Preliminary studies of surface water quality in Damodar River basin (West Bengal, India)

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***Abstract*—The purpose of the research was to study the main parameters of the chemical composition of surface water and its quality in the Damodar River basin near the Durgapur city where the surface water is used for water supply of the local community. During fieldwork water of the Damodar River, its tributaries (Tamla River and small streams – receivers of industrial wastewater and drainage water) and the Maithon Reservoir was sampled from the layer 0.1–0.5 m. Preliminary studies have shown that the main pollutants in the study area are organic compounds, ammonium, phosphate and fluoride ions. Deterioration of water quality in some sampling points is connected with a low content of dissolved oxygen and high concentrations of nitrite, chloride and sulfate ions.**

Keywords—surface water, wastewater, chemical composition, pollution, the Damodar River basin, West Bengal, India.

I. Introduction

The lack of fresh water suitable for drinking purposes is one of the key problems nowadays. Taking into account the population growth in developing countries, the situation will only deteriorate in the future. That is why research on the ecological and geochemical state of surface water and groundwater is of great interest in order to develop measures to improve the efficiency of water protection measures and ensure guaranteed water quality in various regions of the world. In the framework of research carrying out by the working group "Water quality and pollution treatment" (Network University BRICS), the authors have studied the chemical composition of Damodar River which flows through the industrial and mining area of the state of West Bengal and Jharkhand in India.

II. Study Area

The Damodar River forms in the Jharkhand State (India) and afterwards it flows through the western part of the West Bengal (India) and runs into the rivers system of the Bay of Bengal catchment area, the Mundeswari River and the Hooghly River which is one of the arms of the Ganges. The total length of the Damodar River is 592 km, the catchment area is 24,235 km^2. The territory is characterized by a tropical monsoon climate with an average annual temperature of more than 26 ºC and annual atmospheric precipitation value of about 1600 mm/year. The precipitation increases from May to October and provides a significant increase in the water content of the rivers in the region. The least amount of rain occurs from December to March [1], which allows characterizing the phase of the water regime of the Damodar River as low water period during the fieldwork. The water flow of the Damodar River is regulated, and the river itself is a source of water supply for the local community, and a reservoir for the discharge of large volume of wastewater, including drainage waters of coal-mining enterprises and drains of the chemical industry and steel industry.

III. Methodology of the FieldWork and Chemical Analysis

The fieldwork on the sampling of surface water in the West Bengal near the Durgapur city was conducted in March 2019. Water of the Damodar River, its tributaries (Tamla River and small streams – receivers of wastewater and drainage water) and reservoir (Maithon Reservoir, water supply channel of Durgapur Barrage) was sampled from the layer 0.1–0.5 m (Fig. 1):

