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Assessment of Physico-Chemical Quality of Groundwater by Multivariate Analysis in some Populated Villages nearby Sagar City, MP, India

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Abstract

Ground water is one of the major resources of the drinking water in rural area nearby Sagar city, Madhya Pradesh. In the present study groundwater quality of the selected 02 villages near by Sagar city were taken for under investigations, by collecting 75 groundwater samples from entire villages and assessed for their suitability for human consumption. Physico-chemical parameters were carried out during different months of the pre monsoon, monsoon and post monsoon seasons in Oct. 2007– July 2011. WHO water directive value is 44 mg/l for nitrate and11 mg/l nitrate in drinking water. pH values of all samples were between 5.5-8.5 limits. Conductivity of all samples was below WHO water standards. The statistical analysis of the experimentally estimated water quality parameters on water samples yielded the range of the variation, mean, standard deviation, co-efficient of variation, correlation analysis and principal component analysis.

Keywords: Groundwater; Physico-chemical quality; Principal component analysis

Introduction

Ground water is the major source of water for drinking, agricultural, and industrial desires. The availability of water determines the location and activities of humans in an area and our growing population is placing great demands upon natural fresh water resources.

The physico-chemical contaminants that adversely affected the quality of groundwater is likely to arise from a variety of sources, including land application of agricultural chemicals and organic wastes, infiltration of irrigation water, septic tanks, and infiltration of effluent from sewage treatment plants, pits, lagoons and ponds used for storage.

In this study, physico-chemical assessment of ground water samples is determined by using standard analytical methods. The objective of the study is to analyze the 14 parameters of water along 15 locations of 2 villages nearby Sagar city for 3 season's pre monsoon, monsoon and post monsoon (during 2007 - 2011). The aim of this study was to determine the physico-chemical analysis of groundwater sources of Banda and Karrapur village area and to compare with levels obtained with the and WHO drinking water directive.

Study area and collection of water samples

Ground water samples were collected from in and around Sagar city. Each water sample was taken every month during Oct. 2007– July 2011. Hemant Pathak et al [1-21], worked in the physico-chemical investigations of water from 7 years. The samples were collected in prewashed (with detergent, diluted HNO_3 and doubly de-ionized distilled water, respectively) clean polythene 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 physicochemical changes.

Experimental

Physico-chemical Analysis

All the chemicals used were of AR grade. Analysis was carried out for various water quality parameters which were measured by using Standard APHA methods.

Banda and Karrapur village area nearby Sagar city was chosen as study area. 15 locations of 2 villages were selected based on domestic, agricultural and industrial activities. Water samples were collected from 15 stations by using standard methods (APHA). Various water samples were collected in clean and dry polyethylene bottles from bore wells after running them for 5 minutes. All the collection of samples are immediately preserved in dark boxes and processed for the different analysis within 6 hours after collection. All water samples were collected in sterile bottles (5 liter).

In order to quantitatively analyse and confirm the relationship among major and trace element contents in groundwater samples, Pearson's correlation analysis was applied to the data. Correlations among various metal contents, major elements, EC and pH in groundwater samples are calculated. Significant positive correlations among various elements in groundwater samples are evident. Na, Cl, K and Mg are significantly correlated ($0.69<r<0.96$). The strong correlation between Na and Cl (r= 0.96), indicate a common chemical behavior. Ca and Mg are not significantly correlated (0.08) indicating that Ca and Mg are not probably related to dissolution of low magnesium carbonate, or dolomite deposits. Major elements such as Na, Cl, K, and Mg display significant correlation with EC ($0.64<r>0.95$). This reflects the fact that EC of groundwater is strongly controlled by Cl and Na content.

Interpretation of PCA results

Before applying the above finding, its scientific reliability must be validated using other independent methods. One way to achieve this goal is to compare the water quality data with and without the 4

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nonprincipal physico-chemical parameters. In the first case, data from the principal physico-chemical parameters were used to formulate the following four relationships by regression analysis. The R2 value for the regression equation (Y= 1.34+ 1.564X) for data of all the 8 physicochemical parameters was 0.9658, whereas the R2 value for the regression equation (Y= -1.76+1.323 X) for data of the 3 principal parameters was 0.9134.

Verification of the PCA results

The results of PCA were compared with those of cluster analysis and the factor analysis applied to the original data set. CA was performed by means of the Ward's method because of the same reason given above. The dendrogram manifested almost the same clusters compositions as it was found in Figure 4. It also confirms that PC1 and PC2 contain parameters which are most important for the water quality characterization.

