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RESEARCH ARTICLE

Assessment of Water Quality in the Selected Sites on the Tigris River, Baghdad-Iraq

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Abstract

The monitoring of water quality of Tigris River was carried out during July to December 2013. Ten sampling sites were selected. Raised values of physico-chemical parameters indicate the pollution of Tigris River ecosystem as a result of domestic wastes, municipal sewage, industrial effluent and agricultural runoff that influence the water quality directly or indirectly. Cluster analysis was used to identify the similarity groups between the sampling sites based on the heavy metals concentration. It can be concluded that urbanization, city wastewater and human activates are the most important reasons of deteriorating water quality of Tigris River which are increasing in trend from north to south.

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1. Introduction

Water scarcity is increasing worldwide and pressure on the existing water recourses is increasing due to the growing demands in several sectors such as, domestic, industrial, agriculture, hydropower generation, etc. [1]. It is reported that the availability of water in Iraq shows a great deal with spatial and temporal variability, and suffered of remarkable stress in terms of water quantity due to the dams built on Tigris and Euphrates in the riparian countries, the global climatic changes and the local severe decrease of the annual precipitation rates [2]. For the time being, deteriorating water quality is a serious threat in countries with a scarcity of water resources. Therefore, sustainable use of water resources requires continuous monitoring and assessment programs [3].

The quality of water required to maintain ecosystem health is largely a function of natural background conditions. Some aquatic ecosystems are able to resist large changes in water quality without any detectable effects on ecosystem composition and function, whereas other ecosystems are sensitive to small changes in the physical and chemical makeup of the water body and this can lead to degradation of ecosystem services and loss of biological diversity [4].

Contamination of water has been frequently found associated with transmission of diseases causing bacteria, Vibrio, Salmonella, bacterial and parasitic dysentery, and acute infection diarrhea causing E. coli [5]. It is reported that drinking water is a major source of microbial pathogen and considered to be one of the main reasons for increased mortality rates among children in developing countries [6]. However, comprehensive evaluations of microbial quality of water require survey of all the pathogens that have potential for human infections [7].

In recent years there have been increasing interests regarding heavy metal contaminations in the environments, apparently due to their toxicity and perceived persistency within the aquatic systems [8].

Tigris River receives many pollutants when it is passing through Baghdad City, due to many human activities and factories which have been discharged their wastewater into the river without any real treatments. It has been for that reason, Tigris River used as a sink for wastes from agricultural, industry and other human activities due to its flow and ecological nature, Therefore, the objective of this research was to assess the microbiological and physicochemical quality of the Tigris River water in the selected sites within Bagdad City.

2. Materials and Methods

2.1 Description of the study area

The study area (Tigris River within Baghdad city) (Figure 1) is located in the Mesopotamia alluvial plain between latitudes 33°14'-33°25' N and longitudes 44°31'-44°17' E. Tigris River is one of the most important twin rivers in Iraq, sharing with Euphrates River as the main sources for human use, especially for drinking water since they cross the major cities in the country. However, Tigris River is the source of drinking water for Baghdad city also used for the cultivation purpose. The river divides the city into a right (Karkh) and left (Risafa) sections with a flow direction from north to south. The area is characterized by arid to semi arid climate with dry hot summers and cold winters; the mean annual rainfall is about 151.8 mm [1].

Figure 1: Sampling locations across Tigris River, Baghdad City

2.2 Samples collection and preservations

Water samples were collected from ten sites on the Tigris River. Water samples were bimonthly collected during July 2013 to December 2013 in stopper fitted polyethylene bottles that prewashed with dilute hydrochloric acid and then rinsed several times with distilled water. Before filling those with water samples the polyethylene bottles rinsed several times with the river water sample before filling them. These samples were stored at a temperature below 4℃ prior to analysis in the Environmental Research Center laboratories.

