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Assessment of Water Quality Status in Reference to Statistical Parameters in Different Aquifers of Balco Industrial Area, Korba, C.G. INDIA

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Abstract

Nature has provided us all fundamental resources such as air, water and land for growth, development and survival. Air is a mixture of various gases in which nitrogen (78%), oxygen (21%) and rest other gases are main constituents. Water is making hydrosphere in land which account 65% of out body and blood contain 83%. It is chief natural resource. However the safe water become scarce commodity owing to huge blending of contaminated water. We have taken montly as well as seasonal investigation of the water from different aquatic sources in Balco industrial area. 30 Water samples are collected from ten sites (BS1 to BS10) in 2L capacity containers (July 2009 to Sep. 2009) for physical and chemical analysis especially selected heavy metals such as Fe, Al, Zn, Mn and As by recommend procedures. Statistical investigation reveals that mean value for turbidity (SW 156.6 NTU, GW 32.7 NTU), TH (SW 655.3 mg/L), Fe (SW 1.303, GW 2.830 mg/L), Al(SW 2.111 mg/L, GW 0.437 mg/L) were found above the threshold value. Strong +ive relation was calculated for SW and GW between TS vs TDS [SW r(t) = + 0.938(2.706), GW = + 0.977(4.582)]. The high % CV was calculated for Zn 151.8 (GW) and 146.2 (SW). According to results obtained, it is suggested water sources are not suitable for human consumption, without former treatment.

Keywords: Physicochemical parameters, heavy meals, surface and ground water, statistical parameters, WQI, correlation coefficient, Korba, Balco.

Introduction

Water is renewable natural resource of earth and is essential for all living organism for their existence and metabolic processes in the world[1]. In nature 97.2% and 2.8% water is salty and fresh water respectively, in which 20% sources are ground water[2].

Ground water is used for domestic and industrial water supply and irrigation all over the world[3]. There are various ways as water is contaminated as over use of fertilizer in farming[4], explosive population and unplanned urbanization[5], Seepage of effluent bearing water body[6] and industrial discharge without proper treatment[7]. Heavy metals are non-biodegradable and toxic to the living organisms. It enters into environment through combustion of fossil fuel, metallurgical process and agricultural runoff etc[8]. Toxic metals reduce soil fertility and crop yield[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. Topographically, 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 assessment area has been taken 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. 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 monsoon (July –Sep 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

Collection of Water Samples: 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 Figure-1 BS1 to BS10.

Preservation of the Sample: 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.

Analysis of water samples: The method[15,16] used for estimation of various physicochemical parameters are mentioned in the table1(A) while statistical parameters are described in table 1(B).

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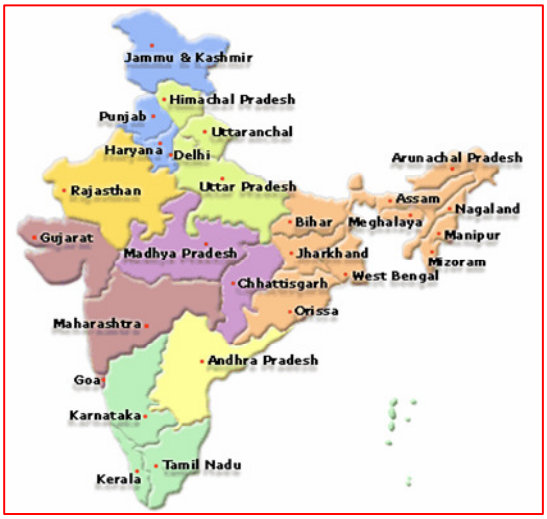

Korba

Chhattisgarh

Study Area

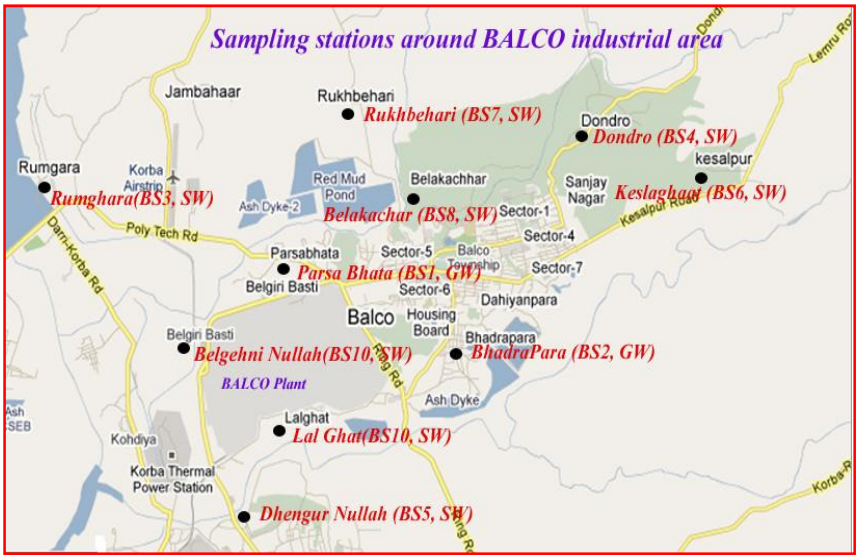

Figure-1
Location Map

Table-1(A)
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 -1(B)
Statistical Parameters for Water Quality Analysis

S. 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

Results and Discussion

The statistical result for various physicochemical parameters was 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 3(A) and 3(B).

pH: In our study the hydrogen ion concentration which measures acid – base equilibrium[17] in terms of pH units. For GW the ranging was obtained from 6.08 to 7.97 and in SW ranged 7.05 to 8.51 indicating the water is slightly alkaline and within the permissible limit given by regulatory body such as BIS[18] and WHO[19] i.e. 6.5 to 8.5.

