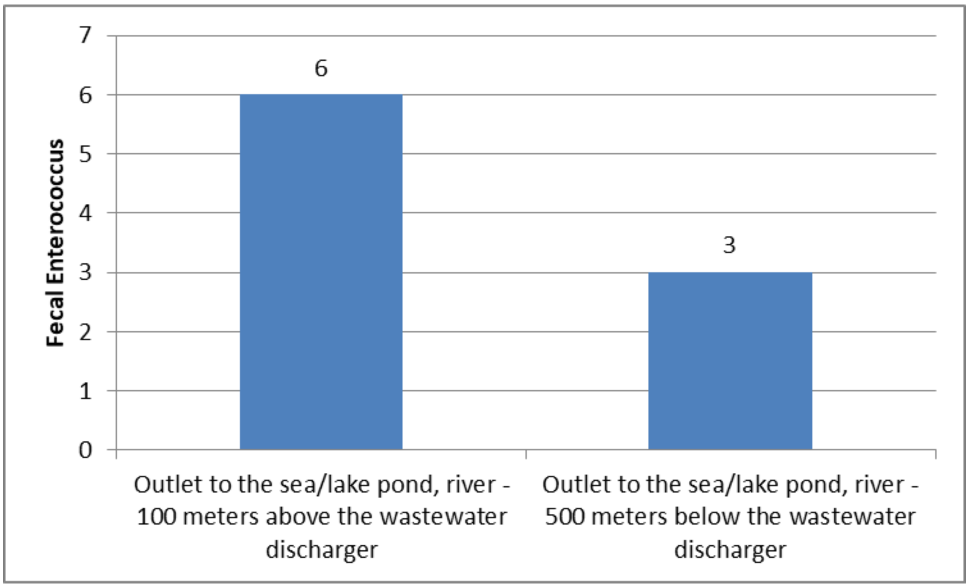


Figure 3.1.2.3. Fecal Enterococcus measurement results

The Fecal Enterococcus value in the Punsu river both 100 meters before and 500 meters after the wastewater discharger was the same. Escerichia coli bacterial measurement results are provided in Figure 3.1.2.4.

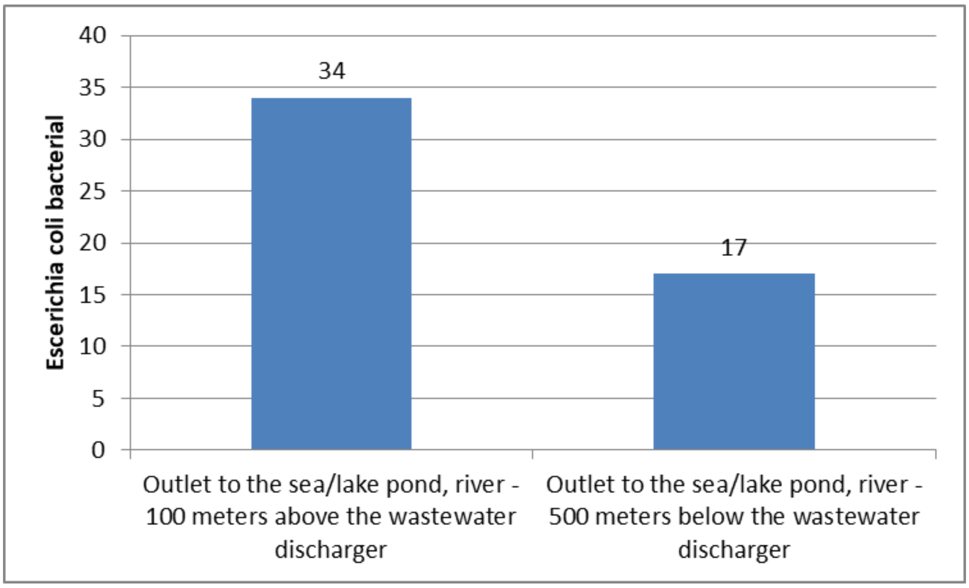


Figure 3.1.2.4. Escerichia coli bacterial measurement results

The found Escerichia coli bacterial value in the Punsu river was higher 100 meters before the wastewater discharger than 500 meters after the wastewater discharger. This shows that released wastewater does not affect the Punsu river's water quality.

3.2. FINLAND

3.2.1. Gennarby

The Gennarby village was built in the first half of the 1900s around a cooperative dairy, which is located by Gennarbyträsk lake. Around the lake there are about ten properties. On the north side of the lake there is a permanent settlement and on the south side a few recreational properties, located there because of the lake. Agriculture is also practiced in the area. (Nowadays agriculture more on hobby basis, no more professional cultivation or cattle husbandry).

The objective of the project is to construct water and sewage pipes to connect to the municipal system. The old, overhead powerlines will be dismantled and replaced with underground cables placed in the same ditch with waste water line, as are the fiber optic cables which are installed in to each household.

When the electric wires are placed underground, the damage caused by thunderstorms will decrease. When laying down optical fiber the most expensive work is the excavation, so it is economically sensible to carry it out in conjunction with the power cables. The scheme of wastewater inflow into the Gennarbyträsk lake is provided in Figure 3.2.1.1.

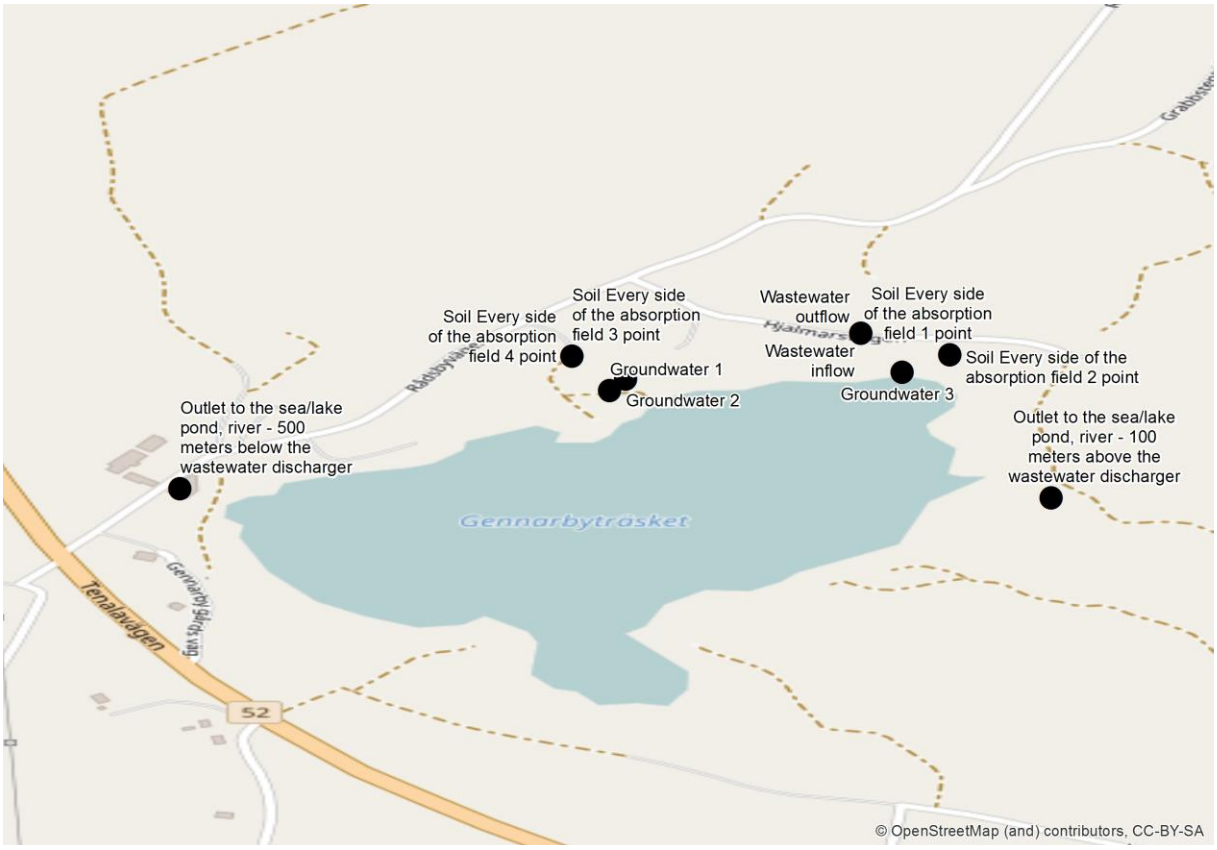


Figure 3.2.1.1. The scheme of sampling points in Gennarby.

There was one single sample taken from one single sedimentation tank in use (one sample from inflow and one sample from the outflow). The pollution of untreated wastewater flowing into the Gennarby wastewater treatment plant has been assessed by identifying the BOD_7, pH value and concentrations of suspended materials, phosphorus and nitrogen. The assessments were conducted in October 2016. The identified indicator values are compared with the limit values regulated by the " Legislation for <100 p.e. wastewater treatment plants: Change of the environmental protection act 19/2017 and Government Decree on Treating Domestic Wastewater in Areas

Outside Sewer Networks (157/2017). According the environmental protection act 527/2014 an environmental permit is required in case when wastewater treatment plant treats at least 100 person's wastewater. Limit values for reduction and for outflows concentrations are defined in environmental permits. Also, Governmet Decree on Urban Waste Water Treatment 888/2006, concerns wastewater treatment plants that have an environmental permit. The results are provided in Table 3.2.1.1.

Table 3.2.1.1.Assessment results of untreated wastewater flowing into the Gennarby wastewater treatment plant

Data	Limit Values	2016 10
pH	Not regulated	8.4
Suspended solids, mg/l	Not regulated	860
BOD_7 mg/l O_2	Not regulated	390
Total phosphorus mg/l	Not regulated	17
Total nitrogen mg/l	Not regulated	90

The pollution of treated wastewater flowing into the Gennarby wastewater treatment plant has been assessed by taking samples in October 2016. The identified indicator values are compared with the limit values regulated by the "Government Decreeon Urban Waste Water Treatment888/2006 (http://www.finlex.fi/en/laki/kaannokset/2006/en20060888.pdf); Government Decree on Treating Domestic Wastewater in Areas Outside Sewer Networks (157/2017). The results are provided in Table 3.2.1.2.

Table 3.2.1.2. Assessment results of treated wastewater flowing out of the old sedimentation tank (2 chambers). One single sample from one sedimentation tank.

Data	The limit value	2016 10
pH	Not regulated	7.7
Alkalinity	Not regulated	7.6
Suspended solids mg/l	<100 p.e. not regulated, ≥100 p.e. 35 mg/l or reduction 90 %.	20
BOD_7 mg/l O_2	<100 p.e. 80 % min reduction, recommended 90 %. ≥100 p.e. 10-15 mg O_2/l & reduction 90-95 %.	36
Total phosphorus mg/l	<100 p.e. 70 % min reduction,recommended 85% . ≥100 p.e. 0,30-1,0 mg P/l & reduction 90-95 %.	6
Soluble phosphorus	Not regulated	5.5
Total nitrogen mg/l	<100 p.e. 30 % min reduction,recommended 40% . 10 000-100 000 p.e. 15 mg/l or reduction 70 %, over 100 000 p.e. 10 mg/l.	58
Ammonia nitrogen mg/l	<100 p.e. Not regulated. ≥100 p.e. not regulated – 4 mg/l & reduction 90- 95 %	55
Nitrates nitrogen mg/l	Not regulated	<0.10
Nitrites nitrogen mg/l	Not regulated	<0.002
Sum of nitrate and nitrite nitrogen mg/l	Not regulated	<0.10
Enterobacteria		350
Coliformic bacteria		12000

Apparent purifying efficiencies (E(M)) of the new waste water system for Gennarby households are presented in Table 3.2.1.3 and calculated using formula (Dauknys, 2007):

$$E(M) = \frac{M_o - M_1}{M_o} \times 100,\ \%$$

Here:

M_o - concentration untreated waste water, mg / l;
M_1 - the residual concentration in treated wastewater mg / l.

and the values of Table 3.2.1.2 for untreated wastewater (Mo) and, respectively, values of Table 3.2.1. 3. for treated wastewater (M1).

3.2.1.3 table. The efficiency of the wastewater treatment in Gennarby, %

Data	Suspended solids	BOD_7	Total phosphorus	Total nitro-gen
2016 10	**98**	**91**	**65**	**36**

Accordingly, the present purification rates seem to meet reasonably the require-ments set for the small communities of the scattered dwellings. Removal of organic matter (BOD) exceeds the requirement. Reduction of total nitrogen is slightly below the required level. Reduction of total phosphorus is significantly lower than the requirement.

The condition of the Gennarbyträsk lake was assessed by taking samples in March, July and August of 2016, 100 meters before and 500 meters after the wastewater discharger. The identified indicator values are compared with the limit values regulated by the "The Ministry of Social Affairs and Health’s decree on water quality requirements and supervision at public beaches (177/2008)". The results are provided in Tables 3.3.4 and 3. 2.1.5.

Table 3. 2.1.4. Assessment results of the Gennarbyträsk lake surface water 100 meters before the wastewater discharger

Data	**The limit value**	2016 04	2016 07	2016 08
Electrical conductiv-itymS/cm	**Not regulated**	5.8	7.2	9
Faecal Enterococcus	400 pmy/mpn/100 ml	1	88	34
Escherichia coli bac-terial	1000 pmy/mpn/100 ml	0	37	4

Table 3. 2.1.5. Assessment results of the Gennarbyträsk lake surface water 500 meters after the wastewater discharger

Data	**The limit value**	**2016 04**	**2016 07**	**2016 08**
Electrical conductiv-ity µS/cm	**Not regulated**	5.9	6.2	10
Faecal Enterococcus	400 pmy/mpn/100 ml	2	12	150
Escherichia coli bac-terial	1000 pmy/mpn/100 ml	3	15	490

Electrical conductivity measurement results provided in Figure 3.2.1.2.

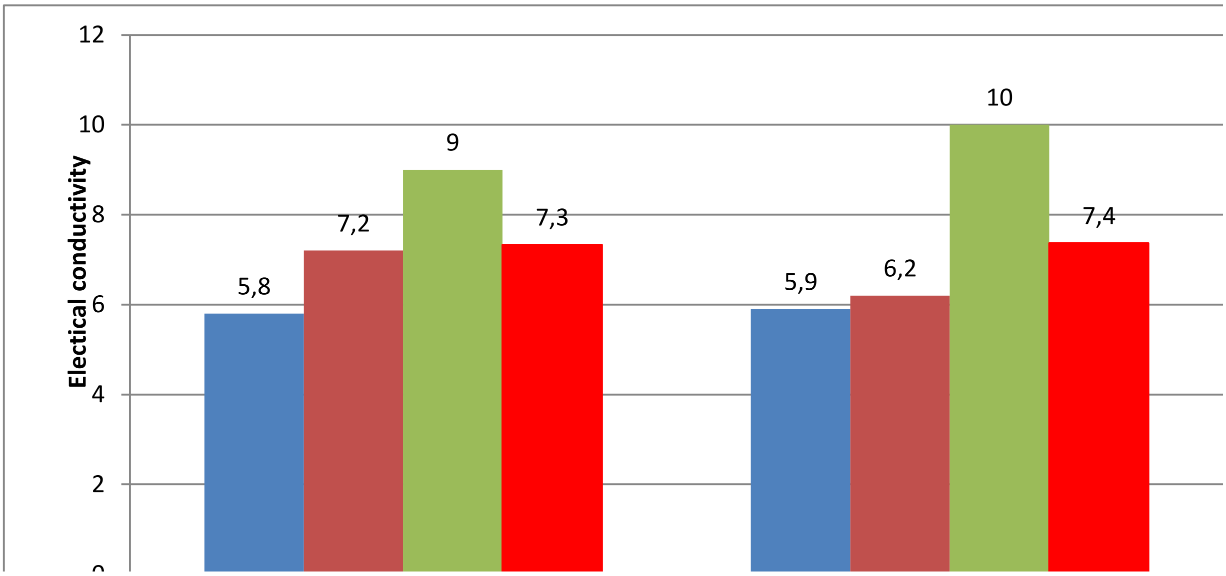


Figure 3. 2.1.2. Electrical conductivity measurement results

The electrical conductivity value increases every month. In every month of the assessment, the measured electrical conductivity value in the Gennarbyträsk Lake was higher 500 meters after the wastewater discharger, except for the month of July. The increase in values doesn't really tell about wastewater effects, but just normal variation. Fecal Enterococcus measurement results provided in Figure 3.2.1.3.

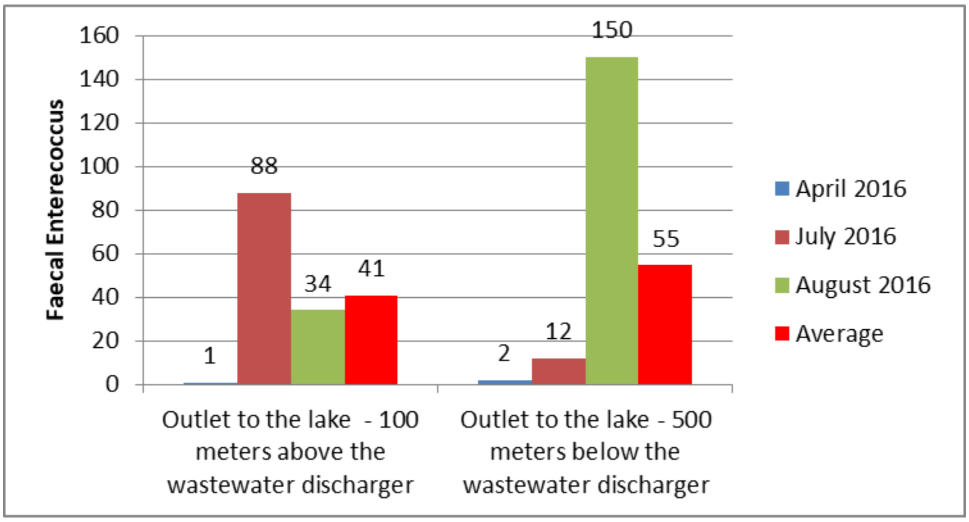
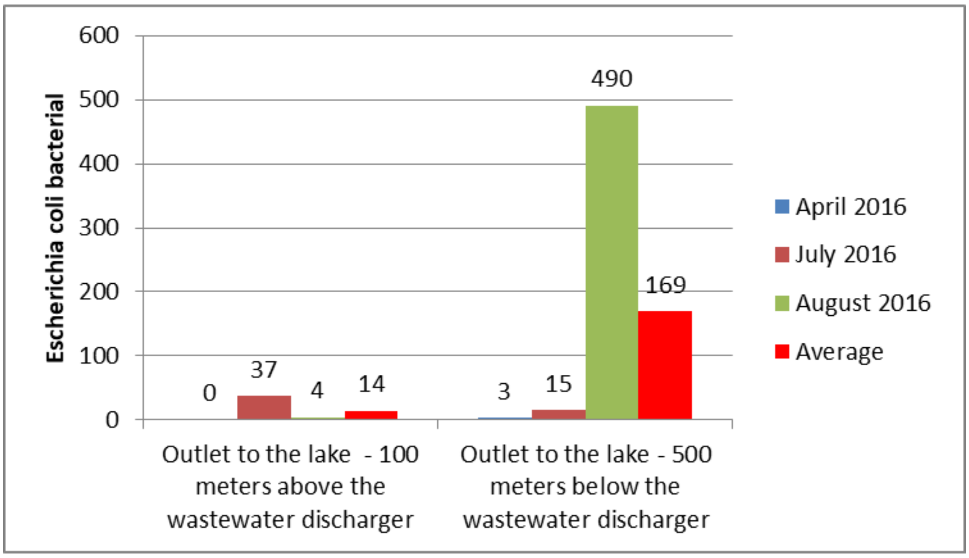


Figure 3. 2.1.3. Fecal Enterococcus measurement results

The Fecal Enterococcus value in the Gennarbyträsk Lake was higher 500 meters after the wastewater discharger, except for the month of July. This shows that released wastewater can affect the Gennarbyträsk lake water quality. Escerichia coli bacterial measurement results are provided in Figure 3.2.1.4.



3.2.1.4.Figure. Escerichia coli bacterial measurement results

Escerichia coli bacterial value in the Gennarbyträsk lake was higher 500 meters after the wastewater discharger, except for the month of July. This shows that released wastewater can affect the Gennarbyträsk lake water quality.

The ground water quality was assessed in August 2016, in three points. The results are assessed by comparing them with the limit values regulated by the Decree of the Ministry of Social. Affairs and Health Relating to the Quality and Monitoring of Water Intended for Human Consumption (1352/2015). The results are provided in Table 3. 2.1.6.

3. 2.1.6. Table. Ground water measurement results

Data	Limit value	1 point	2 point	3 point
Fecal enterococcus	0	21	0	22
Coliformic bacteria	0	13	8	29
E.coli -bacteria	0	0	0	1

The results shows that the ground water is microbiologically contaminated.

For the determination of microbiological quality of soil at chosen wastewater treatment fields, the soil quality was assessed in 4 points (on all sides of the filtration field), 25 cm deep and 100 cm deep. In Finland the solid quality is regulated by - Government Decree on the Assessment of Soil Contamination and Remediation Needs 214/2007. Table 3. 2.1.7 shows the soil results Every side of the absorption field 1-4 point 25 cm depths

3. 2.1.7. Table. Every side of the absorption field 1-4 point 25 cm depths Soil results

Data	2016 10				2017 04			
	1 point	2 point	3 point	4 point	1 point	2 point	3 point	4 point
Enterobacteria	2.20E+02	2.70E+02	7.70E+01	1.80E+02	3.30E+02	7.4€+02	1.00E+02	2.10E+02
Coliformic bacteria	8.00E+02	7.20E+02	1.00E+02	1.40E+02	2.00E+02	4.30E+02	<10	<10
Escerichia coli bacterial	4.00E+01	<10	<10	<10	6.80E+01	<10	<10	<10
Fecal colifomic bacte-	4.00E+01	4.00E+01	<10	<10	4,00E+01	1,90E+02	<10	<10

ria								
Fecal strep-tococci	8.20E+01	<10	<10	<10	3,60E+01	4,00E+01	<10	<10

Enterobacteria assessment results are provided in Figure 3. 2.1.5.

