WATER QUALITY STUDIES OF TWO RIVERS AT BUNDELKHAND REGION, MP, INDIA: A CASE STUDY

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Bewas and Sonar River are some one of the major rivers in Bundelkhand region (M.P.). In the present study, physico-chemical characteristics of two rivers have been compared during 2007-11. Water samples have been analyzed during 4 years for their 26 physico - chemical parameters. The correlation and multiple regression analysis applied to the datasets indicated their interrelationships, for evaluating water quality during the pre monsoon, monsoon, and post monsoon seasons.

The results indicated the, satisfactory water quality of the Bewas river water compare to Sonar river. Both rivers water were found to be potable after suitable disinfection treatment.

Keywords: physico - chemical parameters, correlation, multiple regression analysis

1. Introduction

Bewas River provides drinkable water to the populations of Sagar city: it is the main water resources for domestic purposes. Sonar River is passed through Rehali town in Sagar district and life line of Rehali town. 26 parameters were determined in order to establish the quality of water samples, by using standard analytical methods. The statistical tools such as Pearson correlation, regression and multiple regression have been very important method to determine interrelationship among water quality parameters. It was also helpful to determine the dominant parameter. Water samples were collected from pre to post monsoon seasons, three each during October 2007 to January 2011 by using standard methods [1-15].

Some other prominent scientist used mathematical modeling of physico-chemical parameters to explained water quality studies. (Valerian Antohe and ConstantinStanciu, 2009 [16]; K. Karunakaran etal,2009 [17]; A. K. Misra, 2007[18]).

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2. Material and Methodology

A total of 184 samples were collected from both river divided in to 6 sampling station, samples were taken in prewashed (with detergent, diluted HNO_3 and doubly de-ionized distilled water, respectively) clean polyethylene bottles without any air bubbles and tightly sealed after collection and labeled in the field.

The temperatures of the samples were measured in the field on the spot at the time of sample collection. The samples were immediately analysed in the chemistry lab to minimize the physicochemical changes. The error due to time has been omitted in the present study.

The determinations of the major ions, physical and other chemical properties of the water samples were determined on the same sampling day. Each sample was analysed using procedures outlined in the standard methods for the examination of water and wastewater as suggested in APHA [19].

The duration of sampling was categorized into three pre monsoon, monsoon and post monsoon period. The samples were collected regularly throughout the seasons.

The samples were analysed for 26 physico-chemical parameters using standard analytical techniques. All the chemicals used were of AR grade.

Table 1

List of physicochemical parameters and their test methods

S.N.	Parameters	Unit	Test Methods
1	Water temperature	ºC	Mercury-in-glass thermometer
2	Colour	Hz.U.	Pt-Co Scale
3	pH	-	pH meter
4	Turbidity	NTU	Turbidity tube
5	Dissolved Oxygen (DO)	mg/L	Winkler method
6	Biochemical Oxygen Demand (BOD)	mg/L	5 days incubation at 20° C and titration of initial and final DO.
7	Chemical Oxygen Demand	mg/L	Open Reflux Method
8	Conductivity	ms/cm	Conductivity meter
9	Alkalinity	mg/L	Titration
10	Total Solids (TS)	mg/L	Gravimetric (filtration and weighing of residue)
11	Total Suspended solids(TSS)	mg/L	Gravimetric (filtration and weighing of residue)
12	Total dissolved Solids	mg/L	Digital conductivity meter (LT-51)
13	Chloride	mg/L	Argentometric titration
14	Residual Chlorine	mg/L	Iodometric
15	Orthophosphate ($P0_4^{3-}$ — P)	mg/L	Ammonium molybdate ascorbic acid reduction method