Electrical conductivity: The electrical conductivity of water is chiefly due to the presence of dissolved inorganic salts. The average and ranging value were noted as 1175.5μS/cm and 474μS/cm to 1861 μS/cm in GW. SW fluctuates between 1574 μS/cm and 2191 μS/cm with mean 1964.3μS/cm. Mean and range data are under the acceptable as per BIS[18] standard.

Turbidity: Turbidity of water is due to the presence of silt, clay, microbes and partially dissolved organic compounds. In our investigation the mean and limiting value for the turbidity in GW and SW was 32.7, 156.6 and 19-60 NTU,

58-211 NTU respectively. The range values were beyond from the standard value on set by BIS[18] and WHO[19] standard.

Total Dissolved Solids (TDS): The total dissolved solids are expressed by the weight of residue left when a water sample has been evaporated to dryness. The mean value for GW and SW was 567.2 and 1106.6 mg/L which vacillate between 257.97-861.66mg/L and 343.99-1427.48 mg/L respectively, which comes under maximum allowable limit prescribed by BIS[18] and WHO[19] standard.

Table 2 (A)
Statistical Value of Physico Chemical and Heavy Metal analysis Ground water

Parameter	Range	Mean	SD	%CV	SE	Minimum		Maximum	
						Spot	Month	Spot	Month
Temperature	20.1-22.6	21.0	0.7	3.4	0.2	BS4	AUG	BS1	JUL
pH	6.08-7.97	7.0	0.7	9.6	0.2	BS2	JUL	BS9	JUL
EC	474-1861	1175.5	492.6	41.9	142.2	BS2	SEP	BS4	JUL
Turbidity	19-60	32.7	14.4	44.1	4.2	BS4	SEP	BS2	SEP
TS	391.479-1061.775	766.0	252.1	32.9	72.8	BS4	SEP	BS1	JUL
TDS	257.97-861.66	567.2	246.2	43.4	71.1	BS2	AUG	BS1	JUL
TSS	103.729-296.871	198.8	54.1	27.2	15.6	BS2	SEP	BS4	AUG
T.Aci	95-234	155.6	48.9	31.4	14.1	BS9	JUL	BS2	JUL
T.Alk	198-641	442.9	165.4	37.4	47.8	BS2	AUG	BS9	JUL
TH	197.3-739	382.2	163.2	42.7	47.1	BS4	SEP	BS9	JUL
Mn	0.05-0.12	0.076	0.026	34.9	0.008	*		BS9	SEP
As	0.001-0.003	0.002	0.001	41.2	0.000	*		BS2	AUG
Zn	0.001-1.41	0.383	0.581	151.8	0.168	*		BS9	JUL
Al	0.09-1.84	0.437	0.559	128.1	0.161	BS4	SEP	BS2	JUL
Fe	0.3-10	2.380	2.917	122.6	0.842	BS4	AUG	BS9	AUG

* more than 1 observation

Table 2 (B)
Statistical Value of Physico Chemical and Heavy Metal analysis Surface water

Parameter	Range	Mean	SD	% CV	SE	Minimum		Maximum	
						Spot	Month	Spot	Month
Temperature	27.8-32.15	29.7	1.0	3.4	0.2	BS8	SEP	BS3	JUL
pH	7.05-8.51	7.8	0.4	5.7	0.1	BS3	SEP	BS5	JUL
EC	1574-2191	1964.3	183.0	9.3	43.1	BS7	SEP	BS3	SEP
Turbidity	58-211	156.6	48.2	30.8	11.4	BS7	SEP	BS10	AUG
TS	714.2576-1864.324	1429.4	366.4	25.6	86.4	BS7	SEP	BS5	JUL
TDS	343.99-1427.48	1106.6	356.1	32.2	83.9	BS7	AUG	BS10	JUL
TSS	100.154-514.984	322.7	127.9	39.6	30.1	BS6	SEP	BS5	JUL
T.Aci	81-223	131.6	41.4	31.5	9.8	BS3	JUL	BS7	AUG
T.Alk	313-623	468.6	91.3	19.5	21.5	BS3	SEP	BS5	JUL
TH	439-871.5	655.3	147.6	22.5	34.8	BS6	SEP	BS8	JUL
Mn	0.03-0.3	0.132	0.076	57.4	0.018	BS3	AUG	BS8	AUG
As	0.001-0.03	0.007	0.009	122.1	0.002	*		BS3	SEP
Zn	0.001-0.1	0.024	0.035	146.2	0.008	*		3.000	
Al	0.19-5	1.211	1.185	97.8	0.279	BS8	SEP	BS5	JUL
Fe	0.42-4.95	1.303	1.084	83.2	0.256	BS10	JUL	BS7	SEP

* more than 1 observation

Total Hardness: This water quality is due to the presence of calcium and magnesium salt. The average value for GW and SW were noted 382.2 and 655.3 mg/l with extremes 197.3-739 and 439-871.5 respectively. The value was near about desirable limit as per BIS[18] and WHO[19] standard.

