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Evaluation of Water Quality Index in the Main Drain River in Iraq by Application of CCME Water Quality

Prof.Dr.DheyaaW.Abbood[1*] Dr.KarimR.Gubashi[2] Dr.HananH.Abbood[3]
1. Al-Mustansiriyh University, College of Engineering, Civil Eng. Department, Iraq.
2. Al-Mustansiriyh University, College of Engineering, Environmental Eng. Department, Iraq.
3. Ministry of Water Resources, Directorate General designs, Iraq.
* Email:Dr.Dheyaa@gmail.com

Abstract
Water Quality Index in the Main Drain River in Iraq by Application the Canadian Council of Ministers of the Environment Water Quality Index(CCME WQI) has been achieved .Fifteen water quality parameters (pH, alkalinity, phosphate(PO_4) , nitrate(NO_3), sulfate(SO_4), chloride(Cl), total hardness(TH), calcium(Ca), magnesium(Mg), total dissolved solids(TDS), biological oxygen demand(BOD), dissolved oxygen(DO), electrical conductivity(EC), sodium (Na) and potassium(K) measured at ten stations along the main drain river (Baghdad, Babylon, Qadiysiah, ThiQar and Al-Basrah). The field work was conducted during the years 2004 until 2011. Based on the results obtained from the index the water quality of main outfall drain river ranged between 26.6- 35.5 which indicate that river has the worst quality due to effect of various pollutant sources.
Keywords: Water quality index, Iraq, Main drain, CCME WQI

1. Introduction

Water Quality Index, indicating the water quality in terms of index number, offers useful representations overall quality of water for public or for any intended use as well as in the pollution abatement programmers and in water quality management. Bacteriological , organic and inorganic compounds seriously pollute main drains, posing an environmental hazard to both human and wildlife and restricting reuse from main drains. Chemicals include metals, toxic organics, and were monitored . Heavy metals such as lead, copper, mercury, and zinc can harm aquatic life at low levels and can settle which becomes embedded in sediment, potentially effecting the ecosystems in some way for decades.Nutrients, organic chemicals, or carbon-based had been monitored and found that it has high rate of toxicity at certain levels for some forms.These include pesticides and herbicides, solvents and petroleum compounds and chlorine.

Water quality refers to the chemical, physical, and biological characterization ofa water body.A water quality criterion is “that concentration, quality, or intensive measure that, if achieved or maintained, will allow or make possible a specific water use” (Maidment, 1993).Further,a water quality standard is “the translation ofa water quality criterion intoa legally enforceable ambient concentration, mass discharge or effluent limitation” (Maidment, 1993).There are three components to water quality standards:
(1) designated uses,
(2)criteria necessary to protect or maintain those designated uses, and
(3)an anti-degradation provision.

When evaluating water quality, researchers use approved scientific techniques to measurea number ofdifferent chemical, physical, and biological parameters. They compare these parameters with standards that scientists believe reflecta healthy water body.Researchers base standards on what they know about effects on human and ecosystem health, and they refine these standards as we gain more insight and understanding. The consequences for highly impaired water quality are far- reaching.Humans can compromise their health by coming in contact with poor water or ingesting it.Other effects include an imbalance in healthy natural ecosystems, harm to the food chain, and impaired populations of fish and other wildlife.Reduced recreation potential and economic loss are possible.Finally, an environment with impaired water quality leavesa negative legacy for our children and future generations.

Conversely, healthy ecosystems with good water quality havea profound impact on thewell being ofa community. The beauty ofa clean, healthy river, lake, or estuary affects the lives of all who live and work near it. Quality of life soars as people enjoy swimming, fishing, and other recreational activities.Economic activity results from the harvesting of food sources from the ecosystem as well as the establishment of support services for these industries.Economic prospects further flourish as companies choose to locate in areas with these benefits.

