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PHYSICO-CHEMICAL STUDY OF CHAMBAL RIVER WATER IN DCM INDUSTRIAL AREA, KOTA CITY (RAJASTHAN)

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Water is a vital component of the environment in which sustains an entire array of life. It is therefore necessary to maintain the wholesomeness of water resources to ensure ecological sustainability. Self purification capacity of a water body helps it to restore its original properties, but this power is limited. External processes which disturb the natural equilibrium pose threat to all the ecosystems which are interdependent and articulated to each other. The River Chambal passes through the heart of the Kota City of Rajasthan (India). Industrial and domestic wastes released in the river are its prime pollutants. Present study is concerned with the water quality analysis of canal of river Chambal running through DCM industrial area of Kota with reference to physico-chemical analysis. Regression analysis of BOD and COD of the Chambal indicated a linear relationship between both parameters. Mean BOD observed was 4.8, COD was 31.9 and Biodegradability index was recorded 0.15. The study indicated that proximity to Delhi Cloth & General Mills (DCM) and high anthropogenic activities are adversely affecting the water quality of the Chambal river in Kota city (Raj).

Keywords: Biodegradability index, Correlation, Pollution, Physico-chemical analysis, Regression analysis.

Introduction

Water is well known as the cradle of life but it can become a grave threat for the existence of mankind if not maintained and managed in planned and sensible way. Water pollution now stands as a universal problem. Water bodies are being blemished and the pollution rate is increasing by degrees. In India about 70% of water bodies are polluted due to the release of untreated domestic sewage, detergents and industrial wastes[1]. Alarms have rung. Careless and improper handling of today will be an immense problem for future. Serious and sincere efforts are needed to face this mammoth in order to ensure enduring supply of consumable water. Rivers are major factor responsible for framing and manipulating the topography of a region, and harmonizing the ecological equilibrium of a catchment area[2]. The industrial city of Rajasthan, Kota (25°11' N and 75°51' E) has blossomed around the river Chambal which flows through the heart of the city and is its lifeline. Like other rivers due to overexploitation this waterway has also been tainted. As the river runs, it meets several discharge points where industrial and domestic wastes are loaded which deteriorate its water quality.

Monitoring of biochemical parameters is the most experienced technique for assessment of water quality when pollution is a major menace to river dynamism[3].The present study is concerned with the water quality analysis of canal of river Chambal running through DCM industrial area of Kota city (Rajasthan) with reference to physico-chemical analysis. Analysis of physical and chemical properties of water is the best way to perceive its quality[4].

Material and Methods

Samples were collected in first quarter of, 2020 from five sites of the industrial area of Kota City (Raj) spreading over a stretch of approx. 10 kms from DCM Shriram (Delhi Cloth & General Mills). The study was conducted at the following sites (Fig: A and B):

Sharv Siddh Shani Mandir opp DCM (Site 1)
Near Sen. Sec School, Shriram nagar (Site 2)
Near Overbridge (Site 3)
Dadhdevi modh (Site 4)
Ummedganj Pakshi Vihar (Site 5)

Water samples were collected in Iodine treated PVC bottles according to the recommendations of APHA 2005[5]. Samples were analyzed for various physico-chemical parameters using standard methods of APHA 2005. AR grade reagents were used for the analysis. Double distilled water was used for all preparations. TDS (Total Dissolved Solids), pH and temperature were determined on the spot with digital meters. Other parameters were analyzed within 3 to 6hr of collection in the laboratory. Different parameters and methods used for physico-chemical analysis of water are summarized in Table: 1

Table 1:- Parameters and methods used for physico-chemical analysis

	Parameters of water analysis	Method employed
1	pH	Electrometric
2	Temperature (°C)	Thermometric
3	Total Dissolved Solids	TDS meter
4	Total hardness	Titrimetric
5	Dissolved Oxygen	Iodometric
6	Chemical Oxygen Demand	Titrimetric
7	Biochemical Oxygen Demand	5 Day BOD test
8	Copper	Colorimetry
9	Arsenic	Colorimetry
10	Molybdenum	Colorimetry

