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Original Research Paper

Impact of Industrial Wastewaters on the Physicochemical Characteristics of Chambal River at Nagda, M. P., India

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ABSTRACT

The impact of effluent from chemical and textile industries on the physicochemical characteristics of Chambal river was carried out for period of one year. Water samples were collected quarterly covering all the three seasons. Five sampling stations were chosen along the river, corresponding to the locations with notable industrial discharges into the river. The effluents discharged into stations 2, 3 and 4 led to slight increase in pH, BOD and COD values. *t*-test results revealed that turbidity, TDS, TSS, electrical conductivity, DO, chloride, sulphate and hardness were significantly different among various stations sampled. The upstream (station 1) and downstream (station 5) reference sites recorded lower values of these parameters. Season did not affect much of these parameters except for chloride, sulphate and TDS, which were significantly different among the various sampling periods. The study underscores the need for immediate remediation programmers to control the poor water status of the sections of the river studied.

INTRODUCTION

Good water quality and healthy ecosystems are essential to maintain the aquatic biota (Francis et al. 2008). The freshwaters are usually productive but in industrial areas and urban centers there is some pollution with high levels of faecal coliforms, heavy metals, organic matter and industrial wastes, which contribute health hazards (Okiotola & Osibanjo 2009). Although water quality is to some extent is an index of water pollution. Indices presently used in laboratories are inadequate to indicate the damage that is done by the heavy metals, metalloids, organic and inorganic compounds, and blue green algae. Studies of physicochemical characteristics of water bodies in many many industrial areas have received considerable attention (Rajan et al. 2008, Bhagat 2008, Mishra & Bhatt 2008, and Gupta et al. 2009).

Nagda is situated at 23’27” N and 75’25”, 517 meters above m.s.l. in Ujjain district in the state of Madhya Pradesh (Fig. 1). It is an industrial town and situated on the banks of Chambal river. Presently Nagda is a major industrial town having manufacturing units of viscose fibre, thermal power plant and chemical plants of Grasim Industries Ltd.

River Chambal originates from Barnagar (M.P) and joins River Yamuna afterUdi at Jahika (U.P). From its origin onwards, tributaries Khan and Kshipra join Chambal before Nagda. More than one lakh of residents in and around the Nagda area rely on water from Chambal river for public use, industrial supply, power plant cooling and wastewater treatment. The river receives water from different units of Grasim Industries and sewage from Nagda town. Wastes after coming from the factory complex runs in a channel for about 3 km and joins River Chambal near Juna Nagda.

Fig. 1.Chambal river in Nagda.

The Chambal river in M.P., affected by effluents of industrial complexes, offers an opportunity to quantify the impact of such effluents on the water quality, which may lead to better understanding of pollution processes in the river that may lead to improved regulation and policy development.

The present study aims at describing the seasonal variation of physico-chemical parameters of water affected by the industrial effluents and to identify the parameters that most influence the variations observed.

MATERIALS AND METHODS

Water samples were collected quarterly beginning from the month of June 2008 to May 2009. Description of study stations is as below.

Station 1: This station is located upstream at Methwasa village. Human activities are low here confined only to bathing and fishing. This station was taken as the reference station (control) owing to the absence of industrial discharges (Fig. 2).
Station 2. It is located near Chamunda mata temple. It is close to Nagda town and 4 km away from station 1. Motor vehicles are constantly washed. Also devotees of Goddess immerse their pantheon (pooja material) directly into the river.
Station 3: This station is located near Mukteswar temple at Juna Nagda and is is poorly vegetated. The discharges of industrial complex and domestic waste are drained into this station. It is about 1 km away from station 2 (Figs. 3, 4 and 5).
Station 4: This station is located about 2 km away from station 3. It is located between the village Juna Nagda and Gidhgarh. It is also poorly vegetated (Fig. 6).
Station 5: This station is located near the village Parmer Keri at the downstream of the river. It is 2 km away from station 4. This zone can be considered as recovery zone (Fig.7).

