



Section: Environmental protection

Storm Water Pollution in the Urban Environment of Vilnius, Lithuania

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Abstract

Wastewater – it is precipitation on the surface of urban areas and other waters. Wastewater flow rates varies depending on the time of year and weather conditions, and their contamination depends on industrial and urban development, transport development, human economic activity.

Because of the increasing pollution of surface wastewater bodies, the eutrophication process is intensified. Suspended solids trapped in surface waters can lead to physical (reduced light penetration, changes in water body temperature, sludge formation), chemical (emission of heavy metals, nutrients and pesticide during adsorption to the surface waters from formed sediments) and biological (decrease of dissolved oxygen quantity in the surface water body) changes in water bodies. Therefore, it is necessary to investigate the concentrations and dynamic changes of untreated sewage entering the surface water bodies. After these tests the most pressing areas of pollutants are found where installation of wastewater treatment facilities is needed.

The article analyses the pollution indicators of surface wastewater that is generated in the urban area in the northern part of Vilnius city. These parameters were explored: BDS₅, total nitrogen, total carbon, oil products, suspended solids, pH, amount of dissolved oxygen and temperature.

Keywords: storm water; pollution; environment.

1. Introduction

During expansion of urbanized area more and more attention must be paid to surface wastewater infrastructure development and reconstruction [1]. In 2012, 71.8% of surface runoff, which formed in Vilnius city, was released untreated or insufficiently treated into surface water bodies [2]. The rest – 28.4% of surface runoff generated in Vilnius city on urban surface area has been properly cleaned and discharged into surface water bodies.

Stormwater pollution can vary depending on the area size, the terrain, the waste of potential polluters and precipitation parameters: intensity, resulting rainfall [1]. Surface water is collected from Vilnius city streets, roofs, sidewalks, parking lots and other impervious surfaces. Snow precipitation, entering the urban areas may also form surface wastewater. In Vilnius, the average thickness of snow coverage in 2012 was 24 cm [3]. Snow coverage in the city is relatively small and melts slowly, so when designing drainage systems, the main focus is kept at rain-generated surface runoff [4].

In Lithuanian Republic of surface wastewater regulation it is indicated that the main analyzed surface wastewater pollution indicators are:

- suspended solids (SS);
- biochemical oxygen demand (BOD);
- oil products.

„Suspended solids“ – are mixtures of inorganic and organic matter content (mg) or concentration (mg/l) in the river, lake or pond water – these are particles suspended in turbulence [5, 6]. Along with suspended materials, heavy metals can enter into surface water. In TSS there are a lot of organic material, which when decomposing decreases levels of water dissolved oxygen [6, 7].

Biochemical oxygen demand (BOD) indicates sewage contamination with organic materials. Evaluating BOD is determined by the amount of oxygen needed for easily decomposing organic contaminants to biochemically oxidise [8]. The

amount of oxygen needed for easily decomposing organic contaminants to biochemically oxidise within 5 days – BOD5 [6, 9].

Oil products in surface wastewater can form from operation of vehicles, gas stations, industrial enterprises in the territory. Along with surface runoff into surface water bodies falling oil products form a film that does not let the oxygen molecules get in the water.

Biogenic materials (carbon and nitrogen) concentration in the effluent is established in order to assess the amount of biogenic substances generated in the urban area. Biogenic materials are broken down by microorganisms. The intensity of micro-organisms reproduction depends on the amount of biodegradable organic matter in wastewater [10]. All the carbon and nitrogen content, which is not absorbed by plants becomes pollutant in the water body. Excess of biogenic substances in water can cause natural conditions in water body to become abnormal, excessive growth of plants and other organisms [11]. This process is known as eutrophication, where nutrients and organic substances in water bodies causes the rapid growth of the plants.

2. Research purpose

To identify and evaluate changes in surface contaminants in waste water during the cold time of the year with a positive environmental temperatures, raining.

3. Research purpose

The northern part of the city of Vilnius surface wastewater.