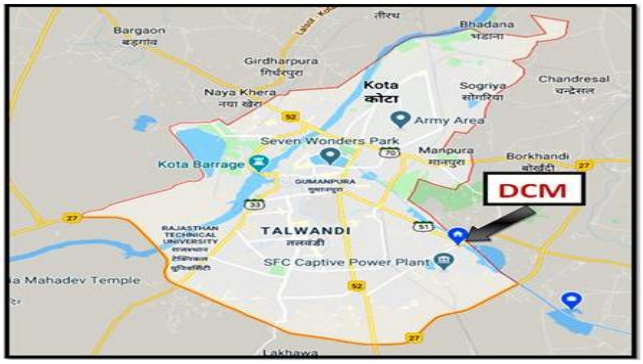

Fig A: Map of Kota City (Raj)

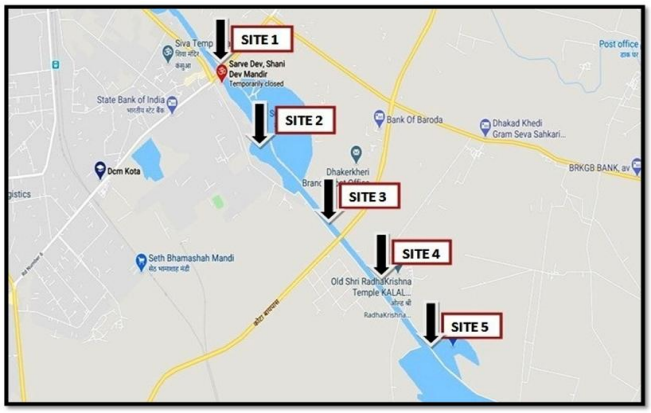

Fig B: Study sites of Chambal river canal

Results and Discussion

Comparison of study results with existing standards: The results of physico-chemical analysis of Chambal river water samples of Kota City (Raj) are summarized in Table: 2 and the comparison of mean values with the WHO and Indian standards of drinking water are given in Table: 3.

pH:

*p*H of all samples ranged between 8.25 to8.75 and was within acceptable limits for sites 1,2,3,4. pH of site 5 (8.75) was slightly higher. pH higher than 8 means that water at all sites is slightly alkaline. Beyond pH 8.5, water becomes bitter in taste.

Temperature:

Temperature affects chemistry and biology of organisms in water. Not much variation in temperature was recorded from all the sites. The temperature varied between 22˚C and 23˚C.Water samples from site 1, 3 and 4 were colourless, odourless and tasteless while that from sites 2 and 5 were cloudy and translucent in appearance and had musty smell.

Total Dissolved Solids (TDS):

Solids include all matter dissolved or suspended in water. Solids directly and indirectly affect other qualities of water like turbidity, visibility, colour etc.TDS (Total Dissolved Solids) of samples was between 131 to 158 mg/L which was within limits for all samples. Lowest TDS was of site 5 and highest was of site 2.

Total Hardness (TH):

Water that has high mineral content is known as Hard water. Hard water contains bicarbonates, chlorides and sulphates of calcium and magnesium. It requires considerable amount of soap to produce foam and also produces scales in appliances and so removal of hardness from water is desirable. Hardness of water varies from place to place. Total hardness of water samples recorded was between 112.5-187.5 mg/L and was within limit. According to a classification of total hardness, hardness ranges describe hardness of water[6] Table: 4.

Chemical Oxygen Demand (COD):

COD is the measure of amount of oxygen in water required for chemical oxidation of pollutants. Chemical oxygen demand (COD) is a definitive parameter for determining the degree of pollution in water[7]. It also aids in evaluating the extent of pollution in water bodies[8].COD of water samples in present study ranged between 29-34 mg/L. Highest COD recorded was of site 1 and 2 (34 mg/L) and lowest was of site 4 (29mg/L).