Results

Table 3 and Table 4 represented statistical evaluation for different parameters in the ground water samples of Banda village and Karrapur villages of Sagar city. Ground water quality parameters of Banda village can be concluded that variables–TDS, TH are slightly higher and Alkalinity, Cl are lower in the post monsoon period than in the

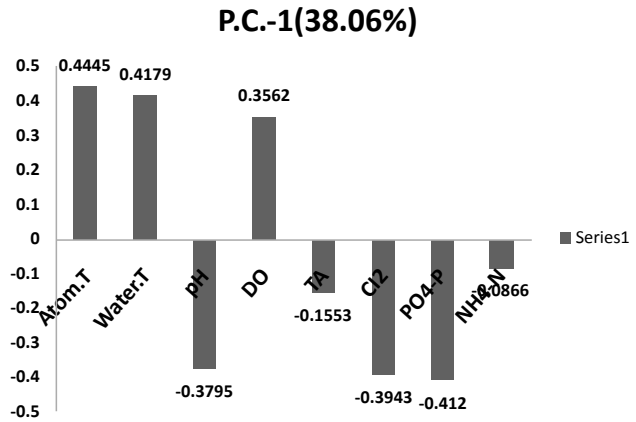

Figure 1: Component loading for the first component (PC1).

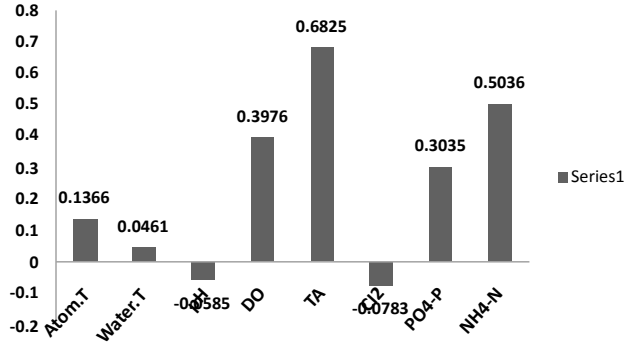

Figure 2: Component loading for the second component (PC2).

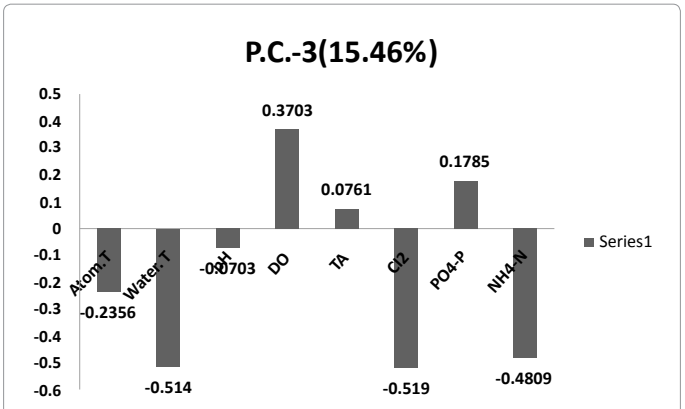

Figure 3: Component loading for the third component (PC3).

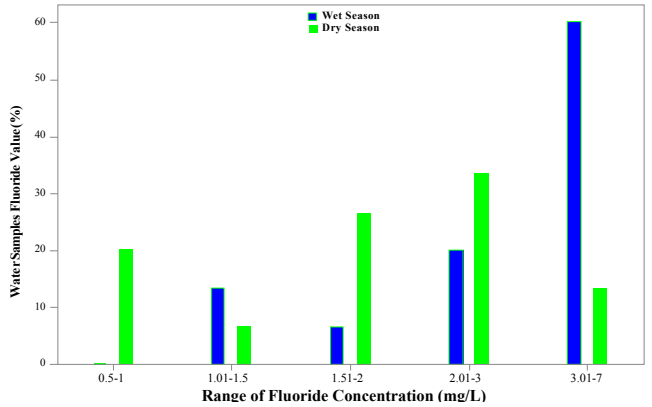

Figure 4: Ranges of fluoride concentration in wet and dry seasons.

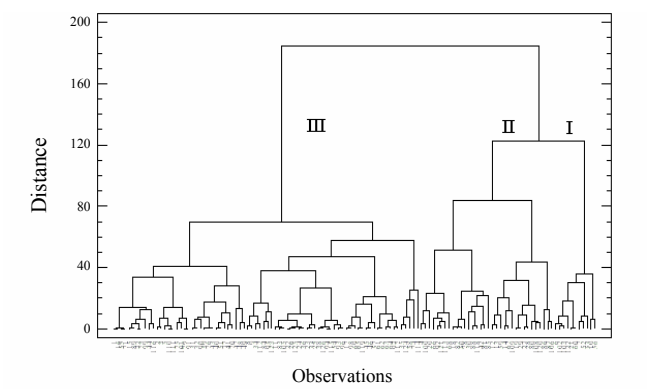

Figure 5: Ward's dendrogram of the drinking water samples defined by the principal components.