4. Research Methodology

Vilnius city surface wastewater pollution research samples were taken in the rain. Samples taken from 10 sites: 5 surface wastewater dischargers and from 5 locations where wastewater is formed on the impervious urban site surface.

Stormwater samples are collected in 5-liter plastic bottles. Bottles are washed with distilled water before each use. While taking samples, the environment and sample temperature is measured. Analyses of surface wastewater samples is started on the same day, but no later than 24 hours. In samples these factors are determined: pH, suspended solids, dissolved oxygen, BOD5, total nitrogen, total carbon. Surface wastewater sample analysis is performed in Vilnius Gediminas Technical University, Department of Environmental Protection laboratory.

Surface wastewater samples temperature is measured by thermometer TP-3001 with the measuring probe, pH concentration is measured with the pH meter – WTW/538, the measurement range – 2–16, and the device measures with 0.01 accuracy. Surface water saturation with oxygen (dissolved oxygen concentration) is determined by oximeter Oxi-3205. Device measurement range is from 0 to 90 mg / l and the measurement accuracy is 0.1 mg / l. Concentration of suspended solids in surface wastewater is determined by screening method, which methodology is presented in the Environment normative document LAND 46-2007 „Water Quality. Suspended materials detection. Filtration through glass fiber method“. Biochemical oxygen consumption in surface effluent BOD is determined with VELP Scientific System sensors system. Measurement limit – up to 999 mg / l. Total carbon and total nitrogen concentration in the wastewater is determined with Carbon analyzer Shimadzu TOC-VCSN/TNM-1.

5. Results

During the research period, the average daily temperature was 2.4 °C. Samples were sampled twice, before taking the first samples there was a sunny period of 5 days, taking the second sample base – sunny period of 3 days.

Because of positive temperatures during the sampling period there was no usage of road maintenance materials: sand, salt. Therefore, the concentrations of suspended solids and biogenic materials in surface wastewater were not affected by it. During sampling period the average daily temperature was 2.8 °C and 4.2 °C. Surface wastewater samples were taken in the northern part of Vilnius city while raining.

In 2008–2013 during winter the average daily temperature, while sampling the surface wastewater in the northern part of Vilnius, was ~0 °C.

Laboratory tests were performed on samples of surface wastewater that were taken from 10 locations. Surface wastewater sampling locations are shown in Figure 1.

33 is surface wastewater basin, from which five wastewater samples were taken, covers 57,5 hectares. 39 is surface wastewater basin, from which one surface wastewater sample was taken, occupies 22,4 hectares. 8 is surface wastewater basin, from which 3 samples of surface wastewater were taken, occupies 176 hectares. 6 is surface wastewater basin, from which 2 surface wastewater samples were taken, covers 215 hectares.

In the northern part of the city of Vilnius, the right shore of river Neris, surface wastewater pollution, besides autotransport can be caused by SC „Kuro aparatūra“, SC „Vilma“, SC „Stafis“ and SC „Autobusų parkas“ [12]. In the northern part of the city of Vilnius, the left shore of river Neris, surface wastewater pollution, besides autotransport can be caused by JSC Lukoil Baltija“. Sampling points that are shown in Figure 1.

