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**Distribution and Fate of Some Heavy Metals and Water Quality
of Lotic Ecosystem : Mashroo AL- Musayyib Stream / Branch of
Euphrates River Babylon , Iraq**

A Thesis

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

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صدق الله العلي العظيم

The Supervisors' Certification

We certify that this thesis entitled "**Distribution and Fate of Some Heavy Metals and water Quality of Lotic Ecosystem : Mashroo AL- Musayyib Stream / Branch of Euphrates River Babylon , Iraq**" was prepared by "**Ashwak Falih Kaizal Fleih AL-Ajely**" under our supervision at the University of Babylon /College of Science /Department of Biology as a partial fulfillment of the requirements for the Degree of Doctor of philosophy of Science in Biology.

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Dedication

I dedicate all my efforts To whom I worship for his merciful

(Allah)

To the one who led the hearts and minds of humanity to the port of safety, the first teacher of humanity, Muhammad, peace be upon him.....

To my beloved father and mother the light of my eyes, may God have mercy on them who taught me that nothing is impossible in the world if we have willpower and self-confidence.....

To the soul of the one who left with his body and did not leave my memory..... My brother Muhannad, may God have mercy on him.....

To my support, my strength, and my refuge after God, my brothers and loved Mushtaq , Hind & Rand.....

To the companion of the path and the friend of all the days with its sweet and bitter My dear husband Akram.....

To the stars that shining my lifeMy children Laith , Malak & Baraa

I dedicate the fruit of my humble effort

Ashwak

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Summary

The current study aimed to assess water quality and investigate the fate and transport of some heavy metals in food chains within the Musayyib channel (branching from the Euphrates River in central Iraq) as Lotic Ecosystem for the period from January 2021 to December 2021 in four sites (1,2,3,4).

This study included some physical and chemical properties of the channel water were also measured, such as Water Temperature (WT), Air Temperature (AT), pH, Electrical Conductivity (EC), Salinity, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD₅). This study examined the determination of seven heavy metals (Iron, Copper, Zinc, Lead, Nickel, Cadmium and Chromium) in water (dissolved phase and particulate phase), sediment and some aquatic organisms including two species of hydrophytes (*Ceratophyllum demersum* and *Phragmites australis*) and one species of clam (*Pseudostapes euphraticus*) and two species of fish (*Oreochromis aureus* and *Leuciscus vorax*) in four sites within the Musayyib Channel / Branch of the Euphrates River, Babylon, Central Iraq. The order of the elements studied in the dissolved phase of water was: Zn > Fe > Cu > Ni > Pb > Cr > Cd, where Zinc recorded the highest rate in the second site in Spring season while Cadmium recorded the lowest rate in the first site in Spring season. In the particulate phase of it, the elements were arranged as follows: Zn > Cu > Fe > Ni > Pb > Cr > Cd, in which Zinc recorded the highest rate in the second site in Spring season, while Cadmium recorded the lowest rate in the fourth site in Spring season, and the elements under study were arranged in the sediments as follows: : Zn > Cu > Fe > Pb > Ni > Cd > Cr. The element zinc recorded the

highest rate in the second site of the Spring season while the element Chromium recorded the lowest rate in the second site in Spring and in hydrophytes *C. demersum* gradient took the following form: Zn> Fe > Cu> Pb> Cr> Ni> Cd Zinc recorded the highest rate in the fourth site in Winter season while Cadmium recorded the lowest in the first site in Autumn season . In *P. australis* the elements were graded in the formula: Zn> Fe> Cu> Pb> Cd> Ni> Cr The element Zinc recorded the highest rate in the second site of the Spring season while the element Chromium recorded the lowest rate in the second site of the Spring season . In clam they were ranked as follows: Zn> Fe> Cu> Ni> Pb> Cd> Cr, Zinc recorded the highest rate in the second site of the Spring season while Chromium recorded the lowest value in site 3 during the Winter of 2021 and in fish species (*O. aureus*) Fe> Zn> Cu> Pb> Cr> Cd> Ni. Iron recorded the highest rate at site 2 in Spring 2021 while element Nickel recorded the lowest rate at site 2 in Spring and in (*L.vorax*) .Iron recorded the highest rate at site 2 for the Summer season while Nickel recorded low values at site 4 in Spring 2021. In addition, the current study aimed to assess the current water quality of the Musayyib River, from which the Mashroo AL- Musayyib Channel is represented and located in the northeast of Babil Governorate, to the east of Mahawil and Musayyib districts. To the city of Jableh by several physical and chemical analyzes using Water Quality Indicators (WQI), Heavy Metal Pollution Index (HPI) and the Contamination index (C_d). The Water Quality Index (WQI) is a tool used to determine whether water is suitable for aquatic life and rivers used for irrigation (IWQI). The aim of this study is to assess the water quality of the Musayyib channel. Several sites were selected in the study area and seventeen physicochemical parameters, heavy element pollution calculation index (HPI) and pollution index (C_d) were applied to assess the validity of

water. For different use from January 2021 to December 2021, the studied period was 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 results of the current study showed that the HPI values that were higher than the average value of the critical pollution index (100), ranging from(74.38388)to(238.5592) in St.3 for winter and St.2 for Spring. The high value of the indicator may be due to the high elements Fe; Cu and Zn more than the permissible limit for portable water and heavy metal concentration As for the pollution index (C_d), the values of (C_d) ranged between (23.061-84.070) in the third site in winter and the second site in spring Figure C_d >3 and the pollution is high.

The state of water quality was (Poor- marginal) and very effected by physical and chemical properties of the river .

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Table of Abbreviations

Symbol	Description
AT	Air Temperature
WT	Water Temperature
pH	potential of hydrogen
EC	Electrical Conductivity
TDS	Total Dissolved Solid
TSS	Total Suspended Solid
DO	Dissolved Oxygen
BOD ₅	Biological Oxygen Demond
Ca	Calcium
Mg	Magnesium
NO ₂	Nitrite
NO ₃	Nitrate
PO ₄	Reactive phosphate
TOC	Total organic carbon in sediments
Fe	Iron
Cu	Copper
Zn	Zinc
pb	Lead
Ni	Nickel
Cd	Cadmium
Cr	Chromium
CWQI	Water Quality index (Canadian Model)
HPI	Heavy Pollution Index
C _d	contamination index
BCF	Bio concentration factor
BSF	Bio sedimentation factor
S	Site

Chapter One

Introduction &
Literatures Review

1- Introduction and Literatures Review

1-1: Introduction

Iraq is characterized by its abundant fresh surface waters, which are represented by the Tigris and Euphrates rivers, as well as the waters of lakes and enormous marshes, which form along the Shatt al-Arab. Iraq is one of the countries that exploits its water for most of the purposes for which water is a source. Al-Saadi (2005) pointed out that Iraq's internal waters cover about 24,000 Km², consisting of about 5% of Iraq's area in the form of various water systems such as streams, rivers, springer, lakes, reservoirs and marshes, which include different groups of organisms, where aquatic plants form the base of the environmental pyramid.

Rivers are contaminated with many pollutants such as heavy metals from various sources such as household ; industrial waste; mining activities and agricultural activities in affecting the environmental balance in the water system (Canli ,1998), or natural water sources are polluted by being influenced by anthropogenic events and various other organisms that lead to a change in the natural qualities of water in addition to the impact of geological components and seasonal changes on aquatic systems (Draver ,1988).

Aquatic ecosystems are water-based habitats where biotic and abiotic elements of the ecosystem interact. The "marine ecosystem" and the "freshwater ecosystem" are the two categories into which "aquatic ecosystems" are typically subdivided (Barange *et al.*, 2010).

The local habitat characteristics of lotic and lotic ecosystems (such as the presence or absence of flow, the duration of water residence), as well as their physical connectedness, are fundamentally different. In a terrestrial matrix, lentic ecosystems are isolated aquatic habitats (De Meester *et al.*2002). Unlike

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dendritic river networks, where lotic ecosystems are typically continuous habitats connected by unidirectional flow (Fagan ,2002). Habitat geometry, which refers to the quantity, configuration, connectivity, and fragmentation of habitats, can have an impact on community structure (France and Duffy, 2006; Starzomski and Srivastava, 2007), and hydrological connectivity can greatly aid aquatic taxa's dispersal and coexistence across multiple sites. (Bilton *et al.*,2001).

According to Aoki (2012) and Avram *et al.* (2018) , a lotic ecosystem is a system made up of biota (plants, animals, and microorganisms) and their physical surroundings, namely a freshwater body. Agriculture, infrastructure construction, and deforestation are examples of intensive human activities that put strain on ecosystems and change their conditions. It has been shown that due to human activity, the aquatic ecosystem's components are highly vulnerable. However, because of climate change, which is caused by both human activity and natural processes, oceanic ecosystems are impacted. The seasonal thermal zoning of river waters is a sign of how climate change is affecting lentic ecosystems, which has an impact on the overall ecosystem. Almost all ecological factors like temperature, light, pH, dissolved gases, dissolved salts in water, turbidity, alkalinity, depth and areal distribution, all of these parameters play an active role in controlling the habitat of aquatic ecosystems. (Lampert and Sommer , 2007). According to Havens and Jeppesen (2018), the rivers' ability to offer habitat for thousands of aquatic species and ecosystem services to civilization is under threat from size loss, increased salinity, and or significantly altered thermal characteristics. For the aggregated broad kinds with the worst ecological status, non- point source affects the greatest proportion of river water bodies, while point source contributes less significantly to deteriorated water quality (Solheim *et al.*,2019). According to Hall *et al.* (2019), both internal and external factors (such as waste from industrial activities, nutrient leaching from

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agriculture, deforestation, and acid rain) contribute to the pollution of lotic ecosystems. In addition, dealing with nonpoint pollution makes it challenging to pinpoint its source, volume, and effects, necessitating comprehensive analyses. Freshwater ecosystems in particular are more vulnerable to further contamination than other environments due to the use of water in numerous industrial processes and the discharge of waste products from industry and urban development (Demirak *et al.* 2006; Fernandes *et al.* 2007). Water contamination is an issue that affects both developed and developing countries globally (Mateo- Sagasta *et al.*, 2017).

Understanding the function and connections between creatures in the aquatic ecosystem's food web is crucial. Predation frequently acts as a regulating element for energy pathways and helps to determine species composition in the environment. Matter cycling, which is mediated via the food chain, is the primary biological interaction in the aquatic food web (Carrillo *et al.* , 2006). In particular, rotifers-copepods, micro/macro invertebrates, and larval mature fish are important food sources at the species level that connect creatures with larger predatory species like crustaceans and fish throughout the grazing food chain (Ihn and Young ., 2020). They therefore act as a pathway for the transportation of organic matter within a variety of creature assemblages positioned in the midst of the two different food webs as well as a way to transfer nutrients and energy from the prey species-predator species loop to higher trophic levels. The biological prey-predation interactions in the food web are thus receiving a lot of attention in order to understand not only the linked biological linkages but also the structure and function of aquatic food webs (Oh *et al.* ., 2017).Pollution is one of the most prominent global problems in the modern era that threatens life forms on the surface of the earth because of the clear effects that pollution has on the physical and biochemical properties. It occurs as a result of the transfer of

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these pollutants from their sources, causing economic and health damage to humans and other living organisms (UNEP, 1993) therefore, pollution is defined as the entry of substances or compounds into the environment that cause disturbance and imbalance in the composition of the environment compared to natural conditions causing damage and loss of balance. This may result due to anthropogenic activity causing physical, chemical and biological changes to the main elements of the environment, water, air and soil (Irabii, 2001; Al- Saadi, 2006).

A heavy metal (HM) is an element with a density more than 5g/cm^3 . Groups are created for HM. The first one is essential elements, such as Nickel, Copper, and Zinc, which are important for the metabolic processes of organisms but become toxic at high concentrations, the second is non - essential elements, like Cadmium, Lead, and Mercury, have harmful effects on organisms even at low concentrations (Richmond, 2004). HMs are naturally occurring substances found in water, sediments, plants, and animals. They can also be released into the environment by a number of natural processes, such as rock weathering, soil leaching, forest fires, and other occurrences of the natural world. In addition to anthropogenic activity, which substantially contributes to the environment's heavy metal pollution (Mason *et al.* , 1990). Heavy metal pollution of the aquatic environment is mostly caused by geochemical composition, agrochemicals, and industrial wastes (UNEP, 2008).

Many studies carried out to find other ways to monitor of pollution levels by heavy metals in lotic aquatic systems by used many aquatic species as bioaccumulators, bio indicators and bio monitors such as macrophyta ,mollusca,fish....etc. (Gałczyńska *et al.*, 2019).

Aim of the study

- 1- Investigate the concentration and fate of some heavy metals within lotic ecosystem in the river (water) ; sediments and some aquatic organisms available in study area .
- 2- Evaluating the water quality in Al-Musayyib channel and showing its suitability for various purposes (river maintenance, irrigation, and live of aquatic organisms) by applying water quality indices.
- 3- Study the bioaccumulation and bio concentration of heavy metals.
- 4- Explaining the pollution sites through applying some heavy metals indices (HPI , C_d).

1-2:Literatures review

1-2-1: Water pollution

1-2-2: Physical and Chemical Properties of Water

The physical and chemical properties have a significant impact on the diversity and density of aquatic organisms (Sangpal *et al.*, 2011) indicated that physical and chemical properties play an important role in the composition, distribution and abundance of organisms aquatic living.

There are many international and local studies researched the physical and chemical properties, including the study of (Mellina *et al.*, 2002) mentioned that temperature affects the solubility of gases in water the solubility of gases, especially oxygen and carbon dioxide, decreases with increasing degree the pH is one of the important factors that affect aquatic organisms, as they depend It has most of the metabolic activities (Wang *et al.*, 2002).

Iqbal *et al* ., (2004) described seasonal changes of physicochemical properties for the water of the Soan River in Pakistan, it was found that the river water is generally within the water specifications standard. Study of (Salman, 2006) in an environmental study of the possible pollution in Euphrates River between the Hindiya Dam and the Kufa region -Iraq and found that the pH, suspended and dissolved solids, and electrical conductivity. The dissolved oxygen is within the permissible limits, while the biological Oxygen Demand (BOD₅) exceeded the border and the water is very hard.

Patil and Prasad (2008) investigated the physical and chemical factors the water of the river Krishna, especially western Maharashtra in India, and the river water is found to be within the standard specifications. Study of Hassan *et al.*, (2010) this study is conducted to reveal possible environmental effects on the Euphrates River from the Al-Hindiya barrage to the downstream end of AlKufa

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city in the middle of Iraq and the waste of military factories, urban run-off, city sewage and the agricultural activities are affecting the physicochemical characteristics of Euphrates River.

At the researcher's Venkatesharaju *et al.* ,(2010) study indicated that the pH is one of the important factors that determine the suitability of water for different purposes, as it is found that its values decreased in the summer. It rose in the winter, attributing this to a decrease in the rate of decomposition as a result of the decrease in the bacterial account in the winter season . Jayalakshmi *et al.*, (2014) mentioned that to assess the physicochemical parameters of water and water drainage of the Krishna River in the city of Vijayawada, where he studied seven study sites and found that the first three sites are slightly polluted, while the four sites are highly polluted, and he attributed this to pollution water with industrial, agricultural and household waste.

Jena *et al* (2013) study to assess water quality by physical and chemical properties of river water Khroon found that the dissolved oxygen values ranged between (1.2- 7.5) mg/l and the values of the requirement the bioavailability ranged between (5.89- 8.12) mg /l and they attributed this to the lack of treatment of liquid waste and water sewage and put it into the river directly. Salman *et al.* , (2015) stated about a gis assesment of water quality in Euphrates river/Iraq and the system database will be used to archive the water data across times and become a common data for different agencies. The results may useful in environmental monitoring of running water in Iraq, especially Euphrates River. The database used to keep tracking the physical, chemical, and biological factor. kadhum *et al.*, (2020) multivariate analysis and geochemical assessment of heavy metals pollution in surface sediment from Euphrates river, Iraq, the multivariate analysis showed a different relationship between heavy metals, TOM, and pH which is TOM play role in increasing the Zn, Pb, and Cu, and

Chapter one Introduction and Literatures Review

these elements are from different sources such as anthropogenic and agriculture activities.

Study of Khaleefa and Kamel (2021) On the evaluation of water quality index case study of Euphrates river, Iraq .The results of this study show the total average WQI is (110,156). The high WQI achieved is caused by the high TDS and magnesium concentration due to the different human activities along the river reach. The Euphrates River quality is classified as 'very poor quality' with a minimum WQI of(97.85) in June and(121.75) in November. Saod *et al* (2021) described Water quality index along the Euphrates between the cities of Al-Qaim and Falluja :A comparative study. This study results concluded that the alterations existed in the concentration of the Physico-chemical parameters in most months, except January and September, along the Euphrates between the cities of Al-Qaim and Fallujah, as a result of harmful practices and this study revealed that the Euphrates River water is polluted due to human activities, agricultural run-off, the release of inadequately treated wastewater, making it unsuitable for human consumption unless treated properly.

Hussien *et al.*, (2021) stated the study of hydrochemical variations and water quality valuation of the Euphrates river. The results of the physico-chemical components found that their values are within their limits in a natural river environment and less than the prescribed limits for domestic use and human drinking purposes during rainy periods, and exceeded the desirable limit for TDS, Ca, and Mg, therefore classified as Fair water in samples collected before and after rainfall.

1-2-3: Heavy metals

Heavy metals are naturally occurring in different environmental media but their wide range of industrial, domestic, agricultural, medical, and technological applications have resulted in their widespread distribution in the environment, raising concerns about their potential effects (Al-Sareji *et al.* , 2021). Heavy metals have a density compared to water more than 5 g/cm³, which are naturally originating and spread in nature very widely. It moves between parts and components of the environment on an ongoing basis (Ali and Khan, 2018). The term "heavy metals" is widely used to refer to metals and semimetals (metalloids) that have been connected to contamination, potential toxicity, or ecotoxicity, according to Arroyo and Molinos-Senante (2018).

Heavy metals have occurred in the aquatic environment by natural and anthropogenic sources .Weathering of metal-bearing rocks and volcanic eruptions are natural sources of heavy metals in the environment, but global trends of industrialization and urbanization on land have increased the anthropogenic share of heavy metals in aquatic systems (Ali *et al.* , 2019). Heavy metals are hazardous even in low concentrations because they are not biodegradable and accumulated in sediments and biota (Brodin *et al.* , 2017).

Geological and erosion processes naturally release heavy metals into the aquatic environment and these metals reach from the original natural source of rocks and sediments to the aquatic environment and these metals are dissolved or suspended in rain water that falls on the soil's surface or to be carried by the wind from one place to another while suspended in the air (Li *et al.*, 2020). Volcanic activity is another natural source that contributes to the contamination of the aquatic environment. It can be reached by acid rain loaded with various pollutants, including toxic elements (Zhang *et al.*, 2018).

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In nature, excessive trace metal concentrations can be caused by geological events like volcanic eruptions, rock weathering, and water-induced leaching into rivers, lakes, and oceans. industrial activities a significant source of heavy metal pollution in the environment is caused by industries such as petroleum, oil refineries, iron and steel plants, copper, glass, aluminum, tanning plants, fertilizers, pesticides, gasoline, and others (Liu *et al* ., 2019). The release of industrial wastes into water bodies, on the other hand, as well as a variety of other human activities that release metal contaminants into the aquatic environment, are examples of anthropogenic sources (Varol, 2011). Rivers continuously acquire heavy metals, which are thereafter deposited as sinks in marine sediment.

Most researchers agreed that heavy metals are among the dangerous groups polluting water and cause direct dangers to the lives of most aquatic organisms and humans alike by moving through the food chain to cause accumulation in the levels of that chain for life in different ecosystems (Mkadmi *et al* ., 2018). Anbuselvan *et al.*,(2018) reached in studying some sources of environmental pollution in sediments to indicated that the physical characteristics are within the permissible limits, except for conductivity and showed that the EC and suspended solids as they exceed these limits and that the chemical properties such as calcium, sodium, potassium, magnesium, fluoride and chlorides are within the limits allowed except for bicarbonates and phosphates.

To identify potential environmental consequences on the eastern Euphrates drainage in Babylon province, Habeeb *et al.* (2015) evaluated water quality and heavy metals in water, sediment, and aquatic macrophytes in the lotic ecosystem..Al-Zughaiby *et al* ., (2020) determined the correlation between some trace element concentrations in the Euphrates River of Iraq.Based on this

research, the rates of concentration of trace element are found in water and soluble form and study sites .

Salman and Al-Shammary(2020) determined the quality of water in Hilla river by examining many physical and chemical properties .

1-2-4: Forms of Heavy Metals in the aquatic environment

There are three forms of Heavy Metals as explained by (APHA , 2003):-

1-Dissolved heavy metals

The metals that are passes through filter paper with mill pore (0.45 μm) .

2-Particulate heavy metals

Items with materials include stuck inside water components that cannot pass through the millipore filter paper (0.45 μm) when filtering a water sample.

3-Heavy Metals in benthic sediments:

A-Exchangeable metals

These elements are not included in the seleucidal or retinal composition of the sediments, but are provided on surfaces of benthic sediment molecules.

B- Residual metals

They are the substances that make up the benthic deposits' silicate or retinal formations. These substances enter water bodies through soil erosion, dust and air precipitation, soil contamination from industrial waste and sewage, and a variety of agricultural and urban activities. They are either water-soluble or linked to roving animals and plants or benthic sediments (Wahab and Al-Zubaidi, 2012).

1-2-5: Sources of Heavy Metals in the aquatic environment

Both anthropogenic and natural sources of heavy metals can be found in the aquatic environment. However, the global trends of industrialization and urbanization on lands have led to an increase in the anthropogenic share of heavy

metals in the aquatic systems. The natural or geological sources of heavy metals in the environment include weathering of metal-bearing rocks and volcanic eruptions. Heavy metals are hazardous even in low concentrations because they are not biodegradable and accumulated in sediments and biota (Ferrey *et al.*, 2018).

1-2-5-1: Natural sources

After being naturally released into the aquatic environment by geological and erosive processes, heavy metals are dissolved or suspended in rainwater that is drifting on the soil's surface or suspended in the air to be carried by wind from one location to another. These metals originate from the original natural source of rocks and sediments (Papagiannis *et al.* ,2004) Other natural sources that contribute to the contamination of the aquatic environment include volcanic activity. Acid rain laden with several contaminants, including poisonous substances, can reach it (Butu and Iguisi ,2013).

1-2-5-2:Anthropogenic source

Heavy metal contamination in the environment is mostly caused by industrial activities, which include the petroleum industry, oil refineries, iron and steel factories, copper, glass, aluminum, tanning plants, fertilizer and pesticide manufacturing, and other businesses. (Majed *et al.*, 2002; Rashed,2001; Papagiannis *et al.* , 2004). Heavy metals can reach the water through pollution with industrial or waste water (Butu and Iguisi , 2013) .