Historically, byproducts of human activity have stressed the river and its tributaries.Wastewater from human sanitation and industrial activity has gone directly into its waters.Rains wash pollutants from agriculture, pasture lands, streets and highways, lawn care, and even contaminants from the air into the river.As community and economic growth and development expand, so do these stresses. Fortunately, in recent years we have developed ways to mitigate or lessen the impacts of those stresses. Also, the river has a remarkable ability to cleanse itself to some degree. The river has seenvast improvements in its health since the Clean Water Act of 1972, which

authorized the regulation of surface waters.With the addition of basic treatment of wastewater, including disinfection, pollutant concentrations throughout the river have dropped dramatically, and once- damaged ecosystems have made great strides in returning to natural, healthy states.We still have much to do.
Specific areas of the river remain highly stressed, especially in the tributaries.Nutrient concentrations exceed healthy levels in parts of the river.Certain areas have poor biological diversity and low species density.Our task asa community is to develop and implement tools to mitigate the stresses to the river and to seek greater understanding of the processes involved in the river'sself cleaning.This is necessary in order to reverse the harm of past stresses. Our goal should be to restore the river toa level of quality that supports these benefits and maintainsa healthy ecosystem to pass on to future generations.

One of the simplest methods to asses water quality conditions by using water quality indices(Salim, 2009). It is a tool that provides meaningful summaries of water quality data that are useful to both technical and non-technical individuals interested in water quality results. It is important to note that the CCME WQI is not a substitute for detailed analysis of water quality data and should not be used as a sole tool for management of water bodies. It was simply developed to provide a broad overview of environmental performance(Khan and et.al., 2004).

2. Materials and Methods

2-1 Study Area

The study area is the main drain river which has been completed in 1992, functions as a main outfall drain collecting drainage waters from more than 1.5 million hectares of agricultural land from the north of Baghdad to the Gulf between the Euphrates and the Tigris along five provinces (Baghdad, Babylon, Qadiysia, ThiQar and Al-Basra). The length of the watercourse, completed in December 1992, is 565 km, with a total discharge of 210 m^3/s. In 1995 an estimated 17 million tons of salt have been transported to the Gulf through this river. The sampling locations and their respective longitude and latitude are given below in Table 1:

Table (1) Samples Locations

Province	Station	Location	Latitude	Longitude
Baghdad	ST1	Abo Ghurabnear to Yogurt Factory	33˚ 18' 01.3"	44˚ 5' 52.8"
	ST2	Usefiah/ Usefiah bridge	33˚ 07' 14.7"	44˚ 21' 32.8"
Babylon	ST3	J'bela	36˚ 29.9' 53"	46˚ 61' 91"
	ST4	Shumaly	35.9˚ 03' 77"	50˚ 97' 87"
Qadiysiah	ST5	Sumer City/near to waterfalls	32˚ 00' 50.2"	44˚ 54' 24.3"
	ST6	Aalbdeer near to bad Tabka	32˚ 10' 41.2"	45˚ 20' 1.0"
ThiQar	ST7	North to Nasriah City	31˚ 05' 24.4"	46˚ 14' 40.7"
	ST8	South to Nasriah City	31˚ 04' 26.6"	46˚ 16' 51.5"
Al-Basra	ST9	Before of Zubar Bridge	30˚ 26' 36"	47˚ 45' 64"
	ST10	After Shat AlarabRegulator	30˚ 24' 70"	47˚ 46' 70"

2-2 Laboratory

Water samples were collected from each ten stations (ST1 to ST10) distribution along the main outfall drain river from Baghdad to Basra during the years 2004 to 2011. Samples were analyzed for 15 parameters: pH, alkalinity, phosphate(PO_4) , nitrate(NO_3), sulfate(So_4), chloride(Cl), total hardness(TH), calcium(Ca), magnesium(Mg), total dissolved solids(TDS), biological oxygen demand(BOD), dissolved oxygen(DO), electrical conductivity(EC), sodium (Na) and potassium(K). Iraq recommended Guidelines 2012(Table 2) were applied to categorize the water primarily for use as irrigation water.

