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Using Heavy Metals Pollution Index (HPI) for assessment quality of drinking water in Maysan Province in Southern East in Iraq

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Abstract

The current study is carried out to determine the water quality by heavy metal concentration from ten sites were collected from water treated that are supplied to residential areas for drinking purposes in Misan province. Eight heavy metals were selected Cobalt (Co), Cadmium (Cd), Zinc (Zn), Iron (Fe), Nickel (Ni), Chromium (Cr), lead (Pb), and Lithium (Li). Heavy metal pollution Index HPI is calculated for assessing total quality of drinking water for human consumption with respect to heavy metals pollution. The results were revealed that the concentrations of heavy metals at all the selected sites were lower than the permissible limits depending on the Iraqi's standards. The value of HPI depending on the mean concentration was found to be 2.49246 which is far below the critical pollution index value of 100. According to these results, it can be concluded that the drinking water can be used as safe water for human consumption without any negatives impacts on human health.

Keywords: Drinking water; Heavy metal pollution index (HPI); water quality.

1. Introduction

One of the most vital sources of economic development is water. Water quality management, water pollution control, and environmental protection must all be prioritized in order to preserve living conditions [1]. Today heavy metals pollution of the drinking water is one of the serious ecological problems. Some of them can cause adverse impacts to human health when their levels overrun the allowable limit in drinking water [2]. The heavy metals are widely spread pollutants, therefore when waters polluted with heavy metals become very toxic and deleterious to human health [3]. The major sources of heavy metals in aquatic ecosystems are either natural sources or anthropogenic activities [4]. The natural sources of heavy metals are derived from the geological weathering processes such as soil leaching, soil erosion and chemical weathering of minerals in the soil [5]. Major anthropogenic sources of heavy metal pollutant are partially treated effluents, mining wastes and disposal of untreated, also heavy metals from various industries like pharmaceutical productions and random use of heavy metal containing pesticides and fertilizer in agricultural areas [6-7]. In addition to those municipal solid wastes can added considerable amounts of heavy metals to the aquatic environment through, inks, paints, plastics materials, body care products, household medicines and pesticides [8]. Heavy metals are dominant in column water in the form of dissolved colloidal and particulate phase [25]. Metals are poisonous to human and have toxic effects on plants and animals [9]. Some of them such as Zn and Cu are essential for the life processes in plants and animals, whereas many other metals like Pb and Cd have no known physiological functions [10-11]. They are serious pollutants in water because of their toxicity, persistence and can ability to accumulate in the biota species and can cause health impacts even at very low concentrations to the human body systems [12-13]. Assessment of drinking water by using some indices are very benefit tool to solve water quality related problems [14]. This study aimed to investigate the drinking water quality status with respect to heavy metal levels in Misan province by

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using eight important heavy metals were chosen for HPI estimation.

2. Material and Methods

2.1. Description of the study area

Misan province is located in southern east in Iraq on the border with Iran and has shares internal boundaries with the provinces of Basra, Wasit and Thi-Qar, so it considered one of the cities of great importance because it is wealthy in natural resources which included six districts are Ali Al-Gharbi, Al-Amara (city center), Al-Maimona, Al-Majar Al-Kabeer, Qalat Saleh and Al-Kahlaa. There are nine sub-districts are Ali Al-Sharqi, Kumait, Al-Mushrah, Said Ahmad Al-Rifai, Al-Salam, Al-Adil, Al-Khair, Bani Hashim and Al-Uzair (**Figure 1**). Misan province has a desert dry climate, cold during winters and hot during summers. Most of the people in Misan province have water treated that are supplied to residential areas for drinking purposes [15].

2.2. Sampling and analysis

Drinking water samples were collected from ten sites in Misan province **Figure 1** by using stopper fitted polyethylene bottles (500 ml capacity). Before collection, bottles have been triple-washed with distilled water and then acidified with nitric acid to a pH below two to minimize precipitation and adsorption of heavy metals on container walls .The digestion procedure for drinking water was used [16] by transferring a measured volume (50 ml) of well mixed acid conserved water specimen to a flask, then 5 ml of concentrated nitric acid (HNO_3) were added into the flask and the mixture was digested on a hot plate and in a fume hood for 30 minutes until a clear solution was seen and volume reached to about 15 to 20 ml , and then the digested solution was transferred to 100 ml volumetric flask and diluted with distilled water. The mixture made up to 100 ml mark, and then the mixture was filtered with filter paper (Whatman no. 42, 0.45 µm pore size). Then the specimens were stocked in refrigerator at a temperature 4°C until analysis. Concentrations of heavy metals (Co, Cd, Zn, Fe, Ni, Cr, Pb and Li) in water samples were determined by using Atomic Absorption Spectrophotometer (Al-1200), Aurora.