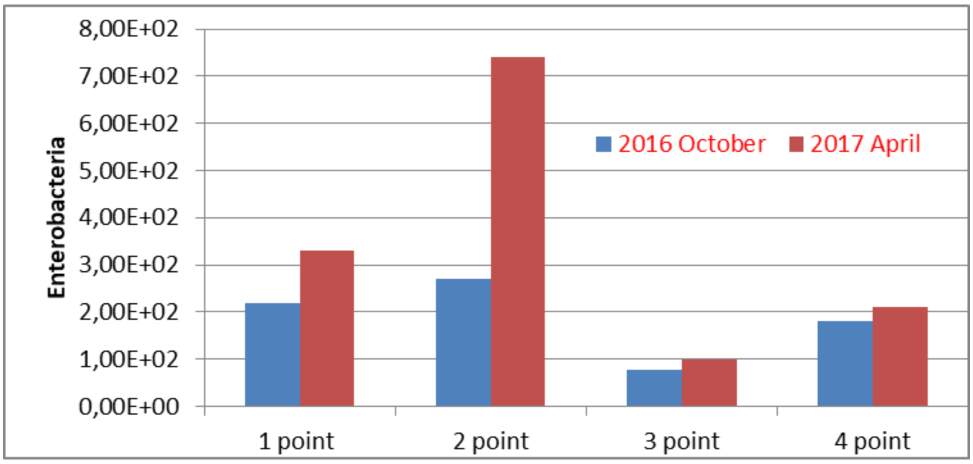


Figure 3.2.1.5. Enterobacteria assessment results 1-4 point 25 cm depths Soil result

The assessment results show that the enterobacteria concentration was higher in 2017. The highest concentration is in point 2. Coliformic bacteria assessment results are provided in Figure 3. 2.1.6.

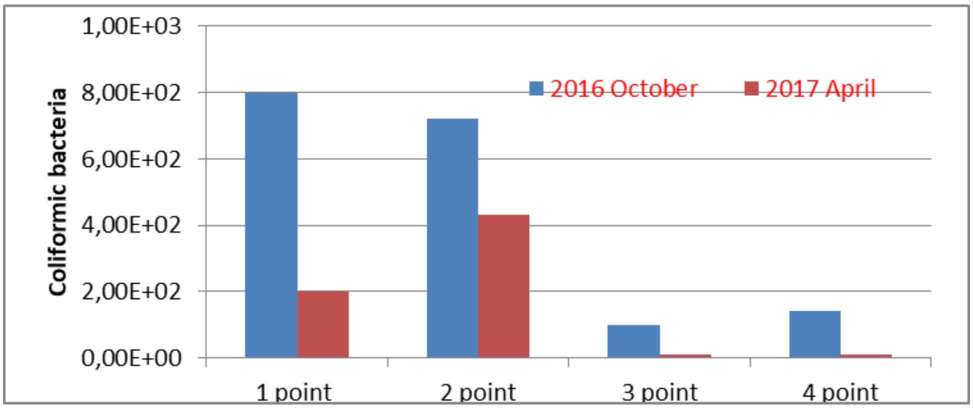


Figure 3.2.1. 6. Coliformic bacteria assessment results 1-4 point 25 cm depths Soil result

The assessment results show that the Coliformic bacteria concentration was higher in 2016. The highest concentration is in points 1 and 2. Escerichia coli bacterial assessment results are provided in Figure 3. 2.1.7.

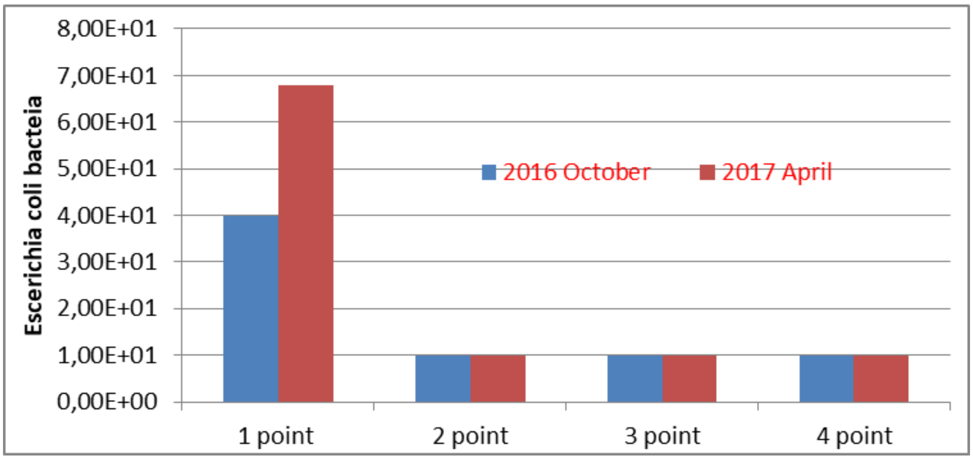


Figure 3.2.1.7. Escerichia coli bacterial assessment results 1-4 point 25 cm depths Soil result

The assessment results show that the Escerichia coli bacterial concentration was higher in 2017 in point 1. In other points the concentration is equal. Fecal colifomic bacteria assessment results are provided in Figure 3. 2.1. 8.

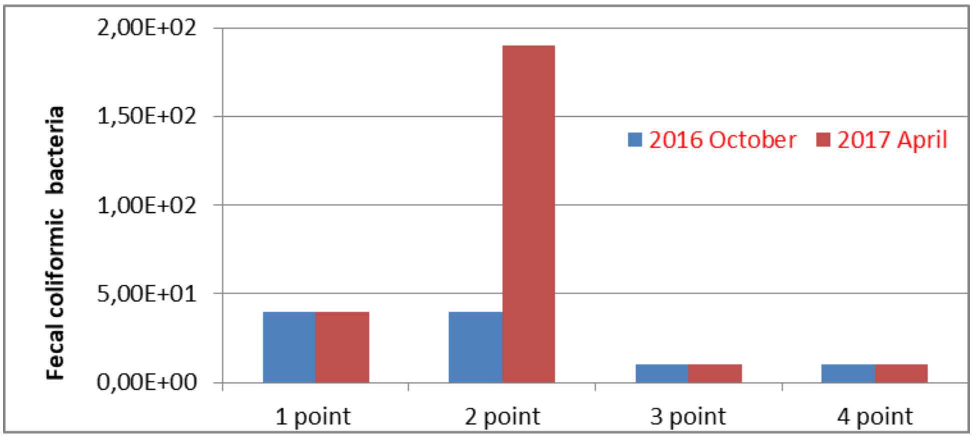


Figure 3.2.1.8. Fecal colifomic bacteria assessment results 1-4 point 25 cm depths Soil result

The assessment results show that the Fecal colifomic bacteria concentration was higher in 2017 in point 2. In other points the concentration is equal. Fecal streptococci assessment results are provided in Figure 3.2.1.9.

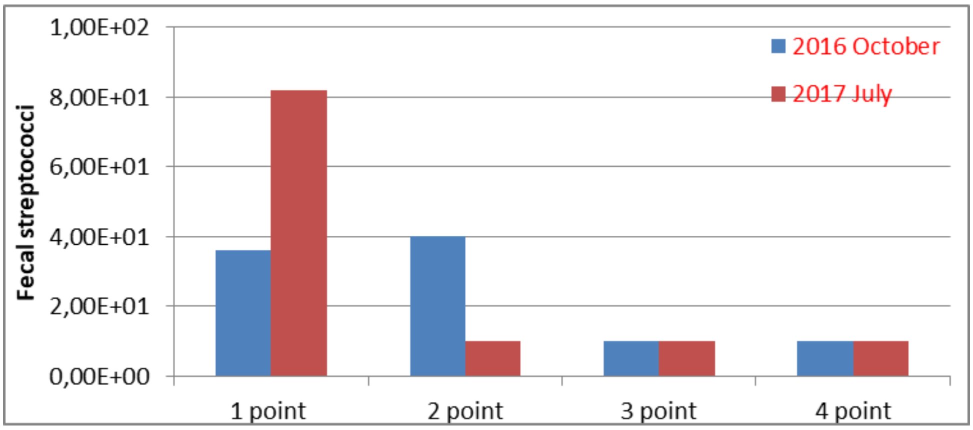


Figure 3.2.1.9. Fecal streptococci assessment results 1-4 point 25 cm depths Soil result

The assessment results show that the Fecal streptococci concentration was higher in 2017 in point 1, in 2016 - in point 2. In other points the concentration is equal.The soil quality was assessed in 4 points (on all sides of the filtration field), 100 cm deep. The soil quality in Finland is regulated by - Government Decree on the Assessment of Soil Contamination and Remediation Needs 214/2007. However, only the values of hazardous material are regulated. Table 3.2.1.8. shows soil results. Every side of the absorption field 1-4 point 25 cm depths.

3.2.1.8. Table. Every side of the absorption field 1-4 point 100 cm depths Soil results

Data	2016 10				2017 04			
	1 point	2 point	3 point	4 point	1 point	2 point	3 point	4 point
Enterobacteria	4.50E+01	<10	<10	4.00E+10	3.20E+01	4.00E+01	5.00E+01	3.20E+01
Coliformic bacteria	4.00E+01	4.00E+01	<10	4.00E+01	<10	<10	<10	<10
Escerichia coli bacterial	<10	<10	<10	<10	<10	<10	<10	<10
Fecal colifomic bacteria	<10	<10	<10	<10	<10	<10	<10	<10
Fecal streptococci	<10	2.7E+01	4.00E+01	5.50E+01	4.00E+01	<10	4.00E+01	4,00E+01

Enterobacteria assessment results are provided in Figure 3.2.1.10.

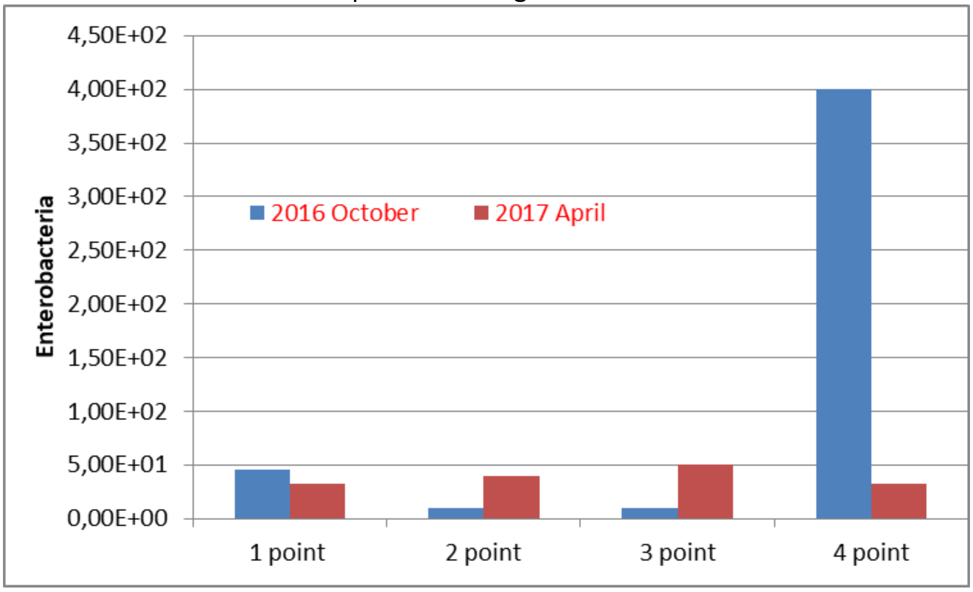


Figure 3.2.1.10. Enterobacteria assessment results 1-4 point 100 cm depths Soil results

The assessment results show that the enterobacteria concentration was the highest in 2016 in point 4. Coliformic bacteria assessment results are provided in Figure 3.2.1.11.

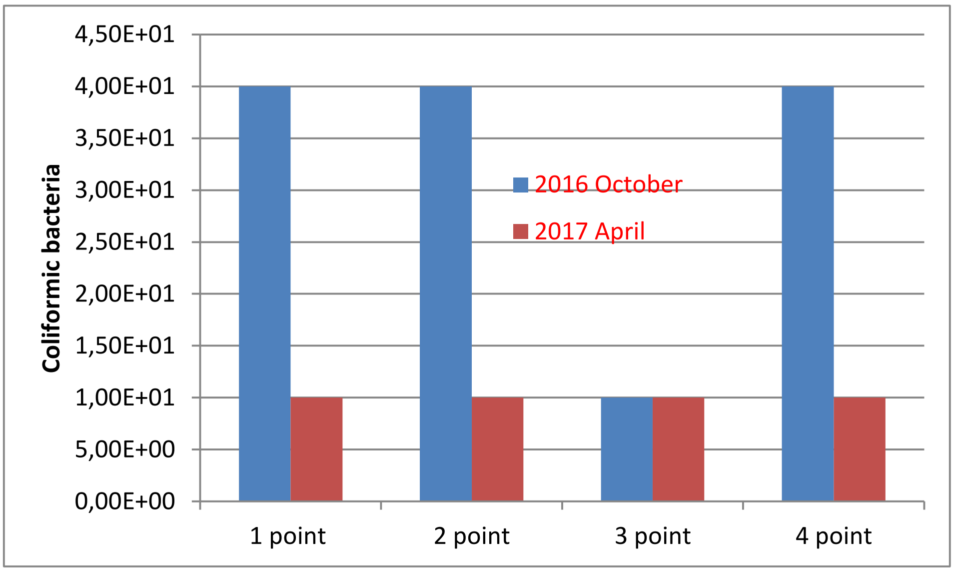


Figure 3.2.1.11. Coliformic bacteria assessment results 1-4 point 100 cm depths Soil results

The assessment results show that the Coliformic bacteria concentration was higher in 2016. The highest concentration is in points 1, 2 and 4. Escerichia coli bacterial assessment results are provided in Figure 3.2.1.12

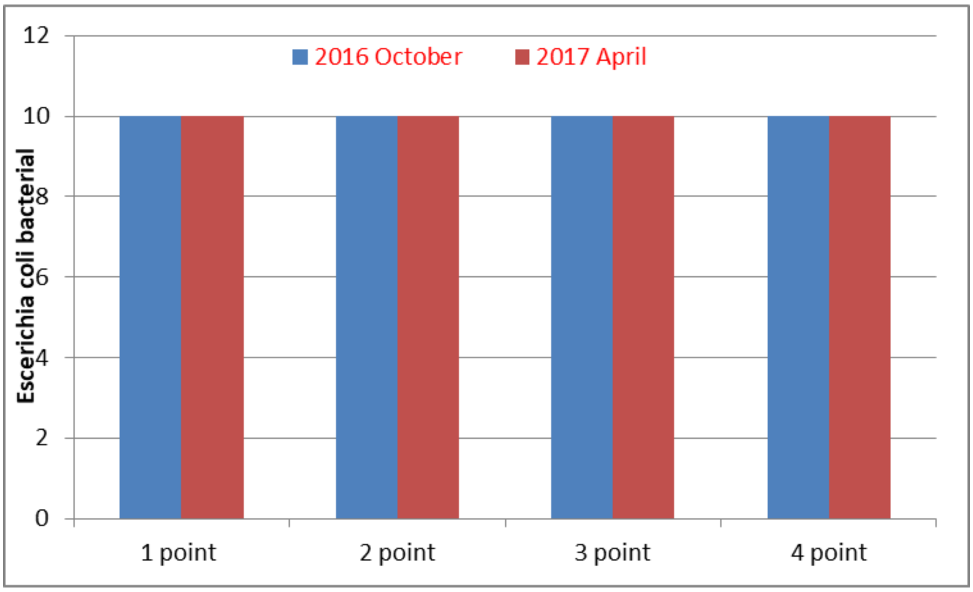


Figure 3.2.1.12. Escerichia coli bacterial assessment results -4 point 100 cm depths Soil results

The assessment results show that the Escerichia coli bacterial concentration was equal in all of the points. Fecal colifomic bacteria assessment results are provided in Figure 3.2.1.13.

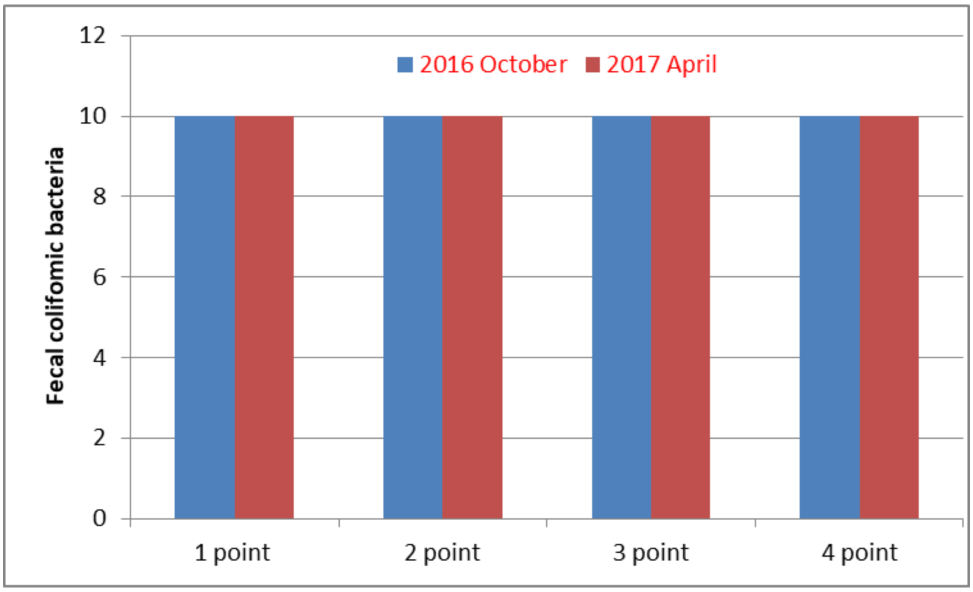


Figure 3.2.1.13. Fecal colifomic bacteria assessment results 1-4 point 100 cm depths Soil results

The assessment results show that the Fecal colifomic bacteria concentration was equal in all of the points. Fecal streptococci assessment results are provided in Figure 3.2.1.14.

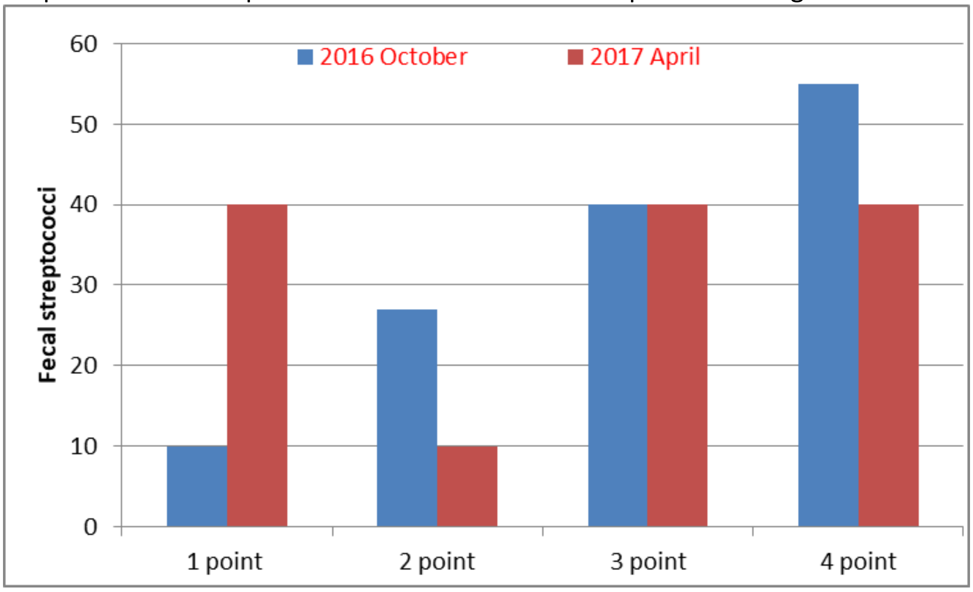
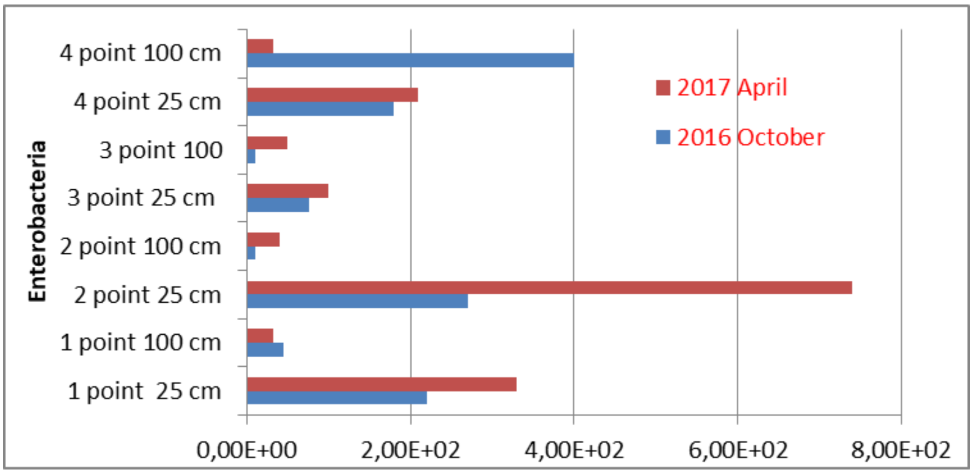


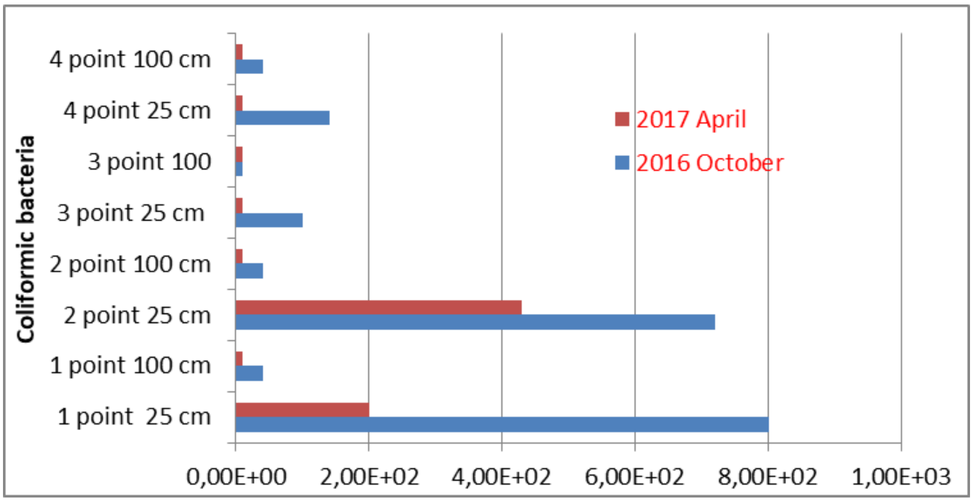
Figure 3.2.1.14. Fecal streptococci assessment results 1-4 point 100 cm depths Soil results

The assessment results show that Fecal streptococci concentration was higher in 2016 in point 4, in 2017 - in points 1, 3 and 4 the concentration was equal.