Dissolved Oxygen (DO):

DO determination measures the amount of dissolved (or free) oxygen present in water. It is essential for the survival of organisms. All samples had dissolved oxygen between 11to 18.5 mg/L which was within acceptable limit.

Biological Oxygen Demand (BOD):

BOD is the amount of oxygen required for the biological decomposition of dissolved organic matter in water under standard condition at a standard time and temperature. BOD is the principle test to give an idea of the biodegradability of any sample and self purification capacity of rivers and streams. It is the only parameter which gives the strength of the waste and an important parameter to assess the pollution of surface waters and ground waters where contamination occurs due to disposal of domestic and industrial effluents. Ordinary domestic sewage may have a BOD of 200 mg/L. Any effluent to be discharged into natural bodies of water should have BOD less than 30 mg/L. Drinking water usually has a BOD of less than 3 mg/L. But, when BOD value reaches 5 mg/L, the water is doubtful in purity. Determination of the BOD of wastes is useful in designing of treatment facilities[9].

BOD from site 4 only was within acceptable limits (2.5mg/L) while for other sites 1,2,3 and 5, BOD recorded was 5.5mg/L, 6 mg/L, 4.5mg/L and 5.5mg/L respectively which was higher than of standard value. This indicates higher level of contamination at all these study sites.

Heavy metals:

Arsenic and Molybdenum were absent in all water samples. Copper was reported only at site2 (0.5 mg/l) and was above limits according to Indian standards.

Comparison of sites and trend of different parameters:

pH showed a rising trend from site 1 to site 5. It was lowest at site 1 and highest at site 5 (Fig: 1). Approximately similar pattern was observed for TDS and TH except site 2 where highest values were recorded (Fig: 3 and Fig: 4). Fluctuation pattern of temperature, COD, DO and BOD were same. They were high at site 1 and 2, low at site 3 and 4 and then again showed a rise at site 5 (Fig: 2,5,6,7,). Copper was detected only at site 2 (Fig: 8). It is clear from above summary that site 1, 2 and 5 had high values of almost all parameters while site 3 and 4 had comparatively lower ones.

Site 1 is closest to DCM and near to Sharv Siddh Shani Mandir. Proximity to DCM and cultural and religious activities at the river bank are main reasons behind the high measures of parameters.

Table 2:- Comparative analysis of study sites of river Chambal with reference to physico-chemical parameters

S.No.	Parameters	SITE 1			SITE 2			SITE 3			SITE 4			SITE 5		
		Min	Max	Mean & SD	Min	Max	Mean & SD	Min	Max	Mean & SD	Min	Max	Mean & SD	Min	Max	Mean & SD
1	pH	8.1	8.4	8.25 ±0.21	8.2	8.3	8.25 ±0.07	8.2	8.4	8.3 ±0.14	8	9	8.5 ±0.71	8.3	9.2	8.75 ±.0.63
2	Temperature (˚C)	21	25	23 ±2.83	21	25	23 ±2.83	20	24	22 ±2.83	20	25	22.5 ±3.54	20	25	22.5 ±3.54
3	TDS (mg/L)	136	145	140.5 ±6.36	154	162	158 ±5.66	137	142	139.5 ±3.54	135	143	139 ±5.66	128	134	131 ±4.24
4	Total Hardness (mg/L)	150	200	175 ±35.56	175	200	187.5 ±17.68	150	175	162.5 ±17.68	95	150	122.5 ±38.89	100	125	112.5 ±17.68
5	COD (mg/L)	29	39	34 ±7.07	23	34	34 ±7.78	26	35	30.5 ±6.36	22	36	29 ±9.9	31	33	32 ±1.41
6	Dissolved Oxygen (mg/L)	14	17	15.5 ±4.24	9	15	12 ±4.24	10	14	12 ±2.83	10	12	11 ±1.41	14	23	18.5 ±6.36
7	BOD (mg/L)	5	6	5.5 ±2.83	4	8	6 ±2.83	4	5	4.5 ±0.71	2	3	2.5 ±0.71	5	6	5.5 ±0.71
8	Copper (mg/L)	0	0	0	0	0.5	0.5 ±0.22	0	0	0	0	0	0	0	0	0
9	Arsenic (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Molybdenum (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3:- Comparison of physico-chemical parameters of river Chambal with that of the WHO and Indian standards

