ENVIRONMENTAL MONITORING OF AL-MUSAYYIB RIVER AS A LOTIC AQUATIC SYSTEM IN MIDDLE OF IRAQ BY APPLICATION OF CANADIAN MODEL OF WATER QUALITY INDEX AND INDEX OF HEAVY ELEMENTS POLLUTION (HPI) AND INDEX OF CONTAMINATION (CD)

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Abstract

The water quality index (WQI) is a tool used to definition whether water is suitable for aquatic life and river used to irrigation (IWQI). The goal of this work is to assess the water quality of AL-Musayyib River as a lotic aquatic system in middle of Iraq. Four sites were selected on the study area and seventeen physicochemical parameters and calculate index of heavy elements pollution (HPI) and index of contamination (Cd) were applied to assess the validity of water to different use from January 2021 to December 2021, the studied period were divided into four seasons (Winter, Spring , Summer , Autumn) . This parameter was (water temperature, pH, DO, BOD5, TDS, NO3, NO2,Ca, Mg, PO4, Cr, Fe, Cu , Zn, Pb, Ni, Cd). The findings of the present study showed were recorded that the HPI values that were the higher than the critical pollution index average mean value of (100), with ranged between 74.38388 to 238 .5592 in St.3 for winter and St.2 for spring. The high value of Index may be due to the rise in elements Fe; Cu and Zn more than the permissible limit for portable water and concentration of heavy metal It is attributed to the presence of many resins such as affect the concentrations of heavy metal , such as : direct drainage from farmlands, dredged materials from the river's upper reaches, as well as the diluting and increase of the water, sewage treatment plants, sediment dissolution, rises in phytoplankton counts in water, accumulation within body organisms , adsorption on surface clay , and binding with organic materials . As for the contamination index (Cd) the values of (Cd) ranged from (23.061-84.070) in site three in winter and site two in spring Fig. Cd >3 the pollution is high. Water quality status Poor- marginal may be due to mainly man - made sources in the area such as waste disposal, industrial waste discharged untreated, solid municipal waste and treatment process.

Key words: - Water Quality Index (WQI), AL-Musayyib river, Heavy metals index, Contamination index (Cd) , heavy metal , Euphrates River .

1. Introduction

Water is a valuable and necessary resource for all life forms and flows continuously between the Earth's surface and the atmosphere Water used in agriculture and animal production can also be shared with the general public1. Water resources are important environmental case that are being researched by a diverse team of scientists, including geologists, hydrologists, engineers, and ecologists, and geomorphologists2. Waterpollution evaluation and monitoring has become a important study area. due to the direct impact of water pollution on aquatic life and humans,3. Pollution and climate change are threatening the environmental health of various ecosystems around the world, and they are causing global warming.Water contamination as a result of human activities, oil spills from boats, and chemicals used in fishing has a substantial impact on the Iraqi river's. As a result, heavy metal concentrations in water in the river basin have increased4. Water is exposed to a variety of caused of human activity influence, which include toxic metals like chromium, cadmium, and lead. The degradation of the water quality caused by theentry of these contaminants is regarded as a major issue in the majority of the industrial cities around the world. The uncontrolled discharge of waste effluents into big bodies of water has had and continues to have a negative impact on both water quality and aquatic life5.Water quality index (WQI) is an accurate and simple method for assessing water quality for various purposes.

WQI uses data on water quality to help environmental agencies modify their environmental policies. The understanding of the water quality parameters for non-specialists and the general public is not simple. As a result, WQI proved to be a simple method of providing information on the quality of water for use by concerned citizens and policymakers6. The water quality index is a mathematical formula for identifying water quality data (such as excellent, good, bad, etc.).Which assesses the purity of lakes, streams, and rivers7. The water quality class is determined by the physical, biological, and chemical factors that were measured., as well as purpose of the water, such as drinking water, agricultural water, or industrial water8. Salman &Hussain9 was described how the information on physico-chemical characteristics and heavy metals in water and sediments would be a good tool for ecological assessment and monitoring of the Euphrates River's ecosystem. Water quality varied according to season and study site; the high concentration of heavy metals in sediment was higher than in Euphrates River water. Khoshnam et al 10 study water quality assessment in Lorestan Province, Iran using a heavy metal index and multivariate statistical analysis .The finding showed numerous sources ofpollution of the area's water resources comes from two main sources: one is related to the region's lithology (the natural component), and the other is caused by local human activity (anthropogenic factors).Abdel- Satar ., et al11 was study water quality indicators and metal pollution in Egypt Nile River, WQI for aquatic life showed that the Nile water quality degraded and ranged from poor to marginal, whereas the WQI for drinking porpoise ranged from marginal to good. As a result, the river is becoming unfit for aquatic life, and the situation is deteriorating due to decreases in the Nile's water budget in Egypt due to the construction of the Grand Ethiopian Renaissance Dam, which will reduce the dilution strength of the Nile system. Study of Salman&Shammary12 on Al-Hilla River in central Iraq using the Water Quality Index (CCMEWQI) and showed high levels of calcium and magnesium that were above WHO and IQS standards (50 mg/l and high levels of total hardness that were above 500 mg/l, respectively). Irrigation water quality index (IWQI) values in the study sites ranged from 66 to 83, with fair and good values. Al-Obaidy et al.,(2022) study's stated that According to the result the water quality index (CCMEWQI) for Tigris within Baghdad City, categorized as Fair for aquatic life and Poor for drinking water. Water quality has deteriorated at the Al-Dura Refinery and Al-Zafaraniya city stations which may be attributed to industrial activities in these areas In general, the outcomes indicated that the Tigris River needs extensive treatment before it can be used for domestic purposes(Noor et al ., 2022).

