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RESEARCH ARTICLE

Measurement of Pollution with Heavy Metals in Water and Sediment Dalmage Lake-Middle of Iraq

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Abstract

The current study aims at determining the quality of the water and the sediments of the Dalmage Lake in terms of pollution. Where some physical characteristics and concentrations of some heavy elements were measured by three different stations from Dalmage Lake which is located in middle of Iraq between Qadisiyah and Al-Kut provinces, from September 2017 to January 2018 . The studied properties included temperature, pH, electrical conductivity and measurement of concentrations of heavy metals (cadmium, lead, copper, cobalt and iron) in the water and sediments of the Dalmage Lake. The results of the study showed that the temperature of the air is compatible with the temperature of water in all stations of the study where the temperature of air between (18 - 35.3)^{0}c and water temperature (12-25)^{0}c. The electric conductivity was recorded between (9.89 - 16.81) ms/cm and the pH values ranged from (7, 72 - 8, 16). As for the concentrations of heavy elements in the water of Dalmage Lake, the study showed that the cadmium concentration ranged between (0.034 - 0.082), lead (0,041 - 0,753), copper (0.039-0,354) Cobalt (0.050 - 0.189) and iron (0.405 - 0.490) mg / L. While in the sediment of Dalmage Lake the pH values (7, 41 - 8, 09) were the electrical conductivity (12.97 - 17.13) ms/cm and the concentrations of heavy metals were recorded for cadmium (0,093-0,010), lead (1,202 - 1,708), copper (0,180 -), Cobalt (0.157-0.521) and Iron (35,170 - 115,971) mg/L. The study showed that the water of Dalmage Lake has a basic character. This corresponds to the Iraqi water which is characterized by basal quality. The electrical conductivity is high because the water of the lake is salty, and the study showed an increase in concentration of heavy elements, this means that the lake is polluted by its because of incompatibility with values of WHO and local standards .

Keywords: *Pollution, Dalmage Lake, Heavy Metals, Sediment.*

Introduction

Many aquatic systems have been contaminated by a variety of pollutants such as organics, inorganics, and heavy metals. Contaminants can also have serious effects on human health and organisms inhabiting the surrounding ecosystems [1]. Pollution is considered as one of the most serious problems that faces human societies in the whole world especially in the developing countries. Though produced by man himself and his activities, it has deleterious effects on human's environments and resources [2].So, pollution and its effects are considered as one of man's greatest crimes against himself. Pollutants may cause primary damage, with direct identifiable impact on the environment, or secondary damage in the form of minor perturbations in the delicate balance of the biological food web that are detectable only over long time periods [3, 4]. Heavy metal is a term taken to include the metallic elements with an atomic weight greater than 40, which have specific gravity greater than 5 g / cm3. Some of heavy metals (e.g. copper, zinc, nickel, manganese and iron) are essential trace elements to living organisms and play irreplaceable roles in the functioning of critical enzyme systems, but become toxic at higher concentrations. Others, such as lead and cadmium, have no known biological function, and may be toxic even at trace levels to exposure [5].Although water analysis is useful in the assessment of rivers pollution with heavy metals, sediments can also serve as pollution indicator. The strong binding affinities of heavy metals result in low concentrations in water and high concentrations in sediments [6]. In sediments, there are six different geochemical forms of metals associated with sediments. In the first one these metals are associated with the sediment in the most

labile obtained manner; these are called exchangeable metals. The second fraction extracts are united mainly with carbonates and is highly sensitive to pH changes. In the third, the metals bonded to Mn oxide and partly amorphous Fe oxide and in the fourth one, to amorphous and poorly crystalline Fe oxide. In the fifth, the metals associated with the organic material and sulfides are released. Finally, the residual fraction, a portion of metals is strongly bonded to the lithogenic minerals of the Sediments [7].

The accumulation of heavy metals in sediments, even when present in low concentrations in the overlying water column, is dependent on various factors such as the sediment particles, the properties of the adsorbed compounds and the prevailing physicochemical conditions [8]. High metal concentrations were measured in sediments, indicating historical contamination of these areas [9]. Sediments are considered as a good reservoir sink for heavy metals in the aquatic ecosystems, and under changing environmental condition they may be release to water column by various processes of remobilization [10]. The heavy metals are important and directly link to the growth, development, and reproduction of the organisms, such as (Zn, Fe, Cu, Mn, Co) that can become toxic at high concentration or have specific biological value, while others are toxic even at low concentrations, such as (Pb, Cd, Cr, Hg & ect.) [11].

