Assessment of Heavy metal Indices for Groundwater of Granitic terrain in South Western Part of Rangareddy District, Telangana State, India

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Abstract- Drinking water quality monitoring is essential regularly in terms of heavy metals and toxic substances. The importance of this study was to estimate the concentration of heavy metals in drinking water to determine the water quality indices from hard rock terrains of Granitic and Deccan trap regions of the area, viz; the heavy metal pollution index (HPI) and heavy metal evaluation index (HEI). The concentration of thirteen eco-toxic heavy metals such as Al, As, B, Ba, Cr, Cu, Fe, Li, Mn, Ni, Pb, Se, and Zn was analyzed for 73 ground water sampling stations by highly accurate and sensitive inductively coupled plasma-optical emission spectrometry (ICP-OES) at Geochemistry lab, National Geophysical Research Institute (NGRI), Hyderabad, India. The concentrations of heavy metals have been found to above the permissible limit of drinking water quality standards. The mean HPI values of ground water in Granitic terrain and Deccan trap area are 401.93 and 206.58 respectively. The results inferred that mean HPI values were found to be above the critical pollution index value of 100. Mean deviation and percentage deviation from the mean HPI value was also calculated for each sampling point. HPI results showed that, 91% of the sampling sites at Granitic terrain were found higher than the critical pollution index 100, however, Deccan trap 61% of the sampling sites showed higher than the critical pollution index. The mean HEI values of ground water at Granitic and Deccan trap area are 66.25 and 25.69

respectively. These results of HEI were used to determine the heavy metal toxicity among the sampling sites confirmed that drinking water quality is poor in terms of heavy metals.

Keywords: Drinking Water quality, HPI (Heavy metal Pollution Index), HEI (Heavy metal Evaluation Index), Granite and Deccan Trap

1. INTRODUCTION

Water is important for our survival on this planet (Venu and Rishi 2011). The boon of natural fresh reservoirs to mankind can't be overexploited (Mahapatra et al. 2012). The UNEP (2000) concluded that there is worldwide deterioration of water quality and different studies recommend it's primarily owing to growing human populations and corresponding economical and industrial development inflicting eutrophication and serious heavy metal pollution in the aquatic environment (Peierls et al. 1998; Pekey et al. 2004; Li et al. 2008; Krishna et al. 2009; Praveen Raj Saxena, G. Sakram et al. 2015). Heavy metal pollution is a major threat concern to ground or surface water owing to rapid spreading urbanization, the expansion of industry, and improper sanitation. Trace metal contagion is crucial to understand its toxicity for the ecosystem and human species (Gueu et al. 2007; Adams et al. 2008; Praveen Raj Saxena, G. Sakram et al. 2015). However few metals, like Cu, Fe, Mn, Ni, and Zn, are indispensable micronutrients for the life cycle in flora and fauna kingdom while others, such as As, Cd, Cr, Pb and, Co, have no established anatomical activities (Kar et al. 2008; Aktar et al. 2010). Natural sources of trace metals include geological phenomenon-volcanism, bedrock erosion, and atmospheric transport; in recent centuries, human activities-specifically mining and industrial processing-have demonstrated significant influence on the biogeochemical cycles of trace metals (Nriagu 1989, 1996). The concentrations of heavy metals present in water determine its use for domestic, irrigation, and industrial purposes. Surface waters are exclusively vulnerable to heavy metal pollution due to their movement for disposal of wastewaters. Several strategies established to develop quality indices for assessment of water quality with respect to water quality parameters Horton (1965); Joung et al. (1979); Landwehr (1979); Lohni and Todino (1984); Tiwari and Misra (1985); Praveen Raj Saxena and G. Sakram et al. (2015); Sakram et al. (2015) and Sakram et al. (2018). In recent years enough consideration has been given to the analysis of significant pollution in ground water and surface water by using the heavy metal pollution index (HPI) Mohan et al. (1996); Reddy (1995). Heavy metal pollution index (HPI) is described as a reflective rating, the complex influence of discrete dissolved heavy metals Sirajudeen et al. (2014). HPI is calculated from a point of view of ground water suitability for human consumption with reference to metal contamination. HPI is an important tool for ranking amalgamated influence of individual heavy metal on the overall water quality Reza and Singh (2010) and a view of the suitability of ground water for human intake Rizwan et al. (2011). The critical drinking water pollution index value is ought to be less than100. Another index is the heavy metal evaluation index (HEI) for drinking water Enaam (2013), which takes possible effect of heavy metals on human health that help to determine the drinking water quality. The higher the metal concentration with reference to MAC (Maximum Allowed Concentration) value makes the quality of water poor. The heavy metal pollution index (HPI) and metal index (HEI) for ground and surface water samples of the study area were determined and presented in this paper.

