WATER QUALITY ASSESSMENT OF THE BULGARIAN DANUBE TRIBUTARIES FROM THE WATER CONSUMPTION POINT OF VIEW

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Abstract: The aim of the present investigation is the establishment and analysis of the water quality categories in the estuary parts of the Bulgarian Danube tributaries from the point of view of the various water consumptions. In spite of the comparatively small contribution of the Bulgarian tributaries in the Danube water quality the estuary parts are investigated and the water quality there is discussed. The alteration of the water quality and the corresponding categories at the estuary parts of the studied rivers is discussed as well.
Keywords: Danube, water quality, water categories

BEURTEILUNG DER WASSERQUALITÄT DER BULGARISCHEN NEBENFLÜSSE DES DONAU-FLUSSES ANGESICHTS DES WASSERVERBRAUCHS

Zusammenfassung: Grundziel der vorliegenden Untersuchung ist Feststellung und Analyse der Kategorien für Wasserqualität in verschiedenen Stellen der bulgarischen Donaunebenflüssen von der Sicht des verschiedenen Wasserverbrauchs. Unabhängig davon, dass der Beitrag der bulgarischen Nebenflüssen zu der Qualität vom Fluss Donau relativ klein ist, die Mündungsrevier sind speziell behandelt und die Wasserqualität dort ist kommentiert. Kommentiert ist auch die Veränderung der Wasserqualität entlang der untersuchten Donaunebenflüssen und die Veränderung der entsprechenden Kategorien.
Schlüsselworte: Donau, Wasserqualität

1. Introduction

The water quality data from nine monitoring stations disposed on the estuary parts of the main Bulgarian tributaries is estimated: the Voinishka river (inflow into the Danube at km 782.2) – Tarniane, the Lom river (inflow into the Danube at km 741.6) - Lom town, the Tzibritza river (inflow into the Danube at km 715.9) – Dolni Tzibar village, the Ogosta river (inflow into the Danube at km 684.7) - Mizia town, the Iskar river (inflow into the Danube at km 636.4) – Oriachovitza village, the Vit river (inflow into the Danube at km 609.4) – Guliantzi village, the Ossam river (inflow into the Danube at km 599.9) – Izgrev village, the Jantra river (inflow into the Danube at km 536.6) – Novgrad village, the Russenski Lom river (inflow into the Danube at km 497.9) – Basarbovo village (Figure 1).

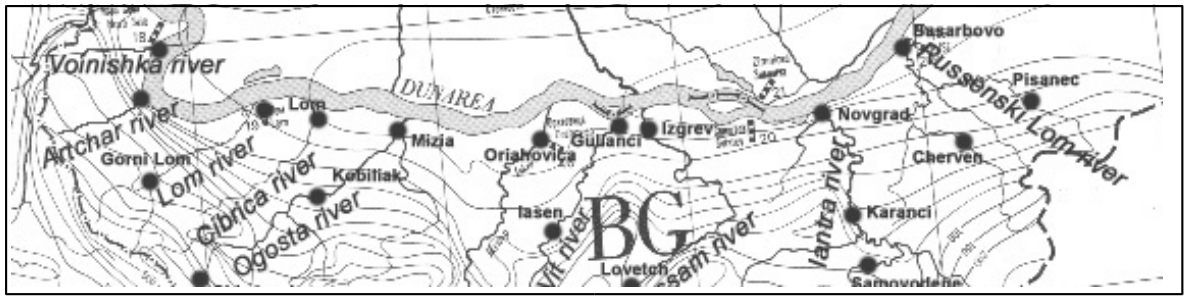

Figure 1. Monitoring of estuary parts of the main Bulgarian tributaries

The investigation is based on the available hydrochemical regime data concerning the Bulgarian Danube tributaries water quality in the National Institute of Meteorology and Hydrology. The information for 5 years period (1997-2001) is collected and analyzed.