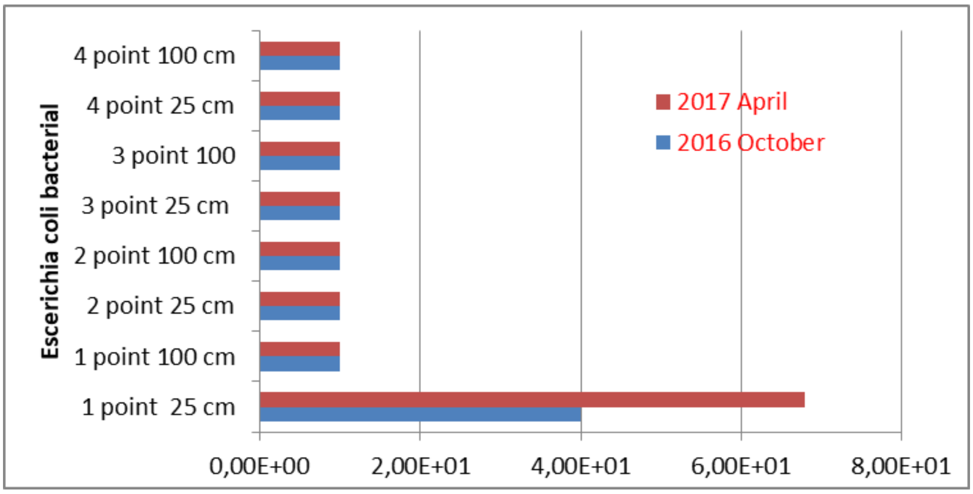
3.2.1.15 Figure. Enterobacteria assessment results 1-4 point 25 and 100 cm depths Soil results

It was found that in all of the points the Enterobacteria concentration was higher in 25-cm-deep soil than 100-cm-deep soil, except for point 4 in October of 2016.



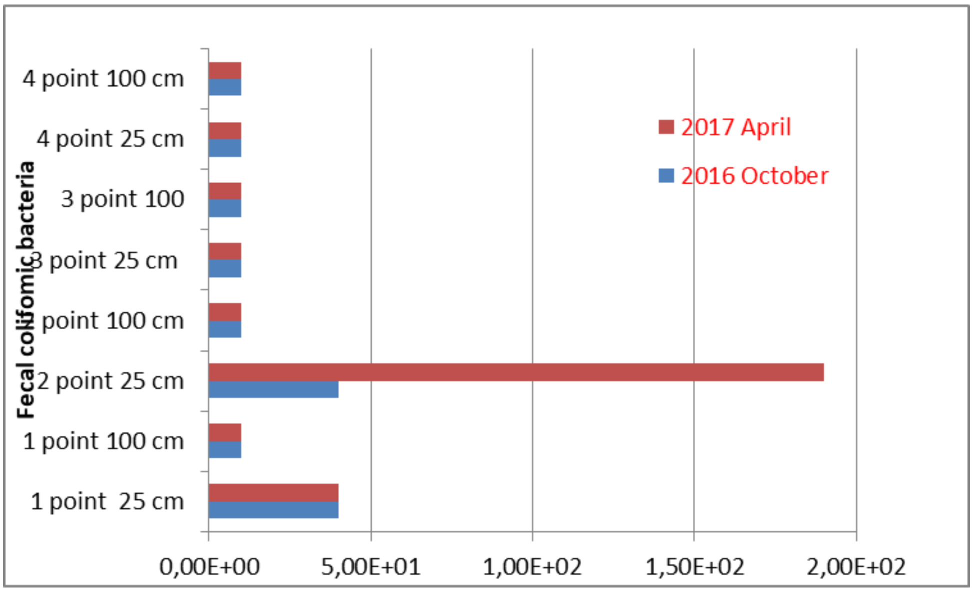
3.2.1.16 Figure. Coliformic bacteria assessment results 1-4 point 25 and 100 cm depths Soil results

It was found that in all of the points the Coliformic bacteria concentration was higher in 25-cm-deep soil than 100-cm-deep soil.



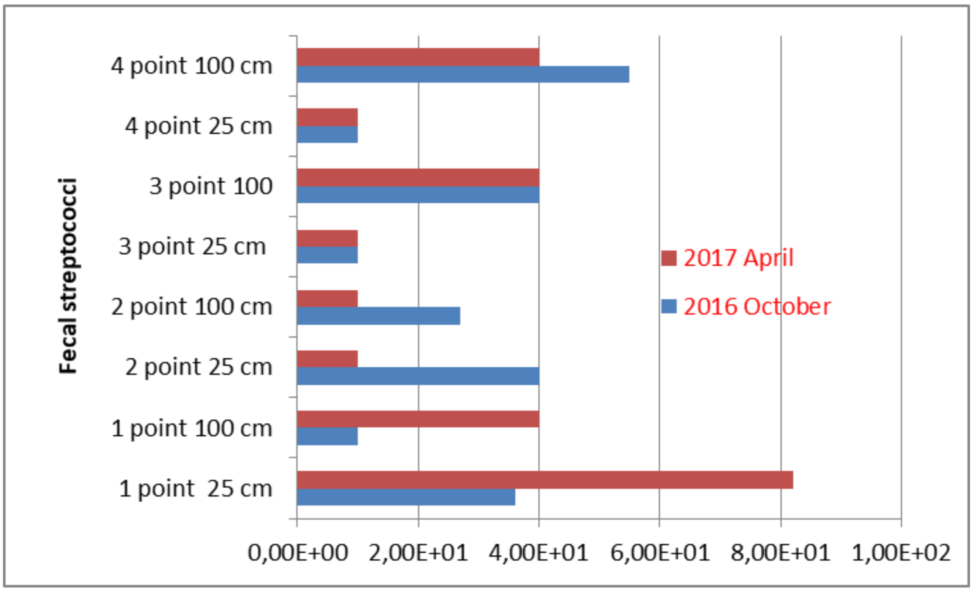
3.2.1.17 Figure. Escerichia coli bacterial assessment results 1-4 point 25 and 100 cm depths Soil results

It was found that in all of the points the Escerichia coli bacterial concentration was equal, except for point 1 – there it was higher in 25-cm-deep soil.



3.2.1.18. Figure. Fecal colifomic bacteria assessment results 1-4 point 25 and 100 cm depths Soil results

It was found that in all of the points the Fecal colifomic bacteria concentration was equal, except for points 1 and 2 – there it was higher in 25-cm-deep soil.



3. 2.1. 19 Figure. Fecal streptococci assessment results 1-4 point 25 and 100 cm depths Soil results

It was found that the Fecal streptococci concentration in points 1 and 2 was higher 25-cm-deep; in points 3 and 4 it was higher in 100-cm-deep soil. It means that in points 3 and 4 the wastewater can have an effect.

3.2.2. Nurmijärvi

The pilot plant is located in southern Finland, Nurmijärvi. This pilot is a project for renewal of one house waste water treatment system. The scheme of wastewater outflow is provided in Figure 3.2.2.1.

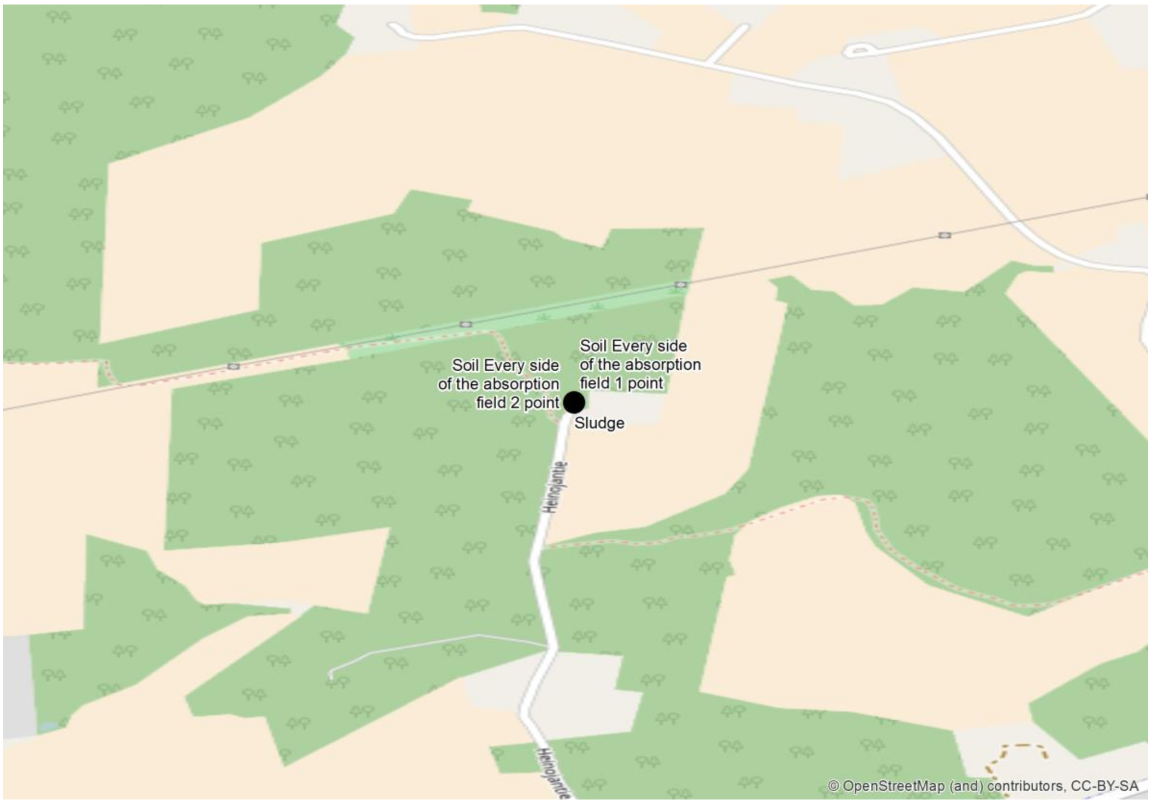


Figure 3.2.2.1. Nurmijärvi

The house is about 300 meters from the nearest houses and the houses do not have the possibility to make a joint wastewater treatment system. The old treatment system, soil filtration with pump has been clogged and the intention is to make similar system next to the old one. The principle of the system is to lift the waste water from the septic tanks through a pump to higher, so that after the filtering field the waters can be discharged to the nearby ditch. Table 3.2.2.1 shows the nutrient analyses in the samples taken from the sewage, sludge, clarification tank and end of outlet of the soil filtrated waste water.

Table 3.2.2.1. Nutrient analyses in samples taken from the Nurmijärvi pilot wastewater treatment system.

	Clarification	End of outlet	Sewage	Sludge
Total phosporus	17.15 mg/l	1.75 mg/l	55.05 mg/l	71.96 mg/l
Soluble phosphorus	14.10 mg/l	1.33 mg/l	22.46 mg/l	21.31 mg/l
Total nitrogen	132.69 mg/l	46.53 mg/l	213.87 mg/l	289.27 mg/l
Soluble nitrogen				
Ammonia nitrogen	130.29 mg/l	13.56 mg/l	121.53 mg/l	150.87 mg/l
Nitrates nitrogen	0.02 mg/l	26.37 mg/l	0.05 mg/l	0.04 mg/l

The results show that treatment of the sewage yields to almost 97% reduction in total phosphorus and nearly 79% reduction in total nitrogen. This indicates the efficiency of soil filtration system in the removal of nutrients and reduction of eutrophic waste reduction in natural waters.

Microbial analyses from the sewage, sludge, clarification tank and end of outlet of the Nurmijärvi pilot wastewater treatment system are depicted in Table 3.2.2.2.

Table 3.2.2.2. Microbial analyses in samples taken from the Nurmijärvi pilot wastewater treatment system.

	Clarification	**End of out-let**	**Sewage**	**Sludge**
Enterobacteria	4.00E+01	2.50E+03	6.00E+03	4.00E+03
Coliformic bacteria	9.10E+01	8.00E+02	7.40E+02	1.00E+03
Escerichia coli bacterial	<10	4.00E+01	6.40E+02	1.00E+03
Fecal colifomic bacteria	4.50E+01	1.50E+03	1.80E+03	4.00E+03
Fecal streptococci	2.70E+01	<10	1.20E+03	1.00E+03

According to the results, the number (cfu/ml) of all analyzed microbe groups decreased during the passage of sludge to clarification tank. Increased numbers of other microbe groups than fecal streptococci at the end of outlet may be a consequence of clogged soil filtration system; microbes attach on the inner surface of the pipe system and are able to propagate to some extent due to available nutrients, humidity and ambient temperature.

3.3. LATVIA

3.3.1. Svētciems

The Pilot Site – Svētciems Village – the old populated area (first historical records about Svētciems are dated with 1638, when a manor of Svētciems is mentioned) is located in Northern part of Latvia next to the Highway Riga–Tallinn. Approximately in 1 km distance from the Gulf of Riga. The population of Svētciems is 473 inhabitants (2006). Settlement is located on the banks of river Svētupe, which in translation from Latvian means – Holy River. This hydronym derives from Holy caves of Svētupe, located approximately 15 km upstream of village. Nowadays settlement exist mainly as a supportive satellite of Salacgrīva town and harbor which is located 6 km northwards.

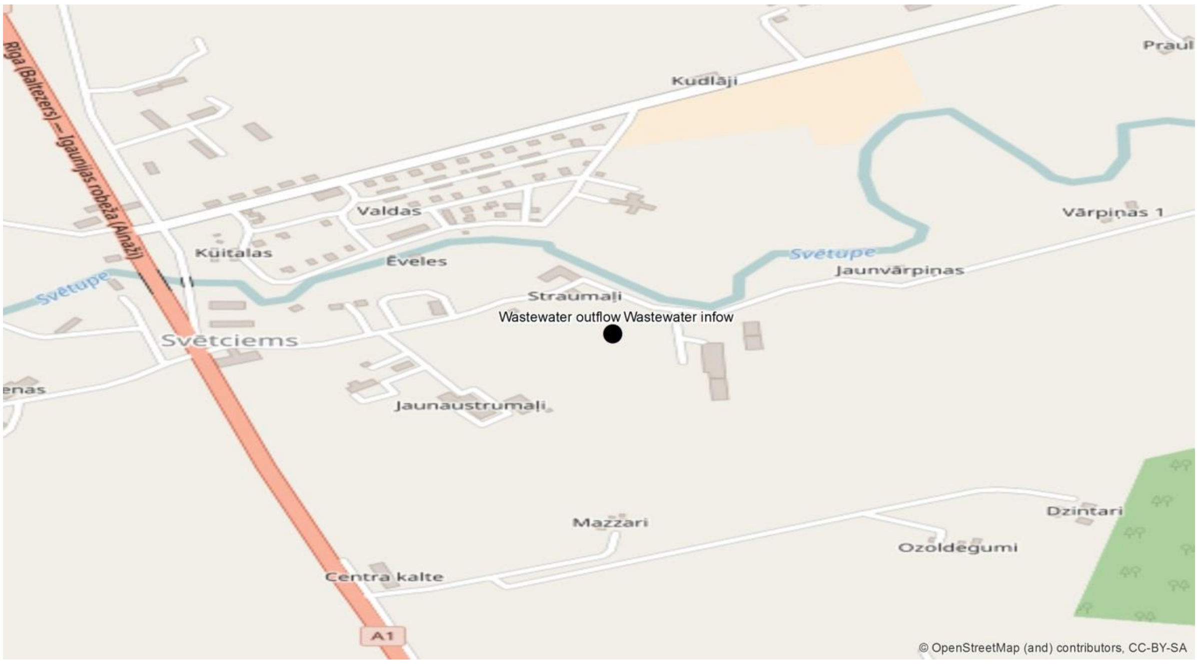


Figure 3.3.1.1. Diagram of wastewater inflow in Svetupe River

Quality of recipient water. River Svētupe is located in the protected site – North Vidzeme Biosphere Reserve, is designated as Salmonid River and also has status of water body at risk. Therefore the more strict requirements for treatment of sewerage water are defined by environmetal authority – regional environmetal board – to ensure quality objectives set (refer table []).

Figure 3.3.1.2. River Svētupe which is productive Salmonid River is also recipient of wastewater originated in village Svētciems

The impact of Svētciems WWT plant as point pollution source to River Svētupe was assessed by taking samples in September of 2016, 1000 meters before and 200 meters after discharge of treated seweragethe treated wastewater discharger. The results of sampling carried out in 2017 are not evaluted yet.

Table 3.3.1.1. Results of water quality assessment – River Svētupe before and after discharge of treated sewerage. 29.09.2016

Parameter	Limit value (*)	River Svetupe	
		1000 m before dis-charge of treated sewerage	200 m after dis-charge of treated sewerage
Temperature, °C	After outlet do not exeed 1,5 °C for salmonid waters, 3 °C – for cyprinid waters	15	15
pH	6-9	8,1	8,1
Electrical conduc-tivity	Is used to explain proceses	462	403
Dissolved oxygen (mg/l O2)	50 % ≥ 9; 100 % > 7	9,24	8,84
Oxygen saturation (%)	Is used to explain proceses	93,1	86
BOD5 (mg/l)	≤ 2	1,6	1,6
Suspended solids (mg/l)	< 25	5,8	5,3
Total P (mg/l)	≤ 0,065	0,117	0,118
N/NH4	< 0,78 (mandatory value); 0,03 (guideline value)	0,042	0,042
N/NH3	Is used to explain proceses	0,0014	0,0014
N/NO2	< 0,01	0,0141	0,0141

Note: (*) According to Cabinet of Ministers Regulation No. 118 “Regulations regarding the Quality of Surface Waters and Groundwater” (12.03.2002).

According to results obtained water quality of recepient water body correspond to requirements set. The only exception is high concentrations of total phosphorus (refer Table []). Newertheless on the bases of existing data it is not possible clearly indicate impacts of point source pollution of Svētciems WWT facilities and diffuse pollution loads originated in the catchment area of river.

Characteristics of existing WWT solutions. Collected wastewater are treated by using biological treatment technology and is characterized as follows:

Year of Construction	1986
WWT Technology and Projected capacity; m³/day	BIO – 100x2: Standard Project with 2 industrially produced aero-tanks with capacity of each – 100 m³ per day
Sewerage disposal	Treated wastewaters from aero-tank are discharged to surface water body through 4 biological ponds having function of surface flow constructed wetland. Thus additional nutrient purification is performed. After passing ponds treated waters enters River Svētupe.

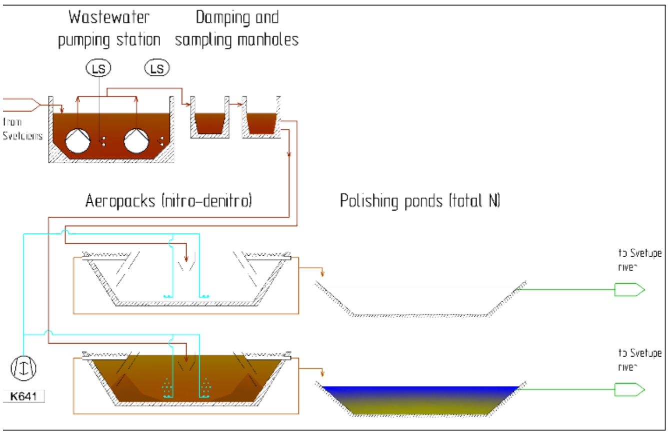


Figure 3.3.1.3. Operation of existing WWT plant.

Table 3.3.1.2. Characteristics of treated sewerage discharger to River Svētupe

Parameter	Limit value (*)	2015		2016			2017	
		09	12	02	05	09	02	06
Suspended solids (mg/l)	< 35	0,9	1	4,3	1,1	5,2	2	1,7
BOD_5 (mg/l)	< 25	3	10	6,4	2,4	3,4	8	6
COD (mg/l)	< 125	40	27	25	40	43	35	29
Total P (mg/l)	no limits	6,3	1,72	2,5	0,16	4,3	2,9	2,5
Total N (mg/l)	no limits	8,9	12,7	17,7	19,1	3,6	34	26

Note: (*) Stated within B category permit issued according to The Law on Pollution (15.03.2001).

