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Contamination of sediments in Varna Lake and Varna Bay

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Abstract Varna Bay is one of the hot spots along the Black Sea coastal zone. Its ecological state is strongly influenced by the connection with the Varna Lake. Along the lake coast are located many sources of pollution such as rivers, ports, chemical industry, WWTPs. The shipping is another pressure on the environment.

The study was carried out in the western part of the Varna Lake and Varna Bay. The following parameters: heavy metals, polichlorinated biphenyls, chlororganic pesticides, phenols, petroleum hydrocarbons were analysed in sediments. The high content of the last one is indicative for an extremely unfavourable long-year exploitation of the lake as a water route. The metals concentration in lakes sediments shows the influence of anthropogenic inputs. Comparative analysis of the sediments shows higher concentrations of contaminants in Varna Lake. and near the ports. As a consequence of the worsened state of the bottom a very poor benthic community characterizes a part of the investigated area in the lake.

Keywords Black Sea; hydrocarbons; metals; PCBs; pesticides; phenols, sediments; Varna Lake

Introduction

Varna Lake is the biggest lake on the Bulgarian Sea coast with a volume of about 165.10^3 m^3 covering an area of 17.4 km^2 . It is connected to the Beloslav lake and Varna Bay via access canals of ~ 12–14 m depth. The system Beloslav Lake–Varna Lake–Varna Bay is one of the areas along Bulgarian Black Sea coast strongly affected by human activities (Konsulova, 1992; Rozhdestvensky, 1992; Shtereva, 2003). The lake is exposed to the indirect influence of the Provadiyska river flowing into the Beloslav Lake. Besides, there is considerable influence of local coastal sources such as: several ports, Thermal Power Station (TPS) "Varna", inflow of water from Waste Water Treatment Plant (WWTP) and a large number of industrial enterprises.

The changes in lake chemistry as a result of industrial and urban processes, have been discussed in a number of works (Rozhdestvensky, 1967, 1992; Andreev, 1984; Stoyanov, 1991). In recent years, the subject of research studies was not only the basic hydrochemical parameters, but also the content of toxic substances in different phases of the lake environment. These results help us to evaluate the influence over biota and negative consequences of increased eutrophication and contamination (Velikova *et al*., 1999; Shtereva *et al*., 2000; Konsulova *et al*., 2000). Some authors present data about an accumulation of the metals in soils and plants in surrounding coastal area (Bekyarova, 2002). There are several papers on metals and TPH in water and surface sediments. However, for organic pollutants, information is lacking on distribution patterns in sediments.

Methods

The study was carried out at 3 stations in the Western part of the lake as follows: Station 1 (VL-1) in the area of TPS port, Station 2 (VL-2) at the fairway at the opening of canal connecting the two lakes and Station 3 (VL-3) situated eastward to St. 1 and St. 2. The fourth Station (VB) is situated in Varna Bay, in front of the mouth of the canal, connecting Varna Lake to the bay. The samples of sediments are collected by vibrocorer providing a core with $D = 110$ mm and $L = 4$ m). The material from each of horizons (0-1 m; 1-2 m; 2-3 m) was well homogenized before analysis. Polichlorinated biphenyls (PCBs) and chlororganic

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pesticides were determined using GC Perkin Elmer 8310 with electron-tripping detector and capillary column, following quantitative extraction from samples with n-hexane and phenols – by GC-FID after extraction with ethylacetate. The sediment samples were analysed: for metals by atomic absorbtion spectrometry (AAS) and for Total Petroleum Hydrocarbons (TPH) by IR spectrometry.

Results and discussion

The contamination of the water column was discussed in Shtereva (2001).

The results of grain-size analysis showed a predominating fraction 0.005-0.1 mm (60-86% for Varna lake and 52% for Varna bay in 0-1 m layer). The sediments under 1 m are characterized with higher percentage (>76%). Only in VB station is the value 35% and an increase in the part of fraction 0.1–2.0 mm is observed (44–60%). The finest fraction is established at station VL-2 (Dachev and Shterev, 1998).

The concentration of each of 13 congener PCBs were below the detection limit (DLM). For most of them DLM is 0.015 μg/kg and only for tetrachlorobiphenyl – 0.020 μg/kg. Due to the toxic effects of organochlorines in human and aquatic organisms, the use of most organochlorine pesticides has been banned and restricted. The results reveal the content of pesticides below DLM, which is as follows: for DDT, DDD, DDE, Methoxychlor – 0.009 μg/kg; for endrin, aldrin, dieldrin – 0,006 μg/kg, for hexachlorcyclohexanes (HCHs) – 0.004 μg/kg. Both of them (α-HCH and β-HCH) were not detected. At all stations γ-HCH appears as the dominant isomer. Lindane registered high content in the port-TPS area (0.52–0.66 μg/kg dry weight) and at st.VB (60 μg/kg). The lowest value (37 μg/kg) was measured at the eastern station of the lake (VL-3). A high percentage of γ-isomer in sediments from the Romanian coast was recorded by Readman *et al*. (2000).

The TPH contamination in Varna Bay surface sediments was more than 2 times higher than that in the lake but in sediments below 1 m TPH were not detected (Figure 1).

This could be attributed to a more active transport on a limited area, and to the proximity of Port "Varna-East" and "Oil" Port. All vessels cross this part of the bay independently of the destination of the port where the vessels arrive. This fact and the presence of TPH in the lower sediments reveal a disturbing trend to accumulation. Higher concentrations also have been measured in the surface layer of port sediments (Shtereva *et al*., 2000). For example TPH in Varna-port were 6,300 mg/kg during the previous study. This fact is indicative of an extremely unfavourable long-year exploitation of the lake as a water route. Conducting of strict control over the transfer of oil-polluted water by the vessels is very important for the protection of the marine/lake environment. The distribution of phenols reveals comparable concentrations in Varna bay and st. VL-2 (Figure 1) but the highest content is found in the 0–2 m layer of lake sediments at st.VL-3.