16	Nitrate -Nitrogen (NO_3 — N)	mg/L	Spectrophotometric method
17	Ammonia-Nitrogen (NH_3 — N)	mg/L	Spectrophotometric (Phenate method)
18	Total Hardness as $CaCO_3$	mg/L	EDTA titration
19	Temporary Hardness as $CaCO_3$	mg/L	EDTA titration
20	Permanent Hardness as $CaCO_3$	mg/L	EDTA titration
21	Calcium Hardness	mg/L	EDTA titrimetric method
22	Magnesium Hardness	mg/L	Calculation after analysing Hardness and Calcium
23	Fluoride	mg/L	Colorimetric Method
24	Iron	mg/L	Colorimetric Method
25	Ca Content	mg/L	EDTA titrimetric method
26	Mg Content	mg/L	EDTA titrimetric method and calculation

Results obtained were subjected to multivariate statistical analysis using SPSS.11 [20], Winks SDA 6.0.5 [21], multivariate statistical analysis has been performed using standard methods. Chemical analysis results were compared with standard guideline produced by WHO [22]/IS: 10500 Standards [23].

3. Results and Discussion

The physico-chemical parameters of both the rivers viz. Sonar river and Bewas river have been compared during 2007 to 2011. From all results, it is cleare that Sonar river water quality was slightly different, compared to Bewas River.

Regarding the study of physico-chemical parameters of both rivers, pH is the controlling factor for silicate. The slightly higher value of pH in Sonar river, compared to that of Bewas river, shows that Sonar river water is more alkaline in nature. In Bewas river, the average values of BOD, COD, ammonia and iron recorded higher in monsoon compared to post monsoon, which could be due to the acidification of water caused by the elevated microbial degradation of organic debris and concentrated dissolved solids in the monsoon period. The application of chemical fertilizers, run off from agricultural field and other anthropogenic sources are the mainly responsible for over degraded quality of Sonar River water. The alkalinity may also be caused due to evolution of CO_2 during decomposition of organic matters.

The water of Sonar river is hard at most places. The concentrations of TH, Mg2+ exceed the safety limit prescribed for drinking water at some of the stations, and may cause physical disorders. At most of the stations, however, water is of good quality for irrigation, and may be used for agricultural purposes.

Regression models are used to predict one variable from one or more other variables. This model allowes prediction about future trends.

Table 2

Statistical evaluation for Physico-Chemical Parameters in Sonar River water Samples (during 2007-2012)

