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Physico – Chemical Characteristics and Correlation Studies on GW and SW of Balco Industrial Area of Korba, District (C.G.), India.

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ABSTRACT

This paper presents the analytical results of different water quality and selected metallic elements of GW and SW sources of Balco industrial area in Korba district (C.G.) India. For this purpose we have selected ten water sampling stations, which are significant for high degree pollution view. The collected water samples were analyzed by the standards methods and compared with the standard value for drinking water stipulated by WHO (2008) and BIS (1991). The results for SW pH(9.970), EC (2521 S cm-1), Turb.(151 NTU), TDS (2250 mg L-1), Total Alkalinity(863 mg L-1) , TH(989 mg L-1),Al(6.700 mg L-1) and Fe(7.510 mg L-1) up to obtained. These concentrations are higher than GW as well as standard value. The amount of iron was detected 21.490 mg L-1,in ground water sources. Strong positive correlation values were established between Mn vs TH (0.910; 10.764), Zn vs TH (0.875; 8.859), TDS vs TS (0.899; 10.046). WQI calculated and ranges were obtained from 1100.598 (BS1) to 6045.697 (BS5), just far beyond the standard ranges (0 to 50). These results indicate the water sources of study area are highly polluted by the undesired foreign materials.

KEYWORDS : Statistical Correlation, Water, Heavy Metal, Balco, Korba

Introduction:

Water is used for variety of purpose like irrigations, industrial, domestic, drinking etc. Apart from the requirements of man; it is key factor in maintaining the ecological balance. Water is the basic elements of all kinds of life, which exists on the surface and underground of earth. It is available in abundance, 79% area of earth planet is occupied by water, yet it remains limited for man. The only one percentage of earth water is safe for human being. The water sources are categorized as surface: lakes, rivers, streams, seas, ponds and ground water. These water sources are further classified into lentic and lotic water (Padmarathy et al. 2003) . The continuously flow of water are called lotic water, while any stagnant water body is called lentic water. The lotic and lentic water differ in their physical – chemical and biological parameters. The chemistry of water is influenced by the inputs of materials containing minerals, toxic metals, fertilizers, pesticides and runoff water from the agricultural fields which also causes the water pollution. Rapid growth of industrialization has affected not only surface water but also GW quality (Mahajan et al., 2005).

Heavy metals like lead, copper, mercury, cadmium, iron, zinc, tin etc. enter in the water through many sources like industries, mines, vehicle exhaust and weathering of rocks and soils. These metals reach man and animals though food chain as resulting damage any organ of the body like kidney, heart, liver etc. when children consumes, they can became mentally retarded.

About the study area:

Formerly the study area; Balco was incorporated with the public sector in the year 1965. Now it disinvested 5% equity in the year of 2001, in favor of Sterlite Industries (P) Ltd. The study Area: Balco plant and its adjoining area are located 8 Km away in north east direction from Korba District headquarters with geographical situation 22° 01′ To 23° 01′ N Latitude and 82° 08′ To 83° 09′ E Longitude with position 304.8m above sea level (Anonymous, 2013). Its geological structure belongs to Gondwana group of Talchir (Guha et al., 2009)formation containing sand stone, silt stone, shale, coal and thin bed of fire clay. The balco study area comes under hot temperate climate zone with low and high temp. 9.85°C and 35.58°C respectively. The average annually precipitation is 1507.6 mm (Anonymous, 2013). The raw materials for the production of refined aluminum are; bauxite procured from mainpat and Bodi Dalai (Kabirdham) mines area. Owing to disorderly management of raw materials, waste product and continuously discharging the effluents, the all kinds of water sources of study fields become polluted by undesired chemicals. So we have undertaken extensively analytical study of different aquatic system in and around of balco industrial area. In this paper we have made an attempt the six month; Jan to Jun 2010, analytical results with interpretation by statistical quality viz: correlation and WQI.