S.No.	Parameters	Present data of Chambal	WHO (1997)	BIS (IS 10500:2012)	
				Acceptable	Permissible
1	pH	8.2-8.75	6.5-9.2	6-8.5	No relaxation
2	Temperature (˚C)	22-23			
3	TDS (mg/L)	131-158	500	500	2000
4	Total Hardness (mg/L)	112.5-187.5	300	200	600
5	COD (mg/L)	29-34			
6	Dissolved Oxygen (mg/L)	11-18.5		>4.00 (IS 2296:1974)	
7	BOD (mg/L)	2.5-6		3.00 (IS 2296:1974	
8	Copper (mg/L)	0.5	2	0.05	1.5
9	Arsenic (mg/L)		0.01		
10	Molybdenum (mg/L)		0.07	0.07	No relaxation

Site 2 is approximately 2km away from DCM and is located at Shri Ram Nagar, which is a densely populated residential area. Due to high anthropogenic activities and discharging of household wastes, fecal matter, animal wastes etc; highest values for all the parameters were recorded here. It appeared as the most polluted site of the study area.

Site 3 and 4 are far from DCM in comparison to the first two. Lower values of parameters at these sites clearly reflect the effect of distance and lack of human interference.

Site 5 is farthest from DCM. It is located at Ummedganj, Pakshi Vihar which is a famous bird sanctuary. It is habitat of variety of fauna and flora. Faunal activities and stagnant water are behind the high values observed here.

Table 4:- Classification of the water samples based on total hardness

S.No.	Description	Hardness (mg/L)	No. of Samples
1	Soft	0-60	-
2	Moderately Hard	61-120	Site 5
3	Hard	121-180	Site 1,3,4
4	Very Hard	>180	Site 2

Comparison of all sites on basis of pH, Temperature, TDS, Total hardness, COD, Dissolved Oxygen, BOD, Copper are represented graphically in figures 1,2,3,4,,6,7,8 respectively. Comprehensive comparison of all the sites on the basis of various physico-chemical parameters is represented graphically in Fig: 9

Correlation and linear regression model between BOD and COD:

Regression models are the best statistical tools for investigating any relationship between dependent and independent variables of small sample size[10]. The Multivariate Linear Relationship (MLR) method is used to design the linear relationship between a dependent variable and one or more independent variables. Two statistical criteria help to evaluate the performance of MLR method:- Coefficient of correlation (r) and Root Mean Square Error (RMSE).Correlation of coefficient (r) is a common criterion for goodness of fit for regression models[10].

MLR model can also be applied to BOD and COD estimation to find out any linear relationship between these parameters.