Water quality analysis: Sampling of water was carried out at the five study stations three times in the year from June 2008 to May 2009, covering monsoon, winter and summer seasons. Water was collected in sterilized phosphate free pre-cleaned polythene bottles and processed within 6 hrs. The samples were analyzed by standard methods (APHA 1985, AOAC 2002) for major physical and chemical water quality parameters like pH, electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), total hardness (TH), dissolved oxygen (DO), biochemical oxygen demand (BOD) and chemical oxygen demand (COD).

Student's '*t*' test was performed to compare the means as well as the seasonal differences in the effluent quality and also the water in the river.

RESULTS

A summary of physicochemical parameters of Chambal river water for the different stations are given in Table 1.

pH: pH fluctuated between 6.8 to 11.5 at all the stations sampled. Station 3 recorded more values oriented to be more acidic than other stations in all the seasons. The highest pH value of 7.1 was recorded for this station in June 2009. There was no distinct seasonal pattern in pH (Fig. 8).

Temperature: Surface water temperature (Fig. 9) was considerably high in summer in all sampling stations. Low temperature was recorded in the month of January for all the sampling stations.

Total dissolved solids (TDS): The value of TDS (Fig. 10) was significantly higher in stations 2, 3, and 4. Station 1 and 5 recorded lower TDS values. The highest TDS value (680 mg/L) was recorded in station 4 in April, 2009. The lowest value of TDS was recorded in the station 1 in November 2008. Results indicated that TDS was significantly different ($p<0.01$) among the stations sampled. It is relatively high in summer months in all sampling stations.

Total suspended solids (TSS): TSS values (Fig. 11) were lower than the TDS values in all the stations and in all the sampling months. TSS fluctuated between 16mg/L and 148mg/L at different sampling stations in different seasons. Relatively higher values of TSS were recorded during month of Nov-Jan, 2009 (winter) compared to summer months. Station 2 recorded relatively higher values of TSS as compared to other stations.

Electrical conductivity (EC): EC fluctuated between 45.5 and 735 µmho/cm (Fig. 12). There was significant difference ($p<0.001$) in EC among the various stations sampled. Station 4 recorded relatively higher value of EC during the year. There was no definite seasonal pattern.

Dissolved oxygen (DO): DO values were consistently low in all the stations and in all the months of the study **(**Fig. 13). DO values fluctuated from 1.4 to 7.5 mg/L. Stations 1 and 5 recorded relatively higher values. There was no marked or distinct variations in DO among the different sampling months.

Biochemical oxygen demand (BOD): BOD fluctuated between 0.3 and 54.4 mg/L (Fig. 14). The upstream station recorded lower values of BOD. Stations 2, 3 and 4 recorded relatively high values of 26.28 and 47.5 mg/L. There was no marked temporal variation in BOD. The lowest BOD value of 0.3 mg/L was recorded in the station 1 in April. A very high BOD value was recorded in the month of November as well as in the month of March at station 2.

Chemical oxygen demand (COD): COD fluctuated between 8 and 43.75 mg/L (Fig. 15). The value of COD was nearly uniform in all the station except station 2. The maximum COD value was recorded as 43.75 mg/L at station 2 in November, 2008. There were no significant differences in the values of COD in different stations neither there was any marked seasonal pattern.

Chloride: The chloride values varied between 1140mg/L and 2685mg/L (Fig. 16). Again, stations 3 and 4 recorded higher values of chloride in all the seasons. Station 1 recorded much lower chloride values in all the months of sampling. No seasonal pattern in chloride fluctuation was observed.

Sulphate: It was fluctuated from 200mg/L to 950mg/L (Fig. 17). Stations 3 and 4 recorded higher

Table 1: Temporal and spatial variation in some physical and chemical characteristics of Chambal River from July 2008 to May 2009.