Materials and Method:

Selection of sampling stations:

Ten sampling spots were chosen at the period of analytical monitoring, on the basis of degree of pollution. The sampling locations are designed as BS1 to BS10.(show in Fig)

Collection of Sample:

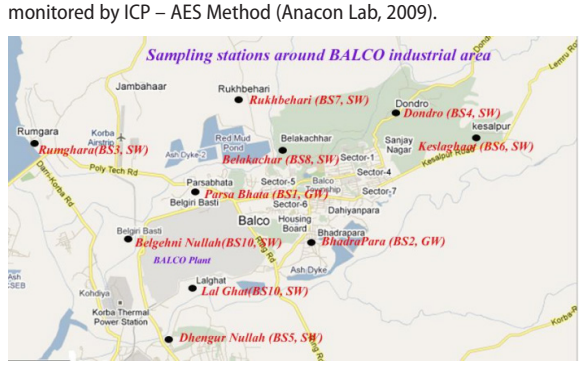
Water samples were collected in pre cleaned glass and polythene bottle separately of one litre capacity at fixed times viz. 1st date of every month between 9.00 am to 4.00 pm.

Preservation Technique:

Collected water samples were preserved by keeping in refrigerator at 4°C and adding 2 – 3 drops of conc. HNO_3 to maintain the pH below 2.

Analytical Procedure:

The physico – chemical features like Temp., pH, EC, Turbidity, TDS, TS, Total Hardness, Total Alkalinity were analyzed as per the standard methods (APHA, 1998, Manivaskam, 2002 and Trivedi and Goel, 1986). The toxic and trace metallic elements viz. Fe, Al, Mn, As and Zn were monitored by ICP – AES Method (Anacon Lab, 2009).



Results and Discussion:

The analytical results of different physic – chemical are given in Table : 1 as statistical form.

Table 1A Statistical Parameters SW Jan - Jun 2010

	Min	Max	Range	Mean	SD	%CV	SE
Temperature	BS3 JAN	BS10 JUN	17.500-37.400	29.219	6.748	23.095	1.157
pH	BS7 FEB	BS3 MAY	7.590-9.970	8.423	0.586	6.957	0.1
EC	BS7 JAN	BS10 MAY	1,561.000-2,521.000	2,171.61	268.591	12.368	46.063
Turbidity	BS7 JUN	BS10 MAR	21.000-151.000	78.583	38.885	49.483	6.669
TS	BS7 JAN	BS10 MAY	781.810-2,659.915	2,017.68	506.008	25.079	86.78
TDS	BS7 JAN	BS10 JUN	631.310-2,250.780	1,694.29	456.863	26.965	78.351
TSS	BS5 JAN	BS6 JUN	109.920-580.298	323.387	124.462	38.487	21.345
T.Aci	BS5 MAR	BS7 MAY	71.000-244.000	131.194	43.928	33.483	7.534
T.Alk	BS7 FEB	BS5 JUN	271.000-863.000	644.75	179.963	27.912	30.863
TH	BS6 JAN	BS5 JUN	391.500-989.700	646.269	204.305	31.613	35.038
Mn	BS3 MAR. JUN	BS6 JUN	0.034-0.671	0.223	0.166	74.439	0.028
As	22 OBS	BS3 MAR	0.001-0.020	0.004	0.006	150	0.001
Zn	36 OBS	-	0.100-0.100	0.1	0	0	0
Al	BS8 JAN	BS6 APR	0.270-6.700	2.098	1.681	80.124	0.288
Fe	BS3 JAN	BS8 JUN	0.320-7.510	2.089	1.678	80.326	0.288

Table 1B Statistical Parameters GW Jan - jun 2010

	Min	Max	Range	Mean	SD	%CV	SE
Temperature	BS4 JAN	BS1 JUN	18.700-23.700	21.404	1.498	6.999	0.319
pH	BS2 FEB	BS9 JAN	6.410-7.860	7.148	0.418	5.848	0.089
EC	BS2 JAN	BS4 MAY	659.000-1,951.000	1,253.42	452.443	36.097	96.461
Turbidity	BS9 FEB	BS2 FEB	11.000-31.000	18.125	4.919	27.139	1.049
TS	BS2 JAN	BS9 MAY	531.180-1,659.412	965.939	270.989	28.054	57.775
TDS	BS2 JAN	BS9 MAY	431.310-1,211.560	825.833	178.544	21.62	38.066
TSS	BS4 JAN	BS9 JUN	29.224-589.642	140.106	135.411	96.649	28.87
T.Aci	BS9 MAY	BS2 MAY	61.000-238.000	138.042	52.284	37.875	11.147
T.Alk	BS2 JAN	BS9 MAR	159.000-675.000	409	153.015	37.412	32.623
TH	BS4 MAR	BS9 APR	144.500-766.700	330.033	199.477	60.442	42.529
Mn	BS2 JAN	BS9 MAY	0.043-0.355	0.139	0.097	69.784	0.021
As	23 OBS	BS2 JAN	0.001-0.011	0.001	0.002	200	0
Zn	7 OBS	BS9 MAY	0.010-3.771	0.66	1.076	163.03	0.229
Al	3 OBS	BS4 MAR	0.010-4.570	1.164	1.257	107.99	0.268
Fe	BS1 JUN	BS9 JUN	0.360-21.490	3.112	4.347	139.685	0.927

