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## TIME AND SPATIAL CHANGEABILITY OF THE MASKAWA RIVER WATERS CHEMISM

### ČASOVO-PRIESTOROVÁ VARIABILITA CHEMIZMU VÓD RIEKY MASKAWY

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The present paper contains the analysis of correlation and trends in the changes of both composition, and state, and intensity of water flow in the closing section. The study displays the authors' own research and its results on the problem of water quality in the Nekla and Dzierznica sections of the Maskawa river carried out in the period from 1986 to 1990; it also includes the conclusions coming from the investigations of the Regional Inspectorate of Environmental Protection in Poznań conducted in 1972, 1977, 1980, 1983, 1986, 1989, 1994 and in 1999 in six measurements - control sections situated along the Maskawa river course. In the section closing the catchments of Maskawa there is a significant dependence between hydrometeorological conditions and water quality. The concentrations of dissolved oxygen, dry residue, sulphates, calcium and nitrates were positively correlated with the intensity of the flow; it can be the proof of washing out of the components by both surface and subsurface runoffs.

**Key words:** hydrology, catchment, river flow, water quality, correlations

Pollution of water resources presents a more and more serious barrier in a domestic and industrial utilization of the reserves. In the Wielkopolska region there are rivers with excessively polluted waters; as much as 76.7% of their course does not meet the normative values requirements (Report of the Institute of Environmental Protection, 2000). The waters of the arable areas are mainly polluted by excessive emissions of the substances coming from fertilizers - compounds of nitrogen and phosphorus, as well as active substances i.e. pesticides from agricultural cultivations (Somorowski, 1998). The surface water eutrophication is intensified together with the growing density of the population of the catchment area (Ilnicki, 2002). The Maskawa river is one of the biggest tributaries of the mid - Varta river section on the area of the Wielkopolskie voievodship, in respect of the size of its catchment surface (820 km<sup>2</sup>) and its length (56.7 km). Recognition of the pollution resources and factors influencing the changeability of surface waters quality is the basis for constructing water protection programmes aiming at preventing a further degradation.

#### Material and methods

A general evaluation of composition and state of water quality of the Maskawa river in a many - year period was presented by Murat-Błażejewska and Sojka (2002). The present paper contains the analysis of correlation and trends in the changes of both composition, and state, and intensity of water flow in the closing section. The study displays the authors' own research and its results on the problem of water quality in the Nekla and Dzierznica sections of the Maskawa river carried out in the period from 1986 to 1990; it also includes the conclusions coming from the investigations of the Regional Inspectorate of Environmental Protection in Poznań conducted in 1972, 1977, 1980, 1983, 1986, 1989, 1994 and in 1999 in six measurements - control sections (1, 2, 3, 4, 5, 6) situated along the Maskawa river course (Fig. 1).

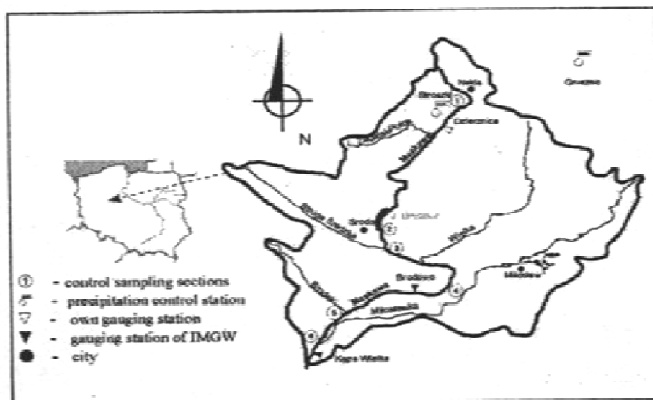
The authors' monthly lab investigations of water samples comprised markings of indices and components characteristic for physical properties of water (pH, temperature), oxygen conditions (content of dissolved oxygen, BOD<sub>5</sub>, COD), concentration of organic substances (dry volatile residue), biogenes presence (nitrogen and phosphorus compounds), as well as mineral composition (sulphates, total iron, chlorides, calcium). The water analyses were carried out in accordance to the „List of norms in the subject area of water and sewage analytics“ (1993). The basis for the evaluation of the quality of the examined waters was The Decree of the Minister of Environmental Protection, Natural Resources and Forestry (1991).