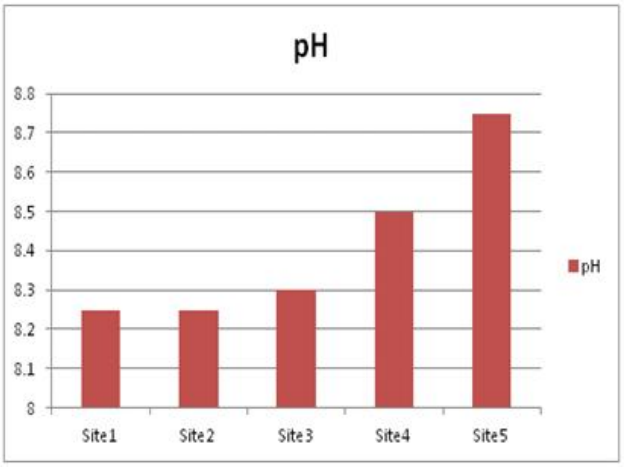

Fig 1: pH

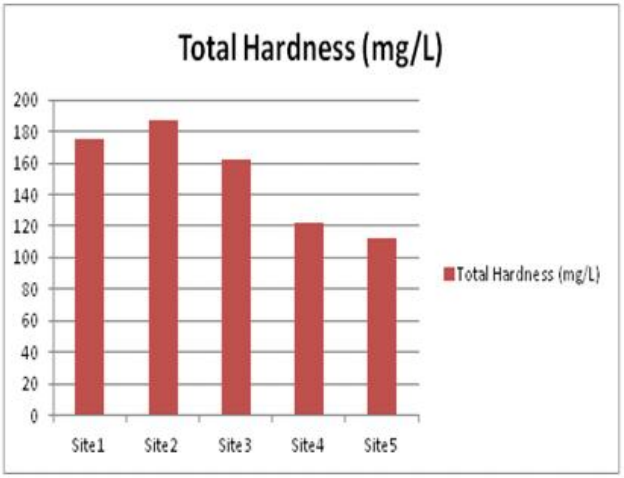

Fig. 4: Total hardness

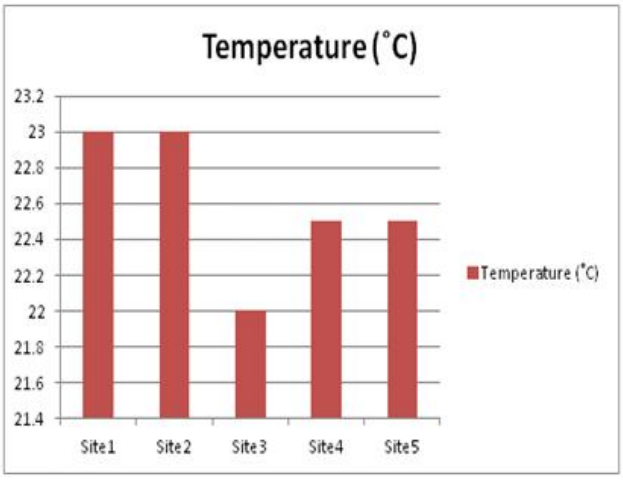

Fig. 2: Temperature

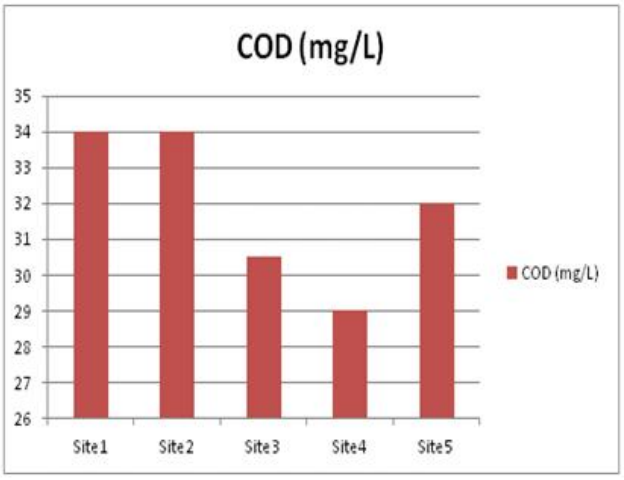

Fig. 5: COD

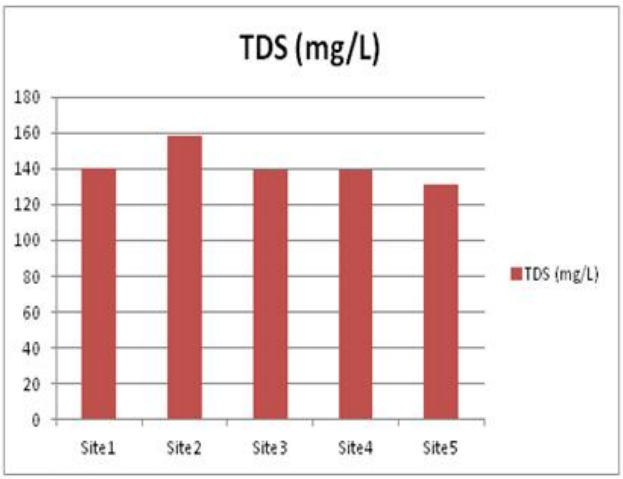

Fig.3: TDS

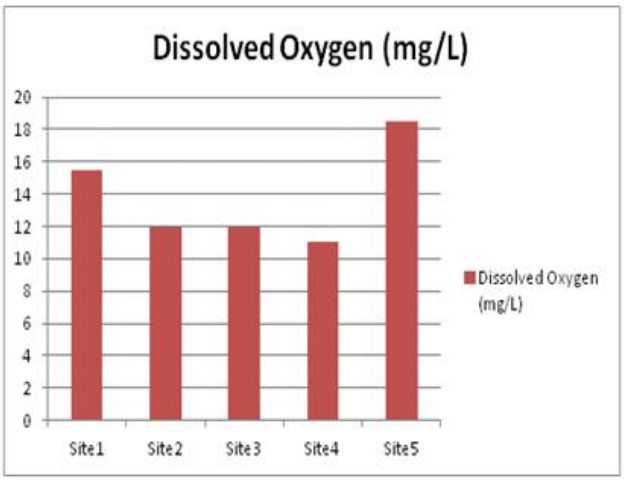

Fig. 6: Dissolved Oxygen

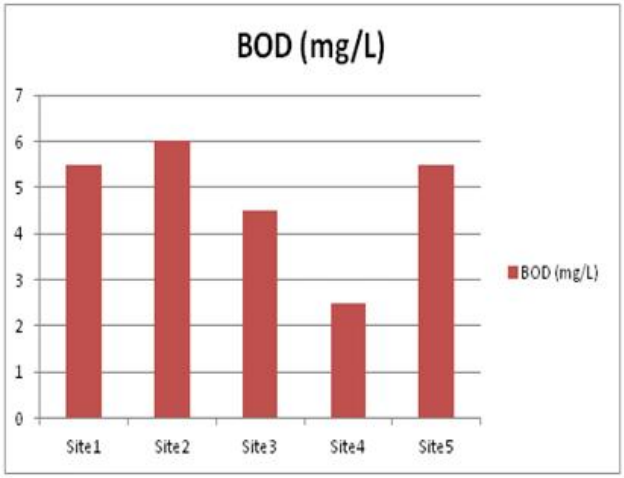