Table (2) Iraq Standard Values, 2012 for use as irrigation water

Parameters	units	Values
pH	-	4-8.6
Alkalinity	mg/l	200
Po_4	mg/l	25
No_3	mg/l	50
So_4	mg/l	200
Cl	mg/l	250
Total Hardness	mg/l	300
Ca	mg/l	450
Mg	mg/l	80
TDS	mg/l	2500
BOD	mg/l	40
DO	mg/l	5
EC	µS/cm	250
Na	mg/l	250
K	mg/l	100

3.Evaluation of the CCME WQI

The CCME WQI model consists of three measures of variance from selected water quality objectives (scope, frequency, amplitude). These three measures of variance combine to produce a value between 0 and 100 (with 1 being the poorest and 100 indicating the best water quality) that represents the overall water quality. Within this range, designations have been set to classify water quality as poor, marginal, fair, good or excellent(Table 3). These same designations were adopted for the indices developed here (Haseen and et. al., 2005). The detailed formulation of the WQI, as described below:

$$F_1 = \frac{\text{No. of Variables}}{\text{Total No.of Variables}} \times 100 \quad (1)$$

The measure for scope is F_1 (scope). This represents the extent of water quality guideline non-compliance over the time period of interest.

$$F_2 = \frac{\text{No of Failed Tests}}{\text{Total No.of Tests}} \times 100 \quad (2)$$

The measure for frequency is F_2 (frequency). This represents the percentage of individual tests that do not meet objectives(failed tests).

The measure for amplitude is F_3. This represents the amount by which failed tests do not meet the objectives. This is calculated in three steps:

a- Calculation of Excursion. Excursion is the number of times by which an individual concentration is greater than (or less than, when the objective is a minimum) the objective.

Table (3) :CCME WQI categorization method

Rank	WQI Value
Excellent	95-100
Good	80-94
Fair	65-79
Marginal	45-64
Poor	0-44

When the test value must not exceed the objective:

$$excursion = \frac{\text{Failed test value}}{\text{Objective}} - 1 \quad (3)$$

When the test value must not fall below the objective:

$$excursion = \frac{\text{Objective}}{\text{Failed test value}} - 1 \quad (4)$$

b- Calculation of Normalized Sum of Excursion. The normalized sum of Excursions. The normalized sum of excursion, nse, is the collective amount by which individual tests are out of compliance. This is calculated by summing the excursions of individual tests from their objectives and dividing by the total number of tests (both those meeting objectives and those not meeting objectives).

$$nse = \frac{\sum_{i=1}^{n} excursion}{Number\ of\ tests} \quad (5)$$

c- Calculation of F_3 . F_3 (Amplitude) is calculated by an asymptotic function that scales the normalized sum of the excursions from objectives to yield a range from 0 to 100.

$$F_3 = \frac{nse}{0.01\, nse + 0.01} \quad (6)$$

The WQI is then calculated as:

$$CWQI=100-\left[\frac{\sqrt{F_1^2+F_2^2+F_3^2}}{1.732}\right] \quad (7)$$

4. Results and Discussion

The results show averages values of CCME WQIs (range from 26.6 to 35.5) indicate the water quality for the five governorates of Iraq can be rated as poor in all site(Fig.(1)). The results of pH varied from 7.3 in Al-Qadiysiah station to 8.21 in Thi-Qar station(Fig. 2) indicating that the water sampler are almost neutral to sub-alkaline in nature. The observed value during year 2004 of total alkalinity was higher than the permissible level recommended by the Iraqi standard 2012 for use of irrigation water except in Al-Basrah station (Fig. 3). Fig. (4) shows the TDS value during year 2011 higher than the permissible value in all sites, where values range from (3159 to 35841). 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(Boyd, C.E.,2000). The concentration of total hardness, TH exceeded the permissible level recommended by Iraq for using irrigation water and higher concentration of TH was recorded (6667 mg/L) in Al-Basrah site during year 2011 (Fig.5). The results of PO_4 are in permissible value range from (0.1 to 1.7) in all sites and in all time (2004-2011). The average concentration of NO_3 in permissible level except in year 2006 which exceeded the permissible value in all sites and in year 2010 the concentration of NO_3 in Thi-Qar and Al-Basrah stations range from (91 to 95) respectively indicating that exceeded permissible value of 50 mg/L. The results show that values of Cl and Mg are exceeded the permissible level in all stations and all time (2004-2011) where the concentration of Ca is in permissible level in all time except in two stations Thi-Qar and Al-Basrah.