Anthropogenic sources on the other hand include sewage waste dumping mining activities agricultural activities discharge of industrial wastes into water bodies and many other human activities that discharge metal pollutants into the aquatic environment . Anthropogenic sources have a high impact on the accumulation of heavy metal in the marine environment. (Demirak *et al.*,

2006) . The rivers continuously acquire heavy metals, which are then deposited as a sink in the marine sediment. Toxicology, bioaccumulation, and biomagnification are the main problems associated with heavy metal persistence, and they have a lasting impact on the ecosystem, human health, and other living things (Perumal *et al.*, 2021).

1-2-6: Heavy Metals in Water

Anthropogenic activity is one of the most important sources of heavy metals in the aquatic environment, and most of the world's rivers and surface water are under the influence of anthropogenic activities leading to the rapid degradation of these environments due to the continuous discharge of contaminated flows (APHA , 1995).

The most important sources of pollution of the aquatic environment with heavy metals include geochemical composition, agricultural chemicals and industrial waste. (Papafilippaki *et al.*, 2008). The sources of pollution of the aquatic environment, as well as the pollutants deposited in the air, increase the concentration of these elements in water to levels harmful to aquatic life and affect the validity of the use of such water in various fields. Many previous studies showed the concentration and distribution of heavy metals in different aquatic systems Al-Khafaji , (2011) stated that distribution of some heavy metals in water ,sediment and fish *Cyprinus carpio* in Euphrates river near Al-Nassiriya city center south Iraq The statistical analysis proved a significant correlation between metal concentration in the sediment and total organic carbon, also apposite correlation is proved between its concentrations in the liver organ and the water.

Salman *et al.* (2015) described a study on the fate of several heavy metals in water and sediment in maritime ecosystems. The results showed that, with the

exception of copper, which is in the exchangeable phase higher than the residual phase, the particulate phase of heavy metal concentrations in water is higher than the dissolved phase, and the residual phase of heavy metal concentrations in sediment was higher than the exchangeable phase.

1-2-7: Heavy Metals in sediments

The sediment may be a source of heavy metals that will be released into the overlying water as a result of natural and anthropogenic processes where they may have a negative impact on the safety of the drinking water and people's health. Furthermore metals can accumulate in benthic biota or other creatures after they consume metal particles or tainted water, which leads to metals entering the food chain (Yin *et al.*, 2011).

Sediments are the main source and transporter of pollutants such as heavy metals (Suresh *et al.* , 2012) . In addition one of the factors that increase the sedimentation of heavy metals and sediments and thus their increased concentration is the result of the formation of insoluble element hydroxides (Remoudaki *et al.*, 2003). Its importance lies in the re-release of these pollutants to the water column. Due to physical and chemical conditions in addition to their absorption by aquatic organisms and thus their transmission through the food chain, which causes their accumulation over time toxic effects of those organisms (Saeed and Shaker., 2008;Ogoyi *et al.*, 2011).

The melting and release of these elements from sediment to the water column depends on several factors, including temperature, pH, running speed and dissolved oxygen (Li *et al.*, 2013).

Habeeb *et al.* , (2015) stated environmental study of water quality and some heavy metals in water, sediment and aquatic macrophytas in lotic ecosystem, Iraq. The results revealed that the concentrations of heavy metals in water for the particulate phase are higher than in the dissolved phase , while in

sediment, their concentrations in the residual phase are higher than their concentrations in the exchangeable phase except for Cd which is in the exchangeable phase higher than in the residual phase.

1-2-8: Heavy Metals in Aquatic Plant

Aquatic plants are used as bio indicator to measure different water pollutants especially heavy metals (Peng *et al* ., 2008). Aquatic plants also play an important role in ridding the water body of many chemical pollutants through their ability to accumulate high levels of these pollutants (Begum and Harikrishna , 2010).

In addition, Aquatic plants have a major role to play in oxygen production, nutrient recycling, sediment stability and water quality conservation, as well as their importance in providing habitat for aquatic organisms (Strayer , 2010) .Due to its ability to accumulate pollutants and dispose of its toxicity, it has now been used to remove pollutants, particularly heavy metals of contaminated water such as industrial waste and sewage, in order to reduce its toxic impact on aquatic organisms when draining that water into rivers and others (Kara., 2005; Afrous *et al* ., 2011). Its ability depends on accumulating these elements to own a number of cellular mechanisms such as the formation of plant claws and the introduction of those elements into the vacuum outside cellular or reserved within the vacules and other mechanisms that maintain the stability of the concentration of these elements within plants and remove their toxicity. (Hall , 2002).

Uddin *et al* ., (2021) stated heavy metal accumulation in rice and aquatic plants used as human food and show hydrophytes can absorb heavy metals through the root systems that transport the metals to edible plant parts, such as leaves, flowers, corms, stems, seeds, etc., with subsequent introduction into the food chain, as confirmed by various reports. Direct ingestion of heavy metal-

contaminated aquatic plants and their bioaccumulation in food chains are the main sources of human exposure to toxic heavy metals from aquatic food plants.

1-2-9: Heavy Metals in Fish

Fish is one of the largest and most important vertebrate groups inhabiting the aquatic environment, located at the top of consumables in the food chain in the aquatic ecosystem . (Dallinger *et al .*, 1987).

Fish are good indicator of pollution by heavy metal in aquatic environment. Heavy metals enter the aquatic food chain in two ways: 1- direct consumption of water and food through the digestive tract 2- non-dietary pathways such as muscle and gills (Ribeiro *et al.*,2005) .

They have ability to aggregate these elements with higher concentrations than in water, and sediments because they feed on algae and small organisms as well as organic matter found in the surround environment (Olaifa, *et al .*,2004). Heavy metals can penetrate the metabolism of fish and become toxic when accumulated in tissues and muscles leading to an imbalance in the physiological functions and reducing its ability to grow and reproduce (Smalinskienė and Abrachmanovas ,2001) .

The composition of food chains in the water system is more complex than land systems, as the mass of small in the aquatic environment can make noticeable changes, making it more sensitive to the impact of pollution. (Förstner and Wittmann , 2012).

Effect of heavy metals on physiological and histological status in the liver of common carp *Cyprinus carpio*, grown in cages and wild in the Euphrates River, Babil/Iraq, is reported by (Alshkarchy *et al.*, 2021). This study demonstrates how environmental conditions affect the concentration and buildup of heavy metals in fish liver and sediments.

The concentrations of the studied metals in the sediments of the Euphrates River showed seasonal variation, being higher in the summer and lower in the winter. The accumulation of heavy metals in the livers of cage fish is higher than that in the livers of wild fish in polluted areas, and the accumulation of heavy metals in the livers of wild fish is higher than that in the livers of cage fish in non-polluted areas.

The fish employed as a bio-indicator of the aquatic environment's heavy metal pollution in many studies (Farkas *et al.*, 2000; Schulz and Martins-Junior , 2001; Van den Broek *et al.*, 2002). The amount of heavy metals that accumulate in fish varies depending on the species of fish, its development rate, metabolism, feeding habits, and ecological requirements (Yilmaz *et al.*, 2010). A significant portion of the population consumes various fish species as a source of protein, making the buildup of heavy metals in fish a serious issue (Rohasliney Hashim *et al.*, 2014).

While there is a substantial inverse link between the concentration of elements in the water and temperature, there is a significant positive correlation between the concentration of heavy investigated metals in water (specifically dissolved) and in fish muscle. Detection of contamination by several trace elements in the muscles of *Carassius auratus* obtained from the Euphrates is described by (Khlaif *et al.*, 2021).

1-2-10: Heavy Metals in Clam

Clam are one of the most specific aquatic organisms to availability in bio indicator The absorption rate of this organisms of elements vary depending on the different species, light sensitivity and it also varies in its content of these elements depending on its ability to return these elements back to the surrounding environment . (Forstner and Wittmann ,1981) . The wide range of accumulation of heavy metals in bivalvia filter feeding and from different food

sources gives an indicator that can use as a key guide or key to determine pollution levels in the environment (Widmeyer *et al.*.,2004).

Seafood is a source of nutrition for humans, but it also contains environmental toxins, therefore eating it could be harmful to consumers' health. (Barchiesi *et al.*, 2020). Otchere (2003) stated that there are many factors that affect the concentration of heavy metals in bivalve tissues the readiness of the element, the time of taking the sample and the hydro chemical factors of the ecosystem in which you live, Such as size, sex reproduction cycle and variations in tissue composition of the Object body.

Al-Taher *et al.*, (2020) estimation of heavy metals in water, sediments and bioaccumulation in *pseudodontopsis euphraticus* and *bellamya bengalensis* in Euphrates river in Al-Nassiriyah city south of Iraq and The findings suggested high levels of pollution in the Euphrates river's waters due to seasonal and local change in the quantities of heavy metals in water, sediments, and soft tissues of mollusks.

Jawad *et al.* , (2022) describe *melanoides tuberculata* as bioindicator of the heavy metal Contamination in water and sediment pollution of euphrates River at Thi-Qar province, Iraq and the finding result Lead and Zink are higher and exceed the permissible level. *Melanoides tuberculata* could accumulate the heavy metals in their metals then it could use as a bio-indicator for these metals to detect the pollution in the Euphrates River

1-2-11: Water Quality and Pollution Indices

For the environment, agricultural and industrial operations, as well as human health, water quality is just as crucial as its quantity. Human actions and natural processes both have an impact on the quality of the water. Each year, between 300 and 400 million tons of toxic materials are dumped into water, and in underdeveloped nations, 80% of sewage is discharged directly into water

bodies without being cleaned. Numerous national and international organizations had established guidelines and criteria for water quality adoption because of this. As a result, the World Health Organization has established water quality guidelines that are regularly revised in accordance with changes in the relevant variables.. Other nations have developed their own standards to meet their needs. Because water quality is so important, the UN organizations (World Health Organization (Al-Ansari *et al.*, 2019).

Water Quality Indices (WQIs) are a group of statistics on many aspects of water quality that are combined to produce a single water quality value, condensing a vast quantity of data into a short and straightforward phrase. Allowing for comparisons of the state of the water's quality for various locations and times, which will eventually enable management and the public learn about the situation simply. The difficulties and restrictions of the already produced models of a comparable kind should be assessed, reviewed, and taken into account before creating and developing an acceptable mathematical model.

In general, WQI calculation methods follow five standard steps: Parameter selection, data transformation from a parametric system to a dimensionless system, and creation are the first three step (Aljanabi *et al* ., 2021).

1-2-12: Previous studies

Heavy metals are naturally occurring elements with large atomic weights and densities that are at least five times larger than those of water. Their vast environmental distribution as a result of their multiple industrial, residential, agricultural, medical, and technical applications has sparked concerns over their potential negative effects on the environment and human health. How dangerous they are depends on the amount, exposure technique, chemical species, as well as the age, gender, heredity, and nutritional status of exposed people.(Briffa *et al* ., 2020)

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Due to their extreme toxicity, arsenic, cadmium, chromium, lead, and mercury are among the priority metals of public health concern. These metallic elements are known to damage many organs even at low exposure levels, making them systemic toxins. (Tchounwou *et al.*, 2012). local and international studies have dealt with the study of heavy metals and their effects on the aquatic environment such as :- (AL-Rawi , 1977) studied heavy metals in the deposits of the flood plain of the Tigris and Euphrates rivers between the cities of Diwaniyah and Hilla.

Al-Taie, (1999) studied the concentration of some heavy metals in the waters and sediments of the Hilla river and it became clear that the concentration of mercury(Hg) element is high and well above the limit, as it was found that anthropogenic, agricultural and industrial pollutants are obvious causes of increased concentrations of iron(Fe), cobalt(Co) and Zink (Zn) in the waters and deposits of the Hilla river.

Also many studies in Iraq dealt with the physical and chemical properties, including Salman's study (2006) in an environmental study of potential pollution in Euphrates river between the Al-Hindiya barrage and the Kufa region of Iraq found that pH, suspended and dissolved solids, electrical conductive and dissolved oxygen are within the permissible limits, while the vital requirement of oxygen exceeded the borders and the water is very difficult.

Calculating Pollution Indices by Heavy Metals in Ecological Geochemistry Assessment and a Case Study in Beijing Parks was suggested by Gong Qingjie *et al.* (2008). From the perspective of an algorithm the two types of commonly employed pollution indices for heavy metals in soils and sediments are single index and integrated index. The reference values for computing single indices are divided into background levels and threshold pollution values, and four

single indices of contamination factor or concentration factor, ecological risk factor, enrichment factor, and index of geo-accumulation are displayed.

Matloob , (2011) described for monthly variations of some physical and chemical characteristics and levels of some heavy metals of the water of the Husseiniya river in Karbala, it is found that the water of the river is very hardness and promised the water base and Salty, where the values of conductivity ranged from 910 -1544 ($\mu\text{s}/\text{cm}$).

Dorne *et al* ., (2011) described human risk assessment of heavy metals: principles and applications. This study introduces the general principles of chemical risk assessment, the common four steps of chemical risk assessment: hazard identification, hazard characterization, exposure assessment, risk characterization, and toxicokinetic and toxicity aspects. Finally, the risk assessments performed by international health agencies such as the World Health Organisation, the Environmental Protection Agency of the United States and the European Food Safety Authority are reviewed for cadmium, lead, mercury, uranium, and arsenic.

The fish species captured in the Kelantan River are found to be contaminated with non-essential metals, according to Rohasliney *et al*(2014) . research (Cd, Ni and Pb). With the exception of *C. chitala*, *O. hasseltii*, and *T. maculatus*, the heavy metal concentration in the fish tissues did not, however, exceed the standards set by the EC, FAO, Malaysian Food Act (MFA), or WHO. Five heavy metals (Cd, Cu, Pb, Fe, and Zn) are chosen to assess the level of contamination of the Al Husseiniya river, according to Salman *et al.*,(2015) study. They are distributed, with concentrations in the dissolved and particulate phases of the water as well as the exchangeable and residual phases of the sediment. The physicochemical properties of the river, such as its temperature, pH, electrical conductivity, total alkalinity, total hardness, calcium, and

magnesium, have all been studied. The results demonstrated that the concentrations of heavy metals in water were higher in the particulate phase than in the dissolved phase. With the exception of Cu, whose concentrations are higher in the exchangeable phase than the residual phase while in sediment, all of these elements had higher residual phase concentrations than exchangeable phase concentrations.

According to a study by Ali *et al.* (2016), pollution of sediment with heavy metals is seen as a global concern that has a significant impact on poor nations like Bangladesh. Arsenic (As), chromium (Cr), cadmium (Cd), and lead (Pb) were four heavy metals that are examined in sediments and water from the Karnaphuli River in Bangladesh. Indicating that the water from this river is unsafe for drinking and/or cooking, the amount of analyzed metals in the water samples above the permissible limits for drinking water. The sediment samples had moderate to high levels of As, Cd, and Pb contamination, according to the contamination factor (CF). The advanced degradation in the quality of the sediment is indicated by the pollution load index (PLI) values being above one (>1). That was suggested by this study. Arora ,(2017) described physical , chemical biological characteristics of water(e content module) These characteristics of the water body have a direct influence on the types and distribution of aquatic biota.

According to Addey *et al.* (2018), surface water contamination is a serious threat to all biotic species reliant on the body of water. In order to identify the sources of heavy metals and the risk of pollution they provide, this study used an indexing approach to evaluate the surface water quality of Comodore Channel in the Lagos Lagoon. According to the study, the main human-caused sources of the heavy metals are untreated industrial discharges

and locally disposed of municipal solid waste. To stop ongoing pollution of the area, environmental protection rules must be swiftly enforced.

Freshwater edible fish *Cyprinus carpio* and *Pelteobagrus fluvidraco*, which are taken from the Meiliang Bay, Taihu Lake, a large, shallow, and eutrophic lake in China, are tested for the bioaccumulation of heavy metals (Cr, Cu, Cd, and Pb) content. The findings demonstrated that the two fish species' edible sections had substantially lower levels of Cr, Cu, Cd, and Pb than the Chinese Food Health Criteria (1994). The results, however, revealed notable changes and noticeable discrepancies in the four metal contents between the two species and various tissues (Rajeshkumar and Li , 2018).

According to Bawuro *et al.* (2018), the bioaccumulation of heavy metals (Zn, Pb, Cd, and Cu) in benthic and pelagic fish species collected from Lake Geriyo over two seasons is assessed in the liver, gills, and fish. Different fish species and organs had dramatically different levels of the heavy metals. These variations are explored in relation to the potential contributions of age, geographic distribution, and species-specific characteristics that might have an impact on metal intake. Algül and Beyhan, (2020) study indicated that The concentrations and sources of heavy metals in shallow sediments in Lake Bafa are investigated. The concentrations of nine heavy metals and the total organic carbon content in sediment samples are determined for between Summer 2015 and Spring 2016. These results highlight that Cd, Cr, and particularly Ni represent the most serious threat in terms of heavy metal pollution in the ecosystem of the lake.

Lateef *et al.*,(2020) In order to determine the water quality parameters of the Shatt Al-Arab River, southern Iraq, the work categorizes the distribution of temporal and spatial water prediction characteristics. This is an example of the potential application of spatial analysis techniques via geographic information

systems (GIS). The findings indicated that SAA has a high salinity with a low sodicity hazard. The Dolomite-Magnesite tie-lines, which showed the disintegration of carbonate rocks, are largely below the SAA waters. This study also discovered that the study region is limited to the area between Al-Maqal station and Abu Flus port station, where the Arabian Gulf's salty marine water remains for longer periods of time. According to Iraqi and World Health Organization (WHO) regulations, the SAA is unfit for use as drinking water or agricultural water. According to this analysis, a blocking dam should be constructed downstream of the SAA to stop saline water from returning from the Arabian Gulf.

According to Barchiesi *et al.*, (2020), a survey on the three-year exposure to cadmium, lead, and mercury by eating bivalve mollusks, gastropods, and sea urchins obtained on Italian shores is conducted among the people of central Italy. According to the benefit-risk analysis, an increase in consumption of bivalve mollusks and sea urchins (Benefit Risk Quotient <1) might be made without endangering one's health. Kadarsah *et al.*, (2020) stated that heavy metal content (Pb and Cu) in waters and sediments from the Kuala Tambangan mangrove ecosystem, South Kalimantan. The average value of heavy metal content (Pb and Cu) both in waters and sediments are shown varying values and it has shown pollution because its value is above the provisions stipulated by the Minister of the Environment.

A different study determined a clear correlation between significantly weaker shell strength in king scallops, *Pecten maximus*, and elevated levels of heavy metal pollution (zinc, copper, and lead) in sediments close to the Isle of Man as a result of previous mining. Due to this vulnerability, more people died while fishing and are more vulnerable to predators. Comparative structural examination showed that the top and bottom valves' foliated regions of the shells

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from the contaminated area are both thinner and showed a noticeable mineralization disruption parallel to the shell surface. Therefore, their research emphasizes how metal contamination affects bivalves' shell mineralization. Stewart *et al.*,(2021).

Pandiyan *et al.*, (2021) investigated assessment of level of heavy metals pollution the cadmium (Cd), copper (Cu), chromium (Cr), cobalt (Co), lead (Pb), mercury (Hg), nickel (Ni) and Zinc (Zn) in the water, sediment and aquatic organisms: A perspective of tackling environmental threats for food security. The study found that the level of heavy metals at various sources in the sanctuary is showing considerable warning and the sanctuary is required intensive assessment on various aspects of pollution since the Point Calimere Wildlife Sanctuary is supporting several species of migratory and endangered shorebirds seasonally.

Perumal *et al.* (2021) examined the content of heavy metals and their spatial distribution in surface sediments taken from the South Indian region of Palk Bay and Thondi. The results of this study showed that the toxicity of the marine environment is increased due to the increased concentration of heavy metals in the study region, which has an impact on the ecosystem.

Mahmoud and Hadi , (2022) in his study of some sources of environmental pollution in the waters of Euphrates River between the cities of Hite and Ramadi, concluded that physical qualities are within the permissible limits except electrical conductivity and suspended solids as they exceeded these limits and that chemical qualities such as chlorides, calcium, sodium, potassium, magnesium, fluoride and chloride are within the permissible limits except sulfates, bicarbons and phosphates.

Vila *et al.*,(2022) The approaches used in this study to assess the water quality in the city of Azogues are the Canadian Council Water Quality Index

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(CCME WQI) and the Arithmetic Water Quality Index (WAWQI) (Ecuador). A drinking water quality risk index (IRCA) is also developed to assess the level of illness occurrence risk associated with water use.

Twelve physicochemical parameters (pH, turbidity, color, total dissolved solids, electrical conductivity, total hardness, alkalinity, nitrates, phosphates, sulfates, chlorides, residual chlorine) from 172 water samples collected over the course of six months are analyzed to produce the data. The findings of this study demonstrated the value of using the CCME WQI, WAWQI, and IRCA as a tool to evaluate and comprehend the quality of drinking water.

Maliki *et al.*, (2022) stated that estimation of total dissolved solids in water bodies by spectral indices case study: Shatt al-Arab river. In recent years, the problem of rising salinity levels in the Shatt al-Arab river in southern Iraq has been repeated, which has directly affected the living and health situation and the agricultural activity of these areas. In the result remote sensing and GIS technologies coupled with spectral modeling are useful tools for providing a solution of future water resources planning and management, and also offer great undertaking as a means to improve knowledge of water quality and support water decision making. There are many local and international studies interested in studying pollution Table (1). There are many local and international studies concerned with the study of pollution Table (1-1) (1-2).

