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RESEARCH ARTICLE

Application of Water Pollution Index for Assessment of Tigris River Ecosystem

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Abstract

Physical and chemical parameters and the concentrations of Cd, Cr, Cu, Ni, Pb and Zn were investigated for water quality assessment of Tigris River, Iraq. With exceptions of Cr and Pb the investigated heavy metals were observed to be within the recommended value for rivers maintaining system and general water from pollution. The results of Pollution index (PI) suggest that the site 3 located in the downstream is more seriously polluted by heavy metals than other sites, attributed to the feeding river input and this site is considerably affected by Different anthropogenic activities.

INTRODUCTION

Rivers have always been the most important freshwater resources, along the banks of which ancient civilizations have flourished, and most developmental activities are still dependent upon them. However, changes in river water quality are mainly the result of human activities that would discharge water pollutants. The highest water quality is typically found upstream, while the most degraded is found in the downstream areas [1]. Huge loads of waste from industries, domestic sewage and agricultural practices find their way into rivers, resulting in large scale deterioration of the water quality [2].

Pollution of rivers and streams has become one of the most crucial Environmental problems [3]. Increasing water pollution causes not only the deterioration of water quality, but also threatens human health and the balance of aquatic Eco- systems, Economic development and social prosperity [4].

Heavy metals are the most common environmental pollutants, and their occurrence in water ecosystem indicates the presence of natural or anthropogenic sources [5], which can have a serious impact on plants and animal life [6].

Physico-chemical characteristics are very important water quality monitoring parameters due to their instability once water is extracted from its source. Knowledge of physico-chemical parameters provides information on the productivity of water resource, type of water treatment process to be adopted and permit better understanding of the ability of populations of organisms to survive in them [7].

The aim of present work was to investigate Physico-chemical parameters and determine the distribution and concentration of certain heavy metals (Cd, Cr, Cu, Ni, Pb and Zn) in the Tigris river water to assess the degree of heavy metals contamination by pollution index in the Tigris River.

2. Materials and Methods

2.1 Study area

The Capital of Iraq Baghdad City (33°14'-33°25'N, 44°31'-44°17'E), is located in the Mesopotamian alluvial plain. Tigris River divides the city into a right (Karkh) and left (Risafa) sections with a flow direction from north to south. In the current research three sites along Tigris River were chosen in order to estimate the heavy metals distribution **(Figure 1).** Site 1 was located upstream, while site 2 was situated in the midstream and the site 3 was located at the downstream.

2.2 Sample collection, preparation and analysis

Water samples were taken from the selected sites during November 2013 to June 2014. The water samples were collected from the subsurface layer (at depth 50 cm) in polyethylene bottles. The samples were brought back to the laboratory of Environmental Research Center, University of Technology**.** Water samples were Filtered using Whatman filter paper (0.45 µm pore size) for estimation of dissolved metal. These water samples were preserved with 1 ml nitric acid to prevent the precipitation of metals. Analysis of dissolved heavy metal was performed with a flame atomic absorption spectrophotometer (AA6300, Shimadzu, Japan). Physical and chemical analyses were carried out according to Standard Methods for Examination of Water and Wastewater [8] (Hydrogen Ion Concentration (pH), Electrical Conductivity (EC: µS/cm), Dissolved Oxygen (DO: mg/L) and Water turbidity (Turb: NTU) were measured in each site by using a portable pH, EC, DO and Turbidity meters. While air and water temperature (Temp: °C) were measured by using mercury thermometer 0-100°C. All devices were calibrated before the use.

