International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 5 Issue 02, February-2016

Evaluation of Water Quality Pollution Indices for part of Bokaro District, Jharkhand

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***Abstract* - Bokaro is a hub of mining, industries, wholesale trade and commerce. Due to rapid industrialization and mining activity many environmental problems like air pollution, subsidence, damage to the aquifer, accelerated soil erosion and destruction of soil structure are rising. Therefore, degrading both the ground water and surface water quality, on which most of the population is dependent for drinking and other domestic purpose. 20 groundwater samples were collected from different locations in Bokaro district, Jharkhand. The dug-wells samples were analysed for various physiochemical parameters and 6 heavy metals including Copper, Iron, Manganese, Lead, Cadmium and Zinc. The contamination levels of 20 locations were evaluated using Contamination Index (C_d) and Heavy Metal Pollution Index (HPI). The result shows that the major heavy metal pollutants exceeding Bureau of Indian Standards (BIS) permissible limits are Copper, Manganese and Iron at various locations. The study recommends proper treatment and maintenance for the affected sites.**

Keywords - Heavy Metal Pollution Index (HPI), Contamination Index (C_d), Heavy Metal, ground water, Bokaro.

I. INTRODUCTION

Water is available throughout the globe and it is a good solvent, which makes it highly vulnerable to pollution. Many a times, it is difficult to provide water of desired quantity and quality at a desired place. At times, enough water may be available but the quality may be so poor that it is of no use without treatment. Groundwater is a widely present natural source for irrigation, drinking, and other purposes of water requirements in many parts of India. More than 90 % of rural and nearly 30% of urban population depend on it for drinking water (NRSA 2008). Unfortunately, excessive use and continuous mismanagement of this vital resource led to clean water scarcity and ecosystem degradation (Tsakiris 2004; Jha et al., 2007; Aggarwal et al.,2009b; Rodell et al., 2009; Chawla et al., 2010). Heavy metals such as Zn, Cu, Pb, Cd, Ni, are present in these water may pose several threats to ecosystem safety and human health such as Kidney damage, Cancer, Nervous system degradation, etc. (Lashun et al., 2008; Vasudevan et al.,2011). Thus the comparative assessment, investigation and management of water quality resource is important. And in order to do so, it is necessary to evaluate the degrees of heavy metals contaminations to analyse present scenario and to take necessary action if required. However, the interpretation of data sets of several metals is complicated (Nasr et al., 2013). For the comparative purpose simplifying multivariate data to generate & a single value may be used (Miyai et al., 1985; Nimic & Moore, 1991). Several other methods such as fuzzy mathematics, membership degrees, factor analysis, gray modelling and hierarchy process are there for evaluation of water quality. Over the past four decades, several authors have developed a number of water quality indices (WQIs), employing various mathematical and statistical methods. Some of these methods have been implemented by water management and environmental agencies and are aiding decision-makers in water resources management, public health and ecosystem protection. One of the major advantage of WQI is that it incorporates data from multiple water quality parameters into a mathematical equation that rates the health of water quality with number (Yogendra, K and Puttaiah, 2008).

II. DESCRIPTION OF STUDY AREA

Bokaro district of the Jharkhand is one of the most industrialized belt in India. It was established in 1991 by carving out one subdivision consisting of two blocks from Dhanbad District and six blocks from Giridih District. Bokaro Steel City is the district headquarters. Bokaro is famous for its Steel Plant which is the biggest in Asia. It is one of the highly industrialized coal belt districts in Jharkhand. Bokaro district is bounded by Giridih in the north, purulia (West Bengal) in the South, Dhnabad in the East and Hazaribagh in the West.

The district is spreaded over 2861 sq. km lying between latitude $23^0$24’27” E to $23^0$57’24” E and Longitude $85^0$34’30” N to $86^0$29’10” N. The district headquarters is at Chas. The district comprises of two sub-divisions i.e. Chas and Bermo with eight blocks namely Chas, Gomia, Nawadih, Bermo, Peterwar, Kasmar, Jaridih and Chandan – kiyari. Geologically the Bokaro district is a part of Chhotanagpur Plateau. It is highly undulating and hilly all over the district. The regional slope of the district is towards east and controlled the alignment of the tributaries of Damodar River. Damodar Basin is the main basin of the district. Groundwater in the district is mainly replenished by the atmospheric precipitation. Influent seepages from canal, streams and other surface water bodies, also to contribute to the groundwater in the district. The hydrogeological condition of the district is very complicated due to vide variability of geology, topography, drainage and mining activity. The district also a mining belt of Parbatpur blocks in its South-East direction.