Toxic heavy metals have the ability to accumulate in the organisms through the transition to different levels of the food chain and reach to human or other organisms at the top of food chains and threaten the life of organisms and sometime causes death[12] . The most significant and natural source of heavy metals is the weathering of rocks. Also, the other sources are geological metamorphosis, soil bacterial activities, and anthropogenic influences through various domestic, industrial and agricultural activities [13].

Materials and Methods

Description of study area

Dalmage Lake is the middle part of the public estuary. In the 1950s, the lake was a shallow depression. Most of its land was both dry in summer or mud in winter and spring. After reclamation, Dalmage Lake was first used for the irrigation of al-Musayyib irrigation project, As a result of the expansion of irrigation and drainage networks in many agricultural lands in Iraq and the establishment of the public estuary, the public estuary was connected to Dalmage Lake in 1992.

At present, the Lake has been used as a reservoir for the public water of the estuary, this natural depression is used as a regulatory reservoir between the water transferred to it from the general estuary and the evaporated water and the second water to the general estuary from the other side. As a result of the storage in Dalmage Lake in reducing the discharge of water to the public downstream of the phenomenon of natural evaporation in the area where the lake and thus became a lake for the evangelism of the brightness of the great sun, which is 3350 hours / year [14]. The highest storage area of the Dulmaj dam (200km^2) is located within the Wassit and Diwaniyah reserves, while the storage capacity is 700 million cubic meters. The lake is surrounded by a 72 km long earth dam with two feeding and unloading regulators. To the lake from the estuary (northern part) 98 m^3 / s [14].

Figure 1: Pictures of study stations

Analytical Procedure

Three stations were selected along Dalmage Lake-Middle of Iraq. Sampling points were geo-located using geographical positioning system (GPS) at the following coordinates: N 59.88 9 32, E 44.84 45^0 22 (station 1); N 58.31 32^0 13 E 59.86 45^0 28 (station 2); N 46.82 32^0 13 E 14.94 45^0 13 (station 3)

Collections of Samples

Collection of Water

Representative water samples (n =40) of about 1 liter were collected from the sampling sites in polypropylene 500ml cleaned bottles. At the sampling time, these bottles were also washed with the respective river water. The samples were collected below the surface about 2-3 feet away from the river banks in such a way that no bubbles were allowed. These water samples were filtered and preserved in 5 ml of 55% HNO_3 per liter of water to prevent metal adsorption on the inner surface of the container and stored at 4◦C before their analyses [15].

Collection of Sediments

50 g sediment samples (n = 10) were collected from a depth of 15 cm from the surface from each site, using a sediment collector with an acid washed plastic scoop and transported to the laboratory in polyethylene bags. They were dried and passed through a 2mmsieve [15].

Analysis of Samples

Temperature, hydrogen potential (pH) and electrical conductivity were measured at the time of sample collection. PH was measured with the Portable pH-meter field, the type (HANNA (MX-645), and conductivity with conductivity meter, type (WTW cond 330i / SET). The temperature was measured by an integrated thermometer in the measurement of conductivity and pH-meter**.**Water samples were collected in the morning between 6:00am, to 9:00 am). Surface water samples were collected in the study stations from the upper 30 cm and 2-4 m from the riverbank. Two liter polyethylene bottles were used, each was pre-washed by river water, soap solution, distilled water and, 1% nitric acid [16]. Dried sediment of one gram was taken in a flask to which 20 ml of analytical grade tri acid (HNO3: H2SO4: HCLO4: 14:1.5:4.5) was added and heated in a chamber till complete digestion of the sediment samples. Following the digestion, the sample was allowed to cooldown and then it was filtered to a 100-ml volumetric flask, distilled water was used to make the volume up to 100 ml of the filtrate. These samples were then used for the analysis of heavy metals using atomic absorption spectrophotometer (AAS) [17].

Results and Discussion

Temperature

Temperature is one of the most important environmental factors because it affects the presence of organisms in the aquatic environment as well as their effect on physical and chemical properties in water [18]. The lowest air temperature values of 18^{0}c were recorded at station 2 in January, while the highest values at station (3) were 35.3^{0}c in September, while the water temperature recorded the lowest value of 12^{0}c at station (2) in January While the highest values at station (3) of 25^{0}c in September, the fluctuation in water temperature of the river depends on the separation, geographical location, sampling time and the degree of flow into the river [19].

