COMPLIANCE OF WASTEWATER TREATMENT PLANTS IN JÄRVA COUNTY WITH THE EU URBAN WASTEWATER TREATMENT DIRECTIVE AND ESTONIAN NATIONAL REQUIREMENTS

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Abstract:

The aim of this study was to assess the treatment efficiency conformity of Wastewater Treatment Plants to the Estonian and European Union requirements in the area of Estonian nitrate vulnerable zone as well as evaluate the existing national wastewater monitoring programme and the efficiency of the self-monitoring programme. Monitoring the results and total pollution load of effluent discharged to the receiving water body from 2007 to 2008 are used to assess the treatment level of WWTPs and the need to establish higher treatment requirements. Estonian national standards, due to the fact that Estonian water bodies are small and vulnerable to pollution, are stricter than the Urban Wastewater Treatment Directive (UWWTD) requirements. If the requirements given in UWWTD are not sufficient to achieve a good status for water bodies, it is proven that wastewater discharge adversely affects the receiving water body and this discharge is one of the important point-pollution sources for water bodies, additional stricter wastewater treatment requirements are needed. WWTPs with a more than a 2,000 population equivalent (p.e.) should be regulated vigorously to guarantee their compliance with the requirements, because WWTPs with more than 2,000 p.e. count for 80% of the total pollution load. A pollution load from WWTPs of less than 2,000 p.e. on the receiving water bodies is marginal; however, the extent of the impact of each individual WWTP depends on, among other things, the characteristics of the wastewater, the turbulence of the receiving water body and the area's sensitivity as well as other pressure sources.

Key Words: Wastewater treatment, pollution load, effluent, receiving water body

Introduction

In Estonia, Järvamaa is one of the three counties that is designated a nitrate vulnerable zone according to European Nitrates Directive (European Community (EC), 1991/1). According to Regulation no. 17 of the Estonian Government, 2003, there is one nitrate vulnerable zone consisting of two subareas – Pandivere and Adavere-Põltsamaa. In Estonia, the rivers of almost all catchment areas (excl. the islands) spring from the slopes of the Pandivere Upland karst area (Environmental Report 7, 1993). In a nitrate vulnerable zone, all water bodies are highly affected by the non-point sources from agriculture and are also easily influenced by point sources from wastewater treatment plants (WWTPs) (Valdmaa et al., 2008). It is important to control the nutrient load, particularly phosphorus pollution, even that of small settlements within agricultural and rural catchments (Jarvie et al., 2006; Iital et al., 2010). Therefore, WWTPs have to comply with the discharge requirements established by both the Urban Wastewater Treatment Directive (UWWTD) and the Estonian national standards (ENS). The European Union integrated water policy main document, which establishes a framework for EU actions in the field of water policy – Water Framework Directive (WFD), sets a goal to protect all waters against pollution and to achieve good status for all waters, promoting sustainable water and wastewater management (European Community (EC), 2000; Ministry of Environment, 2011). One of the most important surface water pressures is point-source pollution (IMPRESS, 2002). Furthermore, the Baltic Sea countries adopted an action plan to achieve the good ecological status of the Baltic Sea by 2021 (Helcom, 2007). One of the main issues covered by the Baltic Sea Action Plan is the further reduction of nutrient inputs in order to limit the eutrophication of water bodies. Estonian water bodies are sensitive to nutrients and have a high eutrophication risk. To limit the eutrophication process, it is important to decrease total phosphorous (TP) and total nitrogen (TN) loads. Several studies have researched the impact of WWTPs on receiving water bodies (Kontas et al., 2004; Millier et al., 2011; Dickenson et al., 2011). For instance, Kontas et al. (2004) studied the concentrations of inorganic nutrients, phytoplankton chlorophyll-α, and N/P ratios before and after the treatment plant. Dickenson et al. (2011) has reported on the presence of trace organic chemicals in municipal wastewater effluents. This paper uses a set of common trace organic chemicals as indicators to assess the degree of impact and attenuation of trace organic chemicals in receiving streams. Also, other Baltic countries are considering the problem of phosphorus and nitrogen removal from wastewater and, therefore, several studies have investigated the different methods of removing nutrients from wastewater. One such study, Vaboliené et al. (2007), evaluated the effect of biological nitrogen removal from wastewater on biological phosphorus removal, and Dauknys et al. (2009) analysed the influence of substrate on the biological removal of phosphorus. These studies use the results of only a few WWTPs and these analyses do not assess the cumulative impact of effluent from all regional WWTPs on receiving water bodies. This study attempts to check the compliance to the established WWTPs requirements for different sized WWTPs in Järva County and assesses the cumulative impact on receiving water bodies. Drawing from study results and taking into account the pollution load and impact on receiving water bodies, it is possible to assess the compatibility of the validated wastewater requirements in Estonia. The monitoring data of WWTPs in Järva County were compared with the requirements set by both UWWTD and ENS. ENS is based on the regulation of the Estonian Government (Government of Estonia, 2001) and water permit requirements (Ministry of the Environment, 2009/2). A further task was to estimate and compare existing national wastewater monitoring and the self-monitoring results and efficiency of WWTPs as well as make proposals to improve monitoring programmes and recommendations to change legislation. These programmes should help to evaluate the wastewater impact on the recipient and the operating efficiency of WWTPs.

