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Assessment of water quality of Tigris River within Baghdad City

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Abstract

This study investigate the effects of the city on the water quality of Tigris River, Water samples were collected from upstream, midstream and downstream sections of the river within Baghdad city. This study included the analyzed of Physico-chemical parameters and compared them with CCME Standard Values for protection of aquatic life and application of CCME mathematical model that facilities the expression of the result and gives a clear picture for the river status, eleven parameter were used to compute the CCMEWQI which are: pH, Water Temperature, Dissolved Oxygen, Total Dissolved Solids (TDS), Chloride (Cl), Ammonia (NH_4), Nitrate (NO_3), Nitrite (NO_2), phosphate (PO_4) Turbidity, Lead (Pb) and Copper (Cu). The result show that all stations in both seasons (winter &summer) have poor valuation, which indicate that's Tigris River in Baghdad city are heavily polluted for the aquatic life.

Key words: Assessment, CCME, WQI, Tigris River.

Introduction

The natural influences and human activities are the major source that affects the quality of any body of surface water. Naturally, Without anthropogenic effects, water quality would be determined by the weathering of bedrock minerals, the natural leaching of organic matter and nutrients from soil, the atmospheric processes of evapotranspiration and the deposition of dust and salt by wind, hydrological factors that lead to runoff, and biological processes within the aquatic environment that can change the Physicochemical component of water [1]. The ability of aquatic ecosystem to sustain healthy are effected by; availability of water and its biological, chemical and physical agents, moreover, when water quality and quantity are eroded, organisms suffer and ecosystem services may be gone [2].

In the recent time, water quality monitoring has become an important topic in stream and river system that's affected by careless disposal of pollutants, where domestic and industrial effluent discharges consider the major sources of aquatic pollution [3]. physico-chemical characteristics such as pH and dissolved oxygen may determine the integrity of water ecosystem [4]. Usually, water quality is determined by comparison of chemical and physical properties of a water sample with water quality objective or guidelines [5].

Water Quality Index (WQI) is the simplest methods that can be use to evaluate the water quality status [6]. WQI essentially consists of a simpler term of more or less complex parameters, which serve as water quality measurements. A number, a verbal description, a range, a color or a symbol could be used to represent the index [7]. four stages are involved in the development of a water quality index which are: the selection of parameter, conversion of parameters to the same scale, development of parameter weightings and the selection of an appropriate aggregation function [8]

Primarily, WQI have been developed to exhibit the changing in the physico-chemical quality of surface waters. However, WQI may be used as indicators of ecological change. Temporal variations occur within an aquatic system. The changing in water system can be recorded by linked water quality to potential use of water [9].

The CCME WQI was developed so it can be use as a tool for simplifying and definition the water quality data [10].The Canadian WQI compares observations value to a objective value, where the objective value may be a water quality guideline [10,11,12]. The CWQI quantifies for one site, over a predatermined period of time (generally one year), the number of parameters that exceed the objective, the number of records in a dataset that exceed a objective, and the magnitude exceed of the objective. The index is flexible in terms of the bench- marks that are used for calculation, and depends on the information required from the index: that is, guidelines for the protection of aquatic life may be used (when available) if the index is being calculated to quantify ecological health of the water, or drinking water quality guide-lines may be used if the interest in the index is in drinking water safety. Alternatively, information describing natural back-ground conditions for a station or region may be used as benchmarks when trying to quantify deviation from natural conditions. Sites at which water quality measurements never or rarely exceed the benchmark have high CWQI scores (near 100), whereas sites that routinely have measurements that exceed benchmarks have low CWQI scores (near 0). The present study the application of the CCME Water Quality Index to monitor the changes in water quality in Tigris River for protection of aquatic life.

Material and Methods

The studied area involved three stations on Tigris River, station one was located at North of Baghdad before entrance of the river in to the city, this station considered the control site, and the second station at the middle part of city, while the third station located at the South part (Fig. 1).

