POLLUTION OF SHOKARSKI STORMWATER CANAL AND ITS INFLUENCE ON THE QUALITY OF THE VARNA BLACK SEA COASTAL AREA, BULGARIA

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ABSTRACT.- Pollution of Shokarski stormwater canal and its influence on the quality of the Varna Black Sea coastal area, Bulgaria. In the present study was investigated the pollution of Shokarski stormwater canal, discharging its water into the Varna Black Sea coastal area. Monitoring was carried out during 2011 year at 5 sites along the canal water flow. The pollution was determined by organoleptic and physico- chemical characteristics, nutrients concentrations and the organic load. Critical levels of dissolved oxygen were measured at some of the monitoring sites ranging from 0,65 to 2,79 mg/dm^3. Ammonium and nitrite concentrations were above the threshold limits at all sites. The phosphates' concentrations varied very dynamically ranging from 0,18 to 11,8 mg/dm^3 and in most of the cases exceeded the threshold limit. Very high levels of biochemically degradable organic pollutants were determined with biochemical oxygen demand values reaching- 68,96 mg/dm^3. The Shokarski canal pollution could be considered as a tremendous thread for the quality of the Varna Black Sea coastal area, Bulgaria.

Keywords: stormwater canal, pollution, threshold limits, Varna Black Sea coastal area, Bulgaria

1. INTRODUCTION

Stormwater runoff from urban areas is one of the leading sources of surface water pollution (Dwight et al, 2002); (Walsh, 2000); (Paul and Meyer, 2001); (Gnecco et al, 2005). Rivers, streams, canals, lakes and oceans are the basic receptacles for every kind of pollution with consequences including human health risk, ecosystem disturbance and aesthetic impact to water resources. Some quantities of the stormwater runoff drain into a sanitary sewage system or separate storm sanitary system but large amounts flow directly to the surface water as a nonpoint source pollution (Carpenter et al, 1998); (Taebi and Droste, 2004). Pollutants running off from urban areas are difficult to be monitored and regulated because they ultimately arise from a multitude of activities and are variable in time because of the effects of weather (Duncan, 1999). This is the reason to consider the

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strormwater pollution as one of the greatest threats to the water quality in most of the industrialized countries.

The stormwater pollution is a serious problem of Varna town which is the biggest marine town in Bulgaria. There are 6 big stormwater canals on the territory of Varna designed to drain the stormwater runoff separately from the sanitary sewage system (Gerasimov and Jelev, 1998). These canals are main receivers of the urban runoff, unregulated sewage water and wastes from various activities and are discharging their water directly into the Varna Black Sea coastal area without any purification.

One of the biggest stormwater canals on the territory of Varna town passing through densely populated areas and receiving the water flow from several mid-size canals is Shokarski canal.

The aim of the present research was to determine the pollution of the Shokarski canal and its influence on the quality of the Varna Black Sea coastal area.

2. MATERIAL AND METHODS

Investigations were carried out from May to November- 2011 year at five monitoring sites along the Shokarski canal. The first and the second sites were situated on the upper part of the canal at the highest elevation. The first site (site 1) was located at the most distant area from the sea coast, in a region with very diverse human activities as gas stations, car wash, repair workshops, meat processing plant etc. The second site (site 2) was located on the territory of the Technical University-Varna. The third site (site 3) was situated above the point where the water of a mid-sized canal is mixing with the water of the Shokarski canal. The fourth site (site 4) was near the Varna Black Sea coast and the fifth site (site 5) was the nearest to the coast. Site 5 was situated at the lowest elevation next to the water discharge of the Shokarski canal into the Varna Black Sea.

The pollution of the Shokarski canal was assessed with reference to the following indices, which have a determining role over the Black Sea coastal water quality: organoleptic; chemical reaction (pH); Dissolved Oxygen (DO); nutrients' content - ammonium nitrogen, nitrite nitrogen, nitrate nitrogen, phosphates; organic contaminants- Biochemical Oxygen Demand (BOD_5), Chemical Oxigen Demand (COD).

The analyzes of the a.m. indices were carried out in the "Water quality control" laboratory, department of "Ecology and Environmental Protection" at Technical University of Varna- Bulgaria, applying standardized methods.

