VERSITA 10.2478/v10310-012-0026-1
Ovidius University Annals of Chemistry Volume 23, Number 2, pp.155-162, 2012

Indicators of the deteriorate water quality status of reservoir, Sagar city, MP, India by multivariate analysis

Hemant PATHAK

Department of Chemistry, Indira Gandhi Govt. Engineering College, Sagar, India

Abstract This study was carried out in the Rajghat reservoir has been used as a drinking water resources from last decades. The aim was to investigate the temporal and spatial variability of water quality. Data investigation was processed using multivariate analysis. Samples were taken in 05 stations spreading out over the water body during three seasons were analyzed for their physicochemical characteristics in order to explore the contamination of reservoir water samples, using Correlation analysis, multiregression analysis and modeling. On comparing the results against BIS water quality standards, it is found that some of the water samples are polluted. A systematic calculation of correlation coefficient between water quality parameters has been done with the objective of minimizing the complexity and dimensionality of large set of data. An attempt has been made to find the seasonal quality of water in reservoir, in order to adopt a statistical model for examine water quality. The results of this study are believed to be valuable to help water resources managers understand complex nature of water quality issues and determine the priorities to improve water quality.

Keywords: correlation analysis, multiregression analysis

1. Introduction

Rajghat reservoir is situated in the nearby of Sagar city (23°50'N latitude and 78°45' E longitude). Reservoirs play a major role in drinking water, agricultural use, fishery, and electricity production, so protection of water quality is a very important issue and it should be kept at acceptable levels. Anthropogenic impact such as urban, industrial and agricultural activities as well as natural processes (precipitation inputs, erosion, etc.) diminish the surface water quality and lower the use for drinking agricultural and other purposes. Polluted rivers and reservoirs affect aquatic life directly. The Concentrations of toxic materials such as heavy Metals, pesticides, and nutrients in excess can cause various problems such as loss of oxygen, fish deaths, loss of biodiversity, and they also have negative effects on human health. In a well-balanced aquatic ecosystem, the quality of water plays a critical role between the organisms and environment. It is also extremely important for the health of the ecosystem. Multivariate statistical analysis helps with the interpretation of the monitored data to better understand the behavior of the pollution sources, the water quality, ecological situation of the studied area, management of the water resources, and solution for the pollution problems. The purpose of this study was to apply multivariate statistical techniques to evaluate the seasonal variations of the water quality parameters, to extract temporal and spatial variations in water quality, to investigate the similarities or dissimilarities between the sampling sites.

Rajghat reservoir supplied drinkable water more than 3 lacs peoples in Sagar city. Aim of this paper to investigating the purity level and drinkability of reservoir water.

H. Pathak *et. al.* [1-16] are the group of researchers studied Sagar division from many years. A vast amount of literature, UNICEF [19], USEPA [20], Madhya Pradesh PCB [21], is spread on websites, journals and books that is helpful to chemical analysis of water samples

2. Experimental

Water samples of 5 sampling places were collected in polyethylene bottles pre-washed with

ISSN-1223-7221

nitric acid, and after sample collection analyses were performed as soon as the samples were carried to the laboratory. All the samples were stored in an ice chest at a temperature of < 4°C Ground water samplings were performed three times at Pre to Post monsoon. The samples were analysed using standard analytical techniques APHA [17] as presented in **Table 1**. All the chemicals used were of AR grade. Regression analysis, multiple regression analysis for the total data points were carried out using SPSS.11 [22], and WINKS SDA [23]. The nature of correlations between parameters was determined based on the correlation coefficient obtained. Data obtained from chemical analysis were compared with BIS [18] guidelines.