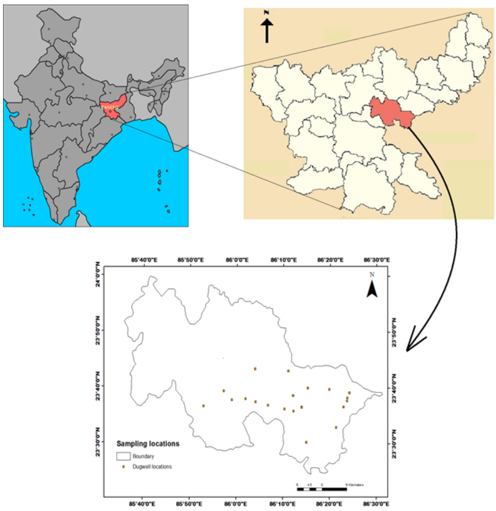

Fig. 1: Study Area / Sampling Locations in Bokaro District (DW)

II. MATERIAL AND METHODS

A. Contamination index(C_d)

C_d summarises the combined effects of several quality parameters considered harmful to household water. The contamination index is calculated from equation below,

$$C_d = \sum_{i=1}^{n} Cfi$$

Where;

$C_{fi} = (C_{Ai}/C_{Ni}) - 1$

C_{fi}= contamination factor for the i-th component

C_{Ai}= analytical value for the i-th component

C_{Ni}= upper permissible concentration of the i-th component. (N denotes the 'normative value')

The sub-index (Qi) of the parameter is calculated by

$$Q_i = \sum_{i=1}^{n} \frac{\{M_i(-)I_i\}}{(S_i - I_i)} \times 100,$$

Where, Mi = monitored value of heavy metal of ith parameter,

Ii = ideal value of the ith parameter

Si = standard value of the ith parameter.

The sign (−) indicates numerical difference of the two values, ignoring the algebraic sign. The critical pollution index of HPI value for drinking water as given by Prasad and Bose (2001) is 100.

IV. RESULTS AND DISCUSSIONS

The evaluation of the eight heavy metals Fe, Mn, Cu, Zn, Cd, Ni, Pb, Hg and other physical parameters from 20 locations (GW1-GW20) were calculated and analysed (Table I & II). Turbidity, Alkalinity, Total Hardness at several locations were found to be exceeding desirable limits.

Contamination index summarized the combinational effects of several quality parameters, that may have harmful consequences to human health/the environment. The value scale for contamination index consists of 3 ranges; Cd< 1 (low contamination), 1 < Cd < 3 (medium contamination) and Cd > 3 (high contamination).

B. Heavy metal pollution index (HPI)

The HPI represent the total quality of water with respect to heavy metals. The HPI is based on weighted arithmetic quality mean method and developed in two steps. First by establishing a rating scale for each selected parameter giving weightage and second by selecting the pollution parameter on which the index is to be based. The rating system is an arbitrarily value between zero to one and its selection depends upon the importance of individual quality considerations in a comparative way or it can be assessed by making values inversely proportional to the recommended standard for the corresponding parameter (Horton, 1965; Mohan *et al.*, 1996). In computing the HPI, Prasad and Bose (2001) considered unit weightage (Wi) as a value inversely proportional to the recommended standard (Si) of the corresponding parameter as proposed by Reddy (1995).

The HPI model (Mohan et al., 1996) is given by:

$$HPI = \frac{\sum_{i=1}^{n} W_i Q_i}{\sum_{i=1}^{n} W_i},$$

where, Qi = sub-index of the ith parameter.

Wi = unit weightage of the ith parameter

n=number of parameters considered.

Also the heavy metals concentration of all the 20 locations were analysed and was found that Iron concentration at most of the locations were exceeding the acceptable limits. Copper, Nickel, Manganese concentration at some locations were exceeding the desirable limits but was within the permissible limits.