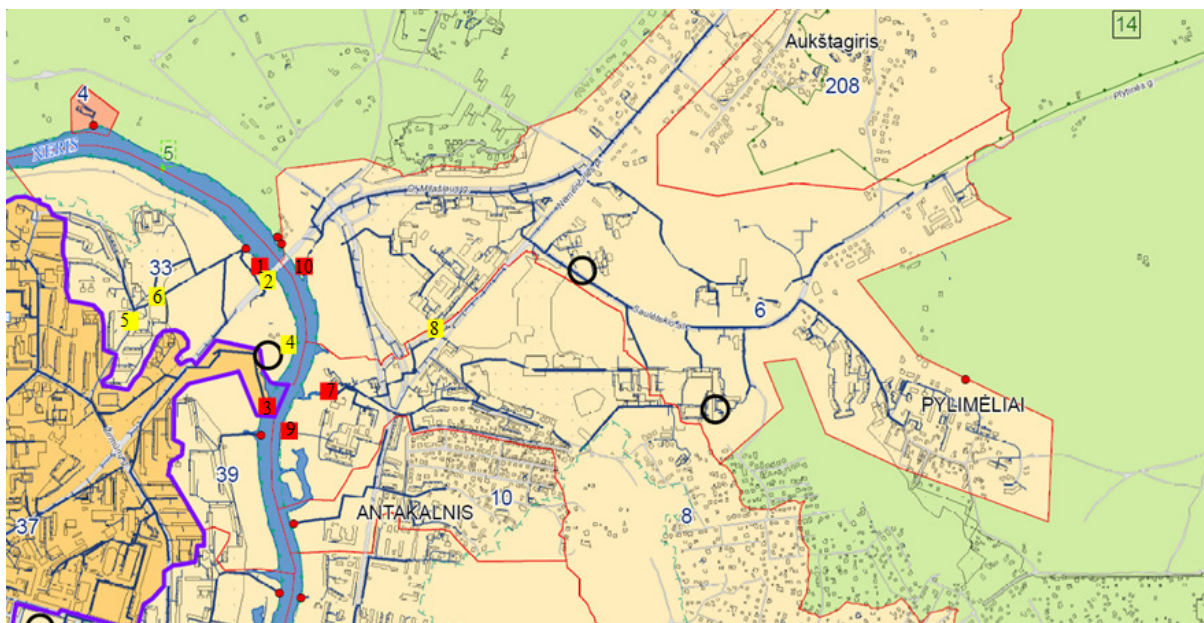


Fig. 1. Vilnius city surface wastewater sampling locations ■ – surface wastewater sampling location from wastewater discharger; ■ – surface wastewater sampling location from urban territory surface; 1 – surface wastewater discharger; 2 – Valakampiai bridge; 3 – surface wastewater discharger; 4 – sample from impervious surface; 5 – sample from impervious surface; 6 – sample from impervious surface; 7 – surface wastewater discharger; 8 – sample from impervious surface; 9 – surface wastewater discharger; 10 – surface wastewater discharger.

Permissible concentration of suspended solids in surface wastewater that is discharged into the environment is 50 mg/l [13]. During the collection of samples in 2014 January, suspended solids in the different sampling points ranged from 40 mg/l to 360 mg/l. The average concentration of suspended solids in analyzed January samples of surface wastewater was 353.5 mg/l. The highest concentration of suspended solids is determined to be in the sample set of surface wastewater sampled from Valakampiai bridge. The maximum instantaneous concentration of suspended solids in this sample exceeded 7.2 times. According to the data obtained from 10 samples, suspended solids concentration has been exceeded in only 2 samples (the 2nd and the 5th surface wastewater), and reached 10 mg/l and 40 mg/l.

Evaluating the pollution data of 6 years in 5 surface wastewater dischargers in Vilnius town northern part, the maximum average concentration of suspended solids is measured during the summer and reaches 148.25 mg/l, the lowest – in the spring – and reaches 30.74 mg/l [12]. Taken into account the previous six years of suspended solids concentrations, in the winter of 2014 in January concentration is greater 2.8 times.

The average concentration of suspended solids during the sampling period can be bigger because of higher temperatures. Rainfall forms at higher temperature (2.4 °C), which by falling down collects from the streets, sidewalks or other impervious surfaces and disposes of the greater part of the suspended matter. What can not be seen during snow precipitation and melting. During winter, suspended solids travel to surface water bodies only when there is a positive temperature or additional ice melting materials for road maintenance are used.

