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Section D: General Section

Research Article

Analytical study of physico chemical and metallic elements of ground water and surface water in Balco industrial Area, Korba, C.G.

Vaishnav M.M.[1*] **Dewangan** S.[2]

[1]Department of Chemistry, G.B.V. Post Graduate College, Hardibazar, Korba (C.G.) India,

[2]Department of Chemistry, C.M.D. Post Graduate College, Bilaspur (C.G.), India

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ABSTRACT

A systematic investigation has been carried out to assess the water quality of SW and GW of Balco industrial areas in context of statistical approach. For this purpose we have taken monthly based investigation of the water. 30 water samples were collected from ten selected sites (BS1 – BS10) in 2L capacity containers, separately (Oct 2009 to Dec 2009). Then water samples were subjected to analytical study prescribed by standard agencies. The results were interpreted via statistical means like mean, SD, SE, %CV, r and WQI. Turbidity (SW 82.05 NTU, GW 21.66 NTU), Fe (GW 2.385mg/L), Al(SW 0.76mg/L,) were found above the threshold value. Strong +ive relation was calculated for GW between TS vs TDS [GW = + 0.950(3.042)] and EC vs TDS [Sw r = + 0.973(4.216)]. The high % CV was calculated for Zn 127.791 (GW) and As in 184.185 (SW). Highest WQI is obtained in case of BS5 : 2472.32. The analysis showed water sources in and around Balco industries are not applicable for any purpose in human development.

Key words: Physicochemical parameters, Heavy meals, Surface and Ground water, Statistical Parameters, WQI, Correlation Coefficient, Korba, Balco..

INTRODUCTION

Water is vital source of life and fresh water being one of the basic necessities for sustenance of life.[1] Potable and safe water gradually became scarce commodity, due to mixing up of huge contaminants through natural process like soil and rock weathering, surface runoffs along with anthropogenic activities such as industrial effluents,

domestic sewage, garbage, over mining activity, explosive population etc.[2,3,4,5] Seepage and percolation of water through solid garbage causes ground water pollution.[6,] Metallic elements are environmentally stable, do not decomposed by microbes, water and air. It enters in living system through aqua medium and accumulated upto prolong period, resulting acute adverse effects on human being, animals and plants.[8 7] Metallic elements have significnt role to increase the degradation of water quality via thermal power plant, extraction of metals, transpiration, over application of fertilizers, pesticides and insecticides.[9] Some heavy metals such as Cu, Fe, Mn, Ni and Zn are compulsory as micro nutrients for flora – fauna and microbes. Besides the metals like Cd, Cr and Pb are harmful beyond a certain limit.[10]

Chhattisgarh is the richest Indian state in mineral and natural resources. The coal, bauxite and iron ore abundantly occur in northern and southern part of this state. Due to these rich raw materials, Korba has been developed as industrial hub whereas coal burned based thermal power plants such as NTPC, CSEB and BALCO are established. Balco industrial area is located 8 Km away from Korba district head quarter in north – east direction. Geologically, the study area is plane and geologically belongs to lower gondwana group[11]. Geographically, the study area is spread in about 38 Km^2, average rainfall 823.6 mm and temp. 35.58°C have been recorded during the study period. The field under investigation is located 304.8 m above mean sea level.[12]

The investigation area has been selected on behave of environmental significance against aluminum refining plant. The input of industrial plant is bauxite procured from Mainpat and Kwardha district in chhattisgarh state. Although the annual production of refined aluminum is 312 KT per annum.[13] the unplanned dumping and loading of raw materials and wastes around, surface water sources become contaminated through industrial effluents and ground water polluted by seepage and wastes leach ate. Hence a continuous monitoring of water sources becomes mandatory. In continuation of our previous work,[14] we have taken Post -Monsoon (Oct –Dec 2009) assessment of water quality status to check the pollutants. In the present paper we have presented the analysis of monsoon observations; however coefficient of correlation matrix, % CV and WQI were used for grading water sources.

