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## **TEMPORAL EVOLUTION OF THE SURFACE WATER QUALITY IN CENTRAL MACEDONIA, GREECE**

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**Abstract.** The temporal evolution of the surface water quality using systematic measurements in four wetlands (Axios river, Loudias river, Koronia lake and Volvi lake) of Central Macedonia -Greece, during the period 1995-1997, is examined in this paper. The water quality parameters examined by a monitoring network are: dissolved oxygen (DO), conductivity, acidity (pH), redox activity (ORP), water temperature and turbidity. The water quality parameters examined by laboratory analyses are: nitrates (NO<sub>3</sub><sup>-</sup>), sulphates (SO<sub>4</sub><sup>-2</sup>), phosphates (PO<sub>4</sub><sup>-3</sup>), ammonium ions (NH<sub>4</sub><sup>+</sup>), chlorine ions (Cl<sup>-</sup>) and suspended solids (SS).

**Keywords:** water pollution, river water, lake water.

### **AIMS AND BACKGROUND**

The Region of Central Macedonia – Greece includes many wetlands. Two of these wetlands are of international importance and they are protected by the Ramsar convention. The first is a wetland complex including the delta of the rivers Axios, Loudias and Aliakmonas. The second is the total of the lakes Koronia (called also Lagada or Agios Vasilios lake) and Volvi. The Axios river delta has surface 22 000 acres, the lake Volvi has 68 600 acres and the lake Koronia has 46 200 acres<sup>1</sup>.

Axios is one of the greater Balkan rivers, starting from FYROM where is its greater part: 90%. Its length is 380 km but only 70 km are in the Greek territory. The Axios delta is 20 km from the Thessaloniki city and is considered as one of the most important European wetlands. The main water pollution sources of Axios are the urban and industrial wastes from FYROM and Greece and the agricultural activity (mainly fertilisers and pesticides)<sup>2</sup>.

The water use of the lakes Koronia and Volvi is a determinant factor for their quality. It is characteristic that the Volvi's and Koronia's depth was 23.5 m and

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\* For correspondence.

8 m, respectively, in 1980 and reached the 19 m and 1.5 m, respectively, in 1995. The main water pollution sources of these lakes are the urban and industrial wastes and the agricultural activity<sup>3</sup>.

Various parameters for the characterization of the surface water quality of the above mentioned wetlands have been studied in previous works, including transboundary pollution phenomena<sup>4,5</sup>.

The temporal evolution of the water quality using systematic measurements in four wetlands of Central Macedonia — Greece, during the period 1995-1997, is examined in this paper and the results are correlated with those from other related studies.

## EXPERIMENTAL

The values of the water quality parameters in the wetlands: Axios river, Loudias river, Koronia lake and Volvi lake resulted from the surface water pollution monitoring network and the laboratory analyses operated by the Ministry of Macedonia — Thrace<sup>6</sup>.

The water quality parameters examined by the monitoring network are: dissolved oxygen (DO), conductivity, acidity (pH), redox activity (ORP), water temperature and turbidity. The water quality parameters examined by the laboratory analyses are: biological oxygen demand (BOD<sub>5</sub>), chemical oxygen demand (COD), nitrates (NO<sub>3</sub><sup>-</sup>), nitrites (NO<sub>2</sub><sup>-</sup>), sulphates (SO<sub>4</sub><sup>-2</sup>), phosphates (PO<sub>4</sub><sup>-3</sup>), ammonium ions (NH<sub>4</sub><sup>+</sup>), chlorine ions (Cl<sup>-</sup>), suspended solids (SS) and metals (manganese — Mn, lead — Pb, copper — Cu, zinc — Zn). A selection of these parameters is presented below.

## RESULTS AND DISCUSSION

The values of the water quality parameters: dissolved oxygen, conductivity, acidity, redox activity, water temperature and turbidity, during 1995-1997, in the wetlands Axios river, Loudias river, Volvi lake and Koronia lake are presented in Figs 1, 2, 3 and 4, respectively.

The values of dissolved oxygen, conductivity, pH, redox activity and water temperature in the rivers water present a non-important temporal variation. It is characteristic that pH value of Axios river was almost the same in previous studies realised during 1992<sup>4</sup>. The turbidity presents a very important temporal variation, especially in Axios river, where it reaches an extremely high value during 1995. This result combined with the transboundary pollution phenomena observed in other studies<sup>5</sup>, leads to the hypothesis that wastes from FYROM and Greece play a very important role to the temporally polluted water of Axios river.

The values of dissolved oxygen, pH and water temperature in the Volvi lake water present a non-important temporal variation. The conductivity and redox

activity have a slight increasing trend, but the most characteristic result is the very low values of turbidity in Volvi lake in comparison to the extremely high values of turbidity in Koronia lake water. This result is representative of the important pollution of Koronia lake by urban and industrial wastes in combination with the temporal decrease of the lake's water volume, due to the increasing water use.

Another significant result is the high value of pH (10.3) in Koronia lake in comparison to the pH values (8.6-8.7) in Volvi lake. It is also important to underline that pH value of Koronia lake is higher than that observed in previous studies realised during 1992<sup>4</sup>. The high pH in Koronia lake water is related to the lake eutrophication due mainly to agricultural wastes.

The values of the water quality parameters: nitrates, phosphates and ammonium ions during 1997 in the wetlands Axios river, Loudias river, Volvi lake and Koronia lake are presented in Fig. 5.