Total Alkalinity: The cause of alkalinity in water is due to the presence of various basic. The mean and range values were recorded as 442.9mg/L, 468.6mg/L and 198 – 641mg/L, 313 – 623 mg/L for GW and SW respectively. These values are under upper limit prescribed by BIS[12] and WHO[13] standard.

Metallic Elements: The main sources of heavy metals in water are mixing of dangerous chemicals and industrial effluents. We have selected only five metallic elements Mn, As, Zn, Al and Fe to assess in different water source of Balco area. Mn imparts objectionable and tenacious stain to laundry and plumping fixtures. In our investigation the mean and ranges value were observed 0.076, 0.132 mg/L and 0.05-0.12, 0.03-0.3mg/L for GW, SW respectively.

The maximum value exceeds the standard value stipulated by the BIS[18] and WHO[19] standard. Arsenosis is main malady due to the excess ingestion of as through potable water. The mean value of as were reported as 0.002 mg/L, 0.007 mg/l for GW and SW with extremes 0.001-0.003mg/L and 0.001-0.03mg/L respectively. It is main constituent of animal enzyme, Low intake of Zn results in anemia[20], immaturation and growth retardation. In our analysis, the statistics 0.383 mg/L, 0.024 mg/L and 0.001-1.41 mg/L, 0.001-0.1 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 so Zn deficiency could prevail in people of the area. Al is the third most abundant element in the earth crust occurring in mineral rocks and clays. In our study the mean value was 0.437mg/L, 1.211mg/L for GW, SW; while fluctuates 0.09-1.84mg/L, 0.19-5 mg/L respectively. The maximum value is several folds greater than maximum permissible limit prescribed by BIS[12] and WHO[13]. 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 2.380 mg/L, 1.303 mg/L and 0.3 - 10 mg/L, 0.42 – 4.95mg/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 coefficient (r) among various water quality parameters for ground water were observed. 14 were found to have significant at 5% level (r > 0.649). Strong positive correlations r(t) are shown by pH vs EC [0.673(0.910)], vs TSS[0.696(0.969)], vs T. Alk. [0.945(2.889)], vs Zn[0.685(0.940)]; EC vs TSS[0.720(1.038)] and T. Alk. [0.674(0.912)]; Turbidity vs T. Aci. [0.804(1.352)]; TS vs TDS [0.977(4.582)] and T. alk. [0.721(1.041)]; T. A ci. Vs Al [0.667(0.895)], T. Alk. vs As [0.733(1.078)]; TH vs Zn [0.724(1.050)] and Fe [0.722(1.044)] and Zn vs Fe [0.854(1.641)]. In case of surface water 09 out of 105 correlation were found to have significant at 5 % level (r = > 0.649). High level positive correlations are shown by pH vs TS[0.810(1.381)], TSS[0.655(0.867)], T. Alk.[0.756(1.155)]; EC vs Turbidity[0.744(1.113)], TS[0.748(1.127)], TDS [0.822(1.443)]; Turbidity vs TS[0.785(1.267)] and TDS[0.906(2.140)]; TS vs TDS [0.938(2.706)]. t – values were used for the testing of these correlations.

% CV is unavoidable statistical parameters, by which experimental results of physicochemical water quality monitoring can be interpreted. In our investigation, the %CV was found higher for Zn 151.8 while 146.2 for GW and SW orderly indicating high variation among various metallic elements in different sampling location. Minimum values of %CV was noted 3.4 for temperature in both sources of water SW and GW concluded too much minute variation in different selected sited for this parameter.

In our investigation WQI values were obtained in wide ranges from minimal 271.311 at the site no. BS4 to maxima 4946.152 at site no. BS5, shown in Graph. 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 industrial and domestic effluent.

Conclusions

On the basis of experimental and mathematical results, it may be concluded that the surface water is more polluted than the ground water owing to direct intrusion of domestic, agricultural and most prominent sources of pollutants “Balco industrial effluents”. Although physicochemical quality and metallic elements were observed in high concentration but Fe was detected at alarming level in SW and GW: 4.95 mg/L (BS7 Sep), 10.0 mg/L (BS9 Aug). Strong positive significant correlation was showed by TS vs TDS (r = +0.997 and +0.938) in GW and SW. Point BS5 had high value of WQI (4946.153) indicated high amount of organic and inorganic contamination. Thus, re-concluded, all selected water sources are not safe for human utilization, proper purification is indispensable.

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