"Environmental Engineering" 10th International Conference
Vilnius Gediminas Technical University
Lithuania, 27–28 April 2017
http://enviro.vgtu.lt

eISSN 2029-7092 / eISBN 978-609-476-044-0

Article ID: enviro.2017.068
DOI: https://doi.org/10.3846/enviro.2017.068

Influence of Anykščiai City on Šventoji River Water Quality

Lina Bagdžiūnaitė-Litvinaitienė[1], Andrius Litvinaitis[2], Laurynas Šaučiūnas[3]

[1,2,3]Department of Water engineering, Vilnius Gediminas Technical University, Vilnius, Lithuania
E-mails: [1]lina.litvinaitiene@vgtu.lt; [2]andrius.litvinaitis@vgtu.lt (corresponding author); laurynas.sauciunas@stud.vgtu.lt

Abstract. Increasing migration of nutrients in the river water is a major factor in determining the quality of river water due to anthropogenic activities. In order to preserve the good water quality in rivers and other surface water bodies, it is necessary to take preventive measures that can be scientific water quality research and analysis. According to research carried out in kind, the article analyses the Anykščiai city as point source pollution, and the influence of it to the water quality of Šventoji river. Also, based on the statistical information a nutrient concentrations trend analysis of the meteorological and hydrological conditions influence was carried out. Investigations were carried out in July-September of 2016. Concentrations of ammonium (NH_4-N), nitrite (NO_2-N), nitrate (NO_3-N), phosphate (PO_4-P) and dissolved oxygen (O_2) was analysed. In order to determine the impact of point source pollution on river water quality, the changes in concentration before and beyond Anykščiai city were evaluated, according to the meteorological and hydrological conditions. It was found that total nitrogen (N_b) and total phosphorus (P_b) concentrations during the investigation period respectively, increases in 6% and 8%.

Keywords: nutrients, point pollution, diffuse pollution, total phosphorus, total nitrogen, anthropogenic activities.

Conference topic: Water engineering.

Introduction

After Lithuania joined to the European Union, became compulsory for to develop the river basin district mana-gement plans and measures put in place to achieve the good of the country's water bodies ecological and chemical status. Water is not a commercial product, but a heritage which must be protected (Eur-lex 2000). This is one of the objectives of water protection, published by the Water Framework Directive 2000/60/EC. Anthropogenic activities are the main factor determining the condition of surface water bodies. The expansion of cities, the growth of industrial and agricultural applications, influences the growth of point and diffuse pollution (Aplinkos apsaugos agentūra 2011). The biggest negative impact on the quality of the river water has access of nutrients into water bodies from diffuse and point sources of pollution (Grimvall *el al.* 2000), leading to eutrophication. Criteria for diffuse pollution of good ecological status does not meet the 19% of the investigated rivers of Lithuania. Diffuse agricultural pollution may comprise 45–80% of the total pollution load that falls on the surface water (Aplinkos apsaugos agentūra 2011). Varying the intensity of agriculture on water quality is evaluated very differently (Gužys 2012) as one of the chemical elements that are used in agriculture, has a greater negative impact than the others (Stakeliūnaitė, Litvinaitis 2015). It is also influenced by the unevenly distributed sediments of different texture in the river basins. Better aeration conditions and intense mineral mineralization are in sandy sediments. Soluble nitrogen compounds (NO_3, NH4) are leaching quickly from sand. Phosphorus migtration in soil is different from nitrogen (Povilaitis 2015; Litvinaitis 2013). Sandy soils phosphorus compounds are also washed away, but found that this process is more intense in the clay soil (Heckrath *et al.* 2008). The flows of nutrient and concentrations of nutrient in the water of river depends on meteorological and hydrological conditions. The examination of nutrient flows in river water is appropriate to take into account the water content change options (Bagdžiūnaitė-Litvinaitienė 2005), since the concentrations is sensitive to changes in the river flow.

The article analyzes the study to assess the anthropogenic activities on the Šventoji river water quality. The Anykščiai city, as a point source of pollution, the influence of the Šventoji river water quality investigation of nutrient concentrations and the concentrations examined dependence on meteorological and hydrological conditions change, not only during the period, but also on the basis of perennial water quality data.

Materials and Methods

The Šventoji river at Anykščiai city were choosed as a study object (Fig. 1). Šventoji is the largest subbasin of the Neris basin. Full part of the Šventoji basin with an area of 6789.2 km^2, falls into Lithuanian territory, so Šventoji is the longest river flowing only in the territory of Lithuania, and its length is 246.0 km (Nemuno upių baseinų... 2015).