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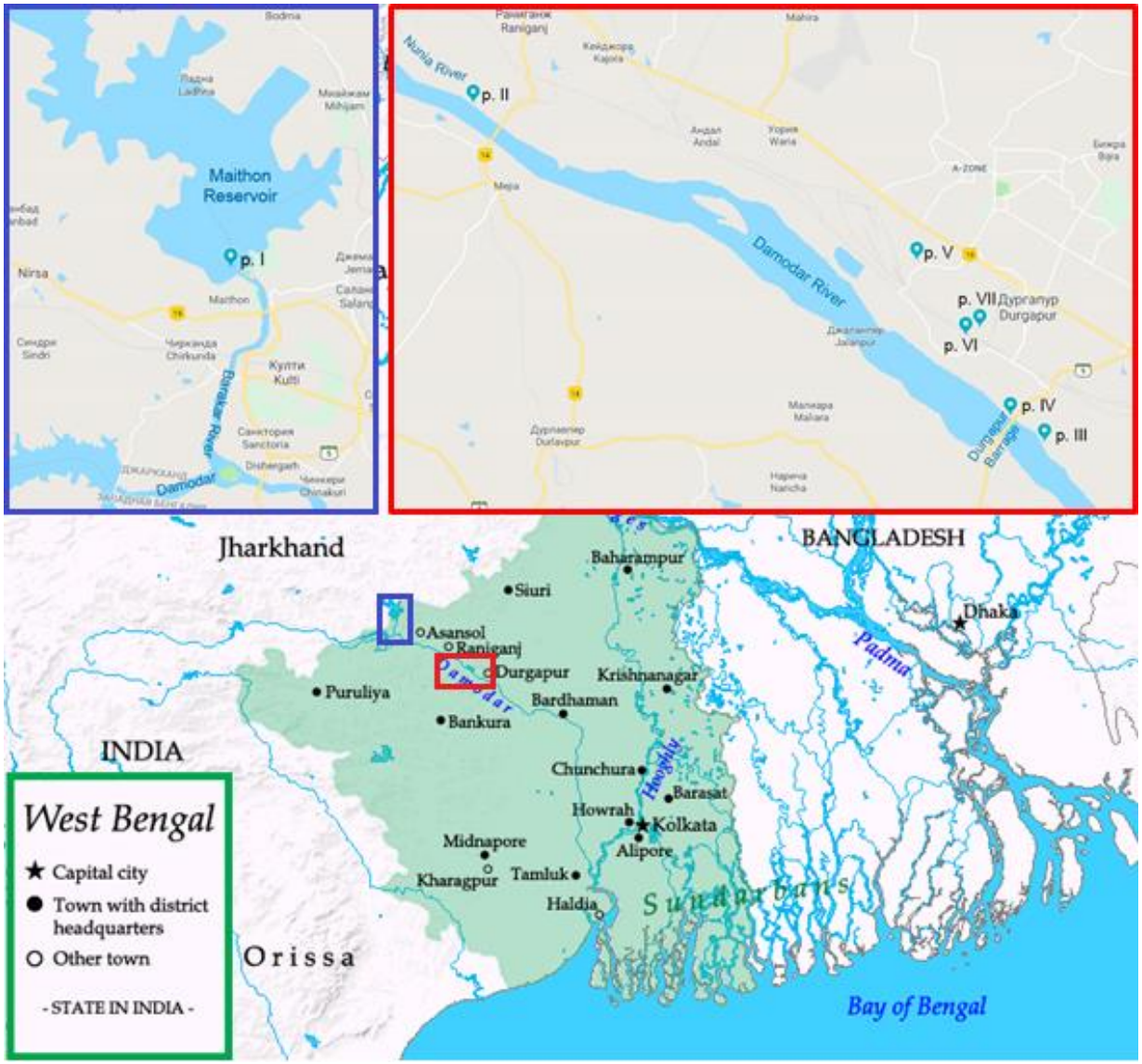

Fig. 1 Scheme of the sampling points location [2, 3]

p. I – Maithon Reservoir on the Barakar River before the confluence with the Damodar River in its middle reach, 65 km upstream (North-West) from the Durgapur city. The sample was taken 300 m from the bank;

p. II – Damodar River, 25 km upstream (North-West) from Durgapur. Sampling was carried out at the left bank of the Damodar River after the confluence with the Nunia River. Coal mines are located in the immediate vicinity of the sampling point;

p. III – the Damodar River, downstream from the Durgapur city;

p. IV – water supply channel outlet from Durgapur Reservoir (Durgapur Barrage, the Damodar River) in Durgapur, which supply water for the left bank of the Durgapur city;

p. V – the Tamla River in Durgapur. Sampling was carried out from the middle of the Tamla River, the tributary of the Damodar River, after the confluence of sewage of alloy steel factory and domestic wastewater;

p. VI – stream near Durgapur Chemicals Limited [4]. At the sampling point, there was a strong unpleasant smell of chemicals. Water is characterized by a very high value of Eh (Table 1);

p. VII – stream near Durgapur Project Limited power station [5], wastewater and drainage water from the plant enters the stream.

Rapidly changing parameters (temperature, pH, Eh, Dissolved Oxygen (DO)) was measured in situ. Samples were stored in 0.5 L and 50 mL polypropylene vials.

The determination of physical-chemical and geochemical parameters was performed in the hydrogeochemical laboratory of Tomsk Polytechnic University (Russia) using potentiometry for pH, conductometry for electrical conductivity (EC); titrimetry for carbonate system (bicarbonate, carbonate, hydrocarbonate), chloride, calcium ion, total hardness, permanganate demand (PD), turbidimetry for sulphate ion, ion chromatography for sodium, potassium, fluoride ions, photocolorimetry for nitrate, nitrite, ammonium and phosphate ions, fluorimetry for chemical oxygen demand (COD), high temperature catalytic oxidation for dissolved organic carbon (DOC).