2.3. Heavy metal pollution index (HPI)

The HPI was first proposed by Mohan *et al* . (1996) [17], the HPI is a method of assessment that shows the compound influence of individual heavy metal on the total quality of water [18]. HPI is sophisticated in two steps. First step by establishing a rating scale for each selected parameter giving weightage, whereas the second step is by selecting the pollution parameter on which the index is to be based. The rating system is an arbitrarily value between 0 to 1 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 (Si) which is taken from the Iraqi standards because it is approved by the central water laboratory to assess the quality of the water used for drinking in Misan province [19]. HPI is calculated by the following equation 1:

$$HPI = \frac{\sum_{i=1}^{n}(WiQi)}{\sum_{i=1}^{n} Wi} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Wi = the unit weightage of the parameter.
n = the number of parameters considered.
Qi = the sub index of the parameter and calculated by equation 2:

$$\mathbf{Qi} = \sum_{i=1}^{n}\left(\frac{[mi-Ii]}{Si-Ii}\right)x100 \quad \ldots\ldots\ldots\ldots (2)$$

mi = the monitored value of heavy metal of parameter.
Ii = the ideal value of the parameter
Si= the standard value of the parameter.

After the completion of the results, the concentration of any pollutant was converted into HPI, the critical HPI value is 100 for drinking water. If the HPI values of water samples were greater than 100, water is not potable because of the higher HPI value causes major damage to the human health [20].

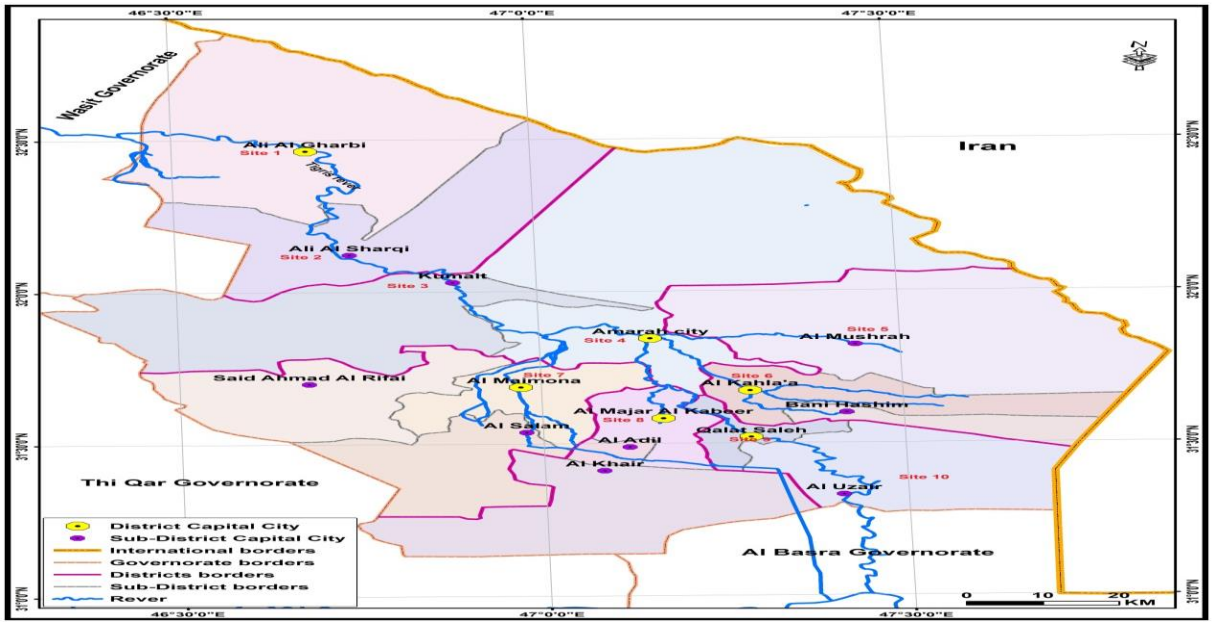


Figure (1): location map of study area.