Methodology for Compliance Check

The monitoring results were based on control sampling conducted by environmental authorities from 2007 to 2008. The total pollution load is calculated using monitoring results and the National Environmental Register (Ministry of the Environment, 2009/1) to get real flow rate of WWTP effluent. 154 samples from Järvamaa WWTP effluents were taken and analysed for biochemical oxygen demand (BOD_7), suspended solids (SS), TN, TP and chemical oxygen demand (COD) concentrations by the Environmental Research Centre of Estonia. The UWWTD only set limit values for WWTPs with a pollution load more than 2,000 p.e. because it aims to establish minimum treatment requirements (European Community (EC), 1991/2). The effluent limit values for WWTPs with a pollution load less than 2,000 p.e. were not regulated by these requirements. Separate criteria are used to assess the compliance of these WWTPs with the requirements. The common limit values given in the permits for the special use of water (Ministry of the Environment, 2009/2) for establishing the criteria for WWTPs with a pollution load less than 2,000 p.e. were used. Both UWWTD requirements and ENS are listed in Table 1 and 2, respectively.

Table 1. Criteria for the assessment of compliance with the UWWTD requirements

Pollution indicator	Limit values, mg/l			
	<2,000 p.e.*	2,000-9,999 p.e.	10,000-99,999 p.e.	≥100,000 p.e.
BOD_7	25	25	25	25
COD	125	125	125	125
SS	35	35	35	35
TP	-	-	2	1
TN	-	-	15	10

* The Urban Wastewater Treatment Directive does not establish common criteria and only requires an appropriate treatment level. These criteria are developed by taking into account the aim of the directives and requirements given in the permits for the special use of water.

Table 2. Criteria for the assessment of compliance with the ENS

Pollution indicator	Limit values, mg/l				
	<500 p.e.*	500-1,999 p.e.*	2,000-9,999 p.e.	10,000-99,999 p.e.	≥100,000 p.e.
BOD_7	25	25	15	15	15
COD	125	125	125	125	125
SS	25	25	25	15	15
TP	-	2	1.5	1	1
TN	-	-	-	15	10

* Estonia do not establish common standards. These criteria are developed by taking into account the aim of the directives and requirements given in the permits for the special use of water.

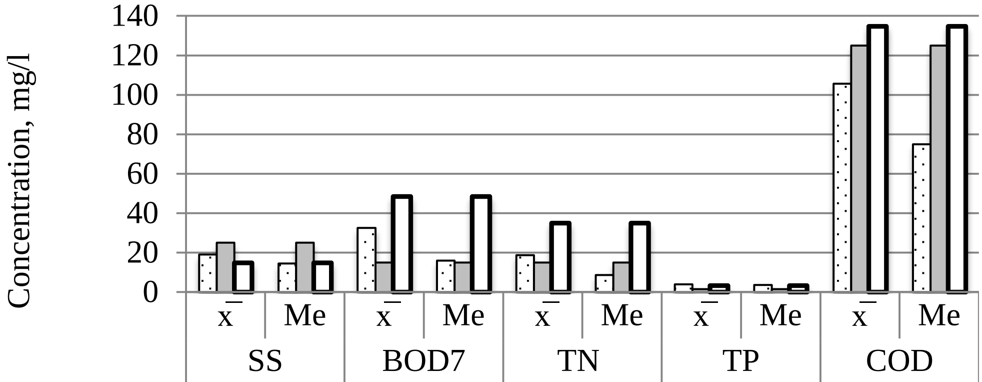
When comparing Table 2 with Table 1, two major differences can be found: 1) ENS regulates BOD_7, COD and SS for WWTPs with a pollution load from 0 p.e. to 500 p.e. and, additionally, TP from 500 to 1,999 p.e. 2) For WWTPs with a pollution load greater than 2,000, the ENS for BOD_7, SS, and TP, are 40%, 57%, and 100% higher than the UWWTD requirements, respectively.

The compliance check of WWTPs to the UWWTD requirements is only made for those WWTPs that fall within the scope of the directive. Because the UWWTD does not establish uniform requirements to be achieved for agglomerations with a pollution load of less than 2,000 p.e, requiring only an appropriate treatment level, the limit values for this study are set to achieve the good status of water bodies required by the WFD. The requirements for WWTPs with a pollution load less than 2,000 p.e. must be proportionate to the requirements for WWTPs with a pollution load more than 2,000 p.e.. Also, the requirements must comply with environmental protection objectives. The limit values for WWTPs with a pollution load less than 2,000 p.e. are given for BOD_7, COD and SS. A TN and TP removal requirement is given only for the WWTPs with a pollution load of more than 10,000 p.e. that discharge the effluent to the pollution sensitive water body according to the UWWTD. Since the whole territory of Estonia is designated as a pollution sensitive area, the criteria also demand TP and TN removal for WWTPs with a pollution load more than 10,000 p.e., as set by the UWWTD in Table 1.

