Water Quality of Kamchia River and Impact on the Black Sea Coastal Zone

Galina Shtereva, Anton Krastev, Ognyana Hristova, Boryana Dzhurova
Institute of Oceanology, Bulgarian Academy of Sciences,
Varna 9000, P.O. Bo 152, BULGARIA, E-mail: chem@io-bas.bg

Abstract

The coastal zone is the recipient for amounts of nutrients and other contaminants from human activities. Kamchia River is the biggest Bulgarian river flowing into the Black Sea. The study of its role for changes of chemical parameters in coastal zone is very important for understanding and estimation of the anthropogenic impact on water quality (WQ).

The study is based on monthly monitoring of Kamchia River. The following parameters were measured: nutrients as dissolved phosphorus (P), nitrogen (N) and silica (Si); BOD; oxidizability, iron and manganese. The investigation of water column in the coastal zone in front of the river mouth was carried out including sampling and "in situ" measurement of temperature, pH, salinity, transparency and dissolved oxygen. The collected water samples were analyzed for nutrients and suspended matter by standard methods.

The results of the study show an anthropogenic influence since the catchment basin contains urban area and regions with intensive agricultural activity. The investigated parameters generally correspond to the Bulgarian WQ standards. The comparison with data from previous periods reveals a relatively improving of WQ in the river. The analysis of data for coastal waters during high flow period (spring) reveals a significant influence of the river discharge on the 1 mile coastal zone. As a consequence of river discharge the close coastal zone is characterized by low transparency and high nutrients concentrations.

Key words : *Kamchia River, Water quality, nutrients, oxygen, Black Sea*

Introduction

The understanding and estimation of the anthropogenic impact on the Water quality (WQ) are of the first importance for a sustainable management in context of EU Water Framework Directive/60/2000. The understanding of the river impact on the coastal area, in particular, is impossible without knowledge for river-sea interactions.

Kamchia River with a length of 245 km and catchment of 5358 km^2 is one of the largest and highly loaded river systems in Bulgarian Black Sea basin watershed. The average slope of the system is 2.9 % and average altitude - 327 m. The river catchment covers 40 % of the Black Sea basin and contributes about half to the freshwater discharge of the sea by the national rivers. Kamchia River discharges into the sea water quantity =19,25 m^3/s.

The area around the mouth and lower course of the river is remarkable for its variety of habitats. The Kamchia reserve is under the protection of UNESCO. The total area of the protected habitats in the reserve, together with Kamchia Sands Protected Area, adds up to 1.200 ha. Besides Kamchia River mouth is an important Bird Area situated on the migratory flyway Via Pontica.

The main pollution sources are the industrialized, urbanizated regions and the area with intensive agriculture. The total industrial wastewater quantity entering Kamchia River during 2002 is $Q=1.85*10^6 m^3/y$; total domestic $Q=15.27*10^6 m^3/y$ (Mihajlov et al., 2005). Therefore its water is affected by anthropogenic inputs, including high content of organic matter and nutrients.

Methods

The study is based on monthly monitoring of Kamchia River, during the period 2001-2002 at one station before flowing into the sea (Fig.1a). The following parameters were measured: nutrients as dissolved phosphorus (P), nitrogen (N) and silica (Si); BOD_5; oxidizability, iron and manganese. The investigation of water column in the coastal zone in front of the river mouth (Fig.1b) was carried out during the high flow (spring) period on sampling network by "in situ" measurement of temperature, salinity, transparency (by Sechi disk) and dissolved oxygen. The collected water samples from 2 or 3 depths/horizons (surface, middle and bottom) were analyzed for nutrients by standard methods (Grasshoff et al., 1983).