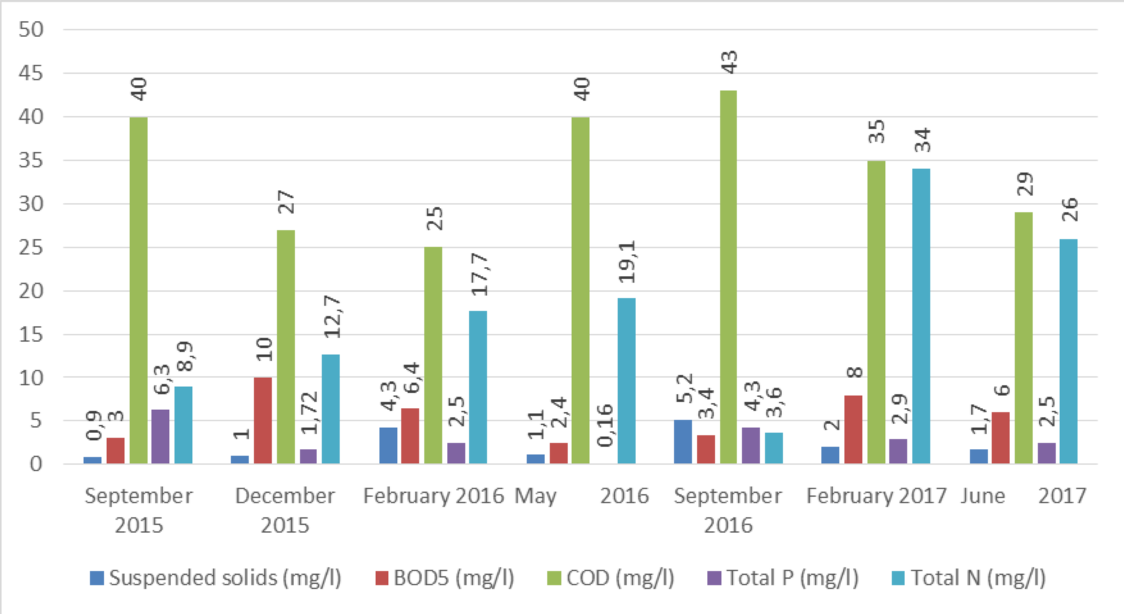


Figure 3.3.1.4. Characteristics of treated sewerage discharger to River Svētupe

Table 3.3.1.3. Characteristics of treatment efficiency of existing WWT plant

Parameter	**Limit value (*)**	**09.2015**		**09.2016**		**06.2017**	
		inlet	**outlet**	**inlet**	**outlet**	**inlet**	**outlet**
Suspended solids (mg/l)	< 35	96	0,9	1260	5,2	130	1,7
BOD_5 (mg/l)	< 25	230	3	140	3,4	230	6
COD (mg/l)	< 125	390	40	420	43	470	29
Total P (mg/l)	no limits	10,2	6,3	7,5	4,3	9,4	2,5
Total N (mg/l)	no limits	94	8,9	56	3,6	86	26
P/PO4	Is used to explain pro-ceses	7,9	5,78	2,81	4,01	7,1	2,36
N/NH4		68	5,8	34	1,51	72	0,5
N/NH3		1,22	0,22	0,68	0,092	0,67	0,08
N/NO3		0,041	0,056	0,02	0,12	0,02	20
N/NO2		0,00013	0,0154	0,0003	0,029	0,00013	0,132
pH		7,6	-	7,6	8,1	7,5	8,8

Note: (*) Stated within B category permit issued according to The Law on Pollution (15.03.2001).

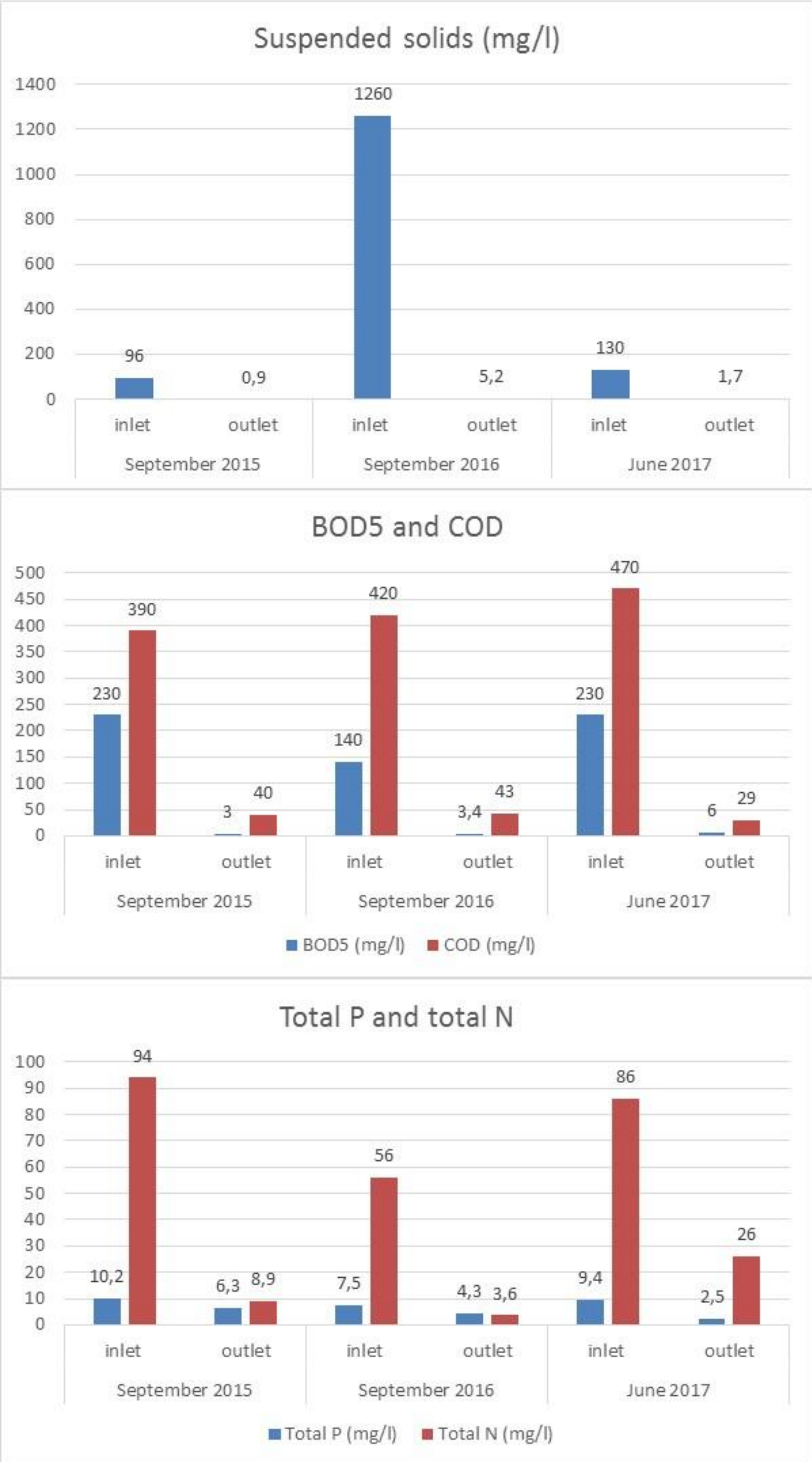


Figure 3.3.1.5. Characteristics of treatment efficiency of existing WWT plant

Problems to be solved. The projected capacity are too large for currently produced wastewater loads. Therefore only one aero-tank is operated;

The wastewater treatment requirements set by the Regional environmental authority are reached not because of efficient treatment within aero-tank, but because of additional purification carried out in ponds having function of surface flow constructed wetland.

3.3.2. Ainaži

The Pilot Area – Ainaži Town is located in Northern part of Latvia on the Riga Gulf and close to the border with the Republic of Estonia. Area is located within neutral zone of North Vidzeme Biosphere Reserve.

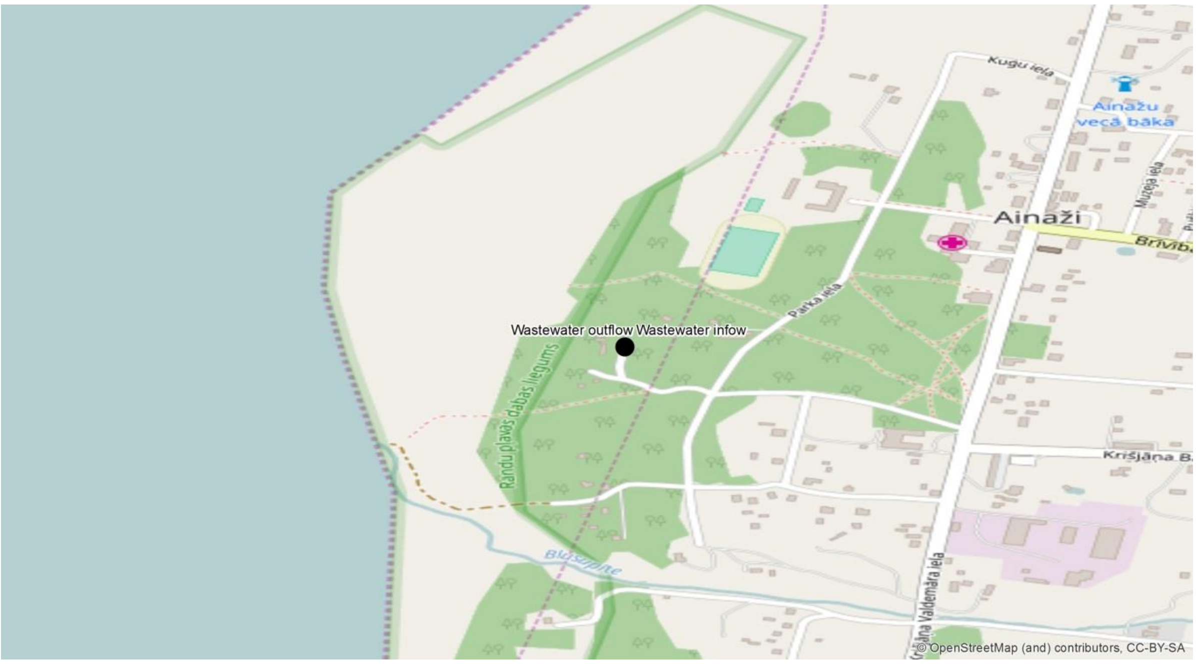


Figure 3.3.2.1 Diagram of wastewater flow

According to data of last inhabitants recording (2015) there are 835 inhabitants in Ainaži Town. Average density: 13 inhabitants 1 km2 including 2,1 inhabitants 1 km^2 in rural area of Ainazi (average in Latvia: 36,6 inhabitants 1 km^2).

Historical background of Pilot site

Ainaži existed for centuries as a Livonian fishing village. Town rights were

granted in 1926. In 1864 the first naval college in the whole Russian Empire was opened there training young Estonian and Latvian farmers to become ship captains. With the opening of the school also ship building industry was developed and harbour was constructed (1900–1905). During the period from

1857 to 1913, over 50 seaworthy vessels were built in the town. Before World War I, Ainaži was the fourth largest port of Latvia. During the Soviet period Ainaži was over–shadowed by nearby Salacgriva. Nowadays Ainazi is the smallest town in Vidzeme.

Historical background of Pilot object

In 1912 narrow gauge railway Ainazi–Valmiera–Smiltene was opened to connect harbour with vast inland agricultural areas were products for import were produced. The pilot object originally were constructed as harbour infrastructure. Nowadays it is used as dwelling with 4 single apartments, but previous railway embankment – as nature track.

Existing wastewater treatment solution

Wastewater is discharged to the individual setlement tanks which is empetd on regular bases and transported to the Ainazi WWTP.

Problems to be solved

1. Pilot is located within area with high level of shallow groundwaters;

Receiving surface water body – open ditch system – is directly connected with the Gulf of Riga.

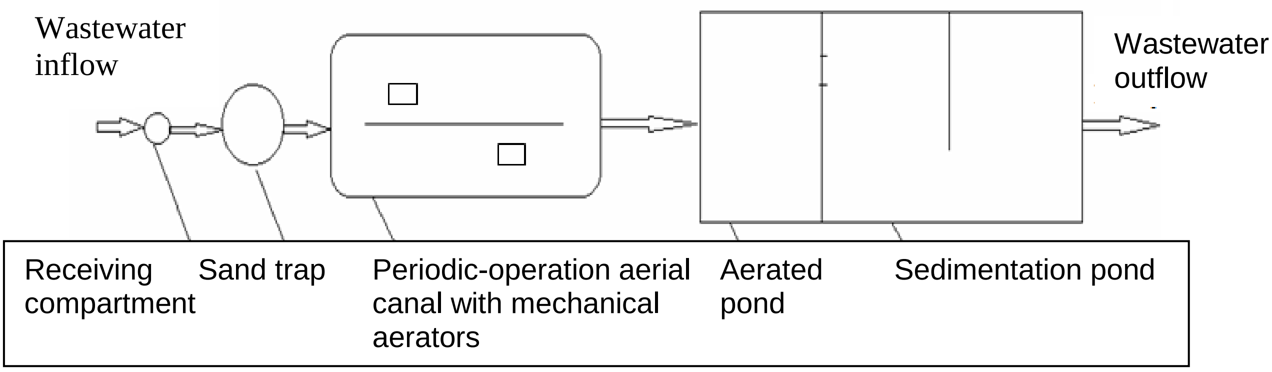
.

Characteristics of water supply and wastewater treatment services provided

Water supply		Sewerage	
Total length of water supply network, km	**12,4**	**6,10**	Total length of sewerage network, km
Inhabitants connected to water supply network	**505**	**357**	Inhabitants connected to sewerage collection network
Extracted groundwater, m^3/ year	**24 718**	**22 402**	Total amount of wastewater treated in WWTP, m^3 /year

3.4. LITHUANIA

Leitgiriai village wastewater is delivered to the wastewater treatment plant by pumps. There they flow to a receiving compartment. Then the wastewater flows by gravity to a sand trap, and from there – to the periodic-operation aerial canal, where the sequence of periodic-operation cycles repeats – filling, mixing, sedimentation and flow down. In the aerial canal, a mixture of activated sludge and wastewater is mixed in circles by two mechanical aerators, at the same time saturating the wastewater with oxygen. The wastewater is aerated this way for about 20 hours, then the aerators are turned off and for 2 hours the process of sedimenting the activated sludge and wastewater mixture is being conducted. Purified water is released to an aerated pond. There the wastewater is mechanically aerated, then flows into a sedimentation pond, after that flows into the Leitė creek.



Internal wastewater inspection is conducted, wastewater samples are taken, and analysis is made once every quarter (according to the economic entity monitoring programme). The scheme of wastewater inflow into the Leitė creek is provided in Figure 3.4.1.

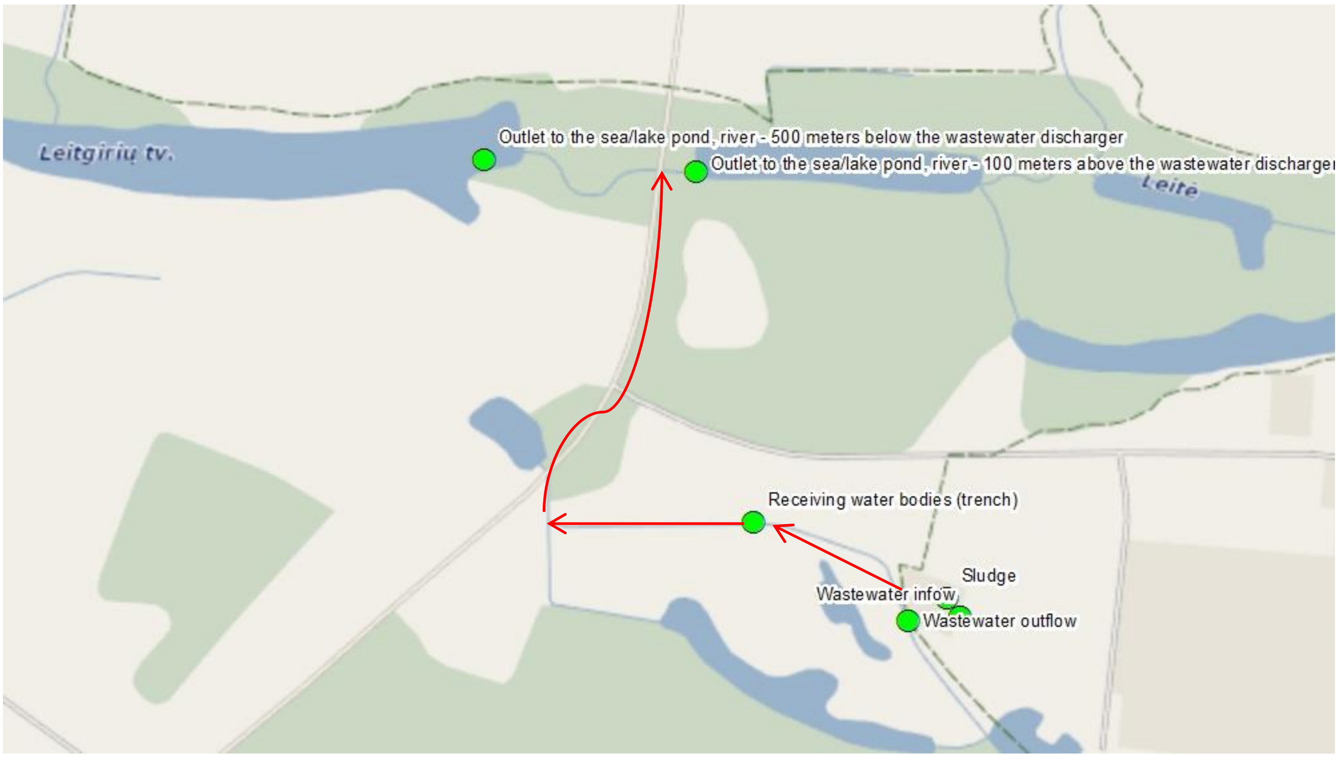


Figure 3.4.1. Scheme of wastewater inflow into the Leitė creek

The pollution of untreated wastewater flowing into the Leitgiriai wastewater treatment plant has been assessed by identifying the BOD_7, pH value and concentrations of suspended materials, phosphorus and nitrogen. The assessments were conducted in July, October and December of 2016, March and June of 2017. The identified indicator values are compared with the limit values regulated by the Wastewater Treatment Regulation 2008 according to general requirements for wastewater released to the sewage system. The results are provided in Table 3.4.1.

Table 3.4.1. Assessment results of untreated wastewater flowing into the Leitgiriai wastewater treatment plant

Data	2016 07	2016 10	2016 12	2017 03	2017 06
pH	7.1	7.4	7.6	7.2	7
Suspended solids, mg/l	29	31	33	38	96
BOD_7 mg/l O_2	29	33	45	41	435
Total phosphorus mg/l	3.25	2.14	4,25	3.91	11.1
Total nitrogen mg/l	19.8	17.2	26,1	24.3	139
Total flow, The average monthly value m^3/day	11.52	18.17	34.94	50.81	

The data in the table shows that the pH and BDS values found in untreated wastewater do not exceed the limit values, therefore the wastewater can be released to the wastewater treatment plants.

The pollution of treated wastewater flowing out of the Leitgiriai wastewater treatment plant was assessed by taking samples in July, October and December of 2016, March and June of 2017. The identified indicator values are compared with the limit values regulated by the Wastewater Treatment Regulation 2008 according to the pollution norms for the wastewater released to the natural enviroment. The results are provided in Table 3.4.2.

Table 3.4.2. Assessment results of treated wastewater flowing out of the Leitgiriai wastewater treatment plant

Data	The limit value	2016 07	2016 10	2016 12	2017 03	2017 06
pH	6.5-8.5	7.3	7.9	7.5	7.1	7.5
Alkalinity	Not regulated	7.5	7.6	7.2	7	
Suspended solids mg/l	Not regulated	19	22	22	20	60
BOD_7 mg/l O_2	<2000 p.e., Average daily limit value 29 mg/l O_2	31	6.2	69	31	22
Total phosphorus mg/l	< 1 0000 p.e., 2 mgP/l	3.19	2.02	3.27	2.18	1.55
Soluble phosphorus	Not regulated	2.2	1.6	2.3	1.3	1.4
Total nitrogen mg/l	< 1 0000 p.e.,	19.01	17.9	25.8	23.8	74.5

	20 mg/l					
Ammonia nitrogen mg/l	5 mg/l	1.58	0.73	2.46	1.22	49.9
Nitrates nitrogen mg/l	23 mg/l	12.5	15.8	0.36	2.5	0.229
Nitrites nitrogen mg/l	0.45 mg/l	0.13	0.128	0.02	0.14	0.125
Sum of nitrate and nitrite nitrogen mg/l	Not regu-lated	14.21	16.658	2.84	3.86	0.354
Total aluminium mg/l	0,5 mg/l	0.29	0.143	0.695	0.28	0.21
Total iron mg/l	Not regu-lated	0.92	0.62	1	0.89	0.48
Enterobacteria	Not regu-lated	7.50E+04	1.50E+03	7.00E+04	7.10E+04	8.20E+04
Coliformic bacteria	Not regu-lated	1.50E+05	1.00E+03	1.00E+04	1.50E+05	1.00E+05
Total flow, The av-erage monthly value m^3/day		11.52	18.17	34.94	50.81	

The data provided in the table shows that the wastewater is not sufficiently treated according to the BOD_7 (10/2016), according to total phosphorus, according to total nitrogen during the cold period in December 2016 and March 2017, according to total concentration of aluminium in December 2016.

The results in the tables illustrate the existence of wastewater treatment problems: Leitgiriai WWTP seasonal uses only periodical operation ditch with mechanical aeration, it does not provide adequate wastewater treatment. During the cold season WWTP stops working because of inability of mechanical aerators to use in freezing temperature.

The concentrations of total nitrogen in the inflowing untreated and outflowing treat-ed wastewater in Leitgiriai are provided in Figure 3.4.2.