2. LOCATION AND GEOLOGY

The present study was carried out at South western part of Rangareddy district, Telangana State, India, which is geographically bounded by 17° 03' to 17° 28' N latitude and 77° 75' to 78° 00' E longitude covering an area of above 381 km^2 (Fig.1). The topography of the area ranges between 689 meters to 526 m above sea level. The region receives 830 mm average rainfall from the south west monsoon during the months of June to September and the climate is semi-arid. The maximum temperature recorded in the summer was 41°C in the summer season.

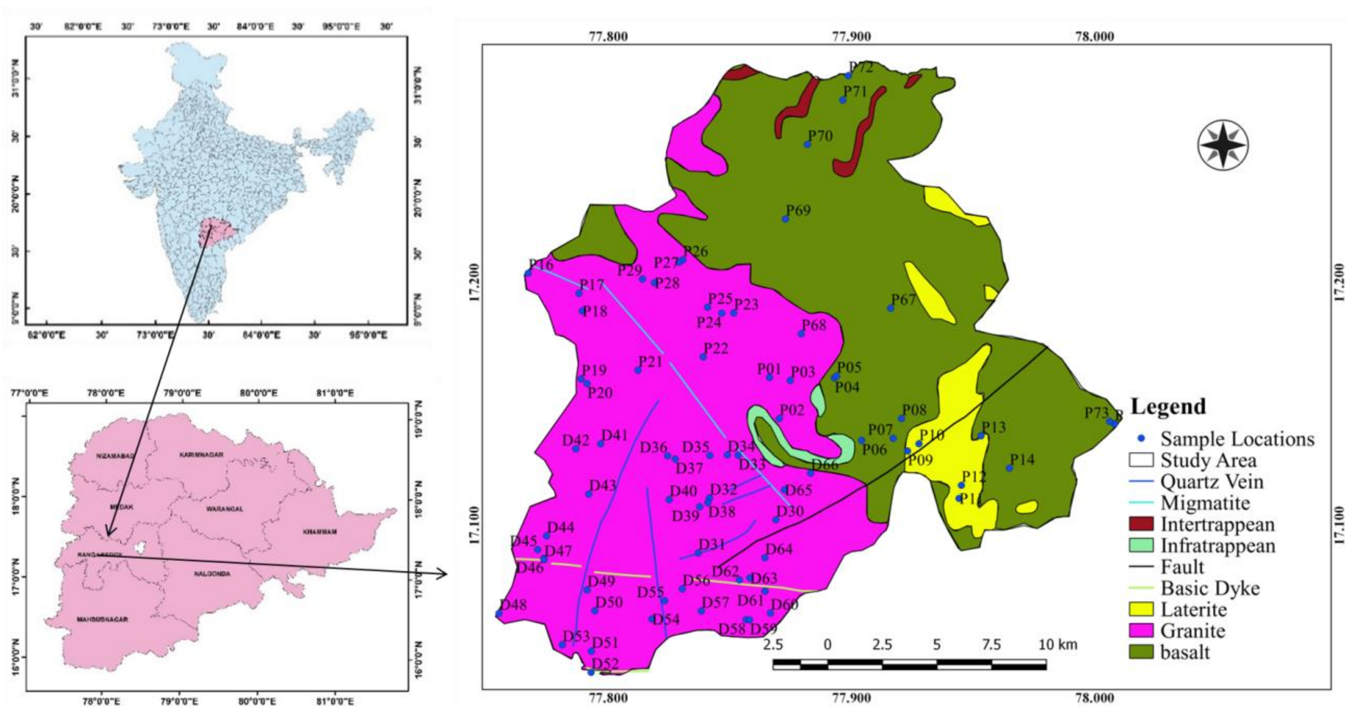

Figure. 1. Geology Map showing Sample

Locations of the study area

Geologically, the study area is underlain by Peninsular Gneissic Complex (PGC) rocks of Precambrian crystalline granites and gneisses along with enclaves of schists (older metamorphic), basic dykes (Proterozoic) and a thin cover of Deccan Traps (Cretaceous to Paleocene) and Laterites (Pleistocene) super group (DRM GSI, 1973) (Fig.1). Hydrogeologically, the study area belongs to the Precambrian hard rock province. The groundwater occurs in semi-confined to confined conditions.

3. MATERIALS AND METHODOLOGY

Sampling was performed according to a standards procedure (APHA 2002). Heavy metals such as Al, As, B, Ba, Cr, Cu, Fe, Li, Mn, Ni, Pb, Se, and Zn was analyzed for 73 water sampling stations were determined by ICP-OES (Instrument Model: Perkin-Elmer OPTIMA-4300DV, USA) was used to measure the concentrations of heavy metals. The concentration of measured heavy metals was presented in parts per billion (ppb) in (Table 1). After determining the concentration, water quality pollution indices were calculated. The heavy metal pollution index (HPI) indicates the overall quality of the drinking water in terms of heavy metals Ameh and Akpah (2011); Prasanna et al. (2012); Yankey et al. (2013); Brraich and Jangu (2015); Tiwari et al. (2015); Sobhanardakani (2016); Balakrishnan and Ramu (2016); Makia et al. (2017); Ghaderpoori et al. (2018).