Descriptive Statistics

	Range	Minimum	Maximum	Sum	Mean		Std.	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
TEMPRATURE	4.40	23.20	27.60	513.00	25.6500	.2618	1.17092	1.371	-.534	.512	-.115	.992
COLOUR	9.00	12.00	21.00	315.00	15.7500	.6604	2.95359	8.724	.653	.512	-.889	.992
pH	1.21	7.44	8.65	162.06	8.1030	.0868	.38814	.151	-.417	.512	-.876	.992
TURBIDITY	15.00	10.00	25.00	263.00	13.1500	.7789	3.48342	12.134	2.127	.512	6.486	.992
DO	3.77	4.05	7.82	129.18	6.4590	.2455	1.09805	1.206	-.973	.512	-.098	.992
BOD	7.55	2.74	10.29	116.42	5.8210	.3733	1.66933	2.787	.392	.512	2.009	.992
COD	11.79	7.85	19.64	220.72	11.0360	.5636	2.52062	6.354	2.195	.512	6.689	.992
CONDUCTIVIT	.29	.40	.68	10.07	.5034	.0144	.06449	.004	1.100	.512	2.245	.992
ALKALINITY	220.00	105.00	325.00	4224.00	211.2000	13.2642	59.31947	3518.800	.039	.512	-.773	.992
TS	157.63	278.54	436.17	6597.16	329.8580	9.1703	41.01093	1681.896	1.368	.512	1.383	.992
TSS	35.81	5.64	41.45	450.70	22.5350	2.3725	10.61000	112.572	.166	.512	-.783	.992
TDS	175.23	242.02	417.25	6146.46	307.3230	8.7806	39.26811	1541.985	1.097	.512	2.233	.992
CHLORIDE	115.00	38.97	153.97	1373.07	68.6535	6.5343	29.22219	853.937	1.819	.512	3.485	.992
RESICHLORIN	.43	.01	.44	2.98	.1490	.0189	.08441	.007	2.040	.512	7.418	.992
PHOSPHATE	3.26	1.04	4.30	36.29	1.8145	.1490	.66643	.444	2.877	.512	10.681	.992
NITRATE	7.86	.93	8.79	44.19	2.2095	.3926	1.75579	3.083	3.127	.512	10.972	.992
AMMONIA	.28	.11	.39	4.20	.2100	.0140	.06274	.004	1.074	.512	2.281	.992
TH	142.22	153.34	295.56	4008.06	200.4030	8.1028	36.23695	1313.116	1.838	.512	3.038	.992
TEMP. HARD.	40.33	118.64	158.97	2791.38	139.5690	2.4731	11.06015	122.327	-.312	.512	-.552	.992
PERM. HARD.	141.80	17.82	159.62	1216.68	60.8340	8.6359	38.62106	1491.586	1.666	.512	2.270	.992
Ca HARDNESS	113.29	113.16	226.45	3068.52	153.4260	7.7382	34.60647	1197.607	1.144	.512	.387	.992
Mg HARDNES	58.71	16.48	75.19	939.54	46.9770	3.3730	15.08453	227.543	.106	.512	-.356	.992
FLUORIDE	1.15	.21	1.36	18.41	.9205	.0893	.39930	.159	-.473	.512	-1.203	.992
IRON	3.95	.02	3.97	24.05	1.2025	.3330	1.48903	2.217	1.081	.512	-.696	.992
Ca CONTENT	45.41	45.35	90.76	1229.78	61.4890	3.1016	13.87062	192.394	1.144	.512	.387	.992
Mg CONTENT	14.27	4.00	18.27	228.22	11.4110	.8198	3.66617	13.441	.106	.512	-.356	.992

Table 3

Statistical evaluation for Physico-Chemical Parameters in Bewas River water Samples (during 2007-2012)

Descriptive Statistics

	Range	Minimum	Maximum	Sum	Mean		Std.	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
TEMPRATURE	7.10	22.90	30.00	521.90	26.0950	.3799	1.69875	2.886	.192	.512	.265	.992
COLOUR	11.00	11.00	22.00	288.00	14.4000	.6424	2.87274	8.253	1.018	.512	1.129	.992
pH	1.95	6.59	8.54	160.10	8.0050	.1154	.51619	.266	-1.613	.512	2.674	.992
TURBIDITY	14.00	8.00	22.00	292.00	14.6000	.7086	3.16893	10.042	.232	.512	.791	.992
DO	2.42	5.28	7.70	140.55	7.0275	.1167	.52208	.273	-2.090	.512	6.067	.992
BOD	8.95	2.23	11.18	105.53	5.2765	.3992	1.78528	3.187	1.675	.512	5.985	.992
COD	13.72	7.60	21.32	204.81	10.2405	.6229	2.78553	7.759	3.573	.512	14.649	.992
CONDUCTIVIT	.34	.44	.78	11.61	.5805	.0201	.08969	.008	.720	.512	.000	.992
ALKALINITY	155.00	150.00	305.00	4246.00	212.3000	8.3745	37.45186	1402.642	.982	.512	1.298	.992
TS	231.33	273.88	505.21	7425.74	371.2870	13.6700	61.13432	3737.405	.879	.512	.278	.992
TSS	53.17	5.46	58.63	338.58	16.9290	2.5104	11.22695	126.044	2.866	.512	10.495	.992
TDS	207.81	268.42	476.23	7087.16	354.3580	12.2478	54.77374	3000.163	.716	.512	-.002	.992
CHLORIDE	57.46	39.38	96.84	1219.67	60.9835	4.2606	19.05401	363.055	.713	.512	-.710	.992
RESICHLORIN	.30	.04	.34	3.17	.1585	.0156	.06991	.005	.455	.512	1.591	.992
PHOSPHATE	4.33	.20	4.53	26.26	1.3130	.1985	.88750	.788	2.561	.512	9.306	.992
NITRATE	4.71	1.18	5.89	40.21	2.0105	.2330	1.04188	1.086	3.047	.512	10.583	.992
AMMONIA	.24	.14	.38	4.67	.2335	.0175	.07836	.006	.521	.512	-1.088	.992
TH	83.33	199.34	282.67	4660.85	233.0425	5.2498	23.47790	551.212	.419	.512	-.582	.992
TEMP. HARD.	82.92	153.76	236.68	3843.01	192.1505	4.9315	22.05435	486.394	.139	.512	-.410	.992
PERM. HARD.	49.93	17.20	67.13	817.84	40.8920	3.3495	14.97937	224.381	.389	.512	-.660	.992
Ca HARDNES	79.30	157.55	236.85	3792.76	189.6380	5.1466	23.01648	529.758	.169	.512	-.720	.992
Mg HARDNES	85.16	16.31	101.47	868.09	43.4045	4.5010	20.12902	405.178	1.239	.512	2.245	.992
FLUORIDE	1.27	.23	1.50	17.51	.8755	.0852	.38086	.145	-.126	.512	-.890	.992
IRON	.93	.13	1.06	7.69	.3845	.0477	.21333	.046	1.554	.512	4.328	.992
Ca CONTENT	31.78	63.14	94.92	1520.02	76.0010	2.0626	9.22430	85.088	.169	.512	-.721	.992
Mg CONTENT	20.69	3.96	24.65	210.86	10.5430	1.0935	4.89027	23.915	1.239	.512	2.245	.992

