STATISTICAL APPROACH FOR THE ASSESSMENT OF WATER QUALITY PARAMETERS OF CHAMBAL RIVER AT NAGDA

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Abstract: Aquatic pollution is one of the major health concerns in the rapidly growing industrializing world. Multiple regressions is an extension of simple linear regression and can be used to predict the value of a variable based on the value of two or more other variables. The present study was aimed to evaluate the pollution status of River Chambal at Nagda, Ujjain. M.P. India, by using multiple regression and correlation analysis. To find out the pollution status, of the river, we selected 7 water samples from two study stations. The samples of December 2016, from both upstream and downstream were analysed to measure the temperature, pH, dissolved oxygen (DO), transparency, Total dissolved solids (TDS), Total hardness (TH) and Electrical conductivity (EC). Statistical analyses were carried out through correlation method and correlation coefficients were calculated between different pairs of parameters to identify the highly correlated and interrelated water quality parameters. A correlation matrix test was performed to check the significant relationship among the water quality parameters at 95% significance level. Results clearly reveal that the River at Juna Nagda (downstream) was more polluted due to various municipal and industrial activities. However, the upstream water at Methwasa was found unpolluted, as all the water parameters were found within the BIS/WHO standards. The present results confirm that the downstream of Chambal River at Juna Nagda are highly polluted. This study provides us an instrument to find the value of water parameters and extent of pollution hypothetically. It also provides the baseline information for assessment of contamination in the Nagda area. Regular supervision of the water quality is recommended to prevent the increase in water quality parameters.

Keywords: Chambal River, Multiple regressions, pollution, water quality parameters.

Introduction: Aquatic pollution is a major global concern. The rapid economic growth achieved after globalization by some of the developing countries including India, has adversely affected the quality of the environment and livelihood impacts. The major sources of drinking water in India are often contaminated by the activities of the adjoining populations and industrial establishments [1] [2] [3] [4] [5] [6]. The earlier publications of Reddy,P.B and his team clearly revealed that water quality of Chambal River, especially in downstream at Juna Nagda was worsening since last 10 years at Juna Nagda (downstream) due to industrial and municipal waste discharges. In any water quality monitoring program, it is very difficult to predict the representative variable due to seasonal and temporal variations in water quality. Therefore, a reliable estimation of the variables is necessary in water quality assessment programs. The application of various multivariate statistical techniques, such as principal component analysis (PCA) and correlation and regression analysis helps in the validation of complex data matrices to better understand the water quality and ecological status of the studied systems. It also permits the detection of possible factors sources that control water systems and offers an important tool for reliable management of water resources [7]. The aim of this study is to analyze the 6 parameters of water in 2 sampling stations of Chambal River at Nagda (M.P.India) for 31 days of December 2016. The acquired data set was subjected to the correlation and regression methods to assess the information about resemblances and differences between sampling stations of the Chambal River at Nagda, Ujjain (M.P.India).

Materials and Methods: Nagda is an industrial town and municipality in Ujjain district of Madhya Pradesh state, India, and is located near the bank of Chambal River. It is very close to tropic of cancer at 23'27N and 75'25 and 517 meters above MSL. The River receives effluents from both municipal and industrial in origin which may cause worsening the river water quality.

Sampling: The surface water samples from upstream (Methwasa) and downstream (Juna Nagda) were collected in winter (December 2016) once in three days for 31 days in air tight glass bottles at about 10 cm below the surface. All collected water samples were transported to the laboratory and stored at 4 ºC. Samples were analysed for different parameters like temperature, pH, dissolved oxygen (DO), transparency, Total dissolved solids (TDS), Total hardness (TH) and Electrical conductivity (EC) using the standard method of APHA [8] within 24 hours of sample collection.

Statistical analysis: The reason of using multiple linear regressions is to enumerate the correlation between several independent or predictor variables and a dependant variable. This statistical method was effectively used by many authors [9] [10] [11] [12] [13] Statistical calculations of multiple linear regressions

(MLR) were performed using XLSTAT 2010 Excel add-in Window software (https://www.xlstat.com/) [14].

