EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES

http://www.ejbps.com

ISSN 2349-8870
Volume: 4
Issue: 3
450-455
Year: 2017

APPLICATION OF WATER QUALITY INDEX (CANADIAN MODEL) AND PRINCIPLE COMPONENT ANALYSIS (PCA) FOR DETERMINE THE VALIDITYOF of AL-GHARRAF RIVER WATER/ SOUTHERN OF IRAQ FOR DRINKING

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Article Received on 17/01/2017 **Article Revised on 06/02/2017** **Article Accepted on 26/02/2017**

1-ABSTRACT

The present work is an application of Canadian Water Quality Index (CCME WQI) for drinking water with using Principal components analysis (PCA) for four stations located at the AL-Garraf River, Water samples collected a monthly during the period from November 2014 to October 2015 and were analyzed for physical and chemical properties immediately after collection. CCME WQI was applied using nine water quality parameter include (electric conductivity, total dissolved solid, dissolved oxygen, biological oxygen demand, chemical oxygen Damend, total hardness, pH, turbidity, total alkalinity, fecal coliform bacteria, Ca, Mg, Cl,Na,NO_3^{-2} SO_4^{-2}, PO_4,Cd, Pb). Based on the results obtained from(CCME WQI), the water quality of River ranged between 19.87- 26.98 which indicate that river has the poor quality. The PCA produced nine significant main components explain more than35.28% of the variance, Na,PO_4,Cl,K,Mg,COD,NO3, Cd and total coliform bacteria. Results proved the Water quality is not suitable to be used for drinking purposes in all study sites and that due to the effect of various urban, industrial and agricultural wastes sources.

KEYWORDS: total dissolved solid, dissolved oxygen, biological oxygen demand.

2-INTRODUCTION

River pollution has been one of the main topics in the environmental issue of urban areas in Iraq. Surface water pollution today a great environmental concern worldwide.[1] Exposed the aquatic environment to various types of pollutants such as heavy metals, pesticides, detergents, petroleum products and other materials, in additional to industrial, agricultural and medical wastes may lead to a negative impact on public health and biodiversity.[2][3] the Drinking water sources are under increasing threat from contamination, with far-reaching consequences for the health of children and for the economic and social development of communities and nations.[4] Became water quality is a growing concern throughout the developing world .World health organization (WHO), has reported that 2.3 billion people in 2025 would suffer from an acute shortage of potable water unless significant steps have to be considered at least reduce water pollution].[5] The quality of water is identified by its physical, chemical and biological properties. The particulate problem in case of water quality monitoring is the complexity associated with analysis a large number of measured variables.[6] The quality of surface fresh water, as measured by the Water Quality Index (WQI) is a state or condition indicator. Water quality indices are used to monitor the water quality. It is a mechanism based on numerical expression for defining the level of water quality.[7] A drinking source water quality index presents a potential communication and analysis tool to facilitate cooperation between diverse interest groups as well as represent composite source water quality[8] The Canadian Water Quality Index (CWQI) is a tool implemented by Canadian Council of Ministers of the Environment (CCME) to provide reports on water quality in Canada. There are three important factors in CWQI. All factors are calculated on the basis of objectives, which provide guideline values developed by Federal- provincial-Territorial Committee on Drinking Water.[9] The index is determined on an annual basis resulting in an overall rating for each station per year. This will allow both spatial and temporal assessment of global water quality to be undertaken. Principal component analysis (PCA) is the method that provides a unique solution, so that the original data can be reconstructed from the results.[10] In recent years many studies have been done using PCA in the interpretation of water quality parameters.[11] The PCA methods contained in the statistical SPSS program was applied to the chemical concentration data in order to study the physicochemical variables, heavy metals and some organic pollutants capable of promoting a characterization of the hydrochemistry of the region and to identify the fundamental factors that govern the general behavior of the polluted water sources.[12]

3-MATERIALS AND METHODS

3-1: Description of the Study Sites

AL-Gharraf River is located in the southeastern of Iraq within Mesopotamian plain, between latitude (32□27□-31□2□ N) and (46□43□- 45□45□ E). It is the largest branch of the Tigris River, and was thus derives its properties from the Tigris River. It branches at north of the Al-Kut city towards the south passes through these cities, Al- Haay, Al-Fajer, Qalaat Sekar, Al-Refaee, Al-Naser then Al-Bada'a district in where it branched to Al-Bada'a river and Al-Shatrah river in the Dhi-Qar.[13] The length of the main river is about 230 km, Al-Gharraf river is the main water source for agriculture and public requirements and has impacts certain on the socio-economic aspects of that area. The river receives most of the wastewater from many cities including industrial, agricultural and domestic wastewater. Associated with the development of the area, the increase of pollutants into the river has been a recent cause for alarm.[14] The study area included four stations on Garraf river, the first station located in Al- Haay city in the area descript agricultural activity, while the second station ST2 is located at Al-Refaee city, the third station ST3 located at Al-Shatrah river, while ST4 located before entrance at AL-Hammar marsh.