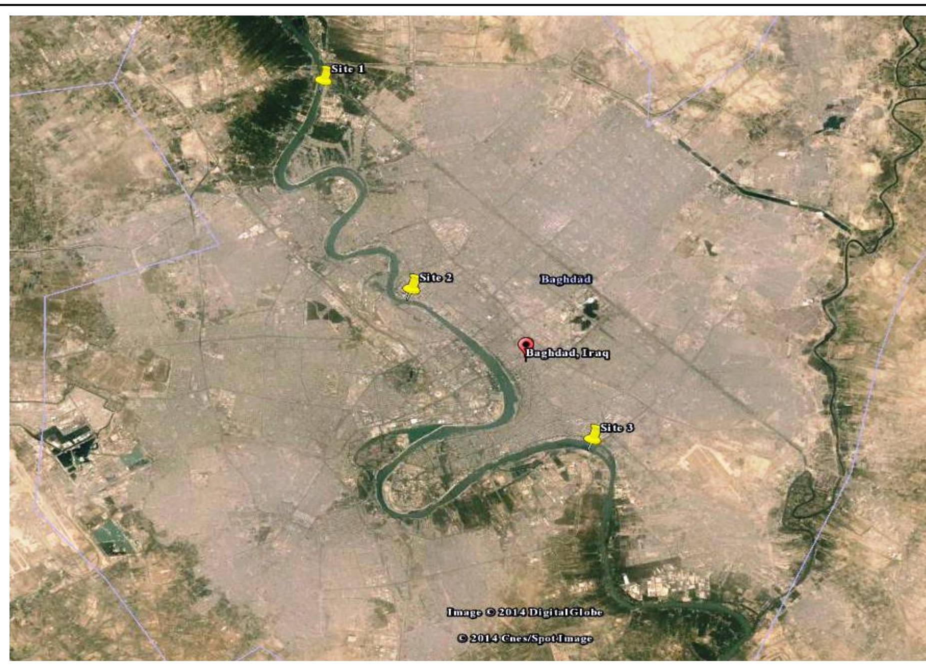

Figure 1: Sampling locations across Tigris River, Baghdad City

3. Results and Discussion

3.1 Physico-Chemical Characteristics

A summary of the physic-chemical parameters of Tigris River water were shown in Table 1. An explanation of the observed characteristics follows in the following sections.

Temperature: Temperature affects the speed of chemical reactions, the metabolic rate of organisms, as well as how pollutants, parasites and other pathogens interact with aquatic residents [9]. The fluctuation in river water temperature usually depends on the season, sampling time and temperature of effluent entering the stream [10]. As given in Table 1. Air temperature varied from 17.90 to 41°C while the water temperature value varies from 11.70 to

25.50 ^{O}C. The results showed that the highest values of water and air temperature were observed during summer and the lowest values were observed during winter [11].

PH: is used as an indicator of alkalinity or acidity of a substance and affects many chemical and biological processes in the water. For example, low pH can allow toxic elements and compounds to become mobile and available for uptake by aquatic plants [12]. It was observed that range of pH varies from 7.80 to 8.70 which indicated neutral to sub-alkaline could be related to photosynthesis and growth of aquatic plants, where photosynthesis consumes CO_2 leads to arise in the pH values. However, the natural water tends to be alkaline because of the carbonates and bicarbonates [13].

Turbidity: Turbidity is the measure of fine suspended matter in water, mostly caused by colloidal particles such as clay, silt, non-living organic particulates, plankton and other microscopic organisms, in addition to suspended organic and inorganic matter. Turbidity values ranged between 6.64-37.20 NTU. The results showed that the highest value of turbidity has been observed during summer and the lowest value has been observed during winter.

Dissolved Oxygen (DO): DO is required for the metabolism of aerobic organisms and it influences organic decomposition. DO was ranged from 7.79 to11.35 mg/L. The results showed that the concentration of dissolved oxygen in Tigris river water raising in winter this may be due to the increase aeration because of rainfall, in addition to the decrease of temperature in winter that increase the oxygen solubility [14], while decreasing in the dissolved oxygen rates in summer this may be due to the raise of temperature will result in a decrease in the concentration of dissolved oxygen [15].

Electrical Conductivity (EC)**:** EC values ranged from 806 to 1940 µs/cm. High EC values were recorded during winter season, while the lowest EC values were found during spring and summer season. The types of salts (ions) causing the conductivity usually are chlorides, sulphates, carbonates, sodium, magnesium, calcium, and potassium [16].

3.2 Heavy Metal Contents

Analysis values of heavy metals are given in Table 2. The order of the mean concentrations of examined heavy metals: Cr>Pb>Zn>Ni>Cu>Cd. The range of the six heavy metals were: Cd (ND-6.80), Cr (130.3-485.2), Cu (ND-43.8), Ni (ND-80.2), Pb (ND-465.4) and Zn (ND-96.7).

With exceptions of Cr and Pb, the average concentration of Cd, Cu, Ni and Zn for all selected sites in the Tigris River within the permissible limit for Iraqi standards of river water [17].