This index is calculated according to Eqs. (1) and (2) as follows:

$$HPI = \sum_{i=1}^{i=n} \frac{Wi.Qi}{Wi} ......(1)$$

$$Qi = \sum_{i=1}^{i=n} \frac{Mi(-)Ii}{Si - Ii} X100......(2)$$

Where, Qi and Wi are the sub-index of the ith parameter and the unit weightage of the ith parameter, respectively. n is the number of parameters considered. M_i, I_i, and S_i are the monitored values of heavy metal, ideal and standard values of the ith parameter, respectively. The sign (−) indicates the numerical differences of the two values, ignoring the algebraic sign. Water quality based on HPI can be classified into three categories including: low (less than 100), the threshold risk (equal to 100), and high (more than 100). If HPI is more than 100, water cannot be used for drinking. Measured values of HPI index for the drinking water samples are presented in (Table 2).

Heavy metal Pollution Index (HPI) = 98.48/0.33 = 300.6. Similarly the HPI values for 73 samples were calculated and the results were given in the (Table 4).

Heavy metal evaluation index (HEI) is a method of estimating the water quality with focus on heavy metals in drinking water (Brraich and Jangu (2015); Sobhanardakani (2016); Ameh and Akpah (2011); Rizwan et al. 2011; Manoj et al. 2012; Ameh (2013); Sakram et al (2014). This index is calculated according to Eq. (3), as follows:

$$HEI = \sum_{i=1}^{i=n} \frac{Hci}{Hmaci} ......(3)$$

Where, Hc and Hmac are the monitored values and maximum admissible concentration of the ith parameter, respectively. The classifications of the HEI index is as follows: low (less than 10), medium (between 10 and 20), and high (more than 20). (Table 3) show the used constants and the values of the calculated HEI (Al-Ami et al. 1987; Aqeel et al. 2010; Eaton et al. 2012 and Khaniki et al. 2017). Similarly the HEI values for 73 samples were calculated and the results were given in (Table 4 & 5).