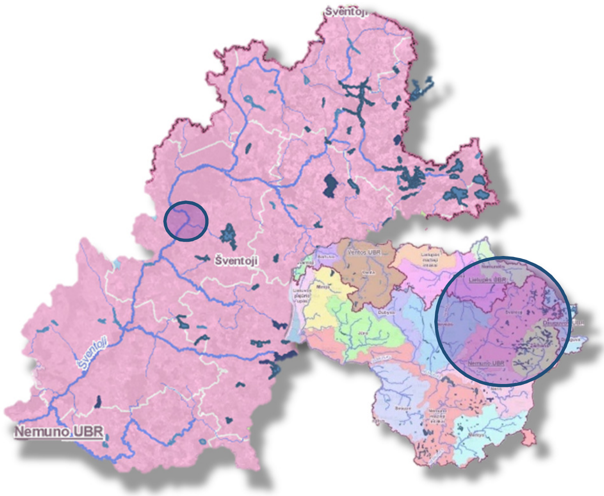

Fig. 1. Location of Anykščiai city in the Šventojí Basín

Basin surface is dominated by medium loams (63%), but there are sand and gravel covered areas (27%). Of forest land – 26%, Over the years the Šventoji Basin falls 750 mm rainfall on average. The basin water year runoff coefficient η = 0.42, and the average flow at the mouth is about 56.5 m^3/s (according Baltromiškė VMS data) (Kilkus, Stonevičius 2011).

Selected 3 sampling points:

- 1st sampling point location is before Anykščiai city, 50 meters before the first storm water discharger. The site was chosen in order to be able to compare the results and to assess the impact of the city of Anykščiai onto water quality;
- 2nd sampling point chosen beyond the last storm water discharger of Anykščiai city. Three samples, 50 m before discharger and beyond 50 m and 500 m for the discharger;
- 3rd sampling point chosen beyond the discharger of the wastewater treatment plant. Three samples, 50 m before of the discharger and 50 m and 500 m beyond the discharger.

Sampling was done in accordance with the guidelines of sampling standard ISO 5667-1: 2007, taking into account all aspects of the water sampling. Sampled once per month: in July, August and September 2016. During the period a total of 21 samples are taken. The nutrient concentrations are measured using photometric analysis. Principle of method – absorption of the material intensity at a specific wavelength is directly proportional to the concentrations of that substance. Concentrations determined using Hanna multi-parametric photometer HI 83205. Hanna multi-parametric photometer optical system consists of special subminiature tungsten lamps and narrow-band interference filters to ensure proper functionality and reliable performance, error of ± 3–10%.

Concentrations observed:

- Ammonia nitrogen (NH_4-N). Ammonium concentration is determined by Nessler method;
- Nitrite nitrogen (NO_2-N). Nitrite concentration is determined by the denitrogenation method;
- Nitrate nitrogen (NO_3-N). Nitrate concentration in the water is determined by cadmium reduction method;
- Phosphate phosphorus (PO_4-P). Phosphate concentration in the water is determined by ascorbic acid method;
- The dissolved oxygen (O_2). The level of dissolved oxygen is determined by the Winkler method;
- Total nitrogen (N_b) and total phosphorus (P_b) concentration calculated from the previous obtained results.

Results and Discussion

It was found that the concentrations of NH_4-N ranged from 0.01 mg/l to 3.0 mg/l in the investigation period. Of all the samples tested very good ecological status by physico-chemical quality elements are in line with the 33% of the samples, a good 28% of the average of 19%, 10% bad, very bad 10% (Fig. 2). Concentrations of NO_2-N ranged from 0.01 mg/l to 3.70 mg/l in the investigation period. Concentrations of NO_3-N ranged from 0.0 mg/l to 5,80 mg/l. Very good ecological status by physico-chemical quality elements are in line with the 42% of the tested samples, a good 10% of the average 8 of 38%, 10% bad, and very bad 0%.

Concentrations of Total nitrogen ranged from 0.10 mg/l to 6.02 mg/l. Of all the samples tested corresponded to high ecological of 28% of the samples, a good 19% of the average 48%, while bad 5%.