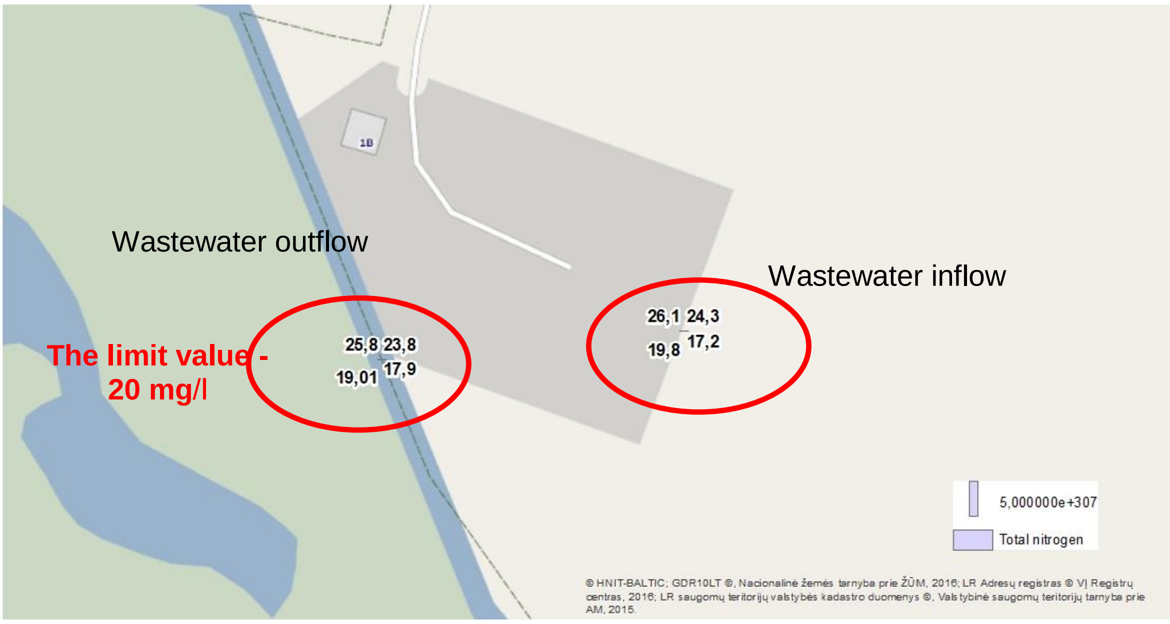


Figure 3.4.2. The concentrations of total nitrogen in the inflowing untreated and outflowing treated wastewater in Leitgiriai

Calculating the efficiency of wastewater treatment was used formula (Dauknys, 2007):

$$E(M) = \frac{M_o - M_1}{M_o} \times 100,\ \%$$

Here:

M_o - concentration untreated waste water, mg / l;

M_1 - the residual concentration in treated wastewater mg / l.

3.4.3 Table. The efficiency of wastewater treatment in Leitgiriai, %

Data	Suspended solids	BOD_7	Total phosphorus	Total nitro-gen
2016 07	34	-7	2	4
2016 10	29	-88	6	-4
2016 12	33	-53	23	1
2017 03	47	24	44	2
2017 06	38	95	86	46

The results have shown that during the treatment process the wastewater is treated inefficiently and vary: submerged materials 29–47%, biochemical oxygen consumption in 7 days (BOD_7) - 88 -95%, it means that the BDS_7 value in the released wastewater is higher than that in the inflowing wastewater; total nitrogen (N_t) –4 - 46%, total phosphorus (P_t) 2- 86 %. During the assessment it was found that the treatment of total nitrogen and ammonium nitrogen has changed the most (%).

Currently, the insufficiently treated wastewater (before reconstruction) is released out of the Leitgiriai wastewater treatment plant into the surface water (canal) which flows into the Leitė creek. In order to assess the effect of the wastewater on the quality of the Leitė creek, the condition of the Leitė creek is assessed 100 meters before the discharger and 500 meters after the discharger.

The condition of the surface water (canal) was assessed by taking samples in July, October and December of 2016, March and June of 2017. Found indicator values are compared with the limit values regulated by the Procedure for determining of the status of surface water quality. In 2016 according to the ecological potential class of rivers that are classified as highly altered water bodies and canals according to the indicators of physical-chemical quality elements. The results are provided in Table 3.4.4.

Table 3.4.4. Surface water (canal) assessment results.

Data	The limit value for very good and good quality class	2016 07	2016 10	2016 12	2017 03	2017 06
Electrical conductivity µS/cm	Not regulated	597	534	612	517	1094
Faecal Enterococcus	Not regulated	7.70E+01	7.00E+00	7.00E+00	8.00E+00	7.10E+01
Escherichia coli bacterial	Not regulated	6.11E+02	2.70E+01	1.80E+03	1.00E+05	8.30E+01
Total phosphorus mg,l	<0.140	0.039	0.029	1.45	0.91	7.23
Total nitrogen mg/l	<3.00	5.19	5.84	5.64	5.23	74.5
Ammonia nitrogen mg/l	<0.20	0,067	0.055	0.27	0.12	0.358
Nitrates nitrogen mg/l	<2.30	3.91	4.82	2.91	3.92	61.7
Nitrites nitrogen mg/l	Not regulated	0.031	0.021	0.01	0.034	0.017
Sum of nitrate and nitrite nitrogen mg/l	Not regulated	3.91	4.896	3.19	3.91	61.717
pH	Not regulated	6.9	7.2	7	7.7	6.9
BOD_7 mg/l O_2	<3.30	28	25	23	28	33

The data provided in the table shows that the condition of the surface water (canal) is bad according to the total nitrogen concentration, nitrate nitrogen concentration, BDS_7 values in all assessment cases, according to ammonium nitrogen and total phosphorus – in December 2016.

The Leitė creek's condition was assessed by taking samples in July, October and December of 2016, March and June of 2017, 100 meters before the wastewater discharger and 500 meter after the wastewater discharger. Found indicator values are compared with the limit values regulated by the Procedure for determining of the status of surface water quality. 2016, according to the river ecological condition class according to the indicators of physical-chemical quality elements. The results are provided in Tables 3.4.5 and 3.4.6.

Table 3.4.5. Assessment results for the surface water in the Leitė creek 100 meters before the wastewater discharger

Data	The limit value for very good and good quality class	2016 07	2016 10	2016 12	2017 03	2017 06
Electrical conductivity µS/cm	Not regulated	120	119	128	138	508
Faecal Enterococcus	Not regulated	2.00E+00	4.00E+00	4.00E+01	2.00E+00	3.90E+02
Escherichia coli bacterial	Not regulated	2.45E+02	1.90E+02	1.50E+02	2.50E+02	5.10E+01
Total phosphorus mg/l	<0.140	0.058	0.125	0.078	0.101	0.056
Total nitrogen mg/l	<3.00	3.27	3.25	3.87	3.12	1.56
Ammonia nitrogen mg/l	<0.20	0.298	0.35	0.167	0.254	0.023
Nitrates nitrogen mg/l	<2.30	2.89	2.7	3.64	3.12	0.716
Nitrites nitrogen mg/l	Not regulated	0.015	0.017	0.023	0.031	0.133
Sum of nitrate and nitrite nitrogen mg/l	Not regulated	3.18	3.067	3.83	3.405	0.849

Table 3.4.6. Assessment results for the surface water in the Leitė creek 500 meters after the wastewater discharger

Data	The limit for very good and good quality class	2016 07	2016 10	2016 12	2017 03	2017 06
Electrical conductivity µS/cm	Not regulated	487	534	537	517	534
Faecal Enterococcus	Not regulated	8.00E+00	3.00E+00	1.00E+00	5.00E+00	7.00E+00
Escherichia coli bacterial	Not regulated	8,30E+01	5.90E+01	6.90E+01	6.20E+01	8.30E+01
Total phosphorus, mg/l	<0.140	0.068	0.05	0.075	0.038	0.508
Total nitrogen, mg/l	<3.00	3.58	5.71	3.97	4.18	2,2
Ammonia nitrogen, mg/l	<0.20	0.12	0.09	0.21	0.24	0.051
Nitrates nitrogen, mg/l	<2.30	3.58	4.81	3.37	3.14	0.557
Nitrites nitrogen, mg/l	Not regulated	0.038	0.025	0.021	0.037	0.036
Sum of nitrate and nitrite nitrogen, mg/l	Not regulated	3.49	4.925	3.601	3.417	0.593

The data provided in the tables shows that the Leitė creek's condition is bad according to the nitrogen concentration, nitrate nitrogen concentration and ammonium nitrogen concentration both before and after the wastewater discharger in all assessment cases. The total nitrogen and total phosphorus concentrations in the wastewater and surface water are shown in Figures 3.4.3 and 3.4.4.

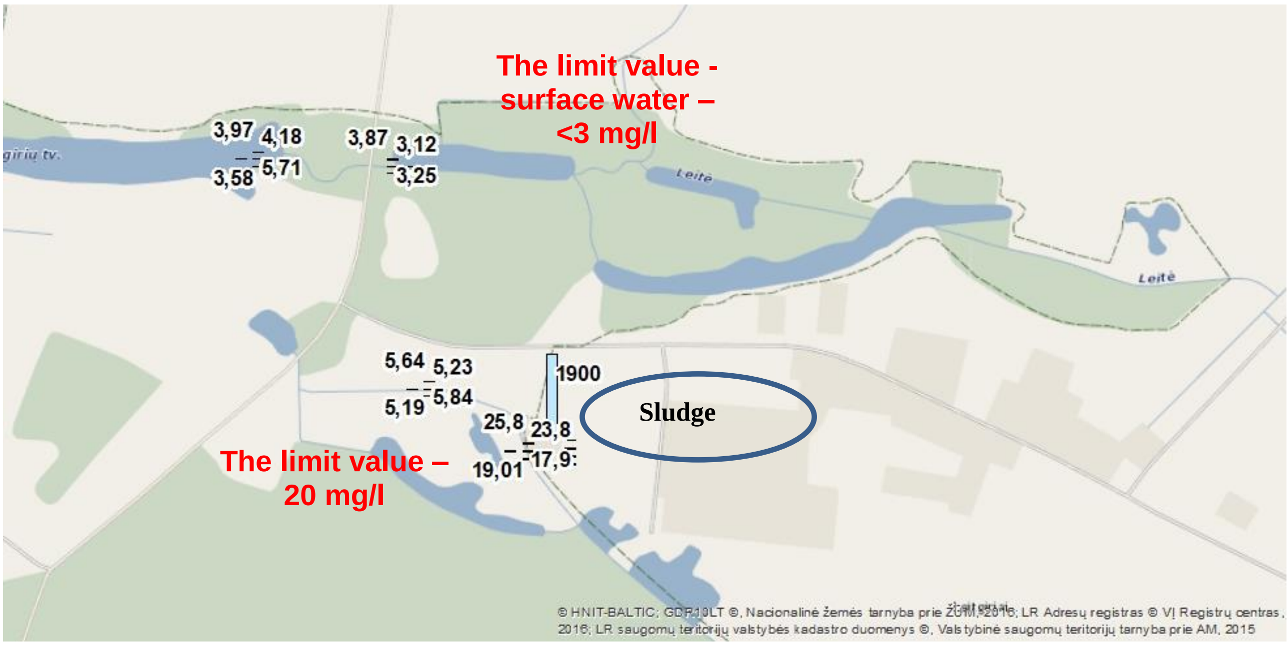


Figure 3.4.3. Total nitrogen concentrations in the wastewater and surface water

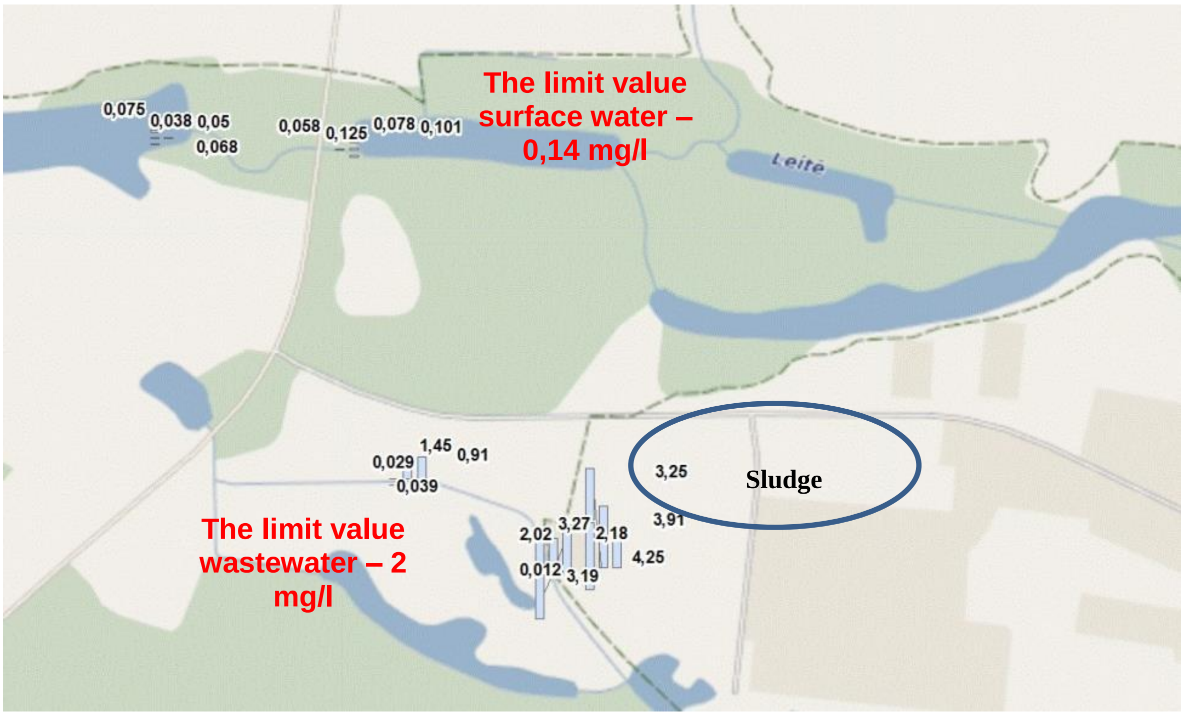
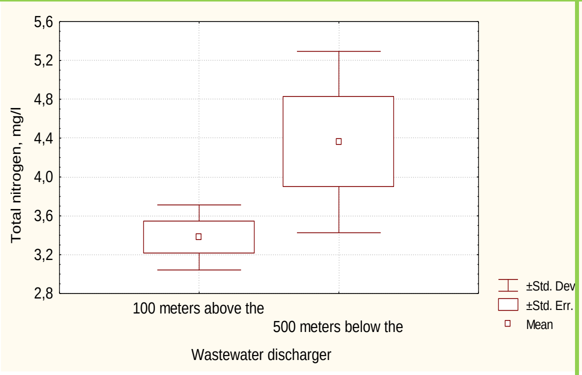
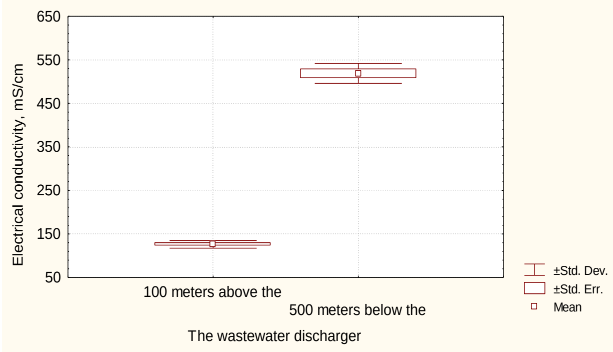


Figure 3.4.4. Total phosphorus concentrations in the wastewater and surface water

In order to assess the effect of treated wastewater on the quality of the Leitė creek, the Student t-criterion has been calculated using the STATISTICA 10 program. The differences between the water-quality indicator values 100 m before and 500 m after the wastewater discharger are significant, if t <0.05.



3.1.5.a



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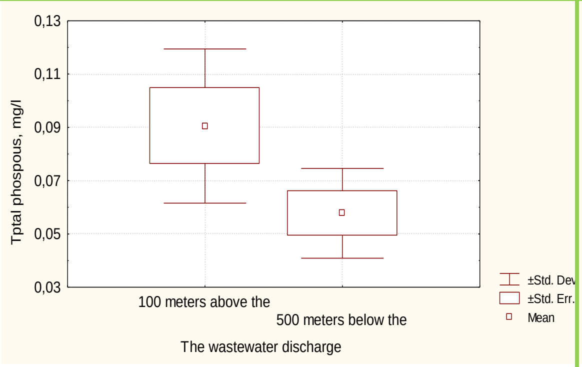

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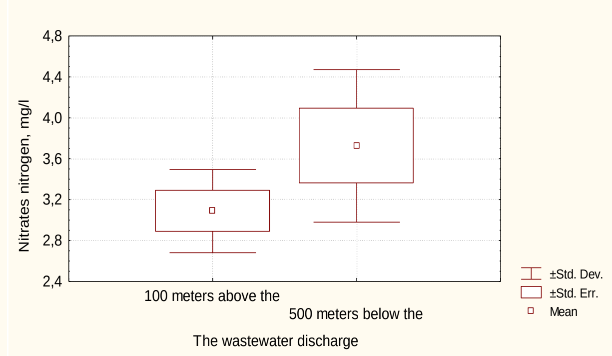

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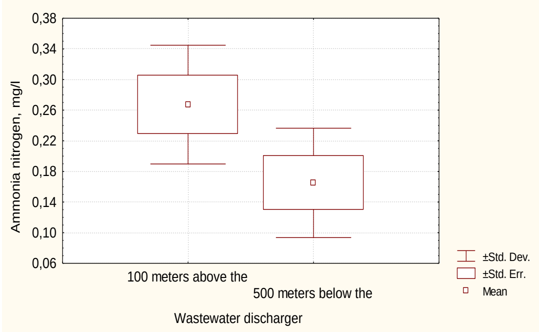

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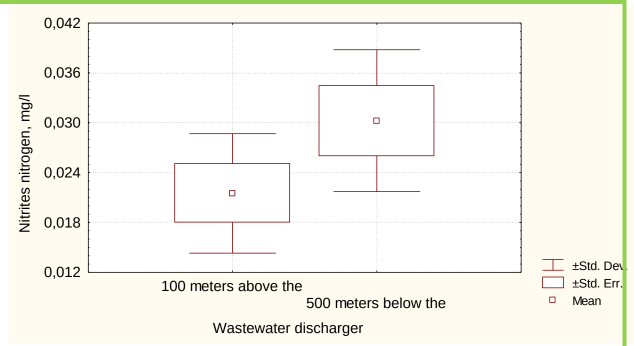
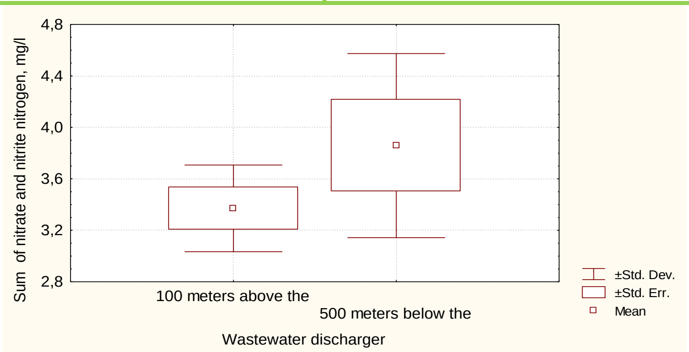


3.1.5.f.



3.1.5.g.

Figure 3.4.5. Water-quality indicator values in the Leitė creek 100 m before and 500 m after the wastewater discharger

It was found that the values of nitrate nitrogen, total nitrogen, electrical conductivity were statistically significantly higher 500 m after the wastewater discharger than 100 m before the wastewater discharger. The differences between the ammonium nitrogen and total phosphorus concentrations were not significant.

In order to identify the relation between the wastewater treatment efficiency and the Leitė creek's water-quality values 500 meters after the wastewater discharger, correlation ratios were calculated. The results are provided in Table 3.4.7.

Table 3.4.7. Matrix of the correlation of the wastewater treatment efficiency and the Leitė creek's water-quality values (500 meters after the wastewater discharger)

	Electrical conductivity, µS/cm	Total phosphorus, mg/l	Total nitrogen, mg/l	Ammonia nitrogen, mg/l	Nitrates nitrogen, mg/l	Nitrites nitrogen, mg/l	Sum of nitrate and nitrite nitrogen, mg/l
The efficiency of wastewater treatment, P %	r= 0.282 p=0.718	r= -0.515 p=0.485	r= -0.193 p=0.807	r= 0.432 p=0.568	r= -0.647 p=0.353	r= 0.139 p=0.861	r= -0.479 p=0.521
The efficiency of wastewater treatment, N%	r= -0.74 p=0.260	r= 0.289 p=0.711	r= -0.972 p=0.028	r= -0.926 p=0.044	r= -0.847 p=0.049	r= -0.65 p=0.355	r= -0.942 p=0.048
Correlations (new.sta) Marked correlations are significant at p < ,05000							

A statistically strong negative correlation was found between the wastewater treatment efficiency according to total nitrogen (%) and the concentrations of total nitrogen, ammonium nitrogen, nitrates nitrogen and sum of nitrate and nitrite nitrogen 500 meters after the wastewater discharger in the Leitė creek. This shows that the lower the treatment efficiency, the worse the quality of the surface water.

The wastewater sludge quality was assessed by taking samples in July 2016 and June 2017. Found indicator values are compared with the limit values regulated by the REQUIREMENTS FOR USE OF WASTEWATER SLUDGE FOR FERTILISATION LAND 20-2001. The results are provided in Table 3.4.8.