The water quality of the Bulgarian Danube tributaries is assessed using nine water quality parameters grouped as follows: mineral content - sulphates (SO_4), chlorides (Cl), hydrocarbonates (HCO_3), calcium (Ca), magnesium (Mg), salts (Na+K), total dissolved solids (TDS); biogenic components - nitrate nitrogen ($N\text{-}NO_3$), nitrite nitrogen ($N\text{-}NO_2$), ammonium nitrogen ($N\text{-}NH_4$), phosphates (PO_4) and parameters of oxygen regime and organic content - dissolved oxygen (O_2), biochemical oxygen demand (BOD5), permanganate oxidation ($_2O_{Mn}$).

2. Methodology

The estimation of river water quality depends on accuracy and frequency of water quality sampling. The available water quality information is based on standard methods of sampling and chemical analysis. The National Institute of Meteorology and Hydrology carries out a seasonal monitoring. But the water quality information is limited by many factors, mainly financial. That is why the information is incomplete at some stations.

The process of categorization aims to assess the possible usage of the river water depending on different needs of the water consumers: for drinking, technical water supply, irrigation, fishery, recreation etc. According to the Bulgarian legislation (Ordinance, 1986) the surface waters are classified into 3 categories concerning water quality. The limiting concentrations pertain to the low water conditions. The characteristic concentration ($C_{95\%}$) that determine river water category corresponds to the average minimal monthly water discharge with 95% reliability. The limiting concentrations concerning the studied parameters for different water categories according to the Bulgarian legislation are presented in Table 1.

Table 1. Limiting concentrations of water quality parameters corresponding to the average minimal monthly water discharge with 95% reliability according to the Bulgarian legislation

water quality parameter	*metric units*	*category*		
		I	*II*	*III*
dissolved oxygen	mg/l	6	4	2
total dissolved solids	mg/l	700	1000	1500
total hardness	mgequv/l	7	10	14
Cl	mg/l	200	300	400
SO_4	mg/l	200	300	400
total Fe	mg/l	0.5	1.5	5.0
$N\text{-}NH_4$	mg/l	0.1	2.0	5.0
$N\text{-}NO_2$	mg/l	0.002	0.04	0.06
$N\text{-}NO_3$	mg/l	5	10	20
PO_4	mg/l	0.2	1.0	2
permanganate oxidation	mg/l	10	30	40
BOD5	mg/l	5	15	25

Because of the non-homogeneity of the water quality information a methodology based on the relationship between the studied water quality parameters and the water discharge is applied (Tzankov, 1998), (Tzankov et al., 2000). At some observation stations the simultaneously obtained sampling data (quantity and quality parameters) allow to search stable relationships between water quantity characteristics (discharges) and water quality ingredients. The Bulgarian experience (Tzankov, 1998) shows that some statistical relationship is significant if the obtained coefficient of correlation has a value $r^2>=0.25$ when the number of the studied parameters in the row is more then 20-30.

The regression analysis is applied in order to establish statistically corresponding equations between the water discharge at the moment of sampling Q (m^3/s) and the corresponding water quality parameter. The concentration ($C_{95\%}$) regarding the minimal monthly water discharge with 95% reliability is determined by these equations. The river water category is determined by $C_{95\%}$ according the Bulgarian legislation (Table 1).

3. Results and discussion

It could be taken into consideration that the Bulgarian tributaries contribution to the Danube water quality formation is relatively small. The hydrochemical load of the main tributaries in the Danube is assessed (Ninov, 2004) as: 2.69% pertain to the total dissolved solids; 5.66% pertain to the permanganate oxidation; 0.36% pertain to the nitrate nitrogen; 4.49% pertain to the nitrite nitrogen; 2.94% pertain to the ammonium nitrogen; 5.45% pertain to the phosphates.

The information about the Bulgarian tributaries water quality is important as well as its general contribution to the Danube water quality and also because of the local impact on the estuary section of the main river. The results of categorization can be used for the assessment of the possible usage of the river water and show water quality status of the Bulgarian tributaries on the background of the general water quality improving of Bulgarian rivers (Tzankov et al., 2000), (Raikova et al.,1991), (Rainova et al., 2001).