To comply with the requirements, a minimum number of effluent samples are required each year, depending on the size of the WWTP. The compliance check for WWTPs with more than 2,000 p.e. is based on the principle that 3 monitoring results of 4 samples must be in conformity with the criteria set down in Table 1 or Table 2. During this study, national monitoring consists of 4 samples per year for all WWTPs with more than 2,000 p.e. and at least 2 samples per year for WWTPs with a pollution load of 500 – 2,000 p.e. All the samples on the basis of this analysis have been analysed in accredited laboratories and all water samplers have the certification of water sampling. The WWTPs of less than 2,000 p.e. are in conformity with the requirements, if all quality indicators (the criteria set down in Table 1 or Table 2) are met in more than 50% of all monitoring results. If the number of samples that confirm and the number of samples that does not confirm with the criteria set out in Table 1 or Table 2 is equal, the compliance check is based on the average monitoring results made by the water user.

Monitoring Results

Based on the 2008 monitoring results, the average effluent concentrations in mean ($\bar{x}$) and median (Me) of WWTPs in Järva County are shown in Figure 1. The mean concentration is influenced by a single extreme value of some WWTPs. The median characterises the average values of pollution indicators more adequately because the median value represents the centre of the data distribution.



	SS $\bar{x}$	SS Me	BOD7 $\bar{x}$	BOD7 Me	TN $\bar{x}$	TN Me	TP $\bar{x}$	TP Me	COD $\bar{x}$	COD Me
Concentration, mg/l	19,0	14,5	32,6	16,0	18,8	8,7	4,0	3,6	105,6	75,0
Limit value, mg/l	25	25	15	15	15	15	1,5	1,5	125	125
Standard deviation (σ)	14,9	14,9	48,4	48,4	35,0	35,0	3,3	3,3	134,7	134,7

Figure 1. Average concentrations of effluent of urban WWTPs in Järva County in 2008.

Figure 1 reflects all of the 46 urban WWTPs, apart from Väätsa landfill. The limit values vary according to the size of the WWTP. The effluent average results are affected by the results of these WWTPs, which are excluded from the UWWTD. The average results of the WWTPs that are not within the scope of the directive are worse by 20% when compared to the WWTPs results given in Figure 1. If Figure 1 did not also reflect the results of the urban WWTPs, which do not belong within the scope of the UWWTD, the maximum difference would be the median of organic matter. The median of organic matter for urban WWTPs covered by the directive is 14 mg/l, which is 12.5% lower than shown in Figure 1. The median for other indicators would be lower for urban WWTPs covered by the directive between 3.5-6.7 %, compared to that given in Figure 1. There were 21 urban WWTPs that do not belong to the directive, which constitutes 42 % of all WWTPs covered in this study. Separately analysed monitoring results for the urban WWTPs that belong within the scope of the directive and the WWTPs outside the scope of the directive are given in Table 3.

Table 3. Average concentrations of the effluent of WWTPs in Järva County

	SS, mg/l		BOD$_7$, mgO$_2$/l		TN, mgN/l		TP, mgP/l		COD, mgO$_2$/l	
	$\bar{x}$	Me	$\bar{x}$	Me	$\bar{x}$	Me	$\bar{x}$	Me	$\bar{x}$	Me
Urban WWTPs belong to the scope of the UWWTD	17.7	14.0	24.7	14.0	15.3	8.4	3.7	3.4	85.1	70.0
Urban WWTPs outside the scope of the UWWTD	22.6	18.0	54.7	22.0	28.7	9.9	4.8	4.2	163.3	80.0
Results difference (%)	21.5	22.2	54.8	36.4	46.7	15.2	23.3	19.0	47.9	12.5

Figure 1 shows that effluent concentration is in compliance with the UWWTD requirements, except TP results, because the UWWTD does not provide TN and TP removal requirement for WWTPs with a pollution load less than 10,000 p.e. Figure 1 and Table 3 represent only two (Paide and Järva-Jaani) WWTPs effluent results with a pollution load more than 10,000 p.e., because the remaining 44 treatment plants have pollution loads less than 10,000 p.e. According to the mean of the results, some WWTPs have problems in removing organic matter. Since the average concentration of organic matter is relatively small (16 mg/l), the removal of organic matter causes difficulties for a few WWTPs in Järva County. Comparing the average concentrations of the effluent of WWTPs that belong within the scope of the UWWTD and are added to the WWTPs results that do not serve the agglomeration, the average of the results differs up to 55%.