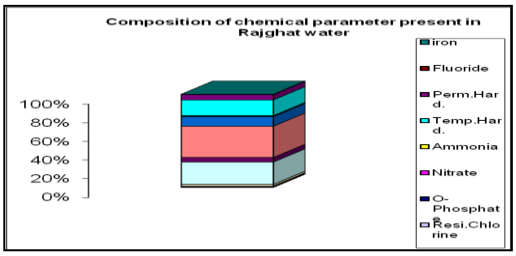
3. Results and Discussion

Reservoir has been exposed to wastewaters from agricultural and domestic sources from decades. Consequently, the quality of reservoir water has rapidly deteriorated in many locations, and polluted water is now a grave public health and ecosystem problem. Furthermore, population growth and elevated living standards have been coupled with ever-increasing demands for clean water.

Figure 1 presents chemical composition of reservoir water by bar and pie diagram and in **Tables 2-4** statistical analysis data are presented

Table 1. List of physico-chemical parameters and their test methods

S.N.	**Parameters**	**Unit**	**Test Methods**
1	Water temperature	°C	Mercury-in-glass thermometer
2	Colour	Hz.U.	Pt-Co Scale
3	Odour	-	Qualitative human receptor
4	pH	-	pH meter
5	Turbidity	NTU	Turbidity tube
6	Dissolved Oxygen (DO)	mg/L	Winkler method
7	Biochemical Oxygen Demand (BOD)	mg/L	5 days incubation at 20° C and titration of initial and final DO.
8	Chemical Oxygen Demand	mg/L	Open Reflux Method
9	Conductivity	ms/cm	Conductivity meter
10	Alkalinity	mg/L	Titration
11	Total Solids (TS)	mg/L	Gravimetric (filtration and weighing of residue)
12	Total Suspended solids(TSS)	mg/L	Gravimetric (filtration and weighing of residue)
13	Total dissolved Solids	mg/L	Digital conductivity meter (LT-51)
14	Chloride	mg/L	Argentometric titration
15	Residual Chlorine	mg/L	Iodometric
16	Orthophosphate ($P0_4^{3-}$ — P)	mg/L	Ammonium molybdate ascorbic acid reduction method
17	Nitrate -Nitrogen (NO_3 — N)	mg/L	Spectrophotometric method
18	Ammonia-Nitrogen (NH_3— N)	mg/L	Spectrophotometric (Phenate method)
19	Total Hardness as $CaCO_3$	mg/L	EDTA titration
20	Temporary Hardness as $CaCO_3$	mg/L	EDTA titration
21	Permanent Hardness as $CaCO_3$	mg/L	EDTA titration
22	Calcium Hardness	mg/L	EDTA titrimetric method
23	Magnesium Hardness	mg/L	Calculation after analysing Hardness and Calcium
24	Fluoride	mg/L	Colorimetric Method
25	Iron	mg/L	Colorimetric Method
26	Oil and Grease	mg/L	Physical observation
27	Ca Content	mg/L	EDTA titrimetric method
28	Mg Content	mg/L	EDTA titrimetric method and calculation
29	Sodium	mg/L	Flame photometric Method
30	Potassium	mg/L	Flame photometric Method



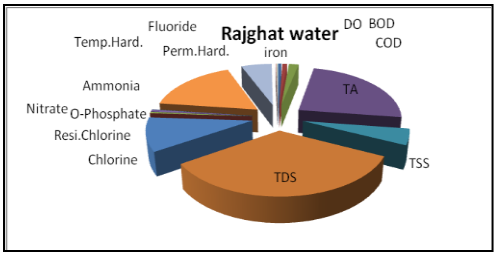


Fig.1. Chemical composition of reservoir water

Table 2. Statistical evaluation for different Parameters in the reservoir water Samples in Sagar City