2.3 Samples analysis

Samples were analyzed for physco-chemical microbiological properties immediately after collection. These parameters are pH value, Salinity, Total Dissolved Solids, Hardness, Calcium, Magnesium, Chloride, and Dissolved heavy metals (Cd, Cr, Cu, Pb, Fe, Mn, Ni, and Zn). Conductivity (EC) and pH were directly measured in situ using portable measuring devices (HANNA instruments, HI9811, portable pH-EC-TDS meter, Italy). Note that before each measurement, the pH meter was calibrated with reference buffer solution. Each analysis was carried out in triplicate and then the mean value was taken. Procedures followed for analysis have been in accordance with the Standard methods for examination of water and wastewater [9].

3. Results and Discussions

The results are demonstrated by the values and of the physco-chemical parameters of Tigris River water as compared to the Iraqi drinking water standards (IQS/417) [10] and rivers maintaining system and general water from pollution (Law 25/1967) [11] are presented in Table 1. An explanation of the observed characteristics follows in the following sections.

3.1 Hydrogen ion activity (pH)

pH is an important parameter which is important in evaluating the acid-base balance of water [12]. The values of pH vary from 7.9 to 8.3 indicating that the river water is almost neutral to sub-alkaline in nature. The observed values show an agreement with pH values of surface water which lie within the range of 6.5 to 8.5 [12].

The observed values suggest that all water samples are within the Iraq drinking water standard [10] and recommended value for rivers maintaining system and general water from pollution [11].

3.2 Total dissolved solid

The values of total dissolved soiled (TDS) vary from 300 to 360 mg/L. Dissolved Solids in natural water are usually composed of the sulfate, bicarbonate and chloride of calcium, magnesium and sodium [1]. The result showed that TDS values are in the permissible level recommended by Iraq drinking water standard [10] and recommended value for rivers maintaining system and general water from pollution [11]. Primary sources for TDS in receiving waters are agricultural and residential runoff, leaching of soil contamination and point source water pollution discharge from industrial or sewage treatment plants [13].

3.3 Hardness

Hardness is very important parameter use to determine and control the quality of drinking water. This is especially true for drinking water plants which add lime to promote softening and coagulation. However, the observed results indicated that the concentration of total hardness in Tigris River are within the allowable limits recommended by Iraq drinking water standard [10] and recommended value for rivers maintaining system and general water from pollution [11].

3.4 Calcium and magnesium

The results indicate that Ca has been the dominant cation. However, for Calcium ion, with exception of observed values in the sites 3, 4 and 6, the other water samples have displayed lower values than the allowable limits recommended by Iraq drinking water standard [10], while the concentration of magnesium has been observed to be lower than Iraq drinking water standard [10].

3.5 Chloride

Chloride is one of the most important parameter in assessing the water quality, and the higher concentrations of chlorides indicate higher degree of organic pollution from sewage and industrial waste [9]. The chloride concentration varies between 59.98 - 129.96 mg/L, and still much lower from the allowable limits (250 mg/L) recommended by Iraq drinking water standard [10]. It is reported that high concentration of chloride can occur near sewage and irrigation drains, and makes water unpalatable and unfit for drinking and livestock watering [14].

3.6 Heavy metals

Heavy metals occur in the environment naturally and are released during anthropogenic activities. However, the monitoring of water quality is very important in rivers that are affected by pollutants discharge from cities, atmospheric precipitation and industrial domestic sewage that represent the major source for water pollution [15]. A brief discussion about individual metals follows:

Cadmium: Cd is generally present in the environment at low levels; however, human activity has greatly increased those levels. It can travel for a long distances from the source of emission by atmospheric transport [16]. The concentration of Cd in Tigris river water sample was found to be in the range of 2.34-3.87 µg/L. However, The results indicated that the mean concentration of dissolved cadmium in the present study within the recommended value for rivers maintaining system, while with exception of site 7 and 8, other water samples have displayed higher values than the allowable limits recommended by Iraq drinking. The reason increasing of concentration of Cd in these study sites may be related to the sewage, industrial and the agricultural activities [17].

Chromium: Chromium is used to call as metal with two faces, that it can be either beneficial or toxic to animals and humans depending on its oxidation state and concentrations [18]. Industrial activities e.g. metal plating, anodizing, dyes, pigments, ceramic; glues, tanning, wood preserving and textiles are reported to contribute Cr [19]. With some exceptions concentrations over the maximum acceptable level for dissolved Cr in drinking water (50µg/L), according to the Iraqi standard [10] and recommended value for rivers maintaining system and general water from pollution [11], were found in Tigris river water.