TABLE I. MAIN PARAMETERS OF CHEMICAL COMPOSITION OF DAMODAR RIVER WATER.

Parameters	Sampling points						
	I – Maithon Reservoir	***II – Damodar River, before Durgapur***	***III – Damodar River, after Durgapur***	***IV – Channel from the Damodar River***	***V – Tamla River***	***VI – Stream near the chemical plant***	***VII – Stream near the thermal power plant***
EC[a], μS/cm^3	185	780	759	345	632	4590	630
pH	8.14	7.60	7.39	7.07	7.44	8.25	7.74
Eh, mV	-4	-10	177	216	-3	680	264
mg/L							
CO_2	<2.0	7.0	7.0	10.6	2.0	<2.0	<2.0
DO[b]	9.2	5.2	6.4	5.2	1.3	7.7	2.2
TDS[c]	149.0	641.7	511.9	259.4	462.7	2648.4	452.7
Ca^{2+}	18.0	47.3	40.3	25.7	40.9	56.0	38.5
Mg^{2+}	4.6	17.5	13.7	6.0	11.7	8.1	14.8
Na^{+}	12.0	85.0	77.0	23.0	49.0	962	53.0
K^{+}	1.2	7.5	7.1	3.0	10.0	3.8	7.1
HCO_3^{-}	92.7	395.0	222.0	146.0	239.0	117.0	229.0
CO_3^{2-}	4.2	<10	<10	<10	<10	9.6	<10
SO_4^{2-}	6.9	39.0	55.0	36.8	49.7	132.0	56.0
Cl^{-}	9.4	50.4	96.8	18.9	62.4	1360	54.3
F^{-}	0.62	0.65	1.51	1.07	1.93	2.88	1.97
PO_4^{3-}	<0.05	5.00	1.10	0.16	4.80	2.02	1.00
NO_3^{-}	0.12	3.05	0.52	2.13	0.26	4.06	0.39
NO_2^{-}	<0.02	1.35	0.42	0.10	<0.02	<0.02	0.02
NH_4^{+}	0.32	14.80	8.60	0.43	13.40	0.19	8.50
PD[d]	2.6	7.5	6.4	3.2	6.7	5.1	7.4
COD[e]	9	44	36	22	43	29.12	43
DOC[f]	1.93	4.70	3.62	2.47	3.70	3.06	3.60

a. Electrical conductivity
b. Dissolved oxygen
c. Total dissoved solids
d. Permanganate demand
e. Chemical oxygen demand
f. Dissolved organic carbon

IV. RESULTS

Analysis of the data obtained have shown that during the low water period surface water are characterized as fresh excluding one of the streams – receivers of wastewater from the chemical plant, in this stream there is a very sharp increase of electrical conductivity due to the increase in concentrations of chloride and sodium ions, and quite high content of sulfate. The values of total dissolved solids (TDS) vary from 149 to 2649 mg/L (Table 1). The values of pH vary from neutral (the Tamla River, water supply channel and the Damodar River downstream from Durgapur) to slightly alkaline (Maithon Reservoir, the Damodar River upstream from Durgapur and the streams-receivers of wastewater).

The Eh values vary widely, from -10 to 680 mV. The highest value characterizes the stream near the chemical plant as mentioned above (point VI in Table 1). The water of the Maithon Reservoir, the Damodar River upstream from Durgapur and the Tamla River have negative values of Eh. At the same time, water of the Maithon Reservoir has the high content of DO, as well as water of the stream near the chemical plant, while the lowest values characterize water of the Tamla River and the stream near the power plant, i.e. the content of DO do not correlate with the values of Eh, which are determined by the presence of other oxidation and reduction agents in the studied waters.