Table (1-1) : some of the international and local studies about heavy metal

Problem	Aims	Main findings	Ref.
Euphrates River pollution With heavy elements.	Environmental study to use aquatic biology as Bio indicator of Euphrates River pollution With heavy elements.	The results showed high concentrations of Heavy Metals in the tissues of the two species of clam under The study showed that this is related to the concentration of elements in the minute state of water due to the filtrational nutrition of these organisms.	Hassan <i>et al</i> ,2010
accumulation of heavy metals in some specious of fish	Study some Heavy Metals in the common <i>Cyprinus carpio</i> fish group from the Euphrates River.	The results indicated that the pollution of the river water with heavy metals mainly from industrial sources, it does not pose a risk to the consumption of fish in those rivers yet, but in the future. It can be a problem to avoid. The results also showed moral differences between the elements in the different parts and in the same the part is at a probability level of 0.05.	Al-Dahimi, 2010
Water pollution in Euphrates	Use Aquatic Plants as Bio indicators of Heavy Metals	The results confirmed an increase in concentrations of heavy metals in tissues of aquatic plant species compared to their means in water and sediments and	Al-Ghanemi,2011

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Problem	Aims	Main findings	Ref.
river	Pollution in Euphrates River – Iraq	this indicated to a phenomenon is called bioaccumulation , the maximum mean of Fe (2469.07) µg/g dry weight was recorded in <i>Myriophyllum. verticillatum</i> while the the least heavy metals concentration is Hg (0.010) µg/g dry weight in <i>Typha. domingensis</i> , despite of these concentrations of this metals but it must be had a good attention because of their importance in bioaccumulation and transferring through trophic levels also this metals is measured at the first time in study location.	
Water pollution	The determination relationships between fish heavy metal concentrations and fish size in the upper and middle reach of Yangtze River	The results of comparisons made between metal concentrations and the fish size parameters demonstrated positive relationships between fish sizes and metal levels in most cases, with negative relationships found only between mercury and chromium levels in the size of catfish and yellow-head catfish. The variance observed in the relationships	Y.J. Yi and S.H. Zhang(2012)

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Problem	Aims	Main findings	Ref.
		between metal concentration and fish size, as measured among different fish species, may be related to the differences in ecological needs, swimming behaviors, and metabolic activity.	
Environmental pollution	This study was conducted to estimate the concentration of some Heavy metals, (cadmium, lead, zinc, iron, manganese, selenium and nickel) in the muscles of three different categories in the weight and length of fish Hamri Barbus luteus (Heckel) collected from the	The results of the study showed seasonal variations in the concentrations of heavy metals in both water phases (dissolved and particulate phase) and in three category of fish muscles . It is found that , the concentrations of heavy metals in the third category is high compared to the first and second categories , results have found a direct correlation between the length and weight of the fish with the concentration of metals as of metals of concentration increase as well weight and height. It is found that the concentrations of heavy metals studied in particulate phase are higher than water soluble phase in addition to the effect of some physical and chemical properties of water such as pH , EC , temperature , flow	Al-Sultany,2014

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Problem	Aims	Main findings	Ref.
	Euphrates River from Saddat- Al- Hindiya Region dam , during October 2009 to September 2010 .	velocity , and salinity on the concentration of heavy metals studied.	
to indicate the possible pollution of the stream waters and sediments with different pollutants,	possible contamination with Heavy Metals and some ecological parameters of water Bani- Hassan stream in the province of Karbala- Iraq	The results of the study recorded a substantial rise in numbers of pollution indicator bacteria (Total Coliform, Fecal Coliform, Fecal streptococcus). Total Coliform ranged between (17×10 ² -160×10 ²) cell/100 ml, fecal coliform ranged between (13×10 ² -160×10 ²) cell/100ml, while the fecal streptococcus ranged between (1.4×10 ² -92×10 ²) cell/100 ml. These rates considered as environmental and biological indicators to the existence of an impressive levels of organic pollution, and an indexes of presence of hazardous microorganisms for population health and organisms.	Al- Sharifi,2014

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Problem	Aims	Main findings	Ref.
determine the degree of contamination of Al - Husseinya river.	A Study on the fate of some heavy metals in water and sediments in lotic ecosystems	The results revealed that the concentrations of heavy metals in water for the particulate phase are higher than in the dissolved phase. While in sediment, their concentrations in the residual phase are higher than their concentrations in the exchangeable phase except for Cu which is in the exchangeable phase higher than in the residual Phase.	Salman <i>et al</i> ,2015
Water pollution	risk Assessment of Heavy Metals in Malaysian Clams	The results revealed that the clams from mentioned sites have higher values than the food safety limits which should be avoided in order to avoid any possible toxicological risks and heavy metal related diseases, such as Parkinson' disease, Wilson's disease, and Hallervorden-Spatz disease, due to long term consumption. On the other hand, according to Malaysian Food Regulation (1985), about 30% and more than 50% sites are safe from Cd and Pb	Hossen <i>et al</i> ., (2015)

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Problem	Aims	Main findings	Ref.
		contamination, respectively, and also the clam species from the other populations studied are safe for consumption.	
Water pollution	Heavy Metals Contamination in Water and their Hazardous Effect on Human Health-A Review	Heavy metal toxicity has proven to be a major threat and there are several health risks associated with it. The toxic effects of these metals, even though they do not have any biological role, remain present in some or the other form harmful for the human body and its proper functioning.	Sankhla, 2016
water pollution	Assessment of Heavy Metal Contamination and Calculation of Its Pollution Index for Uglješnica River, Serbia	The data are used to evaluate Heavy metal pollution index (HPI) of the river water. The mean value of HPI is 67.487 for the spring season, and 80.676 for the autumn season. The average for both seasons and all sampling sites is 74.082. The maximum value of 112.722 found at one sampling site is above the critical index limit of 100. Also, from the values of mean HPI for each sampling site could be concluded that the	Milivojević <i>et al</i> ,,2016

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Problem	Aims	Main findings	Ref.
		pollution load at sampling site-4 is the most significant (HPI 89.575).	
water pollution	This study assessed the surface water quality of commodore channel, Lagos lagoon with respect to its heavy metals pollution level using indexing approach to determine the sources of heavy metal and its associated pollution risk.	The study revealed the sources of the heavy metals are primarily from anthropogenic source attributed to the untreated industrial discharge, and municipal solid waste disposed in the area. Prompt enforcement of environmental protection laws is needed to prevent continuous pollution of the area.	Addey <i>et al</i> ., 2018
accumulation and	Accumulation, depuration and risk	The results of the present study showed that there is a competition between Cd and Pb in the tissues of the	Pham , 2020

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Problem	Aims	Main findings	Ref.
deuration of two heavy metals Cd and Pb in the freshwater clam (Corbicula fluminea) under laboratory conditions.	assessment of cadmium (Cd) and lead (Pb) in clam (Corbicula fluminea) (O. F. Müller, 1774) under laboratory conditions	clams. The total target hazard quotients and the hazard index indicated that people might experience adverse health effects through consuming contaminated <i>Corbicula. fluminea</i> .	
environmental Pollution	The aim of this review is to provide up to date information about metals pollution status, sources, distribution in	The physiological state (e.g. nutritional state) of the aquatic organism has been shown to have a very marked influence on the uptake, distribution and adverse effects of heavy metals. Similarly, environmental factors, such as salinity, oxygen and temperature, may influence permeability and urinary	Al- Naggar <i>et al</i> ., (2018)

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Problem	Aims	Main findings	Ref.
	seawater, sediments in aquatic biota in Egypt and to explore potential ecological risk index methods for heavy metals in sediments	excretion rates of heavy metals in aquatic organisms.	
Environmental pollution of heavy metals	Environmental pollution of heavy metals is increasingly becoming a problem and has become of great concern due to the adverse effects it is causing around the world	the review shows the physiological and biochemical effects of each heavy metal bioaccumulation in humans and the level of gravity and disquieting factor of the disease.	Briffa <i>et al</i> .,(2020)

Table (1-2) : some of the international and local studies about water Quality

Problem	Aims	Main findings	Ref.
<p>Al-Habbaniyah Lake is one of the most significant water projects that are finished between 1943 and 1956 in order to prevent flooding of the Euphrates River and divert extra water during flood seasons to the lake. Monitoring, protecting, and improving water quality reservoirs and lakes is essential for safeguarding these efforts and enhancing environmental quality.</p>	<p>The current study aimed to Discuss the application of GIS and remote sensing to monitor water quality variables in Al-Habbaniya lakes .</p>	<p>The findings of the current investigation demonstrated the convergence of in-situ and distant sensing. TDS, TSS, Chlorophyll-a, and the levels of turbidity are individually explored using these models, and they did not depart significantly from the values measured in the three seasons. Despite this, they are helpful in predicting all study seasons due to the negligible difference between distantly felt values and actual measured values.</p>	<p>Al-Fahdawi <i>et al.</i>,2015</p>

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Problem	Aims	Main findings	Ref.
Silakhor River pollution With heavy metal	Iran's Lorestan Province Water Quality Assessment Using Multivariate Statistical Analysis and the Heavy Metal Index	The findings indicated a multiple source of pollutants for the region water resources including two major sources; one is associated with the region lithology (the natural factor) while the other is caused by human activity in the region (anthropogenic factors)	Khoshnam,2017
Between August 2012 and July 2013, research was done on the Al-Hilla River in the center of Iraq at five specific locations along the river, from Al-Musaib City to Al-Hashimya in the south, to assess its appropriateness for	The current study, which aims to analyze the status of water quality, offers recommendations for using data from water quality monitoring systems and gives a means of merging the complicated data on water quality	The results 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). The study	Salman and Shammary,2020

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Problem	Aims	Main findings	Ref.
irrigation, drinking water, and the aquatic environment (GWQI) (IWQI).	into a single value or statement.	sites' irrigation water quality indices (IWQI) ranged from 66 to 83 and fell between fair and good.	
Pollution or changes in water quality	This research deals with analyzing samples of water from the Euphrates River before and after (50m, 200m, 500m, and 1000m from the outflow)the power plant of AL-Musayyab. A Water Quality Index (WQI) analysis is performed, which is a helpful tool for rapid estimation of the quality of any water resource	The study shows the deterioration of water quality, with the main candidate causes of being the direct discharge of the power plant into the river and high anthropogenic activities.	Makki and Manii(2020)

Chapter Two

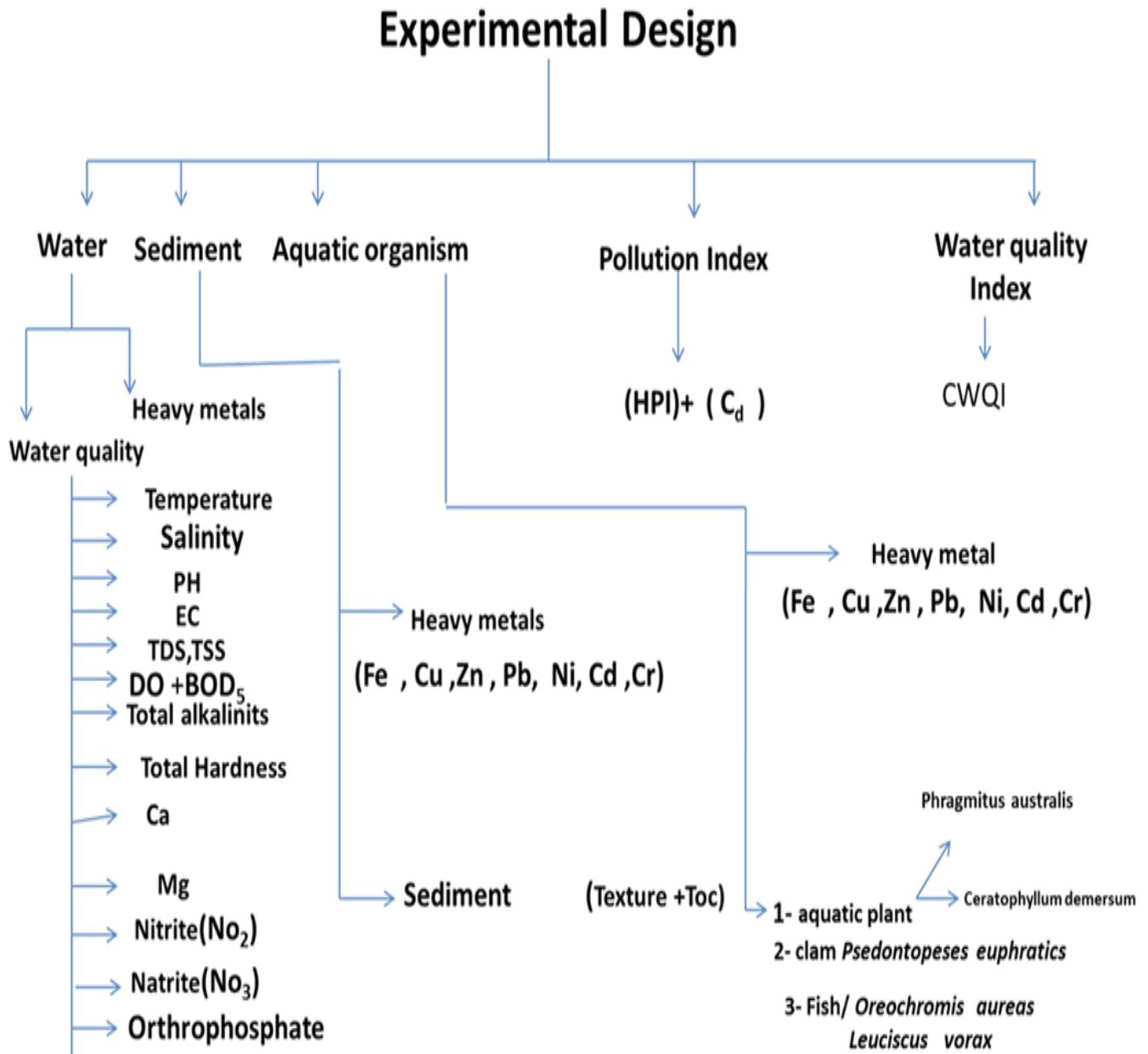
Materials and Methods

2: Materials and Methods

2-1: Study Area

2-1-1: Study Area Description

The study area includes the Musayyib channel , which represents Mashroo Al- Musayyib channel and is located in the north-east of Babil Governorate, to the east of the Mahawil and Musayyib districts. Its source is located on the Euphrates River, north of Al-Hindiyyah barrage, within 9.6 km until the end of the Mashroo at (Al- Massab Al aam) that separates the Babil Governorate from Wasit Governorate, within the limits of 49.5 km, and the Mashroo 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 9.6 km north of Al-Hindiya, and it extends east to 49,5 km. (Figure2-1).



schema (2-1) Experimental Design of current study

2-1-2: Study sites**Table (2-1) Global Position system (Gps) location**

Site	Coordinates		Description
	Longitude	Latitude	
Site 1	044°17.379'E	32°47.597'N	Euphrates River near the city of Musayyib. Its source is located on the Euphrates River, north of the Hindiya Dam, within 9.6 km. This site is characterized by the high water level in the river in most cases, as it noted the abundance of aquatic plants ex:- <i>Phragmitus australis</i> and <i>Ceratophyllum demersum</i> . Photo (2-2)
Site2	044°21.869'E	32°46.997'N	The second site located old Baghdad street ,near the technical institute,traffic density, former military industrial zones the Musayyib River, which represents the Mashroo Al-musayyib channel 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, <i>Phragmitus australis</i> and <i>Ceratophyllum demersum</i> . Photo (2-2)
Site3	044°26.319'E	32°48.835'N	This site located Near the highway an agricultural area. It is noted that there are clear sediments at the edge of the river and a clear spread of plants <i>P. australis</i> Photo (2-2).
Site4	044°36.174'E	32°45.444'N	This site starts from the city of Jabla an agricultural region Until the end of the Mashroo Al-musayyib channel that separates the Babil Governorate from Wasit Governorate, within the limits of 49.5 km. Photo (2-2)

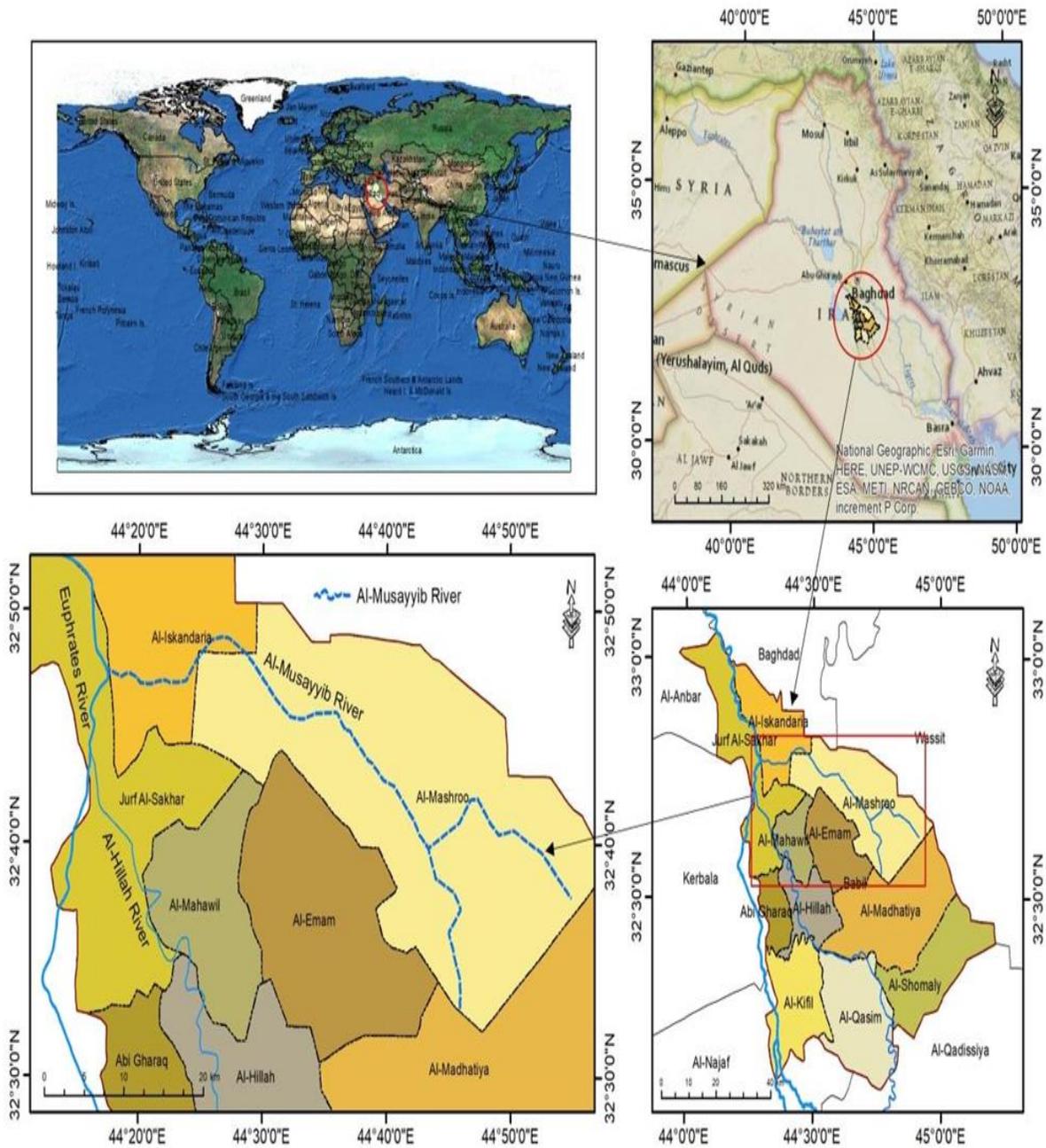
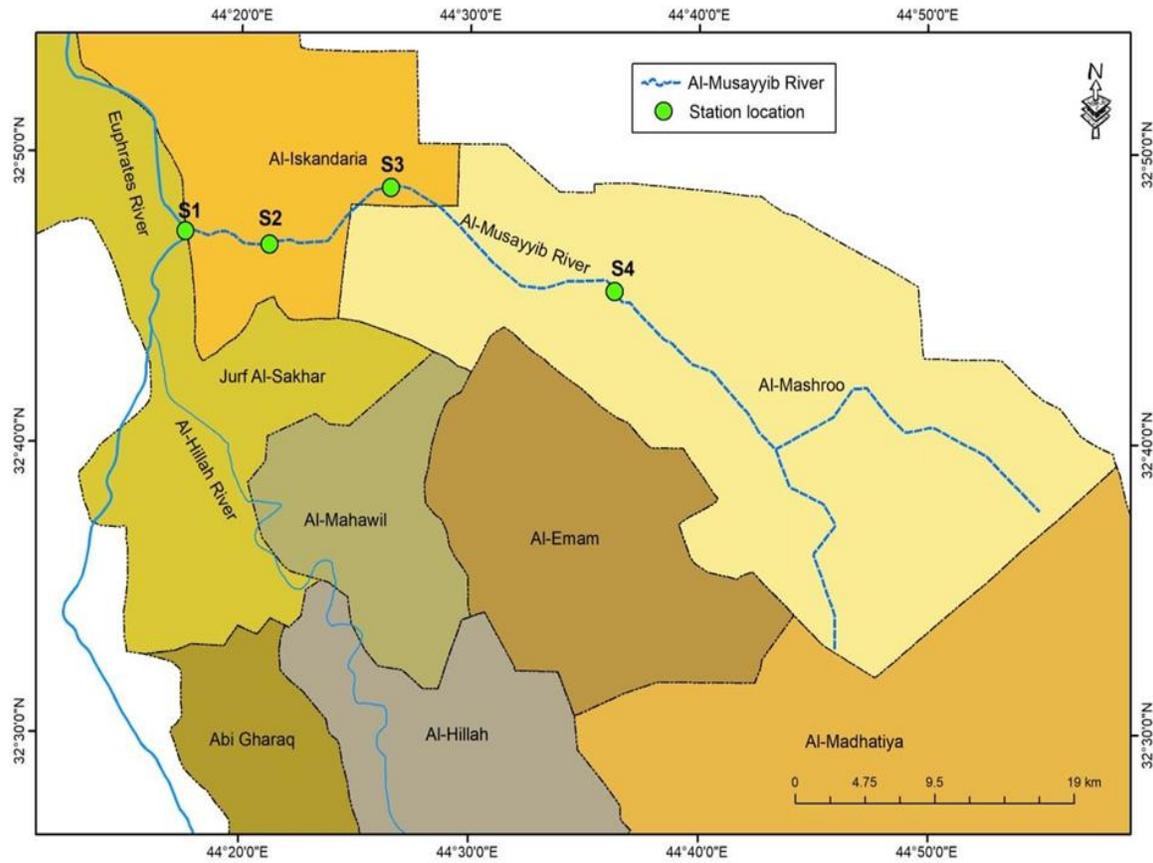


Figure (2-1) map of the Study sites on Mashroo Al-musayyib channel (Ministry of Irrigation ,Iraq)