WWTPs Compliance Check to UWWTD and ENS Requirements

WWTPs compliance check is based on the monitoring results. In 2007, 53 samples were taken from 29 different WWTPs to check compliance with the UWWTD requirements. The compliance check results show that 11 urban WWTPs (37.9 % from all plants) were in conformity with the UWWTD requirements. Only 4 plants (Türi, Paide, Koeru and Järva-Jaani) of these 29 treatment plants were with pollution loads more than 2,000 p.e. One of the WWTPs (Koeru) with a pollution load more than 2,000 p.e was in conformity with the UWWTD requirements. The compliance check to ENS was based on the 71 sampling results, which were taken from the 45 different treatment plants. Some of these plants are not within the scope of UWWTD. 12 WWTPs (26.7%) were in compliance with the ENS requirements.

In 2008, 59 samples were taken from 28 different WWTPs to assess the compliance of Järva County WWTPs with the UWWTD requirements. 18 treatment plants (already 64.3%) were in compliance. Of the WWTPs with pollution loads more than 2,000 p.e., only Paide WWTP met the requirements. The compliance check to ENS was based on the 83 samples that were taken from 47 different WWTPs. 23 WWTPs (48.9%) were in compliance with the requirements.

Taking into account that many WWTPs in Järva County are not in compliance with the established requirements, the results of concentrations of TP, TN, and BOD_7 were also evaluated. Figures 2-4 show the concentrations variability, as well as 10- and 90-percentiles of the concentrations of BOD_7, TP, and TN.

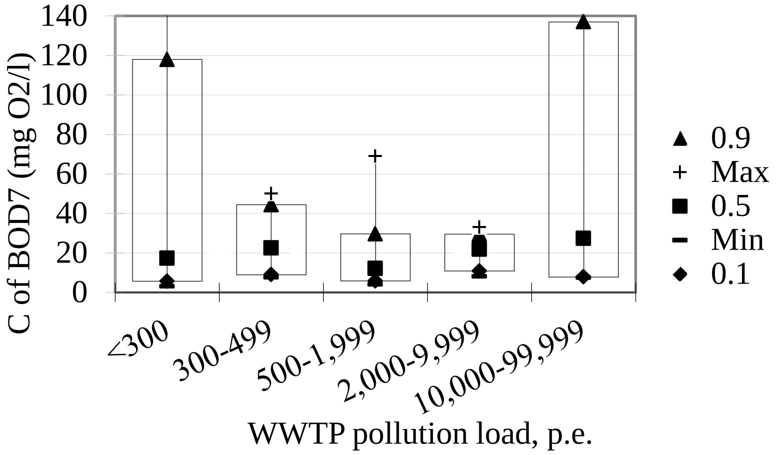


Figure 2. WWTP effluent variability of BOD_7, together with 10- and 90-percentiles in 2008

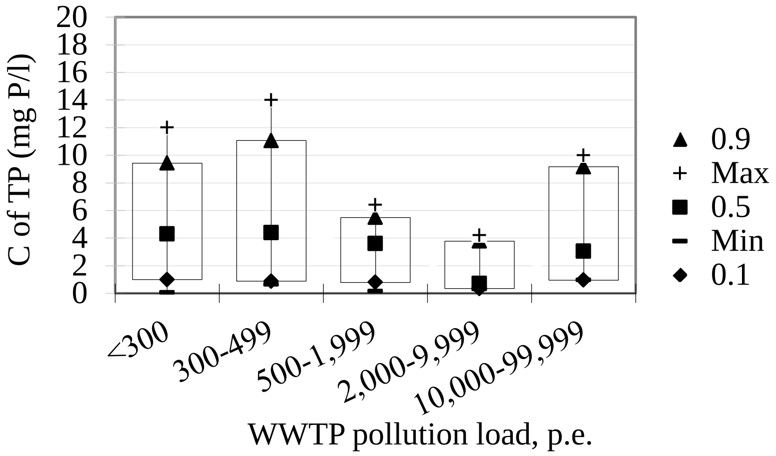


Figure 3. WWTP effluent variability of TP, together with 10- and 90-percentiles in 2008

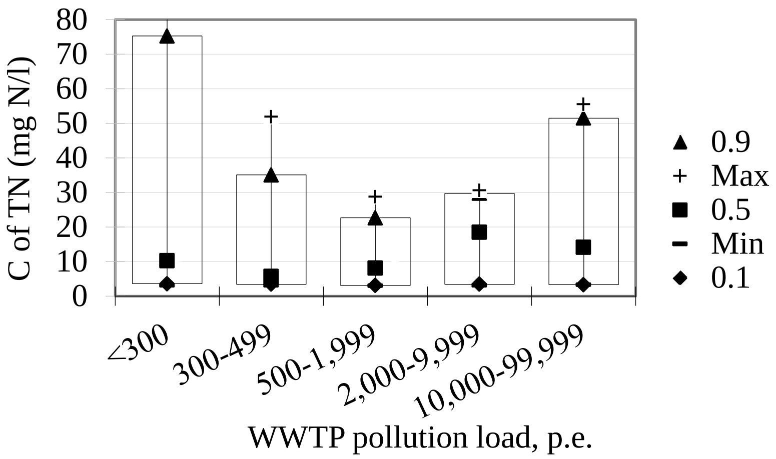


Figure 4. WWTP effluent variability of TN, together with 10- and 90-percentiles in 2008

As Figures 2-4 show, very high concentration variability exists in all WWTPs categories. We can conclude that even bigger WWTPs (more than 2,000 p.e.) have problems with the removal efficiency of all pollutants.