Current study aimed to monitoring AL- Musayyib river –Euphrates river (medill of Iraq) by used Canadian model of water quality index and pollution indices such as index of heavy metal pollution (HPI) and contamination index (Cd).

2. Materials and Methods

2.1. Study area

The research region includes AL-Musayyib river, which represents Al- Musayyib Al-Kaber project and is located in the north-east of Babylon Governorate, to the east of the Mahawil and Musayyib districts. Its source is located on the Euphrates River, north of Al-Hindiyyahbarrage, within 9.6 km until the end of the project at (Al- Massab Al aam) that separates the Babil Governorate from Wasit Governorate, within the limits of 49.5 km, and the project is branched into many of many streams with a total of 12 km / length of 12 km. the main channel is branching from the left side of the Euphrates River in the city of Al-Musayyib is 9.9 km north of Al-Hindiya, and it extends east to 49.5 km. (Figure 1).Study area include four sites on the river: Site 1located on Euphrates River near the city of Al-Musayyib, north of Hindiyabarrage, within 9.6 km. This site is characterized by the high water level in the river in most seasons, as it noted the abundance of aquatic plants such asPhragmitus australis and Ceratophyllum demersum.

Site 2 on AL-Musayyib River near Hilla-Baghdad street ,near the technical institute, it was high traffic density, former military , industrial zones , which represents the Mashroo Al-musayyib Al- kaber and is located in the north-east of Babil Governorate, to the east of the Mahawil and Musayyib districts and clear sediments are noted at the edge of the river and a clear spread of plants, Phragmitusaustralis and Ceratophyllumdemersum.

Site 3was located near Baghdad-Basrah highway and notes many agricultural area around this site. It is noted that there are clear sediments at the edge of the river and a clear spread of some species of aquatic plants.

Site 4is located after the city of Jabla an agricultural region until the end of the Al- Musayyibriver that separates the Babil Governorate from Wasit Governorate, within the limits of 49.5 km.

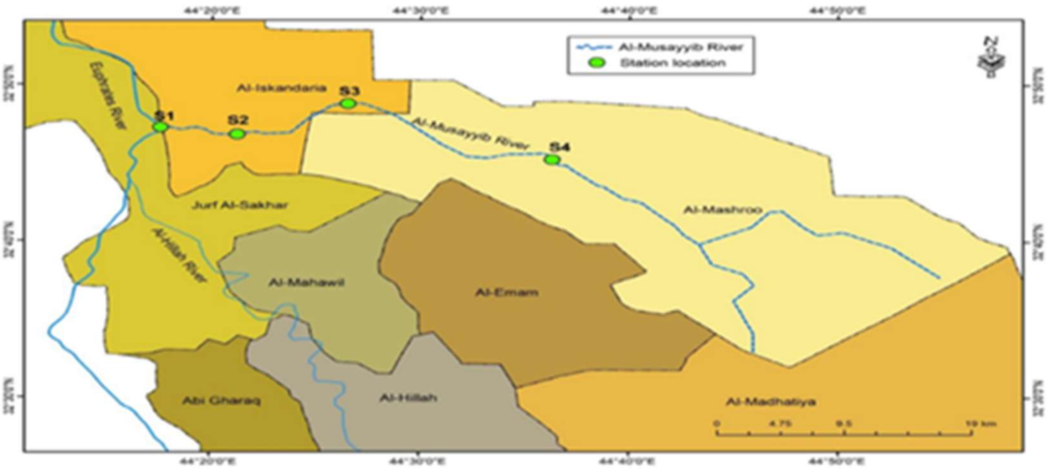

Figure (1): Map of the Study sites on Al-Musayyib River, Babylon governorate, Iraq