Figure 1: Map Showing Study Sites on Al- Garraf River.

3-2: Samples Procedures

Subsurface water samples were collected from the study stations on a monthly basis for the period from November 2014 to October 2015, Sampling were analyzed for physical, chemical and biological. It was measured several of environmental variables included, EC (µS/cm) was measured directly at the sampling sites, BOD was measured by Oxi- direct method is using a device Tento meter type HANNAHI8543, COD used Multi direct method by using a device Lovibond Meter type HANNA Hl9830, Total dissolved solids (TDS), pH, TH (mg CaCO3/L), Na(mg/l), K^{+1}(mg/l), DO(mg/l), NO_3^{-2} (mg/l), SO_4 (mg/l), PO_4^{-2}(mg/l) and heavy metals were measured depending on procedures that has been described by[15] while turbidity (NTU) was measured by turbidity meter type Hanna Hi 25557. total coliform bacteria was measured by(MPN) Most probable Number.

CCME Water Quality Index calculation

The WQI combines three aspects of water quality relative to water quality objectives:

1- F1 represents (Scope): The percentage of parameters that exceed the guideline.

$$F_1 = \left\{\frac{\text{Number of failed Variables}}{\text{Total Number of Variables}}\right\} \times 100$$

2- F2 represents (Frequency)**:** The percentage of individual tests within each parameter that exceeded the guideline.

$$F_2 = \left\{\frac{\text{Number of failed Tests}}{\text{Total Number of Tests}}\right\} \times 100$$

3- F3 represents (Amplitude): The extent (excursion) to which the failed test exceeds the guideline. This is calculated in three stages. First, the excursion is calculated:

$$\text{Excursion i} = \left\{\frac{\text{Objective j}}{\text{Failed Test Value i}}\right\} - 1$$

Second, the normalized sum of excursions (nse) is calculated as follows:

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

F3 is then calculated using a formula that scales the nse to range between 1 and 100:

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

The index value is calculated by the following equation final:

$$\text{WQI} = 100 - \frac{\sqrt{F_1{}^2 + F_2{}^2 + F_3^2}}{1.732}$$

Table 1: Water quality classification based on WQI values according to CCME(2001).

Rank	Score	Water Quality Status
Excellent	**95 –100**	Water quality meets all criteria for use as a source of drinking water

Good	**80 – 94**	Water quality rarely or narrowly violates criteria for use as a source of drinking water
Fair	**60 – 79**	Water quality sometimes violates criteria, possibly by a wide margin, for use as a source of drinking water
Marginal	**45 – 59**	Water quality often violates criteria for use as a source of drinking water by a considerable margin
Poor	**0 – 44**	Water quality does not meet any criteria for use as a source of drinking water

4- RESULTS AND DISCUSSION

The results of the current study showed variation in the physical and chemical factors of water at different stations along the Garraf River. The descriptive statistics analyses for the collected water quality parameters are shown in(Table 2).

Table2: Values of the lower and upper limits for factors though the study period.

Characters Sites	PH	Turb. (NTU)	T.H (mgcaco3/l)	T.D.S (mg/l)	E.C µS/cm	DO (mg/l	BOD (mg/l)	COD (mg/l)	T.Alk (mg/l)	Mg (mg/l)	Ca (mg/l)	Cl (mg/l)	Na (mg/l)	NO_3 (mg/l)	SO_4 (mg/l)	PO_4 (mg/l)	Cd (mg/l)	Pb (mg/l)	Fc Cell /100 ml
Site1	*6.91 **8.41	3.31 6.7	441 519	450 893	939 1511	2.77 7.3	0.91 2.34	6.4 25.3	184 301	42 110	62 171	159 250	101 173	1.35 3.8	202 303	0.03 0.44	1416 44700	186 34700	50 333
Site2	6.9 8.42	3.11 6.27	367 559	336 798	674 1362	1.76 7.5	1.23 3.05	6.9 30.9	191 301	42 131	61 175	118 198	104 179	1.42 4.1	204 246	0.14 0.4	1750 46200	222 13700	55 233
Site3	6.88 8.45	3.38 6.46	382 579	392 659	978 1406	0.63 8.4	1.54 2.62	7.2 26.9	202 297	36 125	52 152	135 292	93 171	1.35 3.7	204 399	0.08 0.39	2133 14500	286 84300	51 286
Site4	5.92 8.5	3.2 5.27	403 833	434 902	771 1622	2.21 6.1	1.26 3.24	6.2 35.4	152 282	35 134	56 179	160 312	100 201	1.36 3.64	229 375	0.06 0.37	2100 49200	183 78466	53 239

* Lower limits.