Table 1 Statistical Analysis of Heavy Metals in ppb

SNo.	Al	As	B	Ba	Cr	Cu	Fe	Li	Mn	Ni	Pb	Se	Zn
P01	bdl	bdl	87.20	153.7	2.33	bdl	568.70	5.65	45.60	bdl	26.88	bdl	488.00
P02	bdl	bdl	5.16	29.20	3.59	13.08	8501	14.55	38.32	bdl	22.56	bdl	2535.0
P03	bdl	bdl	50.00	22.06	3.22	bdl	bdl	17.77	bdl	bdl	Bdl	bdl	bdl
P04	bdl	bdl	11.00	bdl	2.19	7.81	9040	7.46	111.20	bdl	Bdl	11.53	662.20

P05	bdl	bdl	19.52	12.76	5.74	44.14	11470	8.35	61.81	bdl	Bdl	bdl	573.90
P06	bdl	bdl	0.00	1.18	1.81	bdl	4619	6.05	10.48	bdl	Bdl	bdl	10.57
P07	242.20	bdl	65.43	114.7	bdl	bdl	816.3	42.03	12.44	bdl	Bdl	bdl	145.60
P08	170.20	bdl	5.27	4.80	1.71	bdl	2848.00	8.47	6.44	bdl	13.44	bdl	1434
P09	3.12	bdl	22.82	22.80	bdl	bdl	111.7	5.53	bdl	bdl	Bdl	bdl	618.40
P10	bdl	bdl	27.44	16.72	0.50	2.52	4784	6.85	76.28	bdl	Bdl	bdl	152.20
P11	bdl	bdl	44.42	14.42	bdl	bdl	bdl	7.27	51.31	bdl	19.56	bdl	59.11
P12	1449	bdl	56.17	55.43	1.55	bdl	3429	6.22	32.67	bdl	Bdl	bdl	118.40
P13	bdl	bdl	30.43	bdl	bdl	bdl	5848	6.16	11.51	bdl	Bdl	bdl	1146
P14	bdl	bdl	42.80	10.17	0.92	bdl	3667	8.19	6.58	bdl	Bdl	bdl	111.60
P15	20.41	bdl	82.75	1.26	1.78	bdl	2466	24.04	16.38	bdl	Bdl	71.3	1475
P16	0.00	10.86	177.3	136.3	2.26	bdl	10910	45.43	578.80	bdl	Bdl	bdl	35.12
P17	2004	86.55	22.99	126.8	0.71	13.89	28670	5.95	382.30	bdl	Bdl	61.28	1276
P18	bdl	bdl	13.82	59.31	0.29	bdl	14000	42.95	29.66	bdl	1.69	bdl	334.8
P19	bdl	55.17	50.06	101.6	bdl	bdl	26.34	22.05	2.02	bdl	Bdl	bdl	27.66
P20	bdl	bdl	121.3	640.6	3.50	106.60	bdl	67.05	6012	bdl	Bdl	0.91	bdl
P21	19920	109	bdl	385.5	19.2	32.62	216700	19.93	374.30	13.3	Bdl	0.35	76.35
P22	bdl	bdl	45.57	98.24	1.09	9.72	9.86	33.07	108	bdl	Bdl	bdl	194.6
P23	bdl	bdl	50.08	94.36	bdl	bdl	3.48	49.15	49.47	bdl	Bdl	5.74	bdl
P24	bdl	bdl	20.53	53.31	bdl	bdl	7.08	47.91	11.36	bdl	Bdl	bdl	bdl
P25	bdl	bdl	21.52	30.22	0.24	bdl	8545	47.40	14.12	bdl	Bdl	bdl	2683
P26	8017	3.92	bdl	191.9	11.52	40.58	45100	6.59	709.80	10.4	Bdl	bdl	686.50
P27	bdl	17.14	bdl	27.91	bdl	bdl	21280	13.65	13.67	bdl	Bdl	bdl	339.30