Physical Parameters :

pH is the negative logarithm of the active hydrogen ion concentration, pH = - log [H^+](Anonymous, 2007), which is quick tool for determining the acidic and alkaline nature of water. The standard value of pH for drinking water is 6.5 to 8.05 as per set by WHO (WHO, 2008) and BIS(BIS, 2004). In study tenure the ranges values for pH were noted 6.41 (BS2, Feb 2010) to 7.86 (BS9 Jan 2010) for GW while for SW 7.590 (BS7 Feb 2010) to 9.970 (BS3 Jan 2010). 20% (12) observations were found beyond the acceptable ranges and 60% (48) observations were found under the acceptable ranges. Electrical conductance is the ability of substance to conduct the electrical current. Inorganic and organic salts are dissolved in water which carries the EC (Anonymous, 2009). Higher the ionizable solid, greater will be the EC(Anonymous, 2003). In investigation period the ranges values for GW found 659.00 µ S cm^{-1} (BS2, Jan 2010) to 1951.0 µ S cm^{-1} (BS4 May 2010) but in case of SW the EC was recorded as min 1561.00 µ S cm^{-1} (BS7 May 2010) to 2521.00 µ S cm^{-1} (BS10 May 2010). The standard values of EC for drinking water are 750 – 2250 µ S cm^{-1} as per BIS (1991). 26.66 % (16) observations were crossed the upper limit and 73.33% (44) samples showed under acceptable limit. These results were also found in Bhopal lake (Jinwal and Dixit, 2008). Turbidity is the cloudiness or haziness of the fluid caused by individual particles such as clay, silt, finely divided organic, inorganic matter and plankton(Sharma et al., 2008). In the analysis period, the min. conc. of turb. was found 11.08 NTU (BS9 Feb 2010) and max. conc. 31.00 NTU (BS2 Feb 2010) for GW, whereas for SW the min. to max. conc. were observed 21.00 NTU (BS7 July 2010) to 151.00 NTU (BS10 Mar 2010). The standard values for turbidity is 5 to 25 NTU as set be WHO (2008) and BIS (2004). 60% (36) samples showed higher than upper limit (25 NTU) and 40% (25) samples contained fewer amounts of turbidity ingredients. This max value of turbidity 151 NTU was reported by Similarly, results had been reported in Karnataka (Narayana et al., 2008) and in Warangal AP,(Reddy et al., 2009) recorded the highest turbidity in monsoon. Total dissolved solids reflux the dissolved inorganic salts of light and heavy metallic elements along with small amount of organic matter present in water which can influence the taste (Bhagi and Chatwal, 2005) of water as well as palatability (Anonymous, 2001). At the period of testing, the ranges values for TDS were fluctuated between 431.310 mg L^{-1} (BS2 Jan2010) to 1211.560 mg L^{-1} (BS9 May 2010) for GW and 631.310 mg L^{-1} (BS7 Jan 2010) to 2250.780 mg L^{-1} (BS10 Jun 2010) for surface water. The max. conc. was higher than the upper limit; 1500 mg L^{-1} as set by WHO (2008) and BIS (2004). 46.66 % (28) samples contain higher conc. of TDS ingredients while only 53.33 % (32) samples showed upper acceptable ranges (500 mg L^{-1} to 1500 mg L^{-1}).

