INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 6.078
(Volume 6, Issue 5)
Available online at: https://www.ijariit.com

Assessment of metal contamination by using pollution indices in groundwater sources that used for drinking purpose in Olpad taluka, surat, India

Patel Monali
monapatel8692@gmail.com
Veer Narmad South Gujarat University, Surat, Gujarat

Kapila Manoj
kapilamanojeee@yahoo.com
Veer Narmad South Gujarat University, Surat, Gujarat

ABSTRACT

The present study was conducted to judge pollution situation and evaluates their sources and distribution of Heavy Metals in the ground water sources of Olpad taluka, Surat, Gujarat, India. Ground water sources such as hand pump bore well, tube well and open well are used for drinking purpose in different villages of Olpad taluka. Heavy metal pollution index (HPI), Heavy Metal Evaluation Index (HEI) and Degree of Contamination (Cd) is representing a quality of water in terms of index numbers that represents the heavy metal load in the ground water sources. Monthly sampling was done from seven sampling sites (Feb' 2015 to July' 2015). Heavy metals concentration in water samples were measured by following standard method of APHA and analysed by Atomic Absorption Spectrophotometer. Heavy metals like, Cu, Ni, Zn, Fe, Mn, Cd, Pb and Cr were analysed from monthly collected samples. Heavy metal affects the health in a wide range if it is present above the permissible limit. Based on calculated results of HPI, HEI and Cd it was found that the water was contaminated with metals.

***Keywords**: Heavy metals; Heavy Metal Pollution Index; Heavy Metal Evaluation Index; Degree of Contamination; Agricultural activities; Pollution*

1. INTRODUCTION

Water is the second most important parameter after air for living a healthy life. Fresh water from ground water sources fulfils the needs of water supply for domestic, industrial and agricultural uses. Due to human activities, animals as well as biotic activities in environment are affected and quality of water becomes degrades as it obtains contamination from surrounding (Haware et al. 2017). The dissolved constituents in water are serving as micronutrients that required for metabolic activities in human body within acceptable limit. Heavy metals are toxic for human even in minute amount present in water because it accumulates in body. Heavy metals having tendency to accumulate into soil and sediments near the water resources. Major sources of heavy metals in ground water are from chemical weathering of minerals, soil leaching and anthropogenic activities (Kwaya et al. 2019). Agricultural activities also one major source for adding heavy metals in ground water, mainly uses of fertilizers and pesticides (Tadiboyina & Rao, 2016). Metals like, Cu, Fe, Ni, Zn and Mn are require for human growth and biological activities but others such as Cd, Pb, Cr and Co having no physiological importance in human life (Herojeet et al. 2015). Transportation of heavy metals in water may undergo many changes in their speciation because of dissolution, precipitation and sorption process (Varsani & Manoj, 2014)

Parameters which are monitored to evaluate quality of water of a system that gives an idea about the contamination with reference to that specific parameter. But the indices give an explanation of pollution by combining all parameters (Prasad et al. 2014).
The main objective of the present study is to define the status of ground water appropriateness for human consumption with respect to heavy metals.

1.1 Study Area

Olpad taluka is an area that located at North West of Surat, India. It contains about 103 villages and major activity of these villages is agriculture. The peoples of this villages depends for their drinking water purpose on different ground water sources like, hand pump, bore well, tube well and open well. From four villages named Jothan (hand pump), Talad (Open well), Atodara (Tube well) and Sithan (bore well) were selected for the study purpose.

1.2 Materials and Methods

Water samples from the ground water sources were collected monthly from the selected sites with their particular sources for six months from February' 2015 to July' 2015. Two samples from each site (except open well) were collected during morning hours. The samples were collected in previously washed double capped polythene bottle. Water samples were preserved in acidic medium till it digested for analysis. The digestion of water samples was followed the specified method given in APHA. These digested samples were directly measured on Atomic Absorption Spectrophotometer. For the study purpose Cu, Fe, Ni, Zn, Cd, Pb, Cr and Mn metals were analysed on AAS.

2. INDEXING APPROACH

2.1 Heavy Metal Pollution Index (HPI)

In recent years abundant care has been taken for the valuation of heavy metal pollution in ground water by using the heavy metal pollution index (HPI). Heavy metal pollution index (HPI) is definite as a grade reflecting the combined impact of dissimilar dissolved heavy metals. HPI is calculated from a point of view of the correctness of ground water for human intake with respect to metal contamination.