P28	1628	100.9	31.72	104.50	bdl	10.01	24310	6.03	131.40	bdl	Bdl	32.82	453.10
P29	bdl	55.54	35.00	278.5	1.98	24.68	84460	20.04	809.80	bdl	Bdl	bdl	44.32
D30	28.11	bdl	20.96	75.41	0.37	bdl	14140	17.99	8.77	bdl	Bdl	bdl	1303
D31	143.60	173.5	19.08	202.8	0.05	2.94	4955	32.43	248.60	bdl	Bdl	bdl	324.50
D32	14330	78.59	bdl	135.1	20.35	23.73	197300	13.05	547.90	13.54	Bdl	bdl	292.20
D33	10.27	26.14	21.40	54.97	0.85	bdl	8891	78.29	209.50	bdl	Bdl	23.04	96.73
D34	32.65	94.84	4.19	93.59	bdl	27.75	24870	40.96	1133	bdl	30.99	53.24	9982
D35	3510	65.31	5.65	374.9	4.02	9.68	62360	6.72	947.20	bdl	Bdl	bdl	168.40
D36	bdl	39.88	11.36	138.9	0.19	bdl	7827	40.91	104.60	bdl	Bdl	bdl	98.67
D37	10810	61.53	bdl	184.5	14.53	20.28	112300	10.13	364.10	2.34	Bdl	32.74	35.15
D38	bdl	10.66	30.12	62.33	2.30	bdl	15040	31.43	22.15	bdl	Bdl	23.90	268.80
D39	bdl	14.46	16.04	101.0	bdl	bdl	113.40	40.83	286.90	bdl	Bdl	0.35	443.40
D40	bdl	41.41	8.35	106.9	0.78	18.33	34320	37.41	98.23	bdl	Bdl	bdl	432.20
D41	bdl	79.57	114.6	87.29	1.31	bdl	662.80	45.15	bdl	bdl	Bdl	bdl	bdl
D42	24.34	29.83	40.49	22.42	0.22	bdl	590.30	52.10	40.46	bdl	Bdl	bdl	571.10
D43	bdl	66.00	211.9	99.71	bdl	bdl	62.92	89.98	1714	bdl	Bdl	74.74	bdl
D44	bdl	71.96	82.54	48.66	0.23	bdl	116.60	47.46	38.73	bdl	Bdl	bdl	bdl
D45	8786	85.46	0.88	1124	10.47	13.91	93800	11.77	269.40	bdl	Bdl	25.67	7.58
D46	bdl	81.59	74.74	69.28	bdl	bdl	227.90	44.32	2.11	bdl	Bdl	31.92	bdl
D47	bdl	55.78	33.33	63.69	1.99	21.70	68760	51.77	618.30	bdl	Bdl	0.00	730.80
D48	bdl	78.11	74.73	45.96	0.59	bdl	507.50	64.12	60.87	bdl	Bdl	15.31	4.32
D49	403.60	58.21	68.69	191.1	15.82	0.86	3549	24.00	611.30	bdl	Bdl	41.08	1.07
D50	bdl	72.33	44.60	81.33	0.06	bdl	180.70	46.25	20.79	bdl	Bdl	8.40	bdl