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	4.30	23.20	27.50	499.10	24.9550	.2754	1.23180	1.517	.640	.512	-.045	.992
COLOUR	9.00	12.00	21.00	306.00	15.3000	.5287	2.36421	5.589	.451	.512	.179	.992
pH	1.00	7.52	8.52	163.73	8.1865	.0639	.28561	.082	-.812	.512	-.061	.992
TURBIDITY	9.00	10.00	19.00	279.00	13.9500	.6219	2.78104	7.734	.122	.512	-1.006	.992
DO	3.30	4.05	7.35	114.83	5.7415	.2388	1.06802	1.141	-.191	.512	-1.045	.992
BOD	10.11	2.14	12.25	77.48	3.8740	.4773	2.13465	4.557	3.437	.512	13.699	.992
COD	9.61	7.65	17.26	185.35	9.2675	.4595	2.05509	4.223	3.363	.512	13.094	.992
CONDUCTIVITY	.29	.51	.81	12.81	.6405	.0193	.08652	.007	-.135	.512	-.959	.992
ALKALINITY	126.00	170.00	296.00	4303.00	215.1500	7.4453	33.29655	1108.661	.871	.512	.547	.992
TS	187.96	319.95	507.91	8118.62	405.9310	12.9675	57.99239	3363.117	-.259	.512	-1.191	.992
TSS	61.14	4.53	65.67	298.12	14.9060	2.8747	12.85605	165.278	3.491	.512	14.120	.992
TDS	178.04	313.49	491.53	7820.50	391.0250	11.8023	52.78149	2785.885	-.132	.512	-.960	.992
CHLORIDE	90.00	20.43	110.43	730.91	36.5455	4.2920	19.19459	368.432	3.353	.512	12.575	.992
RESICHLORINE	.36	.01	.37	2.94	.1470	.0154	.06868	.005	1.527	.512	5.839	.992
PHOSPHATE	3.46	.55	4.01	32.37	1.6185	.1923	.85992	.739	1.359	.512	1.771	.992
NITRATE	6.12	1.26	7.38	37.67	1.8835	.2947	1.31773	1.736	4.213	.512	18.345	.992
AMMONIA	.28	.11	.39	3.94	.1970	.0165	.07392	.005	.818	.512	.812	.992
TH	93.98	188.36	282.34	4692.39	234.6195	5.5460	24.80256	615.167	.116	.512	-.665	.992
TEMP. HARD.	58.00	158.34	216.34	3614.32	180.7160	3.0286	13.54446	183.452	.833	.512	1.180	.992
PERM. HARD.	81.48	24.48	105.96	1078.07	53.9035	5.5453	24.79956	615.018	.749	.512	-.587	.992
Ca HARDNESS	112.61	128.63	241.24	3680.87	184.0435	6.7116	30.01534	900.921	.053	.512	-.291	.992
Mg HARDNESS	63.17	17.71	80.88	1011.52	50.5760	4.6848	20.95101	438.945	-.165	.512	-1.365	.992
FLUORIDE	1.58	.24	1.82	20.08	1.0040	.0921	.41189	.170	.121	.512	-.274	.992
IRON	1.18	.18	1.36	8.77	.4385	.0536	.23972	.057	3.177	.512	12.415	.992
Ca CONTENT	45.13	51.55	96.68	1475.21	73.7605	2.6899	12.02980	144.716	.053	.512	-.291	.992
Mg CONTENT	15.35	4.30	19.65	245.71	12.2856	1.1383	5.09056	25.914	-.165	.512	-1.365	.992

Interrelationships were established between some physicochemical water pollution indicators where reliable correlations were established using regression analysis.

Table 3. Matrix of Pearson Correlation for different Parameters in the reservoir water Samples of Sagar city