The data from 1972–2000 coming from the Gniezno meteorological station of the Institute of Meteorology and Water Management were used to describe the meteorological conditions in the analysed catchment. The period in focus can be regarded as representative since both dry (1972, 1983, 1989) and mean (1986, 1988, 1994), as well as wet years (1977, 1980, 1999) occurred.

Hydrological conditions in the catchment till 1983 were described on the basis of everyday water levels observations up to the Brodowo section of Maskawa (Annual hydrological reports on water levels) in the period, own measurements of water levels in the Dzierznica section in 1986–1990, whereas in the period 1994–1999 the conditions were established by help of a catchment - analogue. The data for the analogue (Wrześnica - up to the Samarzewo section) were provided by the Institute of Meteorology and Water Management in Poznań.

Drawing up the inventory of the sources of pollution was conducted basing on the local visits, local offices documentation and materials published by the Regional Institute of Environmental Protection in Poznań. The types and kinds of soils were described on the basis of agricultural - soil maps in the scale 1:100 000, and the type of land use was described using materials and documents from commune local offices and paying visits to the sites.

Figure 1 Catchment of the Maskawa river (Map scale 1 : 200 000)  
 Obrazok 1 Povodie rieky Maskawy (Mierka 1 : 200 000)



## Results and discussion

The basic geomorphologic data of the catchments were placed in Tab. 1. The area of the catchments of Maskawa is typically agricultural since about 83% of its surface is covered by arable lands. Additionally, there are enterprises strictly connected with agriculture such as: sugar factories, dairies, distilleries, fruit - vegetable and meat processing plants.

The analysis of the meteorological conditions course in the Maskawa catchment was carried out on the basis of probability distribution of atmospheric precipitation annual sums and mean annual air temperatures measured for the Gniezno meteorological station. The mean annual precipitation sum from the period 1972–2000 reached 528 mm, mean air temperature was 8.2 °C. The analysis showed that in the period 1972–1999 there were dry and warm years (1972, 1973, 1999), average years (1986, 1987, 1988, 1994), as well as warm and damp years (1977, 1980, 1999) in which atmospheric precipitation annual sum was higher respectively by 166 mm ( $p = 3.5\%$ ), 114 mm ( $p = 7\%$ ) and 95 mm ( $p = 17\%$ ) than the many - year mean, and air temperature was higher by 0.5 °C than the many - year mean.

Table 1 The geomorphological characteristics of analysed catchments

Characteristics	Catchment / Gauge station	
	Maskawa Dzierznica	Maskawa Kępa Wielka
Catchment's location	Wielkopolska region	
Catchment area (km <sup>2</sup> )	37.2	620.8
Length river (km)	13.8	56.7
Average slope river (%)	3.6	0.9
Coefficient of hydrographic network density (km.km <sup>-2</sup> )	1.31	0.88
Afforestation (%)	28.4	16.6
Reservoir (%)	0.14	0.2
Arable land (%)	60.0	75.4
Meadows and swamps (%)	9.9	7.3

Tabuľka 1 Fyziografická charakteristika analyzovaného povodia

Small precipitation and high field evaporation brought about by increased air temperature in dry years (1972, 1983, 1989) caused that mean annual flows in Maskawa at the Kępa Wielka section were 1.7–1.9 m<sup>3</sup>. s<sup>-1</sup> and were respectively by 1.6 to 2.5 times lower than in wet years. In the course of the discussed 10 hydrological years the flows oscillated from NNQ = 0.36 m<sup>3</sup>.s<sup>-1</sup> to WWQ = 17.62 m<sup>3</sup>.s<sup>-1</sup>, mean annual flow from the many - year period reached SSQ = 2.67 m<sup>3</sup>. s<sup>-1</sup>, and the longest lasting flow NTQ = 1.0–1.5 m<sup>3</sup>. s<sup>-1</sup>. The mean low flow SNQ identified with the violable flow reached SNQ = 1.06 m<sup>3</sup>. s<sup>-1</sup>. In the discussed hydrological years mean and maximum flows in winter half-years were usually higher than in summer half-years (except 1972 and 1980) (Fig. 2).