S.No.	Season	Stn1	Stn 2	Stn 3	Stn 4	Stn 5
pH						
1.	Monsoon	7.2	7.5	8.7	8.9	7.2
2.	Winter	7.1	9.5	9.4	8.8	6.9
3	Summer	6.8	10.2	11.5	10.2	7.5
Temperature,°C						
1.	Monsoon	24.1	24.0	24.2	24.5	24.0
2.	Winter	22.4	23.1	24.1	24.0	22.8
3	Summer	30.1	31.0	31.5	29.8	30.5
TDS, mg/L						
1.	Monsoon	32.13	114.2	162.0	122.1	51.32
2.	Winter	110.10	448.1	392.1	380.0	82.12
3	Summer	92.10	410.1	415.5	390.0	79.5
TSS, mg/L						
1.	Monsoon	44.1	45.8	42.1	44.0	48.0
2.	Winter	16.1	148.1	140.2	122.0	59.0
3	Summer	21.1	128.1	128.0	126.0	60.0
EC, µmho/cm						
1.	Monsoon	110	120	280	350	120
2.	Winter	85	180	290	419	160
3	Summer	62	162	310	650	110
DO, mg/mL						
1.	Monsoon	7.2	6.9	4.8	6.0	6.5
2.	Winter	7.5	6.1	3.9	4.9	7.5
3	Summer	6.9	5.8	4.5	5.2	6.5
BOD, mg/L						
1.	Monsoon	0.3	2.1	24.2	24.2	15.2
2.	Winter	1.0	16.6	54.4	51.2	22.0
3	Summer	2.2	25.5	48.2	46.8	18.0
COD, mg/mL						
1.	Monsoon	0.8	18.0	15.1	14.0	11.0
2.	Winter	12.0	43.75	38.0	32.0	24.0
3	Summer	10.0	36.0	34.0	24.1	16.0
Chloride, mg/L						
1.	Monsoon	1140	1212	1350	1372	1350
2.	Winter	1170	1322	1972	2021	2010
3	Summer	1210	344	2685	2420	2400
Sulphate, mg/L						
1.	Monsoon	220	280	290	310	350
2.	Winter	240	300	700	690	600
3	Summer	280	350	950	800	780
Total Hardness, mg/L						
1.	Monsoon	250	300	400	390	400
2.	Winter	200	800	1400	1380	800
3	Summer	280	992	1900	1780	1380

values of sulphate in the all seasons except in the months of monsoon. The value of sulphate was uniform and not too different from each other. The values of sulphate recorded in all sampling stations were uniform during monsoon season.

Total hardness (TH): It has been observed that calcium hardness (30-200mg/L) was nearly two-

Fig. 2: Station 1, Upstream.

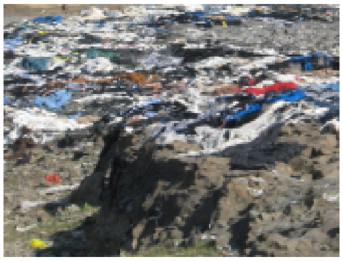

Fig. 3: Station 3 (coloring, bleaching of fibres).

Fig. 4: Effluent channel joins the river.

Fig. 5: Station 3 (pollution zone).

Fig.6: Station 4 (pollution zone).

Fig.7: Station 5 (recovery zone at Parmar kheri).

fold greater than that of magnesium hardness (15-120mg/L). The total hardness fluctuated from 45mg/L to 320mg/L) in all sampling stations during all the seasons (Fig. 18).

DISCUSSION

The physicochemical parameters exhibited considerable variations from sample to sample. The rainfall and relative humidity during the period of the study were typical of the tropical country with relatively high values in June/July (Nosheen et al. 2002).