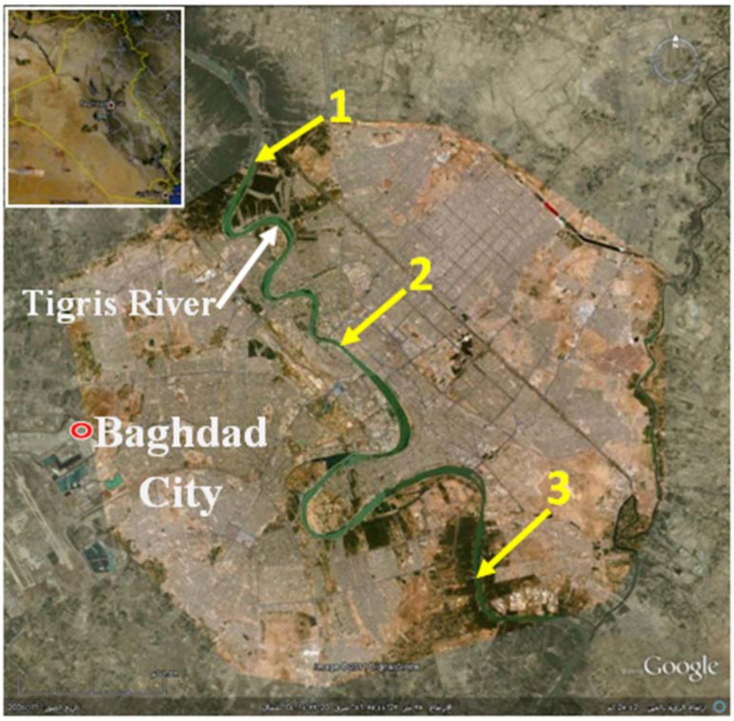

***Figure (1)**: Bagdad City Showing Sampling*

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Sampling

The samples collected from subsurface water by using clean polyethylene bottles from middle of the Tigris River during 2013-2014. Samples were delivered immediately to laboratory for chemical and physical analyzing.

The CWQI computed by select a set of twelve parameters based on both importance and availability of data. These parameter are: Water Temperature, pH, Dissolved Oxygen (DO), Total Dissolved Solids (TDS), Chloride (Cl), Ammonia (NH_4), Nitrate (NO_3), Nitrite (NO_2), phosphate (PO_4) Turbidity, Lead (Pb) and Copper (Cu)which are analyzed according to [13]. CCME WQI was calculated for all sites in the Tigris River using of CCME WQI objective values for protection of aquatic life "Tab.1" [10].

Table (1): CCME WQI Standard Values for protection of aquatic life.

Parameters	CCME guideline
DO (mg/L)	5.5-9
PH	65-9
Water Temp. (°C)	15
TDS (mg/L)	500
Cl (mg/L)	250
NH_4 (mg/L)	1.37
NO_3 (mg/L)	13
NO_2 (mg/L)	0.06
PO_4 (mg/L)	0.3
Turbidity (NTU)	5
Pb (mg/L)	0.007
Cu(mg/L)	0.002

CCME WQI Formulation

The current formulation of the index is based on three measures of compliance or deviation from established water quality guidelines. The first component of the index is referred to as scope, and it measures the number of parameters out of compliance with objectives as a percentage of the total number of parameters measured. The second component is referred to as frequency, and measures how often a water quality objective is exceeded. The final component is referred to as amplitude, and measures by how much the objectives are exceeded. The three components are assembled into a unitless number scaled from 0 to 100. Higher index numbers reflect higher water quality, while lower numbers reflect poorer water quality.