	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	P-11	P-12	P-13	P-14	P-15	P-16	P-17	P-18	P-19	P-20	P-21	P-22	P-23	P-24	P-25	P-26
P-1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
P-2	.	1	-.088	.744	.420	.229	-.699	.173	-.156	.394	.401	.406	.006	-.372	-.551	.493	.130	-.217	-.035	-.319	-.212	-.261	.579	-.114	-.212	-.261
P-3	.	-.088	1	.234	.260	.685	-.605	.240	-.808	.453	.543	.132	.506	-.079	-.401	.096	.878	-.869	-.506	-.501	-.871	-.763	.194	.699	-.871	-.761
P-4	.	.744	.234	1	.060	.547	-.630	.267	-.405	.588	.884	.590	-.173	-.846	-.562	.070	.275	-.359	-.094	-.403	-.342	-.549	.713	.113	-.342	-.548
P-5	.	.420	.260	.060	1	.253	-.675	-.003	.029	.220	-.057	-.069	.779	.450	-.741	.202	.374	-.358	-.455	.101	-.381	.003	-.326	.329	-.381	.004
P-6	.	.229	.685	.547	.253	1	-.533	-.324	-.408	.085	.788	-.165	.023	-.333	-.752	.115	.846	-.845	-.843	-.061	-.840	-.828	.274	.107	-.840	-.828
P-7	.	-.699	-.605	-.630	-.675	-.533	1	-.385	.616	-.678	-.538	-.432	-.564	.179	.726	-.402	-.647	.700	.327	.555	.704	.574	-.416	-.516	.704	.573
P-8	.	.173	.240	.267	-.003	-.324	-.385	1	-.557	.892	.134	.915	.424	-.287	.194	-.095	-.130	.071	.656	-.745	.074	.021	.326	.741	.074	.024
P-9	.	-.156	-.808	-.405	.029	-.408	.616	-.557	1	-.635	-.546	-.483	-.273	.325	.081	-.363	-.667	.716	.061	.905	.706	.784	-.652	-.605	.706	.782
P-10	.	.394	.453	.588	.220	.085	-.678	.892	-.635	1	.490	.919	.482	-.465	-.244	-.116	.153	-.217	.320	-.703	-.214	-.239	.400	.798	-.213	-.236
P-11	.	.401	.543	.884	-.057	.788	-.538	.134	-.546	.490	1	.402	-.162	-.820	-.555	-.067	.532	-.583	-.340	-.363	-.566	-.761	.614	.231	-.566	-.760
P-12	.	.406	.132	.590	-.069	-.165	-.432	.915	-.483	.919	.402	1	.180	-.608	.021	-.154	-.172	.090	.613	-.678	.100	-.060	.504	.571	.100	-.057
P-13	.	.006	.506	-.173	.779	.023	-.564	.424	-.273	.482	-.162	.180	1	.498	-.361	-.009	.334	-.307	-.144	-.197	-.331	.048	-.387	.782	-.331	.050
P-14	.	-.372	-.079	-.846	.450	-.333	.179	-.287	.325	-.465	-.820	-.608	.498	1	.133	.217	.008	.066	-.183	.345	.041	.406	-.694	-.022	.041	.405
P-15	.	-.551	-.401	-.562	-.741	-.752	.726	.194	.081	-.244	-.555	.021	-.361	.133	1	-.048	-.573	.577	.710	-.127	.585	.403	-.003	-.178	.585	.402
P-16	.	.493	.096	.070	.202	.115	-.402	-.095	-.363	-.116	-.067	-.154	-.009	.217	-.048	1	.412	-.457	-.185	-.454	-.455	-.439	.522	-.272	-.455	-.441
P-17	.	.130	.878	.275	.374	.846	-.647	-.130	-.667	.153	.532	-.172	.334	.008	-.573	.412	1	-.994	-.779	-.348	-.995	-.875	.268	.325	-.995	-.875
P-18	.	-.217	-.869	-.359	-.358	-.845	.700	.071	.716	-.217	-.583	.090	-.307	.066	.577	-.457	-.994	1	.731	.425	1.000	.909	-.367	-.325	1.000	.909
P-19	.	-.035	-.506	-.094	-.455	-.843	.327	.656	.061	.320	-.340	.613	-.144	-.183	.710	-.185	-.779	.731	1	-.304	.739	.552	.150	.087	.739	.553
P-20	.	-.319	-.501	-.403	.101	-.061	.555	-.745	.905	-.703	-.363	-.678	-.197	.345	-.127	-.454	-.348	.425	-.304	1	.413	.546	-.754	-.507	.413	.545
P-21	.	-.212	-.871	-.342	-.381	-.840	.704	.074	.706	-.214	-.566	.100	-.331	.041	.585	-.455	-.995	1.000	.739	.413	1	.896	-.343	-.333	1.000	.896
P-22	.	-.261	-.763	-.549	.003	-.828	.574	.021	.784	-.239	-.761	-.060	.048	.406	.403	-.439	-.875	.909	.552	.546	.896	1	-.659	-.175	.896	1.000
P-23	.	.579	.194	.713	-.326	.274	-.416	.326	-.652	.400	.614	.504	-.387	-.694	-.003	.522	.268	-.367	.150	-.754	-.343	-.659	1	-.059	-.343	-.660
P-24	.	-.114	.699	.113	.329	.107	-.516	.741	-.605	.798	.231	.571	.782	-.022	-.178	-.272	.325	-.325	.087	-.507	-.333	-.175	-.059	1	-.333	-.172
P-25	.	-.212	-.871	-.342	-.381	-.840	.704	.074	.706	-.213	-.566	.100	-.331	.041	.585	-.455	-.995	1.000	.739	.413	1.000	.896	-.343	-.333	1	.896
P-26	.	-.261	-.761	-.548	.004	-.828	.573	.024	.782	-.236	-.760	-.057	.050	.405	.402	-.441	-.875	.909	.553	.545	.896	1.000	-.660	-.172	.896	1