Fig.7: BOD

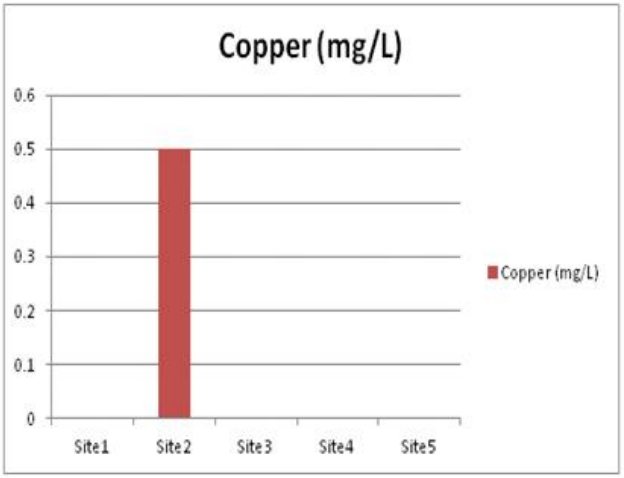

Fig. 8: Copper

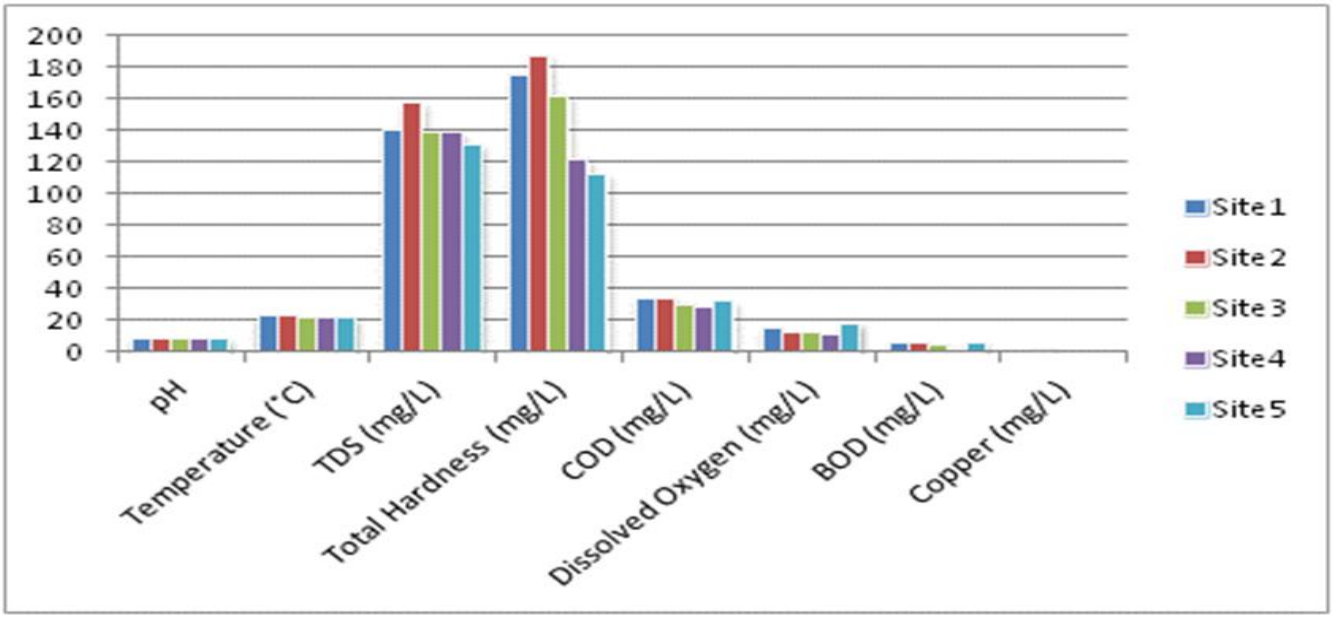

Fig. 9: Comprehensive comparison of all the sites on the basis of various physico-chemical parameters

The BOD values versus the COD values of river Chambal of Kota City were plotted and then regression analysis was used to develop the correlation. The plotted BOD-COD figures (Fig10 and 11) clearly indicate that there was a clear linear relationship between BOD and COD (BOD= 0.5807 COD-13.725 and COD= 1.4295 BOD+25.038 with R^2=0.8301). Since the BOD and COD are correlated, the estimation of BOD values using the COD test and vice-versa is possible. Thus, it can be used as a parameter to evaluate water pollution for quick action[11].