The results from the five monitoring sites were compared with the threshold limits for the quality of the surface water (National Regulation No. 7/1986) and the threshold limits for the quality of the coastal sea water (National Regulation No. 8/2001).

3. RESULTS AND DISCUSSIONS

Investigations of the Shokarski stormwater canal organoleptic indices were carried out with reference to color and smell of the water. The water color varied from colorless at sites 3, 4 and 5 to yellow - brownish at sites 1 and 2. Highest coloring was recorded at sites 1 and 2 where 40-50 color degrees were reached. The yellow - brownish coloring of the water was probably due to contaminants of mineral origin such as sand, clay and soil. The smell could be characterized as swampy, saprogenic and fecal which is typical for sewage water. Hydrogen sulfide smell was recorded at sites 1 and 2 during the warmer months which showed that probably decaying of organic pollutants was undergoing. The intensity of smell varied from 0 to 5 grades. High intensity of smell was determined at all sites during July. July was the month with the highest temperatures and the smell was more noticeable. Maximum values of 5 grades smell intensity were reached again at sites 1 and 2. Having in mind the results of the organoleptic indices the monitoring sites 1 and 2 exhibited highest contamination.

The chemical reaction (pH) of the canal water was neutral and weak alkaline ranging from 6,9 до 8,0 pH in compliance with the surface water standards.

The DO content varied from very low, critical values to very high. The lowest concentrations of DO were measured at site 1 and 2 ranging from 0,65 to 2,79 mg/dm^3 below the threshold limit for II category surface water (O_2 threshold limit for II category - 4 mg/dm^3) (National Regulation 7/1986) (fig. 1).

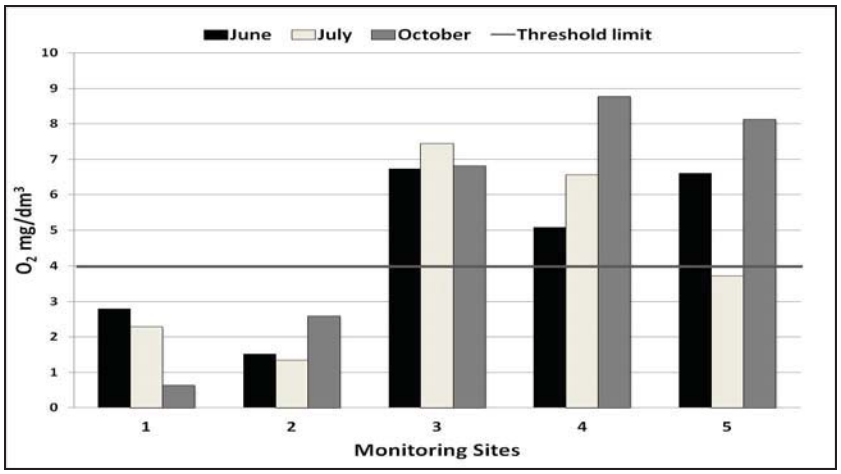

Fig. 1. ***Measured concentration of DO in Shokarski stormwater canal, 2011 year***

According to the National Regulation No. 7 the surface water is classified in three catergories- Ist , IInd and IIIrd. Bearing in mind that the Varna Black Sea coastal water is classified as IInd category surface water body the values of the different indices along the Shokarski canal water flow were compared with the II nd category threshold limits.The lowest levels of DO at sites 1 and 2 were favorable

for saprogenic processes which could explain the hydrogen sulfide smell and the highest intensity of the smell at these sites.

Sites 3, 4 and 5 were characterized with very good oxygen levels for the whole monitoring period. Highest concentrations were measured at sites 4 and 5 in October- 8,78 mg/dm^3 and 8,13 mg/dm^3 respectively. October was the month with the lowest water temperatures which could explain the highest oxygen concentrations. Another reason for the highest DO concentrations might be the topography of the investigated area where sites 4 and 5 were situated at the lowest elevation. This accelerated the water flow and respectively the water aeration.

Regarding the ammonium nitrogen pollution very high concentrations, above the threshold limit for II category water body were measured at all monitoring sites (NH_4^+ threshold limit – 2 mg/dm^3) (fig. 2).