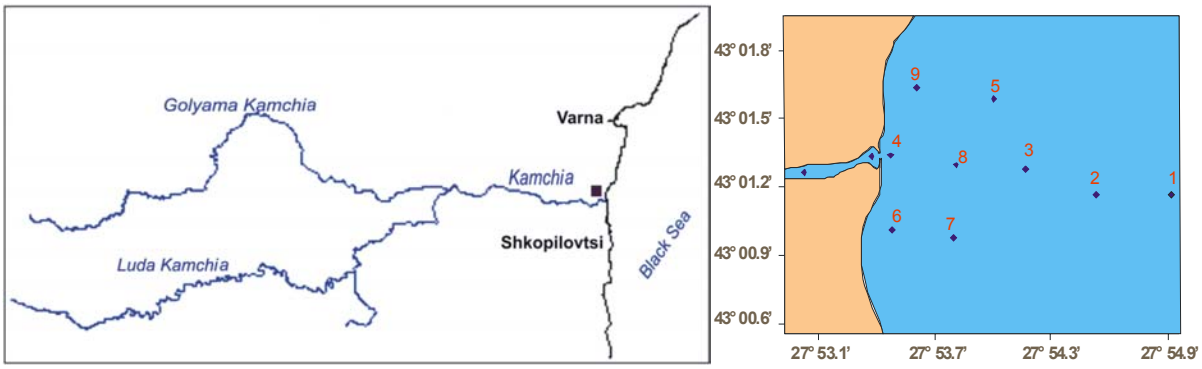

Figure 1. Map of the investigated region

Results:
The river discharge in 2002 is characterized (Fig. 2) with maximums in late winter following the influence of the continental climate and another maximum in early autumn. Long-term data of NIMH reveals monthly river discharge variability from 10.5 % to 17 % of annual discharge during the high flow period from January to May. The mean monthly precipitation totals vary between 13.5 and 98 l/m^2 for the lowland part of the Kamchia watershed.

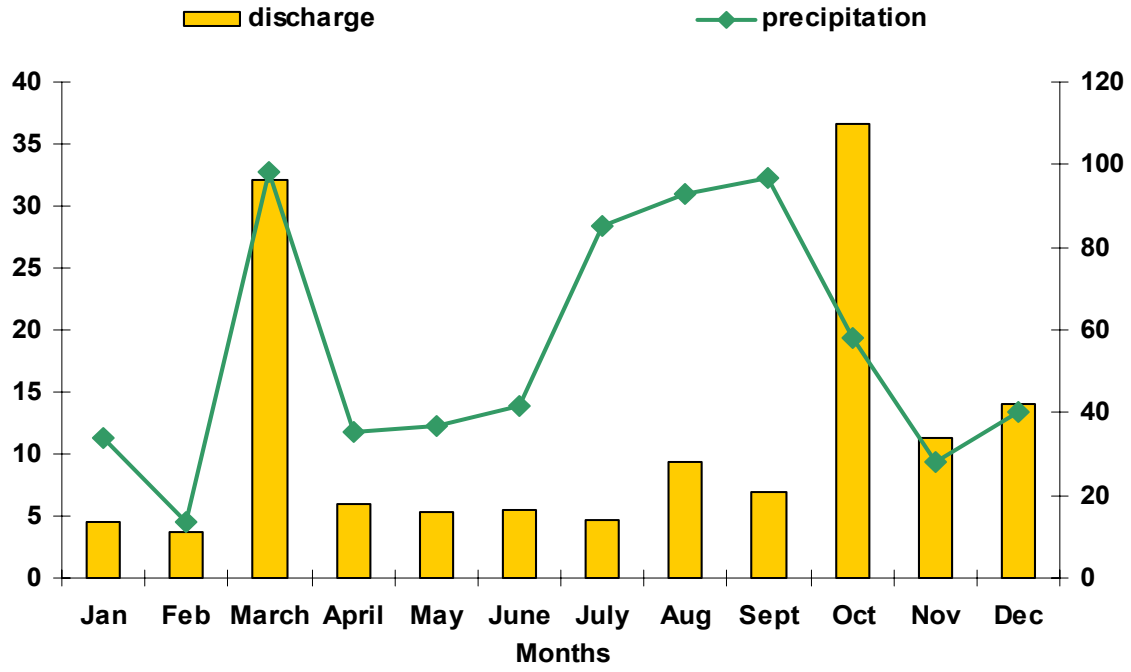

Figure 2. Annual distribution of Kamchia River discharge (m^3*10^6) and precipitation (l/m^2) in 2002