MATERIAL AND METHODS

Surface and Ground water samples were collected in polyethylene cans of 2L capacity separately for physico chemical and heavy metal analysis on monthly basis from July 2009 to Sep 2009 between from 10 different sampling spots (displayed in **Fig. 1 BS1 to BS10**). For physico-chemical analysis water samples were kept in refrigerator maintained at 4°C temp. and for heavy metals analysis 3 – 4 drops of conc. HNO_3 were added to prevent precipitation of dissolved heavy metals. The method[15,16] used for estimation of various physicochemical parameters are mentioned in the **Table: 1(a)** while statistical parameters are described in **Table 1(b).**

RESULTS AND DISCUSSION

The statistical results for various physicochemical parameters were depicted in **Table 2(a) and 2(b)** for surface and ground water correspondingly with Correlation matrix for surface and ground water is shown in **Table. No 3(a)** and **3(b).**

PHYSICO CHEMICAL ANALYSIS

Ground Water: The intensity of active hydrogen ion concentration is measured in terms of pH.[17] In the study period for GW the pH value was detected in the ranging form 6.78 to 7.53 having a mean of 7.2. The data were under the desirable limit and indicated alkaline nature of water. EC measure the conductance power of water which depends upon the dissolved ions. In the monitoring period EC

fluctuated between 447 $\mu S / cm$ and 1764 $\mu S / cm$ with a mean of 1070.5 $\mu S / cm$. The maximum value crossed the upper limit as suggestion by Standard value; 1400 $\mu S / cm$ (WHO).

Turbidity is essential water quality parameter which magnitude depends on suspended particles. Mean and limiting values for the turbidity were calculated 21.64 NTU and 14 – 31 NTU respectively. The upper range is beyond the max. Permissible limit as per BIS[18], indicating GW more safe and potable water. The dissolved ions are measured in reference of TDS by filtration method. In this assessment period 497.72 mg/L calculated as average while ranging was vacillating between 271.25mg/L and781.35 mg/L. The value was covered within the desirable range as per the BIS[18] and WHO[19]. The alkaline nature of water is confirmed by the alkalinity of water which is caused by the presence of inorganic anions. The average and range values were 356.08 mg/L and 198-588 mg/L respectively. Hardness of water is imparting due to Ca^{2+} and Mg^{2+} salts. The results indicate hard quality of GW, also effected by dilution due to rain water. The values observed were 272.46 mg/L as mean and 141 - 451 mg/L as ranges were under the acceptable limits as prescribed BIS[18] and WHO[19] standards.

Surface Water: pH value more altered in SW than GW owing to discharge of various surface pollutants. During the investigation in post – monsoon period the pH value was measured in 7.61 and 6.71-8.41 as average and ranging value within the maximum permissible level as set by BIS[18] and WHO[19]. This observation showed the water sources have slightly alkaline in nature due to dilution factor. EC of surface water is increased in post – monsoon season due to mixing of surface runoff. In analysis period the mean and limiting values was detected as 1841.44 $\mu S / cm$ and 1466-1989 $\mu S / cm$. This statistical data were found beyond the WHO[19] limits while within the BIS[18] standards. High value of EC displayed the dissolved ions are mixed in water sources from different pollution points.

Turbidity of surface water is mostly high than the GW. Weathering of earth's surface and discharge of partial dissolved chemical matter are the cause of turbidity. Analytical results; average and ranging were calculated out 82.1 NTU and 39 NTU – 166 NTU. A total dissolved solid not directly influences human health. Its magnitude was altered by the presence of dissolved ions. TDS experimentally illustrates a vacillation from 371.32 mg/L to 1361.17 mg/L with mean value 1046.52 mg/L.

T. Alk. of water sources depends on the dissolved ions of carbonates, bicarbonates, hydroxides etc. In case of T. Alk., the average and range values are 392.94 mg/L and 309-569 mg/L respectively, which is within the excessive permissible level as per the suggestion specified by BIS[18] and WHO[19]. Hardness of water causes the renal problem in living system. It also effect the leathering efficiency of water, obtained 433.4 mg/L as mean and 347.5-598 mg/L as range values for hardness in the given water analysis. These values are within the excessive acceptable range as per WHO[19] and BIS[18].