While Mercury, Lead, Cadmium & Zinc was found within the range. It can be concluded that most of the pollution problems are due to iron concentration. Further, the Heavy Metal Pollution index was evaluated and was found that HPI value for all the locations lies far below the critical value ie. 100. The methods used to calculate Heavy Metal Pollution Index has been found to be very helpful to analyse and compare variations of all the selected samples. The Contamination index was calculated and it was found that several locations GW-7, GW-8, GW-10, GW-13, GW-14, GW-18, GW-19 was exceeding Cd value 3, showing high contamination degrees. While, at several locations GW-1, GW-2, GW-3, GW-4 GW-5, GW-12, GW-17, GW-20 the Cd value was below 1, showing least contamination.

International Journal of Engineering Research & Technology (IJERT)
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Table I. Physico-chemical parameters at different sampling locations

Sample Code	Location	pH	EC (μs/cm)	Turbidity (NTU)	TDS	Total Alkalinity	Cl	Ca	Mg	Na	K	Total hardness
GW-1	Jharna	7.66	450	2.7	282	212	120.6	92.3	11.8	63.5	3.6	280
GW-2	Bermo	6.98	530	9.2	374	76	32.5	57.6	23.3	44.2	3.5	240
GW-3	Dantu	7.51	630	10.3	269	77	20.2	32	21.8	15.9	2.1	170
GW-4	Kashi Jharia	7.32	750	5.7	482	138	39.6	39.9	24.9	24	5.6	202
GW-5	Dhandaber	7.6	490	6.2	364	179	75.8	75.5	43.2	45.1	6.5	366
GW-6	Siwandih	6.98	898	4.2	1059	212	58.4	96.3	33.1	36.6	3	378
GW-7	Gudkutarh	7.11	1455	0.8	1123	162	186.7	122.3	82	44.5	2.8	642
GW-8	Kalyanpur	7.32	892	4.2	550	539	200.1	106.2	56.6	25.3	10.1	498
GW-9	Mamkudar	6.97	574	1.4	386	302	69.7	76.3	65.9	55.6	3.2	461
GW-10	Bhawanipur	7.87	1518	2.3	1059	154	198.2	93.1	57.2	46.1	4	467
GW-11	Chadankiyari	7.21	1349	3.4	958	289	88.5	81.4	45.5	18.8	4.5	390
GW-12	Khasmahal	6.86	372	4.3	238	302	51.2	92.3	42.2	31.2	9.6	404
GW-13	Sitanalah	7.97	1274	6.9	1195	77	75.5	83.3	61.2	33.8	6.8	459
GW-14	Pidrajora	7.76	1178	2.3	792	378	154.2	70.1	68.7	51.7	9.7	457
GW-15	Tulbul	7.58	880	4.2	713	309	60.2	105.2	22.3	83	7.5	354
GW-16	Peterwar	7.63	1200	5.2	998	399	100.2	69.1	36.9	53.6	3.7	324
GW-17	Jainamore	6.92	750	2.9	586	345	49.2	68.7	37.2	24.4	6.3	325
GW-18	Telgaria more	7.02	1142	6.8	1040	375	58.5	44.2	55.2	34.7	4.55	337
GW-19	Baladih	7.68	879	6.2	682	212	150.2	103.2	52.5	43.7	7.5	473
GW-20	Khutari	6.66	381	6.4	220	155	52.8	39.2	51.4	25.1	3.5	309

All parameters are with unit mg/L unless specified.

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Table II. Heavy metal concentration at different sampling locations