The results are based on the monitoring results made by Estonian Research Centre in accredited laboratories. The monitoring results obtained by WWTPs operators – the self-monitoring required according to the permits for the special use of water (Ministry of the Environment, 2009/2) – were not used in pollution load calculations, as Figure 5 indicates a significant difference in the self-monitoring and national monitoring results. The average monitoring results in 2008 made by WWTPs operators are even better; 65.2% of WWTPs are in compliance with the ENS requirements and 79.3% of WWTPs are in compliance with the UWWTD requirements using WWTPs operators self-monitoring results. Since annual average results instead of individual sample results were used, the difference between the methodologies of assessment of the compliance of WWTPs with the requirements is shown in Figure 5.

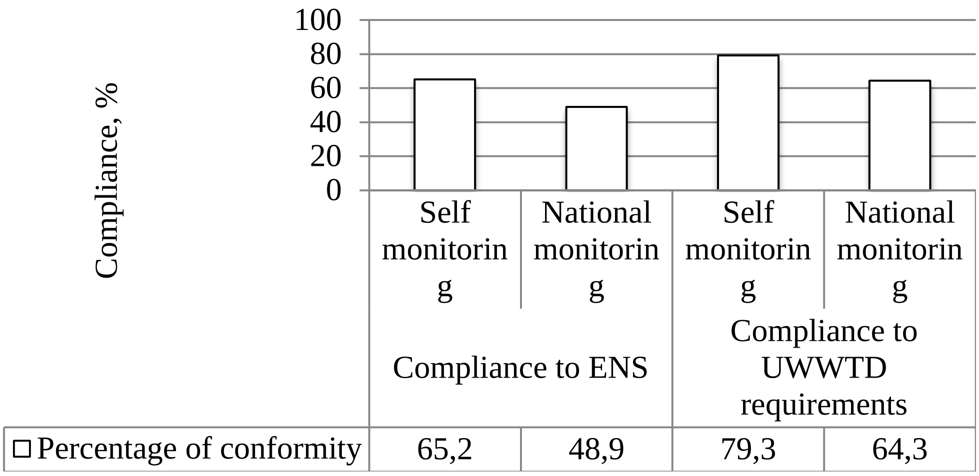


Figure 5. Percentage of compliance of WWTPs according to different methodologies, 2008

Problematic wastewater pollution indicators that do not conform to the established limit values

According to ENS, the marked part of pollution load must not discharge to the environment as shown in Figure 6. If all the WWTPs meet the requirements, the quantity of organic matter impact on water bodies would be reduce by at least 5.4 tons per year and TP 1.9 tons per year. The origin of the above normative pollution load is presented in Figure 6. An above normative pollution load discharged by WWTPs is shown with a pollution load more than 2,000 p.e. and less than 2,000 p.e., respectively.

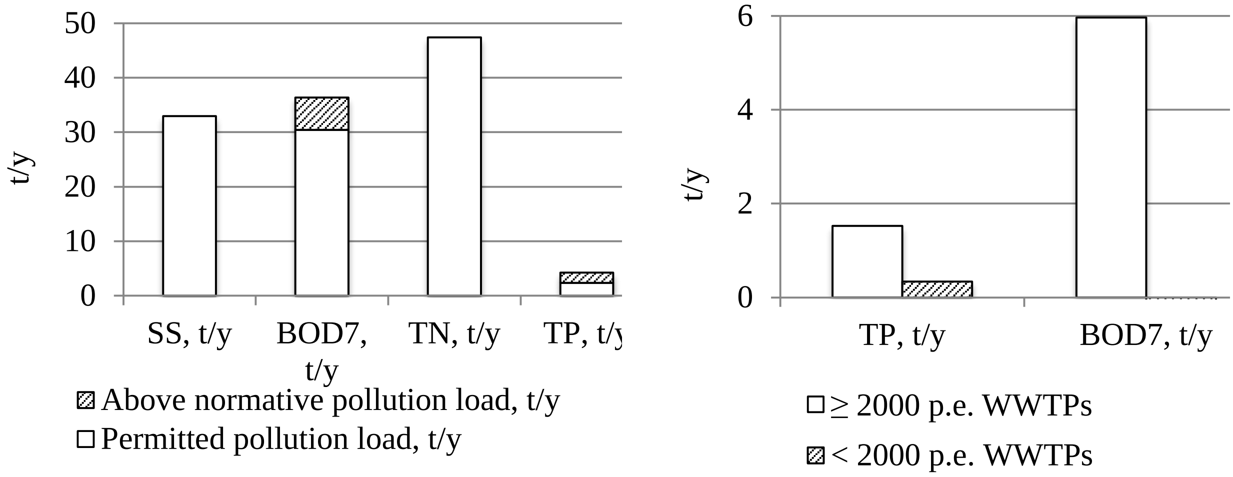


Figure 6. Total pollution load discharged to the receiving water bodies (left) and the origin of the above normative pollution load (right) in Järva County, 2008.