Metallic Elements: Metallic elements possess chief contribution in imparting water pollution. In nature, it sources are domestic wastes, industrial effluents, agricultural and surface runoff. In our investigation we have chosen five metallic elements in the background of environmentally significance. Calculation show mean and ranges value for Mn were 0.233 mg/L, 0.11mg/L and 0.07-0.38 mg/L, 0.05-0.34 mg/L for GW, SW respectively. The maximum value exceeds the standard value stipulated by the ISI : 10500. Arsenic is accumulated in living tissues upto prolong period and causes chronic diseases. We have observed the mean values of As were reported as 0.0029 mg/L, 0.006mg/l for GW and SW with extremes 0.001-0.01 mg/L and 0.001-0.05 mg/L respectively. Zn is

main constituent of animal enzyme, low intake of Zn results in anemia[20], immaturation and growth retardation. In our analysis, the statistics 0.571 mg/L, 0.121 mg/L and 0.1-2.03 mg/L, 0.1-0.28 mg/L as mean and range value were found for GW and SW as set in order, which is far below the minimum requirement of Zinc as framed by BIS[18] and WHO[19] i. e. 5mg/L. *Al* is the third most abundant element in the earth crust occurring in mineral rocks and clays. In our study the mean value was 0.249 mg/L, 0.763 mg/L for GW, SW; while fluctuates 0.01-1.1 mg/L, 0.06-1.75 mg/L respectively. The maximum value is several folds greater than max. Permissible limit prescribed by BIS[18] and WHO[19]. Iron is considered as essential micronutrient, long term consumption of drinking water with high concentration of iron may leads to liver diseases. It was reported 2.385 mg/L, 0.941mg/L and 0.48-5 mg/L, 0.26-1.84 mg/L as the average and ranging value for GW and SW respectively. The highest value of iron was many times greater than maximum tolerable level as per BIS[18] and WHO[19] recommendations.

STATISTICAL ANALYSIS

105 correlation coefficients (r) among various water quality parameters for ground water were observed. 12 were found to have significant at 5% level (r > 0.649). Strong positive correlations r(t) are shown bypH vs EC [0.817(1.417)] and TSS [0.840(1.548)], EC vs TSS [0.949(3.010)], Turb. vs T. Aci. [0.723(1.047)], TS vs TDS [0.950(3.042)], TDS vs Fe [0.733(1.078)], T. Alk. vs TH [0.709(1.005)], vs Zn [0.882(1.872)], vs Fe [0.748(1.127)], TH vs Zn [0.929(2.510)] and Fe [0.819(1.427)], Zn vs Fe [0.861(1.693)]. In case of surface water only 04 out of 105 correlation were found to have significant at 5 % level (r = > 0.649). High level positive correlations are shown by EC vs TS [0.941(2.781)] and TDS [0.973(4.216)], TS vs TDS [0.966(3.736)] and T. Alk. vs TH [0.798(1.324)]. t – Values were used for the testing of these correlations.

In present examination highest %CV was obtained in Zn in GW with value 127.791vacillating between values 0.1-2.03 mg/L and in SW, As with value 184.186 ranging from 0.001-0.050 mg/L.

In our investigation WQI values were obtained in wide ranges from minimal 146.211 at the site no. BS1 to max. 2472.322 at site no. BS5 (shown in Fig. 1 and Table 4). The high value of WQI has been found to be closely related with high values of WQPs such as EC, TDS, Turbidity, TH, T. Alk., Fe and Aluminum. WQI found high for surface water sources than ground water indication of extra pollutants discharge in surface water by anthropogenic and weathering process.

CONCLUSIONS

In this study our aim is to highlight the presence of metallic elements in aquatic systems deposited by means of Balco industrial effluents. Aluminum was found in high concentration 1.1 mg/L, 1.75 mg/L at the sampling spots BS4[Nov 209] for GW and SW . Similarly, iron was also detected in high amount greater than 5mg/L and 1.84 mg/L in GW and SW in many sampling points. From these observations, it is concluded that the extraction process of Balco factory is not efficient to control the pollutants. We have suggested the plant management; prior purification of industrial effluents is necessary and also campaign among peoples to adapt indigenous purification method of water before using for different purpose.