Table 3.4.8. Wastewater sludge assessment data

Data	The limit value	2016 08	2017 06
Total phosphorus mg/l	Not regulated	0.012	20.8
Total nitrogen mg/l	Not regulated	1900	112
Ammonia nitrogen mg/l	Not regulated	4.53	1.06
Nitrates nitrogen mg/l	Not regulated	0.2	76.30
Nitrites nitrogen mg/l	Not regulated	0.52	0.59
Sum of nitrate and nitrite nitrogen mg/l	Not regulated	5.25	76.89
Enterobacteria	0	7.50E+04	8.10E+04
Coliformic bacteria	Not regulated	1.40E+04	1.50E+04
Escherichia coli bacterial	<= 1000	6.00E+01	4.00E+02
Electrical conductivity	Not regulated	113	257
Dry matter content %	Not regulated	49.30	48.5

3.5. POLAND

3.5.1.Sokoly

First pilot domestic wastewater treatment plant is located in municipality of Sokoły (Fig.3.5.1.1.) in Idźki-Wykno village (Fig.3.5.1.2). It is a natural domestic wastewater treatment plant with soil-plant bed and a denitrification pond based on a treatment technology by Halicki (Fig.3.5.1.3.). This is a single domestic installation (3 people) and it was built in 2004

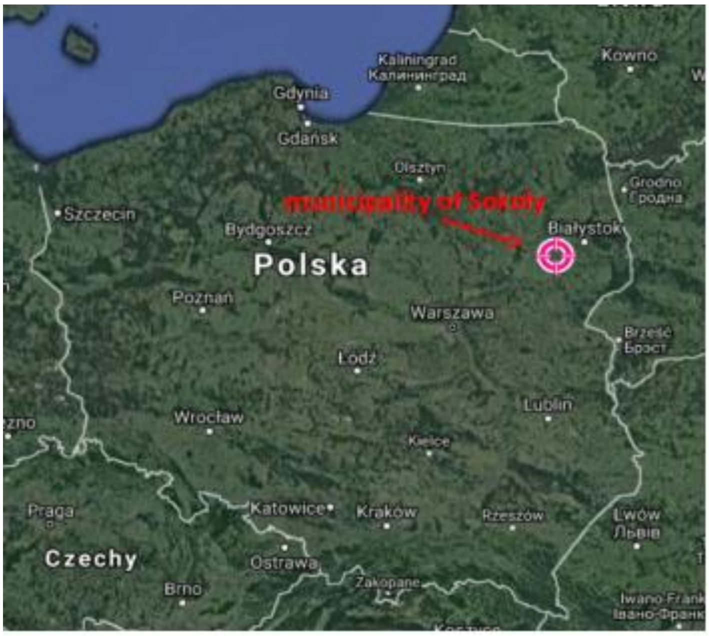


Figure 3.5.1.1. Municipality of Sokoły in Poland

Figure 3.5.1.2. Individual domestic wastewater treatment plant for a single household in Idźki-Wykno village, in the municipality of Sokoły

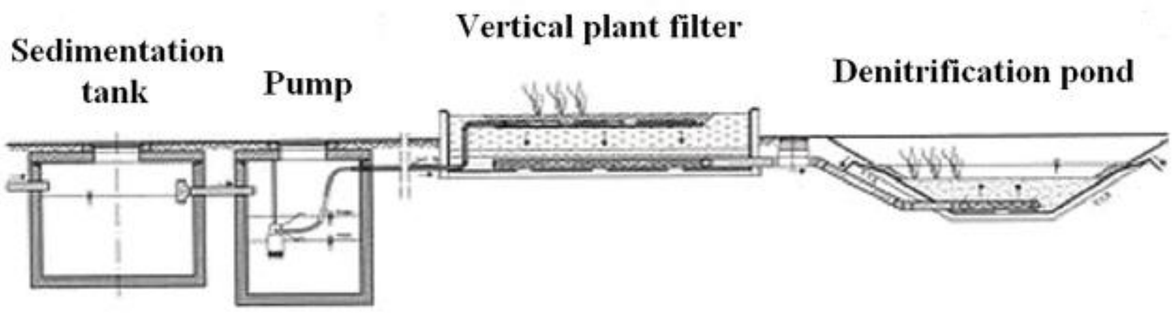


Figure 3.5.1.3. The scheme of the single household (3 people), individual wastewater treatment plant in Idźki-Wykno village (Sokoły municipality)

The natural domestic wastewater plant in the Idźki-Wykno village (Sokoły municipality) is composed of 4 elements: a sedimentation tank [1], a pumping station [2], a vertical plant filter [3] and a denitrification pond [4] (Fig.3.5.1.3). The basic principle of treatment in this technology is the decomposition of pollutants contained in wastewater by microorganisms found in the soil, assisted by the root system of macrophytes. Microorganisms used are native to the soil, but in order to increase the intensity of the pollution reduction process in the treatment plant, an organic layer of BIO-HUMIX is added. The main stage of sewage treatment is the vertical plant filter

[3] and the denitrification pond [4]. **The sedimentation tank [1] and the pumping station [2]**: The sedimentation tank fulfils the function of preliminary mechanical treatment of wastewater. In the sedimentation process, solids fall to the bottom of the sedimentation tank, where they ferment. The pumping station [2] ensures the discharge of liquid to the vertical plant filter [3] when the gravity flow is unobtainable. **The vertical plant filter [3]**: this is the main component of the treatment plant. It is isolated from the soil by a foil layer. The filling of the filter is composed of soil mixed with organic material. The filter area is planted with carefully selected marsh water vegetation. The following plants were planted on the filter:

- stiff sedge *(Caricetum hudsonii)*,
- rush *(Jancus),*
- great manna grass *(Gliceria maksima),*
- yellow flag *(Iris pseudoacorus).*

The denitrification pond [4]: it is a last, cleaning element, serving for further purification of the sewage, most often it has a round shape. Based mainly on the evapotranspiration process. Like the filter, it is isolated from the soil by a foil layer and is also filled with multi-species macrophytes. The pond can also be a life place for different species of fish and amphibians.

It is important that this type of natural individual household wastewater treatment plant **does not have any wastewater outflow, so the last step of wastewater treatment is the denitrification pond, but sometimes, especially during winter when there are no plants in the denitrification pond, purified wastewater can overflow from denitrification pond to the ground.**

The samples for parameters measurement were taken from the following sampling points at the wastewater treatment plant:

- from the sedimentation tank, as wastewater inflow (untreated wastewater) and sludge,
- from the denitrification pond, as wastewater outflow,
- from the groundwater from a piezometer installed in the proximity of the pond,
- from the soil next to the vertical plant filter and next to the denitrification pond.

The assessments were conducted in April 2017. The results are provided in the Table 3.5.1.1. The pollution of untreated wastewater couldn't be assessed by identifying the BOD_5, pH value and concentrations of suspended solids, total phosphorus and nitrogen because in polish law there is no regulation on untreated wastewater.

According to the polish "Regulation of the Minister of the Environment from 18 November 2014 on the conditions to be met for the discharge of sewage into water or soil and on substances particularly harmful for the water environment " §13 point 5 treated wastewater coming from own household, localized on the outside of any agglomeration, could be discharged into the ground in own plot if they fulfil following conditions:

- the amount of wastewater is less than 5 m^3 /day,
- BOD_5 reduction is at least 20%,
- suspended solids reduction is at least 50%.

The above regulation applies only to treated wastewater coming from small individual domestic wastewater treatment plants. For municipal wastewater treatment plant with bigger flow there are other regulations and limit values contained in the same Regulation of the Minister of the Environment.

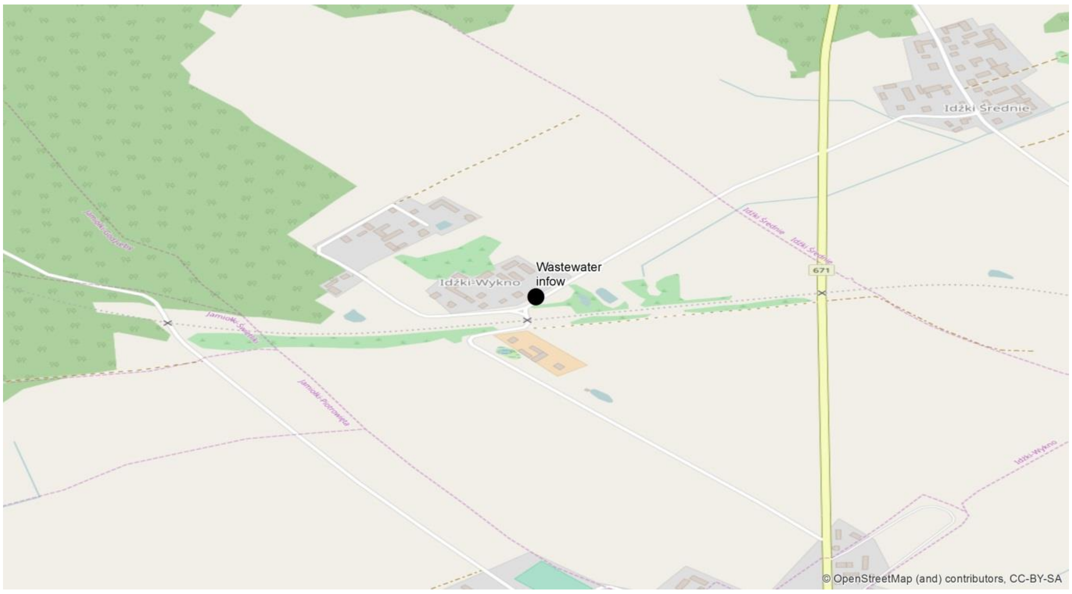


Figure 3.5.1.4. Poland. Sokoly. Wastewater flowing

Samples of untreated wastewater were taken from the sedimentation tank [1] (Fig. 3.5.1.4). The results are provided in Table 3.5.1.1.

Table 3.5.1.1. Assessment results of untreated wastewater flowing into the Sokoly wastewater treatment plant

Data	Limit Values	2017 04
pH	Not regulated	7.25
Suspended solids, mg/l	Not regulated	745
BOD_5 mg/l O_2	Not regulated	1050
Total phosphorus mg/l	Not regulated	135
Total nitrogen mg/l	Not regulated	12.4
Total flow m^3/d	Not regulated	0.572

Figure 3.5.1.5 . The untreated wastewater sampling from the sedimentation tank in Idźki-Wykno village in Sokoły municipality [own photo, 04.2017]

Samples of treated wastewater were taken from the denitrification pond [4]. The results are provided in Table 3.5.1.2.

Table 3.5.1.2. Assessment results of treated wastewater flowing out of the Sokoly wastewater treatment plant

Data	The limit value	2017 04
pH	Not regulated	7.18
Alkalinity mg/l $CaCO_3$	Not regulated	544
Suspended solids mg/l	reduction at least 20%	77.5
BOD_5 mg/l O_2	reduction at least 20%	150
Total phosphorus mg/l	Not regulated	25.17
Soluble phosphorus	Not regulated	7.8
Total nitrogen mg/l	Not regulated	0.92
Ammonia nitrogen mg/l	Not regulated	94
Nitrates nitrogen mg/l	Not regulated	1.06
Nitrites nitrogen mg/l	Not regulated	0.05
Sum of nitrate and nitrite nitrogen mg/l	Not regulated	1.11
Total aluminium	Not regulated	1.46
Total iron	Not regulated	0.65
Enterobacteria MPN/100 ml	Not regulated	3
Coliformic bacteria MPN/100 ml	Not regulated	11000

The data provided in the table shows that the suspended solids have been reduced by nearly 90%, the BOD_5 has been reduced by nearly 86% and the amount of wastewater was less than 5 m3/day, so all condition contained in the Polish “Regulation of the Minister of the Environment from 18 November 2014 on the conditions to be met for the discharge of sewage into water or soil and on substances particularly harmful for the water environment " have been met.

Calculating the efficiency of wastewater treatment was used formula (Dauknys, 2007):

$$E(M) = \frac{M_o - M_1}{M_o} \times 100,\ \%$$

Here:

M_o - concentration untreated waste water, mg / l;
M_1 - the residual concentration in treated wastewater mg / l.

Table 3.5.1.3. The efficiency of wastewater treatment in Sokoly %

Data	Suspended solids	BOD_5	Total phosphorus	Total nitrogen
2017 04	**90**	**86**	**81**	**93**

The results have shown that during the treatment process the wastewater is treated efficiently. The efficiency of natural individual domestic wastewater treatment plant in Idźki-Wykno village in Poland is similar to efficiency of wastewater treatment plant in Gennarby in Finland..

The samples of groundwater were taken from a piezometer installed in the proximity of the denitrification pond [4] (Fig.3.5.1.5). The results were assessed by comparing them with the limit values set by polish Regulation of the Minister of Health of 13 November 2015 on the quality of water intended for human consumption. But on the other hand we know that groundwater is always very polluted and is not suitable for human consumption. However, it is allowed to use them, for example, for watering the garden. The results are provided in Table 3.5.1.4

3.5.1.4. Table. The ground water assessment results

Data	Limit value	**2017 04**
Fecal enterococcus MPN/100 ml	0	< 3
Coliformic bacteria MPN/100 ml	0	< 3
E.coli -bacteria MPN/100 ml	0	1100

The results confirm the thesis that groundwater is not suitable for human consumption due to microbiological contamination.

Figure 3.5.1.6. Groundwater sampling in Idźki-Wykno village in Sokoły municipality [own photo, 04.2017]

The soil samples for the quality assessment were taken in 4 different points. First two samples have been taken next to the vertical plant filter [3] and other two samples of soil have been taken next to the denitrification pond [4]. Sampling depth was 25 cm and 100 cm.

In Poland, there are no regulations on soil quality around the wastewater treatment plant. However, if we want to compare the results of analysis we can use research and guidelines of Institute of Soil Science and Plant Cultivation. State Research Institute (Table 3.5.1.5.)

Table 3.5.1.6. shows soil assessment results. Samples taken from every side of the absorption field in 4 different points at the depth of 25 cm.

Table 3.5.1.5. Nitrates nitrogen content in different categories of soil in autumn [Institute of Soil Science and Plant Cultivation. State Research Institute]

Argonomic category of the soil	$N\text{-}NO_3$ content in the 0-90 cm layer of the soil in kg N / ha				
	very low	low	average	high	very high
very light	< 26	27-42	43-59	60-85	>85
light	< 32	33-51	52-71	73-104	>104
avarage	< 37	38-48	59-81	82-119	>119
heavy	< 39	40-60	61-85	86-123	>123

Table 3.5.1.6. Samples tests results from 4 different points, taken at every side of the absorption field, at the depth of 25 cm

Data	Point 1	Point 2	Point 3	Point 4
Total phosphorus mg/kg	960	930	1000	1140
Soluble phosphorus mg/kg	16250	19695	17921	26899
Total nitrogen mg/kg	1560	1990	1830	1860
Soluble nitrogen mg/kg	43.33	17.67	34.3	17.58
Ammonia nitrogen mg/kg	11.91	6.57	8.11	5.15
Nitrates nitrogen mg/kg	122.08	14.48	8.2	7.78
Nitrites nitrogen mg/l	0.77	0.56	0.89	0.89
Sum of nitrate and nitrite nitrogen mg/l	36.52	11	4.91	5.05
Enterobacteria MPN/100 g	3	4	3	Not tested
Coliformic bacteria MPN/100 g	460000	1100	1100	Not tested
Escerichia coli bacterial MPN/100 g	11000	93	460	Not tested

Sampling points 1 and 2 were located next to the plant filter. Sampling points 3 and 4 were located next to the denitrification pond.

In point 1, concentrations of ammonium nitrogen, nitrates nitrogen, soluble nitrogen, Escerichia coli bacterial and Coliformic bacteria are the highest. In point 2, concentrations of total nitrogen and Enterobacteria are the highest. In point 3 and in point 4, concentration of nitrites nitrogen is the highest. Besides, in point 4 concentrations of total and soluble phosphorus are the highest.

The next Table 3.5.1.7. shows soil assessment results. Samples taken from every side of the absorption field in 4 different points at the depth of 100 cm. The location of sampling points is the same as above.

Table 3.5.1.7. Samples tests results from 4 different points, taken at every side of the absorption field, at the depth of 100 cm

Data	**Point 1**	**Point 2**	**Point 3**	**Point 4**
Total phosphorus mg/kg	610	640	650	830
Soluble phosphorus mg/kg	32355	25771	28326	66770
Total nitrogen mg/kg	490	490	340	480
Soluble nitrogen mg/kg	155.56	33.68	36.61	18.87
Ammonia nitrogen mg/kg	43.73	10.15	10.8	4.68
Nitrates nitrogen mg/kg	18.34	12.54	4.52	9.47
Nitrites nitrogen mg/l	0.95	0.73	0.41	1.12
Sum of nitrate and nitrite nitrogen mg/l	3.25	9.65	3.31	8.23
Enterobacteria MPN/100 g	3	23	< 3	3
Coliformic bacteria MPN/100 g	15000	1100	210	28
Escerichia coli bacterial MPN/100 g	210	460	150	210

In point 1, 100 cm deep – the highest concentrations of total nitrogen (equal to point 2), ammonium nitrogen, nitrates nitrogen, soluble nitrogen and Coliformic bacteria.

In point 2, 100 cm deep – the highest concentration amount of sum of nitrate and nitrite nitrogen and Enterobacteria.

In point 3, 100 cm deep – the lowest concentrations of total nitrogen, nitrates nitrogen, nitrites nitrogen, Enterobacteria and Escherichia coli bacteria.

In point 4, 100 cm deep – the highest concentrations of total and soluble phosphorus and nitrites nitrogen.

The sludge (Fig. 3.5.1.6) was taken from the sedimentation tank [1]. In Poland, there is the Regulation of the Minister of Environment of 13 November 2015 on municipal sewage sludge. In Poland, if you want to use the sludge as a fertilizer it is obligatory to test: Salmonella bacteria, the total number of live eggs of intestinal parasites Ascaris sp., Trichuris sp., Toxocara sp. In this project we tested the contents of other bacteria, so we couldn't compare our results. The results are provided in Table 3.5.1.8.

Table 3.5.1.8. Wastewater sludge assessment data

Data	The limit value	2017 06
EnterobacteriaMPN/100 m		110 000 l
Coliformic bacteria MPN/100 ml		2400000
Escherichia coli bacterial MPN/100 ml		46000

The results show that the microbiological contamination in the sludge is very high. Sewage sludge is collected by specialised companies and transported to the bigger wastewater treatment plants, where it undergoes further processing.

Figure 3.5.1.6. The sludge taken from the sedimentation tank [own photo, 04.2017]

3.5.2.Krynica Zdrój

The second pilot domestic wastewater treatment plants are located in the village of Słotwiny (Fig.3.5.2.2) in the municipality of Krynica-Zdrój (Fig.3.5.2.1). It is a mountain region in the south of Poland.

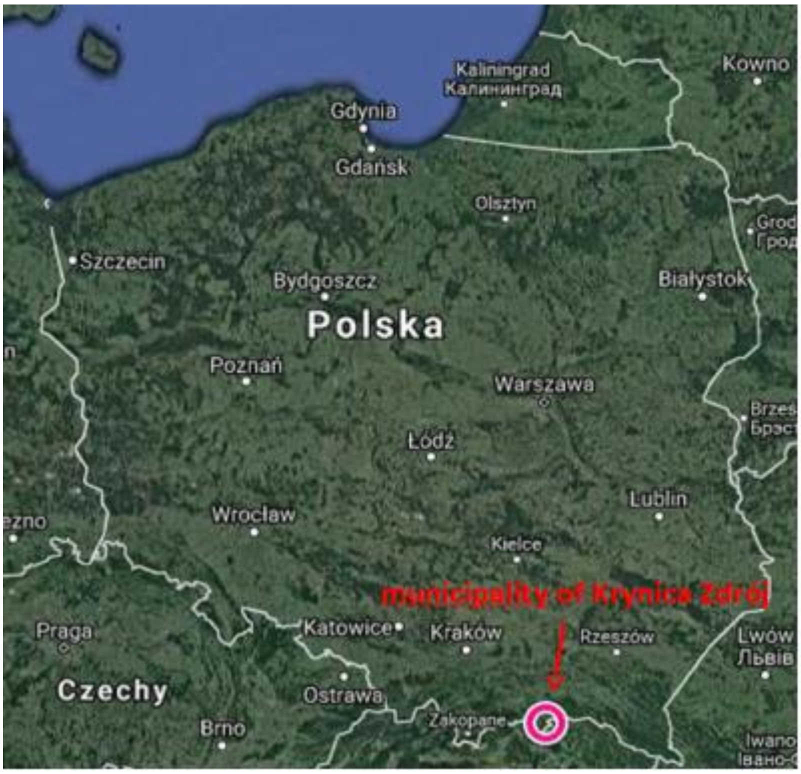


Figure 3.5.2.1. Municipality of Krynica-Zdrój in Poland

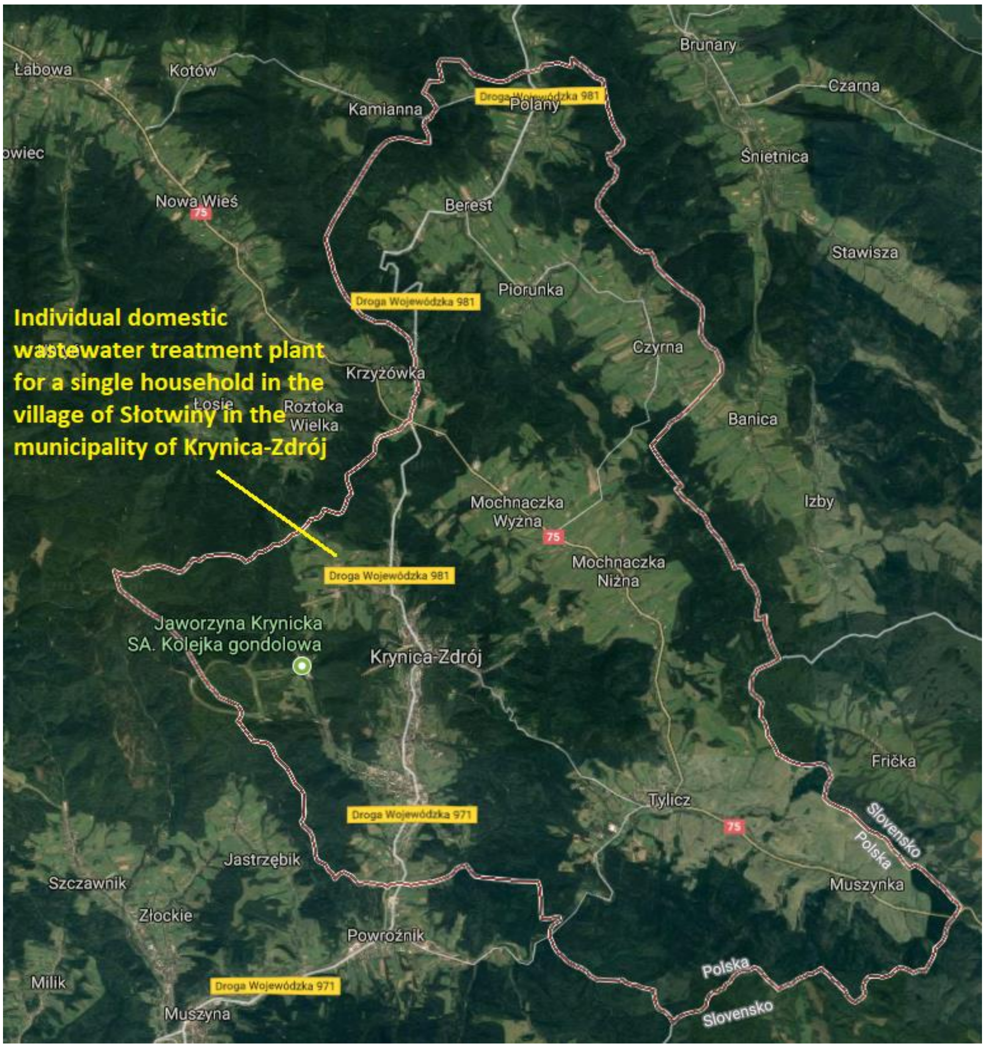


Figure 3.5.2.2. Individual domestic wastewater treatment plant in the village of Słotwiny in the municipality of Krynica-Zdrój in Poland

This pilot wastewater treatment technology was implemented by Institute of Technology and Life Sciences, and it consists of a slope soil-plant bed [4] and vertical flow trickling filter bed [3] (Fig.3.5.2.3).