3. Results and Discussion

In this study, the results shown that heavy metals concentrations (Co, Cd, Zn, Fe, Ni, Cr, Pb, and Li) were detected in all samples taken from different stations are given in **Table 1** and **2**. Cobalt (Co) concentrations in water samples were ranged from 0.001 to 0.85 ppb in S6 and S7 respectively. The results were showed that the values of Co for all samples were lower than the permissible Iraqi criteria limit (50 ppb) in drinking water (**Figure 2**). The values of Cadmium (Cd) were ranged between 0.007 and 0.201 ppb in S6 and S3 respectively (**Figure 3**), the concentrations of Cd in all water samples were below the permissible limits (5ppb) set by Iraqi standards [19]. Cadmium classified as toxic metal tend to accumulate with age in some organs such as the kidney and also it is considered as an agent to cause tumor and cardiovascular diseases [21]. The results of the present study revealed that the Zinc (Zn) value in water samples ranged from 0.014 to 0.104 ppb in S1 and S4 respectively (**Figure 4**). Zn is considered an essential element in our diet, but too much zinc can cause damaging to health such as damage to pancreas, anemia, vomiting and nausea specially in children [10, 22]. According to limits prescribed by Iraqi standards, all water samples were well below the permissible limits (3000 ppb). Iron (Fe) is essential element needed by body of human at low concentration and it is play major role in the hemoglobin synthesis in red blood cells [10]. The concentration of Fe ranged between 0.069 and 0.122 ppb in S1 and S7 respectively (**Figure 5**). The results were revealed that the concentrations of Fe in all water samples were far below the permissible limit (300 ppb) according to proposed standards by Iraqi government for drinking water.

The concentrations of Nickel (Ni) were varied from 0.18 to 0.208 ppb in S1 and S10 respectively (**Figure 6**). However, the levels of Ni were lower than the permissible limits (20 ppb) for drinking water according to [19]. Chromium (Cr) values in water samples were ranged from 1.376 to 4.174 ppb in S1 and S10 respectively (**Figure 7**). The results were revealed that the concentrations of Cr in all water samples were less than the permissible limit (50 ppb) for drinking water depending to proposed standards by [19]. Pb is nonessential and a toxic metal having no nutritional concentration to living organisms [23]. In current study, the concentrations of Lead (Pb) were ranged between 0.31 and 0.55 ppb in S9 and S1 respectively (**Figure 8**), these values are below the maximum permissible limit (10 ppb) recommended by Iraqi's standards) [19]. Li values in water samples were varied from 0.076 to 0.284m ppb in S2 and S6 respectively (**Figure 9**), levels of Lithium (Li) in all water samples were less than the permissible limit (5 ppb) for drinking water according to proposed standards by [19]. Heavy metal pollution index (HPI) was calculated for rating overall quality of the drinking water with regard to the total content of heavy metals. The HPI value of the current study of water specimens in ten sites were 2.49246 which was lower than 100 the standard value for drinking water (**Table 3**), this indicates the water is not critically contaminated with respect to studied heavy metals [3,5,20,24].

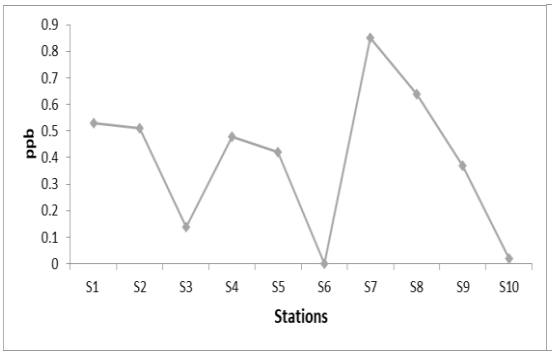


Figure (2): concentrations of cobalt (ppb) in water samples.