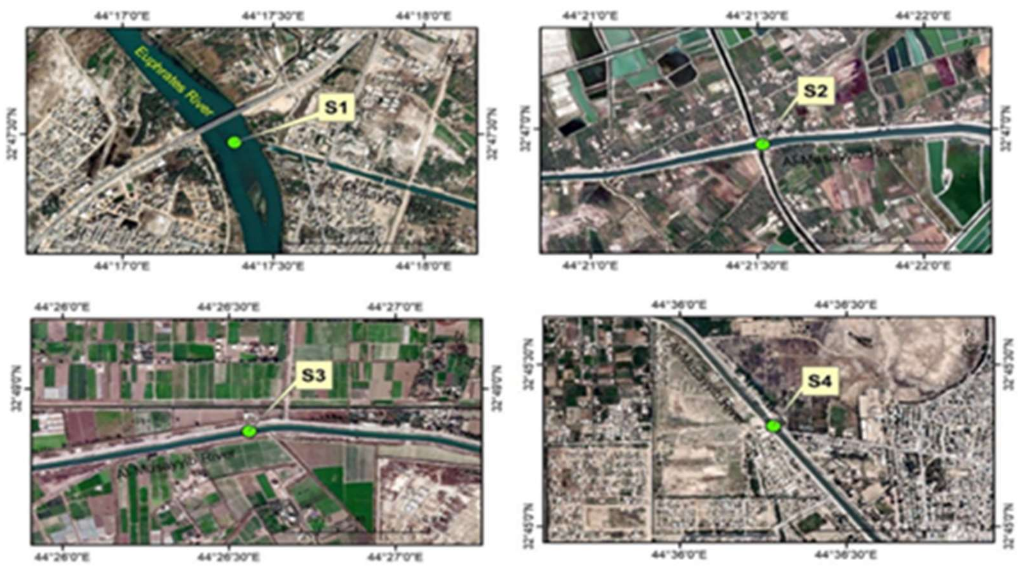

Figure (2) Satellite photos of the Study sites on Al- Musayyib River

2.2. The samples collection

Water samples used from the four sites were gathered monthly from January 2021 to December 2021 from the medial and edge of the river for physical and chemical examinations and heavy metals tests, using 5-litre polyethylene containers with three replicates per sample.

2.3.Physical-chemical parameter analysis

-Temperature of the water was assessed using the Multi-meter directly (manufactured by Hana company).

-pH calculated using Multi-Meter.

-Total dissolved solid (TDS) was assessed using multi-meter (manufactured by Hanna) and is expressed in units of mg/L.

-The Winkler method APHA15 was used to determine dissolved oxygen DO and BOD5.

-Calcium (Ca) Magnesium(Mg) standard method was followed byLind16 .
-No2Nitrite was measured according to the method described by Parson,17.
-No3Nitrate to measure this, a method. APHA15.
-Po4 to measure the effective phosphate follows the method Murphy&Riley18.
2.4. Water Quality Index (Canadian Model)
Water Quality Index (WQI) is one of the most effective ways to communicate water quality because it assesses water quality using calculated water quality indices. The chemical, physical and biological parameters of water are used to define its quality. However, judging quality from a large number of samples containing concentrations for many parameters is difficult19. The Canadian Water Quality Index was calculated using a unique program (CCME WQI 1.0), as stated by the Canadian Council of Ministers of the Environment20. The following formula was used to calculate the WQI:

$$WQI = 100 - \frac{\sqrt{F1^2+F2^2+F3^2}}{1.732} \quad (1)$$

The evidence is based on a combination of three factors:
F1 (Scope): The % of variable that exceed the permissible value

$$F1=\frac{\text{Number of failed variables}}{\text{Total number of variables}} \times 100 \quad (2)$$

F2 (Frequency): The percentage of the total of independent tests for each variable that exceeded the permissible value.

$$F2 = \frac{\text{the Number of failed Test}}{\text{the Total number of Tests}} \times 100 \quad (3)$$

F3 (Amplitude): The degree to which the failed test deviated from the permitted value.

$$F3=\frac{nes}{0.01nes \quad .01} \quad (4)$$

Where nse $=\frac{\sqrt{\text{excursion}}}{\text{Total number of test}}$ and excursion $= \frac{\text{the failed test tests}}{\text{Cuidline value}} - 1$ (5)

Table (1) Water Quality Guide Scale (Canadian Model) CWQI

Water quality status	Index value	Feature
Excellent	95-100	The water is pure and well-protected as it gets closer to ideal water
Good	80-94	The Water is less protected and its specifications rarely stray away from ideal specifications
Fair	65-79	The Water is often protected but sometimes contaminated and sometimes far from ideal
Marginal	45-64	The Water is frequently contaminated and is often far from ideal.
Poor	0-44	The Water is always prone to pollution and is far from ideal at all times.