3.1. Parameters of oxygen regime and organic content

The dissolved oxygen concentrations, BOD5 and permanganate oxidation are important criteria for the river water ecological status and suitability of the water for various applications. The values of these parameters depend on many factors - temperature, air pressure, hydraulic processes.

The results of water quality categorization reveal (Figure 2) that the dissolved oxygen concentrations are comparatively high – the water in the Bulgarian estuary sections is I category with one only exception – the Vit river (II category). It means that the Bulgarian tributaries have not a negative influence on the Danube oxygen regime.

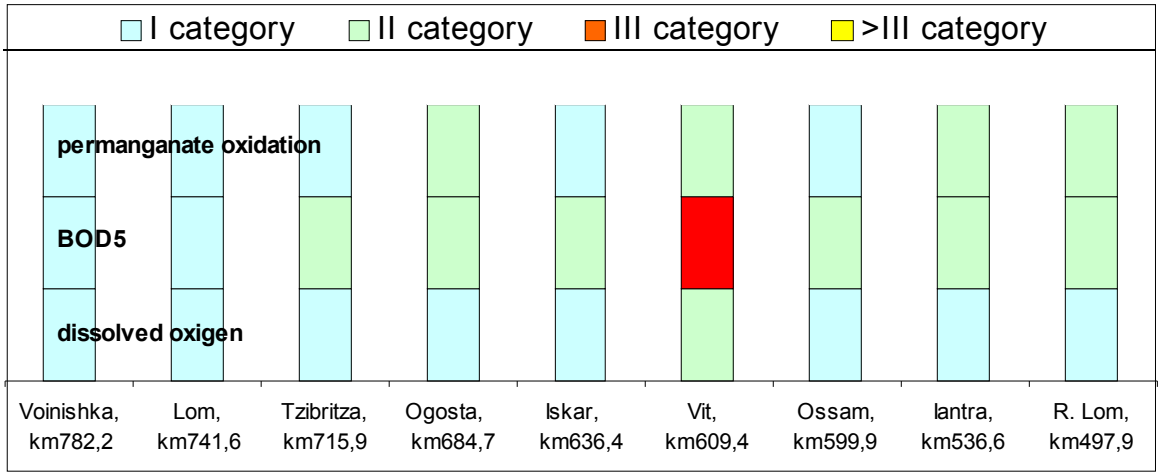

Figure 2. The water quality categories of the main Bulgarian tributaries according to the parameters of oxygen regime and organic content

The content of the organic matter established by the parameter permanganate oxidation is the highest for the Iskar river - II category. The rivers Ogosta, Jantra and Russenski Lom are also assessed as II category. The water quality according to the biochemical oxygen demand – BOD5 in the studied sections of the rivers Voinishka and Lom is I category. The value of $BOD5_{95\%}$ concerning estuary part of the Vit river is 24.93 mg/l and water is III category.

3.2. Biogenic parameters

The biogenic elements concentrations characterize biological production of the rivers and also these concentrations are criteria for self-purification processes. The results of river categorization according to the parameters of mineral nitrogen and phosphates are presented in Figure 3.