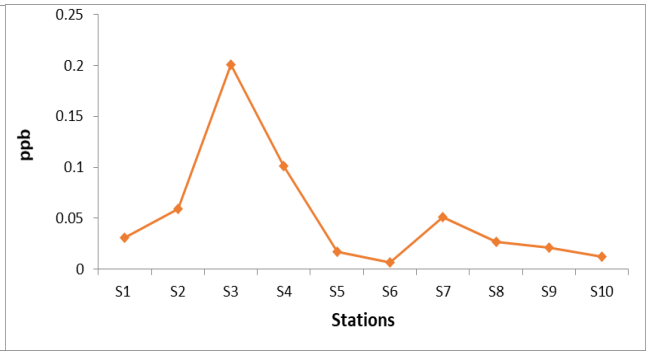


Figure (3): Concentrations of Cadmium (ppb) in water samples.

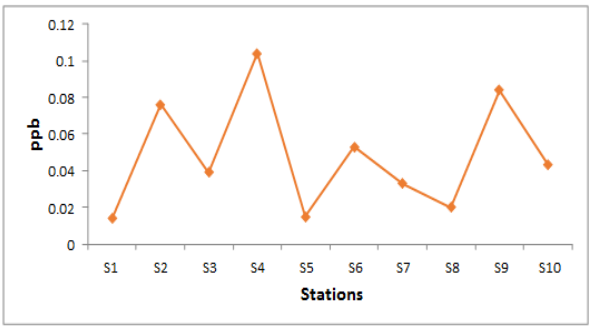


Figure (4): concentrations of Zinc (ppb) in water samples.

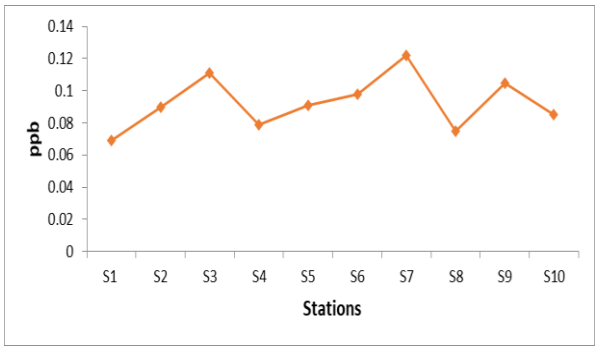
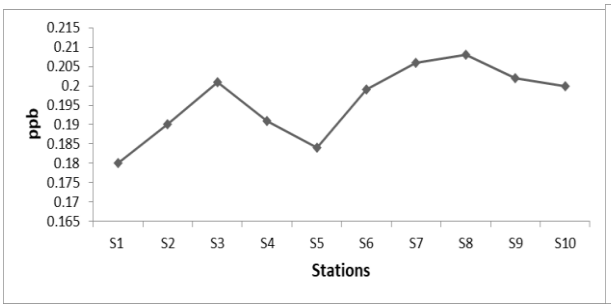


Figure (5): Concentrations of Iron (ppb) in water samples



. Figure (6): Concentrations of Nickel (ppb) in water samples.

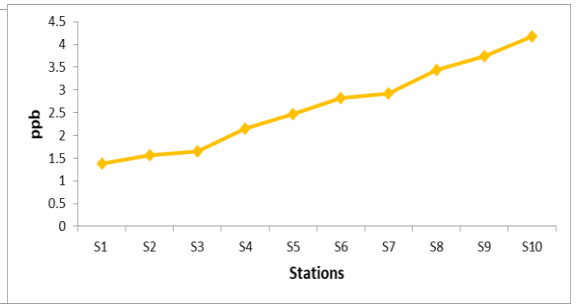
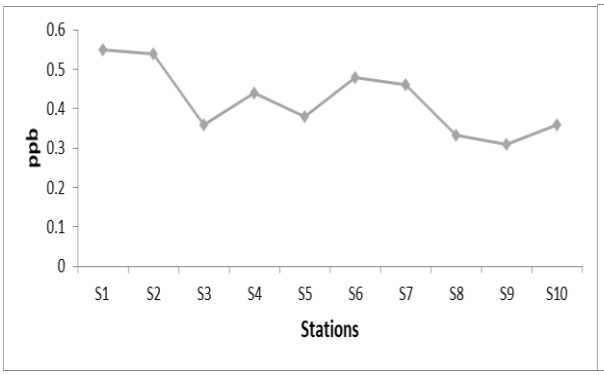


Figure (7): Concentrations of Chromium (ppb) in water samples



. Figure (8): Concentrations of Lead (ppb) in water samples.

