

## **APPROPRIATENESS OF THE BIOLOGICAL MONITORING FOR POLLUTION DETERMINATION OF THE RIVER VARDAR BY HEAVY METALS**

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**Abstract.** The river Vardar, as a major watercourse in the Republic of Macedonia, is a possible transfer medium of transboundary pollution. The authors of this paper are in opinion that the water quality monitoring performed by two famous state institutions is not sufficient for providing authentic data on the intensity and space distribution of the pollution by heavy metals in the river ecosystem. This is the reason why in this paper is elaborated a practical application of biological monitoring related to the presence of heavy metals in the living fish population, caught several weeks after a serious accident of fish poisoning in the river Vardar. It is concluded that for this purpose the most appropriate measure to introduce a continuous monitoring of the living world's condition in the aquathorium of the river ecosystem.

**Keywords:** biological monitoring, heavy metal pollution, river Vardar.

### **AIMS AND BACKGROUND**

The river Vardar rises in the Shar Mountains, near the village of Vrutok at altitude of 683 m. Its riverbed passes through five valleys – the valleys of Polog, Skopje, Veles, Tikvesh and Gevgelija. Of its total length of 420 km, 300 km are in the Republic of Macedonia. South of the town of Gevgelija, at altitude of 44 m a.s.l. it enters into Greece and flows into the Gulf of Salonika of the Aegean sea.

Along its flow in the Republic of Macedonia, it receives communal wastewaters from settlements with very high population density, as well as wastewaters from the main industrial and mining capacities in the country.

The water quality monitoring along the watercourse of river Vardar is performed once per month. According to the average annual values, the concentrations of all monitored heavy metals at the last sampling spot in Gevgelija are within the limits prescribed for II class of water.

Still the authors of this paper believe that this monitoring can not provide sufficiently authentic data on the intensity and space distribution of the pollution by heavy metals in the river ecosystem. This is due to the fact that there is no automatic water sampling system at the existing sampling spots that would provide continuous control of the water quality.

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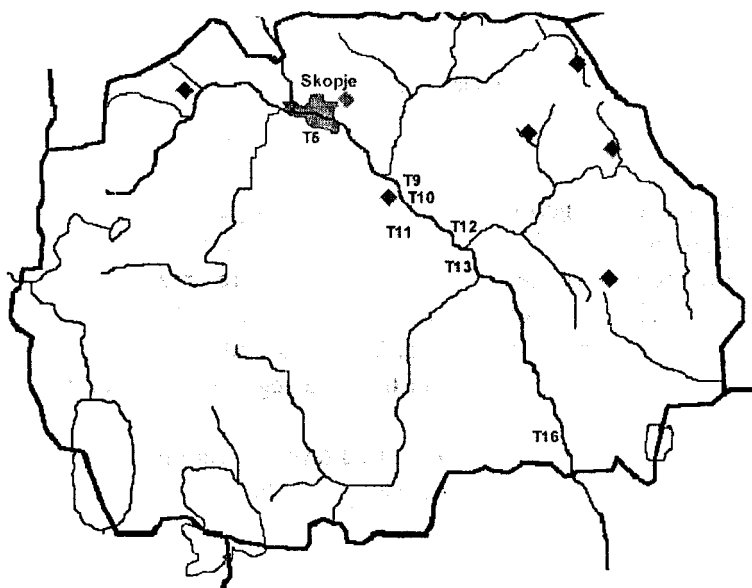
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The investigations that were performed after the accident of fish poisoning in the river Vardar in September 1997 in the vicinity of city Veles will support this assessment.

## RESULTS AND DISCUSSION

The river Vardar pollution by heavy metals is caused by acceptance of communal and industrial wastewaters, wastewaters from landfills of technogenous solid waste, as well as from atmospheric and irrigation waters that rinse the contaminated soil. Thus, the river Vardar may appear as an eventual carrier of transboundary pollution.

The State Hydro-meteorological Institute and the Institute of Biology at the Natural-mathematical Faculty from Skopje perform water quality monitoring at 16 sampling spots along the watercourse of Vardar. The relevant sampling spots and the main sources of pollution by heavy metals are given in Fig. 1.