Table 4

Regression Analysis of chemical Parameters with DO in Sonar water Samples

Dependent Variable	Independent Variable	Regression equation	Slope	R^2
• DO_{mean}	BOD_{mean}	DO = 28.27 - 61.6 * BOD	-61.6	0.77
• DO_{mean}	COD_{mean}	DO = 303.1 - 66.81 * COD	-66.81	0.834
• DO_{mean}	$Alkalinity_{mean}$	DO = 493 - 33.58 * alkalinity	-33.58	.628
• DO_{mean}	TDS_{mean}	DO = 57 + 64.5 * TDS	64.5	.713
• DO_{mean}	pH_{mean}	DO = 3.757 + 1.718 * pH	1.718	.665
• DO_{mean}	$Chloride_{mean}$	DO = - 112.1 + 74.33 * Chloride	74.33	0.579
• DO_{mean}	Residual $Chlorine_{mean}$	DO = 0.092 + 0.039 * Residual Chlorine	0.039	0.016
• DO_{mean}	o-$Phosphate_{mean}$	DO = 9.664 - 6.7 * o- Phosphate	-6.7	0.84
• DO_{mean}	$Nitrate_{mean}$	DO = 43 - 3.9 * Nitrate	- 3.9	.46
• DO_{mean}	$Ammonia_{mean}$	DO = 0.442 + 0.002 * Ammonia	0.002	.001

Table 5

Multiple Regression Analysis for different Parameters in the Sonar river water Samples

Dependent variable is DO, 25 independent variables, 6 Cases.

Variable	Coefficient	Variable	Coefficient
Intercept	-114.0811	Residual Chlorine	863.56592
Temperature	-1.519745	Alkalinity	4.9726868
Colour	1.585022	TS	-.3312836
pH	52.121704	TSS	-11.96387
Turbidity	-11.7403	TDS	-1.13871
BOD	27.491699	Chloride	2.6040039
COD	.5791016	Phosphate	-145.9155
Conductivity	129.20703	Ammonia	546.30078
TH	5329361	Nitrate	-157.8906
Temporary Hardness	1.6137085	Mg Hardness	1.8033447
Permanent Hardness	1.3906555	Fluoride	-320.8691
Ca Hardness	-2.23642	Iron	196.80078
Ca Content	-1.241013	Mg Content	3.197876

R-Square = 0.0 Adjusted R-Square = 1.1364

Cohen's f-square = 0.0, a small effect size.