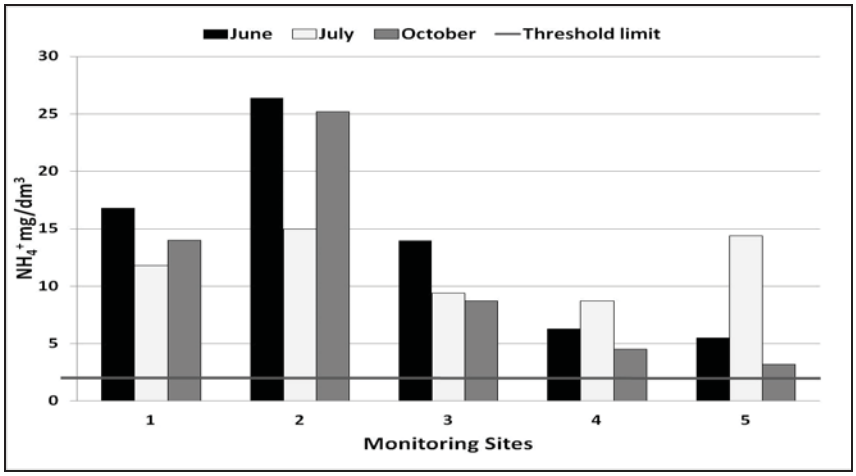

Fig. 2. ***Measured concentration of NH_4^+ in Shokarski stormwater canal, 2011 year***

The highest ammonium concentrations were recorded in June at sites 1 and 2 - 16,8 mg/dm^3 and 26,4 mg/dm^3 respectively which were 8 and 13 times above the limit. Lower concentrations of NH_4^+ were measured during October at sites 4 and 5- 4,5 mg/dm^3 and 3,2 mg/dm^3 exceeding the limit 2 times and 1,6 times respectively. Clear link between ammonium and DO concentrations was observed. At the sites with the highest ammonium levels (sites- 1, 2) were registered the lowest DO levels.

The nitrite nitrogen concentrations repeatedly exceeded the threshold limit varying from 0,20 до 0,66 mg/dm^3 (fig. 3). The highest concentrations were recorded at sites 4 and 5 during the summer months. During July were measured 0,62 mg/dm^3 nitrite concentrations at site 4 and 0,66 mg/dm^3 at site 5 which were 16 – 16,5 times higher than the limit (NO_2^- threshold limit - 0,04 mg/dm^3)

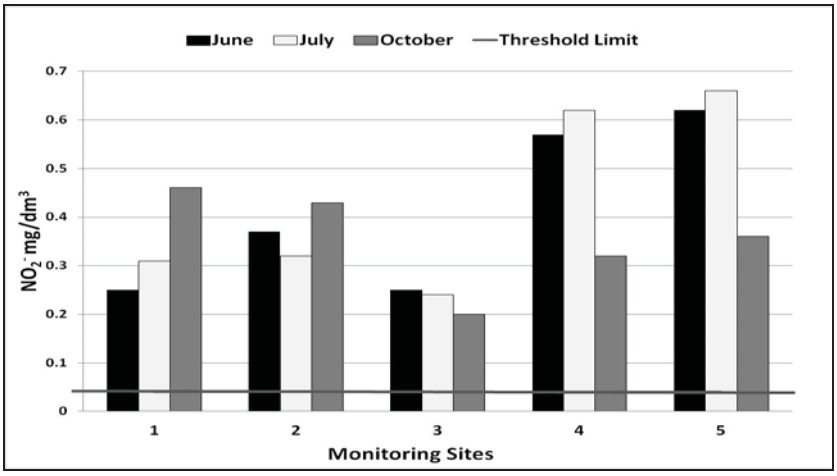

Fig. 3. ***Measured concentration of NO_2^- in Shokarski stormwater canal, 2011 year***

The nitrate nitrogen values were below the threshold limit at all monitoring sites during the whole period varying from 1,1 to 3,5 mg/dm^3 (NO_3^- threshold limit – 10 mg/dm^3). In most of the cases the nitrates concentrations were lower at the monitoring sites where the nitrite and ammonium concentrations were higher. The results showed that the nitrification processes were strongly disturbed and incomplete.

Phosphates' concentrations varied very dynamically through the whole monitoring period- from 0,18 to 11,8 mg/dm^3 and in most of the cases exceeded the threshold limit (fig. 4).