Calculation of HPI is based on weighted arithmetic quality mean method that is developed on two basic steps: First, establishment of rating scale for selected parameters which give weightage to that parameter and, second by the selection of pollution parameters on which the index is to be based. Rating value is between o and 1, and it is selected on the basis of the importance of specific quality consideration or it can also be considered as inversely proportional to the standard permissible value (Mohan, 2014). HPI in water is prepared by conveying the unit weight or rating (*Wi*) for each selected element which is inversely proportional to the standard value (*Si*) of that parameter.

The next step contains an individual Sub index (*Qi*) was calculated for each parameter using following Eq.

$$Qi = \frac{Mi - Ii}{Si - Ii} * 100 \qquad (1)$$

Where, *Mi* =Monitored value of metal present in water,
Ii = Ideal value (Highest desirable value) of each metal, and
Si = Standard value of each metal as per BIS drinking water specifications.
The sign (-) indicates numerical value of two values, ignoring the algebraic sign.
The last step includes summing of all sub-indices resulted in the overall index as in below Eq.

$$HPI = \frac{\sum_{i=1}^{n} Qi \times Wi}{\sum_{i=1}^{n} Wi} \qquad (2)$$

Where, *Qi* = the sub index of i^{th} parameter,
Wi = the unit weightage for i^{th} parameter, and
n = the number of parameter or metal considered.

2.2 Heavy Metal Evaluation Index (HEI)

Heavy metal evaluation index is the process of judging the superiority of water with focussed on heavy metals in water samples. HEI index can be calculated by using following equation (Edet & Offiong, 2003).

$$HEI = \sum_{i=1}^{n} \frac{Hc}{Hmac} \qquad (3)$$

Where,
Hc = Measured value of i^{th} parameter
Hmac = Maximum Admissible Concentration of i^{th} parameter

2.3 The Contamination Index (Cd)

In this method, evaluation of water quality is done by calculating the degree of contamination and calculated separately for each water sample, as a summation of every contamination factors of separable components beyond the upper permissible limit. Hence, Cd summarise the collective effects of numerous water quality parameters that are considered dangerous to household water. The contamination factor can be calculated by the equation that given below

$$Cd = \sum_{i=1}^{n} Cfi \qquad (4)$$

Where,

$$Cfi = \frac{CAi}{CNi} - 1 \qquad (5)$$

Cfi = contamination factor for i^{th} parameter
CAi = Analysed value for i^{th} parameter
CNi = Upper permissible / Maximum allowable concentration for i^{th} parameter (N donates the 'Normative value')

3. RESULTS AND DISCUSSION

The calculated average of HPI from studied ground water samples throughout study period is given in Table-1. The results of HPI ranged from 59.6 to 289.8 with the mean value of 146.4 from all sampling sites. Monthly calculation of HPI six months from Feb'2015 to July'2015 are furnished in Table-2. The critical value of HPI for drinking water is 100 which that given by (Prasad &

Bose, 2001). The results indicate HPI was found high at all sites. During rainy seasons HPI value drops than critical value 100, may be due to addition of fresh water with ground water results in lower the concentration of metals. Hence, average HPI value at each site exceeds the critical value which also denoted in figure-1. It indicates the sites are polluted with analysed metals. High HPI indicates the sites are polluted with human exposures mainly the agricultural activities (fertilizers and pesticides).

Table 1: Standard used for index calculation (BIS, 2012) and (Siegel, 2002)

Metals	**Mean value (ppb)**	**Standard permissible value (ppb) (Si)**	**Highest desirable value (ppb) (Ii)**	**(MAC*) (ppb)**	**Unit Weightage (Wi)**	**Sub index (Qi)**	**Wi × Qi**
Cu	22.0952	1500	50	1000	0.00066666	1.92446	0.00128
Fe	305.500	300	-	200	0.00333333	101.833	0.33944
Ni	36.3095	20	-	20	0.05	181.547	9.07738
Zn	73.8095	15000	5000	5000	6.6667E-05	49.2619	0.00328
Cd	2.73571	3	-	3	0.33333333	91.1904	30.3968
Pb	34.3809	10	-	1.5	0.1	343.809	34.3809
Mn	30.2619	300	100	50	0.00333333	34.8690	0.11623
Cr	11.9381	50	-	50	0.02	23.8762	0.47752
					ΣWi = 0.063842		**Σ Wi ×Qi** = 9.349115
HPI = 146.4							