Chemical Parameters:

Total alkalinity of water is measure of the ability to absorb active hydrogen ion in water without change in pH (Singh and Kumar, 2004). The chief ingredients are At the time of monitoring, the observed values were found as ranges between 159.00 mg L^{-1} (BS2 Jan 2010) to 675.00 mg L^{-1} (BS9 Mar 2010) for GW sources while for SW sources these ranges rates were noted from 271.00 mg L^{-1} (BS7 Feb 2010) to 863.00 mg L^{-1} (BS5 Jun 2010). In both sources of water, the higher values of Total alkalinity were crossed the excessive limit ranges; 200 mg L^{-1} to 600 mg L^{-1} as set by WHO (2008) and BIS (1991). 45 % (27) observations were found above the upper limit where as the 55% (33) samples maintained the total alkalinity. The observed high amount of total alkalinity in surface water was similar to previous author in Aurangabad (Shinde, et al., 2011). Total hardness of water is characterized by the non formation of suds with soap, revealed that enormous amount of soap and detergent will be consumed. The chief chemical constituents of hard water are polyvalent ion viz. Al^{3+}, Fe^{2+}, Mn^{2+}, Cr^{2+} and Zn^{2+} heavy metals and divalent viz. Ca^{2+} and Mg^{2+} light metallic elements [23,24]. The total hardness was found at the period of analytical study cross the excessive permissible limit. Such type of observations were also recorded in coimbatore district (Jothivenkatachalam K. et al., 2010). Only 30% (15) samples showed more than upper limit but 70% (42) samples were not respond high amount of total hardness.

Metallic Elements:

In this project, our focus was to analyze some selective hazardous metallic elements viz. Al, Fe, Zn, As and Mn. Aluminum is the most occurring metallic elements and constitute above 8% of the earth's crust. In water it occurs in dissolved form such as silicates, oxides and hydroxides (Anonymous, 2003). In observation periods its range values spread turns 0.010 mg L^{-1} (30 obs) to 4.5 mg L^{-1} (BS4 Mar 2010). for GW samples, but in SW these ranges data were covered from 0.270 mg L^{-1} (BS8 Jan 2010) to 6.700 mg L^{-1} (BS6 Apr 2010). These statistical showed the SW sources are more contaminated by the aluminum compounds and cross the upper limit; 1.00 mg L^{-1} prescribed by ISI. Such type observations were also by the earlier reporter. Out of 60 samples, 75% (45) observations showed high amount of aluminum concentration. Iron is found as the oxide in the nature. The layer of iron oxide of soil can be affecting the quality of GW and SW. The result of analysis of iron was found as ranges from 0.360 mg L^{-1} (BS1 Jun 2010) to 21.490 mg L^{-1} (BS9 Jun 2010) for GW. However in surface water the ranges from 0.320 mg L^{-1} (BS3 Jan 2010) to 7.510 mg L^{-1} (BS8 Jun 2010). Thus these data indicated the GW sources are more polluted by the iron compounds than SW sources. These mean values are didn't maintained the desirable ranges; 0.3 mg L^{-1} to 1.00 mg L^{-1} . The 61.66% (37) samples exhibited high amount of iron concentration i.e. > 1.00 mg L^{-1} but only 38.33% (23) samples contents maintained the iron concentrations.

Correlation coefficient:

The relations were established between two variables for GW and SW separately. For GW 105 relations were calculated out in which 55 for positive while 55 for negative side .At 5% level (0.553 to 0.684) ten relations, at 1% level (0.684 to 0.784) seven relations whereas at 0.1% level (0.780 to 1.00) nine relations were find out. The high degree r values calculated out between TDS and TS (0.899:10.046), TSS and TS (0.816:6.918), Mn and TS (0.843:7.688)Zn and TSS (0.801:6.563) Mn and TH(0.910:10.764) Zn and TH(0.875:8.859) Zn and Mn (0.829:7.271). These relations are indicated that the chemical constituents of TDS and Ts are identical , the manganese compounds are imparting in total solids and total hardness and Zinc compounds are also contribute in total hardness and TSS . The positive relations established between zinc and manganese is exhibited the sources of these two metallic elements are same. Such types relations were also reported by earlier workers in Turkey(Tuzen and Soylak, 2006). Mild negative relation was obtained between total alkalinity and total acidity with -0.732(5.262). For SW, 91 relations were recorded between different pairs of water quality, in which 70 +ve and 21 –ve relations. For positive relations at 5% level (0.553 to .683) twelve r values at 1% level (0.684 to 0.780) one relation and at0.1 level (0.780to1) three relations were obtained .The high degree +ve relations were formed between TS Vs EC (0.802:7.186), TDS Vs TS (0.972:23.995) and T. alk.Vs Temp.(0.869:10.254).These high degree relations between total solids and electrical conductivity are similar and that electric current is carried by the ions are also imparting in total solids. The chemical ingredient of TSS and TS are also similar. These relations are also seen by the previous worker in Indore validated the undertaken work (Mahajan S. V. et al., 2005). Mild degrees of negative relations were also obtained between total acidity and TDS with r value -0.748(6.565).