There are not very significant differences of the phosphates and ammonium ions values in the water of these wetlands. Nitrates present an extremely high value in Koronia lake in comparison to the nitrates values in the other wetlands. It is very important to underline that nitrates value of Koronia lake is also higher than

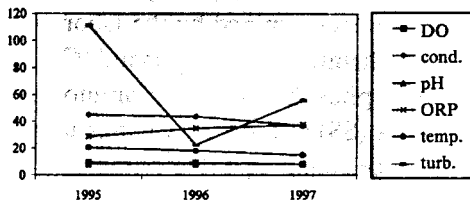


Fig. 1. Temporal evolution of the water quality parameters: dissolved oxygen (DO in mg/dm), conductivity (10 ms/cm), acidity (pH), redox activity (ORP in 10 mV), water temperature (°C) and turbidity (ppm), in Axios river during 1995-1997

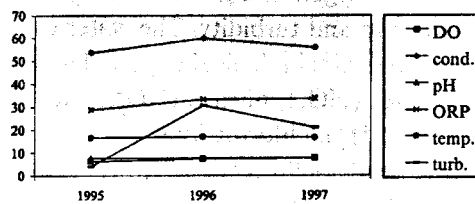


Fig. 2. Temporal evolution of the water quality parameters: dissolved oxygen (DO in mg/dm), conductivity (10 ms/cm), acidity (pH), redox activity (ORP in 10 mV), water temperature (°C) and turbidity (ppm), in Loudias river during 1995-1997

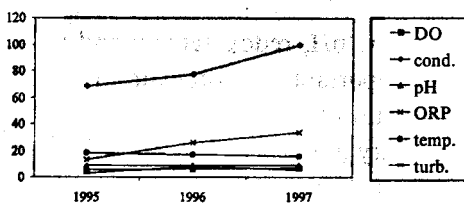


Fig. 3. Temporal evolution of the water quality parameters: dissolved oxygen (DO in mg/dm), conductivity (10 ms/cm), acidity (pH), redox activity (ORP in 10 mV), water temperature (°C) and turbidity (ppm), in Volvi lake during 1995-1997

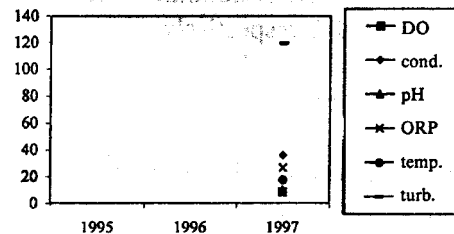


Fig. 4. Water quality parameters: dissolved oxygen (DO in mg/dm), conductivity (100 ms/cm), acidity (pH), redox activity (ORP in 10 mV), water temperature (°C) and turbidity (ppm), in Koronia lake during 1997

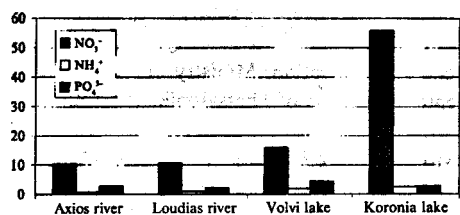


Fig. 5. Water quality parameters: nitrates (NO<sub>3</sub><sup>-</sup> in mg/dm<sup>3</sup>), ammonium ions (NH<sub>4</sub><sup>+</sup> in mg/dm<sup>3</sup>) and phosphates (PO<sub>4</sub><sup>-3</sup> in ppm), in Axios – Loudias rivers and Volvi – Koronia lakes

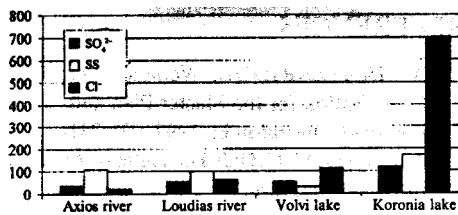


Fig. 6. Water quality parameters: sulphates (SO<sub>4</sub><sup>2-</sup> in mg/dm<sup>3</sup>), suspended solids (SS in mg/dm<sup>3</sup>) and chlorine ions (Cl<sup>-</sup> in mg/dm<sup>3</sup>) in Axios – Loudias rivers and Volvi – Koronia lakes

that observed in previous studies realised during 1992<sup>4</sup>. This result is related to the lake eutrophication due mainly to agricultural wastes (fertilisers).

It is also significant that the nitrates value in Axios river is higher than that observed previously, during 1992, attributed mainly to the same reasons as those described above.

The values of the water quality parameters: sulphates, suspended solids and chlorine ions during 1997 in the wetlands Axios river, Loudias river, Volvi lake and Koronia lake are presented in Fig. 6.

Koronia lake water presents the higher values of all these parameters in comparison to the other wetlands for the same as the above mentioned reasons.

## CONCLUSIONS

The temporal evolution of the surface water quality using systematic measurements in four wetlands (Axios river, Loudias river, Koronia lake and Volvi lake) of Central Macedonia – Greece has been examined. The values of dissolved oxygen, conductivity, pH, redox activity and water temperature in the rivers water present a non-important temporal variation. The turbidity presents a very important temporal variation, especially in Axios river connected to the transboundary pollution phenomena. The values of dissolved oxygen, pH and water temperature in the Volvi lake water present a non-important temporal variation. The most characteristic result is the very low values of turbidity in Volvi lake in comparison to the extremely high values of turbidity in Koronia lake water. The high pH in Koronia lake water is related to the lake eutrophication due mainly to agricultural wastes. There are not very significant differences of the phosphates and ammonium ions values in the water of these wetlands. Nitrates present an extremely high value in Koronia lake in comparison to the nitrates values in the other wetlands.

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