Table (2). Iraqi and international standards used to calculate the water quality index.

Parameters	Rivers Maintenance	GWQI	IWQI
Wt	-	15***	-
pH	6.5-8.5*	6.5-9	6.5-8.4*
DO (mg/L)	>5*	5.5-9	-
BOD5 (mg/L)	<5*	-	-
TDS	500*	500***	3500
Po4	0.4*	0.1***	-
No3	15*	13***	-
No2	-	0.06***	-
Ca	-	-	400**
Mg	-	-	13.5**
Cr	0.05*	0.0089***	0.008***
Fe	0.3*	0.3***	5***
Cu	0.05*	0.002***	0.2***
Zn	0.5*	0.03***	5***
Pb	0.05*	0.007	0.2***
Ni	0.1*	0.15***	0.2***
Cd	0.005*	0.0002***	0.0051***

2.5. Heavy metal pollution index (HPI)

Regarding metals, the HPI rates the water's quality and suitability for drinking 25.
It is based on the following weighted arithmetic quality mean method Mohan et al 26

$$\text{HPI} = \sum^{n} QiWi / \sum_{i=1}^{n} Wi \qquad (6)$$

Wi (weight unit) was calculated as 1/Si, Si represents relevant metal's recommended standard, n represents number of estimated metals, and Qi represents metal's individual quality rating.

$$\text{Qi} = \frac{\text{Ci}}{\text{si}} \times 100 \qquad (7)$$

Ci is the metals' measured value in mg L-1. (Si) were used to determine the standard allowable value for each parameter 27. Typically, a drinking water's critical pollution index score is 100.25

2.5. Contamination index (Cd)

The contamination index separately measures the relative contamination of various metals and manifests the combined effects of all metals. It was calculated as follows28:

$$\text{Cd} = \sum_{i=1}^{n} \text{Cfi} \qquad (8)$$

Cfi was calculated using the following equation:

$$Cfi = \frac{\text{CAi}}{\text{CNi}} - 1 \qquad (9)$$

C fiis metal's contamination, CAi represents its measured value, and CNi represents its maximum permissible value (N refers to the normative value). Three classes are created from the resulting Cd values: high (Cd > 3), medium (Cd = 1-3), and low (Cd 1). The standard permissible value (Si) that was once used in HPI calculation is now referred to as CNi

3.Results and Discussion

The current research was done on AL-Musayyib river from January 2021 to December 2021 at four selected site in the river to assess its suitability for irrigation (IWQI), river maintenance, and the aquatic environment (GWQI). The overall quality of the water is usefully represented by this index which also provides information on pollution, water quality management and decision-making.All data were computed to calculatewater quality index (Canadian Model) CWQI value. The current study model was built up with seventeen physicochemical parameters (Wt, pH, DO, BOD5,TDS, NO3 ,NO2,Ca, Mg,PO4, Cr, Fe, Cu , Zn, Pb, Ni, Cd)The river's physicochemical characteristics are displayed in Fig(3)The water temperature ranged between 14 – 38 C°, it risen in the summer and declined in the winter These findings agreed with earlier research conducted in Iraq. (Qadoori& Al –Tawash29 ; Hassan et al30) pH values ranged 6.6 – 8.34 in site one in may2021 and January respectively.Many factors influence pH levels, including CO2 concentration31 and nature of climate 32. Do values range 1.4 – 6.3(mg/l) in site one in September and march respectively. BOD5 values ranged 0.3 – 3.9 (mg/l) in site four in May and January respectively. TDS values ranged 250-420 (mg/l) in site two in August and site four in December respectively.No2 values ranged 0.01-0.13 (mg/l) in site four in February and November respectively . No3 values ranged 0.213-7.827(mg/l) in site three in August and site four in November respectively .Po4 values ranged 0 -1.087(mg/l) in site four in march and site two in September respectively.Ca values ranged 193.33-646.66 (mg/l) in site two in September and site three in October respectively. Mg values ranged 12.15 -139.32 (mg/l) in site two in June and Septemberrespectively. The findings of the present study demonstrated that therates of heavy metals concentrations in water for the four study sites are in the following order in dissolved phase Zn> Fe > Cu> Ni>Pb> Cr > Cd. The zinc element recorded the highest rate of concentration of the studied elements in the dissolved water While the cadmium element recorded the lowest rate Figure (4).The wastewater discharge into freshwater bodies as a result of the fast pace of industrial and commercial activities demonstrates the importance of regular monitoring and prevention activities.(Shukla et al 33; Tripathi& Shukla.,34). The rapid rise in heavy metal levels has created a risk of biomagnification of these heavy metals through the entry of noxious elements into the food chain35.Possible sources of heavy metal in river water include the discharge of industrial effluents from small-scale manufacturing facilities, electroplating operations, battery manufacturing, and waste disposal36 .