**Figure (2-2) map of the Study sites on Mashroo Al-musayyib channel
(Ministry of Irrigation ,Iraq)**

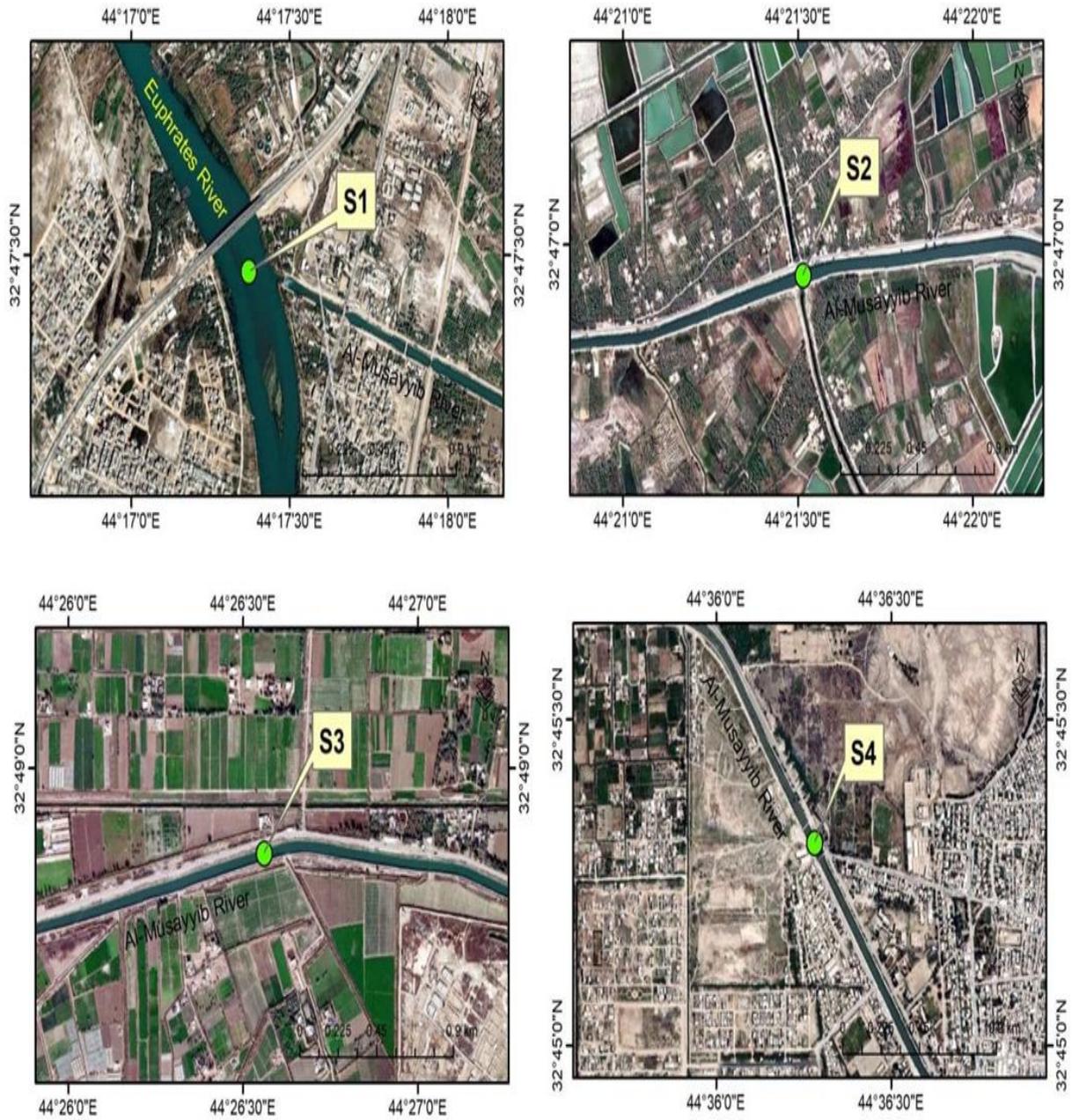


Photo (2-1) satellite photos of the Study sites on Mashroo Al-musayib channel (Ministry of Irrigation ,Iraq)



Site 1:- Euphrates River



**Site 2:- Al-Musayyib river
near technical institute**



Site 3:- near the highway



Site 4:- City of Jabla

Photo (2-2): Study sites on Mashroo Al-musayyib channel

2-1-3: Scientific apparatus

A group of Scientific apparatus were used during the study as shown in the Table (2-2)

Table (2-2) The scientific equipment used in the current study

Equipment	Company	Orgin
Atomic Apsorbtion Spectrophometer AAS	Shemadzu	Japan
Autoclave	Hirayama	Japan
Centrifuge	Spinners SC/F1	Japanese
Ceramic mortar	Volac	England
Compound Microscope	Meiji	Japan
Distiller	Rowa	Taiwan
Electric shaker	KOTTERMANN 4010	Germany
Grab Sampler	UK-made	England
Grain size analysis	Sedigraph ET-5000	China
Hot plate	Gallen Kamp	Germany
Incubator	Gallen Kamp	Garmany
Mili pore filter(45µm)	Sartorius	Germany
Oven	Gallen Kamp	Germany
Refrigerator	Concord	France
Rotary evaporator	Rotaflo	England
Sensitive Balance	Sartorius	Germany
Magnetic Stirrer	Heidolph	Germany
Thermometer	Gallen Kamp	England
Tri-meter-PH,EC,TDS	Hanna	Germany
UV-VIS spectrophotometer	Optima	Japan
Vortex	Heidolph	Germany

A group of chemicals were used during the study as shown in the Table(2-3)

Table (2-3) Chemical Materials used in current study

Chemical	Company	Origin
Ammonia	BDH	England
Ammonium chloride (NH ₄ CL)	BDH	England
Ammonium molybadate (NH ₄)MO ₇ O ₂₄	BDH	England
Antimony potassium tartrate [K ₂ Sb ₂ (C ₄ H ₂ O ₆) ₂	Mole	England
Ascorbic Acid	BDH	England
Calcium carbonates -	Merck	India
Erichrom black T	BDH	England
Ethylene diamine tetra acetic acid disodium (EDTA)	BDH	England
Ferrous ammonium sulfate	Merck	India
Hydrochloric acid (HCL)	Fluka	Germany
Hydrogen peroxide	Merck	India
Magnesium sulphate (MgSO ₄ . 7H ₂ O)	BDH	England
manganous sulphate	BDH	England
Methyl orange	BDH	England
Murexied	BDH	England
NaOH (Sodium Hydroxide)	Fluka	Germany
Nitric Acid (HNO ₃)	BDH	England
N-naphthyl ethylene diamine dihydrochlorid	Fluka	Germany
Perchloric acid (HClO ₄)	BDH	England
Phenanephtaline	Merck	India
Potassium dichromate	BDH	UAE
Potassium Iodide	BDH	England
Sodium chloride	Merck	India
Sodium nitrate	BDH	England
Sodium Thiosulphate	BDH	UAE
Sodiumiodide	BDH	England
Starch	Merck	India
Sulphnil amid	BDH	England
Sulphuric acid (H ₂ SO ₄)	BDH	England

2-2: Physicals and chemicals parameters :

2-2-1: Air Temperature (AT) °C

The air temperature is measured in the study sites during the period of sample collection using a graduated mercury thermometer from 0-100°C.

2-2-2: Water Temperature (WT) °C

The water temperature is measured in the study sites during the period of sampling using the Multi-meter directly (manufactured by Hana company).

2-2-3:pH

Multi-Meter is used to measure pH after calibrating the device using calibration solutions with values (4, 7, 9) to measure water samples directly in the field.

2-2-4: Electrical Conductivity (EC)

The same device above is Multi-Meter used to measure electrical conductivity directly in the field, and the results are expressed in $\mu\text{s}/\text{cm}$.

2-2-5 : Salinity

Salinity is calculated according to the results of electrical conductivity results in accordance with what is stated by (Mackereth *et al.*, 1978) according to the following equation:-

Salinity = E.C value X 0.64 / 1000 and express the result with a unit (S%)

2-2-6 :Total Dissolved Solid (TDS)

Total dissolved materials are measured using The multi-meter (manufactured by Hanna) and is stated in units of mg/l.

2-2-7: Total Suspended Solid (TSS)

The solids suspended are measured by filtering 100 ml of the samples onto filter paper (0.45) μm with a known weight (B) and then drying this paper in oven (103 - 105 $^{\circ}\text{C}$) for 24 hours and then weighed A(2003, APHA).

$$\text{T.S.S (mg/L)} = \frac{(A - B) \times 10^3}{\text{Volume of sample (ml)}}$$

2-2-8 : Dissolved Oxygen (DO)

The common method (Azide modification) is used to measure dissolved oxygen in water (APHA, 2003) and expressed the result by units (mg/l) where winkler transparent bottles are filled directly from the site by placing the bottle in a slanted position of about 10 cm and close the bottle inside the water and add 1-2 ml of hydroses manganous sulphate ($\text{MnSO}_4 \cdot \text{H}_2\text{O}$) solution and after a minute is added 1-2ml of Alkali-Iodide Azide reagent with good shaking and then add sulfuric acid(H_2SO_4) 1-2ml to complete the melting and be A yellow-colored solution and took a certain size 100 ml of the solution and abrasive with the standard sodium thiosulfate solution $\text{Na}_2 \text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ 0.025 N to a pale straw colour then added 1 ml of starch solution where the solution turns blue and complete the sweep until the blue color disappears.

2-2- 9: Biological Oxygen Demond (BOD₅)

The Biological Oxygen Demond is assigned to the Winkler Method (APHA, 2003) to measure dissolved oxygen by taking Winkler bottles and BOD₅ is calculated as follows $\text{BOD}_5 \text{ (mg/l)} = \text{primitive dissolved oxygen} - \text{final dissolved oxygen}$.

2-2-10: Total Alkalinity

Total alkalinity is measured by titration of 100 ml of water sample with sulfuric acid (0.02 N) after adding methyl orange as reagent and expressed the result in units of mg CaCO₃ /l(2003, APHA).

2-2-11: Total Hardness

Total hardness is assessed by titrating with a Na₂ EDTA (0.01N) solution and using Eriochrom Black T (EBT) as a guideline and the result is expressed in mg /L (1979, Lind). The Calcium standard method is followed by (1979, Lind) by slaking with 2NaEDTA solution, adding (1N) NaOH solution and using Murexid dye as a guide and expressing the result in units of mg CaCO₃ /l.

2-2-12: Calcium

The method described before (Lind, 1979) was followed by adding with EDTA-2Na solution, adding NaOH solution (1 N), using Murexid dye as a guide, and expressing the product in mg/l.

2-2-13: Magnesium

The magnesium values are extracted by the mathematical method (1979, Lind) and by the following equation

$$mg Mg^{+2} / L = [mEq hardness / L - mEqCa^{+2} / L] \times 12.16$$

$$mEq hardness / L = [mg hardness] \times 0.01988$$

$$mEqCa^{+2} = [mgCa^{+2}] \times 0.0499$$

2-2-14: Nitrite

Nitrite is measured using a spectrophotometer (543 nm) in accordance with the procedure outlined by (Parson *et al.*, 1984), and the result is reported in µg/l.

2-2-15: Nitrate

To measure this, a method (APHA, 2003) is used, using a cadmium column to reduce nitrate to nitrite. at a wavelength of 543 nm, it is measured using a spectrophotometer, and the result is given in µg/l.

2-2-16: Reactive phosphate

To measure the effective phosphate, follow the method (Murphy and Riley, 1962) described in (Smith, 2004) using a spectrophotometer at a wavelength of 885 nm and express the result in µg/l.

2- 3: Grain size analysis of Sediment

The mechanical analysis of sediment samples is carried out by Hydrometer method to determine the proportion of sediment components (Grain Size Analysis) If 50 g of the sample is taken after sifting it through a filter with a diameter of 2 mm, to get rid of large plankton .The organic matter is removed using hydrogen peroxide (30%) H₂O₂. The sample is dispersed using chalcone (sodium hexameta phosphate) in order to calculate the percentage of sediment particles (sand, silt and clay) according to the method (Day,1965) as these ratios are represented on the soil texture triangle Mouloud *et al* ., (1990).

2-4:Total organic carbon in sediments (TOC)

Method of (APHA , 2003) Used To estimate the sediment content of total organic carbon (TOC), according to the following steps:-

- 1- After collecting the sediment sample, it was dried at room temperature, and the suspended matter and impurities were removed from it.
- 2- It is dried by oven at 60°C .
- 3- (0.5) g of the dry sample is weighed and put into a 500 ml in Conical flask.

- 4- 10 ml of potassium dichromate $K_2Cr_2O_7$ (1N) solution was added to it and mixed well.
- 5- 20 ml of H_2SO_4 concentrate is carefully added, mixed well and left for 30 minutes.
- 6- The above chemicals are placed in another beaker without the sediment sample to represent the Blank.
- 7- After 30 minutes, reduce the volume to 200 ml with distilled water.
- 8- The solution and the blank are crushed with a solution of ammonium ferrous sulfate $Fe (NH_4)_2 (SO_4)_2 \cdot 6H_2O$ (0.5N) and the color turns brownish-grey.
- 9- The total amount (concentration) of organic carbon is calculated using the calculation shown below:

$$TOC (mg/l) = (T-S) \times C \times 8000 / \text{Sample size (ml)}$$

T= Volume of ammoniac ferrous sulfate solution needed to titration the distilled water solution (ml).

2-5: Sample collection

2-5-1: water samples Collection

Water samples from the four sites are collected monthly from January 2021 to December 2021 from the medial and edge of the river for physical-chemical analyses and heavy metals tests, using 5-litre polyethylene containers with three repeaters per sample, and water testers are composed using transparent and opaque Winkler bottles of size (250) ml for the purpose of estimating the Biological Oxygen Demand (BOD₅).

2-5-2: Sediment sample collection

Benthic sediment samples are collected using grab sampler sediment samples from the same place where plant samples are collected, preserved in marked plastic bags and frozen until analysis.

2-5-3: Aquatic organisms Sample

2-5-3-1: Aquatic plants collection

Hydrophytes samples are collected from the study sites and washed with river water and transported to the laboratory by plastic bags marked each according to its location clearly in the laboratory The samples are washed with tap water and then with warm distilled water at a temperature of 38 ° C to remove small invertebrates stuck in them . Plant parts are washed with ion-free distilled water and dried at 70°C. Dry specimens are ground and passed in a sieve with a hole capacity of 40 Mesh (Salman *et al* ., 2017)

Then two types of aquatic plants are diagnosed:- *Phragmitus australis* and *Ceratophyllum demersum* Photo (2-3) . Aquatic plants were diagnosed in the herbarium of the university of Babylon by prof .Dr .Nadaa Adnan.

2-5-3-2: Clam Sample collection

Clam samples are collected monthly using by Hand the samples were washed with river water for the purpose of getting rid of plankton and obtaining the individuals of different sizes after that the samples are placed in marked bags inside a cooler box until they reached the laboratory .We extract soft tissues for samples by a plastic scalpel and placed in a polyethylene pot and remove excess water by filter paper The tissues are dried at 70° C for 24 hours and ground well using a ceramic mortar. (Salman *et al* ., 2017).

The type of clam is diagnosed as (*Pseudontopeses euphraticus*) Photo (2-3) . Clam were diagnosed by prof .Dr. Ibtisam Mahdi Abdul Sahib, Marine Science Center, Basra University .

2-5-3-3: Fish Samples collection

Fish samples are collected monthly using the method of fishing and two types of fish are obtained for the four sites and the two species are diagnosed: 1) *Oreochromis aureas* 2) *Leuciscus vora* Photo (2-3) . Fish were diagnosed by prof .Dr Moayad Jassim Yas, College of Science university of Babylon.

The muscles are separated from the bones, the muscles are dried, and then they are grinded and then passed with a sieve with 0.5 mm holes to remove fibers that cannot be easily broken. (Salman *et al* ., 2017).

2-6: Extraction Methods

2-6-1: Heavy Metal Extraction

2-6-2: Determination of Heavy Metals in water

The total amount (concentrations) of heavy metals under study are estimated according to (APHA, 2017), where the method included the following: (50 ml) of water samples are taken, the water samples are placed inside a sterile glass beaker and (5 ml) of concentrated nitric acid is added to digest the samples. The beaker is heated on a hot plate, and the heating continued on the plate. heated until it reaches the stage of pre-drying, and again added to the samples (5 ml) of concentrated nitric acid while continuing to heat in order to obtain a precipitate, leave the solution to cool down and then complete the volume to (25 ml) with deionized water. The solution is filtered using a filter paper (0.45 µm.) Then the concentrations are measured by Atomic Absorption Spectroscopy (AAS).

2-6-3: Determination of heavy metals in sediment

Heavy metals are estimated for Sediment samples collected, according to Turek, (2019). Weighted (2 g) of air-dried Sediment, placed in a clean glass Flask, added (10 ml) to it from H₂ SO₄, HNO₃ and HClO₄ and 1:1:3, The watch bottle was placed in the Flask, to avoid vaporization of acids, and the samples are heated by using Hot Plat (105°c/90 min) and on the, and we are mitigating, by adding deionized water to (50 ml), Absorption is estimated for each sample by the atomic absorption spectrometer, the absorption is converted into concentration units, by referencing the slope equations of the standard curves of heavy metals (µg/g) dry weight. .



Oreochromis aureus



Leuciscus vorax



Pseudostreptaxys euphratica



Phragmites australis



Ceratophyllum demersum



Ceratophyllum demersum

Photo (2-3) : Samples of Fish , Clam and Aquatic plant

2-6-4: Determination of Heavy Metals in Aquatic Organisms

Sample

2-6- 4-1: Determination of Heavy Metals in (Aquatic plants, Clam ,Fish)

Heavy metals in(plant ,clam , fish) samples are estimated by method of (APHA, 2017):

1. placed 3 g of (plant powder ,clam powder ,fish powder) in volumetric flask (25 ml).
2. Added 3 ml of concentrated Pyrochloric acid (HClO_4) solution (covered the cup using the watch glass bottle.
3. Heated quietly on a hot plate (gradually raise the temperature, in order to complete the digestion process .
4. When the mixture reaches the stage of dehydration , leave the cup to cool.
5. Repeated the steps 2 and 3, where a mixture consisting in a delicate and light color called (light colored digestate).
6. Fumigate until approached the dry phase
7. Added (5 ml) of diluted hydrochloric acid (HCl) (1:1) solution with water .
8. Heating, to dissolve the remaining sample after digestion, and then added distilled water.

As the sample is prepared for analysis using an atomic absorption spectrophotometer, the remaining and non-dissolved elements are removed using filtration, and the size of the solution is adjusted to a size (100 ml, 50 ml or less) in accordance with the expected concentration in the samples (SHEMADZU AA 7000).

2-7: Pollution index

2-7-1: Heavy Metal Pollution Index (HPI)

HPI: is a scale that measures the quality of water and its suitability for drinking purpose concerning the metals contamination. (Bose and Prasad, 2001).It is based on the following weighted arithmetic quality mean method (Mohan *et al.*, 1996)

$$HPI = \frac{\sum_{i=1}^n Q_i W_i}{\sum_{i=1}^n W_i}$$

Where: W_i (weight unit) = $1/S_i$

S_i =standard of the relevant metals

n , number of metals

Q_i =individual quality rating [$Q_i = \frac{C_i}{S_i} \times 100$]

C_i =measured value $/\text{Mgl}^{-1}$. (EWQS, 2007; WHO, 2011). In general, the life-threatening pollution index score for drinkable water is 100 (Prasad and Bose, 2001).

2-7-2:The Contamination index (C_d)

The relative contamination of various metals is measured independently by the contamination index, which also shows the cumulative impacts of all metals. The computation was done as follows (Backman *et al.*, 1997):

$$C_d = \sum_{i=1}^n C_{fi}$$

where C_{fi} was studied as the following equation:

$$C_{fi} = \frac{CA_i}{CN_i} - 1$$

C_{fi} ,factor of contamination ; CA_i ,msured value ; CN_i ,upper allowable value ; N
:Three classifications are created from the resulting C_d values: high ($C_d > 3$),

medium ($Cd = 1-3$), and low ($Cd < 1$). CNi is regarded as the previously introduced standard acceptable value (Si) for HPI calculation.

2-8: Water Quality index (Canadian Model) (CWQI)

After setting the time period, variables and standard standards, Use (CCME WQI1.0) to calculate the Canadian water quality index described by (CCME, 2001), The evidence is based on the combination of three factors:-

1- Scope (F1)

The number of factors or tests that exceeded the standard is divided by the number of factors studied overall, and calculated from the following equation:-

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

2- Frequency (F2)

The number of readings whose value does not correspond to the criteria set for the model (failed tests), divided by the total number of factors, is calculated from the following equation:

$$F2 = \left(\frac{\text{Number of failed tests}}{\text{Total number of tests}} \right) \times 100$$

3 – Amplitude (F3)

The number of readings whose value exceeded the standard standards set represents three steps, and is calculated as follows:

A / Excursion

When reading values are higher than standard values, it is calculated from the following equation:

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

Or the reading values are lower than the standard values and are calculated from the following equation:

$$Excursion = \left(\frac{Objective}{Failed\ Test\ Value} \right) - 1$$

B/ Normalized Sum of Excursion (nes)

It is calculated by dividing total non-standard readings by the total number of tests as follows:

$$nes = \frac{\sum_{i=1}^n excursion}{Number\ of\ tests}$$

The capacity (F3) is then calculated from the following equation:

$$F3 = \left(\frac{nes}{0.01\ nes + 0.01} \right)$$

By calculating the three main steps, the water quality index calculation is from the following equation:

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

Dividing by 1,732 is to keep the resulting directory value between (0-100), It then expresses the state of the water flat by linking the value of the index to a numerical scale (table) divided into five categories, each representing the level of water quality in terms of quality or response.

2-9: Standard Curve Initialization

- 1- Standard solutions of (4) are prepared from the main standard solution, which is usually at a concentration of (1000 ppm).
- 2- Using the general dilution law (N1X V1 = N2X V2), the necessary dilution is performed to prepare the four standard solutions in concentrations.
- 3- The blank solution is prepared and is usually deionized water.

4- After adjusting the device and selecting all the data of the metals to be analyzed, the absorbance of the four standard solutions is read and the calibration curve is obtained.

5- Reading the unknown models to obtain the concentrations.

2-10 : Preparation of Blank solutions

The same previous method is followed to extract heavy metals without adding samples to prepare a blank solution for the purpose of addressing the problem of contamination that may result from the use of chemicals or from laboratory working conditions.

2-11: Bioconcentration factor(BCF) and Biosedimentation factor (BSF)

According to (Kumar *et al*, 2009) method to learn how metals move between water and biology, use (BCF) by dividing the total concentration rate of each metals in the organisms on the value of its concentration in water

$$BCF=A/B.$$

As for identifying the movement of metals between water and sediment, use(BSF) by dividing the total concentration rate of each metals in the organism on its concentration in sediments: -

$$BSF=A/C$$

So if :- A= concentration rate of the metals in organism

B= concentration of the metals in water .

C= concentration of the metals in sediment .

2-12: Statistical Analysis

This study used the analysis of variance (ANOVA), LSD, median, standard deviation , correlation , minimum and maximum to find the significance among the study variances by using SPSS statistical program software (version 17), for creation the plots and tables, used excel microsoft.