Sample Code	Location	Fe	Ni	Cu	Zn	Mn	Cd	Hg	Pb
GW-1	Jharna	992	10.1	4.1	200	190.3	0.2	0.3	0.65
GW-2	Bermo	1125	20.1	1	324	122.2	1.2	0.07	1.02
GW-3	Dantu	1201	12.3	1.2	165	69.9	0.2	0.3	1.96
GW-4	Kashi Jharia	998	10	1.3	62	82.3	0.3	0.8	0.32
GW-5	Dhandaber	789	12	3.8	67	69.8	0.6	0.05	0.19
GW-6	Siwandih	1100	3.9	2.8	72	231	0.3	0.06	0.29
GW-7	Gudkutarh	789	7.9	38.9	32	12.6	0.2	0.12	2.23
GW-8	Kalyanpur	1022	1.8	1.7	25	11.8	1.06	0.78	1.96
GW-9	Mamkudar	600	5.2	2.1	29	9.2	1.07	0.03	1.52
GW-10	Bhawanipur	621	6.2	1.2	87	27.3	0.03	0.04	0.32
GW-11	Chadankiyari	803	4.2	2.1	8	22.4	1.2	0.04	0.18
GW-12	Khasmahal	1056	8.2	1	15	95.1	1.09	0.21	0.95
GW-13	Sitanalah	756	11.5	2	45	9.2	0.04	0.16	0.12
GW-14	Pidrajora	856	26.8	2.9	22	25.3	0.02	0.14	0.01
GW-15	Tulbul	562	24.6	3.2	19	23.5	0.08	0.09	2.01
GW-16	Peterwar	486	10.2	1	11	62.1	0.6	0.19	1.35
GW-17	Jainamore	475	11.9	1	72	162.4	1.02	0.34	1.05
GW-18	Telgaria	702	19.5	51.3	300	215.3	0.44	0.01	1.38
GW-19	Baladih	635	5.3	0.8	229	201.3	0.32	0.78	0.98
GW-20	Khutari	365	9.6	3.1	69	56.8	0.21	0.42	0.84

All parameters are with unit µg/L.