Pre-treatment takes place in a three-chamber septic tank [1] with interchamber separation of floating and easily falling pollution. Sedimentation of suspended solids, anaerobic biochemical decomposition of organic matter, results in organic nitrogen ammonification and sulfur compounds formation. Then wastewater is pumping by pumping station [2] to the vertical trickling filter bed [3]. Biological wastewater treatment takes place in vertical flow trickling filter bed [3] filled with light expanded clay aggregates in a tight casing. That's where an intensive biochemical aerobic decomposition of organic wastewater pollutants (BOD_5, COD) and advanced nitrification of ammonium ions takes place. Tertiary treatment occurs in the horizontal flow slope soil-plant filter bed, which is a strip isolated from the ground. On this stage following processes occur: physical filtration of suspensions, mineralization of residues of organic matter (BOD_5, COD), nitrification and denitrification of nitrogen compounds as well as physical and chemical sorption with precipitation and immobilization of phosphorus compounds in the bed's mineral filling and rhizosphere. The final stage is an infiltration ditch [6].

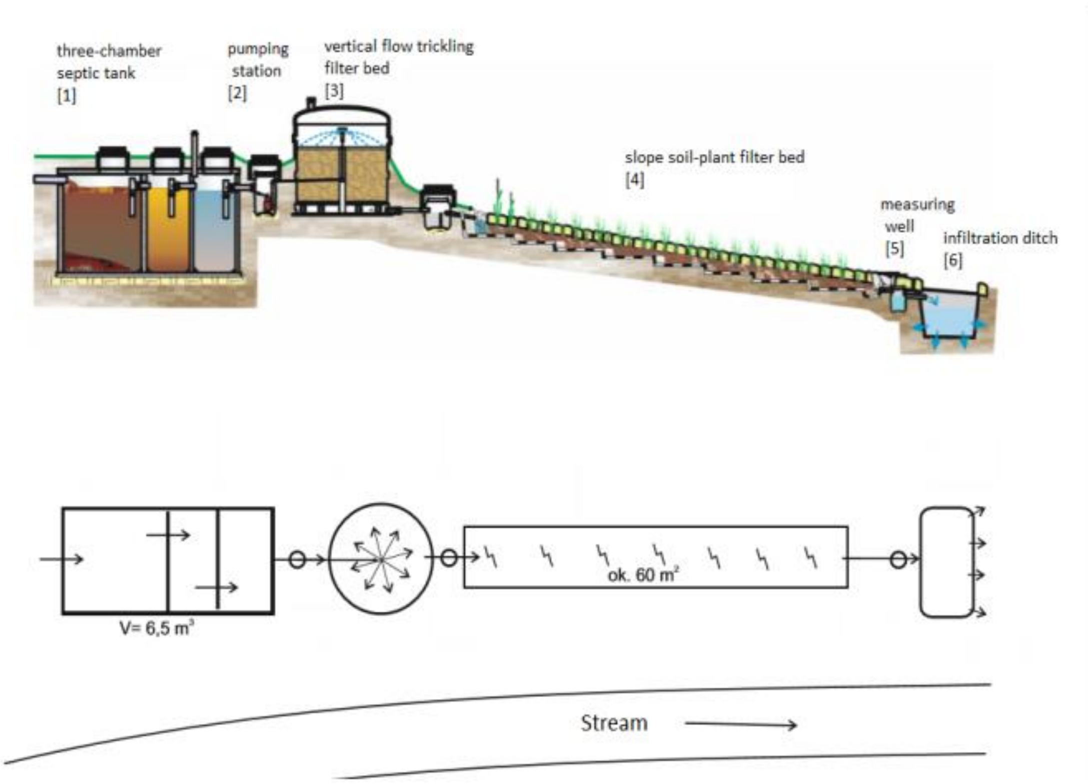


Fig.3.5.2.3. The scheme of the installed small individual domestic wastewater treatment plant for a single household in the Słotwiny village (Krynica-Zdrój municipality)

The wastewater treatment plant in Krynica-Zdrój municipality, same as wastewater treatment plant in Sokoły municipality, is small, individual and designed for a single household, so the same regulations are apply. The assessments were conducted in April 2017.

3.5.2.4.Figure. Poland. KryZdroj

The pollution of untreated wastewater has been assessed by identifying many parameters but only the BOD5, suspended solids and total flow in treated wastewater have limit values. It is the same situation as in the municipality of Sokoły. The samples of untreated wastewater were taken from the third chamber of the septic tank. The results are provided in Table 3.5.2.1.

Table 3.5.2.1. Assessment results of untreated wastewater coming from individual domestic wastewater treatment plant in Słotwiny village (Krynica-Zdrój municipality)

Data	Limit Values	2017 04
pH	Not regulated	7.51
Suspended solids, mg/l	Not regulated	25.2
BOD_5 mg/l O_2	Not regulated	180
Total phosphorus mg/l	Not regulated	8.4
Total nitrogen mg/l	Not regulated	76
Total flow m^3/d	Not regulated	0.463

Comparing the quality of untreated wastewater coming from household in Sokoły municipality and Krynica-Zdrój municipality you can notice that wastewater coming from household in Krynica-Zdrój is less polluted then wastewater coming from Sokoły municipality. Certainly, it depends on many factors.

The samples of treated wastewater were taken from a measuring well [5] located after the slope soil-plant filter bed [4]. The results are provided in Table 3.5.2.2.

Table 3.5.2.2. Assessment results of treated wastewater coming from individual domestic wastewater treatment plant in Słotwiny village (Krynica-Zdrój municipality)

Data	The limit value	2017 04
pH	Not regulated	6.87
Alkalinity mg/l $CaCO_3$	Not regulated	3.05
Suspended solids mg/l	Reduction at least 20%	3.4
BOD_5 mg/l O_2	Reduction at least 20%	3.5
Total phosphorus mg/l	Not regulated	2.4
Soluble phosphorus	Not regulated	2.39
Total nitrogen mg/l	Not regulated	< 10
Ammonia nitrogen mg/l	Not regulated	1.79
Nitrates nitrogen mg/l	Not regulated	3.1
Nitrites nitrogen mg/l	Not regulated	0.03
Sum of nitrate and nitrite nitrogen mg/l	Not regulated	3.127
Total aluminium	Not regulated	< 0.02
Total iron	Not regulated	0.19
Enterobacteria MPN/100 ml	Not regulated	1100
Coliformic bacteria MPN/100 ml	Not regulated	1100

Calculating the efficiency of wastewater treatment was used formula (Dauknys, 2007):

$$E(M) = \frac{M_o - M_1}{M_o} \times 100,\ \%$$

Here:

M_o - concentration untreated waste water, mg / l;
M_1 - the residual concentration in treated wastewater mg / l.

3.5.2.3. table. The efficiency of wastewater treatment in Krynica-Zdrój, %

Data	Suspended solids	BOD_5	Total phosphorus	Total nitro-gen
2017 04	69	82	67	51

The data provided in the table shows that the wastewater is treated sufficiently according to BOD5 and suspended solids. The requirements contained in Regulation of the Minister of the Environment from 18 November 2014 are fulfilled.

The groundwater quality was assessed in April 2017. The results were assessed by comparing them with the limit values, Regulation of the Minister of Health of 13 November 2015 on the quality of water intended for human consumption. But on the other hands we know that groundwater are always very polluted and they are not suitable for human consumption. However, it is allowed to use them, for example, to water the garden. The results are provided in Table 3.5.2.4

3.5.2. 4. Table. The ground water assessment results

Data	Limit value	**2017 04**
Fecal enterococcus MPN/100 ml	0	24
Coliformic bacteria MPN/100 ml	0	93
E.coli -bacteria MPN/100 ml	0	15

Contamination of groundwater is higher in Krynica-Zdrój wastewater treatment plant than Sokoły wastewater treatment plant regarding Fecal enterococcus and Coliformic bacteria but lower regarding E.coli-bacteria. The groundwater in this place is also not suitable for human consumption due to microbiological contamination.

The soil quality was assessed in 4 points. Two samples of soil have been taken next to the slope soil-plant bed and two samples of soil have been taken next to the infiltration ditch. Samples have been taken from a depth of 25 cm and 100 cm.

In Poland there is no regulation on soil quality around the wastewater treatment plant. However, if we want to compare the results of analysis we can use research and guidelines of Institute of Soil Science and Plant Cultivation. State Research Institute (Table 3.5.1.5.). Table 3.5.2.5. shows soil assessment results from every side of the absorption field, points 1-4, at25 cm depth.

Table 3.5.2.5. Samples tests results from 4 different points, taken at every side of the absorption field, at the depth of 25 cm

Data	**Point 1**	**Point 2**	**Point 3**	**Point 4**
	Next to the slope soil-plant bed		**Next to the infiltration ditch**	
Total phosphorus mg/kg	400	280	710	410
Soluble phosphorus mg/kg	0.66	0.16	2.078	0.376
Total nitrogen mg/kg	1390	740	2390	1540
Soluble nitrogen mg/kg	42.74	16.72	27.22	12.88
Ammonia nitrogen mg/kg	3.1	3.59	3.42	2.37
Nitrates nitrogen mg/kg	4.9	2.99	9.43	4.10
Nitrites nitrogen mg/l	0.51	0.58	0.64	0.53
Sum of nitrate and nitrite nitrogen mg/l	3.54	3.03	6.14	3.57
Enterobacteria MPN/100 g	240	240	240	15
Coliformic bacteria MPN/100 g	460	240	240	15
Escerichia coli bacterial MPN/100 g	240	43	43	21

The results show that the most polluted soil at a depth of 25 cm, regarding nitrogen and phosphorus components, was in the sample taken next to the infiltration ditch in point 3. The greatest bacterial contamination occurred in soil taken next to the slope soil-plant bed in point 1. Table 3.5.2.6. shows the soil assessment results from every side of the absorption field, points 1-4, at 100 cm depth.

Table 3.5.2.6. Samples tests results from 4 different points, taken at every side of the absorption field, at the depth of 100 cm

Data	**Point 1**	**Point 2**	**Point 3**	**Point 4**
	Next to the slope soil-plant bed		**Next to the infiltration ditch**	
Total phosphorus mg/kg	400	410	570	410
Soluble phosphorus mg/kg	0.32	0.686	1.130	0.376
Total nitrogen mg/kg	1260	500	1390	1540
Soluble nitrogen mg/kg	14.58	12.2	16.2	12.88
Ammonia nitrogen mg/kg	3.21	5.04	2.12	2.37
Nitrates nitrogen mg/kg	7.87	1.80	9.05	4.10
Nitrites nitrogen mg/l	0.77	0.40	0.35	0.53
Sum of nitrate and nitrite nitrogen mg/l	4.14	2.74	5.49	3.57
Enterobacteria MPN/100 g	150	210	43	15
Coliformic bacteria MPN/100 g	460	93	93	15
Escerichia coli bacterial MPN/100 g	23	93	93	21

The results show that the most polluted soil at a depth of 100 cm, regarding total phosphorus, soluble phosphorus, soluble nitrogen, nitrates nitrogen and sum of nitrate and nitrite nitrogen was in the sample taken next to the infiltration ditch in point 3. The greatest contamination of total nitrogen (1540 mg/kg) occurred in soil taken next to the infiltration ditch in point 4. The greatest amount of Coliformic bacteria (460 MPN/100 g) was detected in point 1. Enterobacteria occurred the most numerously at the point 2 and Escerichia coli bacterial occurred the most numerously at the points 2 and 3.

The sample of wastewater sludge was taken from the third chamber of the septic tank. The amounts of Enterobacteria, Coliformic bacteria and Escherichia coli bacterial, were checked, but as mentioned in the previous chapter in Poland, limit values exist only for other indicators. The results are provided in Table 3.5.2.7.

Table 3.5.2.7. Wastewater sludge assessment data

Data	The limit value	2017 04
Total phosphorus, mg/kg	limits for other indicators	7040
Soluble phosphorus, mg/kg		5.682
Total nitrogen, mg/kg		29680
Soluble nitrogen, mg/kg		2322.17
Ammonia nitrogen, mg/kg		156.49
Nitrates nitrogen mg/kg		8.47
Nitrites nitrogen mg/l		0.61
Sum of nitrate and nitrite nitrogen mg/l		2.31
Enterobacteria MPN/100 m		21000
Coliformic bacteria MPN/100 ml		110000
Escherichia coli bacterial MPN/100 ml		4600

The results show that the sludge in septic tank contains very high concentrations of total phosphorus, total nitrogen, soluble nitrogen, ammonia nitrogen and the bacterial contamination is very high. This indicates that sedimentation and fermentation processes occur in the settling tank.

4. Summary

Eutrophication of Baltic Sea has led to the serious environmental problems during the last century. One of the main contamination sources has been municipal wastewater, including wastewater from the small and scattered settlements. Sparsely populated areas are the third largest source of diffuse nutrient loads into the Baltic Sea.

In this work an enviro-hygienic (chemical and microbiological) assessment was done for the pilots of waste water treatment systems in the VillageWaters-project partner countries. There are two in two pilots in Estonia (Kolgaküla and Valkla), two in Finland (Gennarby and Nurmijärvi), two in Latvia (Svētciems and Ainaži), one Lithuania (Leitgiriai) and two in Poland (Krynica-Zdrój and Sokoly) where the technological changes will be conducted during the project. There wastewater, soil, sludge, soil, groundwater and surface water samples were taken to analyse some nutrients and microbial contamination from them. The aim was to find out a situation of waterborne emissions and other environmental impacts before and after the technological changes, respectively.

When this report was published, all participated organizations were different situations in their pilots. Some samples were taken and analyses started in Estonia, Finland, Lithuania and Poland. In addition, pilot constructions were done in Finland but others were starting it. This report includes only some data before the changes. Later on a second report will be published that covers also results after the changes.

Acknowledgement

We thank all participants in this work. The following people and organisations have participated in the data collection and analysis: In Estonia Tallinn University of Technology (TTÜ), in Finland Natural Resources Institute Finland (Luke) and the Association for Water and Environment or Western Uusimaa (LUVY), in Latvia Latvia University, in Lithuania Aleksandras Stulginskis University (ASU) and in Poland Institute of Technology and Life Sciences Branch in Warsaw.

Appendices

Appendix 1. Table a. Use – standard/test procedure and Methodology in different countries

Appendix 2. Table b. The limit values for EHA results established by national assessment documents.

Appendix 1. Table a. Use – standard/test procedure and Methodology in different countries

Indicator	Methodology	Use – standard/test procedure				
	Recommended by the project Village Waters	Poland	Lithuania	Finland	Estonia	Latvia
Wastewater inflow						
pH	EN ISO 10523:2012	EN ISO 10523:2012	LST EN ISO 10523:2012	EN ISO 10523:2012	EN ISO 10523:2012	LVS ISO 10523:2012
Suspended solids	EN 872:2005	PN-C-04559-02:1972 – old polish standard	LST EN 872:2005	EN 872:2005	EN 872:2005	LVS EN 872:2005
BOD_7/ BOD_5**	EN 1899-1:1998 or EN 1899-2:1998	PN-EN 1899-1:2002 – polish version**	LST EN 1899-1:2000	EN 1899-1:1998	EN 1899-1:1998	LVS EN 1899-2:1998**
Total phosphorus	EN ISO 15681-1:2004 or EN ISO 6878:2004	The method is analogous to EPA 365.2+3, APHA 4500-P E, and DIN EN ISO 6878.	LST EN ISO 15681-1:2005	EN ISO 6878:2004	EN ISO 6878:2004	LVS EN ISO 6878:2005, 7.nod.
Total nitrogen	EN 25663:1993 or EN ISO 11905-1:1998	The method is analogous to EN ISO 11905-1	LST EN 25663:2000	EN ISO 11905-1:1998	EN ISO 11905-1:1998	LVS EN ISO 11905-1:1998
Enterobacteria	CEN ISO/TS 29843-1:2014; CEN ISO/TS 29843-2:2014	Own methodology based on the litarature. Testing by use „the sampling method". The culture in test-tubes on the APB substarate. Incubation at 37°C for 24-48 h. Confirmation of positive results on the substrate of the sodium azide and ethyl violet. Incubation at 37 °C for 48 h.				LVS EN ISO 7899-2:2006
Coli-	EN ISO 9308-	Own methodology	EN ISO	EN ISO	EN ISO 9308-	LVS EN ISO

fomic bacteria	2:2014 or EN ISO 9308-3:1998, EN ISO 9308-3:1998/AC:2 000	based on the li-tarature. Testing by use „the fermentation sampling meth-od". The culture in test-tubes with Durham tubes on the Eijkman sub-starate. Incubation at 37°C for 24-48 h (control after 24 h). Confirmation of positive results on the Endo sub-strate. Incubation at 37 °C for 48 h.	9308-2:2014 00	9308-2:2014	2:2014	9308-2:2014
Total flow	-	Water meter. We read water con-sumption from the water meter in-stalled in the house.				
Wastewater outflow						
pH	EN ISO 10523:2012	EN ISO 10523:2012	LST EN ISO 10523:20 12	EN ISO 10523:20 12	EN ISO 10523:2012	LVS ISO 10523:201 2
Alkalini-ty	EN ISO 9963-1:1995 or EN ISO 9963-2:1995	The method is analogous to EN ISO 9963-1:1995	LST EN ISO 9963-1:1999	EN ISO 9963-2:1995	EN ISO 9963-2:1995	LVS ISO 9963-1:1995
Sus-pened solids	EN 872:2005	PN-C-04559-02:1972 – old polish stand-ard	LST EN 872:2005	EN 872:2005	EN 872:2005	LVS EN 872:2005
BOD_7/ BOD_5**	EN 1899-1:1998 or EN 1899-2:1998**	PN-EN 1899-1:2002 – polish version**	LST EN 1899-1:2000	EN 1899-2:1998	EN 1899-2:1998	LVS EN 1899-2:1998**
Total phos-phrus	EN ISO 15681-1:2004 or EN ISO 6878:2004	The method is analogous to EPA 365.2+3, APHA 4500-P E, and DIN EN ISO 6878.	LST EN ISO 15681-1:2005	EN ISO 15681-1:2004	EN ISO 15681-1:2004	LVS EN ISO 6878:2005, 7.nod.
Soluble phos-	EN ISO 10304-	The method is analogous to EN	LST EN ISO	EN ISO 10304-	EN ISO 10304-1:2009	LVS EN ISO 10304-

phorus	1:2009	ISO 10304-1:2009	10304-1:2009	1:2009		1:2009
Total nitro-gen	EN 25663:1993 or EN ISO 11905-1:1998	The method is analogous to EN ISO 11905-1	LST EN 25663:2000	EN ISO 11905-1:1998	EN ISO 11905-1:1998	LVS EN ISO 11905-1:1998
Ammo-nia ni-trogen	ISO 7150-1:1984	The method is analogous to EPA 350.1, APHA 4500-NH3 F, ISO 7150-1 and DIN 38406-5.	LST ISO 7150-1:1998	ISO 7150-1:1984	ISO 7150-1:1984	LVS EN ISO 11732-1: 2005
Nitrates nitro-gen	EN ISO 10304-1:2009 or EN ISO 13395:1996		LST EN ISO 10304-1:2009	EN ISO 10304-1:2009	EN ISO 10304-1:2009	LVS EN ISO 13395:1996
Nitrites nitro-gen	EN 26777:1993 or EN ISO 10304-1:2009 or EN ISO 13395:1996	The method is analogous to EPA 354.1, APHA 4500-NO2- B and DIN EN 26777.	LST EN 26777:1999 or LST EN ISO 13395:2000	EN 26777:1993 or EN ISO 10304-1:2009	EN 26777:1993 or EN ISO 10304-1:2009	LVS EN ISO 13395:1996
Sum of nitrate and nitrite nitro-gen	EN ISO 13395:1996	The sum of nitrate and nitrite nitro-gen determined above		EN ISO 13395:1996	EN ISO 13395:1996	LVS EN ISO 13395:1996
Total alumin-ium	EN ISO 12020:2000	The method is analogous to APHA 3500-Al-B and DIN ISO 10566 E30	LST EN ISO 12020:2000	EN ISO 10523:2012	EN ISO 10523:2012	LVS ISO 10566: 1994
Total iron	ISO 6332:1988		LST ISO 6332:1995	EN ISO 9963-1:1995 2:1995	EN ISO 9963-1:1995 2:1995	LVS ISO 6332:1988
Total flow		inflow and usually assume that out-flow is the same.)				
Surface waters						
Electri-cal con-ductivi-ty	EN 27888:1993	-	LST EN 27888:2002	SFS-EN 27888: 1994	EVS EN 27888:1999	LVS EN 27888: 1993