The results of hydrochemical investigations showed that the Maskawa river waters along its course met purity class II and III requirements in respect of the majority of the indices, and as far as mean annual biogenic and organic substances concentrations were concerned they did not meet the norms in some years. In respect of biogenic substances content the Maskawa waters were varied, they contained high concentrations of phosphates and low concentrations of ammonium nitrogen. Mean annual content of phosphates in the

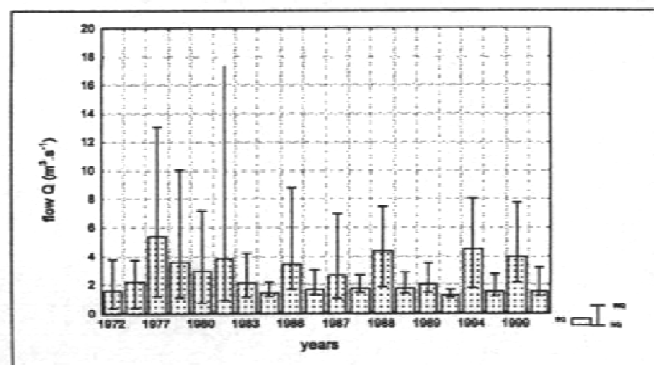
Table 2 Statistical significance of correlation between water flow intensity and water quality indexes of the Maskawa river at gauging station Kępa Wielka in years 1972 to 1999

No	Parameter	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1.	flow intensity (m <sup>3</sup> .s <sup>-1</sup> )	■	+	0	0	+	-	+	+	-	0	0	+
2.	dissolved oxygen (mg O <sub>2</sub> .dm <sup>-3</sup> )	+	■	-	0	0	-	0	0	-	0	0	+
3.	BOD <sub>5</sub> (mg O <sub>2</sub> .dm <sup>-3</sup> )	0	-	■	+	0	+	-	0	+	0	0	0
4.	COD (mg O <sub>2</sub> .dm <sup>-3</sup> )	0	0	+	■	0	+	-	0	+	0	0	0
5.	residue dry (mg.dm <sup>-3</sup> )	+	0	0	0	■	0	+	+	-	+	0	+
6.	ammonium nitrogen (mg.dm <sup>-3</sup> )	-	-	+	+	0	■	-	0	+	0	0	-
7.	sulphates (mg.dm <sup>-3</sup> )	+	0	-	-	+	-	■	+	-	+	0	+
8.	calcium (mg.dm <sup>-3</sup> )	+	0	0	0	+	0	+	■	-	+	0	+
9.	phosphates (mg.dm <sup>-3</sup> )	-	-	+	+	-	+	-	-	■	0	0	-
10.	chlorides (mg.dm <sup>-3</sup> )	0	0	0	0	+	0	+	+	0	■	0	+
11.	nitrites (mg.dm <sup>-3</sup> )	0	0	0	0	0	0	0	0	0	0	■	0
12.	nitrates (mg.dm <sup>-3</sup> )	+	+	0	0	+	-	+	+	-	+	0	■

Tabuľka 2 Štatisticky preukazné korelácie medzi intenzitou prietoku a ukazovateľmi kvality vody rieky Maskawy v priezeze Kępa Wielka v rokoch 1972–1999  
 + – correlation coefficient significant (at  $\alpha = 0.05$ ) and  $> 0$ , - - correlation coefficient significant (at  $\alpha = 0.05$ ) and  $< 0$ , 0 – no significant correlation ( $\alpha = 0.05$ )

**Figure 2** Changes of characteristic flows in the Maskawa river at gauging station Wielka Kępa in winter and summer half-years chosen hydrologic years 1972–1999

**Obrázok 2** Príbeh prietokov charakteristických pre zimné a letné polročia v priereze Kępa Wielka rieky Maskawy vo vybraných hydrologických rokoch 1972–1999



river ranged from 0.01 to 7.8 mg PO<sub>4</sub> dm<sup>-3</sup> and in majority of cases they were values not meeting water purity norms.