PreMonsoon. On the other hand parameters–BOD, COD, Ammonia and Nitrate are clearly higher in all the season showed a clear cut temporal effect. BOD is out of the highest desirable limit or maximum permissible limit set by WHO except TH, Alkalinity and conductivity which recorded high values. It was reported that groundwater was contaminated from nitrate fertilizers and manures used in agriculture. Hence, these sample water can be absolutely fit for drinking after disinfectants treatment. Results of the analysis of groundwater revealed that a total of 30 samples had slightly more pH levels as per Indian standards. Possible sources of this contamination may be intensive

S.N.	Parameters	Unit	Test Methods
1	pH	-	pH meter
2	Dissolved Oxygen (DO)	mg/L	Winkler method
3	Biochemical Oxygen Demand (BOD)	mg/L	5 days incubation at 20° C and titration of initial and final DO.
4	Chemical Oxygen Demand	mg/L	Open Reflux Method
5	Conductivity	ms/cm	Conductivity meter
6	Alkalinity	mg/L	Titration
7	Total dissolved Solids	mg/L	Digital conductivity meter (LT-51)
8	Chloride	mg/L	Argentometric titration
9	Orthophosphate ($P0_4^{3-}$ — P)	mg/L	Ammonium molybdate ascorbic acid reduction method
10	Nitrate -Nitrogen (NO_3 — N)	mg/L	Spectrophotometric method
11	Ammonia-Nitrogen (NH_3 — N)	mg/L	Spectrophotometric (Phenate method)
12	Total Hardness as $CaCO_3$	mg/L	EDTA titration
13	Fluoride	mg/L	Colorimetric Method
14	Iron	mg/L	Colorimetric Method

Table 1: List of Chemical parameters and their test methods.

Parameter	**PC1**	**PC2**	**PC3**
Alkalinity	0.31881	-0.41704	-0.12066
Ammonia	-0.10772	0.06600	-0.05462
Calcium	0.43365	-0.15237	-0.10097
COD	-0.29351	-0.07623	-0.13840
Colour	-0.08028	-0.24234	0.44076
Conductivity	0.42307	-0.19351	-0.11142
Hardness	0.43420	-0.17996	-0.09648
Chlorine	0.04218	-0.01864	-0.18426
Iron	0.04309	-0.13804	0.52467
o-Phosphate	-0.04226	-0.06378	-0.02941
Nitrate	0.26770	0.44664	0.13679
Nitrite	-0.09440	0.11824	-0.04021
pH	-0.23475	-0.44597	-0.20023
Temperature	0.04915	-0.10005	0.14823
Turbidity	0.04797	-0.17656	0.54698
Eigenvalue	4.51970	2.62920	2.39520
Percent of variance	25.11	14.61	13.31
Cumulative percentage	25.11	39.72	53.02

Table 2: Principal component axis data.

agriculture and urbanization in Karrapur and Banda village. In rural areas drinking water generally supplied groundwater

Conclusion and Recommendation

From the PCA findings given above, follows that 14 parameters used for the drinking water quality characterization can be replaced by the 3 principal components explaining about 83% of the data variance: nitrate/pH, iron and ammonia. Regarding the physico-chemical properties and hygienic importance of these parameters, only the six of them can be used for the frequent water quality monitoring: Conductivity, nitrate, iron, chloride and nitrite.

FA mostly confirmed the PCA results and, additionally, in the case of alkalinity showed relations between hardness and bicarbonate/carbonate concentrations. The first two principal components explaining about 50 % of data contain the key variables of the drinking water supply system and nitrate/pH.

The PCA scatter plots and dendrograms were used for the samples clustering. Also the combination of scatter plots and cluster analysis was found to be advantages. The revealed clusters gather the drinking water samples according to their origin (surface and ground water).

Multivariate methods were found to be suitable for reducing the water quality parameters and the determination of relationships among them, and also for the samples clustering, as well. These techniques can be helpful for assessors to obtain a global view on the water quality in any urban or other geographical territory when analysing large data sets without a priori knowledge about them.

The correlation coefficients between Temp and DO (-0.89): There is a negative correlation between and pH, Cl_2, PO_4 – P; Water Temp and

	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	42.127	.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
CONDUCTIVITY	.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
RESICHLORINE	.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 HARDNESS	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 different Parameters in the Ground water Samples of Banda village in Sagar City.