This indicates the reliability of the relationships which suggests that it can be used to predict the levels of pollution by the parameters investigated and possibly offering a preventive measure prior to detailed investigation of the reservoir water or in pollution monitoring.

Multiple regression analysis method was used to evaluate relationship between DO and among other water properties. Identification of variables (Turbidity, BOD, Conductivity, pH, Residual chlorine, o-phosphate, Nitrate, Ammonia, Fluoride, Iron) which have significant and separate effects on the dependent variables.

Table 4. Multiple Regression Analysis for different Parameters in the reservoir water samples of Sagar city

Dependent variable is DO, 25 independent variables, 26 Cases.

Variable	Coefficient	Variable	Coefficient
Intercept	-214.0547	RESI.CHLORINE	1337.8438
TEMPRATURE	56.761719	PHOSPHATE	26.699219
COLOUR	15.403809	NITRATE	-215.5313
pH	58.015625	AMMONIA	12.5
TURBIDITY	-18.57641	TH	2.2039337
DO	174.21094	TEMP. HARD.	9.326416
BOD	139.31055	PERM. HARD.	11.737671
COD	-50.85254	Ca HARDNESS	-2.44519
CONDUCTIVITY	-1562.625	Mg HARDNESS	8.3937988
ALKALINITY	5.786499	FLUORIDE	498.65625
TS	-2.140076	IRON	-346.3047
TSS	5.1581573	Ca CONTENT	-25.61328
TDS	-4.55661	Mg CONTENT	-84.05469
CHLORIDE	2.9721069		

R-Square = 0.0 Adjusted R-Square = 1.4444
Cohen's f-square = 0.0, a small effect size.

Analysis of Variance to Test Regression Relation

Source	Sum of Sqs	df	Mean Sq	F	p-value
Regression	71292.313	26	2742.012	.	N.A.
Error	-71286.59	-18	.		
Total	5.7265991	8			