Results and Discussion: The results of the correlation studies of water quality parameters of Chambal River at Nagda from both upstream and downstream was presented in Table.1. Few of the constraints shown significant correlation, while the others exhibited are not. This is possibly due to highly variable nature of chemical concentrations in industrial and municipal effluents as in the past [1] [2].Temperature showed significant difference between two stations ($p<0.01$). The high temperature at Juna Nagda (Staion-2) may due to severe discharge of sewage and also superficiality of the pond. Besides, the high temperature in summer months in this study was due to the intensity of sunlight ($46^{o}C$) and shallowness of the ponds. This is in support of the findings of Prasad, K.H et al [15], Hardikar, R., et al [16] and Bharathi, H.R et al [17]. Transparency has a major influence on the primary productivity of an aquatic system. Elevated water currents generally disturb all the suspended materials in any aquatic system, especially in shallow waters. Besides, transparency values can be influenced greatly by many factors like such as time of the day, clearness of the sky at the time of measurement (Cloudy or not) and suspended solids in water including plankton [18]. In the present investigation the transparent values were highly decreased in downstream. Excess amount of turbidity, dissolved substance or influx of sewage waste material and suspended particles in downstream might reduced the light penetration and photosynthesis of aquatic plants which finally reduced the dissolved oxygen (DO) in aquatic bodies.

pH in water is an important indicator of water quality of an aquatic system as most of the biological and metabolic activities are pH dependent. The optimum range for most aquatic organisms falling between pH is 6.5-8 [19]. The results of the present study clearly shown that pH of River water was ranged in between 7.1 to 8.4 (Table-1) and showed a neutral or slightly alkaline tendency at upstream. But the values of pH at downstream were found be significantly high ($p<0.01$). The increase in pH at downstream pointed out high pollution due to the addition of sewage and other wastes particularly when water flow was low or /and due to utilization of bicarbonate and carbonate buffer system in winter season. Besides, the entire biota constantly produces CO_2 as a product of respiration. The submerged aquatic plants remove CO_2 from the water as part of photosynthesis. Thus, the comparative rates of respiration and photosynthesis inside the aquatic body determine whether there is an addition or removal of carbon dioxide, and consequently pH falls or rises [20].

The total dissolved solids (TDS) of the present study ranged from 69.1 to 214.14 mg/L. Differences in TDS may be due to the entry of municipal waste, agriculture wastes and also by evaporation and less rainfall. TDS values of downstream were higher than the prescribed standards (BIS/WHO) and are not fit for drinking purposes. Water sources may contain a inconsistent quantity of inorganic salts like Ca2+, Mg2+, Cl- , SO4 2-, CO3 2- and HCO3 – in dissolved state. Total hardness (TH) is mainly a measure of calcium and magnesium concentration in water. According to Bhatnagar and Devi [21] hardness values lower than 20ppm causes stress and 75-150 ppm is optimum for aqua culture. However hardness above >300 ppm is fatal to aquatic life as it increases pH, resulting in non-availability of nutrients. In the present study the total hardness ranged from the lowest value of 54 mg/L obtained at upstream while the highest of 140 mg/L obtained at Juna Nagda (station2). We observed a significant difference in hardness ($P<0.05$) between two stations which may be due to decrease in water level in the ponds due to evaporation, concentrating the calcium and magnesium salts. Moreover, geographical background of various reservoirs is also responsible for variations in the hardness [22]. Dissolved oxygen (DO) refers to the concentration of oxygen gas integrated in water. Water absorbs oxygen from atmospheric air and also from aquatic plants during photosynthesis. Adequate amount of DO is essential for the growth and reproduction of aerobic aquatic life. In the present study the DO values ranged between 6.1 to 8.1 mg/L in different seasons and in different ponds. The elevated dissolved oxygen (DO) concentration observed during the winter season might be due to higher values of transparency which promoted the higher rate of photosynthesis by aquatic plants. Higher velocity wind also a cause which helps in freshwater mixing [23]. Results also confirmed that dissolved oxygen showed an inverse trend against the temperature. The depletion of DO at Juna Nagda may be credited to the increase in surface water temperature, reduced transparency and depth of water. The reduced transparency decreased the rate of photosynthesis which may be another reason for low DO in this study station. Statistical analysis (correlation matrix) clearly reveals that the transparency positively correlated with DO ($r = 0.760776$) while temperature significantly negatively correlated ($r = -0.75588$) at downstream. Total hardness (TH) also showed positive correlation with TDS ($r = 0.41615$) and pH ($r = 0.4533$).