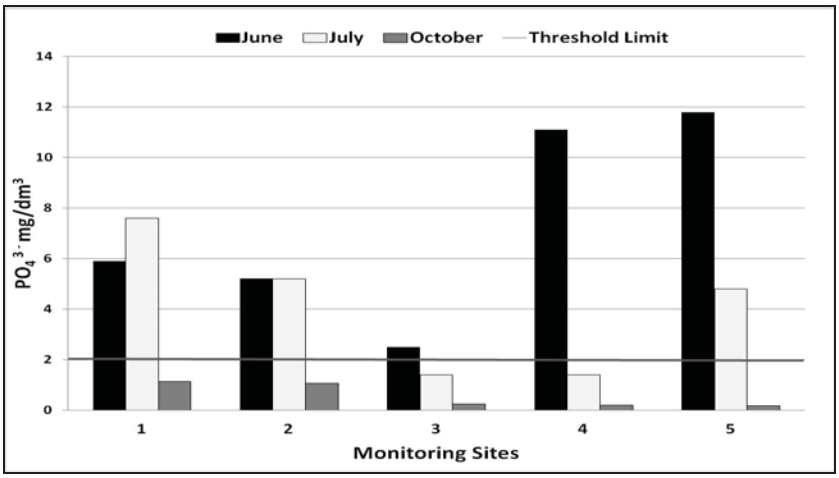

Fig. 4. ***Measured concentration of PO_4^3 in Shokarski stormwater canal, 2011 year***

Higher concentrations were measured in June and July in most of the cases and considerably low in October. The highest phosphates' concentrations were

measured in June at sites 4 and 5- 11,1 and 11,8 mg/dm^3 respectively which were 6 times higher than the limit (PO_4^3 threshold limit – 2 mg/dm^3).

The levels of the organic contamination were determined by the indices BOD_5 and COD. The highest levels of organic contamination were registered again at sites 1 and 2 through the whole monitoring period. The BOD_5 concentrations varied from 4,08 to 68,96 mg/dm^3 (fig. 5) and COD concentrations varied from 32 до 223 mg/dm^3 (fig. 6). The highest BOD_5 concentrations were measured in June at site 2- 92,36 mg/dm^3 exceeding the threshold limit - 6 times; at site 1- 68,96 mg/dm^3 exceeding the limit 5 times and at site 5 - 65,095 mg/dm^3 exceeding the limit 4 times (BOD_5 threshold limit – 15 mg/dm^3).

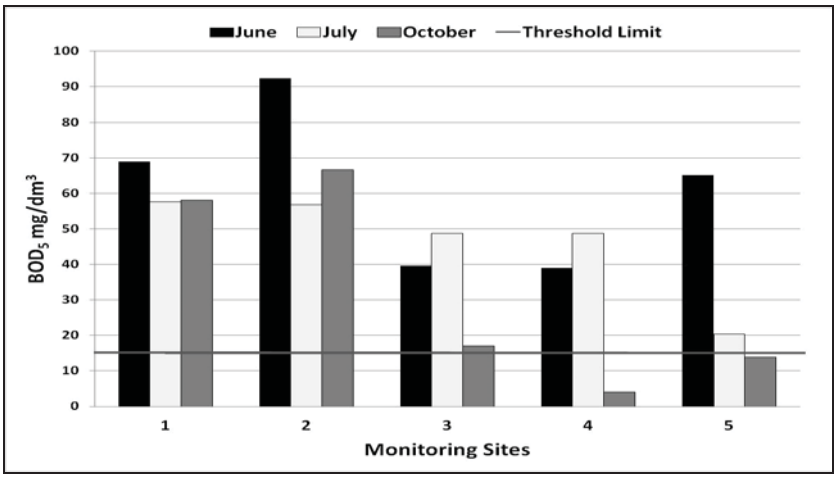

Fig. 5. ***Measured concentration of BOD in Shokarski stormwater canal, 2011 year***