Copper: The Cu concentration in the Tigris river water varies from 15.6-40.5 µg/L. The observed values of Cu in this study have been within the allowable limits recommended by Iraq drinking water standard [10] and recommended value for rivers maintaining system and general water from pollution [11].

Lead: Lead is one of the oldest metals known to man and is discharged on the surface water through paints, solders, pipes, building material, gasoline etc. [20]. Pb value varied from 13.3 to 36.9 µg/L. The Pb value of the different sites of river water samples were found above the Iraqi permissible limit of drinking water (10 µg/L) [10], and within the recommended value for rivers maintaining system and general water from pollution [11]. Lead is a well known metal toxicant and it is gradually being phased out of the materials that human beings regularly use. Combustion of oil and gasoline account for > 50% of all anthropogenic emissions, and thus form a major component of the global cycle of lead [20].

Iron: The Fe concentration in the Tigris river water varies from 197.4-257.1 µg/L. The observed values of Fe in the study sites have been within the allowable limits recommended by Iraq drinking water standard [10] and recommended value for rivers maintaining system and general water from pollution [11].

Manganese: The Mn concentration in the Tigris river water varies from 43.0-95.2 µg/L. The observed values of Mn in the study sites have been within the allowable limits recommended by Iraq drinking water standard [10] and recommended value for rivers maintaining system and general water from pollution [11].

Nickel: The Ni concentration in the Tigris river water varies from 15.9-38.4 µg/L. The observed values of Ni in the study sites have been within the allowable limits recommended by Iraq drinking water standard [10] and recommended value for rivers maintaining system and general water from pollution [11].

Zinc: The Mn concentration in the Tigris river water varies from 43.0-95.2 µg/L. The observed values of Mn in this study have been within the allowable limits recommended by Iraq drinking water standard [10] and recommended value for rivers maintaining system and general water from pollution [11].

From the foregoing discussions on heavy metals, it can be concluded that Cd, Cr and Pb have elevated concentrations in the river water samples. Further, the results of this study showed that elevated heavy metals concentrations in water samples decreased according to the rank order of metals Pb> Cr> Cd. However the main sources of pollution of the Tigris River may be related to urban, agricultural, and industrial wastewaters.

Cluster analysis was applied on the heavy metals data of the ten selected sites of the Tigris River to identify inter- relationships and discover different sub clusters within the water quality that might help us to explain how the water quality is affected by the course of the river through the city.

The cluster analysis was carried out applying Ward's method, using Squared Euclidean Distance as a measure of similarity. Ward's method was chosen for this purpose as it aims to minimize the loss of information at each step in the clustering process [21]. The results of cluster analysis for the heavy metals data are illustrated with a tree dendrogram (Figure 2). It is clear that the heavy metal results of this study divided the sites on Tigris River into four separate sub-clusters. Sites 1 and 2 which they are situated at upstream combined with site number 8 to form the first sub-cluster, while sites 3, 4, 5, 6 and 8 which they are to be found at the midstream forms the second sub-cluster. Finally sites 9 and 10 which they are located at downstream forms the third sub-cluster. Similar finding were reported by Al Obaidy et al. [1]. It can be concluded that city wastewater and human activates are the most important reasons of deteriorating water quality of Tigris river which are increasing in trend from north to south. This comes in accordance with the findings of Fulazzaky [22] and Ouyang [23] who referred to these factors are the main reasons for deteriorated water quality in the urban areas.