Figure 6 shows WWTPs with a pollution load of 2,000 p.e or more overloading the receiving water bodies with an above normative TP pollution load over 4 times more than WWTPs with a pollution load less than 2,000 p.e. It should also be pointed out that only 4 WWTPs have a pollution load more than 2,000 p.e. in Järva County and 42 WWTPs (without Väätsa landfill) have a pollution load less than 2,000 p.e.

The excessive input of organic matter distribution between WWTPs with a pollution load more than 2,000 p.e. and less than 2,000 p.e. is worse than for an excessive TP load. An above normative organic matter pollution load comes entirely from WWTPs with a pollution load more than 2,000 p.e. The actual total quantity of organic matter from WWTPs with less than 2,000 p.e. is 0.59 tons lower per year than the amount permitted by the established standards. The discharge from WWTPs with a pollution load more than 2,000 p.e. has to be reduced to protect the sensitive water bodies in Estonia. There is a need to introduce third level high-grade treatment in WWTPs, which will improve treatment efficiency and result in an immediate impact (Pachel, 2010; Bryhn, 2009; Humborg et. al, 2007).

Distribution and origin of WWTPs effluent pollution load discharged to the receiving water body

The distribution of pollution load is presented in terms of BOD_7, TP, and TN, which affect the receiving water body. Figure 7 shows that biodegradable organic matter derives 82% from WWTPs with a pollution load more than 2,000 p.e and only 18% of the total pollution load comes from less than 2,000 p.e. WWTPs. TP and TN derive 76% from the WWTPs with a pollution load more than 2,000 p.e.

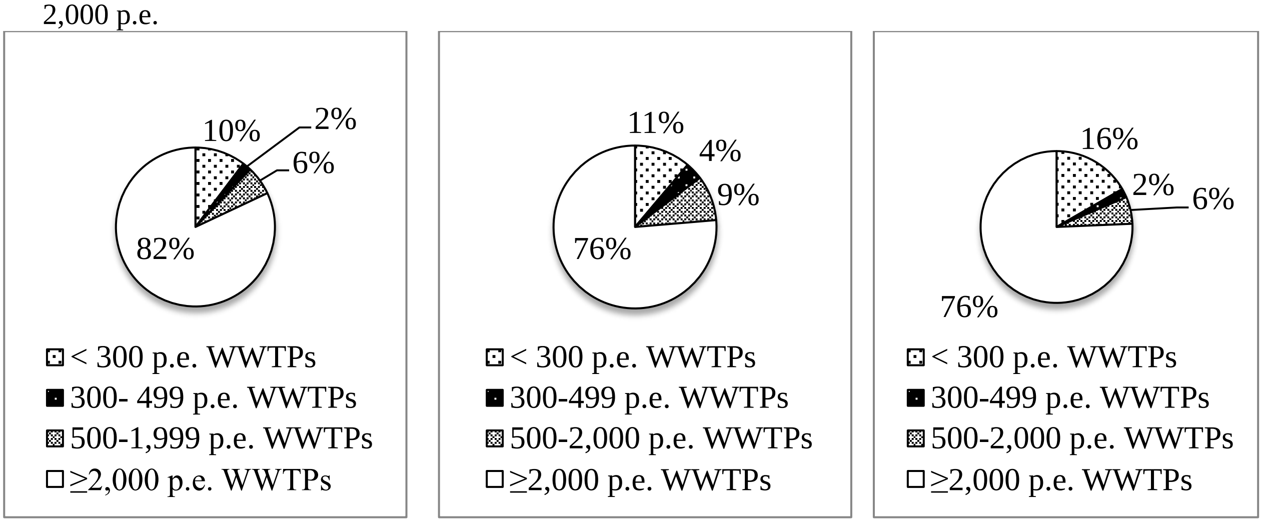


Figure 7. Distribution of BOD_7 (left), TP (centre) and TN pollution load in Järva County in 2008

Figure 7 suggests that to reduce the pollution load, which is discharged to the receiving water bodies, the discharge from WWTPs with more than 2,000 p.e. has to be reduced because WWTPs with a pollution load less than 2,000 p.e. contribute only ca 20% of the total biodegradable load discharged into the water bodies.