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

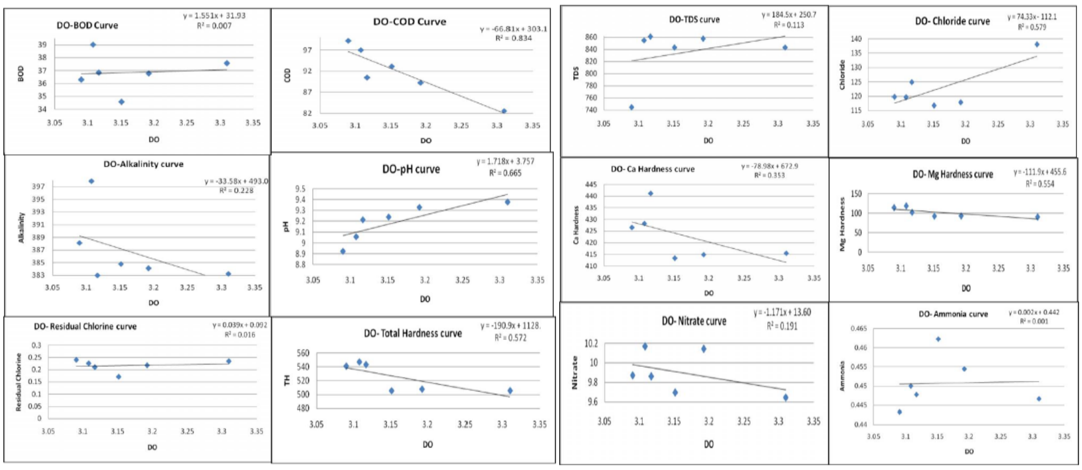


Fig.2. Regression curves between the mean chemical Parameters (independent) and the mean DO (dependent) in reservoir water Samples of Sagar city (Monsoon 2007 to Pre Monsoon 2011)

In **Fig. 2** various regression curves are presented.

Results of detailed Chemical analysis are discussed as:

1. Colour values of reservoir sampling points (S1 and S5), where water is greenish yellow in colour. Dissolved lightly organic material from decaying vegetation, algal metabolism and certain inorganic matter is the cause of this colour.

2. Water temperature of reservoir is changing with respect to season, affecting physical, chemical, and biological characteristics of reservoir. At PreMonsoon 2008, 2009, 2010, Warm waters are more susceptible to eutrophication a build-up of nutrients and possible algal blooms because photosynthesis and bacterial decomposition both work faster at higher temperatures.

3. At Reservoir, fishy bad Smell comes during entire period. Water Odor is usually the result of volatile organic compounds and may be produced by phytoplankton and aquatic plants or decaying organic matter. Organic compounds, inorganic chemicals, oil and gas can all cause Odor to water. At PreMonsoon (summer) temperatures increasing metabolic activity and decay products.

4. During Monsoon 2007 and Monsoon 2008, there were higher values of electrical conductivity at all collection points due to the presence of high dissolved solids. At monsoon rainwater dissolved many solids, nutrients from soil and mixed with water sources.

5. Turbidity value of all surrounding points is high during all season. At post monsoon 2007, PreMonsoon 2008, 2010 the value is higher comparing to other season because of lack of water and High turbidity can cause increased water temperatures because suspended particles absorb more heat and can also reduce the amount of light penetrating the water. Excessive turbidity can provide food and shelter for pathogens leading to waterborne disease. Then there is need of high amount of disinfectant to provide safety from water/air borne diseases.

6. In reservoir, sampling point (S2 to S3), concentration of TS, TSS is far above the any other places of Sagar. At monsoon 2007 value of TS is higher comparing to other season this may be due to mixing of domestic waste/sewage/agriculture/urban run-off mixing in to water sources. All Sampling point of reservoir is highly polluted from TSS.

7. Total dissolved solids (TDS) values are higher at monsoon 2007, 2008, and 2009. It may be due to raining. Rainwater dissolved many solids, nutrients from soil and mixed with water sources. Sampling point S10 to S15 have higher TDS value, this is also supported by higher pH value.