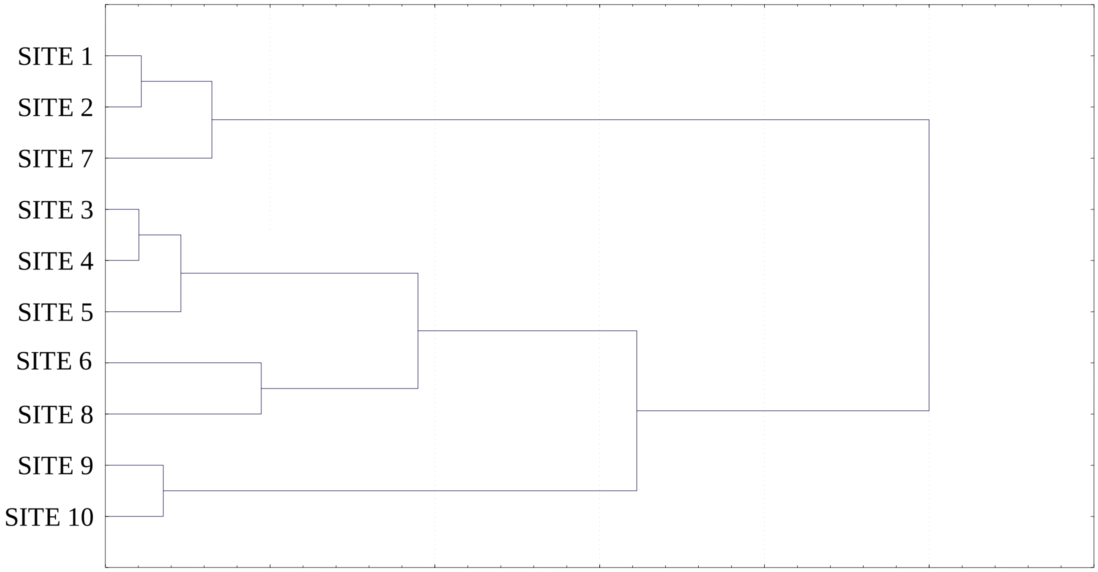

Figure 2: Dendrogram obtained using ward's method for heave metals data

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. **Table 1: Water quality data of selected sites on the Tigris River as compared to the Iraqi drinking water standards (IQS/417) and rivers maintaining system and general water from pollution (Law 25/1967)**

Parameters	**Sites**											**IQS/417 [10]**	**Law 25/1967 [11]**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	All river sites mean values		
pH Value	8.3	8.1	8.1	8.2	8.1	8.1	8	8.1	8.1	7.9	8.1	6.5-8.5	6.5-8.5
TDS (mg/L)	330	340	360	340	340	350	340	340	300	300	334	1000	----
Hardness (mg/L)	320	330	400	390	370	340	300	340	350	360	350	500	----
Ca (mg/L)	36.1	48.1	56.1	54.1	38.1	52.1	42.1	46.1	40.1	48.1	46.1	50.0	----
Mg (mg/L)	28.9	28.5	43.56	41.62	40.66	39.96	22.6	41.4	45.31	45.7	37.821	50.0	----
Cl (mg/L)	89.97	79.9	119.9	109.9	109.97	129.96	59.98	79.97	109.97	79.97	96.949	250	200
Cd (µg/L)	3.62	3.41	3.12	3.04	3.21	3.20	2.34	2.71	3.87	3.11	3.163	3.0	5.0
Cr (µg/L)	56.0	41.3	54.8	59.9	63.4	64.6	37.6	72.0	37.6	33.6	52.08	50.0	50.0
Cu (µg/L)	17.1	15.6	19	17.1	20.5	25.6	21.8	37.3	40.5	37.1	25.16	1000	50.0
Pb (µg/L)	18.5	13.3	28.7	26.3	28.7	23.5	24.1	35.9	32.6	36.9	26.85	10.0	50
Fe (µg/L)	218.2	236.4	231.2	253.2	197.4	257.1	215.6	236.4	280.5	245.5	237.15	300	300
Mn (µg/L)	47.8	63.7	43.0	62.2	78.9	81.3	95.2	80.0	86.5	83.2	72.18	100	100
Ni (µg/L)	15.42	14.0	17.49	12.6	13.08	18.31	21.0	15.76	17.04	19.42	16.412	20.0	100
Zn (µg/L)	33.0	29.9	27.5	38.4	29.9	32.6	15.9	20.7	35.0	30.6	29.35	3000	500