Thefindings of the current study showed that the concentrations of both Fe, Cu, Znexceeded the World Health Organization's permissible limit for portable water37 WhilePb , Ni , Cd was within the desirable limit. The heavy metals' relative abundance was in the following order: in dissolved phaseZn> Fe > Cu > Ni>Pb> Cr > Cd.The majority of residents in the study area, who rely heavily on the water for domestic and agricultural purposes, may face serious health risks as a result of the elevated heavy metal concentrations in the area. The heavy metal pollution index for the study area was calculated using the mean concentration values of the selected metals (Zn, Fe,Cu, Ni, Pb,Cr,and Cd). In the current study inthe river to determine its suitability for irrigation (IWQI) were depended on(13) total parameter each season Table (2) the results showed the CWQI value for the maintenance of rivers ranging from (24.901-39.600) at the fourth site of the autumn and the third site for the winter respectively Fig.(5, A) and when compared with the global determinants of water conservation it turns out that (poor) Water is always prone to pollution and is far from ideal at all timesTable (1) and the reason for the minimum of the fourth site of the autumn season as some parameters exceeded the required limit as in the decrease of dissolved oxygen from the required limit where recorded less than 5 and a rise in the elements of Po4 , zinc, copper and iron. The reason for the rise of the element zinc may be attributed to the diversity in the sources of pollution with this element or the difference in the quantities of polluting materials to the river or it may be because ofthe difference in the water level or some of the life activities carried out by some living organisms that are affected by the amount of food, Reproduction and photoperiod.38 As fordetermining the suitability the river foraquatic environment (GWQI) were depended on(14) total parameter each season Table (2) the results showed the CWQI value for thedetermine its suitability for aquatic environment ranging from (8.279- 19.474) at the first site of the Autumn and the fourth site for the spring respectively Fig. (5, B) and when compared with the global determinants of water conservation it turns out that (poor)Water is always prone to pollution and is far from ideal at all timesTable (1) and the reason for the minimum of the first site of the autumn season as some parameters exceeded the required limit as in the decrease of dissolved oxygen from the required limit where recorded less than 5 and a rise in the elements of Po4,No2 , Zn, Cu ,Fe ,Cd.Wanget al 39statedthat among the six metal concentrations in the water, sediments, and aquatic organisms in the rural rivers, Zn concentration was highest and Cd concentration was lowest. In addition to total heavy metal concentrations in water and sediments, metal speciation concentrations in sediments were also correlated with heavy metal accumulation in aquatic organisms and The greatest ecological risk to the environment came from cadmium in sediments.As for determining the suitability of the river for irrigation, it depended on (11) total parameter each season Table (2) the results showed the CWQI value ranging from(43.044-61-422) at the first site of the Autumn and the third site for the winter respectively Fig(5,C) . and when compared with the global determinants of water conservation it turns out that (Marginal) Water is frequently contaminated and is often far from ideal except first site of the Autumn be (poor)Water is always prone to pollution and is far from ideal at all timesTable (1) and the reason for the minimum of the first site of the autumn season as some parameters exceeded the required limit as in the rise in the elements of Ca , Mg, Zn ,Cu.

As for the Index of pollution, two types of were Index studied to determine the extent of pollution of the river heavy Pollution Index (HPI)& the contamination index (Cd). The HPI values which were noticed were recorded greater than the Critical Pollution Index of (100)average value (74.38388 - 238 .5592)in St.3 for Winter season and St.2 for spring season Fig.(6,D) .The reason for the high value of the Index is due to the rise in heavy elements (Fe, Cu ,Zn) exceeded the permissible limit for portable water. As for the contamination index (Cd) The values of (Cd)ranged from (23.061-84.070) in site three in winter and site two in spring Fig.(6,E) .Cd >3 the pollution is high