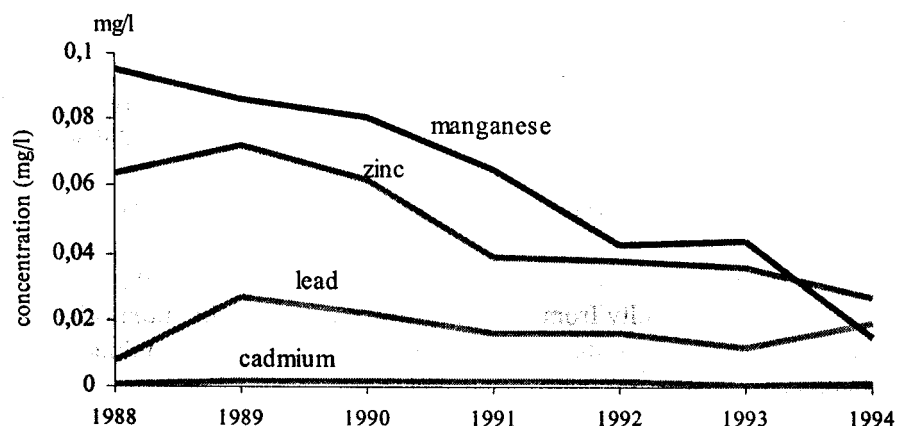
**Fig. 1.** Location of sampling spots and heavy metal pollution resources

Source: National Environmental Action Plan – Analyses and Estimation of the Conditions and the Solid Waste Management

Note: Sampling spots: T5 – Skopje, T9 – Bashino Selo, T10 – Veles, T11 – Post r.Babuna , T12 – v. Nogaevci, T13 – Staro Gradsko, T16 – Gevgelija

Sources of heavy metal pollution (◆): jugohrom, steel works, lead and zinc mines, zinc and lead smelter “Zletovo”, fertilizer plant, gold mine “Buchim”

In accordance with the average annual values at the last sampling spot in Gevgelija, the concentrations of all monitored heavy metals, except manganese, are within the limits prescribed for II class of water. This could be seen in Fig. 2.



**Fig. 2.** Concentrations of heavy metals at the last sampling spot in Gevgelija  
 Source: National Environmental Action Plan – Quality of Waters, 1994  
 Note: In accordance with the state regulation, the maximum permitted levels for II class of waters are: cadmium 0.005 mg/l; lead 0.05 mg/l; zinc 0.2 mg/l; and manganese 0.05 mg/l

Long years of investigations show that the most polluted by heavy metals is the middle flow of the river, right beneath the city of Veles. The city of Veles suffers from acute environmental problems, which are created both by uncontrolled industrial discharges of the local zinc and lead smelter “Zletovo”. As a result, serious contamination of the river Vardar is evident.

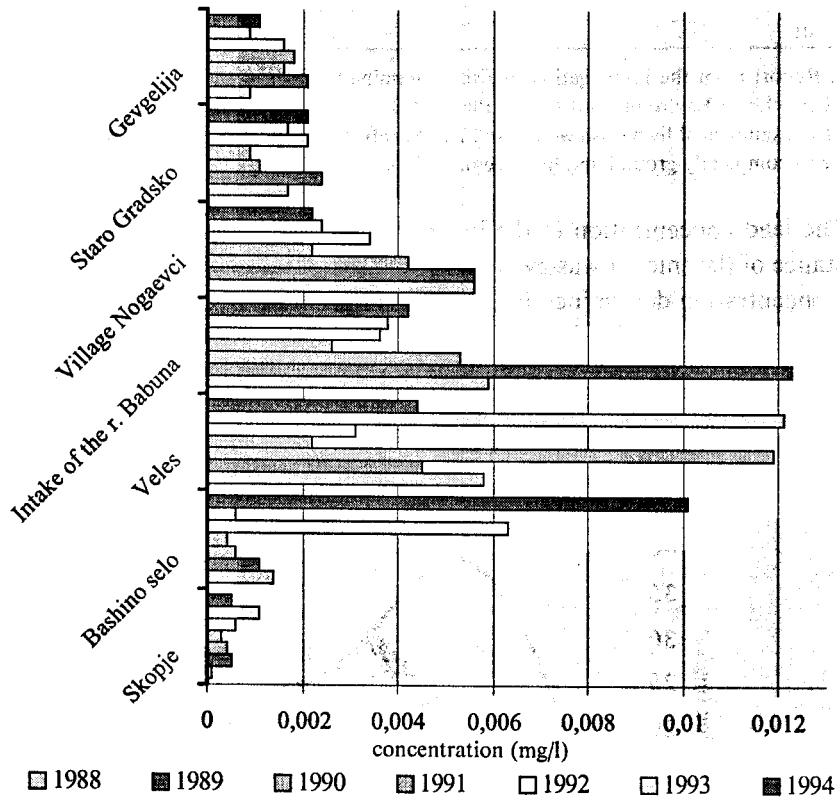
This condition could be seen from the data regarding the pollution by cadmium given in Fig. 3.

It could be concluded that the permitted level for cadmium concentration is mostly exceeded in the vicinity of Veles, while at the last sampling spot in Gevgelija it is within the permitted level.

However, the real condition is not so favourable due to the fact that: (a) there is no automatic water sampling system; (b) there are big oscillations of the river flow intensity and accepted wastewaters; (c) the quality and form of the emitted heavy metals vary a lot during the time.