Chapter Three

Results

3: Results

3-1 : Physical and Chemical Properties

3-1-1: Air Temperature (AT) °C

Through field measurements of Air Temperature, it is found that there are clear changes between the months, while the changes are minor between the study sites and the air temperature ranged between (12.5- 46 °C) in S2 for the of February 2021 and S3 for the of July respectively. Fig (3-1) Table (3-1).

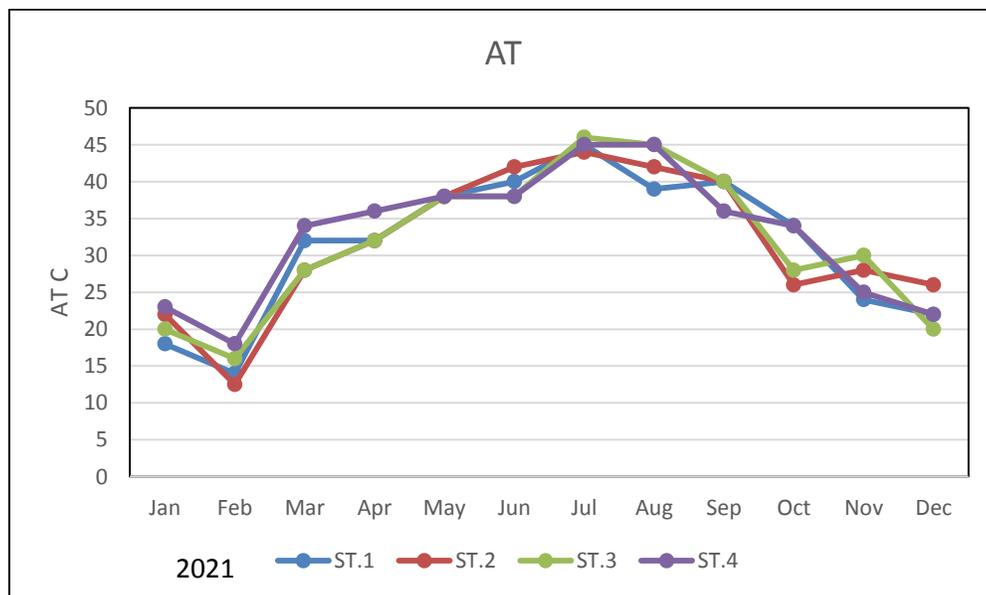


Figure (3-1) Spatial and Temporal variations of air temperature (°C) in study sites of Mashroo Al-Musayyib channel

The results of the statistical analysis showed a negative significant correlation between AT and for each of the (DO , BOD₅ , pH , Ec , Salinity , TDS,NO₂,NO₃ , PO₄) at the $p \leq 0.05$, $r = (-0.54, -0.28, -0.46, -0.60, -0.45, -0.45, -0.48, -0.05, -0.26, -0.14)$ respectively and a positive significant correlation for each of the(WT ,TSS ,TH ,Ca ,Mg ,AT) at the $p \leq 0.05$, $r = (0.94 , 0.45, 0.22, 0.09, 0.16, 0.02)$ respectively as shown in Appendix (1) .

3-1-2: Water Temperature (WT) °C

Through field measurements of water temperature, showed clear changes between months and sites and ranged water temperature ranges between (13.6 -38 °C) in the S1 for the of February and the S3 for the of July respectively.

Fig (3-2) Table (3-1).

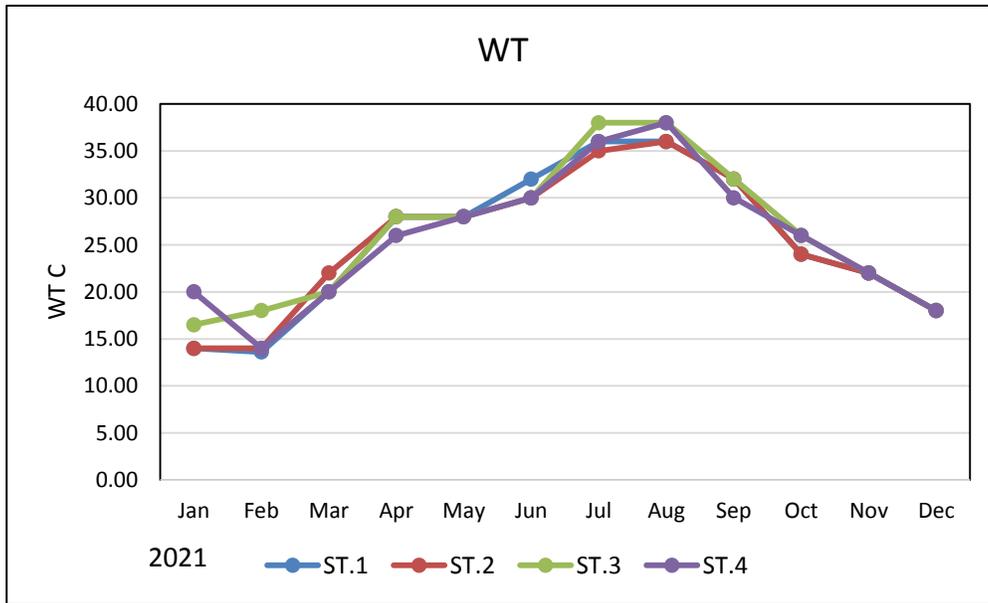


Figure (3-2) Spatial and Temporal variations of water temperature (°C) in study sites of Mashroo Al-Musayyib channel

The results of the statistical analysis showed a positive significant correlation between WT and for each of the(AT ,TSS ,TH ,Ca ,Mg ,AT) at the $r = (0.94 , 0.46, 0.22, 0.08,0.16,0.0)$ respectively and a negative significant correlation between WT for each of the (DO , BOD₅ , pH , EC , Salinity , TDS,NO₂,NO₃, PO₄) at the $p \leq 0.05, r = (-0.59, -0.29, -0.54 , -0.60 , -0.51, -0.51, -0.54, -0.07, -0.27, -0.12)$ respectively as shown in Appendix (1).

3-1-3: pH

The results of the study recorded clear changes in the pH values of water, reaching the highest value (8.34) in the first site for a February 2021 and the lowest value (6.66) in the first site for May 2021. Fig (3-3) Table (3-1).

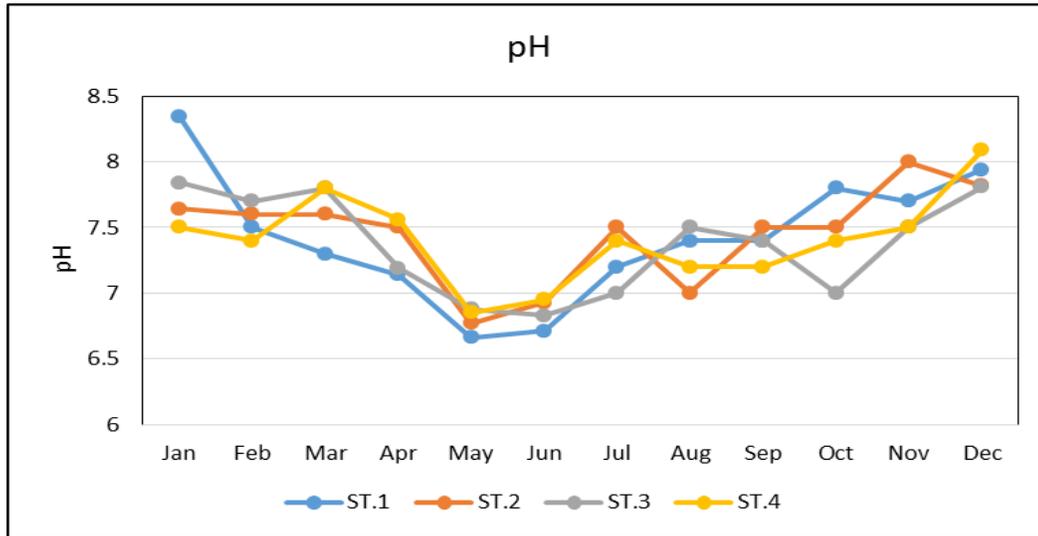


Figure (3-3) Spatial and Temporal variations of pH value in study sites of Mashroo Al-Musayyib channel

The results of the statistical analysis showed a positive significant correlation between pH and for each of the(DO,BOD₅ , EC , Salinity , TDS, NO₂,NO₃, PO₄ , TH, Ca , Mg , AT) at the $p \leq 0.05$, $r = (0.38 , 0.33, 0.53, 0.53,0.54,0.17,0.21,0.30,0.21,0.08,0.16,0.13)$ respectively and a negative significant correlation between pH for each of the (WT,AT,TSS) at the $p \leq 0.05$, $r = (-0.60, -0.60, -0.13)$ respectively as shown in Appendix (1).

Chapter Three..... Results

Table (3-1) Monthly Variation of the environmental physical and chemical properties of Mashroo Al-Musayyib channel in study site between January 2021+December

Month	Site	At (°C) Min-Max M ±SD	Wt (°C) Min-Max M±SD	pH Min-Max M±SD	EC (µs/cm) Min-Max M±SD	Salinity % Min-Max M ±SD	TDS(mg/l) Min-Max M±SD	TSS(mg/l) Min-Max M±SD	DO (mg/l) Min-Max M±SD
January 2021	S1	17-19 18 ±0.816	13.8-14.2 14±0.163	8.30-8.38 8.34±0.033	410-420 415±4.082	0.2555-0.2757 0.2656±0.008	300-302 301 ±0.816	5-20 11.667 ±6.236	5.4-6.2 5.8±0.327
	S2	21-23 22 ±0.816	13.9-14.1 14±0.082	7.59-7.71 7.64±0.049	429-431 430±0.816	0.2554-0.2950 0.2752±0.016	300-306 303 ±2.449	10-10 10 ±0	5.9-6.3 6.1±0.163
	S3	18.5-21.5 20 ±1.225	16.3-16.7 16.5±0.163	7.80-7.88 7.84±0.033	430-440 435±4.082	0.2673-0.2895 0.2784±0.009	300-314 307 ±5.715	5-15 8.333 ±4.714	3.2-3.6 3.4±0.163
	S4	22-24 23 ±0.816	19-21 20±0.816	7.2-7.8 7.5±0.245	439-446 442±2.867	0.2717-0.2939 0.28288±0.009	312-314 313 ±0.816	10-10 10 ±0	5.9-6.3 6.1±0.163
February 2021	S1	13.5-14.5 14±0.408	13.4-13.8 13.6±0.163	7.3-7.7 7.5±0.163	439-441 440±0.816	0.2811-0.2821 0.2816±0	300-322 311 ±8.981	4-5 4.667 ±0.471	3.5-3.9 3.7±0.163
	S2	12-13 12.5±0.408	17.9-18.1 18±0.163	7.5-7.7 7.6±0.082	438-444 441±2.449	0.28220-0.28228 0.28224±0	316-320 318 ±1.633	1-5 3.667 ±1.886	4.4-4.6 4.5±0.082
	S3	15.5-16.5 16±0.408	17.8-18.2 18±0.163	7.6-7.8 7.7±0.082	432-436 434±1.633	0.2778-0.2778 0.2778±0	307-309 308 ±0.816	2-5 4 ±1.414	5.4-5.8 5.6±0.163
	S4	17-19 18±0.816	14.3-14.8 14±0.205	7.3-7.5 7.4±0.082	437-439 438±0.816	0.2803-0.2803 0.2803±0	313-317 315 ±1.633	10-20 15 ±4.082	5.3-5.7 5.5±0.163
March 2021	S1	31-33 32±0.816	19-21 20±0.816	7.1-7.5 7.3±0.163	526-528 527±0.816	0.3-0.3 0.3±0	360-364 362 ±1.633	5-10 7.5 ±2.041	6.1-6.5 6.3±0.163
	S2	28-28 28±0	19-21 20±0.816	7.4-7.8 7.6±0.163	460-462 461±0.816	0.3-0.3 0.3±0	315-325 320 ±4.082	5-10 7 ±2.16	5.0-5.8 5.4±0.327
	S3	27-29 28±0.816	19-21 20±0.816	7.8-7.8 7.8±0	437-437 437±0	0.3-0.3 0.3±0	305-315 310 ±4.082	5-20 11.667 ±6.236	4.4-4.6 4.5±0.082

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Month	Site	At (°C) Min-Max M ±SD	Wt (°C) Min-Max M±SD	pH Min-Max M±SD	EC (µs/cm) Min-Max M±SD	Salinity % Min-Max M ±SD	TDS(mg/l) Min-Max M±SD	TSS(mg/l) Min-Max M±SD	DO (mg/l) Min-Max M±SD
	S4	33-35 34±0.816	20-20 20±0	7.7-7.9 7.8±0.082	475-477 476±0.816	0.3-0.3 0.3±0	335-339 337 ±1.633	3-15 7.667 ±5.249	4.3-4.9 4.6±0.245
April 2021	S1	31-33 32±0.816	27-29 28±0.816	7.12-7.16 7.14±0.021	410-412 411±0.816	0.3-0.3 0.3±0	289-291 290 ±0.816	5-60 25 ±24.833	2.8-3 2.9±0.082
	S2	31-33 32±0.816	27-29 28±0.816	7.4-7.6 7.5±0.082	416-416 416±0	0.3-0.3 0.3±0	290-298 294 ±3.266	10-20 13.333 ±4.714	3.5-3.9 3.7±0.163
	S3	32-32 32±0	28-28 28±0	7.18-7.20 7.19±0.008	379-381 380±0.816	0.2-0.2 0.2±0	269-271 270 ±0.816	5-10 7.333 ±2.055	3.4-3.6 3.5±0.082
	S4	35-37 36±0.816	26-26 26±0	7.6-7.6 7.6±0	420-422 421±0.816	0.3-0.3 0.3±0	297-299 298 ±0.816	5-20 11.667 ±6.236	3.2-3.8 3.5±0.245
May 2021	S1	37-39 38±0.816	27-29 28±0.816	6.64-6.68 6.66±0.016	411-413 412±0.816	0.26-0.26 0.26±0	290-292 291 ±0.816	5-15 10 ±4.082	1.8-2 1.9±0.082
	S2	38-38 38±0	28-28 28±0	6.75-6.79 6.77±0.021	406-408 407±2.625	0.26-0.26 0.26±0	287-289 288 ±0.816	5-40 18.333 ±15.456	3.4-3.6 3.5±0.082
	S3	38-38 38±0	27-29 28±0.816	6.86-6.90 6.88±0.016	381-383 382±0.816	0.24-0.24 0.24±0	270-272 271 ±0.816	5-10 7.333 ±2.055	2.8-3 2.9±0.082
	S4	37-39 38±0.816	27-29 28±0.943	6.85-6.85 6.85±0.005	417-417 417±0	0.27-0.27 0.27±0	294-296 295 ±0.816	25-35 30 ±4.082	2.3-2.5 2.4±0.082
June 2021	S1	39-41 40±0.816	31-33 32±0.816	6.70-6.72 6.71±0.008	440-448 444±3.266	0.3-0.3 0.3±0	315-317 316 ±47.148	5-5 5 ±0	4.1-4.3 4.2±0.082
	S2	42-42 42±0	29-31 30±0.816	6.90-6.96 6.93±0.024	436-438 437±0.816	0.3-0.3 0.3±0	310-312 311 ±4.967	5-10 6.667 ±2.357	4.2-4.4 4.3±0.082
	S3	37-39 38±0.816	30-30 30±0	6.80-6.86 6.83±0.014	420-424 422±1.886	0.3-0.3 0.3±0	299-301 300 ±0.816	5-10 6.667 ±2.357	3.1-3.3 3.2±0.082

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Month	Site	At (°C) Min-Max M ±SD	Wt (°C) Min-Max M±SD	pH Min-Max M±SD	EC (µs/cm) Min-Max M±SD	Salinity % Min-Max M ±SD	TDS(mg/l) Min-Max M±SD	TSS(mg/l) Min-Max M±SD	DO (mg/l) Min-Max M±SD
	S4	38-38 38±0	30-30 30±0	6.92-6.98 6.95±0.024	404-406 405±0.816	0.3-0.3 0.3±0	250-260 255 ±4.082	10-20 13.333 ±4.714	5.7-5.9 5.8±0.082
July 2021	S1	44-46 45±0.816	35-37 36±0.816	7-7.4 7.2±0.163	404-406 405±0.816	0.29-0.31 0.3±0	283-287 285 ±1.633	30-35 32.667 ±2.055	3-3.2 3.1±0.082
	S2	43-45 44±0.816	34-36 35±0.816	7.4-7.6 7.5±0.082	388-390 389±0.816	0.2-0.2 0.2±0	250-260 255 ±4.082	20-25 23 ±2.16	4-4.4 4.2±0.163
	S3	46-46 46±0	38-38 38±0	7-7 7±0	412-418 415±2.449	0.3-0.3 0.3±0	288-292 290 ±1.633	10-15 13 ±2.160	3.3-3.7 3.5±0.163
	S4	44-46 45±0.816	35-37 36±0.816	7.4-7.4 7.4±0	420-420 420±0	0.29-0.31 0.3±0	282-288 285 ±2.449	35-40 37 ±2.160	4.7-4.9 4.8±0.082
August 2021	S1	38-40 39±0.816	35-37 36±0.816	7.2-7.6 7.4±0.163	401-403 402±0.816	0.3-0.3 0.3±0	282-288 285 ±2.449	10-20 15.667 ±4.19	2.2-2.6 2.4±0.163
	S2	41-43 42±0.816	34-38 36±1.633	7-7 7±0	368-370 369±0.816	0.2-0.2 0.2±0	249-251 250 ±0.816	5-10 8 ±2.16	3.1-3.9 3.5±0.327
	S3	44-46 45±0.816	37-39 38±0.816	7.4-7.6 7.5±0.082	419-421 420±0.816	0.29-0.31 0.3±0	291-299 295 ±3.266	10-10 10 ±0	18-2 1.9±0.082
	S4	45-45 45±0	38-38 38±0	7.1-7.3 7.2±0.082	417-417 417±0	0.3-0.3 0.3±0	291-295 293 ±1.633	25-55 38.333 ±12.472	2-4 3±0.816
September 2021	S1	39-41 40±0.816	31-33 32±0.816	7.2-7.6 7.4±0.163	418-422 420±1.633	0.29-0.31 0.3±0	299-301 300 ±0.816	15-50 33.333 ±14.337	1.2-1.6 1.4±0.163
	S2	39-41 40±0.816	30-34 32±1.633	7.5-7.5 7.5±0	438-442 440±1.633	0.3-0.3 0.3±0	320-322 321 ±0.816	25-30 26.667 ±2.357	1.5-1.9 1.7±0.163
	S3	40-40 40±0	32-32 32±0	7.3-7.5 7.4±0.1	450-450 450±0	0.3-0.3 0.3±0.001	327-333 330 ±2.449	15-16 15.333 ±0.471	1.8-1.8 1.8±0

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Month	Site	At (°C) Min-Max M ±SD	Wt (°C) Min-Max M±SD	pH Min-Max M±SD	EC (µs/cm) Min-Max M±SD	Salinity % Min-Max M ±SD	TDS(mg/l) Min-Max M±SD	TSS(mg/l) Min-Max M±SD	DO (mg/l) Min-Max M±SD
	S4	35-37 36±0.816	29-31 30±0.816	7.2-7.2 7.2±0	450-460 455±4.082	0.3-0.3 0.3±0	308-312 310 ±1.633	40-55 46.667 ±6.236	2.1-2.7 2.4±0.245
October 2021	S1	33-35 34±0.816	23-25 24±0.816	7.7-7.9 7.8±0.082	464-466 465±0.816	0.29-0.31 0.3±0	325-329 327 ±1.633	10-15 12.333 ±2.055	4.8-5 4.9±0.082
	S2	25-27 26±4.784	24-24 24±0	7.3-7.7 7.5±0.163	456-458 457±0.816	0.3-0.3 0.3±0	318-324 321 ±2.449	5-10 7.667 ±2.055	4-6 5±0.816
	S3	28-28 28±0	25-27 26±0.816	7-7 7±0	460-462 461±0.816	0.3-0.3 0.3±0	323-325 324 ±0.816	5-10 8000 ±2.160	4.6-4.6 4.6±0
	S4	33-35 34±0.816	25-27 26±0.816	7.2-7.6 7.4±0.163	460-468 464±3.266	0.3-0.3 0.3±0	325-329 327 ±1.633	5-10 7.333 ±2.055	4.5-4.9 4.7±0.294
November 2021	S1	22-26 24±1.633	20-24 22±1.633	7.6-7.8 7.7±0.082	499-501 500±0.816	0.31-0.33 0.32±0.008	340-342 341 ±0.816	5-10 8.333 ±2.357	4.8-5 4.9±0.082
	S2	27-29 28±0.816	22-22 22±0	7.9-8.1 8±0.082	479-481 480±0.816	0.29-0.31 0.3±0	335-344 339 ±3.682	20-30 25000 ±4.082	5-5.2 5.1±0.082
	S3	29-31 30±0.816	21-23 22±0.816	7.4-7.6 7.5±0.082	470-474 472±1.633	0.29-0.31 0.3±0.009	335-337 336 ±0.816	5-40 23.333 ±14.337	5-5.4 5.2±0.163
	S4	24-26 25±0.816	21-23 22±0.816	7.5-7.5 7.5±0	440-448 444±3.266	0.3-0.3 0.3±0	312-320 316 ±21.463	10-30 20 ±8.165	5.3-5.5 5.4±0.082
December 2021	S1	20-24 22±1.633	17-19 18±0.816	7.90-7.98 7.94±0.033	580-590 585±4.082	0.39-0.41 0.4±0.009	410-416 413 ±2.449	5-15 10 ±4.082	4.5-5.5 5± 0.408
	S2	25-27 26±0.816	17.5-18.5 18±0.408	7.80-7.84 7.82±0.016	573-579 576±2.449	0.39-0.41 0.4±0.009	407-411 409 ±1.633	5-10 8.333 ±2.357	4.3-4.5 4.4±0.082
	S3	19-21 20±0.816	18-18 18±0	7.80-7.82 7.81±0.008	560-560 560±0	0.4-0.4 0.4±0.009	397-399 398 ±0.816	10-15 11.667 ±2.357	3.3-3.9 3.6±0.245
	S4	22-22 22±0	17-19 18±0.816	8.09-8.09 8.1±0	592-596 594±1.633	0.4-0.4 0.4±0.008	415-425 420 ±4.082	5-10 6.667 ±2.357	4-4.4 4.2±0.163

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Table (3-2) Monthly Variation of the environmental physical and chemical proporites of Mashroo Al-Musayyib channel in study site between January 2021+December