D51	bdl	82.32	18.81	32.43	bdl	bdl	124.40	48.80	bdl	bdl	Bdl	39.12	bdl
D52	3.96	75.92	29.26	bdl	bdl	bdl	266.70	42.19	253.80	bdl	Bdl	0.00	bdl
D53	bdl	132.5	110.9	26.71	2.39	bdl	269.70	49.77	1233	bdl	Bdl	73.70	bdl
D54	bdl	115.7	163.5	141.1	2.43	bdl	23050	51.36	753.80	bdl	Bdl	bdl	29.30
D55	13.57	85.25	26.80	150.4	bdl	bdl	238.50	44.88	3.90	bdl	Bdl	81.72	133.80
D56	bdl	43.55	2.15	96.03	bdl	0.04	39980	27.82	46.42	bdl	Bdl	21.96	21.95
D57	bdl	102.5	10.03	6.34	bdl	1.23	279.00	57.14	57.79	bdl	Bdl	90.87	bdl
D58	bdl	47.57	11.22	45.14	bdl	14.74	9190	35.39	75.99	bdl	Bdl	35.8	484.80
D59	17820	56.53	bdl	211.4	16.08	9.79	256600	16.33	440.40	7.80	54.98	bdl	131.90
D60	bdl	49.53	bdl	271.0	bdl	0.00	44580	47.41	2126	bdl	Bdl	4.88	125.10
D61	3948	20.56	19.12	314.9	2.50	301.60	37270	8.01	635.10	bdl	Bdl	5.31	361.30
D62	bdl	73.35	82.98	20.29	0.01	16.57	23910	44.93	779.10	bdl	Bdl	3.85	3016
D63	bdl	127.3	42.34	46.29	bdl	bdl	683.90	28.44	1351	bdl	Bdl	20.57	0.00
D64	bdl	97.20	46.36	72.29	bdl	20.54	1030	40.04	130.20	bdl	Bdl	24.28	2738
D65	bdl	125.8	bdl	432.4	2.53	2.86	88410	31.66	263	bdl	Bdl	11.23	94.62
D66	bdl	90.77	17.36	31.95	1.40	9.13	16420	28.07	7.01	bdl	Bdl	bdl	400.60
P67	58.43	101.7	0.00	12.41	4.25	39.43	32990	11.59	151	bdl	Bdl	25.99	84.71
P68	bdl	94.23	31.47	32.93	2.57	bdl	235.10	24.32	bdl	bdl	Bdl	26.63	bdl
P69	52.24	169.5	85.91	94.98	3.48	3.75	40160	8.16	76.54	bdl	Bdl	88.62	115.00
P70	bdl	71.36	58.96	30.17	0.18	3.59	8638	23.31	11.70	bdl	Bdl	74.51	200.20
P71	1182	110.9	159.5	131.8	bdl	39.21	26290	27.16	32.93	bdl	Bdl	bdl	677.80
P72	206.70	116.5	254.3	42.20	bdl	0.70	2029	13.82	58.24	bdl	Bdl	1.90	bdl
P73	bdl	52.27	71.31	19.63	bdl	8.84	133.50	5.15	163.80	bdl	Bdl	16.23	1876.00

min	bdl	bdl	bdl	bdl	bdl	bdl	bdl	5.15	bdl	bdl	Bdl	bdl	bdl
max	19920	173.50	254.30	1124	20.35	301.60	256600	89.98	6012.00	13.54	54.98	90.87	9982.00
mean	1298.87	51.60	44.74	115.27	2.44	12.56	24870.44	29.38	352.13	0.65	2.33	15.91	560.71

*Note: bdl- below detection limit

Table 2 HPI Calculation for ground water sample

Heavy Metals	Mean Value (ppb) Mi	Standard Permissible Value (ppb) Si	Highest Desirable Value (ppb) Ii	Unit Weightage Wi	Sub Index Qi	WixQi
Al	1298.87	100-200	200	0.01	649.44	3.25
As	51.6	10	10	0.10	516.00	51.60
B	44.74	2400	2400	0.00	1.86	0.00
Ba	115.27	700	700	0.00	16.47	0.02
Cr	2.44	50	50	0.02	4.88	0.10
Cu	12.56	2000	2000	0.001	0.63	0.00
Fe	24870.44	300-1000	1000	0.00	2,487.04	2.49
Li	29.38	50	50	0.02	58.76	1.18
Mn	352.13	50	50	0.02	704.26	14.09
Ni	0.65	70	70	0.01	0.93	0.01
Pb	2.33	10	10	0.10	23.30	2.33
Se	15.91	40	40	0.03	39.78	0.99
Zn	560.71	10-50	50	0.02	1,121.42	22.43
				∑0.33		∑98.48