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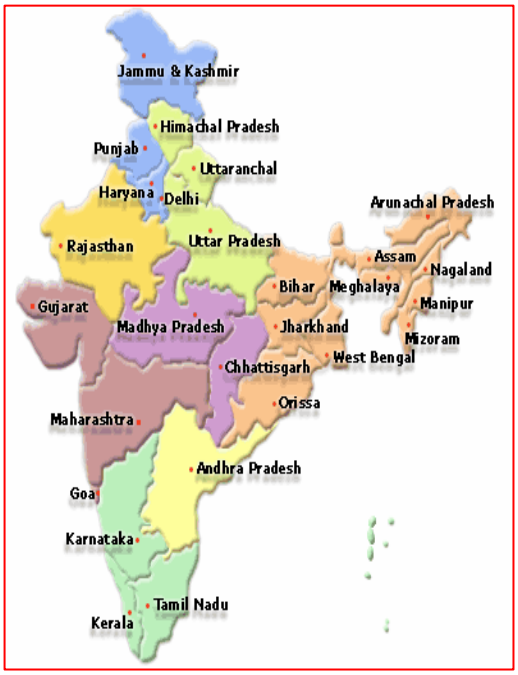
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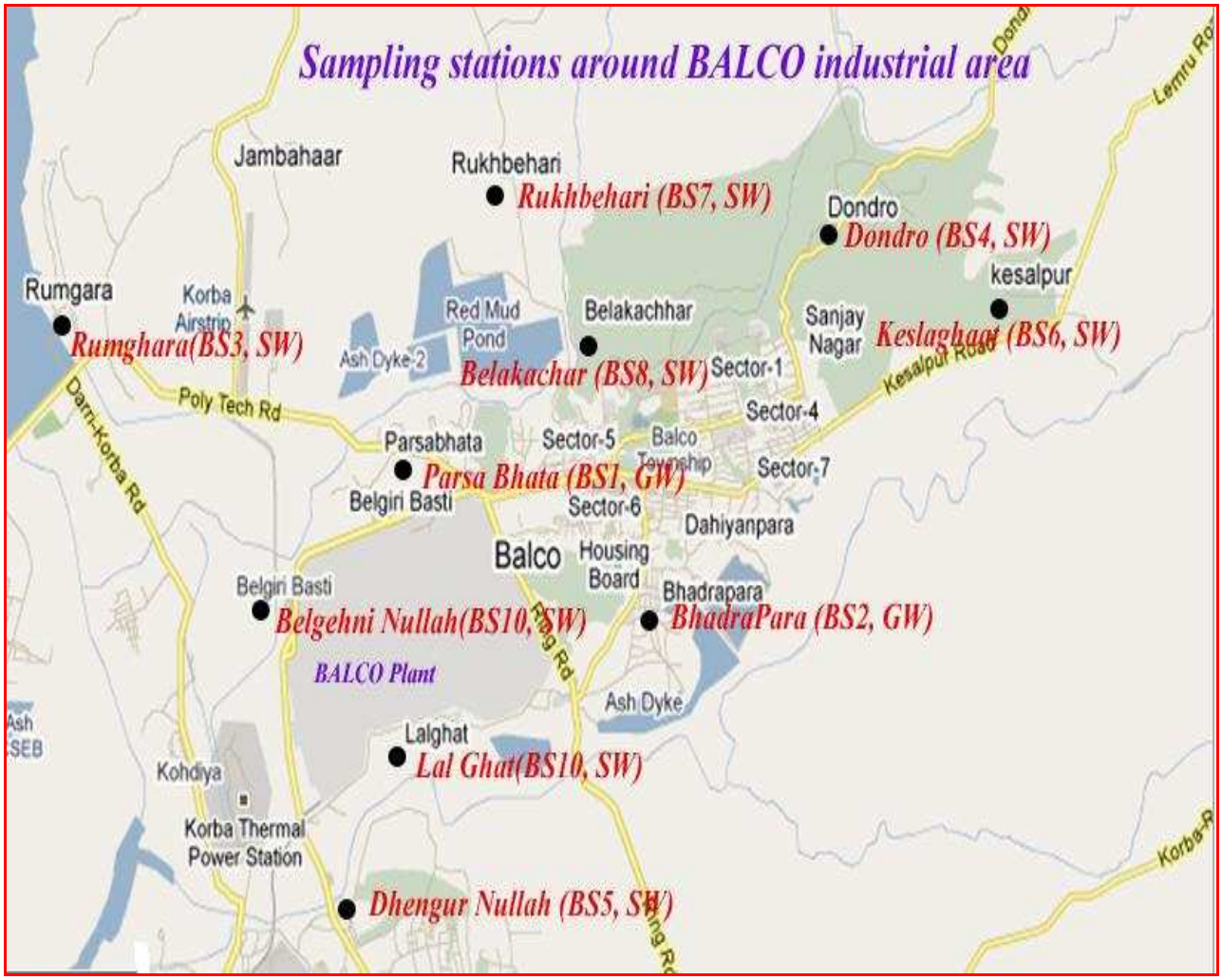