The results for the river water show a nutrient content (most frequently for nitrite) over Limiting permissible concentration (LMC) determined by Bulgarian Water quality standards (Regulation №7).
A similar fact was established during the previous measurements (Shtereva, Hristova, 2006). The interannual distribution of hydrochemical parameters is presented at Fig. 3. Maximums of nutrients content in August-September correspond to high values of precipitations (Fig. 2). A maximum of silica content in April was measured in consequence of high river run - off in March. The values for oxidizability, iron and manganese are in the range determined by Bulgarian water quality standards.

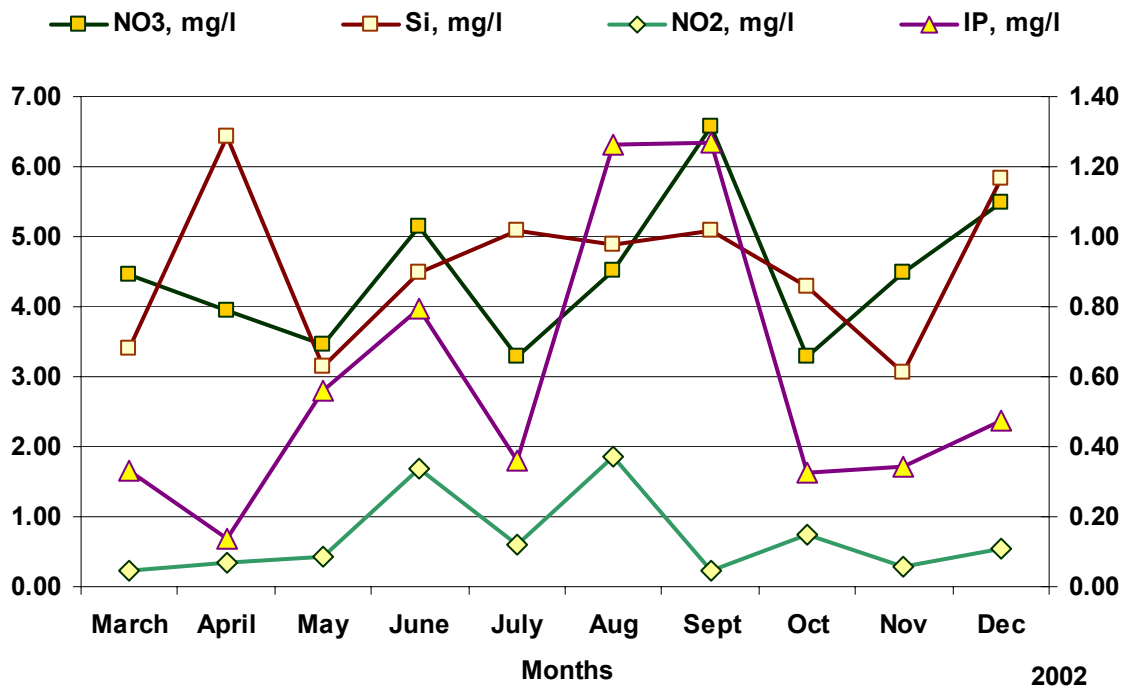

Figure 3. Interannual distribution of nutrients in Kamchia River (2002)

The comparison with data from previous periods of investigation (Fig. 4) reveals a slight tendency of decreasing of nutrients in river waters, best expressed for inorganic (phosphate) phosphorus (IP). A similar tendency is not observed for nitrates. About 2-fold decrease in BOD was found in river waters in comparison with the 1993 due to diminished land-based input of organic matter (Shtereva, Hristova, 2006). This sign of improving of ecological conditions due to reduction of agricultural and industrial production is determined by collapse of economy in our country after 1990.