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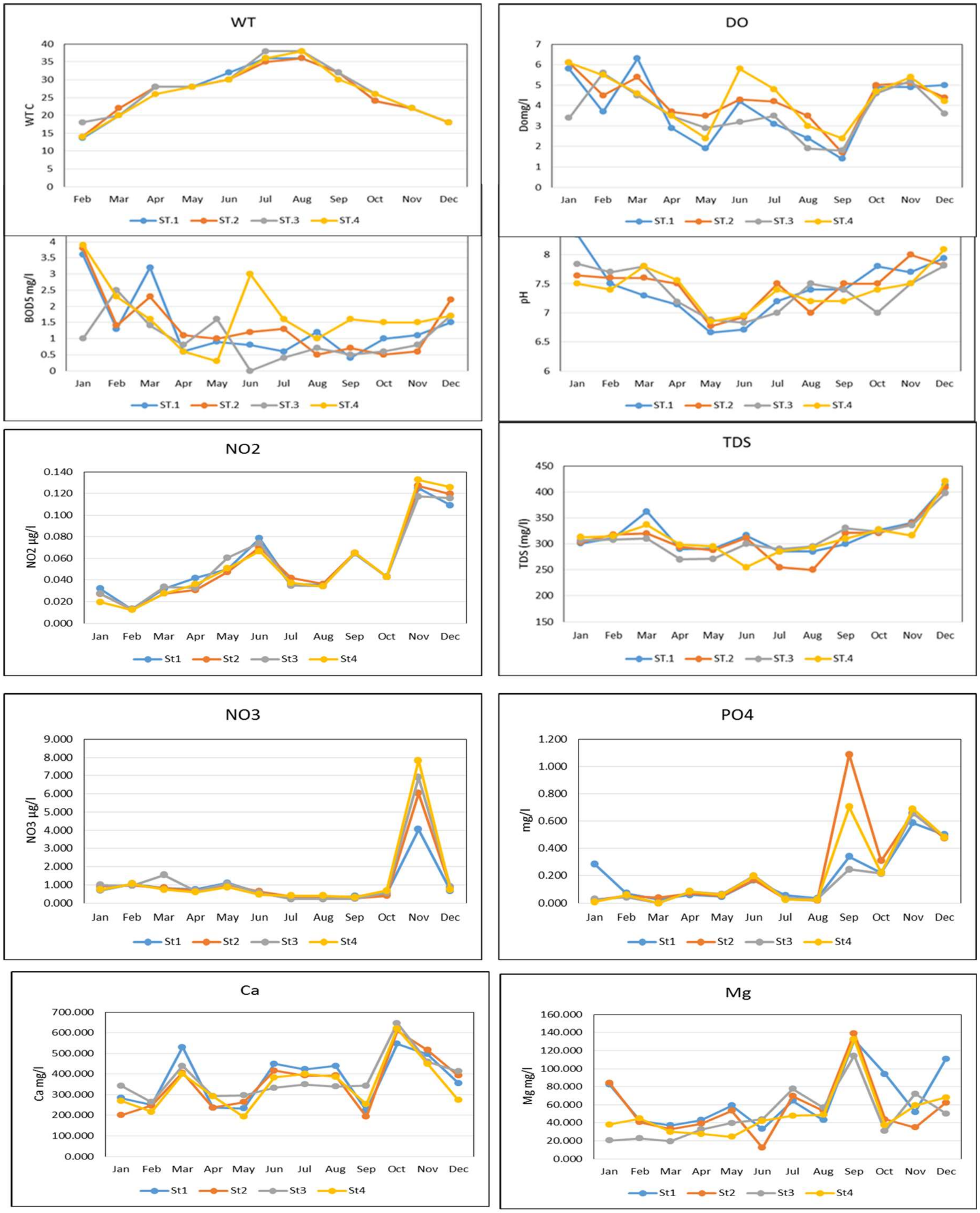


Figure (3) Physicochemical properties (Wt, DO,BOD5, pH, No2,TDS,No3,Po4,Ca,Mg)