The content of DOC and related values of PD and COD is quite high in all sampling points except the water of the Maithon Reservoir

Hydrocarbonate, calcium and sodium ions prevail in chemical composition in most of the sampling points (Fig. 2). However, it should be noted that chloride ion has a significant proportion in the chemical composition of waters of the stream near the power plant, the Tamla River and downstream of the Damodar River, while in the stream near the chemical plant it prevails and reaches 1360 mg/L. In this sampling point, the content of sulfate ions is also quite high

Studied waters are soft according to the values of total hardness, the concentrations of Ca^{2+} and Mg^{2+} vary from 18 to 56 mg/L and from 4.6 to 17 mg/L, respectively (Table 1). The concentrations of Na^{+} is quite high in the water of the Damodar River, the Tamla River and the stream near the power plant, and prevail in the water of the stream near the chemical plant. In this point the content of potassium is the highest among studied water (10 mg/L), quite high concentrations of K^{+} in comparison with average content for river water [6] are observed also in the water of the Damodar River and the stream near the power plant.

Quite high content of fluoride is observed in the Tamla River, the streams near the plants and the Damodar River downstream from Durgapur. While ammonium and phosphate concentrations are raised in almost all sampling points except water of the Maithon Reservoir and water supply channel. It means that fluoride ion enters to the water of the Damodar River with polluted water of its tributaries, but the increase of the concentrations of nitrogen and phosphorus compounds results from a nonpoint source of pollution, e.g. agricultural activity. It should be noted also the increase of nitrite content in some sampling points.

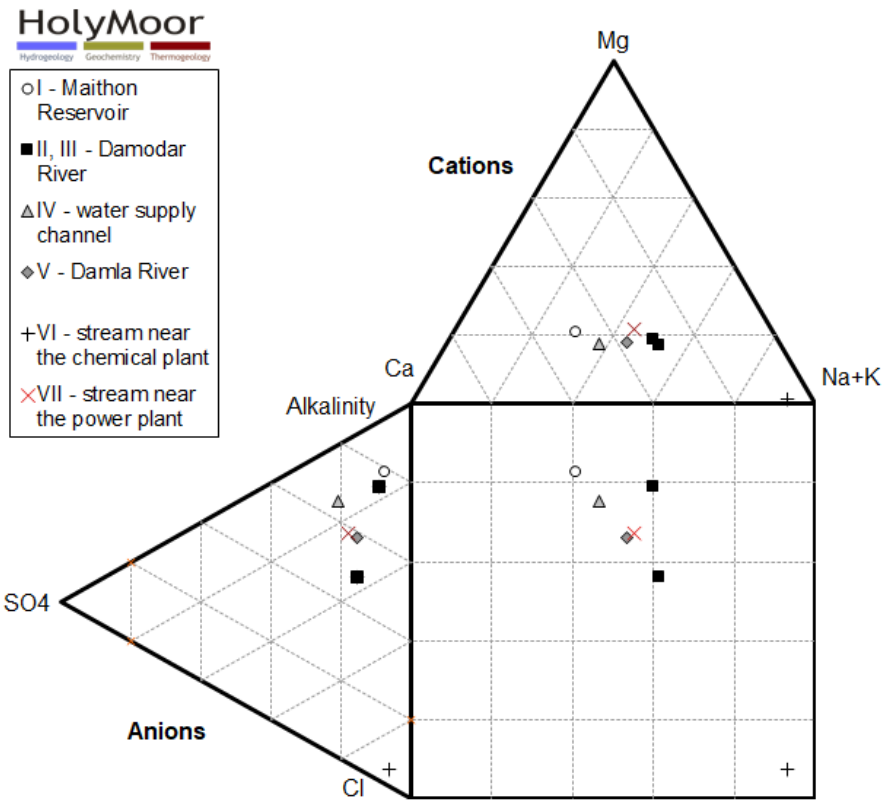

Fig. 2 Durov diagram with data of the surfase water chemical composition in the Damodar River basin.

V. Conclusion

Data obtained on the chemical composition of surface water in the Damodar River basin indicate rather low water quality.

The least polluted water is the water of the Maithon Reservoir, where concentrations of all substances are less than maximum permissible concentrations.

Deterioration of water quality is associated with a high content of organic substances (according to the values of COD and PD), ammonium nitrogen, fluoride and phosphate ions in most of the sampling points. In some sampling points, high concentrations of nitrite, chloride, sulfate, and sodium are observed, as well as low content of DO.

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