Data obtained in Radviliškis town in 2010 about suspended solids concentration in surface wastewater samples ranged from 7.5 to 30.8 mg/l [4]. In Vilnius city northern part, the concentration of suspended solids in the tested samples was found higher than the concentration of suspended solids in Radviliškis town. The highest concentration of suspended solids in Vilnius is 11.69 times higher than in Radviliškis town.

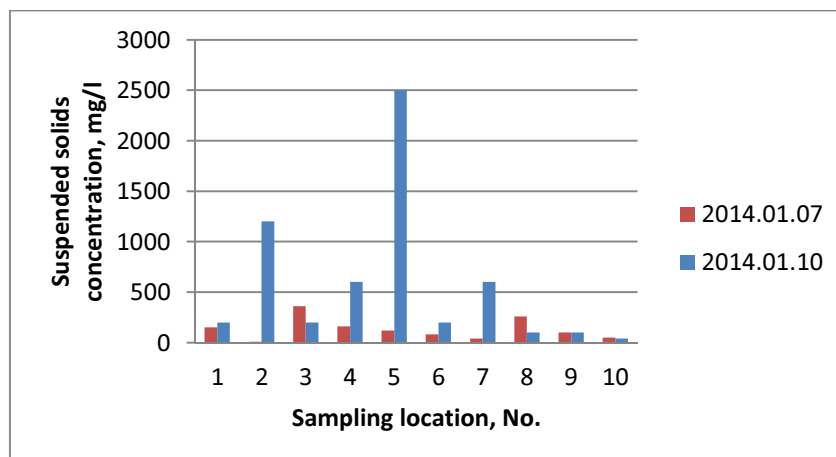


Fig. 2. Concentration of suspended solids in surface wastewater in northern part of Vilnius city

pH concentration in the samples was found weakly alkaline. pH in the samples, which were sampled in 2014 January ranged from 7.13 to 8.99. The highest pH value determined in the sample, which was taken from the Valakampiai bridge. Surface wastewater pH in dishchargers over the past six years, ranged from 7.27 to 8.59. During the winter period 2008–2013, the pH ranged from 7.48 to 8.37, the highest pH value measured in the summer [12]. Changes in pH depend on the wastewater pollutants: havy metals, concentrations of suspended solids, dissolved oxygen and biogenic materials.

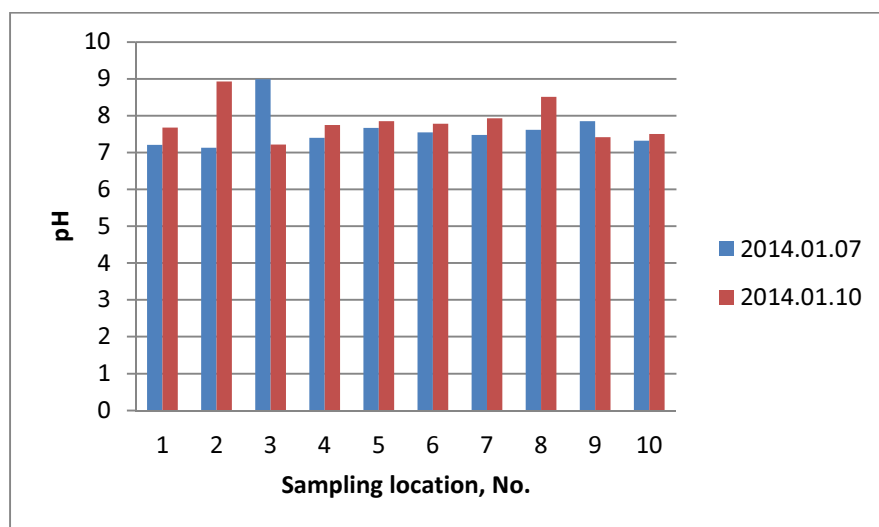


Fig. 3. pH in surface wastewater in northern part of Vilnius city

The dissolved oxygen concentration in the surface runoff samples that have been taken from the northern part of the city of Vilnius surface wastewater dischargers and from impervious surfaces varied from 0.03 mg O₂/l to 0.04 mg O₂/l (dissolved oxygen concentration in water can vary from 0 to 14 mg O₂/l). The lower the concentration of dissolved oxygen in the water, the more organic matter is in the water.