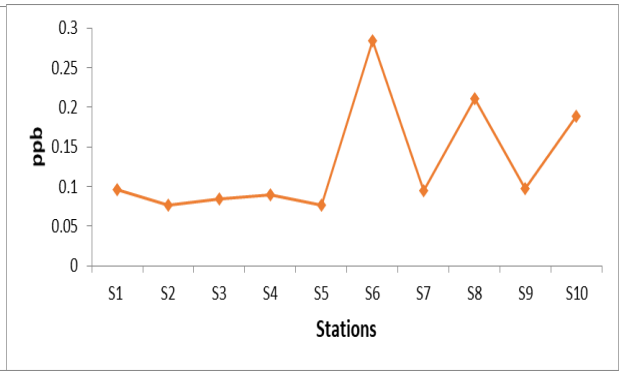


Figure (9): Concentrations of Lithium (ppb) in water samples.

Table 1
Minimum, maximum, mean and standard deviation values of heavy metals in water samples.

Metal	n	Min	Max	Mean	SD
Co	10	0.001	0.85	0.39	0.26
Cd	10	0.007	0.201	0.05	0.05
Zn	10	0.014	0.104	0.04	0.03
Fe	10	0.069	0.122	0.09	0.01
Ni	10	0.18	0.208	0.19	0.009
Cr	10	1.376	4.174	2.63	0.91
Pb	10	0.31	0.55	0.42	0.08
Li	10	0.076	0.284	0.13	0.07

Table 2
Average heavy metal concentration (ppb) in drinking water samples.

Station	Co	Cd	Zn	Fe	Ni	Cr	Pb	Li	∑wi
S1	0.53	0.031	0.014	0.069	0.18	1.376	0.55	0.096	
S2	0.51	0.059	0.076	0.09	0.19	1.572	0.54	0.076	
S3	0.14	0.201	0.039	0.111	0.201	1.656	0.36	0.084	
S4	0.48	0.101	0.104	0.079	0.191	2.15	0.44	0.089	
S5	0.42	0.017	0.015	0.091	0.184	2.466	0.38	0.076	
S6	0.001	0.007	0.053	0.098	0.199	2.826	0.48	0.284	
S7	0.85	0.051	0.033	0.122	0.206	2.917	0.46	0.094	
S8	0.64	0.027	0.02	0.075	0.208	3.437	0.33	0.211	
S9	0.37	0.021	0.084	0.105	0.202	3.747	0.31	0.097	
S10	0.02	0.012	0.043	0.085	0.2	4.174	0.36	0.189	
Si*	50	5	3000	300	20	50	10	5	
Wi	0.02	0.2	0.00033	0.00333	0.05	0.02	0.1	0.2	**0.59366**

***Iraq criteria**

Table 3
Calculation of HPI of drinking water in Misan province.

Metal	Mi (n=10)	Si	Ii	Wi	Qi	Wi*Qi	HPI
Co	0.3961	50	0.85	0.02	0.923499	0.01847	
Cd	0.0527	5	0.201	0.2	3.090227	0.618045	
Zn	0.0481	3000	0.104	0.00033	0.001863	6.15E-07	
Fe	0.0925	300	0.122	0.00333	0.009837	3.28E-05	
Ni	0.1961	20	0.208	0.05	0.060125	0.003006	
Cr	2.6321	50	4.174	0.02	3.364684	0.067294	
Pb	0.421	10	0.55	0.1	1.365079	0.136508	
Li	0.1296	5	0.284	0.2	3.273961	0.654792	
				0.59366	11.16578	1.479679	2.49246

Mi: mean concentration, Si: standard permissible value, Ii: highest value, Wi: unit weightage, Qi: sub index

4. Conclusion

According to the results, levels of heavy metals in the drinking water samples in Misan province were found lower than the permissible limit recommended by Iraqi drinking water standard [19]. Heavy metal pollution index (HPI) is very helpful tool in evaluating over all pollution of water samples with respect to heavy metals. HPI value of this study of water specimens in all sites were 2.49246 which was (HPI < 100) the standard value for drinking water indicates that the water samples from the water treated that are supplied to residential areas for drinking purposes are not polluted with heavy metals. However, it is recommended that extreme precautions should be taken for preventing the sources of drinking water pollution in the study area.

5. Acknowledgments

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6. Conflicts of interest

"There are no conflicts to declare".

7. Formatting of funding sources

Self

8.References

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