Location Map Figure No. 1

Table No.1a

Water Quality Parameters and Methods for Analysis

Serial No.	Parameter	Method
1.	Temp.	9-parameter analyzer kit
2.	pH	9-parameter analyzer kit
3.	Turbidity	9-parameter analyzer kit
4.	Electrical Cond.	9 -parameter analyzer kit
5.	TH, ,	Titrimetric
6.	T.Aci.	Titrimetric
7.	T. Alk.	Titrimetric
8.	TS	Gravimetrically
9.	TDS	Gravimetrically as well as analyzer kit.
10.	TSS	Mathematically TSS = TS - TDS
11.	Heavy Metals, Mn, Fe, Zn, Al, As	ICP – AES

Table. No. 1b
Statistical Parameters

Serial No.	Parameter	Formula	Remarks
1	Mean	$\mu = \frac{\sum x}{N}$	x = Value of Observation, N = Number of Observation
2	Standard Deviation	$\sigma = \sqrt{\frac{n\sum x^2 - (\sum x)^2}{n(n-1)}}$	x = Values of Parameter. n = No. of Observations
3	Standard Error	$S.E. = \frac{S}{\sqrt{N}}$	S = Standard Deviation N = No. of Observation
4	% CV	$CV = \frac{\sigma}{\mu} \times 100$	Σ = Standard Deviation μ = Average
5	Correlation coefficient	$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{n\sum x^2 - (\sum x)^2}\sqrt{n\sum y^2 - (\sum y)^2}}$	x,y = the values if array 1 and array 2 respectively. n = Number of Observations.
6	Water Quality Index	$WQI = \frac{\sum_i (q_i w_i)}{\sum_i w_i}$	qi = quality rating w_i = water quality parameter

Table No. 2 (A)

Statistical Value of Physico Chemical and Heavy Metal analysis Ground water

Parameter	Range	Mean	SD	%CV	SE	Min		Max	
						Spot	Month	Spot	Month
Temperature	17.3-21.1	19.7	0.9	4.7	0.3	BS4	DEC	BS1	NOV
pH	6.78-7.53	7.2	0.3	3.6	0.1	BS1	OCT	BS4	OCT
EC	447-1764	1070.5	466.1	43.5	134.5	BS2	OCT	BS4	NOV
Turbidity	14-31	21.7	5.3	24.5	1.5	BS4	NOV	BS2	OCT
TS	336.887-911.349	632.7	197.2	31.2	56.9	BS2	DEC	BS1	OCT
TDS	271.25-781.35	497.7	185.5	37.3	53.5	BS2	NOV	BS1	OCT
TSS	55.407-248.047	135.0	61.4	45.4	17.7	BS2	DEC	BS4	OCT
T.Aci	106-229	157.9	39.1	24.7	11.3	BS4	DEC	BS2	NOV
T.Alk	198-588	356.1	139.7	39.2	40.3	BS2	DEC	BS9	OCT
TH	141-451	272.5	98.6	36.2	28.5	BS4	DEC	BS4	DEC
Mn	0.07-0.38	0.2	0.1	48.1	0.0	BS4	OCT	BS9	DEC
As	0.001-0.01	0.0	0.0	118.3	0.0	*		*	
Zn	0.1-2.03	0.6	0.7	127.8	0.2	*		BS9	DEC
Al	0.01-1.1	0.2	0.3	123.6	0.1	BS1	OCT	BS4	NOV
Fe	0.48-5	2.4	1.9	79.0	0.5	BS4	OCT	*	

* more than 1 observation

Table No. 2 (B)