Discussion

The study analyses the impact of different sized WWTPs on the environment. Also, the study is unique as it was first time the cumulative impact of different sized WWTPs on the environment was analysed, using state-controlled monitoring results as well as self-monitoring results for comparison. The study reflects all 46 urban WWTPs results in Järva County and the results show that 42 WWTPs form only 18% of the entire BOD_7 pollution load and only 4 WWTPs with a pollution load of 2,000 p.e. or more form 82% of the entire BOD_7 pollution load. Similarly TP and TN pollution load distribution between WWTPs with a pollution load of less than 2,000 p.e. and more than 2,000 p.e. was 24% and 76%, respectively. The major sections of the WWTPs were constructed between the 1970s and the 1990s and have been in operation without any significant renovation; therefore, they are depreciated and outdated. Nutrient removal in these WWTPs is problematic. Eutrophication was not recognised as an important issue some decades ago. The main problem is relatively high phosphorus concentration in WWTP effluents. The high content of phosphorus causes problems in the recipient waterbodies, resulting in algae blooms and excessive plant growth. Figure 8 indicates phosphorus cumulative distribution; each point on the figure characterises a single WWTPs average result in 2007 based on 1-4 monitoring samples.

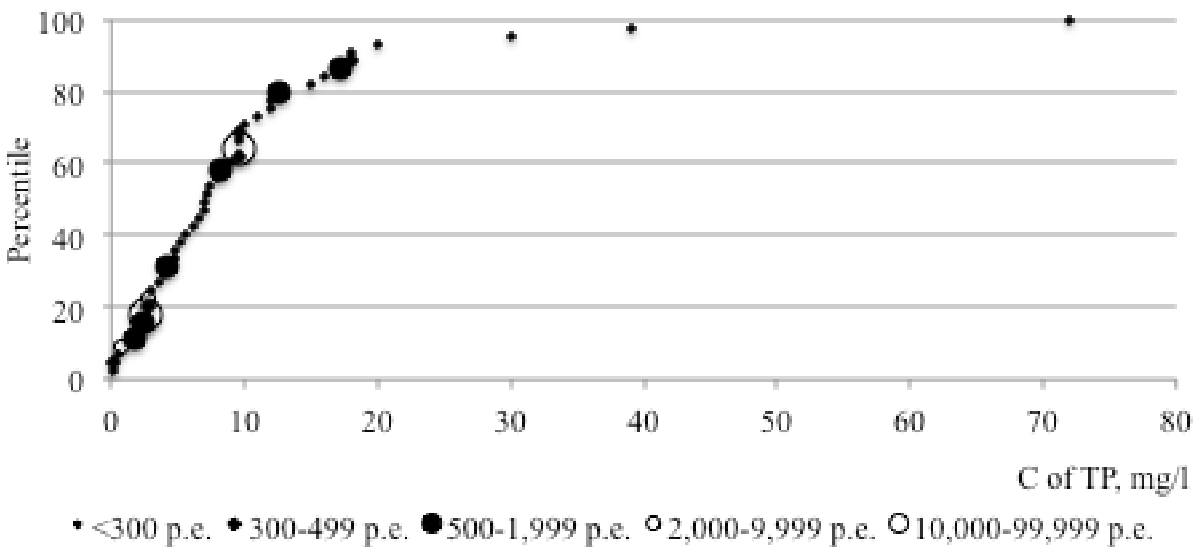


Figure 8. Percentile values of TP of different sized WWTPs in 2007

The 50-percentile value of TP for all types of WWTPs is 7.1 mgP/l; the outlet concentrations of only 5 WWTPs are below 2.0 mgP/l. To improve the ecological status of small rivers, it is necessary to improve TP values for WWTP effluents. Furthermore, existing national monitoring programmes, the data collection system, and data analyses need improvement in order to adequately assess treatment efficiency and the impact on the status of water bodies, especially in minimal runoff periods when water flow is low.

Järva County rivers have a small catchment area and, therefore, are relatively poor in water. This situation causes problems in using rivers as recipients for wastewater discharge because of insufficient dilution. Several studies point out that the majority of P tends to be retained within river systems during low-flow periods i.e. at times of greatest eutrophication risk (Jarvie et al., 2006, Pachel, 2010, Millier and Hooda, 2011, Reddy et al, 1999, Jarvie et al., 2006/2, Bukaveckas et al., 2005, Nemery and Garnier, 2007). According to the national wastewater monitoring programme, the measurements of water discharge in WWTP outlets and mixed river profile are not included at all. This is essential for calculating the actual wastewater load and its impact in low-flow rate periods. Therefore, legislation ought to be improved so that the monitoring frequency could depend on the size of the WWTP, together with the condition of the WWTP and the status of the receiving water body.

Also during this study, the above normative pollution load to obtain comprehensive information regarding the status of WWTPs was analysed. This was done to get basic knowledge on whether the established wastewater treatment standards are in conformity with the required investments and usage cost of WWTPs while taking into account that the impact of WWTPs on the environment must be minimal. As the study results show, it is essential to bring into focus WWTPs with a pollution load of 2,000 p.e. and more, while these plants have the biggest impact on the environment. On the other hand, these WWTPs are not in conformity with the established wastewater treatment standards, which cause water bodies to be overloaded with TP and biodegradable organic matter pollution. Unfortunately, it is not possible to compare the study results with earlier results due to a lack of these kinds of studies. Furthermore, as the state-controlled WWTPs effluent monitoring results show, the monitoring results differ between national and self-monitoring results by as much as 25%; therefore, it is not suitable to mix these data. As a result, self-monitoring results do not reflect the actual WWTP situation due to the low reliability of the monitoring results. During this study, we found that it is crucial to change the WWTP effluent monitoring requirements and data collecting system. Otherwise, we do not have enough reliable information about the effluent impact of WWTPs on the environment.

