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Environmental Evaluation of the Surface Water, Ground Water and Wastewater using Pollution Indices at the Landfill Site, Southern Baiji, Salah Al-Din, Northern Iraq

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Abstract

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The current study aimed to assess the environmental risk of the municipal dump site on the quality of surface and groundwater in the city of Baiji in Salah al-Din Governorate, as 20 water samples were collected divided into three groups according to their type, 3 samples from the water of the Tigris River passing through the study area and 14 samples from water wells. Groundwater and 3 samples from the sewage drain passing through the study area. With regard to the concentrations of heavy metals, the results of the iron ion concentrations in the water samples of the Tigris River showed that they were within the permissible limit, while the percentage of 0.86 of the groundwater samples was within the permissible limit. Tigris and groundwater samples were within the permissible limit. The results of manganese and cobalt concentrations in all samples showed that they were above the permissible limit and the results of nickel concentrations in the Tigris River water samples showed that all of them were within the permissible limit, while the groundwater was 0.50 was within the permissible limit and 0.50 was above the permissible limit, while the concentrations of cadmium and zinc the device did not read them because their concentrations were below detection limit of the device. In terms of pollution of the Tigris River water and groundwater in the study area, the Heavy Metal Water Pollution Index showed that the Tigris River water samples were of medium pollution, as 0.78 of the groundwater samples were of low pollution and 0.22 of them were moderately polluted. Heavy metals results showed that the waters of the Tigris River were highly polluted, 0.78 of the groundwater samples were highly polluted, and 0.22 of them were moderately polluted and unfit for drinking according to the heavy metals assessment index. As for the degree of pollution index (Cd), it showed that the water samples of the Tigris River were of a high degree of pollution and that 0.71 of the groundwater samples were of low pollution, 0.21 of them were highly polluted and one well of medium pollution.

Keywords: Pollution indices; Water quality; Heavy pollution index; landfill site

1. Introduction

Most developing countries suffer from the problem of municipal solid waste, as it is removed in an unscientific method and placed in open places, which causes a serious danger to the surrounding environment, as it is placed in low places and close to cities without abiding by the regulations and laws

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taken to protect the environment, as the location of the landfill affects the soil and on the quality of groundwater and thus affects the surface quality because of the landfill leachate, as hydrological factors such as rain precipitation, chemical weathering of minerals, topography of the landfill area and life interactions play a key role in filtering solid waste that results from human activities on the quality of groundwater. (Mishra et al., 2019). Since water quality is the product of a hydrochemical and environmental interaction between the four main environmental components (hydrosphere, lithosphere, gaseous envelope and biosphere) and that any pollution indicator that occurs in water quality is the result of a change in the composition of the natural ecosystem and its impact is reflected on human health, living organisms and the lack of plant productivity (Abdul Hafedh, 2019). The selection of a sanitary landfill site in developed and developing countries is affected by several geological and environmental factors that are taken into consideration when designing a sanitary landfill, including topography, site geology, site hydrogeology, soil type, land uses, slope, vegetation cover, fault areas and faults, as well as engineering, economic and legal requirements for building And the construction of sanitary waste dumps, as the inability to effectively manage this waste has become an issue of great importance because a number of solid waste contain toxic organic and inorganic pollutants (such as heavy metals) that threaten human health and the entire ecosystem, hence the need for a landfill. Sanitary Waste (Ireaja et al., 2018). Landfill leachate, which is a term used to express polluted and infiltrated water into the soil, surface and ground water, resulting from rainwater accompanied by dissolved and suspended municipal waste. , which may contain potentially harmful substances (Warith, 2003), leachate can cause serious problems because it is capable of transporting pollutants that may contaminate soil, groundwater and surface water. Landfill gas, the primary gases that can be found in landfills include ammonia, carbon dioxide, methane, nitrogen and oxygen, produced from the decomposition of the organic part of municipal solid waste, methane and carbon dioxide are among the main landfill gases that are produced from waste components Biodegradable landfill organics (Ireaja et al., 2018). The aim of this study is to assess the environmental impact of the municipal landfill site on the surface and ground water southern of Baiji city using pollution indicators (Al-Hejuje, 2014). The researcher studied the evaluation of the Shatt al-Arab water and its impact on different water uses. He studied water pollution with heavy metals (Ni, Cd, Cu, Fe, Mn, Pb, Zn), and the results showed that the concentration rate of Pb, Fe, and Cd metals exceeded the permissible limits. to the specifications of the World Health Organization (WHO) (Abed, 2016). The objective of the study is to assess the environmental risk of the industrial sector, which includes the North Refineries Company, the fertilizer company, the detergent factory, the heat and gas station on the waters of the Tigris River in the city of Baiji. The surface water showed no potential health risk to adults and children from consumers and workers, whether from drinking or from skin contact, except for bromine, which poses negative effects on digestion for children (Hussain and Abdulkader, 2017) The researchers studied the pollution of surface and ground water with heavy metals resulting from the waste of the Al-Quds Electricity Station, North of Baghdad, and it was found that the amount of danger resulting from digestion of all elements except zinc is less than 1 for adults and children and therefore does not pose a threat to public health, while the results of the risk index showed the risk of skin absorption of the two elements (Zinc and manganese) for children were more than 1 and thus pose a risk to the skin.