Month	Site	BOD ₅ (mg/l) Min-Max M±SD	Total Alkalinity (mgCaCo3/l) Min-Max M±SD	T.H(mgCaCo3/l) Min-Max M±SD	Mg(mgCaCo3/l) Min-Max M±SD	Ca(mgCaCo3/l) Min-Max M±SD	NO ₂ (µg/l) Min-Max M±SD	NO ₃ (µg/l) Min-Max M±SD	Po ₄ (µg/l) Min-Max M±SD
January 2021	S1	3.4-3.8 3.6±0.163	32-44 41.333 ±1.866	580-670 640.000 ±58.878	70.47-106.92 82.62 ±17.183	230-330 283.333 ±41.096	0.025-0.041 0.032 ±0.007	0.68-0.69 0.687 ±0.003	0.27-0.29 0.284 ±0.007
	S2	3.4-4.2 3.8±0.327	36.3-38.3 37.333 ±3.771	220-720 443.333 ±24.944	41.31-150.6 84.24 ±47.632	100-280 200.000 ±74.833	0.022-0.031 0.027 ±0.003	0.8-0.9 0.908 ±0.023	0.005-0.029 0.02 ±0.010
	S3	0.8-1.2 1±0.094	32-72 50.667 ±15.434	410-460 443.333 ±12.472	7.29-26.7 20.25 ±9.164	300-410 343.333 ±47.842	0.027-0.028 0.028 ±0.001	0.9-1 0.977 ±0.055	0.01-0.04 0.028 ±0.010
	S4	3.5-4.3 3.9±0.189	32-44 34.000 ±2.000	400-420 410.000 ±10.000	7.29-60.75 38.07 ±22.564	150-430 270.000 ±117.757	0.01-0.027 0.02 ±0.006	0.6-0.8 0.717 ±0.083	0.005-0.01 0.008 ±0.003
February 2021	S1	1-1.6 1.3±0.141	28-40 33.333 ±4.989	400-440 433.333 ±28.674	36.45-46.17 42.12 ±4.130	210-290 250.000±32.660	0.012-0.013 0.013 ±0	1.005-1.09 1.048 ±0.035	0.072-0.072 0.072 ±0
	S2	1.4-1.4 1.4±0	32-40 34.667 ±4.989	300-470 380.000 ±8.165	34.02-51.03 40.500 ±7.512	240-260 246.667 ±9.428	0.012-0.013 0.013 ±0	0.94-0.97 0.96 ±0.010	0.054-0.054 0.054 ±0
	S3	2.5-2.5 2.5±0	24-32 30.667 ±4.989	300-400 363.333 ±44.969	7.29-31.59 22.68 ±10.927	240-280 263.333 ±16.997	0.013-0.013 0.013 ±0	0.91-0.99 0.955 ±0.036	0.035-0.047 0.042 ±0.005
	S4	2.3-2.3 2.3±0	28-36 30.000 ±2.000	390-410 405.000 ±5.000	38.88-48.6 44.55 ±4.130	200-230 216.667 ±12.472	0.011-0.013 0.012 ±0.001	1.01-1.08 1.051 ±0.026	0.053-0.059 0.057 ±0.002
March 2021	S1	3-3.4 3.2±0.163	36-40 34.667 ±4.989	640-720 666.667 ±55.578	26.73-48.6 37.26 ±8.947	490-580 530.000 ±37.417	0.031-0.032 0.032 ±0	0.7-0.9 0.829 ±0.072	0.023-0.029 0.027 ±0.002
	S2	1.8-2.8 2.3±0.408	28-32 30.667 ±1.886	510-590 503.333 ±24.944	14.58-48.6 33.21 ±14.076	360-470 406.667 ±46.428	0.028-0.028 0.028 ±0	0.75-0.88 0.822 ±0.052	0.005-0.07 0.039 ±0.027
	S3	1.4-1.4 1.4±0	32-40 33.333 ±4.989	470-550 526.667 ±26.247	12.15-29.16 19.44 ±7.154	400-490 440.000 ±37.417	0.032-0.034 0.033 ±0.001	0.9-2 1.542 ±0.445	0 0 ±0

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Month	Site	BOD ₅ (mg/l) Min-Max M±SD	Total Alkalinity (mgCaCo3/l) Min-Max M±SD	T.H(mgCaCo3/l) Min-Max M±SD	Mg(mgCaCo3/l) Min-Max M±SD	Ca(mgCaCo3/l) Min-Max M±SD	NO ₂ (µg/l) Min-Max M±SD	NO ₃ (µg/l) Min-Max M±SD	Po ₄ (µg/l) Min-Max M±SD
	S4	0.9-2.3 1.6±0.572	28-32 30.000 ±2.000	490-560 540.000 ±20.000	21.87-36.45 29.97 ±6.061	390-410 400.000 ±8.165	0.027-0.03 0.028 ±0.004	0.6-0.8 0.734 ±0.055	0 0 ±0
April 2021	S1	0.6-0.6 0.6±0	8-28 12.000 ±3.266	320-490 380.000 ±45.461	34.02-55.89 42.93 ±9.376	180-270 236.667 ±40.277	0.03-0.05 0.042 ±0.007	0.67-0.86 0.738 ±0.091	0.058-0.06 0.06 ±0.001
	S2	0.9-1.3 1.1±0.163	8-16 12.000 ±3.266	360-440 413.333 ±37.712	34.02-43.74 38.88 ±3.968	180-280 236.667 ±41.899	0.029-0.031 0.031 ±0.001	0.62-0.71 0.667 ±0.038	0.066-0.072 0.07 ±0.002
	S3	0.6-1 0.8±0.163	12-16 16.000 ±0	400-440 410.000 ±21.602	24.3-46.17 32.4 ±9.787	250-330 293.333 ±32.998	0.032-0.033 0.033 ±0	0.65-0.67 0.663 ±0.007	0.079-0.084 0.083 ±0.002
	S4	0.2-1 0.6±0.327	16-20 16.000 ±4.000	390-450 415.000 ±35.000	7.29-48.6 27.54 ±16.874	250-350 293.333 ±41.899	0.032-0.039 0.036 ±0.003	0.54-0.65 0.602 ±0.043	0.07-0.09 0.084 ±0.008
May 2021	S1	0.8-1 0.9±0.082	28-56 40.000 ±11.776	470-495 490.000 ±16.330	46.17-70.47 59.13 ±9.986	180-280 233.333 ±41.096	0.045-0.059 0.05 ±0.007	1.03-1.16 1.104 ±0.053	0.040-0.049 0.046 ±0.004
	S2	0.9-1.1 1±0.082	32-36 33.333 ±1.886	420-520 473.333 ±41.096	31.59-65.61 53.46 ±15.496	250-290 263.333 ±18.856	0.046-0.048 0.047 ±0.001	0.94-1.04 0.996 ±0.039	0.04-0.06 0.054 ±0.005
	S3	1.6-1.6 1.6±0	28-36 33.333 ±3.771	350-500 396.667 ±85.765	31.59-46.17 39.69 ±6.061	270-310 296.667 ±18.856	0.056-0.065 0.06 ±0.004	0.93-1.19 1.071 ±0.108	0.060-0.066 0.063 ±0.002
	S4	0.1-0.5 0.3±0.163	28-36 32.000 ±4.000	250-340 295.000 ±45.000	14.58-41.31 24.3 ±12.069	170-230 193.333 ±26.247	0.05-0.051 0.051 ±0.001	0.85-0.89 0.871 ±0.017	0.061-0.061 0.061 ±0
June 2021	S1	0.7-0.9 0.8±0.082	32-52 33.333 ±1.886	530-640 536.667 ±100.775	14.58-58.32 33.21 ±18.435	400-490 450.000 ±37.417	0.077-0.079 0.078 ±0.001	0.50-0.58 0.543 ±0.035	0.16-0.17 0.167 ±0.005
	S2	1-1.4 1.2±0.163	28-32 29.333 ±1.886	400-590 516.667 ±77.172	4.86-21.87 12.15 ±7.154	310-550 416.667 ±99.778	0.07-0.07 0.07 ±0	0.59-0.65 0.624 ±0.028	0.14-0.19 0.17 ±0.017
	S3	1.1-1.1 1.1±0	32-36 32.000 ±3.266	380-610 540.000 ±113.431	4.86-65.61 43.74 ±27.564	300-360 333.333 ±24.944	0.071-0.077 0.074 ±0.002	0.53-0.60 0.568 ±0.030	0.19-0.20 0.199 ±0.002

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Month	Site	BOD ₅ (mg/l) Min-Max M±SD	Total Alkalinity (mgCaCo3/l) Min-Max M±SD	T.H(mgCaCo3/l) Min-Max M±SD	Mg(mgCaCo3/l) Min-Max M±SD	Ca(mgCaCo3/l) Min-Max M±SD	NO ₂ (µg/l) Min-Max M±SD	NO ₃ (µg/l) Min-Max M±SD	Po ₄ (µg/l) Min-Max M±SD
	S4	2.8-3.2 3±0.163	24-40 32.000 ±8.000	390-650 520.000 ±130.000	12.15-58.32 42.12 ±21.215	340-410 383.333 ±30.912	0.0654-0.0678 0.067 ±0.001	0.43-0.47 0.456 ±0.018	0.178-0.21 0.196 ±0.014
July 2021	S1	0.6-0.6 0.6±0	30-45 33.333 ±2.357	655-710 688.333 ±23.921	60.75-70.47 64.393 ±4.325	400-450 423.333 ±20.548	0.033-0.038 0.037 ±0.002	0.22-0.29 0.261 ±0.027	0.04-0.06 0.055 ±0.006
	S2	1-1.6 1.3±0.245	30-43 37.000 ±5.354	640-700 646.667 ±36.818	48.6-92.34 69.66 ±17.893	320-450 393.333 ±54.365	0.041-0.042 0.042 ±0	0.343-0.355 0.351 ±0.006	0.029-0.033 0.032 ±0.002
	S3	0.1-0.7 0.4±0.245	38-50 42.667 ±5.249	600-710 686.667 ±26.247	60.75-99.63 77.76 ±16.240	300-400 350.000±40.825	0.033-0.036 0.035 ±0.001	0.19-0.25 0.226 ±0.026	0.033-0.036 0.034 ±0.001
	S4	1.5-1.7 1.6±0.082	30-38 33.000 ±3.000	540-650 570.000 ±30.000	34.02-48.6 47.79 ±10.927	350-450 400.000 ±40.825	0.036-0.039 0.037 ±0.001	0.38-0.41 0.398 ±0.013	0.022-0.027 0.025 ±0.002
August 2021	S1	1.1-1.3 1.2±0.082	40-44 40.000 ±3.266	570-660 623.333 ±28.674	36.45-51.03 42.93 ±6.061	400-470 440.000 ±29.439	0.034-0.036 0.036 ±0.001	0.19-0.38 0.284 ±0.078	0.01-0.05 0.034 ±0.017
	S2	0.2-0.8 0.5±0.245	36-44 37.333 ±4.989	590-640 613.333 ±20.548	51.03-55.89 53.46 ±1.984	360-420 393.333 ±24.944	0.034-0.037 0.036 ±0.001	0.27-0.31 0.297 ±0.017	0.02-0.02 0.02 ±0
	S3	0.5-0.9 0.7±0.163	32-56 42.667 ±9.428	500-630 596.667 ±69.442	46.17-72.9 56.7 ±11.626	200-420 340.000 ±99.331	0.033-0.035 0.034 ±0.001	0.13-0.29 0.213 ±0.066	0.025-0.031 0.028 ±0.002
	S4	0.1-1.9 1±0.735	28-36 32.000 ±4000	540-660 550.000 ±10.000	43.74-58.32 48.6 ±6.873	320-480 386.667 ±67.987	0.033-0.034 0.034 ±0	0.39-0.41 0.407 ±0.009	0.019-0.025 0.022 ±0.002
September 2021	S1	0.2-0.6 0.4±0.163	24-40 33.333 ±6.799	690-850 760.000 ±57.155	119.07-143.37 132.03 ±9.986	200-260 223.333 ±26.247	0.061-0.065 0.064 ±0.002	0.28-0.45 0.374 ±0.071	0.23-0.43 0.338 ±0.082
	S2	0.4-1 0.7±0.245	24-40 33.333 ±6.799	720-830 760.000 ±37.417	104.49-172.53 139.32 ±27.801	120-320 193.333 ±89.938	0.063-0.066 0.065 ±0.001	0.263-0.27 0.269 ±0.005	0.58-1.58 1.087 ±0.409
	S3	0.4-0.6 0.5±0.082	40-48 42.667 ±3.771	780-850 800.000 ±35.590	72.9-150.66 114.21 ±31.931	230-510 343.333 ±120.370	0.064-0.065 0.065 ±0	0.236-0.238 0.237 ±0.001	0.23-0.25 0.246 ±0.007

Chapter Three..... Results

Month	Site	BOD ₅ (mg/l) Min-Max M±SD	Total Alkalinity (mgCaCo3/l) Min-Max M±SD	T.H(mgCaCo3/l) Min-Max M±SD	Mg(mgCaCo3/l) Min-Max M±SD	Ca(mgCaCo3/l) Min-Max M±SD	NO ₂ (µg/l) Min-Max M±SD	NO ₃ (µg/l) Min-Max M±SD	Po ₄ (µg/l) Min-Max M±SD
	S4	1.2-2 1.6±0.327	40-48 42.667 ±3.771	770-850 815.000 ±35.000	89.91-157.95 132.84 ±30.50	160-400 253.333 ±104.987	0.063-0.066 0.065 ±0.002	0.27-0.34 0.315 ±0.027	0.29-1.11 0.704 ±0.337
October 2021	S1	0.9-1.1 1±0.082	40-40 40.000 ±0	900-950 900.000 ±40.825	85.05-109.35 93.96 ±10.927	450-600 546.667 ±68.475	0.042-0.044 0.043 ±0.001	0.50-0.53 0.516 ±0.013	0.220-0.225 0.223 ±0.002
	S2	0-1 0.5±0.408	36-40 37.333 ±1.886	750-850 780.000 ±29.439	36.45-53.46 43.74 ±7.154	550-680 610.000 ±53.541	0.041-0.044 0.043 ±0.001	0.34-0.44 0.396 ±0.041	0.20-0.41 0.308 ±0.087
	S3	0.6-0.6 0.6±0	32-40 36.000 ±3.266	730-820 746.667 ±16.997	29.16-31.59 30.78 ±1.146	600-690 646.667 ±36.818	0.043-0.043 0.043 ±0	0.53-0.60 0.573 ±0.035	0.20-0.22 0.215 ±0.006
	S4	1.1-1.9 1.5±0.327	28-52 40.000 ±9.798	740-820 790.000 ±30.000	7.29-77.76 37.26 ±29.717	500-710 620.000 ±88.318	0.049-0.043 0.043 ±0	0.66-0.69 0.683 ±0.013	0.214-0.225 0.221 ±0.005
November 2021	S1	1.1-1.1 1.1±0	28-40 33.333 ±4.989	670-750 690.000 ±43.205	24.3-75.33 51.84 ±21.029	400-570 496.667 ±71.336	0.123-0.125 0.125 ±0.001	3.1-4.9 4.036 ±0.759	0.57-0.59 0.586 ±0.005
	S2	0.5-0.7 0.6±0.082	28-40 33.333 ±4.989	630-710 703.333 ±61.283	19.44-55.89 34.83 ±15.411	470-550 516.667 ±33.993	0.12-0.13 0.127 ±0.005	5.8-6.2 6.027 ±0.152	0.63-0.69 0.657 ±0.029
	S3	0.7-0.9 0.8±0.082	32-36 33.333 ±1.886	650-790 680.000 ±98.995	46.17-97.2 72.09 ±20.841	380-600 460.000 ±99.331	0.114-0.119 0.117 ±0.002	6.4-7.3 6.911 ±0.366	0.64-0.67 0.656 ±0.013
	S4	1.5-1.5 1.5±0	0.9-1.1 1.000 ±0.082	550-780 765.000 ±15.000	36.45-92.34 59.13 ±24.001	350-600 450.000 ±108.012	0.125-0.139 0.133 ±0.006	7.2-8.4 7.827 ±0.466	0.68-0.69 0.689 ±0.002
December 2021	S1	0.9-2.1 1.5±0.49	40-60 46.667 ±9.428	760-840 770.000 ±85.245	55.89-143.37 110.97 ±39.149	250-550 356.667 ±136.951	0.104-0.113 0.109 ±0.004	0.507-0.868 0.673 ±0.149	0.48-0.51 0.5 ±0.012
	S2	2.1-2.3 2.2±0.082	32-40 37.333 ±3.771	600-700 616.667 ±62.361	53.46-72.9 62.37 ±8.019	300-480 393.333 ±73.636	0.12-0.12 0.12 ±0	0.82-0.9 0.862 ±0.032	0.46-0.48 0.473 ±0.009
	S3	1.4-2 1.7±0.245	32-44 37.333 ±4.989	550-660 590.000 ±92.014	36.45-63.18 50.22 ±10.927	340-500 413.333 ±65.997	0.115-0.118 0.116 ±0	0.84-0.94 0.891 ±0.039	0.47-0.49 0.486 ±0.010
	S4	1.5-1.9 1.7±0.163	32-40 34.667 ±3.771	460-600 600.000 ±0	38.88-104.49 68.04 ±27.277	170-350 273.333 ±75.865	0.123-0.128 0.126 ±0.002	0.5-0.9 0.721 ±0.180	0.47-0.48 0.479 ±0.005

3-1-4: Electrical Conductivity (EC)

Electrical Conductivity values vary between the highest value (594) $\mu\text{s}/\text{cm}$ is recorded in the S4 for December and the lowest value (369) $\mu\text{s}/\text{cm}$ in S2 for an August 2021. Fig (3-4) Table (3-1).

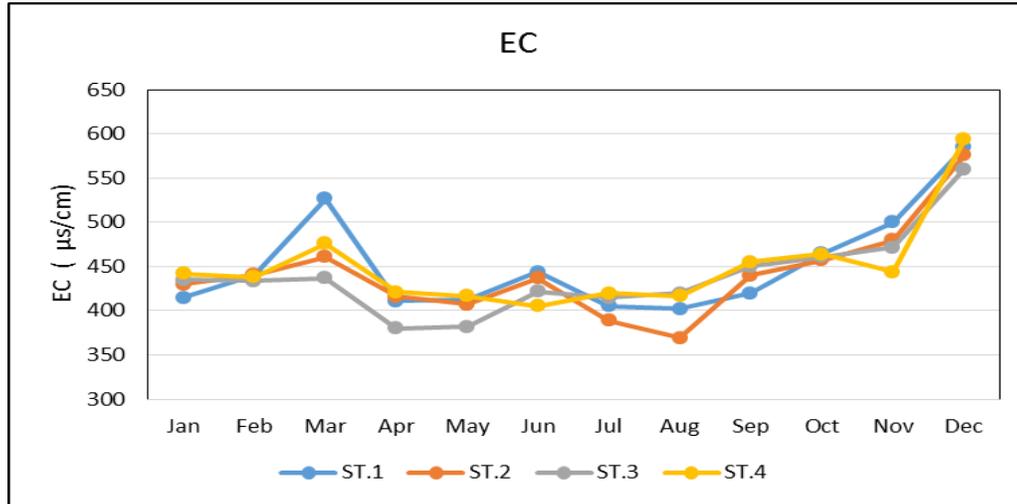


Figure (3-4) Spatial and Temporal variations of EC value in study sites of Mashroo Al-Musayyib channel

The results of the statistical analysis showed a positive significant correlation between EC and for each of the(DO, BOD₅ , pH , Salinity , TDS, NO₂,NO₂, PO₄ , TH , Ca , Mg, AT) at the $p \leq 0.05$, $r = (0.31 , 0.20, 0.53, 1 , 0.98, 0.59, 0.17, 0.48 , 0.33, 0.27 , 0.15, 0.22)$ respectively and a negative significant correlation between EC for each of the (WT,AT,TSS) at the $p \leq 0.05$, $r = (-0.51, -0.45, -0.21)$ respectively as shown in Appendix (1) .

3-1-5: Salinity

The lowest salinity value (0.2) ‰ is recorded in the S2 and S3 for (July, August, April) respectively and the highest value (0.4) ‰ recorded in the S4 for a December 2021. Fig (3-5) Table (3-1).

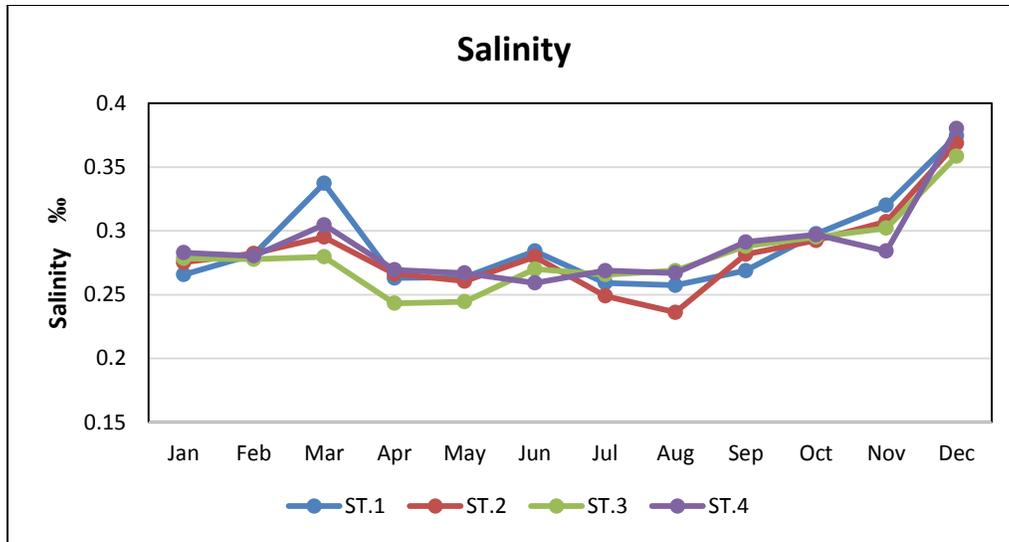


Figure (3-5) Spatial and Temporal variations of Salinity value in study sites of Mashroo Al-Musayyib channel

The results of the statistical analysis showed a positive significant correlation between Salinity and for each of the(DO, BOD₅ , pH , EC , TDS, NO₂,NO₃, PO₄ , TH , Ca , Mg, AT) at $p \leq 0.05$, $r = (0.31 , 0.20, 0.53, 1,00 ,0.98,0.59, 0.17, 0.48 ,0.33,0.27 ,0.15, 0.22)$ respectively and a negative significant correlation between Salinity for each of the (WT,AT,TSS) at $p \leq 0.05$, $r = (-0.51, -0.45, -0.21)$ respectively as shown in Appendix (1) .