Statistical Value of Physico Chemical and Heavy Metal analysis Surface water

Parameter	Range	Mean	SD	% CV	SE	Min		Max	
						Spot	Month	Spot	Month
Temperature	18.3-29.1	23.2	3.8	16.2	0.9	BS4	DEC	BS1	NOV
pH	6.71-8.41	7.6	0.5	6.0	0.1	BS1	OCT	BS4	OCT
EC	1466-1989	1841.4	185.5	10.1	43.7	BS2	OCT	BS4	NOV
Turbidity	39-166	82.1	32.0	38.9	7.5	BS4	NOV	BS2	OCT
TS	651.5587-1673.376	1252.7	331.4	26.5	78.1	BS2	DEC	BS1	OCT
TDS	371.32-1361.17	1046.5	338.5	32.3	79.8	BS2	NOV	BS1	OCT
TSS	38.867-362.026	206.2	87.0	42.2	20.5	BS2	DEC	BS4	OCT
T.Aci	97-206	135.1	28.8	21.3	6.8	BS4	DEC	BS2	NOV
T.Alk	309-569	392.9	76.8	19.5	18.1	BS2	DEC	BS9	OCT
TH	347.5-598	433.4	65.1	15.0	15.3	BS4	DEC	BS4	DEC
Mn	0.05-0.34	0.1	0.1	62.6	0.0	BS4	OCT	BS9	DEC
As	0.001-0.05	0.0	0.0	184.2	0.0	*		*	
Zn	0.1-0.28	0.1	0.1	44.5	0.0	*		BS9	DEC
Al	0.06-1.75	0.8	0.6	74.8	0.1	BS1	OCT	BS4	NOV
Fe	0.26-1.84	0.9	0.4	42.5	0.1	BS4	OCT	*	

* more than 1 observation

Table No.3(A)

Correlation matrix for Ground Water

	Temperature	*pH*	*EC*	*Turbidity*	*TS*	*TDS*	*TSS*	*T.Aci*	*T.Alk*	*TH*	*Mn*	*As*	*Zn*	*Al*	*Fe*
Temperature															
pH	-0.343(0.365)														
EC	-0.315(0.332)	0.817(1.417)													
Turbidity	0.279(0.291)	-0.633(0.818)	-0.856(1.656)												
TDS	0.246(0.254)	0.116(0.117)	0.333(0.353)	-0.534(0.632)											
TSS	0.352(0.376)	-0.155(0.157)	0.040(0.040)	-0.294(0.308)	0.950(3.042)										
TS	-0.274(0.285)	0.840(1.548)	0.949(3.010)	-0.826(1.465)	0.342(0.364)	0.032(0.032)									
T.Aci	0.378(0.408)	-0.698(0.975)	-0.792(1.297)	0.723(1.047)	-0.581(0.714)	-0.382(0.413)	-0.714(1.020)								
T.Alk	-0.055(0.055)	0.405(0.443)	0.359(0.385)	-0.152(0.154)	0.470(0.532)	0.390(0.424)	0.331(0.351)	-0.606(0.762)							
TH	0.221(0.227)	-0.159(0.161)	-0.382(0.413)	0.444(0.496)	0.206(0.211)	0.341(0.363)	-0.369(0.397)	-0.008(0.008)	0.709(1.005)						
Mn	0.029(0.029)	-0.321(0.339)	-0.477(0.543)	0.487(0.558)	-0.501(0.579)	-0.339(0.360)	-0.586(0.723)	0.448(0.501)	0.051(0.051)	0.476(0.541)					
As	0.273(0.284)	0.060(0.060)	0.168(0.170)	-0.334(0.354)	0.060(0.060)	0.042(0.042)	0.065(0.065)	0.163(0.165)	-0.256(0.265)	-0.302(0.317)	0.182(0.185)				
Zn	0.063(0.063)	0.156(0.158)	-0.048(0.048)	0.146(0.148)	0.349(0.372)	0.381(0.412)	-0.031(0.031)	-0.307(0.323)	0.882(1.872)	0.929(2.510)	0.308(0.324)	-0.255(0.264)			
Al	-0.237(0.244)	0.106(0.107)	0.208(0.213)	-0.181(0.184)	-0.411(0.451)	-0.438(0.487)	0.002(0.002)	0.050(0.050)	-0.138(0.139)	-0.225(0.231)	0.599(0.748)	0.585(0.721)	-0.198(0.202)		
Fe	0.158(0.160)	0.031(0.031)	-0.086(0.086)	-0.002(0.002)	0.655(0.867)	0.733(1.078)	-0.109(0.110)	-0.402(0.439)	0.748(1.127)	0.819(1.427)	0.095(0.095)	-0.147(0.149)	0.861(1.693)	-0.325(0.344)	

Table No. 3(B)