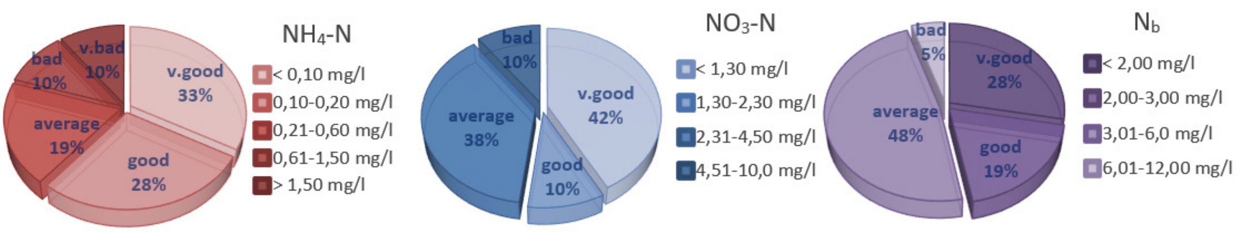

Fig. 2. Ecological status by physico-chemical (NH_4-N, NO_3-N, N_b) elements of quality indicators, expressed in percentage- of the total number of samples %

Concentrations PO_4-P varied from 0.50 mg/l to 24.10 mg/l. According PO_4-P, all samples showed 100% very bad ecological status. Concentrations of Total phosphorus varied from 0.20 mg/l to 7.80 mg/l. Of all the samples tested, the average condition corresponded to 5% of the samples, a bad condition as well as 5% of the samples, and a very bad 90% of the tested samples.

The examination of changes in the concentration of nutrients, it is important to evaluate the influence of weather conditions, since it is one of the key factors in determining hydrological parameters change, especially in the river flow (Bagdžiūnaitė-Litvinaitienė 2005).

The average flow rate at Anykščiai amounted to 10.30 m^3/s on July, the maximum flow recorded on 30th July – 14.50 m^3/s, while the lowest – 8.49 m^3/s on 21th July. The flow rate was of 9,76 m^3/s on sampling day, on 13th July. 77.1 mm of rainfall in total during the month fell in July, and the average monthly temperature was 18.7°C (Fig. 3 AAA5). It rained a heavy rain fell during the day, even 8.0 mm of precipitation on sampling day.

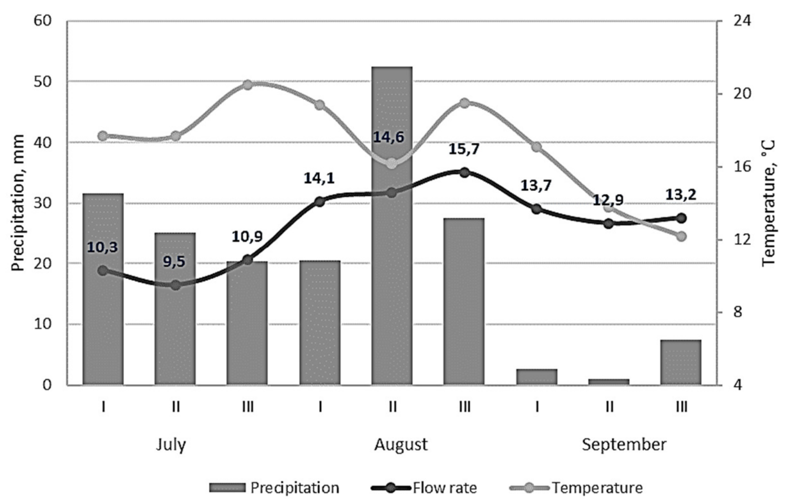

Fig. 3. Dependences of flow rate, temperature and precipitation on July–September 2016

The average flow rate was 14.8 m^3/s on August. The flow rate at Anyksciai was 16.2 m^3/s on sampling day on 19th August. During the month of August 100.5 mm of rain fell, and the average monthly temperature was 18.4 °C. There was not precipitation on sampling day. The average flow rate at Anyksciai was 13.3 m^3/s on September. The flow rate of 12.9 m^3/s on sampling day on 24th September. 9.7 mm of rainfall, and the average monthly temperature was 14.0°C. It rained gentle rain in a day fell by 0.5 mm of precipitation on sampling day.