3-1-6 :Total Dissolved Solid (TDS)

Through field measurements of TDS values, showed clear changes between months and sites and ranged TDS values ranges between (250 -420) mg/l in the S2 for in August and the S4 for in December respectively. Fig (3-6) Table (3-1).

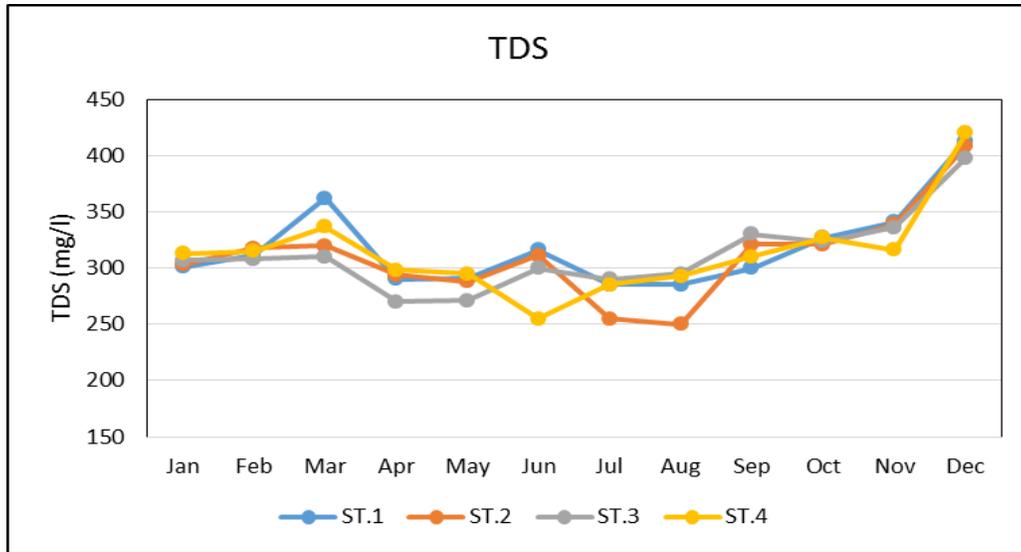


Figure (3-6) Spatial and Temporal variations of TDS value in study sites of Mashroo Al-Musayyib channel

The results of the statistical analysis showed a positive significant correlation between TDS and for each of the (DO, BOD₅ , pH , EC , Salinity , NO₂,NO₃, PO₄ , TH , Ca , Mg, AT) at the $p \leq 0.05$, $r = (0.25 , 0.16, 0.54, 0.98 ,0.98,0.57, 0.17, 0.49 ,0.31,0.21 ,0.17, 0.20)$ respectively and a negative significant correlation between TDS for each of the (WT,AT,TSS) at the $p \leq 0.05$, $r = (-0.54, -0.48, -0.22)$ respectively as shown in Appendix (1) .

3-1-7: Total Suspended Solid (TSS)

Total Suspended Solid values vary if the lowest value (3.667) mg/l in the S2 for a February 2021 and the highest value (46.667) mg/l is recorded in the S4 for September 2021 . Fig (3-7) Table (3-1). The results of the statistical analysis showed a positive significant correlation between TSS and for each of the (WT,AT, NO₂,NO₃, PO₄, TH , Mg) at the $p \leq 0.05$, $r = (0.46 , 0.45, 0.10, 0.09 ,0.27,0.25, 0.45)$ respectively and a negative significant correlation between TSS for each of the (DO, BOD₅ , pH , EC , Salinity , TDS, Ca , AT at the $p \leq 0.05$, $r = (-0.37, -$

0.25, -0.13, -0.21 , -0.21 ,-0.22, -0.17 , -0.07) respectively as shown in Appendix (1) .

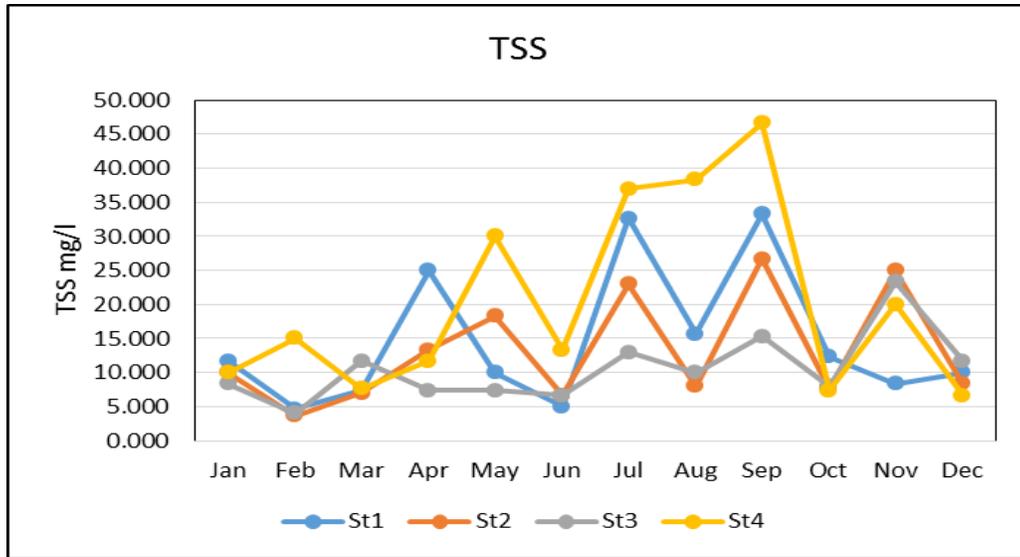


Figure (3-7) Spatial and Temporal variations of TSS value in study sites of Mashroo Al-Musayyib channel

3-1-8: Dissolved Oxygen (DO)

The lowest DO value (1.4) mg/l is recorded in the S1 for September 2021 and the highest value (6.3)mg/l recorded in the S1 for a march 2021. Fig (3-8) Table (3-1).

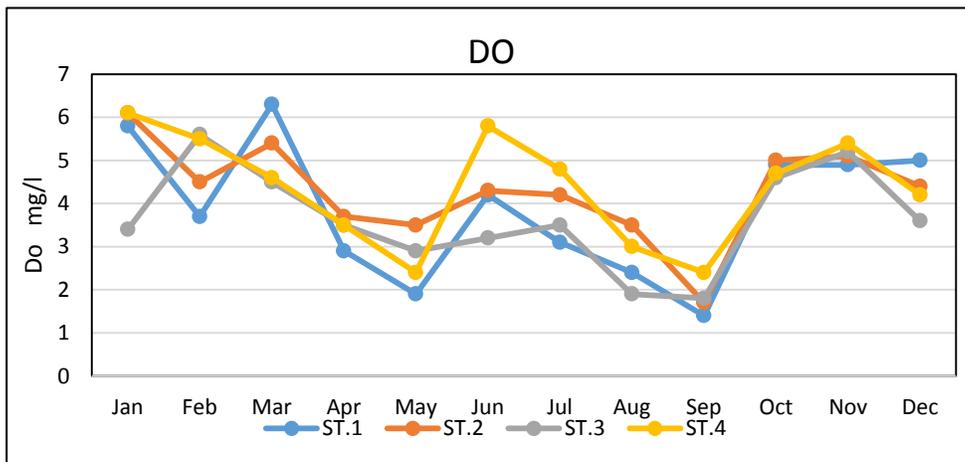


Figure (3-8) Spatial and Temporal variations of (DO) value in study sites of Mashroo Al-Musayyib channel

The results of the statistical analysis showed a positive significant correlation between DO value and for each of the (BOD₅ , pH , EC , Salinity , TDS, NO₂,NO₃, Ca) at the $p \leq 0.05$, $r = (0.68 , 0.38, 0.31, 0.31 ,0.25,0.02, 0.31,0.36)$ respectively and a negative significant correlation between DO value for each of the (WT,AT, PO₄ ,TSS, TH , Mg, AT)at the $p \leq 0.05$, $r = (-0.59, -0.54, -0.04, -0.37 , -0.03 ,-0.32, -0.09)$ respectively as shown in Appendix (1) .

3-1-9 : Biological Oxygen Demand (BOD₅)

The lowest BOD₅ value (0.3) mg/l is recorded in the S4 in May 2021 and the highest value (3.9)mg/l recorded in the S4 in January 2021 . Fig (3-9) Table (3-2).

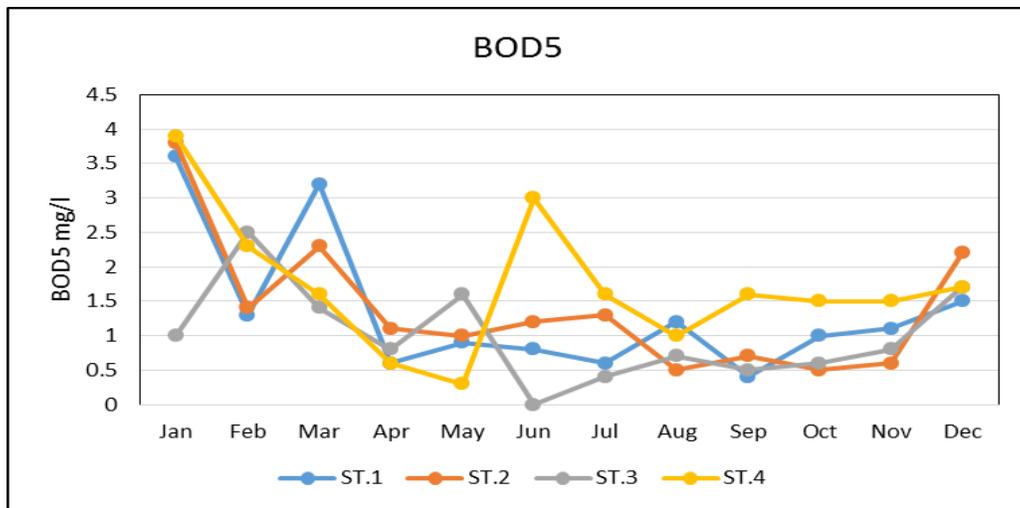


Figure (3-9) Spatial and Temporal variations of (BOD₅) value in study sites of Mashroo Al-Musayyib channel

The results of the statistical analysis showed a positive significant correlation between BOD₅ value and for each of the (DO, pH ,EC, Salinity , TDS, AT) at the $p \leq 0.05$, $r = (0.68 , 0.33, 0.20, 0.20 ,0.16 ,0.07)$ respectively and a negative significant correlation between BOD₅ value for each of the (WT,AT, NO₂,NO₃, PO₄ , TSS ,TH , Ca , Mg,) at the $p \leq 0.05$, $r = (-0.54, -0.46, -0.16,-0.06 ,-0.12 ,-0.25 ,-0.21 , -0.14,-0.06)$ respectively as shown in Appendix (1) .

3-1-10: Total Alkalinity

Through field measurements of Total alkalinity values, showed clear changes between months and sites and ranged Total alkalinity values ranges between (1.000 -50.667) CaCo₃ mg /l in the S4 in November 2021 and the S3 in January 2021 respectively. Fig (3-10) Table (3-2).

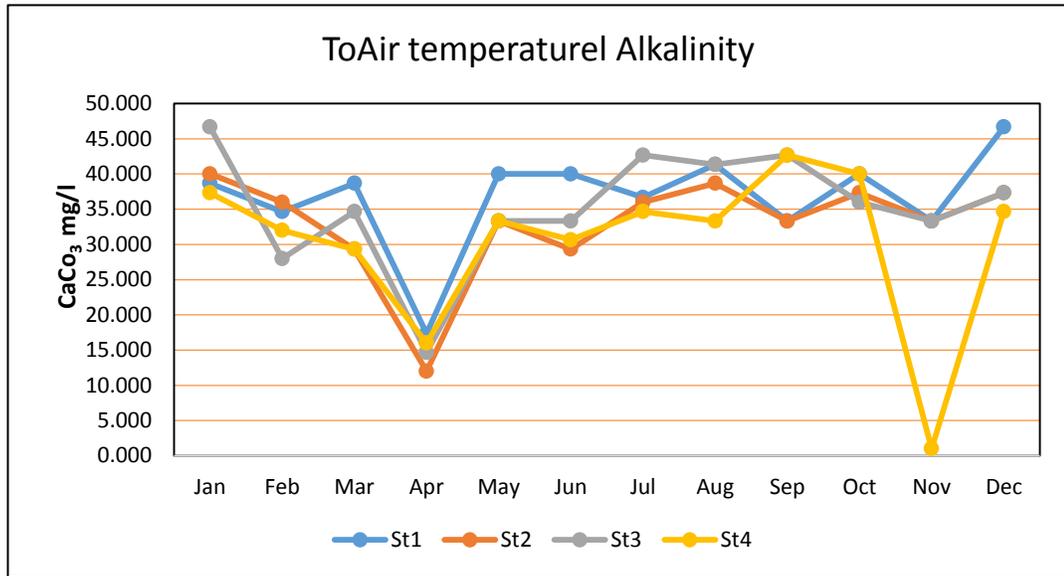


Figure (3-10) Spatial and Temporal variations of Total Alkalinity value in study sites of Mashroo Al-Musayyib channel

The results of the statistical analysis showed a positive significant correlation between Total alkalinity value and for each of the (WT,AT, BOD₅, PH, EC, Salinity , TDS, TH ,Ca ,Mg) at the $p \leq 0.05$, $r = (0.00 , 0.02, 0.07, 0.13 ,0.22 ,0.22,0.20, 0.33 ,0.14 ,0.30)$ respectively and a negative significant correlation between Total alkalinity value for each of the (DO,NO₂,NO₃, PO₄ , TSS) at the $p \leq 0.05$, $r = (-0.09, -0.06, -0.36,-0.01 , -0.07)$ respectively as shown in Appendix (1) .

3-1-11: Total Hardness

Through field measurements of Total Hardness values, showed clear changes between months and sites and ranged Total Hardness values ranges between (295.000 -900.000) CaCO₃ mg /l in the S4 in May 2021 and the S1 in October 2021 respectively. Fig (3-11) Table (3-2).

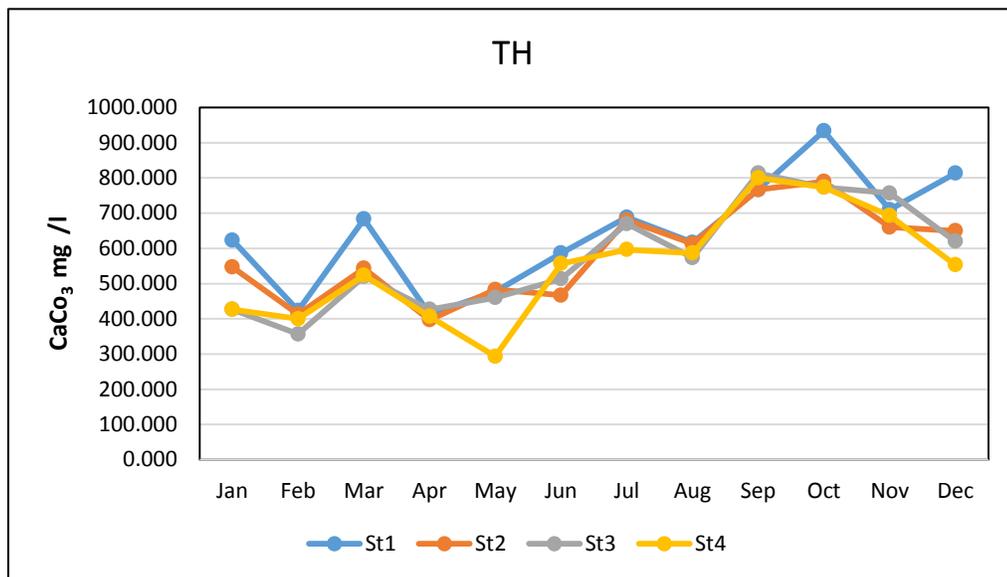


Figure (3-11) Spatial and Temporal variations of Total Hardness value in study sites of Mashroo Al-Musayyib channel

Statistical analysis showed a positive significant correlation between Total Hardness value and for each of the (WT,AT, , PH, EC, Salinity , TDS, NO₂,NO₃, PO₄ , TSS , Ca ,Mg ,AT) at the $p \leq 0.05$, $r = (0.22 , 0.22, 0.21, 0.33 ,0.33 ,0.31,0.42, 0.17 ,0.58 ,0.25,0.58 , 0.62 ,0.33)$ respectively and a negative significant correlation between Total Hardness value for each of the (DO, BOD₅) at the $p \leq 0.05$, $r = (-0.03, -0.21)$ respectively as shown in Appendix (1) .

3-1-12: Calcium (Ca)

The monthly vary showed that the highest value of calcium Hardness is (646.667) mg CaCO₃ /L at the S3 for the October 2021 and the lowest value is

(193.333) mg CaCO₃/L at the S2 and S4 for the September and May 2021 respectively. Fig (3-12) Table (3-2) .

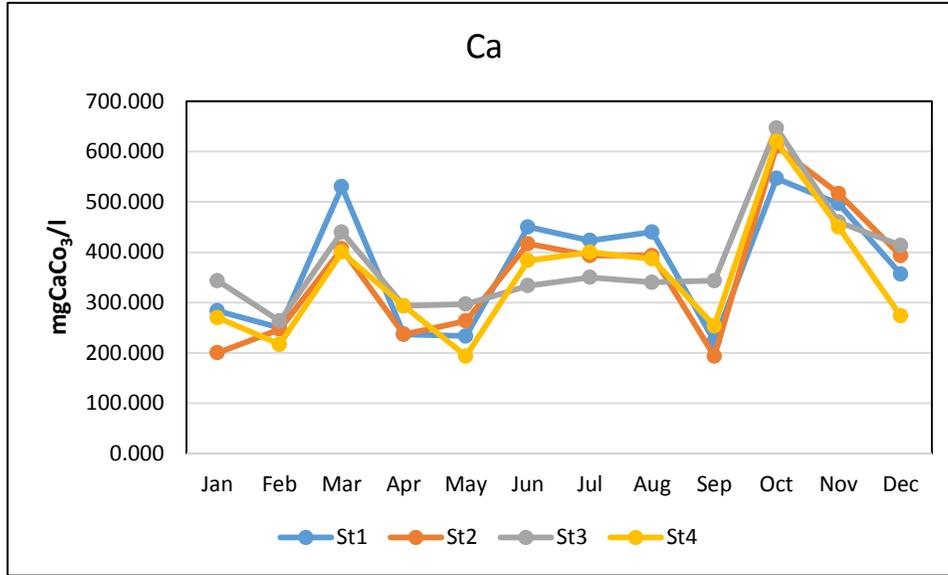


Figure (3-12) Spatial and Temporal variations of Calcium value in study sites of Mashroo Al-Musayyib channel

The results of the statistical analysis showed a positive significant correlation between calcium hardness value and for each of the (WT,AT, DO, PH, EC, Salinity , TDS, NO₂,NO₃, PO₄ , TH,AT) at the $p \leq 0.05$, $r = (0.08 , 0.09, 0.36, 0.08 ,0.27 ,0.27,0.21, 0.24 ,0.25 ,0.11,0.58 , 0.14)$ respectively and a negative significant correlation between calcium Hardness value for each of the (BOD₅ ,TSS , ,Mg) at the $p \leq 0.05$, $r = (-0.14, -0.17, -0.25)$ respectively as shown in Appendix (1).

3-1-13: Magnesium (Mg)

The monthly vary showed that the highest value of Magnesium is (139.320) mg CaCO₃/L at the S2 for the September 2021 and the lowest value is (12.150) mg CaCO₃/L at the S2 for the June 2021. Fig (3-13) Table (3-2). The results of the statistical analysis showed a positive significant correlation between Magnesium

value and for each of the (WT,AT, PH, EC, Salinity , TDS, NO₂, PO₄ , TSS ,TH,AT) at the $p \leq 0.05$, $r = (0.16 , 0.16, 0.16, 0.15 ,0.15 ,0.17,0.25, 0.56 ,0.45 ,0.62,0.30)$ respectively and a negative significant correlation between Magnesium value for Each of the (DO ,BOD₅ , No₃, Ca) at the $p \leq 0.05$, $r = (- 0.32 , -0.06 , -0.07, -0.25)$ respectively as shown in Appendix (1) .

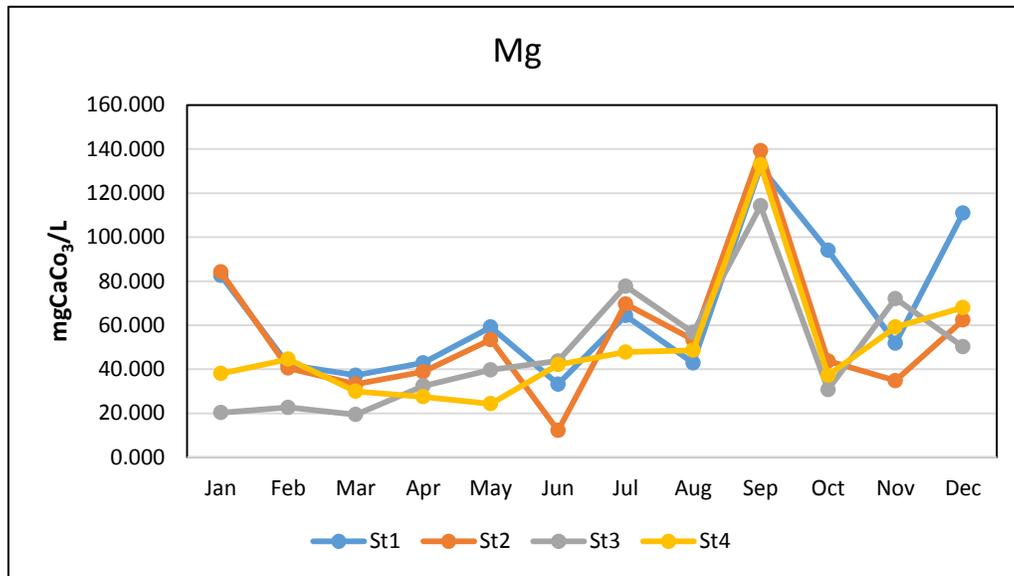


Figure (3-13) Spatial and Temporal variations of Magnesium value in study sites of Mashroo Al-Musayyib channel

3-1-14: Nitrite (NO₂)

The lowest nitrite value (0.012) µg/l is recorded in the S4 for February 2021 and the highest value (0.133) µg/l recorded in the S4 for a November 2021. Fig (3-14) Table (3-2). The results of the statistical analysis showed a positive significant correlation between Nitrite value and for each of the (DO, PH, EC, Salinity , TDS, NO₃, Po₄ , TSS ,TH, , Ca ,Mg) at the $p \leq 0.05$, $r = (0.02 , 0.17, 0.59, 0.59 ,0.57 ,0.59,0.76, 0.10 ,0.42 ,0.24,0.25)$ respectively and a negative significant correlation between Nitrite value for each of the (WT,AT ,BOD₅, AT)

at the $p \leq 0.05$, $r = (-0.07, -0.05, -0.16, -0.06)$ respectively as shown in Appendix (1).