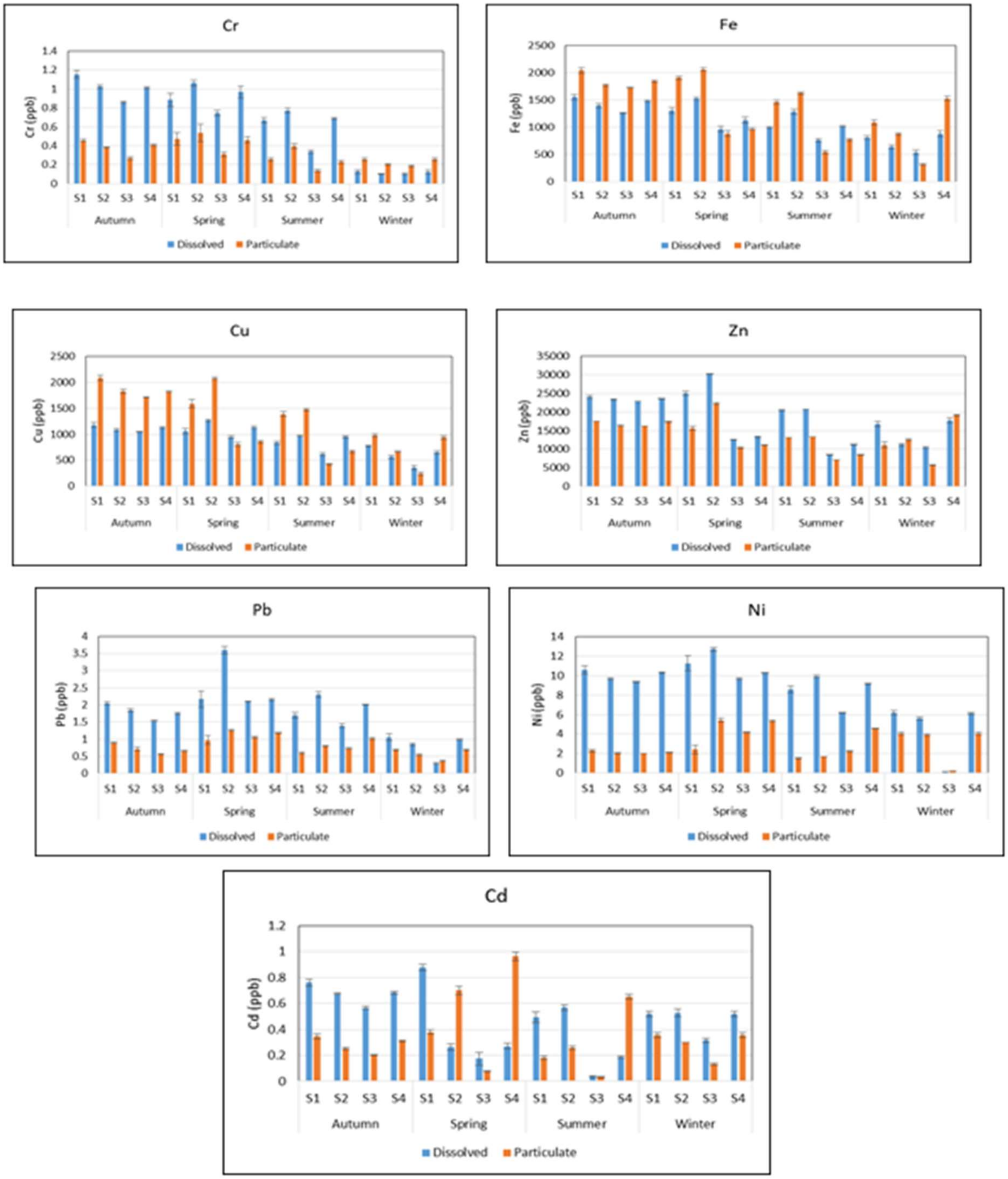
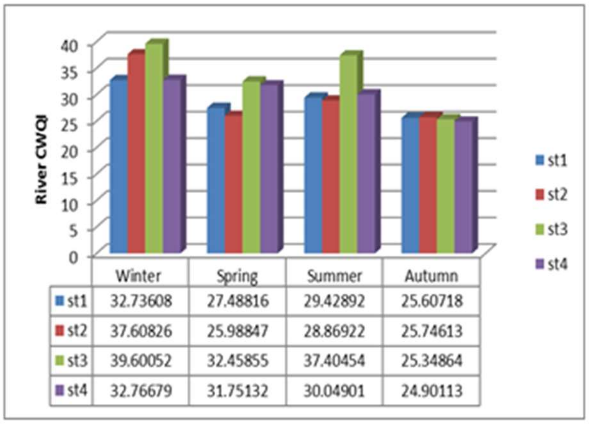
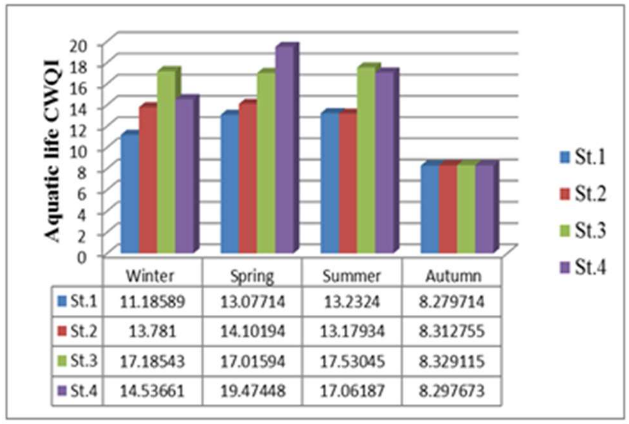