*= Maximum Allowable Concentration

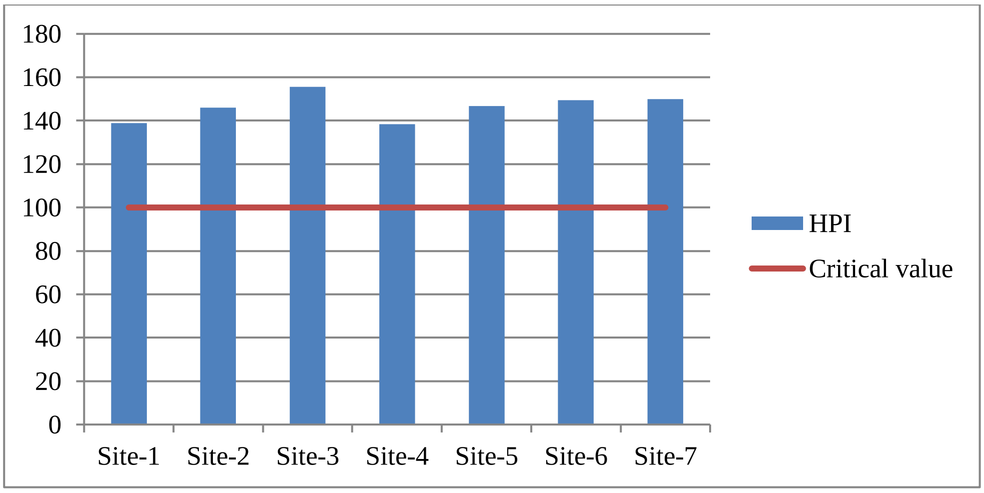

Fig. 1: Average value of HPI at each sampling sites exceeds the critical value

The degree of contamination (Cd) was used as a reference to cover the area of metal pollution. The lowest degree of contamination was found 3.11 and the higher degree of contamination was found 45.55 with mean value 20.06. Cd is classified in to 3 categories according to (Edet & Offiong, 2003) and also supported by (Sobhanardakani et al. 2016) are as follows; Low (Cd<1), Medium (Cd=1-3) and High (Cd>3). According to the Table-2, Cd was found exceeds the value 3, which indicating the water is highly polluted with analysed metals. Figure-2 also indicates high level of degree of contamination at each sampling sites.

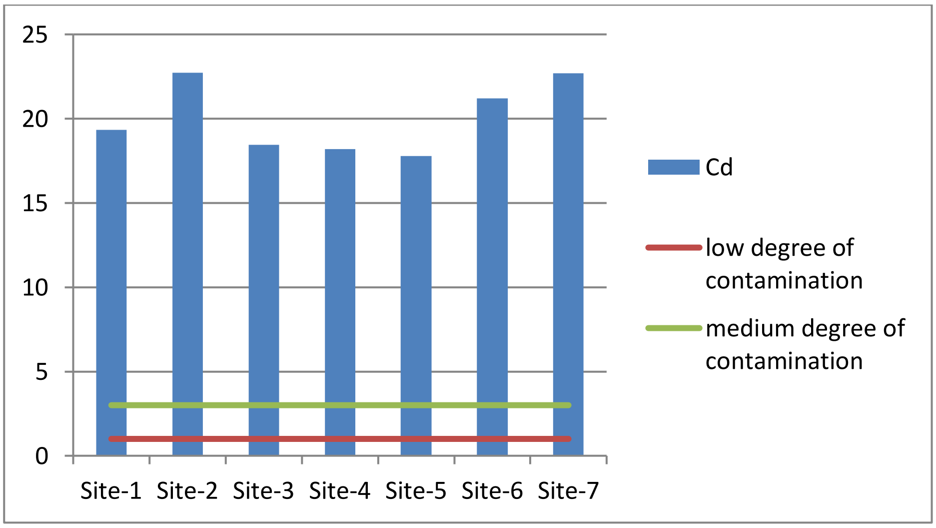

Fig. 2: Degree of contamination founded high level at each sites

The heavy metal evaluation index used for well considerate of pollution indexes. The value of HEI found in the range of 11.11 to

53.55 with the mean value 28.06. The criteria of HEI categories for samples are as follows: Low (HEI<10), Median (HEI=10-20) and High (HEI>20) also suggested by (Pundir et al. 2018). The calculated HEI index from Table-2 suggested that water showed high level of contamination in sunny days. Water showed medium level of contamination during rainy days. Average HEI index at each sampling sites were showed high level of pollution that depicted in figure-3.