Analysis of Variance to Test Regression Relation

Source	Sum of Sqs	df	Mean Sq
Regression	18833.864	25	753.35455
Error	-18832.77	-22	.
Total	1.0934749	3	

Note: - A low p-value suggests that the dependent variable DO may be linearly related to independent variable(s).

Table 6.1

Regression curve between the mean chemical Parameters (independent) and the mean DO (dependent) in Sonar River water Samples

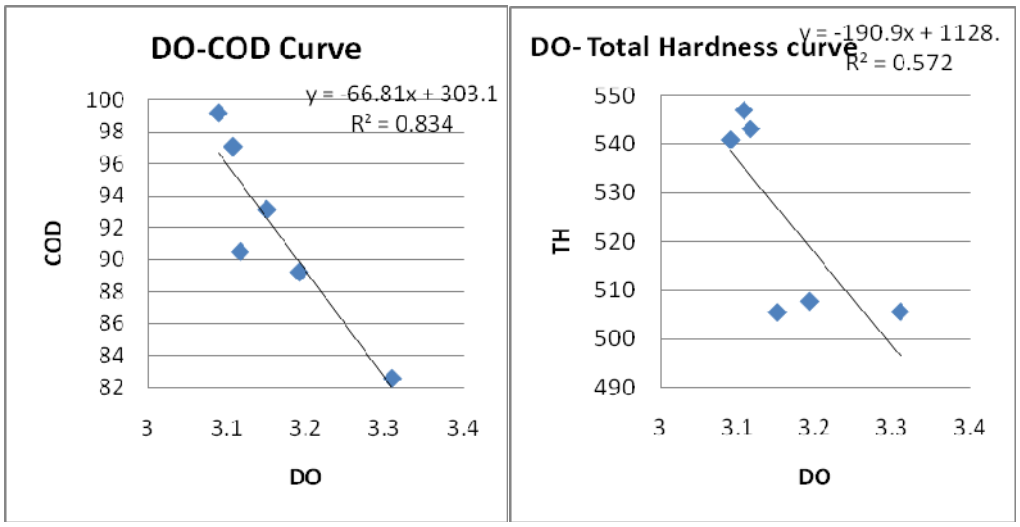

Table 6.2

Regression curve between the chemical Parameters (independent) and the DO (dependent) in Bewas River water Samples