PH

The results showed that the lowest PH value of the water of Dalmage Lake at the second station, amounted to 7.72 in September,

while the highest value in the third station for the month of January, which amounted to 8.16, This increase in the value of pH to the low temperature and low concentration of the second Carbon dioxide, high dissolved oxygen values and base ions [20] while their decrease is due to high temperature, low dissolved oxygen values, organic matter degradation and carbon dioxide release [21]. In the Dalmage Lake precipitation, PH values also recorded mild base values, with the lowest values of 7.41 at the first station for September, while the highest of 8.09 at the third station during the month of January, where the values were relatively high in January due to low concentration of bicarbonate In sediment and relatively low during September because of the high concentration of bicarbonate in September.

Electrical Conductivity

The results showed that the highest value of electrical conductivity at the third station was 16.81 ms / cm during September, while the lowest electrical conductivity recorded at the first station was 9.89 ms / cm in January. The rise in the month of September due to the impact of severe dust storms and increase the rates of dry fall to the surface water sources and increase the concentrations of salts, especially calcium salts and chlorides [22], which led to an increase in the rates of EC, which increases the increase of TDS concentrations[23], The value of electrical conductivity decreased during December, due to the increase in water levels and precipitation in that period, as it reduces the amount of soluble salts relative to the volume of water, as well as the amount of salts added by the erosion of soil caused by the fall of rain[24], either.

The results showed that the highest value of electric conductivity was recorded in the third station, reaching 17.13 ms / cm for September and the lowest value recorded in the second station, which amounted to 12.97 ms/cm high values for September due to the decrease solubility of sediments in the sediments due to the drop in water levels Lal this season, while values decline in the month of January attributable to rising water levels, which works to increase the amount of salt that can melt sediment in the water.

Table 1: the physical variable of the water of Dulmaj Lake

Month / physical variable	September			January		
	station 1	station 2	station 3	station 1	station 2	station 3
T (^{0}c)	23.9	22	25	14	12	14.5
PH	7.84	7.72	7.75	8.15	8.15	8.16
EC (ms/cm)	10.63	12.76	16.81	9.89	11.04	13.16

Table 2: the physical variable of the sediment of Dulmaj Lake

Month / physical variable	September			January		
	station 1	station 2	station 3	station 1	station 2	station 3
PH	7.84	7.72	7.75	8.15	8.15	8.16
EC (ms/cm)	10.63	12.76	16.81	9.89	11.04	13.16

Heavy Metals

Cadmium (Cd)

The results showed that the highest value of cadmium in the water of Dalmage Lake recorded 0.082 mg / L in the third station during September, while the lowest value in the first station during the month of January amounted to 0.034 mg / L. The water of Dalmage Lake is contaminated with toxic cadmium. Resulting from the widespread use of fertilizers and pesticides in agricultural areas adjacent to Lahore, as well as the depletion of water from cadmium pollution in industry and the heavy dumping of heavy water in the Tigris River without treatment, which in turn flows into Dalmage Lake. The study showed a decrease in the month of January and its rise in September, due to the mitigation factor caused by the increase in rainfall for the month of January and the high temperatures in September leads to evaporation and then increase the concentration of cadmium [25].In the sediment, the highest value was recorded in the second station during the month of September and amounted to 0.210 mg / L while the lowest value recorded 0.093 mg / L in the first station in January, due to the rise in September because of the base of water

during the month, Iron hydroxides have a positive effect on cadmium deposition.

Lead (Pb)

The results of the study showed that the highest value of lead in the water of Dalmage Lake was recorded in the third station during the month of January at 0.753 mg / L while the lowest value recorded in the first and third stations was 0.241 mg / L during the month of September and the reason for the high values during the month of January This is due to the effect of rain, which works on washing sources of pollution from air, soil and container to high concentrations of lead and its shelf to the marshes[26]. The reason for the lack of concentration of lead in water may be due to its accumulation in phytoplankton, zooplankton, plants and other aquatic organisms, or because of its absorption on sediment surfaces or the formation of complexes with organic matter [27].

In the sediment of Dalmage Lake, the highest value of lead in the second station in January was 1.708 mg / L and the lowest value was 1.202 mg / L at the third station in September, the results showed that the concentration of heavy elements in the sediments is higher than in the dissolved state Which can be added to the sediment layer in addition to adsorption on the surfaces of organic matter and clay grains. A The current study found that water marsh during the study period was characterized by clear base, which may make it effective in increasing the concentration of elements in the sediment[28].