Concentrations of biogenic materials are found in samples of surface wastewater in order to assess the amount of biodegradable material that reaches the surface water bodies in surface wastewater. The total carbon concentration in samples that were sampled in 2014 January ranged from 12.76 to 55.81 mg/l. The highest concentration (55.81 mg/l) was measured in the sample, which was taken from surface wastewater discharger (4 sampling site, discharger).

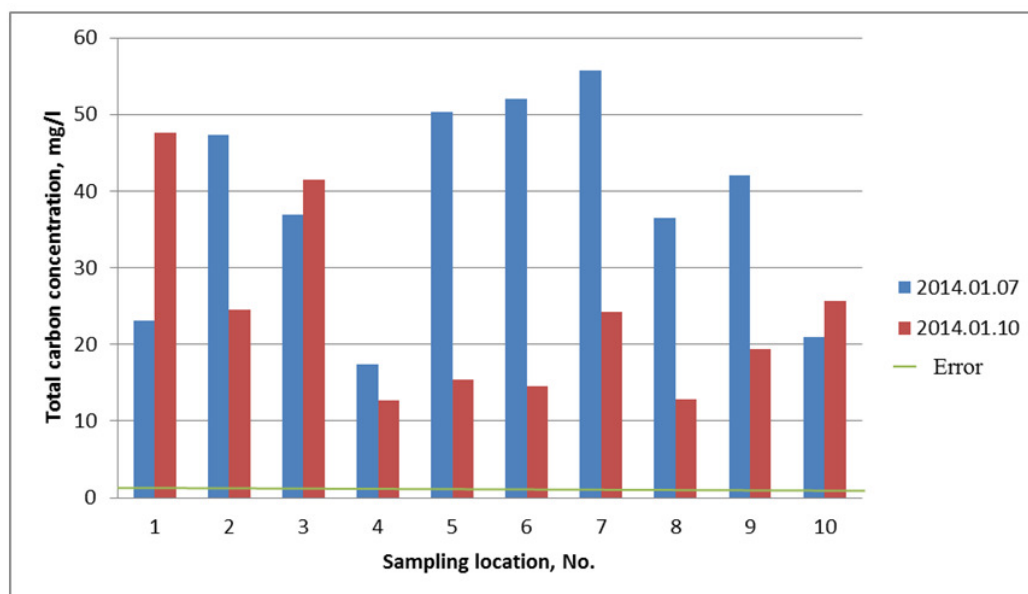


Fig. 4. Total carbon concentration in the surface wastewater in northern part of Vilnius city

Total nitrogen concentration in the surface wastewater samples, which were taken in 2014 January ranged from 0.25 to 8.46 mg/l. The highest concentrations were found in surface wastewater discharger (4 sampling point, discharger). Total nitrogen concentration in surface wastewater samples, that were taken from impervious surfaces and surface wastewater dischargers in the northern part of Vilnius city did not exceed 20 mg/l.