Table 3B Correlation matrix SW Jan - jun 2010

	Temperature	pH	EC	Turbidity	TS	TDS
Temperature						
pH	0.473(3.128)					
EC	0.588(4.242)	0.572(4.066)				
Turbidity	-0.079(0.464)	0.529(3.634)	0.545(3.787)			
TS	0.470(3.101)	0.624(4.653)	0.802(7.816)	0.514(3.496)		
TDS	0.427(2.750)	0.579(4.139)	0.778(7.218)	0.527(3.617)	0.972(23.995)	

	Fe	Al	Zn	As	Mn	TH	T.Alk	T.Aci	TSS
Temperature	0.384(2.427)	0.316(1.939)	0.000(0.000)	0.094(0.549)	0.096(0.560)	0.550(3.837)	0.869(10.254)	-0.049(0.287)	0.343(2.131)
pH	0.049(0.287)	0.435(2.817)	0.000(0.000)	0.446(2.904)	-0.119(0.699)	0.638(4.828)	0.574(4.091)	-0.461(3.026)	0.411(2.630)
EC	0.221(1.324)	0.043(0.249)	0.000(0.000)	0.182(1.080)	-0.231(1.386)	0.535(3.690)	0.577(4.122)	-0.567(4.014)	0.403(2.569)
Turbidity	-0.231(1.382)	0.137(0.807)	0.000(0.000)	0.249(1.501)	-0.399(2.534)	0.464(3.052)	0.050(0.294)	-0.618(4.587)	0.155(0.918)
TS	0.226(1.355)	0.256(1.545)	0.000(0.000)	0.221(1.324)	-0.044(0.259)	0.413(2.645)	0.650(4.983)	-0.681(5.426)	0.499(3.355)
TDS	0.180(1.065)	0.237(1.421)	0.000(0.000)	0.300(1.835)	-0.113(0.665)	0.446(2.902)	0.638(4.829)	-0.748(6.565)	0.280(1.700)
TSS	0.261(1.575)	0.172(1.018)	0.000(0.000)	-0.201(1.198)	0.236(1.415)	0.044(0.258)	0.300(1.834)	-0.025(0.147)	
T.Aci	0.141(0.831)	0.038(0.223)	0.000(0.000)	-0.446(2.906)	0.272(1.649)	-0.454(2.972)	-0.230(1.377)		
T.Alk	0.435(2.817)	0.538(3.722)	0.000(0.000)	0.276(1.674)	0.113(0.662)	0.551(3.849)			
TH	0.271(1.641)	0.259(1.564)	0.000(0.000)	0.321(1.979)	-0.095(0.556)				
Mn	0.432(2.794)	0.108(0.635)	0.000(0.000)	-0.235(1.413)					
As	-0.138(0.815)	0.213(1.272)	0.000(0.000)						
Zn	0.000(0.000)	0.000(0.000)							
Al	0.302(1.844)								
Fe									

Table 3A Correlation matrix GW Jan - jun 2010

TS	Turbidity	EC	pH	Temp.
0.457(2.518)	-0.238(1.199)	-0.004(0.018)	-0.069(0.339)	
0.571(3.412)	-0.514(2.934)	0.479(2.672)		
0.048(0.237)	-0.408(2.187)			
-0.381(2.021)				