2. The Location of the Study Area

The study area is located between the coordinates (363966 - 362038) East and (3865151 to 3863408) North, its height ranges between 111-104 m above sea level and slopes towards the river, and the height of the river level in natural conditions is within the limits of 102.8-103.5 m above sea level, about 41 km away from Tikrit, the center of Salah Governorate. The area is bounded on the east by the Tigris River and the village of Al-Ba aiji, on the west by the main road (Baiji-Mosul), on the north by

the city of Baiji, on the southeast by the village of Al-Malah, and on the south by the farm Fig. 1. The map of the study area showing on it the Tigris River, the sampling sites, the Baiji highway and the flood dam and adjacent sites.

Fig. 1. The map of the study area

3. Materials and Methods

20 different water samples were collected in the study area, which included 14 samples of groundwater wells and their symbols (GW1, GW2 and GW14), 3 samples of surface water (Tigris River) and their symbols (S1, S2, S3) and 3 Wastewater samples and their symbols (W1, W2, W3). The concentrations of heavy metals (such as iron, copper, manganese, cobalt, nickel, cadmium and copper) were analyzed in the atomic absorption spectrometer, and then the equations for heavy metal pollution

indicators (HPI), heavy metals assessment index (HMEI) and Contamination degree (Cd) were applied. on the results of analysis of heavy metal concentrations (Table 1).

4. Results

4.1. Pollution Indices

4.1.1. Heavy Metals Pollution Index (HPI)

The heavy metal pollution index is an indicator that shows an estimate of the impact of each heavy metal on water quality in general (Reza and Singh, 2010). The heavy metal water pollution index, HPI, can be calculated in three steps according to Shankar (2019) as follows:

- Determine the weight of each heavy metal.
- Determine the values of the sub-indicators.
- The sum of the sub-indices for each heavy metal is calculated using the following equation:

$$W_i = k/S \quad (1)$$

Where W_i : weight of the heavy metal, $k = 1$: proportionality constant, S_i : the permissible limit within the standards (WHO, 2017). The sub-indicators can be calculated using the following equation:

$$Q_i = \sum_{i=1}^n \frac{(M_i - L_i)}{(S_i - L_i)} \times 100 \quad (2)$$

The Q_i is a sub-index for heavy metal.

S_i : the permissible limit for a heavy metal.

M_i : The analyzed result for heavy metal in mg/L.

L_i : The ideal value for a heavy metal.

$$HPI = \sum_{i=1}^n Q_i W_i / \sum_{i=1}^n W_i \quad (3)$$

W_i : the weight of each heavy metal.

HPI is a heavy metal pollution index.

Table 1. Classification of heavy metal pollution index (HPI) according to Biswas et al. (2017)

Class	Level of pollution
< 300	Low
300_ 600	Medium
> 600	High

4.1.2. Heavy Metal Evaluation Index (HMEI)

The Heavy Metals Rating Index (HMEI) gives information about water quality for heavy metals, and the following equation is used to calculate the (HMEI) (Zakir et al., 2020).

$$HMEI = \sum_{i=1}^n HM_{Conc} / HM_{MPC} \quad (4)$$

Since HM_{con} is the measured concentration of a specific heavy metal, HM_{mpc} is the internationally permissible concentration of a heavy metal. Water was classified according to the value of the heavy metals assessment index (HMEI) (Table 4).