Faecal Entero-coccus	EN ISO 9308-2:2014 or EN ISO 9308-3:1998, EN ISO 9308-3:1998/AC:2000	-	LST EN ISO 7899-1+AC:2000	SFS-EN ISO 7899-2: 2000	EVS-EN ISO 7899-2:2002	LVS EN ISO 7899-1:2006 +AC L
Escrichia coli bacteri-al	EN ISO 9308-1:2014 or EN ISO 9308-2:2014	-	LST EN ISO 9308-1:2014	ISO 9308-2:2012	EVS-EN ISO 9308-1:2014	LVS EN ISO 9308-1:2001 or LVS ISO 9308-2:2014
Total phos-phorus	EN ISO 15681-1:2004 or EN ISO 6878:2004	-	LST EN ISO 15681-1:2005		EVS-EN ISO 6878:2004	LVS EN ISO 6878:2005 part 7.
Soluble phos-phorus	EN ISO 10304-1:2009	-	LST EN ISO 10304-1:2009		EVS-EN ISO 6878:2004	
Total nitro-gen	EN 25663:1993 or EN ISO 11905-1:1998	-	LST EN 25663:2000		EVS-EN ISO 11905-1:2003	
Soluble nitro-gen		-	LST ISO 7150-1:1998			
Ammo-nia ni-trogen	ISO 7150-1:1984	-	LST EN ISO 10304-1:2009		SFS 3032	LVSE N ISO1 1732:2005
Nitrates nitro-gen	EN ISO 10304-1:2009 or EN ISO 13395:1996	-	LST EN 26777:1999 or LST EN ISO 13395:2000		EVS-EN ISO 13395:1999	
Nitrites nitro-gen	EN 26777:1993 or EN ISO 10304-1:2009 or EN ISO 13395:1996	-	LST EN ISO 15681-1:2005		SFS 3029	LVS ISO 6777:1984
Sum of nitrate and nitrite	EN ISO 13395:1996	-			EVS-EN ISO 13395:1999	

nitro-gen						
Groundwater						
Enterobacteria	CEN ISO/TS 29843-1:2014; CEN ISO/TS 29843-2:2014	Own methodology based on the litarature. Testing by use „the sampling method”. The culture in test-tubes on the APB substarate. Incubation at 37°C for 24-48 h. Confirmation of positive results on the substrate of the sodium azide and ethyl violet. Incubation at 37 °C for 48 h.	LST CEN ISO/TS 29843-1:2014; LST CEN ISO/TS 29843-2:2014	SFS-EN ISO 7899-2:2000 (TL64)		
Coliformic bacteria	EN ISO 9308-2:2014 or EN ISO 9308-3:1998, EN ISO 9308-3:1998/AC:2000	Own methodology based on the literature. Testing by use „the fermentation sampling method”. The culture in test-tubes with Durham tubes on the Eijkman substrate. Incubation at 37°C for 24-48 h (control after 24 h). Confirmation of positive results on the Endo substrate. Incubation at 37 °C for 48 h.	LST EN ISO 9308-3+AC:2000	SFS 3016:2011 (TL64)	EVS-EN ISO 9308-1:2014	
Fecal Enterococcus	EN ISO 9308-2:2014 or EN ISO 9308-3:1998, EN ISO 9308-3:1998/AC:2000	Own methodology based on the liter-ature. Testing by use „the fermentation sampling meth-od“. The culture in test-tubes with Durham tubes on the Eijkman sub-	LST EN ISO 7899-1+AC:2000	SFS 4088: 2001 adapted (TL64)	EVS-EN ISO 7899-2:2002	

		strate. Incubation at 44°C for 24-48 h (control after 24 h). Confirmation of positive results on the Endo sub-strate. Incubation for 24 h (the pres-ence of Fecal En-terococcus and suspected Esche-richia coli). If the result is positive confirmation of belonging to E. Coli by Kovac's reagent on trypto-phan broth. Incu-bation at 44°C for 24 h.				
Soil						
Enterob acteria	CEN ISO/TS 29843-1:2014; CEN ISO/TS 29843-2:2014	Own methodology based on the literature. Testing by use „the sampling method”. The culture in test-tubes on the APB substrate. Incubation at 37°C for 24-48 h. Confirmation of positive results on the substrate of the sodium azide and ethyl violet. Incubation at 37 °C for 48 h.	-			
Colifor mic bacteria	CEN ISO/TS 29843-1:2014; CEN ISO/TS 29843-2:2015	Own methodology based on the literature. Testing by use „the fermentation sampling method”. The culture in test-tubes with Durham tubes on the Eijkman substrate. Incubation at 37°C for 24-48 h (control after 24	-			

		h). Confirmation of positive results on the Endo substrate. Incubation at 37 °C for 48 h.				
Escherichia coli bacteria	CEN ISO/TS 29843-1:2014; CEN ISO/TS 29843-2:2016	Own methodology based on the literature. Testing by use „the fermentation sampling method“. The culture in test-tubes with Durham tubes on the Eijkman substrate. Incubation at 44°C for 24-48 h (control after 24 h). Confirmation of positive results on the Endo substrate. Incubation for 24 h (the presence of Fecal Enterococcus and suspected Escherichia coli). If the result is positive confirmation of belonging to E. Coli by Kovac's reagent on tryptophan broth. Incubation at 44°C for 24 h				
Total phosphorus	EN ISO 15681-1:2004 or EN ISO 6878:2004	PB/31/02:2014.	-			
Soluble phosphorus	EN ISO 10304-1:2009	PN-EN 13652:2002	-			
Total nitrogen	EN 25663:1993 or EN ISO 11905-1:1998	PB/31/03:2014	-			
Soluble nitro-		PN-EN 14255: 2001.	-			

gen						
Ammonia nitrogen	ISO 7150-1:1984	PN-EN 14255: 2001.	-			
Nitrates nitrogen	EN ISO 10304-1:2009 or EN ISO 13395:1996	PN-EN 14255: 2001.	-			
Nitrites nitrogen	EN 26777:1993 or EN ISO 10304-1:2009 or EN ISO 13395:1996	PN-ISO 14256:2:2010.	-			
Sum of nitrate and nitrite nitrogen	EN ISO 13395:1996	PN-EN 14255: 2001.	-			
Sludge						
Total phosphorus	EN ISO 15681-1:2004 or EN ISO 6878:2004	PB/31/02:2014.	EN ISO 15681-1:2004			
Soluble phosphorus	EN ISO 10304-1:2009	PN-EN 13652:2002	EN ISO 10304-1:2009			
Total nitrogen	EN 25663:1993 or EN ISO 11905-1:1998	PB/31/03:2014	EN ISO 11905-1:1998			
Soluble nitrogen		PN-EN 14255: 2001.				
Ammonia nitrogen	ISO 7150-1:1984	PN-EN 14255: 2001.	ISO 7150-1:1984			
Nitrates nitrogen	EN ISO 10304-1:2009 or EN ISO 13395:1996	PN-EN 14255: 2001.	EN ISO 10304-1:2009			
Nitrites nitrogen	EN 26777:1993 or EN ISO 10304-	PN-ISO 14256:2:2010.	EN ISO 10304-1:2009			

	1:2009 or EN ISO 13395:1996					
Sum of nitrate and nitrite nitro-gen	EN ISO 13395:1996	PN-EN 14255: 2001.	EN ISO 13395:19 96			
Entero-bacteria	CEN ISO/TS 29843-1:2014; CEN ISO/TS 29843-2:2014	Own methodology based on the literature. Testing by use „the sampling method". The culture in test-tubes on the APB substrate. Incubation at 37°C for 24-48 h. Confirmation of positive results on the substrate of the sodium azide and ethyl violet. Incubation at 37 °C for 48 h.	LST CEN ISO/TS 29843-1:2014; LST CEN ISO/TS 29843-2:2014			
Coli-formic bacteria	CEN ISO/TS 29843-1:2014; CEN ISO/TS 29843-2:2015	Own methodology based on the literature. Testing by use „the fermentation sampling method". The culture in test-tubes with Durham tubes on the Eijkman substrate. Incubation at 37°C for 24-48 h (control after 24 h). Confirmation of positive results on the Endo substrate. Incubation at 37 °C for 48 h.	LST CEN ISO/TS 29843-1:2014; LST CEN ISO/TS 29843-2:2015			
Esche-richia coli bacteri-al	CEN ISO/TS 29843-1:2014; CEN ISO/TS 29843-	Own methodology based on the literature. Testing by use „the fermentation	LST CEN ISO/TS 29843-1:2014; LST CEN			

	2:2016	sampling method“. The culture in test-tubes with Durham tubes on the Eijkman substrate. Incubation at 44°C for 24-48 h (control after 24 h). Confirmation of positive results on the Endo substrate. Incubation for 24 h (the presence of Fecal Enterococcus and suspected Escherichia coli). If the result is positive confirmation of belonging to E. Coli by Kovac's reagent on tryptophan broth. Incubation at 44°C for 24 h	ISO/TS 29843-2:2016			

Appendix 2. Table b. The limit values for EHA results established by national assessment documents.

2.1.2. Table. Assesment documents

Wastewater inflow					
	Poland	**Lithuania**	**Finland**	**Estonia**	**Latvia**
National document	Regulation of the Minister of the Environment from 18 November 2014 on the conditions to be met for the discharge of sewage into water or soil and on substances particularly harmful for the water environment	Wastewater Management Regulation. 2008	Legislation for <100 p.e. wastewater treatment plants: Change of the environmental protection act 19/2017 and Government Decree on Treating Domestic Wastewater in Areas Outside Sewer Networks (157/2017). According the environmental protection act 527/2014 an environmental permit is required in case when wastewater treatment plant treats at least 100 person's wastewater. Limit values for reduction and for outflows concentrations are defined in environmental permits. Also Governmet Decree on Urban Waste Water Treatment	Government Regulation no 99 on Wastewater and Stormwater Effluent Requirements, Pollution Parameters Compliance Limits and the Control Measures, 2012	Cabinet of Ministers Regulation No. 34 "Regulations Regarding Discharge of Polluting Substances into Water"; 22.01.2002

			888/2006, concerns wastewater treatment plants that have an environmental permit.		
The limit value					
	Poland	**Lithuania**	**Finland**	**Estonia**	**Latvia**
pH	Not regulated	6,5- 9,5	Not regulated	6-9	Not regulated
Suspended solids	Not regulated	Not regulated	Not regulated	300–1999 PE: 35 mg/l; 70 % reduction 2000–9999 PE: 25 mg/l; 80 % reduction 10 000–99 999 PE: 15 mg/l; 90 % reduction 100 000 PE and >: 15 mg/l; 90 % reduction	Not regulated
BOD_7/ BOD_5**	Not regulated	800 mg/l O^2	Not regulated	300–1999 PE: 25 mg/l; 70 % reduction 2000–9999 PE: 15 mg/l; 80 % reduction 10 000–99 999 PE: 15 mg/l; 80 % reduction 100 000 PE and >: 15 mg/l; 80 % reduction	Not regulated
Total phosporus	Not regulated	Not regulated	Not regulated	300–1999 PE: 2 mg/l; 70 % reduction 2000–9999 PE: 1 mg/l; 80 % reduction 10 000–99 999 PE: 0,5 mg/l; 90 % reduction 100 000 PE and >: 0,5 mg/l; 90 % reduction	Not regulated
Total nitrogen	Not regulated	Not regulated	Not regulated	300–1999 PE: 60 mg/l; 30 % reduction	Not regulated

				2000–9999 PE: 45 mg/l; 30 % reduction 10 000–99 999 PE: 15 mg/l; 80 % reduction 100 000 PE and >: 10 mg/l; 80 % reduction	
Enterobac-teria	Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
Coliformic bacteria	Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
Total flow					
Wastewater outflow					
	Poland	**Lithuania**	**Finland**	**Estonia**	**Latvia**
pH	Not regulated	6,5-8,5	Not regulated	6 - 9	Not regulated
Alkalinity	Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
Suspended solids	50 mg/l	Not regulated	<100 p.e. not regulated, ≥100 p.e. 35 mg/l or reduc-tion 90 %.	35 mg/l	less than 35 mg/l; 90% re-duction of pollu-tion
BOD_7/ BOD_5**	40 mgO_2/l**	<2000 p.e., Av-erage daily limit value 29 mg/l O_2	<100 p.e. 80 % min reduction, recommended 90 %. ≥100 p.e. 10-15 mg O_2/l & reduction 90-95 %.	40 mgO_2/l	< 200 PE: ap-propriate treat-ment; 200–1999 PE: appropriate treatment; 2000–9999 PE: 25 mg/l; > 10 000 PE: 25 mg/l**
Total phosporus	5	< 1 0000 p.e., 2 mgP/l	<100 p.e. 70 % min reduction, recommended 85% . ≥100 p.e. 0,30-1,0 mg P/l & reduction 90-95 %.	Not regulated	< 200 PE: ap-propriate treat-ment, no limits; 200–1999 PE: appropriate treatment, 10–15% reduction of pollution; 2000–9999 PE: 2 mg/l, 80% re-duction of pollu-tion; > 10 000 PE: 1 mg/l, 80% reduction of pollution
Soluble phospho-rus	Not regulated	Not regulated	Not regulated	Not regulated	Not regulated

Total nitrogen	30 mg/l	< 1 0000 p.e., 20 mgN/l	<100 p.e. 30 % min reduction, recommended 40% . 10 000-100 000 p.e. 15 mg/l or reduction 70 %, over 100 000 p.e. 10 mg/l.	Not regulated	< 200 PE: appropriate treatment, no limits; 200–1999 PE: appropriate treatment, 10–15% reduction of pollution; 2000–9999 PE: 15 mg/l, 70–80% reduction of pollution; > 10 000 PE: 10 mg/l, 70–80% reduction of pollution
Ammonia nitrogen	10,0 - 20,0 mg/l	5 mg/l	<100 p.e. Not regulated. ≥100 p.e. not regulated – 4 mg/l & reduction 90-95 %	Not regulated	Not regulated
Nitrates nitrogen	30 mg/l	23 mg/l	Not regulated	Not regulated	Not regulated
Nitrites nitrogen	1 mg/l	0,45 mg/l	Not regulated	Not regulated	Not regulated
Sum of nitrate and nitrite nitrogen	Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
Total aluminium	3 mg/l	0,5 mg/l	Not regulated	Not regulated	Not regulated
Total iron	10 mg/l	Not regulated	Not regulated	Not regulated	Not regulated
Total flow					
Surface waters					
	Poland	**Lithuania**	**Finland**	**Estonia**	**Latvia**
National document		Procedure for determining of the status of surface water quality. 2010	The Ministry of Social Affairs and Health's decree on water quality requirements and supervision at public beaches (177/2008)	Minister of the Environment Regulation no. 44 of 28 July 2009, "Procedures for establishing surface water bodies, list of surface water bodies	Cabinet of Ministers Regulation No. 118 "Regulations regarding the Quality of Surface Waters and Groundwater"; 12.03.2002 (1); Cabinet of Ministers Regu-

				whose status class is to be determined, status classes for surface water bodies and procedures for determining quality(II class or GOOD class limit value)	lation No 608 “Regulations Regarding Monitoring of Bathing Water, Quality Assurance and Requirements for Informing the Public”; 06.07. 2010 (2); Cabinet of Ministers Regulation No. 834 “Regulation Regarding Protection of Water and Soil from Pollution with Nitrates Caused by Agricultural Activity”; 23.12.2014 (3)
The limit value					
Electrical conductivity		Not regulated	Not regulated	Not regulated	Not regulated
Faecal Enterococcus		Not regulated	400 pmy/mpn/100 ml	Not regulated	CFU/100 ml/100 for bathing waters (2)
Escherichia coli bacterial		Not regulated	1000 pmy/mpn/100 ml	Not regulated	CFU/100 ml/2000 for bathing waters (2)
Temperature, °C		0,1-0,14 mg/l	Not regulated	Not regulated	After outlet do not exeed 1,5 °C for salmonid waters, 3 °C – for cyprinid waters (1)
Total phosphorus		Not regulated	Not regulated	0,08 mg/l	Do not exceed 50 mg/l in waters of vulnarable zone (3)
Soluble phosphorus		<3,0 mg/l	Not regulated	Not regulated	Not regulated
Total nitrogen		Not regulated	Not regulated	3 mg/l	Not regulated
Soluble nitrogen		<0,2 mg/l	Not regulated	Not regulated	Not regulated
Ammonia		<2,3 mg/l	Not regulated	0,3 mg/l	≤ 0,78 for salm-

nitrogen					onid and cyprinid waters (1)
Nitrates nitrogen		Not regulated	Not regulated	Not regulated	Not regulated
Nitrites nitrogen		Not regulated	Not regulated	Not regulated	≤ 0,01 for salmonid waters; ≤ 0,03 for cyprinid waters (1)
Sum of nitrate and nitrite nitrogen		Not regulated	Not regulated	Not regulated	Not regulated
Groundwater					
	Poland	**Lithuania**	**Finland**	**Estonia**	**Latvia**
National document	Regulation of the Minister of Health of 13 November 2015 on the quality of water intended for human consumption	Drinking water safety and quality requirements. Hygiene Standard HN 24:2003	Decree of the Ministry of Social. Affairs and Health Relating to the Quality and Monitoring of Water Intended for Human Consumption (1352/2015)	Social Minister Regulation nr 82 on Drinking Water Quality and Control Requirements and Analysis Methods	Cabinet of Ministers Regulation No. 118 “Regulations regarding the Quality of Surface Waters and Groundwater”; 12.03.2002 – defines quality requirements for groundwater used for water abstraction (1); Cabinet of Ministers Regulation No. 42 “Regulations Regarding Procedures for Ascertaining of Groundwater Resources and Quality Criteria”; 13.01.2009 (2)
The limit value					
Enterobacteria	0	0	0	0	Not regulated
Coliformic bacteria	0	0	0	0	Not regulated
Fecal Enterococcus	0	0	0	0	Not regulated
Soil					
	Poland	**Lithuania**	**Finland**	**Estonia**	**Latvia**
National document	Research and guidelines of Instytute of Soil		http://www.finlex.fi/en/laki/kaan-	Government Regulation no 99 on	Cabinet of Ministers Regulation No. 804 “Regu-

	Science and Plant Cultivation. State Research Instytute (Table 1).		nokset/2007/en20070214.pdf	Wastewater and Stormwater Effluent Requirements, Pollution Parameters Compliance Limits and the Control Measures, 2012 (WW outlet into the soil)	lations on Soil and Sand Ground Quality Standards; Rīgā 25.10.2005
The limit value					
Enterobacteria	Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
Califormic bacteria	Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
Escherichia coli bacteria	Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
Total phosphorus	Not regulated	Not regulated	Not regulated	Not regulated	
Soluble phosphorus	Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
Total nitrogen	Not regulated	Not regulated	Not regulated	Not regulated	
Soluble nitrogen	Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
Ammonia nitrogen	Not regulated	Not regulated	Not regulated	Not regulated	
Nitrates nitrogen	$N\text{-}NO_3$ content from < 26 to > 123 in 0-90 cm layer of the soil in kg N / ha.	Not regulated	Not regulated	Into the karstic lake 45 mg/l	
Nitrites nitrogen	Not regulated	Not regulated	Not regulated	Into the karstic lake 0,1 mg/l	
Sum of nitrate and nitrite nitrogen	Not regulated	Not regulated	Not regulated	Not regulated	
Sludge					
	Poland	**Lithuania**	**Finland**	**Estonia**	**Latvia**
National document	Regulation of the Minister of Environment of 13 November 2015 on municipal sewage sluge. It is	Requirements for use of sewage sludge for fertilization LAND 20-2001	The government decree on limiting certain emissions from agriculture and horticulture,	Environment Minister Regulation nr 78 on Sewage sludge in agriculture, landscaping and	Cabinet of Ministers Regulation No. 362 “Regulations Regarding Utilisation, Monitoring and

	obligatory to test: Salmonella bacteria, the total number of live eggs of intestinal parasites Ascaris sp., Trichuris sp., Toxocara sp		"nitrates decree" (1250/2014) and The Decree of the Ministry of Agriculture and Forestry on Fertiliser Products 24/11	recultivation requirements for use	Control of Sewage Sludge and the Compost thereof"; 02.05.2006
Total phosphorus	Not regulated	Not regulated	Not regulated	Not regulated	40 kg/ha annually for agricultural lands
Soluble phosphorus	Not regulated	Not regulated	400 kg/ha/5y agriculture, 600 kg/ha/5y horticulture	Not regulated	Not regulated
Total nitrogen	Not regulated	Not regulated	Animal manure may be applied on a field as fertilizer equivalent to up to 170 kg/ha/year of nitrogen.	Not more than 1 helminth egg per 10 gram of treated sludge wet weight	Not regulated
Soluble nitrogen	Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
Ammonia nitrogen	Not regulated	Not regulated	Not regulated	Not regulated	30 kg/ha annually for agricultural lands
Nitrates nitrogen	Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
Nitrites nitrogen	Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
Sum of nitrate and nitrite nitrogen	Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
Enterobacteria	Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
Coliformic bacteria	Not regulated	Not regulated	Not regulated	Not regulated	Not regulated
Escherichia coli bacterial	Not regulated	**<= 1000**	*"Not detected 25g sample 1000 cfu/g" "	Escherichia coli of less than 1000 cfu per gram of treated sludge wet weight;	Not regulated
			*'Residual sludge, whether treated or untreated, from urban waste		

			water treat-ment plants, may not be discharged into waterways (Government Decree on Ur-ban Waste Wa-ter Treatment 888/2006)"		

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