	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	6.30	22.30	28.60	506.50	25.3250	.3269	1.46211	2.138	.091	.512	.409	.992
COLOUR	14.00	10.00	24.00	298.00	14.9000	.7674	3.43205	11.779	1.179	.512	1.295	.992
pH	1.86	6.51	8.37	148.47	7.4235	.1203	.53783	.289	-.256	.512	-.784	.992
TURBIDITY	10.00	8.00	18.00	219.00	10.9500	.5452	2.43818	5.945	1.347	.512	2.638	.992
DO	4.60	3.25	7.85	118.28	5.9140	.2563	1.14626	1.314	-.898	.512	.888	.992
BOD	7.29	3.02	10.31	104.19	5.2095	.3146	1.40701	1.980	2.424	.512	9.618	.992
COD	17.10	8.25	25.35	221.32	11.0660	.8357	3.73726	13.967	3.222	.512	12.033	.992
CONDUCTIVITY	.33	.45	.78	11.82	.5911	.0186	.08302	.007	.858	.512	.464	.992
ALKALINITY	174.00	104.00	278.00	3900.00	195.0000	10.3115	46.11427	2126.526	.420	.512	-.381	.992
TS	227.24	281.47	508.71	7597.52	379.8760	12.8426	57.43397	3298.660	.662	.512	-.009	.992
TSS	61.87	3.36	65.23	378.92	18.9460	3.2345	14.46497	209.235	1.756	.512	4.579	.992
TDS	201.31	274.95	476.26	7218.60	360.9300	11.3274	50.65748	2566.180	.863	.512	.470	.992
CHLORIDE	108.75	28.64	137.39	1136.87	56.8435	5.6457	25.24846	637.485	1.916	.512	4.587	.992
RESICHLORINE	.26	.05	.31	2.95	.1475	.0156	.06995	.005	.703	.512	.032	.992
PHOSPHATE	3.13	1.51	4.64	48.50	2.4250	.1366	.61102	.373	2.536	.512	9.416	.992
NITRATE	5.63	1.06	6.69	39.61	1.9805	.2930	1.31018	1.717	2.768	.512	8.778	.992
AMMONIA	.34	.11	.45	4.06	.2030	.0187	.08367	.007	1.309	.512	2.595	.992
TH	117.87	150.19	268.06	4130.55	206.5275	5.9582	26.64606	710.013	.366	.512	.743	.992
TEMP. HARD.	116.09	96.60	212.69	3158.14	157.9070	6.4247	28.73225	825.542	-.304	.512	.072	.992
PERM. HARD.	76.33	14.36	90.69	972.41	48.6205	4.2379	18.95236	359.192	.060	.512	.177	.992
Ca HARDNESS	94.69	114.36	209.05	3204.22	160.2110	6.3270	28.29535	800.627	-.101	.512	-1.203	.992
Mg HARDNESS	56.50	18.77	75.27	926.33	46.3165	3.6065	16.12864	260.133	-.093	.512	-.967	.992
FLUORIDE	1.35	.21	1.56	17.15	.8575	.0944	.42206	.178	-.034	.512	-1.296	.992
IRON	1.94	.04	1.98	8.78	.4390	.0879	.39322	.155	3.370	.512	13.666	.992
Ca CONTENT	37.95	45.83	83.78	1284.17	64.2085	2.5359	11.34095	128.617	-.101	.512	-1.203	.992
Mg CONTENT	13.73	4.56	18.29	224.99	11.2495	.8764	3.91952	15.363	-.092	.512	-.966	.992

Table 4: Statistical evaluation for different Parameters in the Ground water Samples of Karrapur village in Sagar City.

pH, TA, Cl_2, PO_4 – P; pH and DO respectively. A negative correlation is also shown by DO with Cl_2, PO_4-P.

It is interesting to observe that a high positive correlation (0.7797) exist between Water Temp and there is hardly any correlation between PO_4-P and NH_4-N; Cl_2 and TA respectively.

PCA results show that 5 physico-chemical parameters (Water Temp, pH, TA, Cl_2, NH_4-N). Identified as less important in explaining the annual variance of the data set, and therefore could be the non-principal parameters. Identification of less important water quality parameter can be seen in which show component loading (eigenvector) for PC1, PC2 and PC3 respectively.

Thirty groundwater samples collected for physico-chemical analysis of water samples of Karrapur and Banda villages of sagar city. Physico-chemical parameters are out of the highest desirable limit or maximum permissible limit set by IS: 10500. Hence, these sample water cannot be absolutely fit for directly drinking. Some essential treatment needed to convert in drinkable water.