It was observed that the pH fluctuated between 6.8 and 11.5 in all the stations. It is obvious that only bleaching samples have pH with permissible limit, while other samples have higher pH values especially mixed effluents. These results are in accordance with the results of (Nosheen et al. 2002), who reported that textile wastes are highly alkaline. pH effluents affect physicochemical properties of water which in turn adversely affects aquatic life, plants and humans. This also changes soil permeability which results in pollution of underground water (Rump & Krist 1992). Though pH has no direct effect on human health, all biochemical reactions are sensitive to variation of pH. For most reaction as well as for human beings neutral pH is considered as best and ideal. In the present study the pH values of water samples from stations 2, 3 and 4 were higher than the permissible limits. pH was positively correlated with conductance and total alkalinity.

The EC values were found higher in stations 2, 3 and 4, which is due to dissolved salts present in the effluent. Very low conductivity was found at sampling stations 1 and 5. Water temperature did not show any marked seasonal variation.

The influx of industrial effluents significantly lead to increase in total dissolved solids in stations 2, 3 and 4. Stations 1 and 5 recorded comparatively lower values of TDS. Dissolved solids values were high during summer period and low in rainy season, thus reflecting the seasonal pattern. TDS values of majority of the samples are much higher than the permissible limits, which predicts the

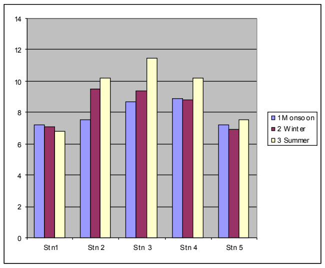

Fig. 8: pH

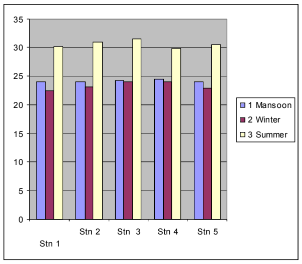

Fig. 9: Temperature

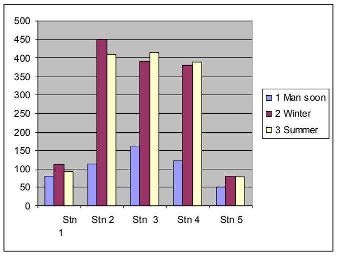

Fig. 10: TDS, mg/L

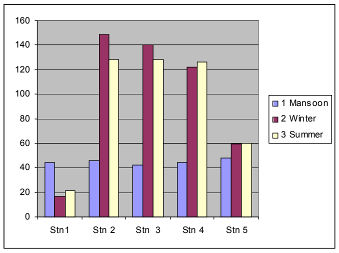

Fig. 11: TSS, mg/L

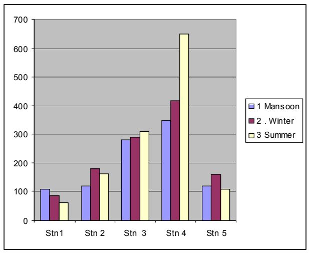

Fig. 12: EC, µmho/cm

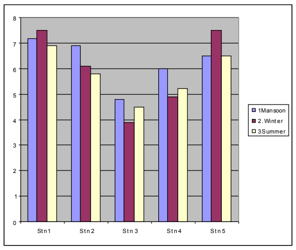

Fig. 13: DO, mg/L

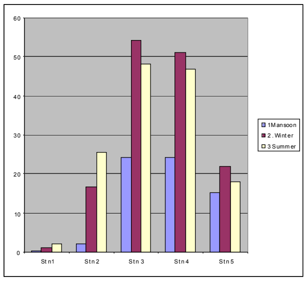

Fig. 14: BOD, mg/L

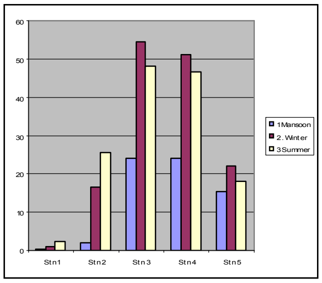

Fig.15: COD, mg/L

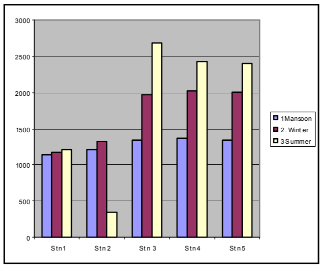

Fig. 16: Chloride, mg/L

presence of excess dissolved matter in the effluent. These values are very close to the findings of Francis et al. (2008). High suspended solids are one of the major sources of sediments which reduce the light penetration into water and ultimately decrease the photosynthesis. Consequently it reduces the DO level (Tyagi & Mehra 1990).