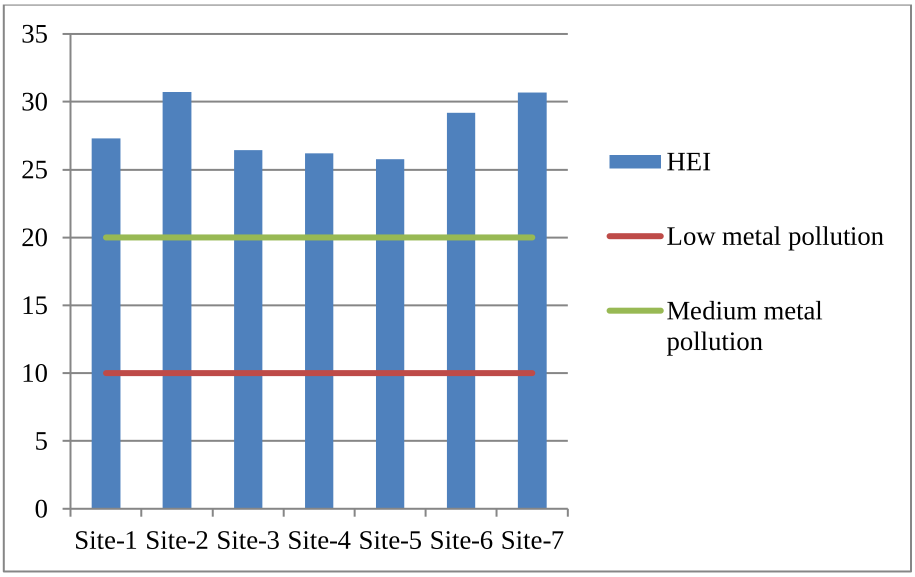

Fig. 3: HEI value founded high level at each sites

Mean deviation and % deviation of HPI, HEI and Cd also calculated at each month which is given in the Table-3. From all months around 29% sampling times HPI was found under the critical limit which is mainly found during rainy months. From all months around 31% sampling times HEI was found at medium contamination level and 69% times it was found at high contamination level. But Cd was found 100% above contamination level. % deviation indicates the degree of pollution with mean values. Higher negative deviation indicates better water quality and more positive deviation indicates worst water quality. Hence, all samples having higher mean value than required level.

Pearson's correlation co-efficient of heavy metals was studied from sampling sites and concise in table 4. The analysis shows that strong positive correlation was observed between Mn and Zn with 0.01 level of significant. The metals group such as Cu - Ni and Cd - Pb also shows positive correlation with 0.01 significant levels. Ni and Zn relation was found positive at 0.05 level of significant.

Table 2: Water pollution indices (HPI, HEI and Cd) at different site of Olpad taluka from Feb'2015 to July'2015.

Sites	Months	HPI	Average	HEI	Average	Cd	Average
Site-1 (Hand pump)	Feb'15	129.5	138.93	31.23	27.32	23.23	19.32
	Mar'15	268.0		52.06		44.06	
	Apr'15	145.7		35.87		27.87	
	May'15	86.41		18.35		10.35	
	June'15	115.4		15.36		7.36	
	July'15	88.7		11.11		3.11	
Site-2 (Hand pump)	Feb'15	117.2	146.05	30.89	30.73	22.89	22.73
	Mar'15	289.8		52.72		44.72	
	Apr'15	148.1		34.28		26.28	
	May'15	121.9		30.21		22.21	
	June'15	111.6		24.41		16.41	
	July'15	87.76		11.88		3.88	
Site-3 (Open well)	Feb'15	125.8	155.65	29.85	26.44	21.85	18.44
	Mar'15	277.7		49.90		41.90	
	Apr'15	151.0		32.07		24.07	
	May'15	83.35		22.97		14.97	
	June'15	91.96		12.69		4.69	
	July'15	204.1		11.16		3.16	
Site-4 (Tube well)	Feb'15	121.2	138.46	25.70	26.19	17.70	18.19
	Mar'15	244.6		41.25		33.25	
	Apr'15	160.0		32.79		24.79	
	May'15	110.3		24.48		16.48	
	June'15	86.42		20.90		12.90	
	July'15	108.3		12.05		4.05	
Site-5 (Tube well)	Feb'15	126.2	146.77	29.96	25.78	21.96	17.78
	Mar'15	254.5		38.51		30.51	
	Apr'15	175.1		30.42		22.42	
	May'15	145.7		28.17		20.17	