	Fe	Al	Zn	As	Mn	TH	T.Alk	T.Aci	TSS	TDS
Temp	0.045(0.222)	0.398(2.128)	0.052(0.253)	-0.328(1.698)	0.263(1.336)	0.145(0.717)	0.313(1.613)	0.005(0.022)	0.183(0.914)	0.555(3.266)
pH	0.272(1.387)	-0.469(2.603)	0.517(2.958)	-0.325(1.685)	0.533(3.083)	0.380(2.015)	0.708(4.911)	-0.731(5.244)	0.354(1.852)	0.599(3.667)
EC	-0.270(1.376)	-0.102(0.501)	-0.178(0.888)	-0.280(1.428)	-0.197(0.982)	-0.406(2.176)	0.445(2.432)	-0.548(3.209)	-0.039(0.189)	0.103(0.505)
Turb.	-0.050(0.244)	0.234(1.177)	-0.253(1.281)	0.471(2.615)	-0.209(1.047)	-0.068(0.332)	-0.304(1.566)	0.395(2.107)	-0.055(0.271)	-0.537(3.119)
TS	0.617(3.844)	-0.183(0.914)	0.790(6.305)	-0.342(1.781)	0.843(7.688)	0.768(5.877)	0.783(6.158)	-0.616(3.828)	0.816(6.918)	0.899(10.046)
TDS	0.350(1.828)	-0.249(1.261)	0.591(3.587)	-0.471(2.613)	0.769(5.900)	0.620(3.873)	0.725(5.149)	-0.587(3.553)	0.480(2.682)	
TSS	0.774(5.995)	-0.038(0.188)	0.801(6.563)	-0.063(0.311)	0.673(4.461)	0.720(5.077)	0.611(3.779)	-0.458(2.525)		
T.Aci	-0.235(1.186)	0.458(2.521)	-0.377(1.996)	0.142(0.705)	-0.476(2.654)	-0.290(1.483)	-0.732(5.262)			
T.Alk	0.373(1.972)	-0.073(0.358)	0.572(3.414)	-0.348(1.819)	0.695(4.740)	0.571(3.412)				
TH	0.673(4.461)	-0.144(0.715)	0.875(8.859)	-0.065(0.320)	0.910(10.764)					
Mn	0.551(3.234)	-0.194(0.970)	0.829(7.271)	-0.212(1.064)						
As	-0.104(0.512)	-0.140(0.691)	-0.129(0.636)							
Zn	0.619(3.860)	-0.198(0.991)								
Al	-0.098(0.483)									
Fe										

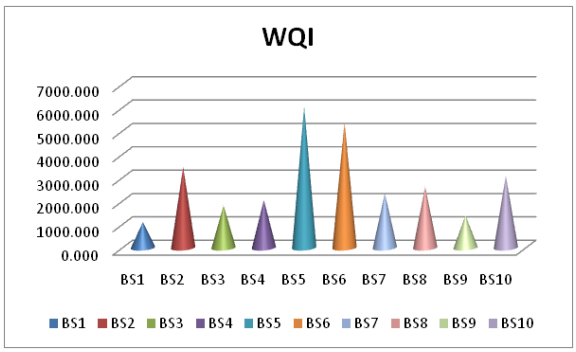
Water Quality Index:

The concept of water quality index was first proposed by Horten (Horton, 1965), which is an effective tool to assess the states of water sources. In investigation period water quality index was calculated on the basis of selective water quality parameters for all selected ten sampling sites.

The obtained results were ranges between low 1100.598 (BS1) to high 6045.697 (BS5)These values were just beyond from the standard values: 0 to 50, These results are indicated the water quality of all water quality of all water sources are poor and contaminated by the foreign undesirable chemicals and made unfit the water sources for various purpose.

Jan - Jun WQI Year 2010

Sampling Spots	∑QiWi	∑Wi	WQI = ∑QiWi / ∑Wi
BS1	362815.783	329.653	1100.598
BS2	1139583.514	329.653	3456.915
BS3	595502.976	329.653	1806.452
BS4	675004.207	329.653	2047.619
BS5	1992983.680	329.653	6045.697
BS6	1766161.170	329.653	5357.633
BS7	768874.561	329.653	2332.373
BS8	864143.340	329.653	2621.370
BS9	456021.600	329.653	1383.337
BS10	1014442.498	329.653	3077.301



Conclusion:

These studies show that GW and SW of balco industrial area of Korba district (CG) India was high degree polluted in context of water quality pH, EC, TDS, total alkalinity, total hardness, Fe and Al parameters. These parameters were recorded in excess amount than upper limit. The SW sources are more received these contaminates than GW sources, so the SW water sources are more needed for purification before using. Strong positive correlations were mathematically calculated between TDS and TS (0.899), Mn and TH (0.910), Zn and TH (0.875), Zn and Mn (0.829) for SW and GW. WQI obtained (1100.598 to6045.697) far beyond from standard ranges, which concluded that the water sources are not fit for any kind of purpose. We have suggested to Balco managements and public health departments of state governments, some simple indigenous technique may apply for purification of water..

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