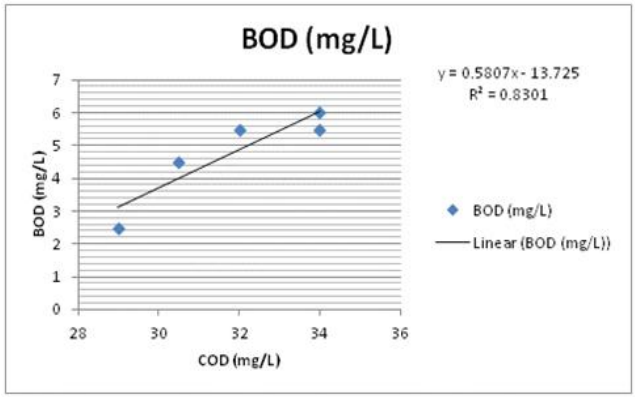

Fig. 10

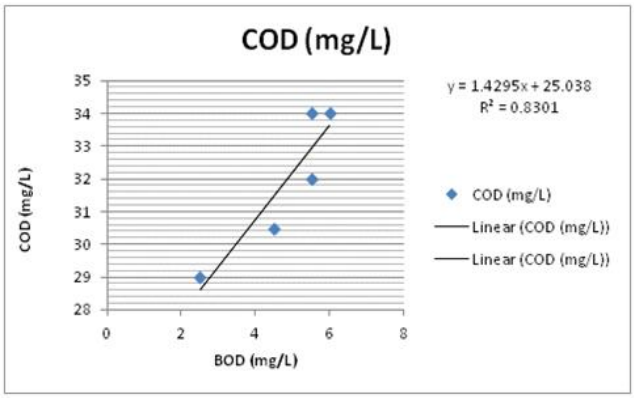

Fig. 11

Fig10 and Fig 11: Regression analysis and correlation between BOD and COD

BOD and COD ratio:

There exists a definite correlation between COD and BOD and by determining the COD, the information about the BOD can be derived[12]. COD results are typically higher than BOD values and the ratio between them vary according to water characteristics[13]. The COD and BOD results of the present study are graphically represented in Fig: 12 which show the similar pattern.

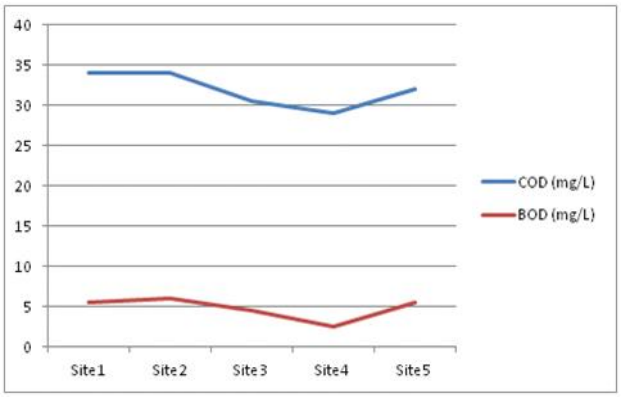

Fig. 12: COD and BOD ratio

According to Metcalf and Eddy 2003[14] the ratio of BOD and COD is used as an indicator for biodegradation capacity of a water body and it is known as "Biodegradability index" (B.I.). Biodegradability Index represents the slope of the plotted correlation of BOD and COD. It is considered as the cut-off point between biodegradable and non-biodegradable waste[15]. If BOD/COD is > 0.6 then the waste is fairly biodegradable, and can be effectively treated biologically. If BOD/COD ratio is between 0.3 and 0.6, then seeding is required to treat it biologically. If BOD/COD < 0.3, biodegradation will not proceed, thus it cannot be treated biologically. In river water study, BOD: COD ratio can be applied as an evaluative criteria for determining the extent of pollution and in delineation of a river[16]. The BOD and COD ratio of all five sites of present study are given in Table: 5.

Table 5:- BOD and COD ratio of different sites of river Chambal

Parameter	Site 1	Site 2	Site 3	Site 4	Site 5	Mean
BOD	5.5	6	4.5	2.5	5.5	4.8
COD	34	34	30.5	29	32	31.9
BOD:COD	0.16	0.18	0.15	0.09	0.17	0.15

From the Table: 5 we can conclude that B.I. of all sites is < 0.3 which indicates that waste here are non-biodegradable. None of the site falls in first two categories (fairly biodegradable and biodegradable after seeding) which is not a good condition. For river Chambal the mean BOD was 4.8, COD was 31.9 and BOD: COD ratio was observed 0.15.

Conclusion

The study clearly indicates that proximity to Delhi Cloth Mill (DCM) and high anthropogenic activities adversely affect the water quality of the Chambal river in Kota city (Raj). It is necessary to take preventive and remedial measures at earliest to prevent the deterioration of river quality for sake of consumable water supply and better future.

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