The concentrations was almost 90% before Anykščiai higher than beyond on 13th July. Although the flow rate during the period was the lowest and amounted to 9.8 m^3/s, the concentrations before the city received much higher than at a maximum flow rate of 16.2 m^3/s. Fallen 8.0 mm rainfall on 13th July, resulted the surface and subsurface runoff formation and the beginning of leaching of nutrients from the basin surface layer of soil, resulting affect of diffuse pollution; the concentrations before the Anykščiai city received far greater than beyond it. This was also influenced by surface water, which falls into the river from Anykščiai stormwater outlets. Rain water is a little polluted with nutrients, and the persistence of long-term rain concentrations of nutrients in rain water is negligibly decreasing, so the rain water has reduced concentrations of Total nitrogen of river water by diluting the concentrations beyond the city and received much less.

Before the city on 19th August concentrations of Total nitrogen received 42% less than on 13th July, although the flow rate was higher in 1.6 times. A large leak formed on August, then was rainfall of 100.5 mm. There was no precipitation on sampling day, however, a few days before it fell out as well as a large amount of rainfall, which led to intense leaching of nutrients and formed a high water levels. A few days followed a steady flow after the rain, and the river had time spontaneously purify up to 19th August, when sampled. The greatest amount of nutrients from the basin surface layer of soil has been washed, so the concentrations was lower than in July. River water quality was also influenced Anykščiai city. Concentrations before the city received 5% higher than beyond it.

A distinct difference between the concentrations before and beyond the city shows on 24th September. Concentrations of Total nitrogen before the city was 88% higher than beyond. This explains fallen low rainfall, only of 9.7 mm on September, so nutrients leaching from the basin was relatively small. Anykščiai city as point pollution source had no appreciable effect on the river water quality on September.

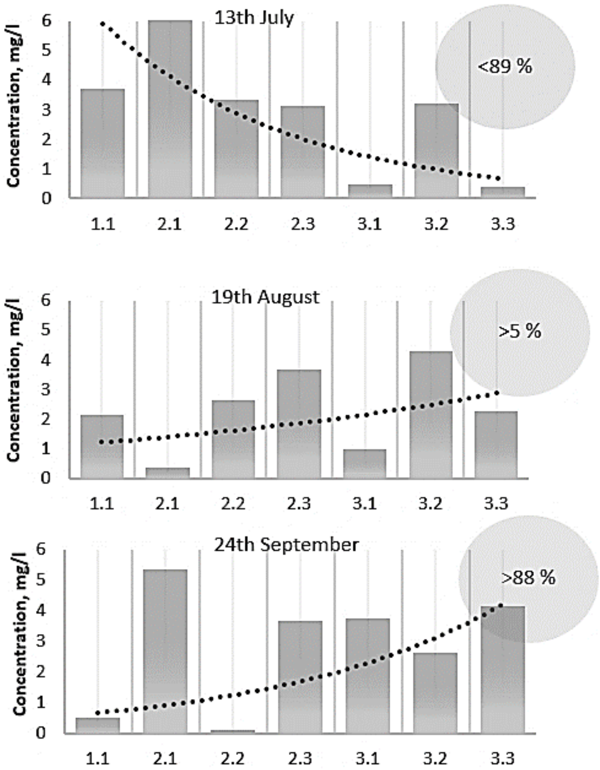

Fig. 4. The change of concentration of Total nitrogen on July–September 2016

Concentrations of Total phosphorus are less sensitive to meteorological and hydrological conditions change as previously discussed concentrations of Total nitrogen. Difference in concentrations during the period varied slightly. Concentrations of Total phosphorus before Anykščiai city was also higher than that beyond it on 13th July, but the difference was only 14%. Another sampling days concentrations of Total phosphorus were higher beyond the city: on 19th August 18% and on 24th September 21%. The highest concentration of Phosphorus obtained on 19th August when the flow rate was the highest and amounted to 16.2 m^3/s. Phosphorus compounds are not as agile as nitrogen in soil: leaching of their is determined by soil texture and surface runoff (Povilaitis 2015; Litvinaitis 2013). A large-surface runoff was formed by rainfall of 100.5 mm on August, so the highest concentrations of Total phosphorus flow.

Concentrations of nitrogen compounds are much more sensitive to meteorological and hydrological conditions change over phosphorus compounds. The examination of the concentrations dependence of meteorological and hydrological conditions, it is necessary to take into account not only the existing conditions of the sampling day, but also to their changes prior to sampling, in order to understand the changes in the concentrations trends in turbulent conditions. The results shows that during the period of Anykščiai city only increases the nutrient concentrations marginally in the Šventoji river water. According to Total nitrogen 6%, whereas according to Total phosphorus 8%. Small differences in the concentrations before and beyond Anykščiai city, which is seen as a point source of pollution indicates that a greater impact on the migration of nutrients in the river water to diffuse pollution. Literary sources say that the diffuse pollution may comprise 45–80% of the total basin pollution (Aplinkos apsaugos agentūra 2011).