The CCME Water Quality Index takes the form: (10)

- F_1 (*Scope*).

$$F_1 = \left[\frac{Number\ of\ Failed\ Variables}{Total\ Number\ of\ Variables}\right] \times 100$$

- F_2 (*Frequency*).

$$F_2 = \left[\frac{Number\ of\ Failed\ Tests}{Tolal\ Number\ of\ Tests}\right] \times 100$$

- F_3 (Amplitude);

When the test value must not exceed the objective:

$$ecursion = \left[\frac{Failed\ Test\ Value\ i}{Objective}\right] - 1$$

When the test value must not fall below the objective:

$$excursion = \left[\frac{Objective}{Failed\ Test\ Value}\right] - 1$$

$$nse = \frac{\sum_{i=1}^{n} excursion}{Number\ of\ Tests}$$

$$F_3 = \left[\frac{nse}{0.01\ nse + 0.01}\right]$$

$$CWQI = 100 - \left[\frac{\sqrt{F_1{}^2 + F_2{}^2 + F_3{}^2}}{1.732}\right]$$

The final equation produces a value between 0 and 100 and gives a numerical value to the state of water quality. Note a zero (0) value indicates a very poor water quality, whereas a value close to 100 indicates excellent water quality
The water quality is ranked in the following 5 categories which represented in “Tab. 2”:

Table (2): water quality rank

Rank	CCME WQI values
Excellent	95–100
Good	80–94
Fair	60–79
Marginal	45–59
Poor	0–44

Results and Discussion

Water Quality Index

The WQI abbreviate the complicated raw data and generates a single number that expresses subjectively the water quality. Such a rating scale allows for simplicity and consumer comprehensibility. The WQI approach has many variants in the literature, and comparative evaluations have been undertaken [14]. The physico-chemical characteristics give a fair amount of idea to assess the ecological health of Tigris River. The results of water quality index showed values in winter 39.5, 42.51, 31.33, while in summer the value were 39.39, 44.42, and 35.65 in stations 1, 2 and 3, respectively “Fig. 2”.

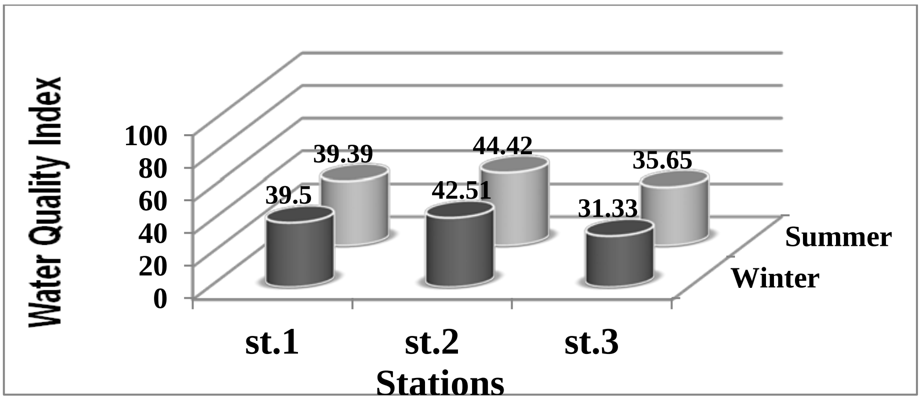

Figure 2: Water quality index for protection of aquatic life at different locations along Tigris River.

The investigation results showed that all stations in both seasons get the poor valuation, hence it can be said that water of Tigris River in Baghdad city are heavily polluted for the aquatic life, which may reflect the Discharge of pollutants to a water system from many resource like industrial wastes, domestic sewers discharges, agricultural runoff and other sources, all of which may be untreated and can have significant effects on both short term and long term duration on the quality of a river system [15,16]. From the data that obtained from this study which demonstrated that all sites are have the poor value, where station 1 considered the control site, so eventually it's clear that's; Tigris river are uploaded by the pollutant before its entering Baghdad city. Decreasing the WQI value refer to the following parameters: Water Temperature, Ammonia, phosphorus, were exceed the CCME standard value for protection aquatic life sometime, while total Dissolved Solids, Turbidity, copper, lead that were exceed the standard value all the time in all stations. The statistical analyses which involved the mean and standard deviation and range of the parameters of the study sites are presented in "Tab. 3".