** Upper limits.

These values have been introduced in three index equations As described above to calculate CCME WQI. each study sites are shown in (**Figure2**) according to.[9] The results showed that the highest value of this indicator recorded in ST1 Was24.18 and the lowest value in ST2 and amounted to 22.5 either in ST2 was equal to 23.98 andST3 recorded24.13.

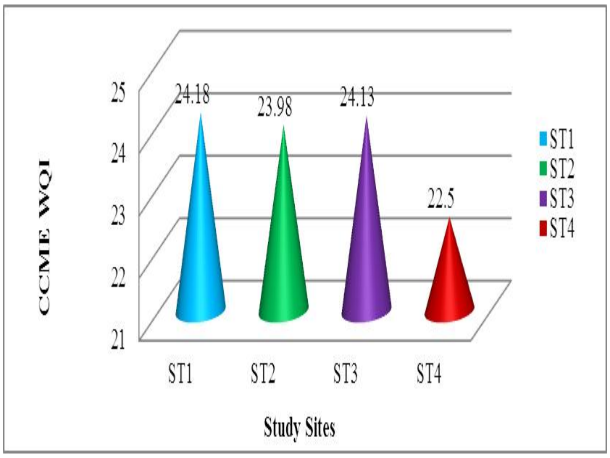
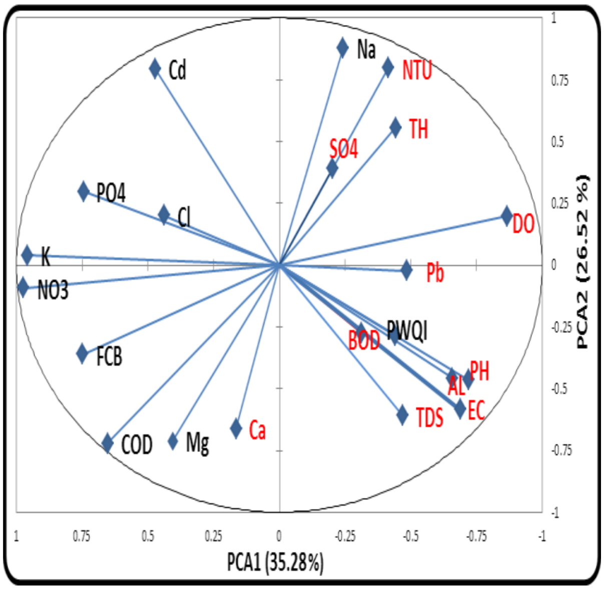


Figure 2 Values of CCME WQI index for drinking water in the sites during the study period.

By comparing these values with table 1 that classifies water quality into main five categories to show their suitability for drinking purpose found that water quality in all sites of Al- Garraf river during the study period within Poor class and characterized by non-suitability for drinking purposes.

Principal Components Interpretations

The results of PCA Among the most responsible for the pollution of the river water changes. Show in in **(Fiugre3).**



(Figure3): Water Quality responsible for the variation in water quality for the processing of drinking water, the values of variables according to the analysis of the principal components (PCA)

Principal component 9, This component has high loading in the NO3, pH, K and PO4, Cd, Pb, Cl, Mg, COD, K, Na,FC, Represent 35.28% of the total variance. The description of the study sites in the Al-Garraf river during the current study as poor may be can indicate to the effect to several reasons, including the discharge of pollutants to a water resource system from domestic sewage discharges, industrial process pollutants, agricultural runoff and other sources, this is may be untreated, can have significant effects of both short and long term duration on the quality of a river system.[16] the other reason of poor water quality that the Garraf river represents downstream of a branch of the Tigris River which is loaded with many of the pollutants that it has received from the medical waste and sewage and etc. CCME WQI It reflects the intervention between natural effects and those of anthropogenic activities.[17]

5- CONCLUSION

The CCME WQI is an effective tool to evaluate water quality for water supply systems. The WQI model used for rating of drinking water quality in AL-Garraf river indicates that the quality is “poor” in all sites. Heavy metals is the most important parameter that determinates the rating of water quality, exceeding the standards (objective) of drinking water. Principal components analysis of water quality data for AL-Garraf river showed seasonal effects, agricultural wastes and storm water effects, geological and ground water of the river basin effects, domestic, industrial waste water discharges and its organic loads are caused the main variation in water quality of the Garraf river in all sites. The results of PCA reflected a good look on the water quality monitoring and interpretation of the surface water.

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