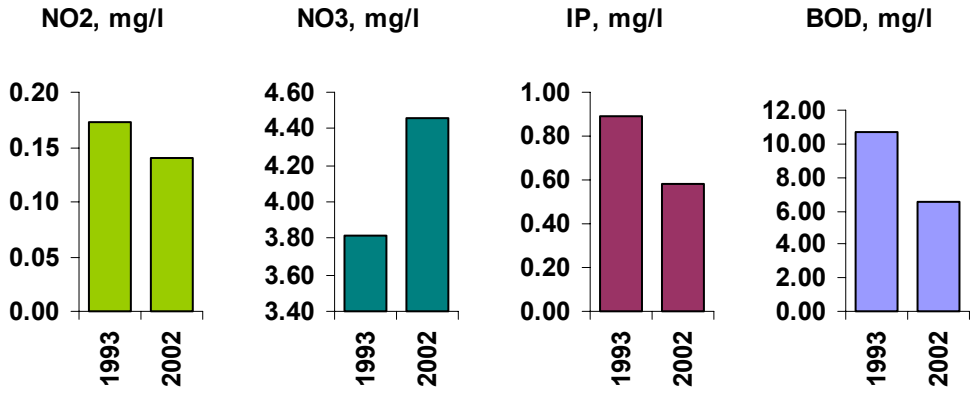

Figure 4. Comparison of nutrients content and BOD between 1993 and 2002

The established trend is very important for WQ of the river since both nutrients (P and N) are responsible for eutrophication not only in the river and in the coastal waters also. A similar trend for the long-term WQ was presented by Mihajlov G. et al. (2002).

As a recreation area Kamchia mouth zone requires a constant environmetric control of WQ there and of contamination sources as well. The Kamchia River mouth is a preferred tourist area and better results from the monitoring of the Water quality could contribute to the national tourist policy. In this connection the results for mixing zone are very interesting and indicative of active interactions

between river and sea. As a consequence of river discharge the close coastal zone WQ does not correspond to the Bulgarian standards (Regulation № 8) not only for nutrients. The measured concentration for BOD and total P exceed LPC. Investigations in coastal zone are carried out under still weather conditions (no wind and waves). Several hydrochemical parameters (nutrients, transparency and salinity) are used to define the impact area. The size of this area, related to the advection of the river plume, depends on the amount of Kamchia River waters discharged into the Sea, as well as on the winds and current system in this part of the Western Black Sea. South-easterly and easterly winds press the eutrophic waters towards the coast, however during high river inflow as was presented by Rozhdestvenski (1980). The main features of the river influenced waters in the coastal area are the lower salinity, higher nutrients and suspended matter content. The surface salinity distribution is illustrated at Fig. 5.