5. Conclusion

The water quality index in the Main Drain river in Iraq by application of CCME Water Quality has been computed using fifteen water quality parameters pH, Po_4, So_4, Cl, TH, Ca, Mg, TDS, BOD, DO, Ec, Na and K. The results show higher values of concentration of TDS, TH, and Cl and the river has the poor water quality.

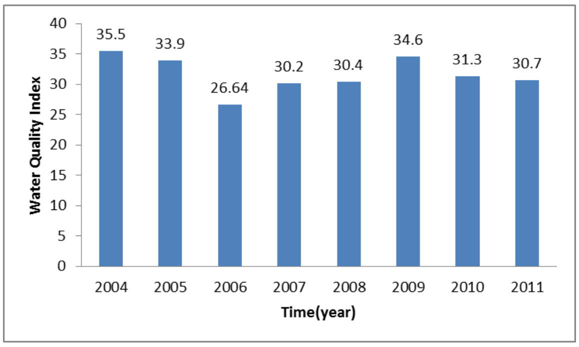

Figure 1. Average water quality index of main drain in Iraq

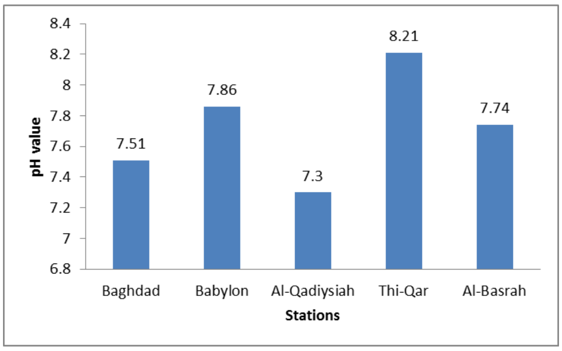

Figure 2. Variation of pH in stations during year 2004

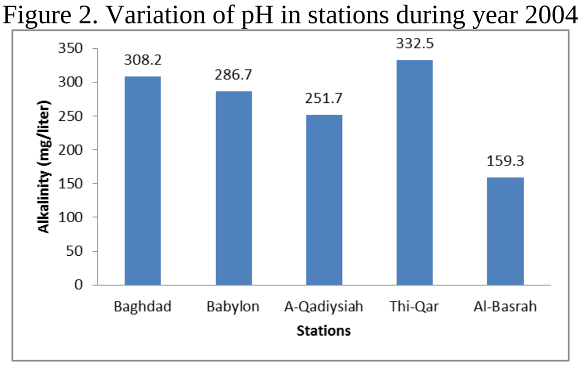

Figure 3. Alkalinity values in station during 2004

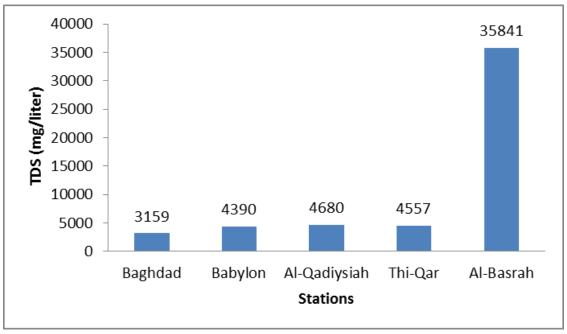

Figure 4. Total dissolved solids in stations during 2011

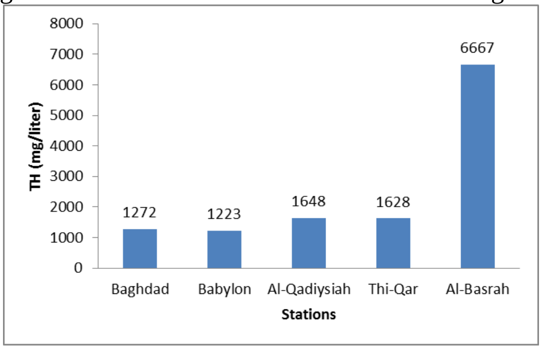

Figure 5. Total hardness, TH in stations during 2011

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