The DO of the stretch of the river examined showed that it was poorly aerated, irrespective of the seasons. It may be due to nature of the effluents discharged into the water that exerts high demand on dissolved oxygen. Again, the raw effluents discharged into the water resulted in high COD and BOD values. Both, BOD and COD values in experimental stations 2, 3, 4 and 5 were high. It indices that almost all the samples are highly polluted. In addition, the higher levels of suspended solids in the waters increased BOD and COD, which depleted DO in waters. These results are in close agreement with Francis et al. (2008) who also reported a high BOD and COD values in textile effluent. It shows that the effluents have high oxygen demanding materials, which causes depletion of dissolved oxygen. Moreover, high BOD and COD can also produce offensive color. Hence, the BOD of these

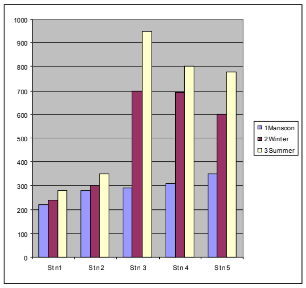

Fig. 17: Sulphate, mg/L

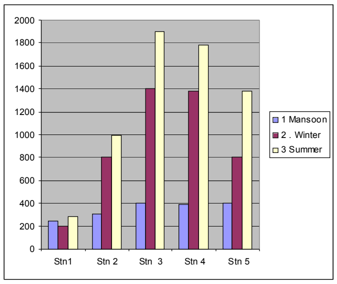

Fig. 18: Total hardness, mg/L

effluents renders them unfit for irrigation and decrease the recreation value of water (Tyagi & Mehra 1990).

The water samples from all the sampling stations were high in total hardness. Water hardness is the traditional measure of the capacity of water to react with soap. Hard water requires considerably more soap to produce lather. Hardness is one of the important properties of groundwaters from utilizing point of view for different purposes. In the present study, water was very hard and crossed the permissible limits. It is well known that hardness is caused by variety of dissolved ions, predominantly calcium and magnesium. The high concentration of total hardness in waters may be due to dissolution of ions from sediment rocks, seepage and run off. In the present study, total hardness was positively correlated with chloride, calcium and magnesium.

All the textile effluents have alarmingly high values of chloride contents. High chloride contents are harmful to metallic pipes as well as for agricultural crops. Moreover, it also affects microorganisms, which are important in food chains of aquatic life. In addition, bleaching effluents have high chloride contents. They are not easily biodegradable and are highly toxic (Agrawal 1996). Total alkalinity is a measure of the ability of the water to neutralize strong acids. The constituents of alkalinity in natural systems include mainly carbonate, bicarbonate, hydroxide and other components. These components result from dissolution of mineral substances in soils and from atmosphere (Lee et al. 1997).

The work presented here only threatens the chemical quality of a segment of the river, but it is equally important to extend the study to include measurement of a range of biological as well as physicochemical properties of soils which receive this polluted water for irrigation purposes, identification and chemical analysis of plants grown on soils receiving this water, and microbial analysis of soils (Sail et al. 2006).

From the data obtained in this study, the physicochemical parameters monitored in stations 2, 3 and 4 showed high levels of dissolved and suspended solids. This must have been as a result of the nature of effluents discharged from the industries. Accordingly, water from these sampling stations is not free from the pollution and cannot be used for domestic purposes, drinking and even for agriculture without proper treatment.

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