Table (3): Show the mean and standard deviation and range of water quality parameters of the study sites

Parameter	Station 1	Station 2	Station 3
DO (mg/l)	7.79-11.35 9.6-1.49546	7.80-11.02 9.497-1.4768	8.00-10.66 8.93-1.231
pH	8.10-8.40 8.2-.12583	7.80-8.70 8.225-.44253	8.00-8.40 8.125-.1893
Water T. (c^o)	11.70-24.60 17.9-5.6517	11.70-25.50 18.425-5.857	12.80-24.30 18.525-4.998
TDS (mg/l)	638.00-1650 969.75-476.53	583-759.00 644-82.829	560-887 723.75-167.547
Cl (mg/l)	34.99-94.9 69.98-26.45	24.99-149.00 69.737-54.751	24.99-274.9 114.957-110.03
NH_4 (mg/l)	0.21-1.78 0.6556-.75051	ND -0.38 0.175-.18168	0.05-3.33 1.115-1.49909
NO_3 (mg/l)	ND -21.7 8.1955-9.58697	ND -2.66 0.886-1.2529	ND -4.43 1.772-2.1702
NO_2 (mg/l)	ND-0.07 0.0358-.02746	ND -0.09 0.0386-.0367	ND -0.49 0.1383-.2332
PO_4 (mg/l)	0.01-0.78 0.2600-.35147	0.04-1.90 0.835-.90839	0.06-1.50 0.495-.6761
Turbidity(NTU)	14.50-30.9 23.15-6.739	18.80-37.20 28.75-8.8790	6.64-23.1 16.585-7.320
Pb (mg/l)	0.075-0.2081 0.1415-.05434	0.075-0.1822 0.1092-.04916	0.4034-0.465 0.429-.0258

Cu (mg/l)	0.0281-0.0557 0.0463-0.01302	0.053-0.0226 0.0334-.01440	0.0023-0.0177 0.0103-0.0085

Chemical and Physical Parameters

Dissolved oxygen (DO) considered the critical parameter for Distinction the health of an Aquatic ecosystem and is usually use as a water quality indicator [4]. There was no degrease in dissolved oxygen value at any station throughout the study period, the lowest values recorded were 7.79 mg/l during summer in station 1, while high levels recorded during the winter season throughout Tigris River and reached to 11.35mg/l in station 1. So many factor helps increasing DO in water like; photosynthetic in the system, low temperature, low of salinity and the mixing of atmospheric oxygen with waters through wind and stream current action [17].

The result of pH varied from (7.8-8.7) indicating that the water of Tigris River is almost neutral to sub-alkaline in nature, which agrees with Iraqi published data [18,19]. pH is an important factor that determines the suitability of water for various purposes [20].

Water Temperature ranged between 11.7-25.5 mg/l and exceeded the standard values during the winter. Water temperature reflects the atmospheric temperature, and it presents the most significant difference among seasons, where Atmospheric conditions are principally responsible for the heat exchange process at the water surface [21]. Water Temperature is important in aquatic systems because its affects many physical, biological, and chemical characteristics of a river like; amount of oxygen that can be dissolved in water, photosynthesis of plants, the metabolic rates of aquatic organisms, and the sensitivity of organisms to toxic wastes [22].

Dissolved Solids in natural water are generally consistence from bicarbonate, chloride, calcium, magnesium, sodium and sulfate [23]. The result showed that TDS value was exceed permissible level recommended by CCME all the time, where values rang from (560to 1650 mg/l). the primary sources for TDS in receiving waters are; leaching of soil contamination, agricultural and residential runoff and point source water pollution discharge from industrial or sewage treatment plants [24].

Chloride concentration ranged between (24.99-274.9 mg/l), where exceed permissible levels that recommended by CCME only one time in station 3 during winter, and it not a serious increasing which may be return to rain fall that helps melting of chloride ion from adjacent land of the banks of the river as a result of soil erosion [25].