8. The pH values of reservoir water samples are alkaline in nature. pH values are higher at monsoon 2007, post monsoon 2007 and premonsoon 2008 compare to other season. Higher pH value indicated higher degree of eutrophication.
9. Alkalinity values are higher at PreMonsoon 2008, 2009, 2010, Monsoon 2009, post Monsoon 2009 at all sampling places. It protects against pH changes and makes water less vulnerable to acid rain. Excess alkalinity present in reservoir water is harmful for aquatic life and reservoir Water is not suitable for irrigation, which leads to soil damage and reduce crop yields.
10. Hardness is the property of water which prevents the later formation with soap and increases the boiling points of water. Hardness of water mainly depends upon the amount of calcium or magnesium salts or both. The total hardness values shown range from 196.73 mg/L to 580.27 mg/L. The high concentration of TH in reservoir water samples may be due to dissolution of polyvalent metallic ions from, sewage and run off from soil. Ca hardness is higher at all seasons. Mg hardness is higher at PreMonsoon 08, 09, Monsoon 09, PreMonsoon 2010. Ca hardness is higher than Mg hardness, it means Calcium is the predominant cations in the reservoir water. The values are higher than the desirable limit.
11. The high value of chloride content in the investigated area with an annual average of 122.85 mg/l as an indication of organic pollution due to the disposal of industrial, sewage effluents, agricultural and road run-off. Values are below 250 Mg/L at all the locations (sampling points, during entire season are within the desirable limit prescribed by the IS-10500:1991, standard.
13. Residual chlorine Fluoride, Nitrate (NO_3^-) concentration is found within the desirable limit prescribed by the IS-10500:1991.
14. Ammonia concentrations are found higher than the permissible limit prescribed by CPCB, New Delhi over all season. Higher value indicated organic pollution., High ammonia concentrations may also be found in the bottom waters of reservoir which have become anoxic.
15. Concentrations of orthophosphate in all sampling places are found beyond the permissible limit;
17. The DO values indicate the degree of pollution in water bodies. DO values varied from 3.05 to 8.8. The sampling points S1 and S5 showed low DO values indicating heavy contamination by organic matter. Value of dissolved oxygen (DO) in reservoir is minimum due to increased value of BOD and COD. Coloured water restricts the penetration of light, which subsequently retard the photosynthetic reactions. This also indirectly affects the reoxygenation capacity of receiving water.
18. Higher values of BOD/COD at all collection places (S1 to S5), indicated the high pollution load produce by waste matter. Then the value of DO is very lower in Reservoir. Studies have shown that the Rajghat reservoir contains high concentrations of nitrates and phosphates which led to the quick growth as well as death of plants and algae. The result is accumulation and decomposition of organic wastes leading to high BOD values. The higher values of COD indicate the presence of oxidizable organic matters
19. Concentrations of Iron and other heavy metals in all sampling places of reservoir are found beyond the permissible limits due to the disposal of idol at festival season and domestic waste disposal.
20. Oil and Grease present in few amount at all sampling places, this is by anthropogenic activity like disposal of domestic waste, idol at festival season in and use of motor boat in reservoir. Oil and gas can all impart Odour to water.
21. Ca content and Mg content is found within permissible limit prescribed by the IS-10500:1991, Standard, this increased concentrations of calcium content may be due to disposal of idol at festival season it means concentrations of calcium are increased at festive season.

High BOD levels indicates decline in DO because the oxygen that is available in the water is being consumed by the bacteria leading to the inability of fish and other aquatic organisms to survive in the river.As a result, water pollution and water shortages have now become a severe problem, which has received more and more attention from the public and the government.

The toxicity of reservoir sites contaminated with water soluble chemical waste is therefore usually not of an acute, but of a chronic nature, as humans as well as aquatic life are typically exposed only to the low concentrations in water, which however can be maintained over a long period of time in the surroundings of a contaminated site also dependent on rainfall events. The consumption of unsafe water has been implicated as one of the major causes of this disease. Other religious activities like offering flowers, milks, sweets etc. into the water should be controlled as it increases the pollution load on water body. Clothes washing at Dhobi/Chakra Ghat should be strictly banned because it not only causes organic, inorganic and biological contamination but also increase the detergents content. It hampers oxygen diffusion rate in the reservoir water affecting the self purification capacity as well as other biological activities. The results suggested that the reservoir water may be altered in future if there should be proper disposal of solid slurry after treatment as well as recycling of wastewater along with periodical monitoring of the water.