Table 3 HEI Calculation for ground water sample

Heavy Metals	Concentration Ci (ppb)	Standard Permissible Value (ppb) Si	Maximum Allowable Conc. (MAC)	HEI=∑ Ci/MAC
Al	1298.87	100-200	200	6.49
As	51.6	10	10	5.16
B	44.74	2400	2400	0.02
Ba	115.27	700	700	0.16
Cr	2.44	50	50	0.05
Cu	12.56	2000	2000	0.01
Fe	24870.44	300-1000	1000	24.87

Li	29.38	50	50	0.59
Mn	352.13	50	50	7.04
Ni	0.65	70	70	0.01
Pb	2.33	10	10	0.23
Se	15.91	40	40	0.40
Zn	560.71	10-50	50	11.21
				∑56.25

Table 4 HPI and HEI values of water samples in Granitic Terrain

S.No.	HPI	M.D	% D	HEI	S.No.	HPI	M D	% D	HEI
P01	144.74	-209	-59	14.34	D40	291.34	-62	-18	50.00
P02	401.91	48	14	62.64	D41	238.37	-115	-33	9.72
P03	2.53	-351	-99	0.47	D42	168.08	-186	-52	17.02
P16	143.70	-210	-59	25.50	D43	421.21	67	19	44.84
P17	557.62	204	58	82.37	D44	219.44	-134	-38	9.14
P18	95.86	-258	-73	22.41	D45	614.18	260	74	154.52
P19	166.34	-187	-53	6.74	D46	248.50	-105	-30	10.24
P20	730.44	377	106	122.69	D47	536.42	183	52	102.51
P21	1,125.58	772	218	337.76	D48	246.34	-107	-30	11.40
P22	40.50	-313	-89	6.91	D49	267.01	-87	-25	25.76
P23	12.91	-341	-96	2.28	D50	219.87	-134	-38	9.10
P24	7.34	-346	-98	1.28	D51	251.82	-102	-29	10.36
P25	355.02	1	0	63.49	D52	256.51	-97	-27	13.81
P26	357.15	3	1	114.31	D53	552.19	198	56	41.15
P27	157.56	-196	-55	30.37	D54	505.19	151	43	51.63
P28	450.35	97	27	55.34	D55	284.31	-69	-20	14.75
P29	519.74	166	47	107.96	D56	261.68	-92	-26	46.95
D30	202.22	-152	-43	41.00	D57	327.79	-26	-7	15.11
D31	591.52	238	67	35.43	D58	243.36	-110	-31	26.84
D32	997.09	643	182	294.68	D59	1,255.38	902	255	369.36
D33	152.84	-201	-57	19.93	D60	554.21	200	57	96.01
D34	1,787.77	1434	405	262.22	D61	313.12	-41	-11	79.95
D35	529.40	176	50	109.51	D62	745.94	392	111	108.21
D36	168.54	-185	-52	16.91	D63	540.38	187	53	41.60
D37	626.20	272	77	182.11	D64	638.25	284	80	69.65

D38	119.21	-235	-66	23.30	D65	679.27	326	92	109.73
D39	134.93	-219	-62	17.14	D66	364.96	11	3	34.30
					P68	281.87	-72	-20	10.92
					Mean	401.93			66.25

Table 5 HPI and HEI values of water samples in Deccan Trap region

Samples	HPI	M.D	% D	HEI
P04	123.10	-231	-65	25.00
P05	112.38	-241	-68	24.51
P06	17.32	-336	-95	5.20
P07	27.74	-326	-92	6.22
P08	222.44	-131	-37	34.06
P09	75.24	-279	-79	12.65
P10	42.66	-311	-88	9.54
P11	70.86	-283	-80	4.35
P12	36.62	-317	-90	13.95
P13	157.19	-197	-56	29.13
P14	26.28	-327	-93	6.25
P15	202.04	-152	-43	34.73
P67	428.93	75	21	49.17
P69	652.23	298	84	63.82
P70	274.16	-80	-23	22.41
P71	495.02	141	40	58.32
P72	353.99	0.23	0	16.37
P73	400.23	46	13	46.73
Mean	206.58			25.69