It was observed that in the section closing the investigated catchment in the period in interest, there is a significant dependence between hydrometeorological conditions and water quality. The analysis of linear correlation between chosen parameters of water quality in the discussed period of time showed that some parameters are significantly correlated with each other at significance level  $\alpha = 0.05$  (Tab. 2). The concentration of dissolved oxygen, dry residue, sulphates, calcium and nitrates were positively correlated with the intensity of the flow; it can prove the components are washed out by surface and subsurface runoffs.

Concentrations of ammonium nitrogen and phosphates were negatively correlated with the flow intensity. Concentrations of sulphates were also negatively correlated with concentrations of phosphates. Negative correlation between phosphates and sulphates concentration indicates their balance (low phosphates content - high sulfates concentration).

High diversification of biochemical indices BOD<sub>5</sub> (from 1.3 to 90 mg O<sub>2</sub>.dm<sup>-3</sup>) and chemical oxygen demand COD (from 8.2 to 182 mg O<sub>2</sub>.dm<sup>-3</sup>) were observed.

The quantities of the indices were not in agreement with normative values and were positively correlated (Fig. 3). It confirms a constant pollution of the Maskawa waters with organic substances and reduced inorganic compounds. It can be supposed that the pollutants are both domestic and coming from small food processing plants.

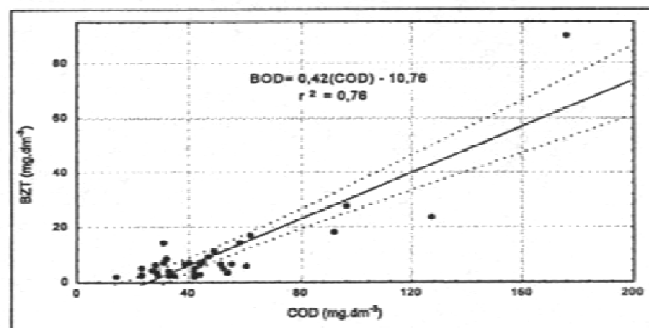
The analysis of the time trends of the composition and state of the pollution, as well as flow intensity, consisted in testing the hypotheses with zero regression line gradient, expressed in the changes of the given parameters in time according to McBean and Rover's methodology (1984). The conducted analysis proved that only dry remainder and chlorides show statistically significant non-stationary.

### Conclusion

In the section closing the catchments of Maskawa there is a significant dependence between hydrometeorological conditions and water quality. The concentrations of dissolved oxygen, dry residue, sulphates, calcium and nitrates were positively correlated with the intensity of the flow; it can be the proof of washing out of the components by both surface and subsurface runoffs. The analysis of the correlation between the selected water quality

**Figure 3** Relationship between BOD<sub>5</sub> and COD in the Maskawa river at gauging station Kępa Wielka

**Obrázok 3** Súvislosť BZT<sub>5</sub> s ChZT vo vodách rieky Maskawy v priereze Kępa Wielka



indices in the Kępa Wielka section showed there is a dependence between phosphates and sulphates, BOD<sub>5</sub> and COD. The trend analysis proved that only in the case of dry residue and chlorides there is a statistically significant non-stationary.

### Súhrn

V príspevku sú výsledky výskumu kvality vôd Maskawy pozdĺž jej behu, ktoré sa týkajú ôsmich rokov (z výskumného obdobia 1972–1999). Analýza časových trendov zloženia a stavu znečistenia a taktiež intenzity prietoku vody v priereze uzatvárajúcim povodie ukázala, že iba v prípade suchých zvyškov a chloridov existuje štatisticky preukazná variabilita. Zistilo sa, že pozdĺž behu rieky vystupuje tesná závislosť medzi hydrometeorologickými podmienkami a kvalitou vody.

**Kľúčové slová:** kvalita vody, hydrológia, prietoky, dynamické zmeny, korelácia

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