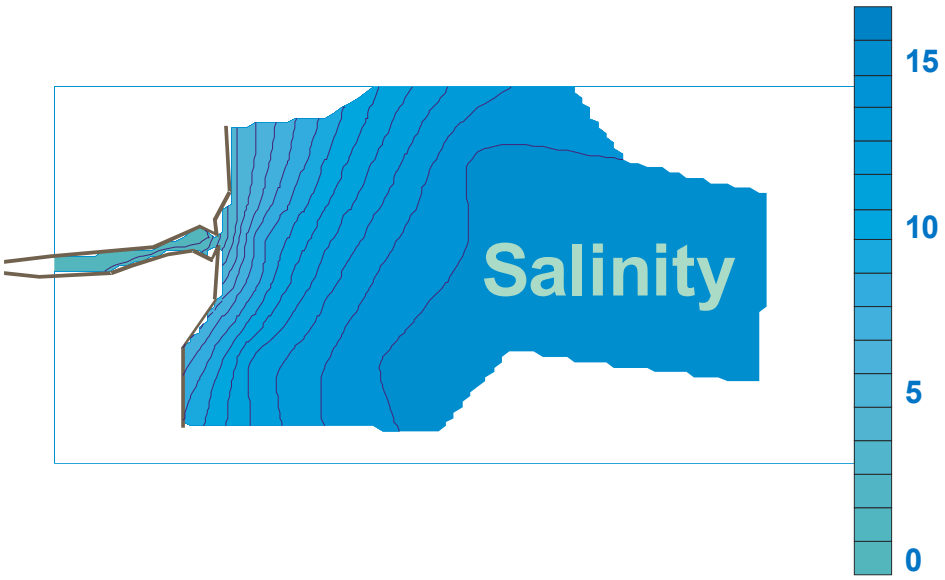

Figure 5. Spatial distribution of salinity in surface coastal waters

A highly impacted area spreads in south and east direction due to the current direction along the coast and is characterized by low transparency (0.5 - 1.5 m), pH 8.09 - 8.25, salinity < 8.3 ‰ . The farthest two stations – 1 and 2, are similar according to parameters distribution, showing absence of river influence at the corresponding distance.

The observed parameters vertical distribution confirms the impact area location (Fig. 6). Salinity vertical profile is an evidence for relatively homogenized water column in the area between station 1 and station 3.

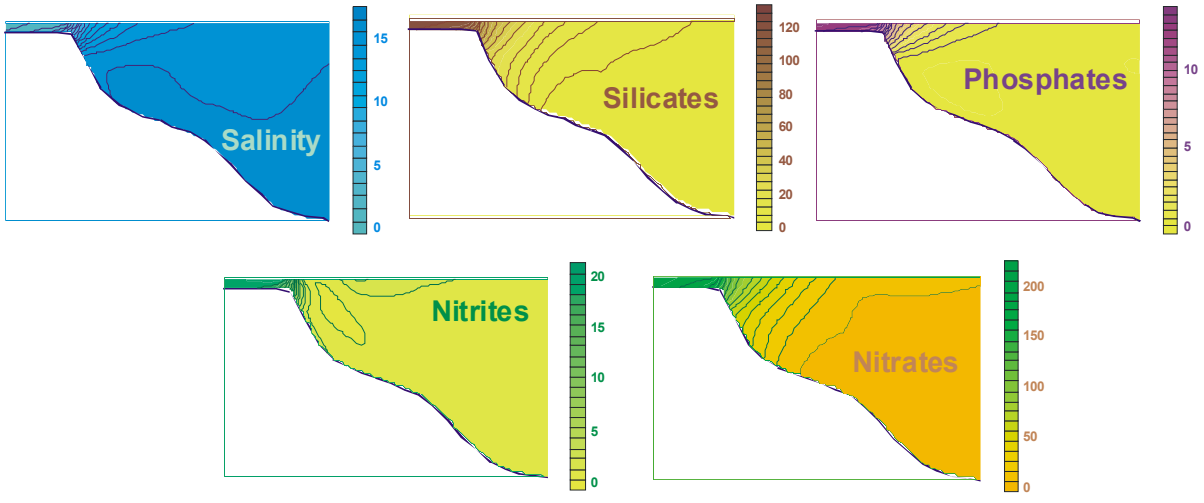

Figure 6. Vertical distribution of Salinity and nutrients in Kamchia coastal area

An influence of Kamchia River on the close coastal zone was established on the base of silica content data in sea waters and Si discharge by the river during the previous studies. High Si load during the winter leads to high concentration in the coastal water (Shtereva, Hristova, 2006). The transformed river water enriched with nutrients are delivered by current to the South.
The analysis of received data reveals a presence of fresh water low transparency layer with maximal thickness of 3 - 5 m. Transforming river waters are distributed south and east, participating in increasing turbidity at stations 8, 6 and 7, as well as in decreasing salinity, especially in surface waters. Direct river influence on the sea waters area is in immediate proximity of the river mouth. Decreasing river influence is possible to be tracked as far as 1 n.m. from the coast.
There is a good correlation between nutrients and salinity distribution (Fig. 7).