Also, the study shows that it is not necessary to have strict treatment standards at present, as too many WWTPs are not in compliance with today's established standards and, therefore, cause water bodies to be overloaded with TP and biodegradable organic matter pollution as a result. In Järva County, bigger WWTPs are also unexpectedly not in compliance with the established standards.

There are now several activities being implemented to reduce the significant input of organic pollutants and nutrients into water courses in Estonia. In recent years, important efforts to reduce the phosphorus load have been put into the upgrading of existing WWTPs as well as the construction of new high-grade plants with phosphorus removal and also the renewal of existing sewers and the construction of new ones in order to connect more settlements to public WWTPs. Considering the fact that most of the Estonian WWTPs are in a renovation phase at the moment, it would be necessary to analyse the WWTP effluent contaminants and nutrient ratio following the renovation of these WWTPs.

Conclusions

In Estonia, much effort has been devoted to reducing the anthropogenic loads of TN and TP to water bodies, in terms of upgrading the existing WWTPs and building new high-grade plants with nitrogen and phosphorus removal. Nevertheless, the effluent impact of WWTPs on the water bodies is considerable. The UWWTD does not impose any specific effluent limit values for WWTPs with a pollution load less than 2,000 p.e., and therefore the criteria for a compliance check have been developed in this study. However, when assessing the compliance of WWTPs with the ENS, it must acknowledge that the national requirements are much stricter than the WWTPs can actually accomplish. Only half of the WWTPs are able to comply with the national requirements. Due to the total pollutant load and origin of above normative pollution load, it is imperative to address the priority of WWTPs with a pollution load of more than 2,000 p.e., since these plants represent more than 80% of the total WWTPs pollution load and these treatment plants also have the biggest impact on the above normative pollution load because of the non-conformity treatment level.

The study indicates that due to non-compliance, WWTPs will cause rivers to overload with nutrients. The reasons for non-compliance have been due to a lack of purification capacity and operational and maintenance problems. The effluent inlets of WWTPs have the biggest adverse effect in terms of TP content in receiving water bodies. Also, the study shows that to minimise the adverse effects of effluent from WWTPs, it is not necessary to establish stricter treatment requirements, because it was apparent that the treatment levels of many WWTPs were not in compliance with the validated requirements. At the same time, it is essential to make crucial changes in legislation to improve the national monitoring programmes and data collection system. As the study results show, the self-monitoring system of the operators and the national monitoring results are not reliable enough to assess the actual state of affairs of WWTPs and the WWTP effluent impact on the receiving water bodies. On the other hand, national monitoring frequency and scope are not representative enough to make comprehensive conclusions. Therefore, we suggest changing the existing monitoring system so that all monitoring goes under state-control as well as establishing more frequent national monitoring.

This will abolish the existing double-system, improve data reliability and give more adequate information about the status of water bodies.

In summary, the study shows that:

1) the biggest impact on water bodies are WWTPs that have a pollution load more than 2000 p.e.;

2) WWTPs less than 2000 p.e. have the highest impact in terms of TP and WWTPs with a pollution load of 2000 p.e. and more having the highest impact in terms of BOD_7 and TP. Therefore, WWTPs TP removal efficiency and established TP limit values need urgent re-evaluation;

3) WWTPs self-monitoring results differ from the national monitoring results; therefore, the monitoring system needs essential changes.

Furthermore, the authors found that it is essential to undertake more complex studies in Estonia in order to analyse the cumulative impact on environmental processes.

In summary, WWTPs with more than 2,000 p.e. should be regulated vigorously to guarantee their compliance with the requirements, because WWTPs with more than 2,000 p.e. count for 80% of the total pollution load in Järva County. The number of WWTPs with less than a 2,000 p.e. impact on the receiving water bodies is marginal. Measures also have to be adopted for WWTPs with less than 2,000 p.e. to comply with the ENS, since the extent of the impact of each individual WWTP depends on, among other things, the characteristics of the wastewater and water turbulence. Also, since a very small WWTP may affect the status of a water body depending on the characteristics of the wastewater and receiving water body, particularly careful handling should be applied to the up-streams of watercourses. Considering the fact that most of the Estonian WWTPs are in a renovation phase at the moment, it would be necessary to analyse the WWTPs effluent contaminants and nutrient ratio following the renovation of these WWTPs and also re-evaluate their conformity in 2014–2015. After that, it will be possible to analyse contiguous data that were discovered during this study conducted before the WWTPs renovation phase with data collected from 2014–2015 after the renovation of the WWTPs.

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