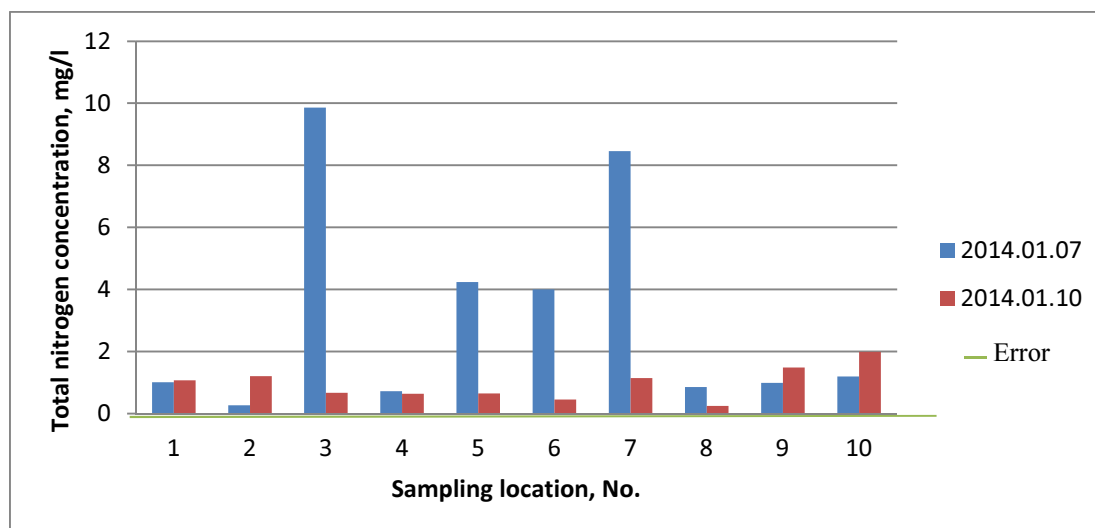


Fig. 5. Total nitrogen concentration in the surface wastewater in the northern part of Vilnius city

Amount of oil products was studied in samples that were taken in 2014 January. Oil concentrations in surface wastewater samples were set:

- 1-st surface wastewater discharger 0.12 mg/l;
- 1-st sample from impervious surface (Valakampiai bridge) 3.03 mg/l;
- 2-nd sample from impervious surface 3.00 mg/l;
- 4-th discharger 1.30 mg/l;
- 5-th sample from impervious surface 1.81 mg/l.

Permissible concentration of oil products, according to the Republic of Lithuania surface wastewater regulations, in surface wastewater is 7 mg/l. In samples that were tested for oil concentration, the allowable concentration of oil products has not been exceeded. In the investigated samples the highest oil concentration (3.03 mg/l) was found in the sample, which was taken from the bridge of Valakampiai (1-st sample from an impervious surface).

Taking into account the surface wastewater oil pollution in the past six years (2008–2013 m.) the maximum measured pollution level was found during the winter and was 12 mg/l. Average oil pollution during the cold time of the year is 1,69 mg/l [12]. Oil pollution levels in Radviliškis town in 2010 were measured in controlled surface wastewater dischargers: maximum level of surface wastewater pollution with oil products amounted to 0.49 mg/l. In Vilnius city, the biggest oil pollution level was found to be 3.03 mg/l. Found pollution in Vilnius city is 6.18 times bigger than in Radviliškis town.

Biochemical oxygen consumption was studied in samples that were taken in 2014 January. BDS5 in samples ranged from 0 to 79 mg/l. The maximum established biochemical oxygen demand in 5 days is found in the sample, which was taken from the bridge of Valakampiai (1st sample from an impervious surface).

6. Conclusion

1. The maximum concentration of suspended solids (360 mg/l) was observed on the impervious surface (Valakampiai bridge). The permissible concentration of suspended solids in surface waste water discharged into the environment is 50 mg/l [13].

2. During the cold time of the year with a positive environmental temperature, surface wastewater pollution with suspended materials and oil products was considerably higher than that of the samples that were tested during negative temperature cold season.

3. Concentrations of biogenic materials that enter surface water bodies during the period does not exceed the maximum allowable concentrations in wastewater in Lithuania (20 mg/l total nitrogen concentration). Surface water pollution with biogenic materials did not have a significant impact.

4. The biggest surface wastewater pollution was found in a sample taken from the bridge of Valakampiai (sample number. 2). Here, in comparison with other samples of surface wastewater, the maximum concentration of suspended solids, biogenic materials and oil levels, as well as the pH value of this sample is the highest of all samples. Most likely, this is due because the Valakampiai bridge has the largest automobile traffic intensity (compared to the other locations of sampling points from impervious coatings). It is necessary to apply a surface wastewater treatment equipment in these basins.

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