In conclusion, from the results of the present study it may be said that the people in these rural areas are therefore at higher potential risk. Both villages water is not absolutely fit for directly drinking purpose need treatments to minimize the contamination. It is recommended that water analysis should be carried out from time to time to monitor the rate and kind of contamination.

It is need of human to expand awareness among the people to maintain the cleanness of water at their highest quality and purity levels to achieve a healthy life.

References

1. Hemant P, Limaye SN (2011) Pollumeter: A Water Quality Index model for the assessment of water quality. Green Pages.
2. Hemant P, Limaye SN (2011) Study of seasonal variation in groundwater quality of sagar city (india) by principal component analysis. J chem 8: 2000-2009.
3. Hemant P, Limaye SN (2011) Interdependency between physicochemical water pollution indicators: a case study of river Babus, Sagar, M.P., India. Analele UniversităŃii din Oradea – Seria Geografie 1: 23-29.
4. Hemant P, Limaye SN (2011) A mathematical modeling with respect to DO for environmentally contaminateddrinking water sources of Sagar city (M.P.), India: A case study. Ovidius University Annals of Chemistry 22: 87-93.
5. Hemant P, Deepak P, Limaye SN (2011) Seasonal study with interpretation of the chemical characteristics of water pond in reference to quality assessment: A case study. Analele UniversităŃii din Oradea – Seria Geografie 2: 233-238.
6. Hemant P, Limaye SN (2012) Assessment of Physico-Chemical Quality of Groundwater in rural area nearby Sagar city, MP, India. Advances in Applied Science Research. Pelagia Research Library 3: 555-562.
7. Hemant P, Deepak P, Limaye SN (2012) Studies on the physico-chemical status of two water bodies at Sagar city under anthropogenic Influences. Advances in Applied Science Research 3: 31-44.
8. Multivariate evaluation of fluoride contamination in ground water samples of Sagar city, M.P., India: A case study, Instasci Journal of Chemistry, 2012, 2(1), ISSN: 2277-6931.
9. Ground and Tap water Quality assessment of Sagar city especially in terms of saturation index, *THE POLYTECHNIC INSTITUTE OF IAŞI,* 2012, Issue LVII (LXI), Fasc. 4. ISSN: 0254 – 7104.
10. An water quality index mathematical modeling of water samples of Rajghat, water supply reservoir Sagar (M.P.) with respect to total dissolved solids: A regression analysis, *THE POLYTECHNIC INSTITUTE OF IAŞI,* 2012, Issue LVII (LXI), Fasc. 4. ISSN: 0254 – 7104.
11. Hemant P (2012) Assessment of Physico-Chemical Quality of municipal water samples of Makronia sub-urban area of Bundel khand region, India, Analele UniversităŃii din Oradea – Seria Geografie 1: 569.
12. Participated in 26th conferences of Indian Council of Chemists held at Dr. H. S. Gour University, Sagar on 26th-28th February, 2008.
13. A mathematical modeling for environmentally polluted water soluble impurities: A case study(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).
14. Assessment of Physico-Chemical Quality of municipal water samples of Sagar city, MP, India, (National Seminar on Soil, Air and Water Resource Management, Organised by, Govt. Auto. Girls P.G. College, Sagar, Sponsored by, U.G.C., New Delhi).
15. Contaminant evaluation of boreholes water (drinking water sources) in Gambhiria village, Sagar (MP), April 2012, National symposium on Advances in Environmental chemistry and green technologies, Organised by RJIT tekanpur, Gwalior, Sponsored by, M.P. Council science and technology, Bhopal.
16. Physico-chemical Analysis of Ground Water Samples of Sagar city with respect to water soluble pollutants (National Seminar of Environment protection & waste management , Organised by, Govt. P.G. College, Bina, Sponsored by, U.G.C., New Delhi).
17. Statistical Study on Physico-Chemical Parameters and Water Quality assessment of Lakha banzara pond, Sagar (M.P.) (National Seminar of Environment Safety and solid waste management, Organised by, Govt. Arts and Commerce College, Sagar, Sponsored by, U.G.C., New Delhi).
18. Assessment of Physico-Chemical Quality of municipal water samples of Sagar city, MP, India, (National Seminar on Soil, Air and Water Resource Management, Organised by, Govt. Auto. Girls P.G. College, Sagar, Sponsored by, U.G.C., New Delhi).
19. APHA, "Standard methods for the examination of water and waste water", 21st edition, American Public Health Association, Washington, DC., USA, 2005.
20. Indian standard drinking water, Specification (First Revision) IS-10500:1991. BIS, New Delhi, India
21. SPSS Advanced Models™ 11.0.