Analysis of Environmental Protection Agency data provided in period of July–September of 2004–2014 shows that in nearly all cases, it is directly dependent on the flow of Šventoji river. Increasing of flow river increases concentrations. The examination of the results when the sample was taken once a month, it is difficult to discern the direct-pathways, it is necessary to assess the flow of the change prior to sampling.

Conclusions

Based upon in-kind research of concentrations of nutrients evaluated the Šventoji river water quality at Anykščiai city. According to Total nitrogen, 48% of samples tested met the average ecological status class, 28% very good, 19% good, and 5% bad. According to Total phosphorus vast proportion of the samples as much as 90%, met with the very bad ecological status class, while 10% of the samples respectively resp-poor and average condition.

Concentrations of nutrient are sensitive to the change of meteorological and hydrological conditions, but not always a direct dependence, it shows when samples are taken once a month. It is necessary to take into account the conditions of not only the sampling day, but also to their changes prior to sampling. When assessing multi-annual water quality test results can already be seen directly from the concentrations dependence of the flow rate. With greater flow rate, resulting in higher concentrations. It was also found that the concentrations of Total nitrogen more responsive to changes in weather conditions than Total phosphorus concentration. In different flow rates of the investigation period, of Total phosphorus concentrations changes in the sampling points are not as bright as concentrations of Total nitrogen.

It was found that on the period of July–September 2016, Anykščiai city, as a point source of pollution, only slightly increased the concentrations of nutrients in the Šventoji river water. Concentrations of Total nitrogen increased on average by 6%, while the Total phosphorus 8% beyond the city.

Based on the studies and analysis of the data, it can be said that the small differences in the concentrations before and bellow the Anykščiai city, which is seen as a point source of pollution indicates that a greater impact on nutrient migration Šventoji river water has diffuse pollution.

References

Aplinkos apsaugos agentūra. 2011. *Reikšmingi žmogaus veiklos poveikiai* [online], [cited 11 February 2017]. Available from Internet: http://vanduo.gamta.lt/cms/index?rubricId=ba5c154f-43eb-45f8-a3cd-b1a509861e32.

Bagdžiūnaitė-Litvinaitienė, L. 2005. Mineralinio azoto ir fosforo srautų upių vandenyje pokyčiai įvairaus vandeningumo laikotarpiais, *Journal of Environmental Engineering and Landscape Management* 13(3): 132–140.

Eur-lex. 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for community action in the field of water policy, *Official journal of the European Communities* L327(43): 1–72

Grimvall, A.; Stålnacke, P.; Tonderski, A. 2000. Time scales of nutrient losses from land to sea – a European perspective, *Ecological Engineering* 14(4): 363–371. https://doi.org/10.1016/S0925-8574(99)00061-0

Gužys, S. 2012. Skirtingo intensyvumo žemdirbystės sistemų įtaka azoto išplovimui drenažu, *Vandens ūkio inžinerija* 41(61): 46–56.

Heckrath, G.; Bechmann, M.; Ekholm, P.; Ulen, B.; Djodjic, F.; Andersen, H. E. 2008. Review of indexing tools for identifying high risk areas of phosphorus loss in Nordic catchments, *Journal of Hydrology* 349: 68–87. https://doi.org/10.1016/j.jhydrol.2007.10.039

Kilkus, K.; Stonevičius, E. 2011. *Lietuvos vandenų geografija*. Vilnius: Vilniaus universitetas. 15 p.

Litvinaitis, A. 2013. *Pakrančių nuogulų įtakos upių vandens kokybei įvertinimas.* Vilnius: Technika. 143 p. ISSN 9786094574719.

Nemuno upių baseinų rajonų valdymo planas. 2015. Aplinkos apsaugos agentūra.

Povilaitis, A. 2015. *Žemių sausinimo poveikis biogeninių medžiagų transformacijoms dirvožemyje ir vandens telkinių taršai.* Kaunas: Akademija. 10 p.

Stakeliūnaitė, E.; Litvinaitis, A. 2015. Stambaus sutelktojo taršos šaltinio įtaka Neries upės vandens kokybės parametrų kaitai, in *the 18th Conference Aplinkos apsaugos inžinerija*, 09 April, 2015, Vilnius, Lithuania, 14: 94–99.