Ammonia (NH_4) and Nitrite (NO_2) were exceed permissible level recommended by CCME just one time during winter in station 3, while Nitrate (NO_3) exceed permissible level in station 1 during the same season, where value ranged between (ND- 3.3318mg/l) (ND- 0.4873mg/l) (ND-21.707 mg/l) respectively. NH_4, NO_2 and NO_3 are naturally occurring ions in water system that are part of the nitrogen cycle. The sources of nitrogen Compounds in aquatic environments include the decomposition or breakdown of organic waste matter, gas exchange with the atmosphere, animal waste, nitrogen fixation processes, domestic wastewater, Fertilizer and sewage [26,27]. Nitrate is the stable form of combined nitrogen for oxygenated systems, and can be reduced by microbial action. Nitrite ion contains nitrogen in a relatively unstable oxidation state; many chemical and biological processes can further reduce nitrite to various compounds or oxidize it to nitrate under oxygenation or reduce it to ammonia under Deoxygenation [28]. The uptake of nitrate by plants is responsible for most of the nitrate reduction in surface water, which may reflect the reduction of the concentration of nitrate in Tigris River during the summer season where most of biological processes take places during the hot season [29].

PO_4^{-3} concentration was far above the maximum limit for aquatic life most of the time (0.3 mg/l), its concentration ranged between (0.01 -1.9 mg/l). For the record, PO_4^{-3} considered an important nutrient in a water body and one of most significant limiting factor, and is the only form of soluble inorganic phosphorus directly utilized by aquatic biota [17]. Low concentrations of phosphorus may lead to decreased production in water bodies, but in other way high concentrations have a similarly prejudicial effect. High concentration of phosphorus may lead to algal blooms and excessive growth of aquatic plants “Eutrophication”, which often lead to anoxic conditions in a water body [30,6]. Phosphorus occurs naturally in surface water from atmospheric deposition, natural dissolution of rocks and minerals, weathering of soluble inorganic materials, decomposition of biomass, runoff, and sedimentation. While anthropogenic sources include; human activity and development, fertilizers, detergents, animal wastes, wastewater and septic system effluent, industrial discharge [31].

Turbidity levels are a simple but efficient parameter to assess water quality especially for aquatic life [32]. In this study the observed value which ranged between (6.64-37.2 NTU) were higher than the permissible level recommended by CCME for protection of aquatic life for both season in all stations, were values above 5 NTU become perceptible to the eye and considered out of permissible level [10]. Turbidity in aquatic environment is caused by suspended and colloidal matter, such as clay, silt, finely divided organic and inorganic matter, plankton and other microbial organisms [13].

Lead and copper are potentially toxic if present and taken up by living organisms in excessive amounts from the environment, where higher concentrations can lead to poisoning, heavy metals are dangerous because they tend to bioaccumulate [33,34]. Lead and copper in this study always exceeds the CCME guideline for protection of aquatic life, which indicates a serious pollution by Pb and Cu, where values ranged between (0.075-0.465 mg/l) (0.0023-0.053mg/l) respectively. In general, fresh waters hold traces amounts of heavy metals that came from the terrigenous sources such as weathering of rocks resulting into geo-chemical recycling of heavy metal elements in these ecosystems [35]. The sources indicate in the excessive content of trace metals in aquatic surfaces are direct input of the pollutants that contain metals [36], Meanwhile, Tigris River Considered the major recipient of discharge from industrial effluent, untreated sewage and wastewater from commercial, industrial and domestic establishments [37].

Conclusions

The advantages of a WQI as an indicator of ecological altering may be briefed as follows:

(1) A large amounts of water quality data can be reduced to a single index value in a simple way.

(2) The scores of index are Understandable, accurately indicate to quality state, rather than the close approximation provided by a classificatory system. Which can consider an important factor, because the final rating generated from a water quality monitoring may be used in the development of river quality standard.

Thus, the information that obtained during this research, provide a rigorous image of water quality and exhibit a serious problem of water pollution for Tigris River by heavy metals.

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