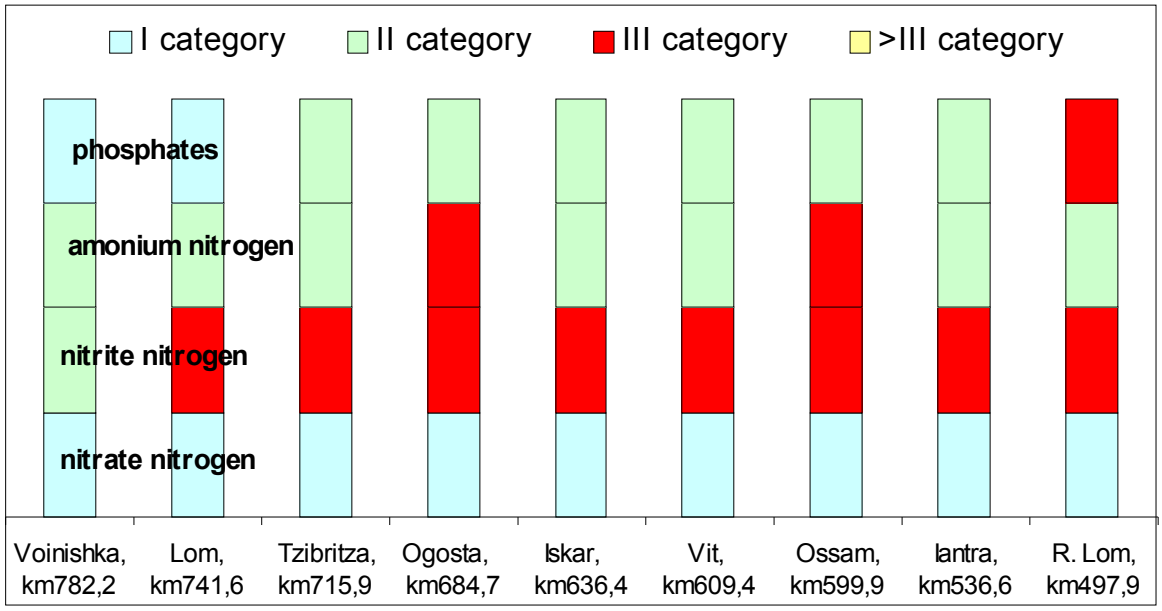

Figure 3. The water quality categories of the main Bulgarian tributaries in accordance with the biogenic parameters concentrations

The concentrations of nitrate nitrogen ($N\text{-}NO_3$) are low and respectively the corresponding categories of the Bulgarian tributaries show good water quality. The nitrogen pollution of the Bulgarian tributaries is connected mainly with $N\text{-}NO_2$ concentrations. The increased concentrations of nitrite ions ($N\text{-}NO_2$) and ammonium ions ($N\text{-}NH_4$) – II and III category, and phosphate ions (PO_4) – mainly II category, show that the biogenic pollution is characteristics of all Bulgarian tributaries. This pollution is a result of municipal wastewaters and the significant agricultural and stockbreeding activity in the whole region.

3.3. Mineral content

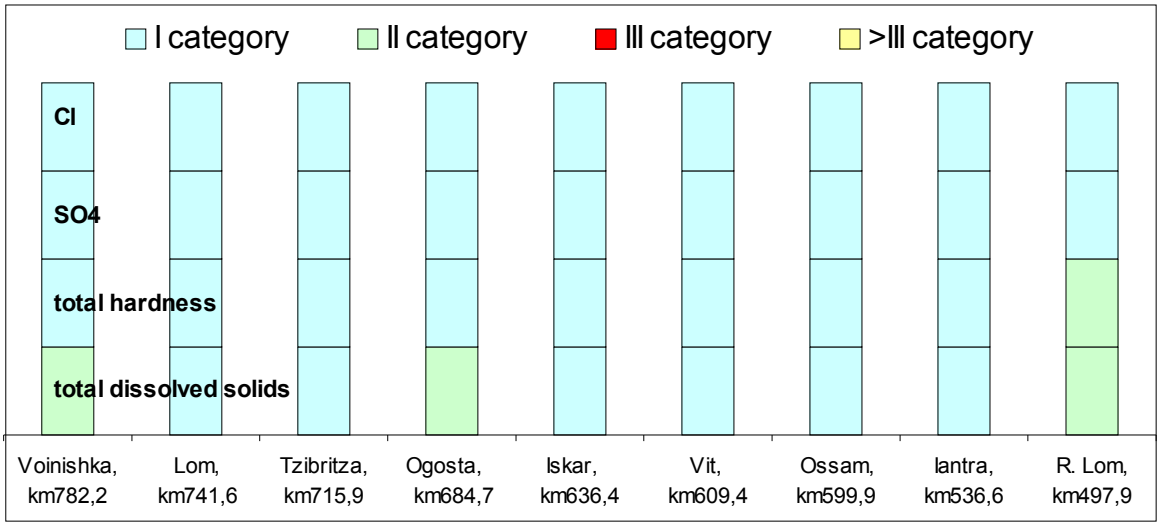

Figure 4. The water quality categories of the main Bulgarian tributaries in accordance with the mineral content parameters

As characteristics of the mineral content of the Bulgarian Danube tributaries the following parameters are investigated: total dissolved solids, sulphates (SO_4), chlorides (Cl),

hydrocarbonates (HCO_3), calcium (Ca), magnesium (Mg), salts (Na+K). The results of categorization carried out are presented in Figure 4.