	June'15	119.6		16.50		8.50	
	July'15	59.60		11.14		3.14	
Site-6 (Bore well)	Feb'15	219.7	149.51	53.55	29.2	45.55	21.2
	Mar'15	244.6		44.73		36.73	
	Apr'15	183.9		34.11		26.11	
	May'15	97.53		16.14		8.14	
	June'15	79.90		12.14		4.14	
	July'15	71.42		14.57		6.57	
Site-7 (Bore well)	Feb'15	118.9	150.01	28.53	30.7	20.53	22.7
	Mar'15	248.8		43.11		35.11	
	Apr'15	203.6		41.58		33.58	
	May'15	144.3		31.47		23.47	
	June'15	94.57		24.85		16.85	
	July'15	89.96		14.72		6.72	
Maximum		289.8		53.55		45.55	
Minimum		59.6		11.11		3.11	
Mean		146.4		28.06		20.06	

In order to know the main pollution contributing metals to the indices the correlation was carried out between metals and pollution indices that furnished in Table-5. The Pearson's correlation matrix revealed that the heavy metal pollution indices (HPI, HEI and Cd) are directly affected with Cd and Pb metal concentrations. HPI, HEI and Cd indices shows strong positive correlation with Cd metal (0.878, 0.531and 0.531) and significant positive correlation with Pb metal (0.845, 0.982 and 0.982).

High concentration of Cd and Pb was detected in the water sample of sampling site it may be due to major use of fertilizers and pesticides during agriculture practices, explosion of sewage sludge and combustion of fossil fuel. Major sources of Pb is generally plumbing

Table 3: Mean deviation and % deviation values of pollution indices

Sites	**Months**	**Mean deviation**			**% Deviation**		
		Cd	**HPI**	**HEI**	**Cd**	**HPI**	**HEI**
Site-1 (Hand pump)	Feb'15	3.2	-16.9	3.2	15.84	-11.5	11.33
	Mar'15	24.0	121.6	24.0	119.68	83.0	85.55
	Apr'15	7.8	-0.7	7.8	38.94	-0.5	27.84
	May'15	-9.7	-60.0	-9.7	-48.41	-41.0	-34.61
	June'15	-12.7	-31.0	-12.7	-63.28	-21.2	-45.24
	July'15	-17.0	-57.7	-17.0	-84.52	-39.4	-60.42
Site-2 (Hand pump)	Feb'15	2.8	-29.2	2.8	14.13	-20.0	10.10
	Mar'15	24.7	143.4	24.7	122.96	97.9	87.90
	Apr'15	6.2	1.7	6.2	31.03	1.2	22.18
	May'15	2.2	-24.5	2.2	10.74	-16.7	7.68
	June'15	-3.7	-34.8	-3.7	-18.21	-23.7	-13.01
	July'15	-16.2	-58.6	-16.2	-80.65	-40.1	-57.65
Site-3 (Open well)	Feb'15	1.8	-20.6	1.8	8.96	-14.1	6.41
	Mar'15	21.8	131.3	21.8	108.89	89.7	77.84
	Apr'15	4.0	4.6	4.0	20.03	3.2	14.32
	May'15	-5.1	-63.1	-5.1	-25.35	-43.1	-18.12
	June'15	-15.4	-54.4	-15.4	-76.63	-37.2	-54.78
	July'15	-16.9	57.7	-16.9	-84.25	39.4	-60.23
Site-4 (Tube well)	Feb'15	-2.4	-25.2	-2.4	-11.74	-17.2	-8.39
	Mar'15	13.2	98.2	13.2	65.81	67.1	47.04
	Apr'15	4.7	13.6	4.7	23.59	9.3	16.86
	May'15	-3.6	-36.1	-3.6	-17.82	-24.6	-12.74
	June'15	-7.2	-60.0	-7.2	-35.68	-41.0	-25.51
	July'15	-16.0	-38.1	-16.0	-79.79	-26.1	-57.04
Site-5 (Tube well)	Feb'15	1.9	-20.2	1.9	9.49	-13.8	6.78
	Mar'15	10.4	108.1	10.4	52.10	73.8	37.24
	Apr'15	2.4	28.7	2.4	11.80	19.6	8.43
	May'15	0.1	-0.7	0.1	0.58	-0.5	0.41
	June'15	-11.6	-26.8	-11.6	-57.63	-18.3	-41.20
	July'15	-16.9	-86.8	-16.9	-84.32	-59.3	-60.28
Site-6 (Bore well)	Feb'15	25.5	73.3	25.5	127.09	50.0	90.85
	Mar'15	16.7	98.2	16.7	83.14	67.1	59.43
	Apr'15	6.1	37.5	6.1	30.19	25.6	21.58
	May'15	-11.9	-48.9	-11.9	-59.44	-33.4	-42.49
	June'15	-15.9	-66.5	-15.9	-79.37	-45.4	-56.74
	July'15	-13.5	-75.0	-13.5	-67.25	-51.2	-48.07
	Feb'15	0.5	-27.5	0.5	2.34	-18.8	1.67