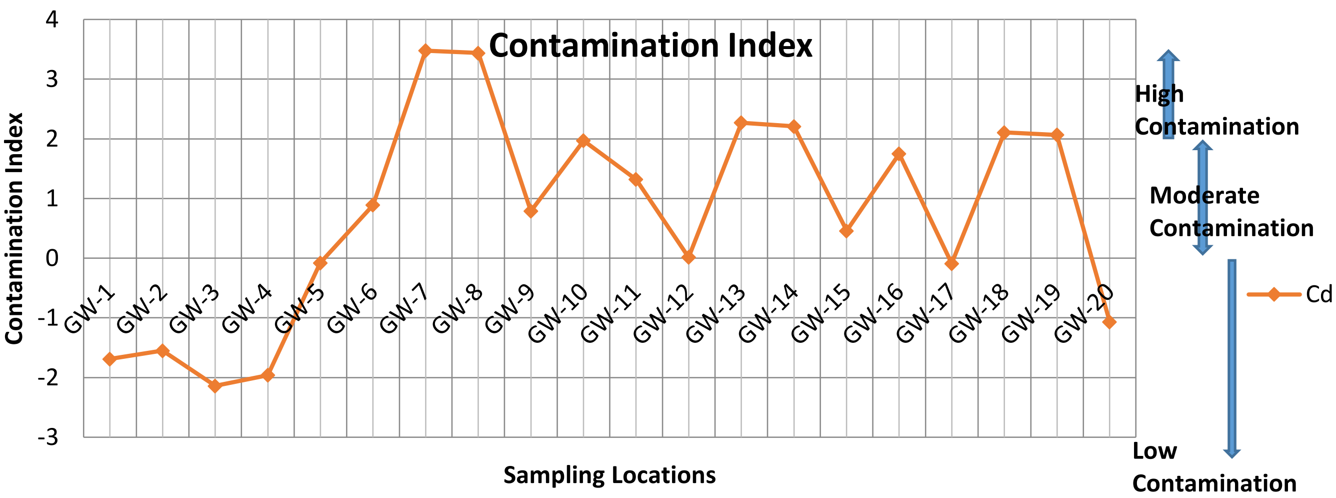

Figure 2: Graphical Representation of degree of Contamination Index

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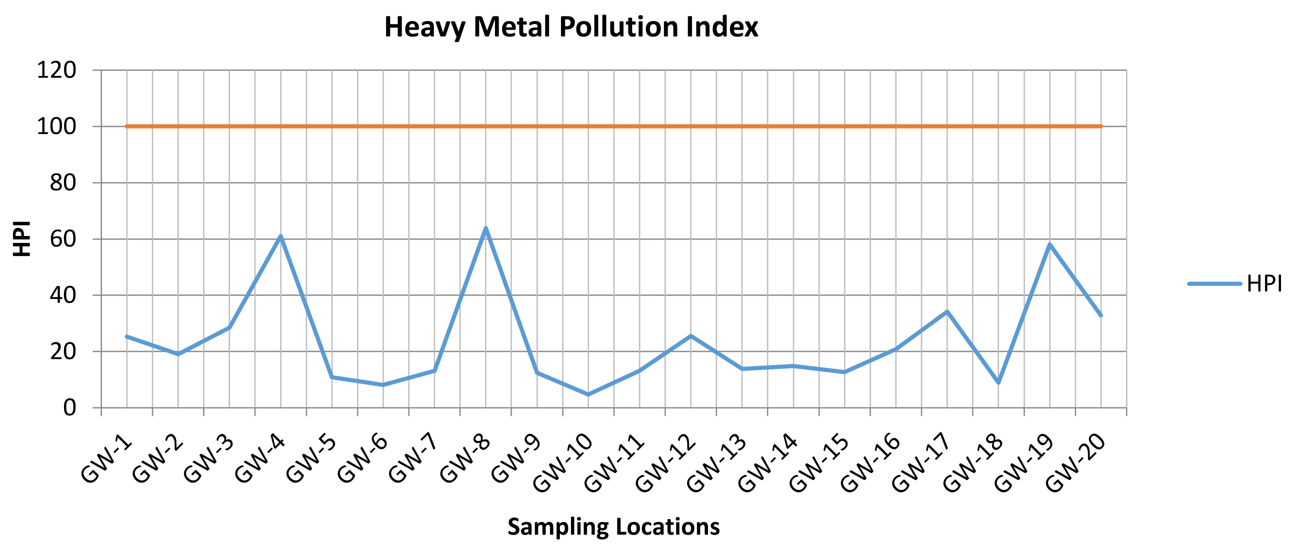

Figure 3: Graphical Representation of Heavy Metal Pollution Index

CONCLUSION

We have analysed all the samples from 20 locations from Bokaro district and the areas are affected by mining & industrial activities. Though the heavy metal pollutions lie below the critical value of HPI but the Iron contamination is affecting the ground water severely day by day. So, the control of activities that causes Iron contamination is recommended. The Contamination Index(Cd) of 2 locations i.e. Gudkutarh & Kalyanpur (Baru) are found to be highly contaminated.

REFERENCES

[1] R. Agarawal, M. Kaushal, B. Farmaha, 2009., "Water resourse management for sustainable agriculture in Punjab, India", Wat. Sci. Tech., Vol. 60, No 11, pp 2905-2911.

[2] Akoteyon,2012., "Evaluation Of Groundwater Quality Using Contamination Index In Parts Of Alimosho, Lagos – Nigeria", American Academic & Scholarly Research Journal Vol. 4, No. 4.

[3] B. Backman, D. Bodis, P. Lahermo, S. Rapant, & T. Tarvainen, 1998., "Application of a groundwater contamination index in Finland and Slovakia", Environ Geology., Vol. 36, pp 55-64.

[4] H. Bokar, J. Tang and N. Lin,2004., "Groundwater quality and contamination index mapping in Changchun City, China", Chinese Geog. Sci., Vol 14, No 1,pp 63-70.

[5] P. Bably and S. Kumari, 2008., "Heavy metal pollution index of groundwater of an abandoned open cast mine with Fly Ash: A case study", Mine Water Environ, No 27, pp 265-267.

[6] A.E. Edet and O.E. Offiong, 2002., "Evaluation of water quality pollution indices for heavy metal contamination monitoring, A study case from Akpabuyo-Odukpani area, Lower Cross River Basin south-eastern Nigeria", GeoJournal, Vol 57, pp295–304.

[7] B. Hamadoun, T. Jie, LIN Nian-feng,2004., "Ground water Quality and Contamination Index Mapping in Changchun City, China", Chinese Geographical Science Vol 14, No 1, pp 63-70.

[8] J. D. Hem,1985., "Study and interpretation of the chemical characteristics of natural water". USGS. 3rd. Ed., Water supply paper, pp 2254.

[9] R.K. Horton,1965., "An index system for rating water quality", Journal Water Pollution Control Federation Vol. 3, pp 300-306.

[10] P. Jenkins, T. Southern, V. Truesdale, A. Jeary, S. Watts, L. Halliwell, 1996., "Essential environmental science. Methods and Techniques London, pp 336-350.

[11] H.M. Joung, W.W. Miller, C.N M ahammah and J.C.A. Gultjens,1979., "A generalized water quality index based on multivariate factor analysis. Journal Environmental Quality" Vol.8, pp 95-100.