Figure (4) Iron ,Copper ,Zinc ,Lead ,Nickel ,Cadmium, chromium Concentration rate (µg /l) in water



(A)



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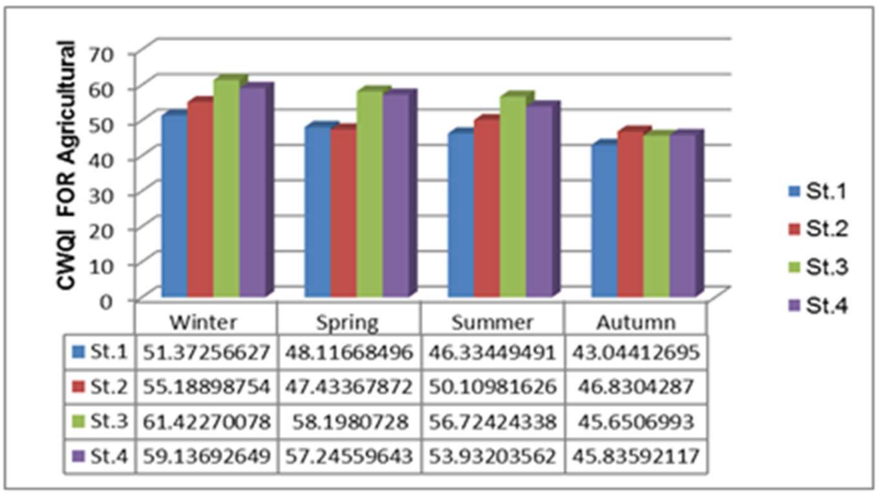
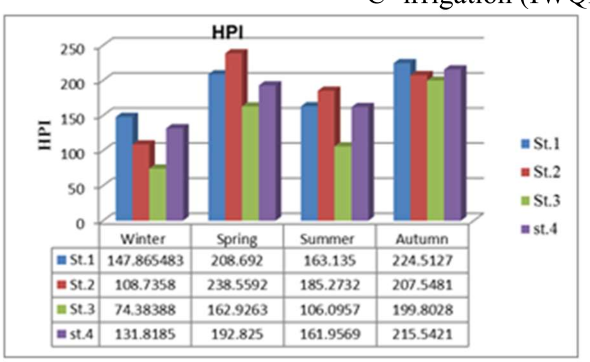


(C)

Figure (5) A – Rivers Maintenance CWQIfor Al-Musayyib river
B-(GWQI) water quality index for the aquatic life for Al-Musayyib river
C- irrigation (IWQI) water quality index.



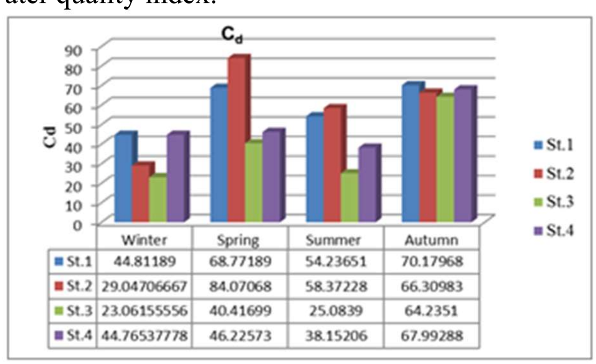


Figure (6) D - (HPI) Heavy metal index for Al-Musayyib river
E- (C_d)Contamination index for Al-Musayyib river

4. Conclusion

Water quality varied according to different study sites and seasons and for several purposes for irrigation, aquatic life and maintenance of rivers .The high concentration of heavy metals (Fe , Cu , Zn) in water exceeded the World Health Organization's permissible limit for portable water. led to a rise in the values of pollution index (HPI, Cd).The current information of the physico-chemical characteristics and the presence of heavy metals in water would serve as a useful resource for ecological assessment and ecosystem monitoring in the Musayyib River.

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Author Contribution

This work was carried out in collaboration between all authors. A F K diagnosis the cases then collected the samples and doing the tests. J M S, wrote and edited the manuscript with revisions idea. P K, analysis the data with revisions idea . All authors read and approved the final manuscript.

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