Table 2. The classification of water according to the value of HMEI

Level	HMEI
Low	< 10
Medium	$10 \leq \text{HMEI} \leq 20$
High	> 20

4.1.3. Contamination Degree (C_d)

The pollution index (Cd) shows the relative pollution of different heavy metals separately. The index is calculated using the following equation (Backman et al. 1998)

$$C_d = \sum_{i=1}^n C_{fi} \quad (5)$$

$$C_{fi} = \frac{CA_i}{CNI} - 1 \quad (6)$$

As C_{fi} is the pollution factor for metal i , CA_i is the measured concentration of heavy metal i , CNI is the permissible concentration of heavy metal globally, and the water was classified according to the degree of pollution by (Biswas et al., 2017) (Table 3)

Table 3. Classification of water according to the degree of pollution (Cd)

C_d	Contamination degree
< 150	Low
150 _ 300	Medium
>300	High

Table 4. Coordinates of sample sites and water tests and results of pollution indices

Sample	Easting	Northing	Fe mg/l	Cu mg/l	Mn mg/l	Co mg/l	Ni mg/l	Zn mg/l	Cd mg/l	HPI	HMEI	Cd
W1	362035	3864725	0.19	8.42	0.9	0.027	0.004	0.402	0.002	382.24	21.47	427.71
W2	362979	3864646	0.04	7.83	0.96	0.023	0.005	0.654	0.04	354.95	31.6	346.1
W3	363396	3864356	0.54	7.66	1	0.058	0.008	0.835	0.088	366.15	66.9	365.78
S1	364171	3863852	0.01	0.1	0.7	0.034	0.002	-	-	213.76	18.87	363.33
S2	363524	3863675	0.01	0.08	0.9	0.032	0.004	-	-	247.65	18.4	416.05
S3	362957	3863426	0.02	0.04	0.6	0.031	0.002	-	-	199.53	17.13	94.88
GW1	363104	3864891	0.04	0.064	0.63	0.045	0.003	-	-	257.33	24.3	451.74
GW2	362362	3863940	0.03	0.06	0.58	0.039	0.006	-	-	224.76	23.87	99
GW3	362832	3864419	0.014	0.05	0.5	0.041	0.004	-	-	241.01	21.9	99.15
GW4	362809	3865084	0.028	0.046	0.54	0.057	0.007	-	-	347.81	30.11	99.41
GW5	363570	3864912	0.02	0.037	0.62	0.029	0.005	-	-	194.66	16.24	99.63
GW6	363179	3865364	0.02	0.058	0.48	0.036	0.008	-	-	204.04	19.46	94.62
GW7	362281	3865082	0.02	0.028	0.5	0.041	0.006	-	-	246.71	21.95	97.68
GW8	362611	3864850	0.018	0.039	0.57	0.052	0.005	-	-	316.75	20.89	99.31
GW9	362998	3864875	0.027	0.02	0.46	0.039	0.007	-	-	233.84	24.57	318.73
GW10	363687	3864527	0.016	0.04	0.55	0.046	0.006	-	-	276.08	24.57	297.59
GW11	363671	3864064	0.027	0.05	0.61	0.037	0.005	-	-	222.08	44.71	437.77
GW12	363559	3864377	0.031	0.067	0.63	0.029	0.003	-	-	186.63	16.27	99.52
GW13	363894	3865372	0.019	0.052	0.52	0.043	0.006	-	-	250.59	23.01	99.4
GW14	363326	3863961	0.023	0.017	0.47	0.039	0.003	-	-	382.24	20.82	99.42

5. Discussion

The iron ion concentration ranges in the water models of the Tigris River and the two models (W1, W2) of wastewater and groundwater samples (GW2, GW3, GW4, GW5, GW6, GW7, GW8, GW9, GW10, GW11, GW13, GW14) within the permissible limits. The World Health Organization (WHO, 2017), while the two samples (GW1, GW2) had iron ion concentrations above the permissible limits due to the presence of iron oxide minerals in the sediments containing them in ground and surface