The analysis of the results reveals that the Bulgarian tributaries waters are with low mineralization. The total hardness, determined as a sum of Ca and Mg ions, varies and the tributaries water quality is assessed as I category concerning the rivers Voinishka, Lom, Tzibritza, Ogosta, Iskar, Vit, Ossam and Jantra and II category regarding the river Russenski Lom (Figure 4).

The comparison of the main ions distribution is in the base of many river water classifications. The diagrams, shown in the Figure 5, present the main ions distribution concerning the Bulgarian tributaries and the Bulgarian section of the Danube. They reveal the similarity in distribution of these ions in spite of the lower mineralization of the Danube.

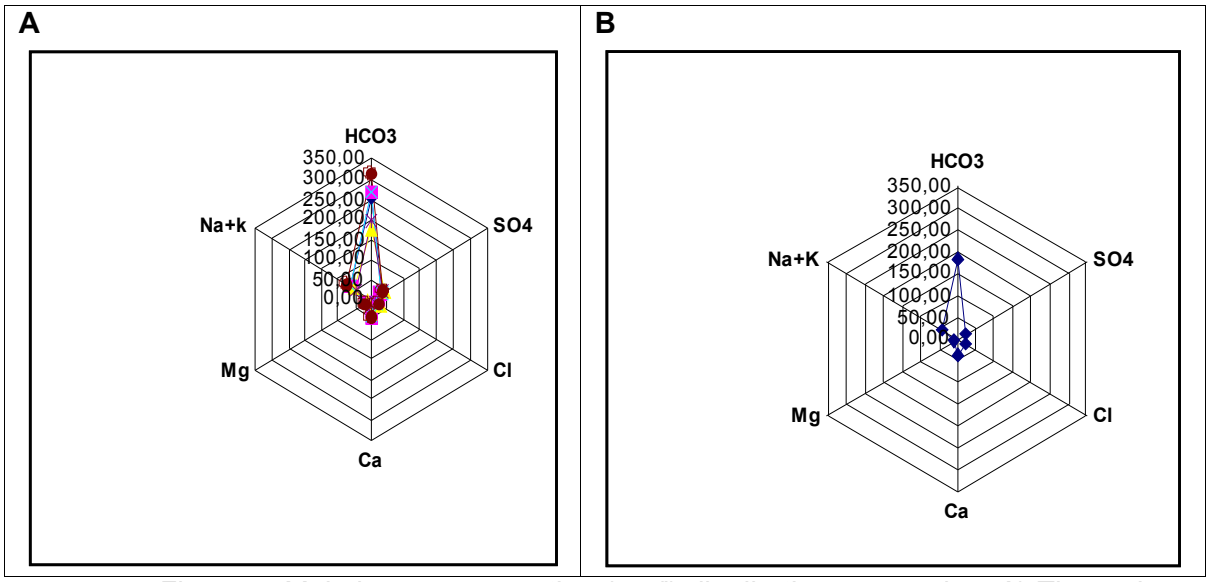

Figure 5. Main ions concentration (mg/l) distribution concerning: A) The main Bulgarian Danube tributaries; B) The Danube at Nikopol town

4. Conclusions

The categorization of the Bulgarian Danube tributaries regarding the investigated parameters reveals that the concentration of biogenic elements is the most unfavorable. Regarding the oxygen regime and mineral content characteristics waters pertain to the categories I – II i.e. water possess better quality.

The relatively small distribution of the Bulgarian tributaries into the Danube gives ground to assert that their influence is restricted mainly in the estuary parts.

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