Persistent in the aquathorium is only the living world, which can provide the most authentic data on the intensity and space distribution of the pollution by heavy metals in the river ecosystem. This is the reason why in this paper is elaborated the investigations made on living fish population, caught at few spots along the river, near the accident spot of fish poisoning in the river Vardar in September

1997. It was proved that letting out insufficiently treated wastewaters from the local smelting complex provoked the accident. In the examples of dead fish was found lead concentration of 0.8 mg/kg, mercury concentration of 25 mg/kg, zinc concentration of 22 mg/kg, cadmium concentration of 0.02 mg/kg, etc<sup>1</sup>. Few weeks later investigations were made on living fish population, caught at four spots along the river in line of 15 km. The results, which are given in Table 1, are formidable.



**Fig. 3.** Cadmium concentrations along the watercourse of Vardar  
 Source: National Environmental Action Plan – Quality of Waters, 1994  
 Note: The maximal permitted levels for cadmium is 0.005 mg/l for I and II class of water and 0.01 mg/l for III and IV class of water  
 The water classification at the sampling spots Skopje, Bashino Selo and Gevgelija is according to I and II class of water, and at the sampling spots Veles, the intake of river Babuna, village Nogaevci and Staro Gradsko according to III and IV class of water

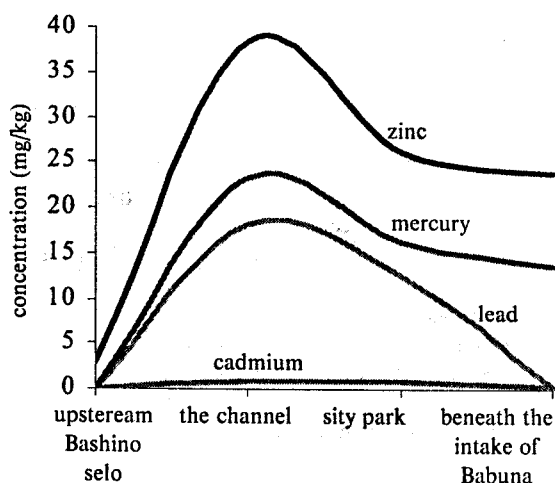
**Table 1.** Heavy metals in the bodies of living fish (mg / kg)

Examined parameters	Maximal permitted level	Spot of taking living fish examples			
		Bashino selo	the channel	city park	post r. Babuna
Lead	0.01	0.01	18.2	12.5	0.19
Zinc	15	3.0	38.3	26.1	23.8
Mercury	0	0	23.1	16.2	13.5
Cadmium	0.3	0	0.9	0.8	0.4

Source: Report from the investigation of fish contamination by heavy metals, caught in Veles in September – Local Environmental Action Plan, 1998

Note: The examples of living fish were taken 20 days after the accident. The results from the analyses refer to completely ground and homogenized fish.

The lead concentration in the living fish population caught in the region of acceptance of the smelter wastewater channel, was 23 times higher than the analogous concentration determined in the time of the accident in the dead fish bodies. The mercury concentration in the living fish was similar to the concentration found in the dead fish and amounted to 23.1 mg/kg. High concentration of mercury, cadmium and zinc were determined in the living fish population caught 10 km downstream the accident spot, beneath the intake of river Babuna. They are only 1.6-2.3 times lower than the ones from the accident spot (see Fig. 4).



**Fig. 4.** Concentration of heavy metals in the living fish bodies caught 20 days after the accident

Source: Agricultural Faculty, Fishery Department – Skopje

Note: High concentration of mercury, cadmium and zinc are noticed in the living fish population caught 10 km downstream the accident spot

Existence of very high concentrations of lead, mercury and cadmium in the living fish points to conclusion that the fish poisoning was caused by other heavy metals that were not investigated in this accident. The assumption of the authors of this paper is that those were the heavy metals thallium, arsenic, and copper that are not regularly investigated by the state institutions in charge. The inappropriate practice of excluding other heavy metals during the regular and accidental investigations is also present in some other important studies related to water contamination, as in the case of the feasibility study *Effluent treatment and monitoring system for MHK "Zletovo"*. This kind of behaviour contributes to making inappropriate assessment of certain ecological problems.

## CONCLUSIONS

The existing monitoring system of water quality in the river Vardar is assessed as insufficient. Therefore, it is necessary to implement automatic water sampling system at the existing sampling spots. At the same time it is also necessary parallel biological monitoring of the living world in the aquathorium to be carried out. In such a way it could provide authentic data on the intensity and space distribution of the pollution by heavy metals and other contaminants in the river ecosystem. This conclusion was approved by the stated example of biological monitoring, elaborated in this paper.

## REFERENCES

1. Local Environmental Action Plan for Municipality of Veles. Agency ATREZ, Skopje, 1998.

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