Metals are characterized by the following order of spreading: Zn > Cu >Pb, Ni >Cr >As >Cd, Hg. Zinc predominated in agreement with published data. The accumulation rate is higher for Cr and Cu than for As and Zn (Andreev, 1988). The highest metal contents in

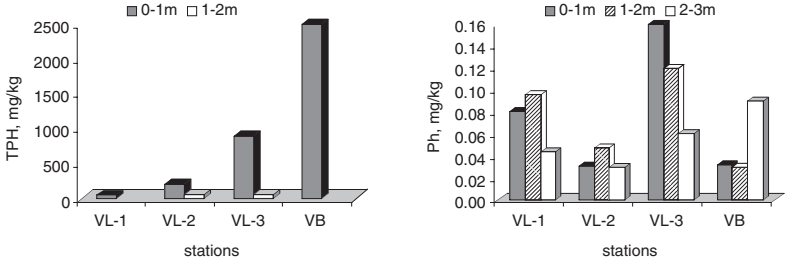

Figure 1 Distribution of TPH and phenols in sediments of Varna Lake (VL1, VL2, VL3) and Varna Bay

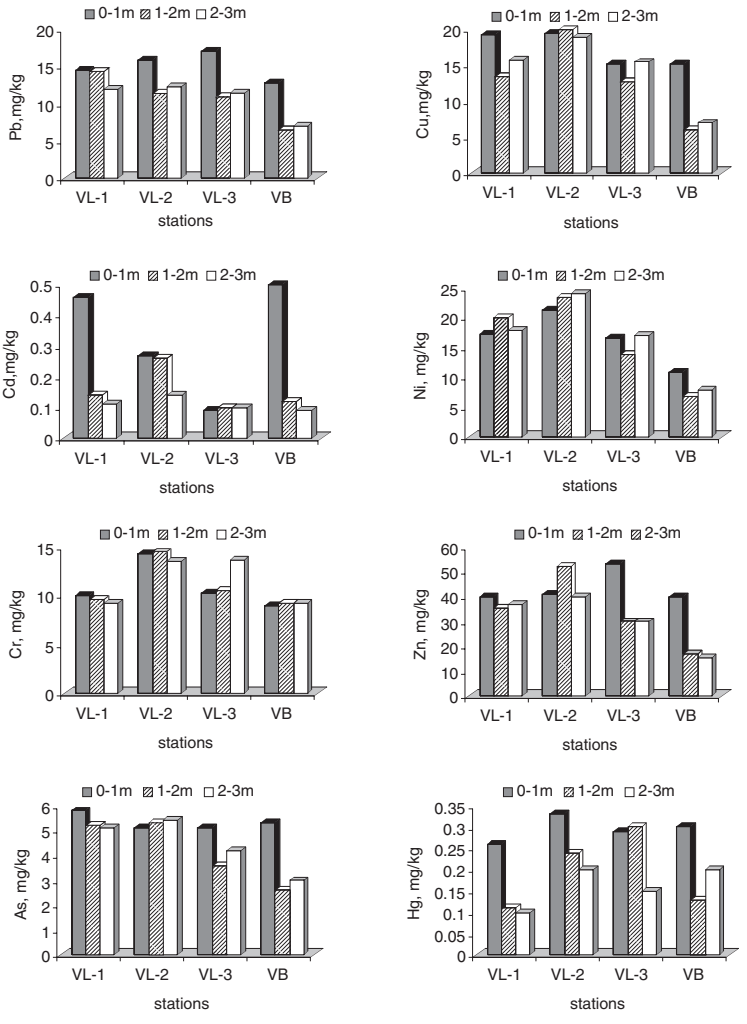

Figure 2 Distribution of metals in sediments of Varna Lake (VL1, VL2, VL3) and Varna Bay

sediments are lower in VB station than in Varna Lake (Figure 2). Similar improvement in the tendency of macrozoobenthic communities ecological status moving from the Western to Eastern part of the area was established. The sampled area in front of the TPS is a dead zone (Trayanova and Stefanova, 2002). Here was the maximum of As in all horizons. According to Konsulova *et al*. (2000) the investigated area of Varna Lake is characterized by a very poor benthic community.

Probably, the complex impact of metals and other pollutants influences the ecological state of the bottom. The results for benthic fauna showed a level of environmental stress.

As evident from the figures, the station VL-2 is influenced by current from Beloslav Lake. Maximal content of most metals not only for 0–1 m, but for the whole investigated sediment layer was measured here. A typical natural property of the fine-grained sediments of the West part of the lake (VL-2) is their relatively high content of elements such as Cu, Cr, Ni, Zn. It is suggested that the potential toxicity to aquatic ecosystem could be caused by the fine sediments.

Conclusions

Varna Lake is not polluted with PCBs and Cl-pesticides. The metal content in surface sediments collected in Varna Lake showed the influence of anthropogenic inputs. The results obtained revealed that the intensity of ship traffic is an important factor for TPH contamination in the lake environment. In this respect, the obtained information for the lake sediments could be useful in the event of the restructuring, widening of ports, digging of navigation canals, while taking into account the possible transfer of pollutants in water. The contaminated sediments could be dangerous during dredging operations and transportation, when the pollution could be spread in the environment and affected areas, where it was not observed. This issue is especially serious for the investigated area because of the link between the lake and the bay, and the worsened quality of seawater, respectively.

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