Table 1: The physical and chemical parameters in the Tigris river water

Parameters	Site 1			Site 2			Site 3		
	Min	Max	Mean±SD	Min	Max	Mean ±SD	Min	Max	Mean ±SD
Air Temp. ^{O}C	19.40	41.00	30.20±15.27	17.90	37.00	25.33±8.18	18.10	40.00	24.65±10.35
Water Temp. ^{O}C	11.70	24.60	18.25±5.50	11.72	25.50	18.43±5.86	12.80	24.30	18.25±5.1
pH (standard unites)	8.10	8.40	8.28±0.13	7.80	8.70	8.23±0.44	8.00	8.40	8.13±0.19
Turbidity (NTU)	14.50	30.90	23.15±6.74	18.80	37.20	28.75±8.88	6.64	23.10	16.59±7.32
DO (mg/L)	8.10	11.35	9.64±1.50	7.82	11.02	9.50±1.47	7.79	10.66	9.24±1.30
EC (µS/cm)	896.0	1940	1320.75±441.82	806.0	1221.0	1067.0±182.05	824.0	1190.0	1062.0±163.96

Table2: Dissolved of heavy metals in the Tigris River water

Metal (µg/L)	Site 1			Site 2			Site 3		
	Min	Max	Mean ±SD	Min	Max	Mean ±SD	Min	Max	Mean ±SD
Cd	ND	4.50	1.13± 2.25	0.8	6.80	1.90± 3.29	0.8	5.20	1.50±2.5
Cr	216.00	485.20	336.73±83.14	169.80	391.70	290.30±146.4	130.3	432.60	276.28±111.26
Cu	2.00	40.10	18.40± 21.27	ND	35.50	15.20±15.75	3.30	43.80	20.93±15.18
Ni	7.30	80.20	46.87±35.68	ND	42.09	12.59±20.00	ND	61.82	27.63±32.35
Pb	8.60	403.80	165±181.75	63.00	465.40	185.30±189.59	ND	424.30	163.90±183.18
Zn	ND	94.00	39.03±43.72	ND	96.70	46.23±45.17	ND	95.60	43.85±43.73

Chromium: Cr concentration in the Tigris River water varies from 130.30 to 485.20µg/L. The observed vales were found well above the recommended values for rivers maintaining system and general water from pollution [17], which was 50µg/L. The reason of increasing Cr concentration may be related to industrial activities e.g. metal plating, dyes, pigments, ceramic; glues, tanning, wood preserving are reported to contribute Cr [18].

Lead: Pb value varied from ND to 465.40µg/L. The observed vales were found well above the recommended values for rivers maintaining system and general water from pollution [17], which was 50µg/L. The high level of Pb in water could be attributed to the industrial and agricultural discharge as well as from spill of leaded petrol from fishing boats and dust which holds a huge amount of Pb from the combustion of petrol in cars [19].

3.3 Water Pollution Index

Pollution index (PI) is one approach used for comparing metal concentrations in the dust samples [20]. Furthermore, Pollution Index may be used to calculate the degree of pollution of heavy metals in the water samples with respect to background. The revised pollution index was computed by averaging the ratios of metal concentration to the permissible level. The recommended value of heavy metals for rivers maintaining system and general water from pollution [17] were used as permissible levels and pollution index has been calculated as:

$$\text{PI} = \left[\left(\frac{Cd}{5}+\frac{Cr}{50}+\frac{Cu}{50}+\frac{Pb}{50}+\frac{Ni}{100}+\frac{Zn}{500}\right)/\,6\right]$$

The value of pollution index greater than 1.0 indicates that metal concentrations are above the hazard criteria, the permissible level. The index less than 1.0 indicates that average levels of metals are below the selected standards but does not necessarily indicate that there is no anthropogenic source or other enrichment over background. Each heavy metal was classified as low contamination ($PI \leq 1$), moderate contamination ($1<PI\leq 3$) or high contamination ($PI>3$) [21].

The results of the pollution index (Table 3) indicate that the pollution index is higher than one in all sites, each heavy metal was classified as moderate contamination ($1<PI\leq 3$).

The degree of pollution of heavy metals in the water samples for the sites in the following order: 3>2>1, suggesting that the site 3 located in the downstream is more seriously polluted by heavy metals than other sites, attributed to the feeding river input and this site is considerably affected by Different anthropogenic activities.

Table 3: Pollution index Values of Tigris River water

Site 1	Site 2	Site 3	All sites
2.52	2.82	2.87	2.74

Permissible level (µg/L), Cd=5, Cr=50, Cu=50, Ni=100, Pb=50, Zn=500

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