Copper (Cu)

The results of the study showed that the highest value of copper in the water of Dalmage Lake was recorded in the second station during the month of January at 0.354 mg / L while the lowest value recorded in the second station was 0.039 mg / L during September, the increase in copper concentration due to the use of copper in Agricultural products, soya and soya [29]. In the sediment of Dalmage Lake, the highest value of copper at the third plant in January was 0.396 mg / L and the lowest value was 0.180 mg / L in the first station in September, the decline of copper concentration may be due to the correlation with many simple and complex primary metals.

Cobalt (Co)

The results of the study showed that the highest value of cobalt in the water of Dalmage Lake was recorded in the third station during the month of September at 0.189 mg / L while the lowest value recorded in the second station was 0.050 mg / L during the month of January, the high concentration of cobalt during September To higher temperatures that increase evaporation and thus increase concentration. In the sediment of Dalmage Lake, the highest value of cobalt in the second station was recorded in September and amounted to 0.521 mg / L and the lowest value was 0.157 mg / L at the first station during the second month of March. The increased concentration of the cobalt element in the sediment is influenced by several factors: soil origin and composition, as well as by human activities, as well as the effects of sewage and spills [30].

Iron (Fe)

The results of the study showed that the highest value of iron in the water of Dalmage Lake recorded in the third station during the month of September, amounted to 0.490 mg / L while the lowest value recorded in the first station was 0.405 mg / L during the month of January, the rise in iron values in September may be Because of the microorganisms found in marsh water that use organic waste and the remnants of decaying plants in the water, iron oxidation and reduction is involved as a source of energy that may cause the release of iron ions into water [31] or due to water levels due to water evaporation and thus increase the concentration of iron ions. In the sediment of Dalmage Lake, the highest value of lead in the second station in September was 115.971 mg / L and the lowest value was 35.170 mg / L in the first station during the month of January, the increase in the value of iron during the month of September is due to the element is a complex with different compounds Including sulphates, chlorides, hydroxides, phosphates, nitrates and carbonates due to the low value of pH [32].

Under anaerobic conditions, iron is associated with sulfur, a component of ferrous sulphide, which increases the bonding and deposition of certain heavy elements in sediments such as copper and lead. In some locations the sediments were black. As well as the process of adsorption has a direct impact in the exchange of heavy

elements between the dissolved state and solid state. In addition, the concentration of the iron element in the sediment may be affected by erosion, erosion, wind, groundwater leakage and different speed of current [33]. All of which may be due to the addition of a new layer to the sediments may be loaded with high concentrations of the element or may lead to increase the surface area of the absorption of the element[34].

Table 3: Concentrations of heavy elements in the waters of Dalmage Lake during the study period in mg / L units

month / element	September			January		
	station 1	station 2	station 3	station 1	station 2	station 3
Cd	0.055	0.050	0.082	0.034	0.043	0.052
Pb	0.241	0.468	0.241	0.578	0.578	0.753
Cu	0.052	0.039	0.079	0.329	0.354	0.215
Co	0.119	0.105	0.189	0.076	0.050	0.103
Fe	0.426	0.447	0.490	0.405	0.426	0.426

Table 4: Concentrations of heavy elements in the sediment of Dalmage **Lake during the study period in mg / L units**

month / element	September			January		
	station 1	station 2	station 3	station 1	station 2	station 3
Cd	0.127	0.210	0.142	0.093	0.193	0.120
Pb	1.212	1.501	1.202	1.309	1.708	1.309
Cu	0.180	0.188	0.197	0.327	0.378	0.396
Co	0.194	0.521	0.297	0.157	0.514	0.238
Fe	51.964	115.971	61.466	35.170	78.190	50.278

Table 5: Global and local standards for concentrations of heavy elements studied for drinking water compared with current study in mg / L units

Element	WHO 2017	Iraqi determinants 2001	The current study 2018-2017
Cd	0.005	0.003	0.082
Pd	0.05	0.01	0.753
Cu	1	1	0.354
Co	0	0.05	0.189
Fe	0.3	0.3	0.490

The results of the present study of the water of Dalmage Lake recorded high concentrations of cadmium, lead, cobalt and iron to be inconsistent with international and Iraqi standards, which confirms that the water of the lake is contaminated with heavy elements, its water is considered unsuitable for human drinking and the high concentrations of these elements make it accumulate in aquatic plants and animals. To the death of most aquatic organisms

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