Domestic wastewater and industrial effluents should be treated to acceptable levels and standards before discharging them into natural sources.

4. Conclusion

All the physico-chemical water quality parameters of reservoir water are out of the maximum desirable limit set by BIS. Hence these sample water cannot be much fit for drinking, and domestic used. The statistical analysis of the experimentally estimated water quality parameters on water samples yielded the range of the variation, mean, standard deviation and co-efficient of variation. Results of correlation analysis show that all applied water quality parameters are beyond the maximum desirable limit set by BIS-10500:1991. Towards this end, as a humble start a regular environmental monitoring programme must be conducted in reservoir for pollution abatement needs to be initiated as per BIS guidelines.

5. References

e-mail address: hemantp1981@yahoo.co.in

[1] H. Pathak, Doctoral thesis (awarded), Dr. H. S. Gour central university, Sagar, M.P., India, (2012)
[2] H. Pathak and S. N. Limaye, E- Journal of chemistry, **8**(4), 2000-2009 (2011)
[3] H. Pathak and S. N. Limaye, Analele Universitătii din Oradea – Seria Geografie, 1, 23-29 (2011)
[4] H. Pathak and S. N. Limaye, Ovidius University Annals of Chemistry, **22**(2), 87-93 (2011)
[5] H. Pathak and S. N. Limaye, Analele Universitătii din Oradea – Seria Geografie, 2, 233-238 (2011)
[6] H. Pathak and S. N. Limaye, Advances in Applied Science Research (Pelagia Research Library), **3**(1), 555-562, (2012)
[7] H. Pathak and S. N. Limaye, Advances in Applied Science Research (Pelagia Research Library), **3**(1), 31-44, (2012)
[8] H. Pathak and S. N. Limaye, Analele Universitătii din Oradea – Seria Geografie, **2**, 122-127 (2012)
[9] H. Pathak and S. N. Limaye, Bulletin of the Polytechnic Institute Of Iaşi, 1, 85-104 (2012)
[10] H. Pathak and S. N. Limaye, Bulletin of the Polytechnic Institute of Iaşi, 2, 119-126 (2012)
[11] H. Pathak and S. N. Limaye, The Green Pages: Directory for Environmental Technology, http://www.eco-web.com/edi/110128.html, (2011)
[12] H. Pathak and S. N. Limaye, Proceedings of the 45th Annual convention of chemists and international conference on recent advances in chemistry, organised by Indian chemical society hosted by Karnataka university, Dharwad, November 23-27, (2008)
[13] H. Pathak and S. N. Limaye, National Seminar of Environment protection & waste management, organised by, Govt. P.G. College, Bina, sponsored by, U.G.C., New Delhi
[14] H. Pathak and S. N. Limaye, National Seminar of Environment Safety and solid waste management, organised by, Govt. Arts and Commerce College, Sagar, sponsored by, U.G.C., New Delhi
[15] H. Pathak, J Environ Anal Toxicol, **2**(5), 01-05 (2012)
[16] H. Pathak, J Environ Anal Toxicol, **2**(6), 01-05 (2012)
[17] APHA, "Standard methods for the examination of water and waste water", 21st edition, American Public Health Association, Washington, DC., USA, (2005)
[18] Indian standard drinking water, Specification (First Revision) IS-10500:1991. BIS, New Delhi, India
[19] A water handbook United Nations Children's Fund (UNICEF) Water, Environment and Sanitation Technical Guidelines- No.2, (1999)
[20] USEPA, National Drinking water standards. United States Environmental Protection Agency, http://www.epa.gov/safewater/, (2009)
[21] Official website of Madhya Pradesh pollution control board, Bhopal, www.mppcb.nic.in
[22] SPSS Advanced Models™ 11.0 Web site at http://www.spss.com
[23] WINKS SDA software, Version 6, Web site at www.texasoft.com

Submitted: March 31th 2012
Accepted in revised form: October 31th 2012