Table:6 Classification Based on HPI

Classification	Category	No. of Samples in Granites	% in Granites	No. of Samples in Deccan Traps	% in Deccan Traps	Total % of Samples
<100	Low	5	9.09	7	38.89	16
=100	Threshold	Nil	Nil	Nil	Nil	Nil
>100	High	50	90.91	11	61.11	84

Table:7 Classification Based on HEI

Classification	Category	No. of Samples in Granites	% in Granites	No. of Samples in Deccan Traps	% in Deccan Traps	Total % of Samples
<10	Low	8	14.55	5	27.78	17.81
10-20	Medium	12	21.82	3	16.67	20.55
>20	High	35	63.64	10	55.56	61.64

4. RESULTS AND DISCUSSION

The HPI values for 73 water samples was calculated and the results were tabulated in (Table 4) and used to assess the quality of water samples. The mean heavy metal pollution indexes (HPI) in Granitic and Deccan trap area found to be 401.93 and 206.58 respectively, which are found above the critical index value 100. Mean deviation and percentage deviation from the mean HPI value has also been calculated for each sampling point and presented in (Table 4 & 5). This index values confirmed that heavy metal contamination in the study area.

In Granitic region, approximately 91% of the water samples were found above the critical index value 100 (Table 6), sampling sites at D62, P20, P21, D32, D34 and D59 were found to be very high HPI Value, due to leaching of heavy metals from industries, fertilizers, poultry etc., were located in this study area. Mean deviation and percentage deviation results showed that forty three sampling points (55%) recorded an index value lower than the mean value (Table 4). The percentage deviation fall on the negative side, this indicates a slightly better quality with respect to heavy metals. As, Fe, Zn Mn Al, Pb and Se were found to be contributed more in metal pollution. In Deccan trap region, 61% of ground water samples reported high HPI value than the critical pollution index 100 (Table 6), sampling sites at P73, P67, P71 and P69 were found to be very high HPI Value. As, Fe, Mn, Pb, Se and Zn were found to be contributed more to the heavy metal pollution. Mean deviation and percentage deviation results showed that thirteen sampling points (72%) recorded an index value lower than the mean and the percentage deviation on the negative side (Table 4) which indicate a slightly better quality with respect to heavy metals (Yankey et al. 2013).

The HEI value of water samples in Granitic and Deccan trap region were found to be 66.25 and 25.69 respectively (Table 4 & 5). The HEI results in Granitic region showed that 63.64 % of the sampling sites were observed as highly polluted with respect to heavy metals (Table 7). This is due to the iron industries, poultry farms and excess usage of fertilizers in the area. In Deccan trap region, 55.56 % of the sampling sites were recorded as highly polluted with respect to heavy metals (Table 7).

Based on the (HEI) classification and the experimental results revealed that most of the water samples in Granitic region were highly affected with respect to metal pollution. The water samples in Deccan trap region was moderately affected due to industrial pollution. The mean HEI value of ground water in Granitic region is 66.25

which indicate the ground water is highly affected due to industrial pollution, where as in Deccan trap region was 25.69 which indicates the water quality is from moderate to high when compared with Granitic region.

5. CONCLUSION

In the present investigation, the mean heavy metal pollution index (HPI) of Granitic and Deccan trap region are 401.93 and 206.58 respectively were found above the critical index value 100, which indicates that are represented as ground water pollution with respect to heavy metals. Similarly the mean heavy metal evaluation index (HEI) values of ground water samples in Granitic and Deccan trap region are 66.25 and 25.69 respectively also reported. The HPI model used here seems to be encouraging and is proved to be an important tool in evaluating the overall pollution level of ground water in terms of heavy metals. The another index (HEI) was used to evaluate the ground water samples with respect to heavy metals showed that Granitic region water samples were highly polluted when compared to Deccan trap region water samples in the study area. These results of HPI and HEI among the sampling sites revealed that drinking water quality is poor and not suitable for drinking in terms of heavy metals.

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