Site-7 (Bore well)	Mar'15	15.0	102.4	15.0	75.04	69.9	53.64
	Apr'15	13.5	57.2	13.5	67.43	39.1	48.20
	May'15	3.4	-2.1	3.4	17.04	-1.4	12.18
	June'15	-3.2	-51.8	-3.2	-16.00	-35.4	-11.44
	July'15	-13.3	-56.4	-13.3	-66.49	-38.6	-47.53

Table 4: Correlation matrix between analysed metal concentrations

Metals	Cu	Fe	Ni	Zn	Mn	Cd	Pb	Cr
Cu	1							
Fe	-0.025	1						
Ni	.417**	-0.019	1					
Zn	0.197	0.138	.348*	1				
Mn	0.161	0.161	0.232	.796**	1			
Cd	-0.078	-0.287	-0.235	-0.121	-0.2	1		
Pb	-0.073	-0.007	-.343*	-0.132	-0.101	.558**	1	
Cr	0.112	0.132	-0.175	-0.187	-0.155	-0.11	0.077	1

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed).

and dumping the domestic waste which containing battery wastes also water sources containing pipes were from ancient time so, the pipes may be containing Pb content that also comes with water.

According to the mean value from the Table 1 Cu, Zn, Mn and Cr was found under the permissible limit for drinking water. Fe was found near the permissible limit that can be neglected. Ni found high than the permissible limit but it was not a major component for the high pollution indices.

Table 5: Correlation analyses between metal concentration of metals and pollution indices.

Metals	HPI		HEI		Cd	
	r	P	r	p	r	p
Cu	0.008	0.959	-0.012	0.942	-0.012	0.942
Fe	-0.173	0.272	0.1	0.528	0.1	0.528
Ni	-0.114	0.471	-0.221	0.161	-0.221	0.161
Zn	-0.071	0.656	-0.015	0.924	-0.015	0.924
Mn	-0.128	0.419	0.017	0.913	0.017	0.913
Cd	.878**	0	.531**	0.000	.531**	0.000
Pb	.845**	0	.982**	0.000	.982**	0.000
Cr	-0.046	0.773	0.073	0.648	0.073	0.648

**. Correlation is significant at the 0.01 level (2-tailed)

4. CONCLUSION

HPI, HEI and Cd are proven to be a useful tool for evaluating overall metal pollution level. The present study shows the water from different ground water sources of Olpad taluka, Surat, India contains high concentration of Pb, Cd and Ni with lower concentration of Cu, Fe, Zn, Cr and Mn. High degree of contamination (>3) situate the water in to high contamination level. On the other hand high HPI index indicates the quality of water was critical. High HEI index specifies water quality falls within a zone of pollution. It also supports HPI and Cd index categorised quality of water. All the pollution indices indicate that the water was polluted and its quality was fluctuated during seasons. The water needs a better treatment before it used for drinking purpose. The sources required conservation management for sustainable development unless it may be harmful to the humans.