waters. The concentration of copper in the waters of the Tigris River ranges between 0.1-0.031 mg/liter and at a rate of 0.073 mg/liter, while its concentration in groundwater ranges between 0.1-0.017 mg/liter and at a rate of 0.024 mg/liter, which is within the permissible limit of the World Health Organization (WHO, 2017) of 2 mg / liter in the water samples of the Tigris River and groundwater samples, which are very low concentrations due to the presence of the sulfate ion in the region and the union of the copper ion with it or due to the adsorption processes on the surfaces of clay minerals in the study area (Al-Khalidi, 2008), while the wastewater samples were copper ion concentrations above the permissible limits (WHO, 2017). The concentration of manganese in the waters of the Tigris River ranges between 0.9-0.6 mg/liter and at a rate of 0.073 mg/liter, while its concentration in groundwater ranges between 0.63-0.47 mg/liter and at a rate of 0.547 mg/liter. The water models of the Tigris River and the groundwater and wastewater samples had manganese concentrations above the permissible limit (WHO, 2017) due to human activities and the study area was taken as a site for municipal waste dumping. The concentration of cobalt in the waters of the Tigris River ranges between 0.034-0.031 ppm while its concentration in groundwater is 0.057 -0.029 ppm at a rate of 0.041 mg / liter. The concentration of nickel in the waters of the Tigris River ranges between 0.004-0.002 ppm, while its concentration in groundwater ranges between 0.008-0.003 ppm, which indicates that the water samples of the Tigris River, groundwater models and wastewater models were within the limits Allowed according to specifications (WHO, 2017). The Tigris River water models and groundwater samples did not show results for cadmium concentrations, which indicates that the cadmium concentrations in the Tigris River water models and groundwater models in the study area are less than the limits of detection by the Atomic Adsorption Spectrum, which is 1 0.00 mg/L. The results of zinc concentration in the water samples of the Tigris River and groundwater models did not appear, which indicates that the concentrations of zinc in the water samples of the Tigris River and groundwater models in the study area are less than the detection limits of the atomic absorption spectrometer (which is 1 0.00 mg/L).

The results of the heavy metal pollution index showed that the samples (W1, W2, W3, GW4, GW8, GW14) were moderately polluted, while the samples (S1, S2, S3, GW1, GW2, GW3, GW5, Gw6, GW7, GW9, GW10, GW12, GW13, GW14) were of low pollution according to the classification of Biswas et al. (2017), the values of the heavy metal pollution index in the Tigris River water samples, groundwater samples and wastewater samples. All results of the heavy metal assessment index showed that the samples (W1, W2, W3, GW1, GW2, GW3, GW4, GW7, GW8, GW9, GW10, GW11, GW13, GW14) were highly polluted, while the samples (S1, S2, S3, GW5, GW6, GW12) average pollution according to the classification of Zakir et al. (2020). The results of the degree of pollution showed that the samples (W1, W2, W3, S1, S2, GW1, GW9, GW10, GW11).) were of a high degree of pollution, while the samples (S3, GW2, GW3, GW4, GW5, GW6, GW7, GW8, GW12, GW13, GW14) had a low degree of pollution according to the classification (Biswas et al., 2017).

The current location is not suitable as landfill. We recommend the local administration in the city of Baiji not to use the study area as a dumping ground because of its impact on the quality of ground and surface water and its various uses. Lining the sewage stream from its beginning to its downstream place in the Tigris River to ensure that sewage water does not infiltrate into the groundwater. Choosing a suitable site for dumping waste, taking into consideration all environmental, geological, engineering, climatic, economic and legal factors. Holding seminars that undertake to educate the local people to take care of the environment and to preserve the natural resources of surface and ground water, soil, rocks, minerals and vegetation cover and its impact on the health of the local population. The necessity of adhering to the legal legislation established to protect the environment.

6. Conclusions

- Iron ion concentrations in the models were within the permissible limits of the World Health Organization in groundwater and the waters of the Tigris River, while the concentrations of copper were very few in the waters of the Tigris River and groundwater compared to what was permitted by the World Health Organization.
- The concentrations of manganese and cobalt ions in the waters of the Tigris River and groundwater in all models are above the permissible limits of the World Health Organization, while the nickel ion concentrations in all models were within the permissible limits of the World Health Organization.
- The concentrations of zinc and cadmium ions were very few and less than the detection limits of the device in the Tigris River water models and groundwater models in the study area, due to the fact that the basal pH values in the water of the Tigris River and groundwater, which helped to stabilize zinc and cadmium in their minerals, were not liberated into the water.
- By applying the HPI it was found that the waters of the Tigris River were of low pollution, while 78.5% of the groundwater samples were of low pollution and 21.5% were moderately polluted, while sewage water was moderately polluted.
- The HMEI showed that the wastewater and 66.3% of the Tigris River samples and 78% of the groundwater samples in the study area were highly polluted.
- The results showed that the highly polluted wastewater according to the contamination degree of pollution index (Cd), 66.3% of the Tigris River samples were highly polluted and 28.6% of the groundwater samples in the study area were highly polluted, while 71.4% of the water samples Underground low pollution and .333%. The water samples from the Tigris River were low in pollution.

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