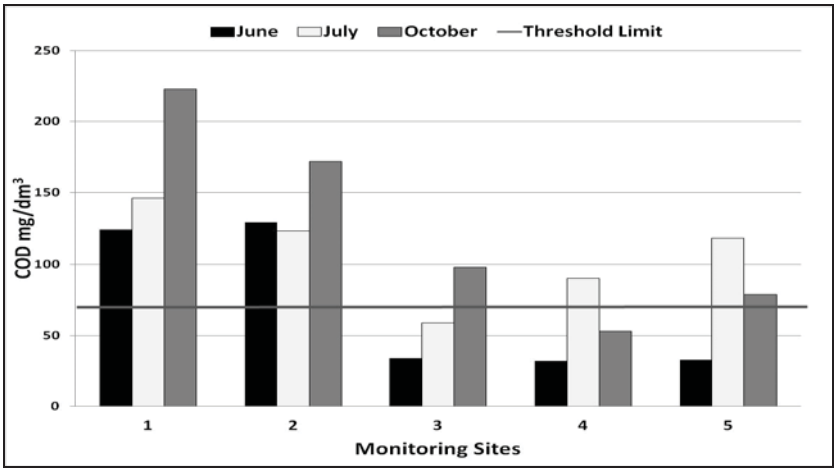

Fig. 6. ***Measured concentration of COD in Shokarski stormwater canal, 2011 year***

The highest COD concentrations were measured at sites 1 and 2 during October - 223 and 172 mg/dm^3 respectively (COD threshold limit – 70 mg/dm^3). The ratio between COD and BOD_5 indices was significantly higher than 1 which exhibited very high stability of the organic pollutants towards biochemical destruction. The COD and BOD_5 ratio at site 1 was 1,79 in June; 2,5 in July and 3,8 in October. However, the concentrations of the biodegradable pollutants were very high.

Bearing in mind the analyses of the Shokarski canal indices the following tendencies were outlined for the whole monitoring period: highest contamination at sites 1 and 2, lowest concentrations of the pollutants at site 3 and higher contamination at sites 4 and 5 - the nearest to the Varna Black Sea coastal area. The highest contamination at sites 1 and 2 could be explained with the diversity of anthropogenic activities around and the unregulated sewage discharges in the canal. The lowest concentrations of the pollutants at site 3 were probably due to the water self- purification, facilitated and accelerated by variety of abiotic factors in this section of the canal. The higher levels of the pollutants at sites 4 and 5 could be a result of the mixing of the Shokarski canal water with the water of another mid-sized canal discharging probably additional pollutants.

Generaly the Shokarski canal stormwater was assessed as highly contaminated comparable with sewage water. Most of the values of the investigated indices were repeatedly above the threshold limits regarding the surface water.

In order to determine the influence of the canal on the quality of the Varna Black Sea coastal water, the concentrations of the pollutants at site 5 (the nearest to the coast) were compared with the threshold limits for coastal sea water (National Regulation 8/2001) (table 1).

Table 1. Measured values of DO, nutrients and BOD_5 at monitoring site 5, 2011 year

Indices	**Threshold limits for coastal water**	**Measured values, mg/dm^3**		
		June	**July**	**October**
O_2	6,2	6,60	3,73	8,13
NH_4^+	0,1	5,5	14,4	3,2
NO_2^-	0,03	0,62	0,66	0,36
NO_3^-	1,5	2,5	2,2	4,0
PO_4^{3-}	0,1	11,8	4,8	0,18
BOD_5	6,0	65	20,34	13,84

The results showed extremely high concentration of all pollutants for the whole monitoring period. The ammonium nitrogen was exceeding the limit for

coastal water from 32 to 144 times. The nitrite nitrogen concentrations were from 12 to 22 times above the limit. The nitrate nitrogen levels were above the limit for coastal water (1,6 - 2,7 times higher). The phosphates' concentrations were exceeding the limit- 118 times in June and 48 times in July. Only in October the phosphates were comparable with the limit. The BOD_5 concentrations were reaching concentrations from 2 to 11 times above the limit. The DO concentrations (excluding the values measured in June) were in compliance with the coastal water standards.

4. CONCLUSION

The water chemistry of the Shokarski canal was characterized with worse organoleptic indices and critical DO levels especially in the upper part of the canal; considerably high concentrations of the most of the nutrients and very high organic contamination at all monitoring sites.

Generally the Shokarski stormwater canal exhibited very high levels of pollution and could be considered as a tremendous thread for the quality of the Varna Black Sea coastal area.

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