Correlation matrix for Surface Water

	Temperature	*pH*	*EC*	*Turbidity*	*TS*	*TDS*	*TSS*	*T.Aci*	*T.Alk*	*TH*	*Mn*	*As*	*Zn*	*Al*	*Fe*
Temperature															
pH	0.099(0.099)														
EC	-0.064(0.064)	0.347(0.370)													
Turbidity	0.260(0.269)	-0.038(0.038)	0.549(0.657)												
TDS	0.058(0.058)	0.583(0.718)	0.941(2.781)	0.521(0.610)											
TSS	0.005(0.005)	0.424(0.468)	0.973(4.216)	0.540(0.642)	0.966(3.736)										
TS	0.204(0.208)	0.570(0.694)	-0.201(0.205)	-0.117(0.118)	0.049(0.049)	-0.209(0.214)									
T.Aci	0.227(0.233)	-0.175(0.178)	-0.831(1.494)	-0.356(0.381)	-0.734(1.081)	-0.777(1.234)	0.228(0.234)								
T.Alk	0.131(0.132)	0.584(0.719)	0.496(0.571)	0.104(0.105)	0.607(0.764)	0.512(0.596)	0.319(0.337)	-0.361(0.387)							
TH	0.263(0.273)	0.396(0.431)	0.500(0.577)	0.111(0.112)	0.590(0.731)	0.507(0.588)	0.272(0.283)	-0.334(0.354)	0.798(1.324)						
Mn	-0.175(0.178)	0.373(0.402)	0.553(0.664)	0.550(0.659)	0.591(0.733)	0.560(0.676)	0.074(0.074)	-0.485(0.555)	0.308(0.324)	0.114(0.115)					
As	-0.281(0.293)	-0.416(0.457)	0.088(0.088)	0.132(0.133)	0.008(0.008)	0.027(0.027)	-0.074(0.074)	-0.048(0.048)	-0.084(0.084)	0.218(0.223)	0.050(0.050)				
Zn	-0.335(0.356)	0.190(0.194)	-0.284(0.296)	-0.178(0.181)	-0.212(0.217)	-0.273(0.284)	0.256(0.265)	0.374(0.403)	-0.151(0.153)	-0.183(0.186)	-0.081(0.081)	-0.125(0.126)			
Al	0.164(0.166)	0.052(0.052)	0.405(0.443)	0.311(0.327)	0.403(0.440)	0.467(0.528)	-0.283(0.295)	-0.383(0.415)	0.658(0.874)	0.446(0.498)	0.254(0.263)	-0.131(0.132)	-0.333(0.353)		
Fe	-0.020(0.020)	-0.014(0.014)	0.003(0.003)	0.035(0.035)	0.076(0.076)	0.071(0.071)	0.012(0.012)	0.134(0.135)	0.190(0.194)	0.200(0.204)	0.090(0.090)	0.161(0.163)	0.366(0.393)	0.423(0.467)	

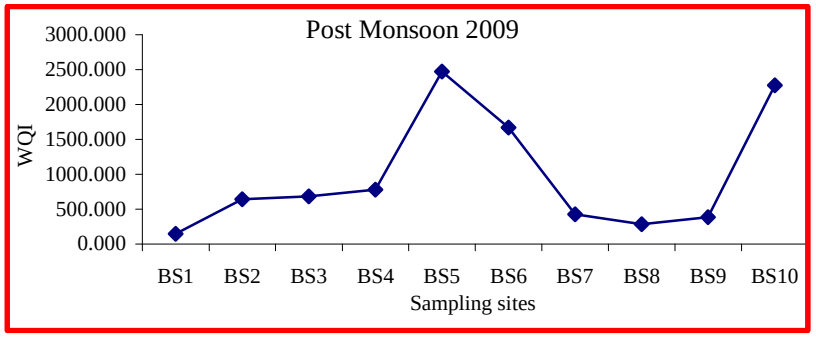

Table No.4			
Post - Monsoon 2009			
Sampling Spots	∑QiWi	∑Wi	WQI = ∑QiWi / ∑Wi
BS1	48198.901	329.653	146.211
BS2	211246.430	329.653	640.814
BS3	225908.084	329.653	685.290
BS4	257457.526	329.653	780.995
BS5	815008.937	329.653	2472.322
BS6	550007.898	329.653	1668.444
BS7	140000.926	329.653	424.691
BS8	94424.630	329.653	286.436
BS9	127698.342	329.653	387.372
BS10	749676.406	329.653	2274.136

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***Correspondence Author: Vaishnav** M.M.

[1]Department of Chemistry, G.B.V. Post Graduate College, Hardibazar, Korba (C.G.) India,