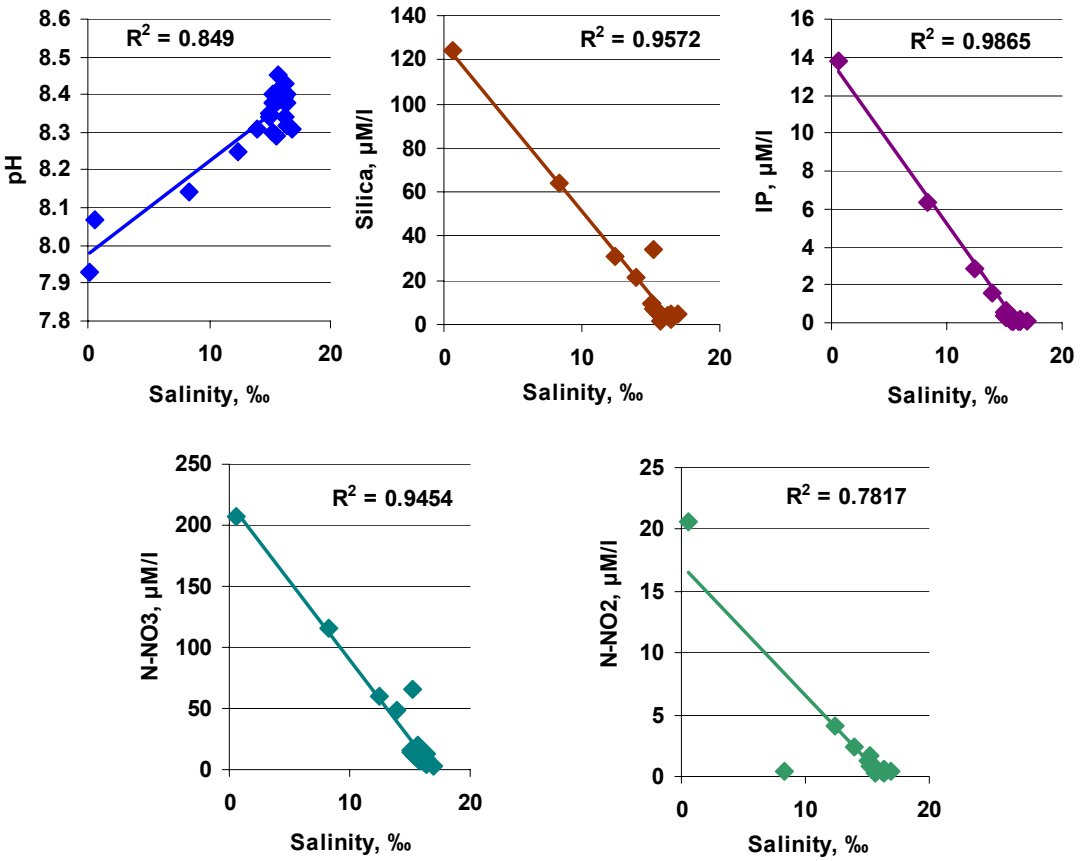

Figure 7. Correlation between chemical parameters and salinity

In registered hydrometeorological spring situation during high river flow period, the river influence is distributed in south and south-east direction and affects considerably the upper surface layer.

Conclusions:

Nutrients content (nitrite, phosphate) in Kamchia River downstream does not always correspond to national WQ standards. The comparison of data from different periods of investigation reveals a slight tendency of decreasing of phosphate and nitrites content and BOD. A decreasing tendency was established as a positive sign of WQ evolution last years.
The Kamchia River discharge during high river flow period impacts the coastal zone in an area located about 1 navy mile eastern and southern from the river mouth. Most significant river influence is established in the upper surface layer.

Acknowledgements
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