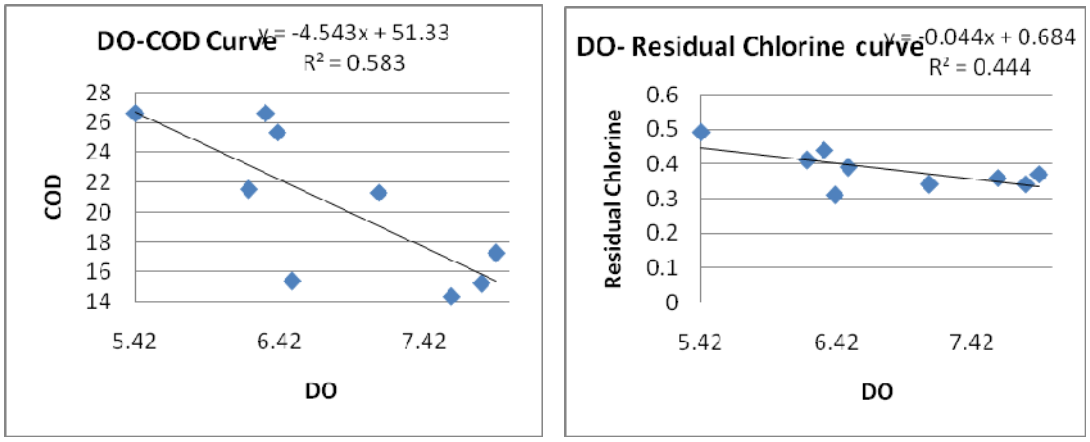

Table 7

Regression Analysis of chemical Parameters with DO in Bewas River water Samples

Dependent Variable	Independent Variable	Regression equation	Slope	R^2
DO_{mean}	BOD_{mean}	DO = 31.93 + 1.551 * BOD	1.551	0.007
DO_{mean}	COD_{mean}	DO = 303.1 - 66.81 * COD	-66.81	0.834
DO_{mean}	$BOD_{mean,}$ COD_{mean}	DO = 2.6645816 + .0081708 * BOD + .0021325 * COD		.0323
DO_{mean}	$Alkalinity_{mean}$	DO = 493 - 33.58 * alkalinity	-33.58	.228
DO_{mean}	TDS_{mean}	DO = 250.7 + 184.5 * TDS	184.5	.113
DO_{mean}	pH_{mean}	DO = 3.757 + 1.718 * pH	1.718	.665
DO_{mean}	$Chloride_{mean}$	DO = - 112.1 + 74.33 * Chloride	74.33	0.579
DO_{mean}	Residual $Chlorine_{mean}$	DO = 0.092 + 0.039 * Residual Chlorine	0.039	0.016
DO_{mean}	$o\text{-}Phosphate_{mean}$	DO = 9.664 - 1.510 * o- Phosphate	-1.510	0.465
DO_{mean}	$Nitrate_{mean}$	DO = 13.60 - 1.171 * Nitrate	- 1.17	.191
DO_{mean}	$Ammonia_{mean}$	DO = 0.442 + 0.002 * Ammonia	0.002	.001

Table 8

Multiple Regression Analysis for different Parameters in the Bewas River water Samples

Dependent variable is DO, 25 independent variables, 6 Cases.

Variable	Coefficient	Variable	Coefficient
Intercept	605.27	Residual Chlorine	4716.32
Temperature	-99.77	Alkalinity	2.405
Colour	101.62	TS	-1.96
pH	236.72	TSS	95.664
Turbidity	145.33	TDS	-1.681
BOD	-580.74	Chloride	-5.69
COD	131.272	Phosphate	-145.9155
Conductivity	1699.1	Ammonia	-14443.75
TH	-5.7037	Nitrate	-564.4
Temporary Hardness	15.97	Mg Hardness	-4.29
Permanent Hardness	8.647	Fluoride	-1464.6
Ca Hardness	-1.085	Iron	-4818.602
Ca Content	5.722	Mg Content	54.91

R-Square = 0.0 Adjusted R-Square = 1.1364

Cohen's f-square = 0.0, a small effect size.

Analysis of Variance to Test Regression Relation

Source	Sum of Sqs	df	Mean Sq
Regression	-23786.73	25	-951.4691
Error	23786.741	-22	.
Total	.012675	3	

Note: - A low p-value suggests that the dependent variable DO may be linearly related to independent variable(s).

4. Conclusion

Comparing the values of water quality parameters for both rivers, it can be concluded that water quality of both rivers is within the prescribed limit set by WHO/ IS: 10500. These sample waters can be absolutely fit for drinking water after the disinfection treatment. Water quality analysis should be carried out from time to time, in order to monitor the rate and the contamination type. It is necessary that the human expand awareness among the people to maintain the river water at their highest quality and purity levels. From the results obtained, it can be concluded that Bewas river need to be more treated than Sonar river. Water of both rivers can be used for drinking purpose after disinfectant treatment. The present study recommends to continue the monitoring that is useful for the sustainable development through planning and for the implementation of remediation methods in the future, in order to mitigate the adverse effects of the poor quality of water on human health, as well as on plant growth.

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