Conclusions: Majority of the sample values of downstream were found to be higher than WHO/BIS standards. The correlations recognized between physicochemical parameters using regression equation can be used to predict the level of contamination of Chambal river water by different parameters. The case study of surface water pollution due to uncontrolled municipal and industrial effluent discharges and the results of multiple regression analysis predicted two factors for surface water for controlling their variability in waters of Chambal River. Multivariate statistical approaches show that the polluted surface water is strongly affecting the water quality of the River. The present study recommends that frequent monitoring of the quality of River water should be undertaken temporally and spatially to identify the source of toxic pollutants. The modern agricultural practices and anthropogenic activities were among the responsible sources for surface water pollution in Chambal River at Nagda, M.P.India. The present investigation provides the baseline information for assessment of contamination in the Nagda area. Regular supervision of the water quality is required to check the rise in water quality parameters.

Acknowledgments: This study was financially supported by UGC/CRO/Bhopal (Letter No.F.No.MS-86/107005/XII/14-15/CRO dated 09-02-2015) to Dr.P.B.Reddy. Author would also like to express his sincere thanks to the Principal and staff of microbiology and biotechnology of Govt.PG College, Ratlam for helping in both fish sampling and biochemical estimations.

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Table,1. Physico-chemical properties of water samples of Chambal River at Nagda, M.P.India

1.Temperature ^{0}C			2.Transparency (cm)		3.TH mg/L		4.TDS mg/L		5.pH		6.DO ml/L	
Sampling day	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
1	19.2	19.8	22.4	11.2	63	184	87	177	7.1	7.8	7.8	6.1
3	20.4	19.9	11.2	10.2	184	176	147	186	8.4	7.9	5.2	5.7
6	19.2	21.1	16.2	12.2	72	175	98	187	7.3	7.7	7.6	5.6
9	19.8	20.1	18.5	12.1	87	168	91	191	7.3	7.8	7.8	5.4
12	20.1	21.2	18.8	14.1	91	178	101	212	8.1	7.9	7.3	5.4
15	19.2	21.5	16.7	13.2	101	145	87	213	8.1	7.8	7.4	5.3
18	19.8	21.6	15.6	12.1	123	144	91	198	7.8	7.8	7.2	5.2
21	18.2	22.1	16.2	13.1	129	187	87	213	7.3	7.6	6.9	5.4
24	19.2	21.8	14.2	11.8	154	176	111	247	7.7	8.1	6.8	5.3
27	20.1	21.7	13.8	12.1	143	176	117	218	7.9	8.2	6.9	5.1
31	18.2	21.2	13.2	11.9	184	169	104	201	7.4	8.1	7	5.2

Table.2.Correlation Matrix of water parameters of Upstream

	1.Temperature	*2.Transparency*	*3.TH*	*4.TDS*	*5.pH*	*6.DO*
1.Temperature	1					
2.Transparency	0.595089	1				
3.TH	-0.18328	-0.14348	1			
4.TDS	0.759245	0.390463	-0.02067	1		
5.pH	0.11278	-0.20509	0.048931	0.524795	1	
6.DO	-0.75588	-0.46775	0.45447	-0.67504	-0.3695	1

Table.3.Correlation Matrix of water parameters of Down stream

	1.Temperature	*2.Transparency*	*3.TH*	*4.TDS*	*5.pH*	*6.DO*
1.Temperature	1					
2.Transparency	-0.51593	1				
3.TH	0.62077	-0.7862	1			
4.TDS	0.208786	-0.69551	0.41615	1		
5.pH	-0.11699	-0.48105	0.453303	0.475445	1	
6.DO	-0.22475	0.760776	-0.79478	-0.71864	-0.6568	1

All the r values are significant at the 0.05 level

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