5. ACKNOWLEDGEMENT

This work was supported by Department of Aquatic biology Veer Narmad South Gujarat University, Surat and Pollucon laboratories Pvt. Ltd, Surat for providing lab facilities. I'm grateful to Dr. Kapila Manoj for her constant advice and help during research work.

6. REFERENCES

[1] APHA, (1998). *Standard methods for the Examination of water and wastewater American Public Health Association* (20th Ed.). New York.
[2] Bureau of Indian Standard. IS 10500(2012). Drinking Water Specifications 2nd Revision. Manak Bhavan, New Delhi 110002.
[3] Edet, A.E., & Offiong, O. E. (2003). Evaluation of Water Quality Pollution indices for heavy Metal Contamination Monitoring. A Study Case from Akpabuyo-Odukpani area, Lower Cross River Basin (Southeastern Nigeria). *Geo. Journal*, *57*:295-304.
[4] Haware, D., Kumar, R., Ramteke, D and Inam, F. (2017). Studies of Heavy Metals (Pb, cd, mn, Cu, Ni) in Drinking Water Sources in mysuru City, Karnataka, India. *Research Journal of Chemical Science*, *7*(5), 1-6.

[5] Herojeet, R., Rishi, M. S and Kishore, N. (2015). Integrated Approach of Heavy Metal pollution Indices and Complexity Quantification Using Chemometric Models in the Sirsa basin, Nalagarh vally, Himachal pradesh, India. *Chinese Journal of Geochemistry, 34*(4), 620-633.
[6] Kwaya, M. Y., Hamidu, H., Mohammed, A. I., Abdulmumini, Y. N., Adamu, I. H., Grema, H. M., Dauda, M., Halilu, F. B and Kana, A. M. (2019). Heavy Metals Pollution Indices and Multivariate Statistical Evaluation of Groundwater Quality of Maru Town and Environs. *Journal of Materials and Environmental Sciences, 10*(1), 32-44.
[7] Mohan, S.V., Nithila, P., & Reddy, S.J. (1996). Estimation of Heavy Metals in Drinking Water and Development of Heavy Metal Pollution Index. Journal of *Environmental Science and Health, A31*(2), 283-289.
[8] Prasad, B, & Bose, J. M. (2001). Evaluation of the Heavy Metal Pollution Index for Surface and Spring Water near a Limestone Mining Area of the Lower Himalayas. *Environmental Ecology, 41*, 183-188.
[9] Prasad, B., Kumari, P., Bano, S., & Kumari, S. (2014). Ground Water Quality Evaluation near Mining Area and Development of Heavy Metal Pollution Index. *Applied Water Sccience, 4*, 11-17.
[10] Pundir, S., Singh, R., Singh, P., Aswal, R., & Kandari, V. (2018). Water Quality Indices for Asessing Heavy Metals Contamination in Drinking Water Sources of Lachchiwala Gram Panchayat, Dehradun. *International Journal of Research in Advent Technology, 6*(5), 708-714.
[11] Siegel, F. R. (2002). *Environmental Geochemistry of Potentially Toxic Metals(1st Ed.)*. Washington, DC: Springer-Verlag Berlin Heidelberg, New york.
[12] Sobhanardakani, S., Taghavi, L., Shahmoradi, B., & Jahangard, A. (2016). Groundwater Quality Assessment Using the Water Quality pollution Indices in Toyserkan Plain. *Environmental Health Engineering and Management, 4*(1), 21-27.
[13] Tadiboyina, R., & Rao, P.P. (2016). Trace Analysis of Heavy Metals in Ground Waters of Vijaywada Industrial Area. *International Journal of Environmantal and Science Education, 11*(10), 3215-3229.
[14] Varsani, A., & Manoj, K. (2014). Analysis of Water from Industrial Creek with Respect to Heavy Metals Around Surat City, Gujarat. *Journal of International Academic Research for Multidisciplinary, 2*(11), 269-273.