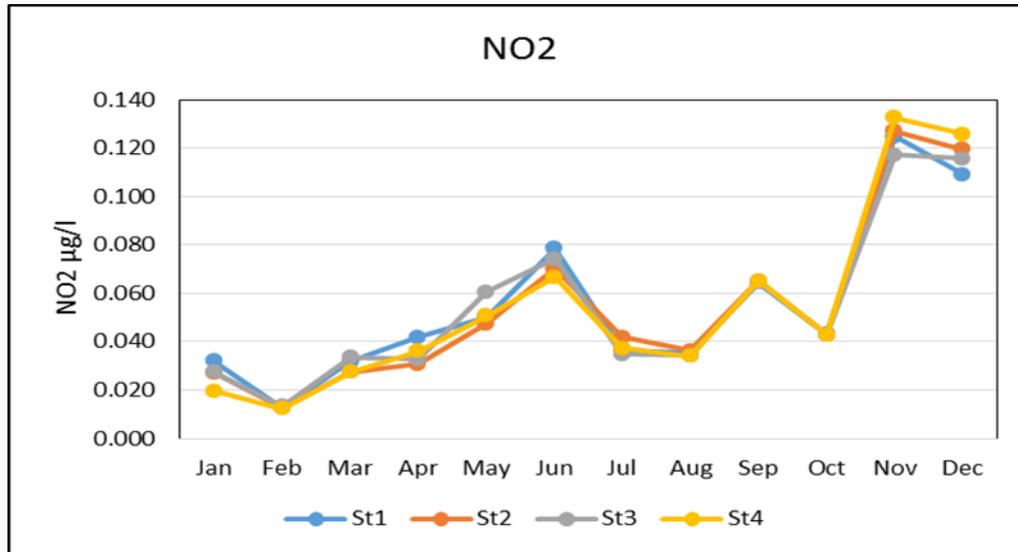


Figure (3-14) Spatial and Temporal variations of Nitrite value in study sites of Mashroo Al-Musayyib channel

3-1-15: Nitrate (NO₃)

The monthly vary showed that the highest value of nitrate is (7.827) µg/l at the S4 for the November 2021 and the lowest value is (0.213) µg/l at the S3 for August 2021 Fig (3-15) Table (3-2)

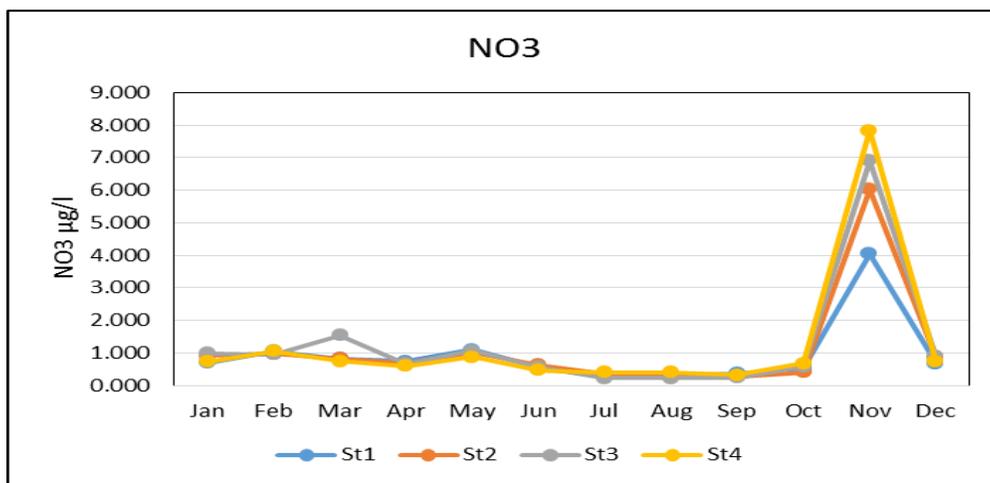


Figure (3-15) Spatial and Temporal variations of Nitrate value in study sites of Mashroo Al-Musayyib channel

The results of the statistical analysis showed a positive significant correlation between Nitrate value and for each of the (DO, pH, EC, Salinity , TDS, NO₂, PO₄ , TSS ,TH, , Ca) at the $p \leq 0.05$, $r = (0.31 , 0.21, 0.17, 0.17 , 0.17 , 0.59, 0.48, 0.09 , 0.17 , 0.25)$ respectively and a negative significant correlation between Nitrate value for each of the (WT,AT ,BOD₅ ,Mg, AT) at the $p \leq 0.05$, $r = (-0.27 , - 0.26, -0.06, -0.07,-0.36)$ respectively as shown in Appendix (1) .

3-1-16: Reactive phosphate (PO₄)

The lowest Reactive phosphate value (0.000) µg/l is recorded in the S3 and S4 for March 2021 and the highest value (1.087) µg/l recorded in the S2 for a September 2021 . Fig (3-16) Table (3-2) .

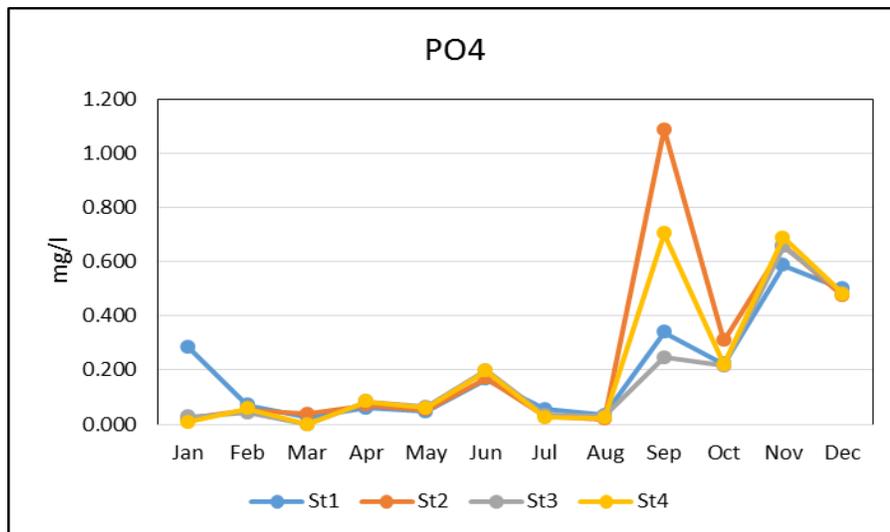


Figure (3-16) Spatial and Temporal variations of Reactive phosphate value in study sites of Mashroo Al-Musayyib channel

The results of the statistical analysis showed a positive significant correlation between Reactive phosphate value and for each of the (, pH, EC, Salinity , TDS, NO₂,NO₃, TSS ,TH, , Ca ,Mg) at the $p \leq 0.05$, $r = (0.30 , 0.48, 0.48, 0.49 , 0.76$

,0.48,0.27, 0.58 ,0.11 ,0.56) respectively and a negative significant correlation between Reactive phosphate value for each of the (WT, AT ,DO ,BOD5, AT) at the $p \leq 0.05$, $r = (-0.12 , -0.14, -0.04, -0.12 , 0.01)$ respectively as shown in Appendix (1) .

3-2: Total organic carbon in sediments (TOC)

The results of the study showed that the highest values of Total organic carbon content are at the third and fourth sites during the winter if they reached (33.6) mg/l while the lowest value (4.8) mg/l is recorded at the third site of the spring . Fig (3-17) Table (3-3).

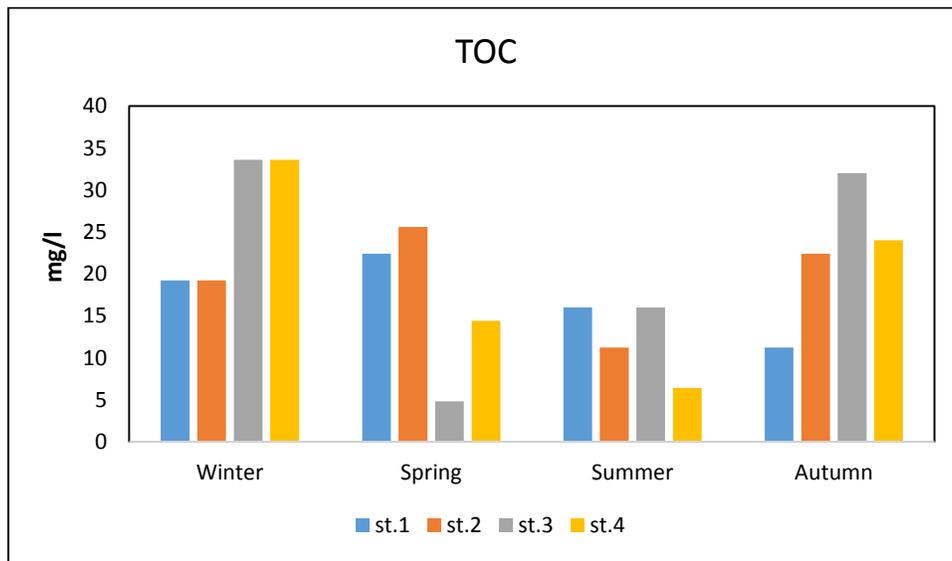


Figure (3-17) Total organic carbon concentration average(mg/l) in sediments of study sites of Mashroo Al-Musayyib channel

Table (3-3) average concentration of TOC (mg/l) in sediments

Site \ Sea.	Winter mg/l	Spring mg/l	Summer mg/l	Autumn mg/l
S1	19.2	22.4	16	11.2
S2	19.2	25.6	11.2	22.4
S3	33.6	4.8	16	32
S4	33.6	14.4	6.4	24

3-3: Grain size analysis of Sediment

The results showed that sediment in the Mashroo Al- Musayyib channel consists of a mixture of sand, silt and clay so the Percenatge of these components is(72.5 , 20, 7.5) % in S1 and (80, 15, 5)% in S2 and (65, 27.5,7.5) % in S3 and (60,30,10) %in S4 .Fig.(3-18)(3-19) Table (3-4). It is noted through the results of the study that the deposits of the study sites are Sandy loam.

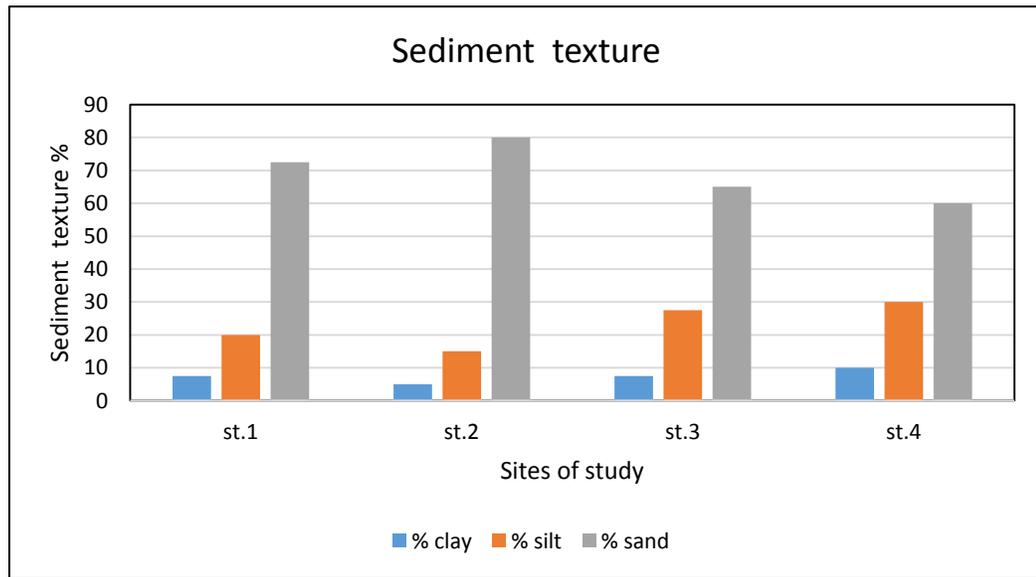


Figure (3-18): Percenatge of Sediment texture components in the study sites of Mashroo Al-Musayyib channel

Table (3-4): Percenatge of Sediment texture components in the study sites of Mashroo Al-Musayyib channel

Sample Sites	Sediment texture			Sediment class
	Clay (%)	Silt (%)	Sand (%)	
S1	7.5	20	72.5	Sandy loam
S2	5	15	80	sandy Loam
S3	7.5	27.5	65	Sandy loam
S4	10	30	60	Sandy loam

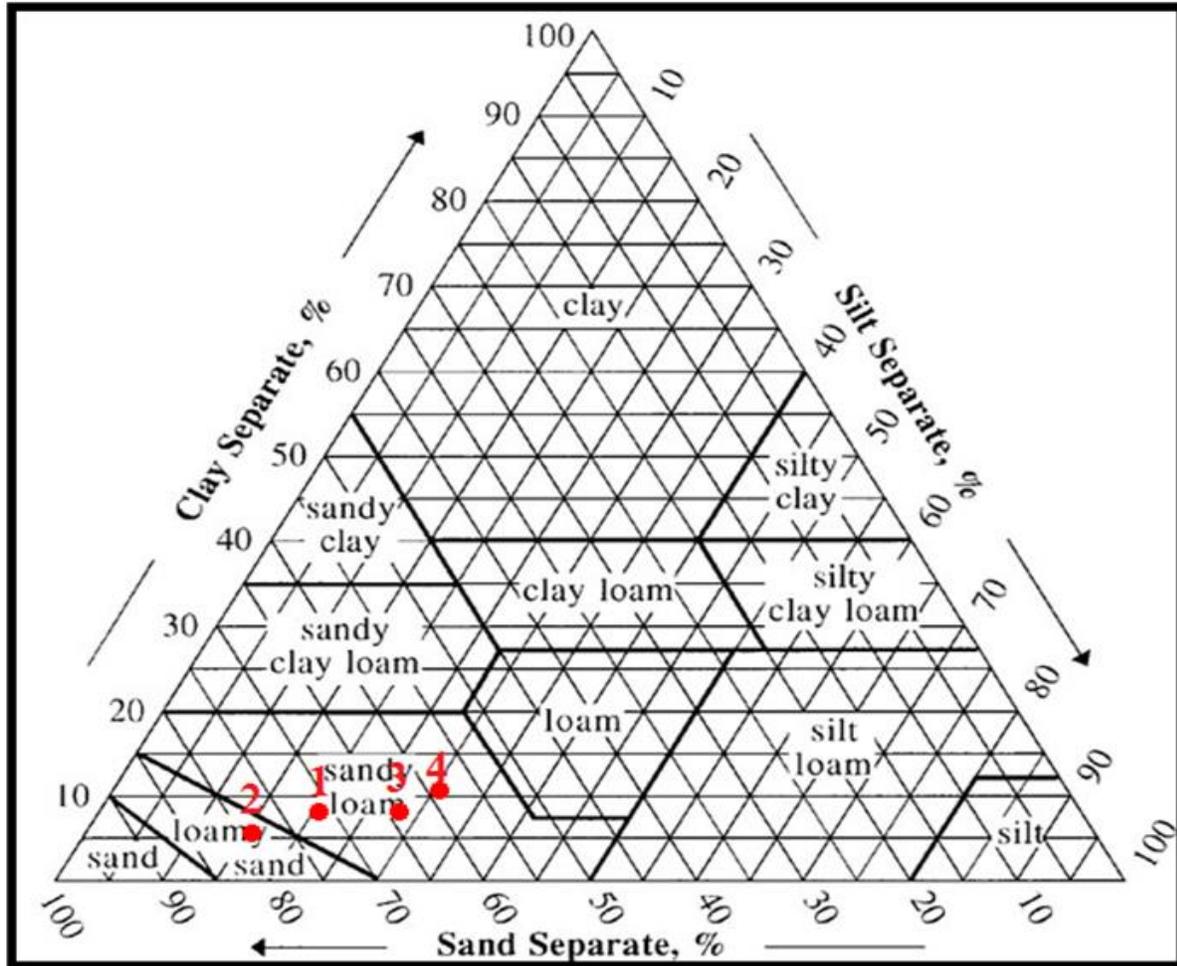


Figure (3-19) Percentage of Sediments texture components in the study sites of Mashroo Al-Musayyib channel

3-4: Heavy metals

3-4-1: Concentration of Heavy Metals in Water

1- Iron (Fe)

The results of heavy metals analysis concentration showed that in the waters The results recorded the lowest average concentration of dissolved Iron (Fe) (537 µg/l) in the S3 for the winter and the highest concentration rate if it reached (1533 µg/l) in the S1 for the autumn 2021. As for (Fe) concentrations in particulate phase the lowest concentration rate is (313 µg/l) in the S3 of the Winter and the highest concentration rate of(2063 µg/l) if it is reached in the S2 for the spring. (Table3-5) (Figure 3-20).

From the statistical analysis, it was showed that there are for dissolved Iron significant differences are found between sites except for S1 and S4 for the Autumn at the significant 0.05 level .the spring significant differences are found between all sites at the significant 0.05 level and significant differences are recorded in the summer in S2 and S3 respectively and there are no significant differences between S1 and S4 at the significant 0.05 level but in the winter significant differences are found between S2 and S3 and there are no differences Significantly between S1 and S4 at the significant 0.05 level and the correlation matrix for heavy metals in water showed that the dissolved Iron had a positive correlation with (Cr, Mg , Ca) at $p \leq 0.05$, $r = (0.92, 0.33, 0.50)$ respectively and positive relationship with the (water temperature , NO₂, NO₃, PO₄ ,TSS,TH) at $p \leq 0.05$, $r = (0.35, 0.37 , 0,50 ,0.36 ,0.54 ,0.51)$ respectively . It is also clear that there is negative relationship with (DO,BOD5,pH, Salinty , AT) at $p \leq 0.05$, $r = (- 0.23,-0.47,-0.30,-0.21,-0.53)$ respectively As shown in Appendix (2).

For particulate iron significant differences are found between for the four seasons at the significant 0.05 level except for S2 and S3 for the Autumn so no significant differences are recorded. and the correlation matrix for heavy metals in water showed that the particulate Iron had a positive correlation with (Cr, Mg , Ca) at $p \leq 0.05$, $r = (0.74, 0.43, 0.37)$ respectively and positive relationship with the (water temperature, salinity , DO,NO₂, NO₃, PO₄ ,TSS,TH) Appendix(3) . It is also clear that there is negative relationship with (BOD₅ ,pH ,AT) at $p \leq 0.05$, $r = (-0.23,-0.15,-0.33)$ respectively Appendix(3).

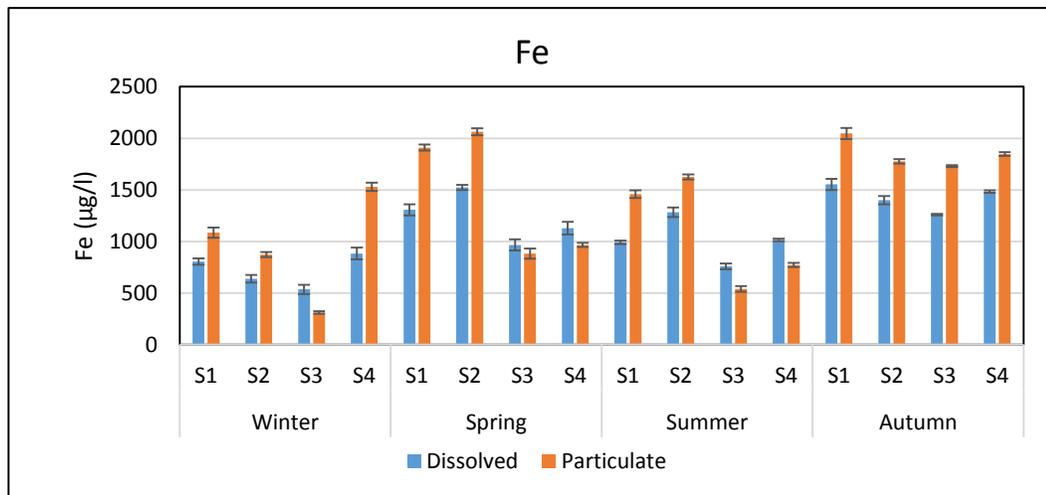


Figure (3-20) Iron Concentration rate µg /l of water in study site of Mashroo Al-Musayyib channel

Table (3-5) Iron Concentration rate $\mu\text{g/l}$ of water in study site of Mashroo Al-Musayyib channel

Sea. Sites	Heavy metal phase	Winter2021	Spring2021	Summer2021	Autumn2021
		Min-Max M($\mu\text{g/l}$) \pm SD			
S1	Dissolved	780-850 806.7 \pm 30.9	1250-1380 1306.7 \pm 54.4	970-1010 993.3 \pm 16.9	1490-1620 1553.3 \pm 53.1
	Particulate	1020-1140 1086.7 \pm 49.8	1880-1950 1910 \pm 29.4	1410-1500 1460 \pm 37.4	1980-2110 2046.7 \pm 53.1
S2	Dissolved	600-690 640 \pm 37.4	1490-1550 1523.3 \pm 24.9	1230-1340 1283.3 \pm 44.9	1350-1450 1400 \pm 40.8
	Particulate	840-890 873.3 \pm 23.6	2030-2110 2063.3 \pm 33.9	1600-1660 1626.7 \pm 24.9	1750-1800 1776.7 \pm 20.5
S3	Dissolved	480-590 536.7 \pm 44.9	890-1010 966.7 \pm 54.4	740-800 760 \pm 28.3	1250-1270 1260 \pm 8.2
	Particulate	300-330 313.3 \pm 12.5	820-940 883.3 \pm 49.2	520-580 540 \pm 28.3	1720-1740 1730 \pm 8.2
S4	Dissolved	810-950 883.3 \pm 57.3	1050-1200 1130 \pm 61.6	1000-1030 1016.7 \pm 12.5	1470-1500 1483.3 \pm 12.5
	Particulate	1480-1580 1530 \pm 40.8	940-990 966.7 \pm 20.5	750-800 773.3 \pm 20.5	1820-1860 1846.7 \pm 18.9

2- Copper (Cu)

The results of Copper (Cu) analysis concentration showed that in the waters (Table 3-6) (Figure 3-21). The results recorded the lowest average concentration of dissolved Copper ($360 \mu\text{g/l}$) in S3 for the winter and the highest concentration rate if it reached ($1263 \mu\text{g/l}$) in S2 for the Spring. as for the lowest concentration rate is ($247 \mu\text{g/l}$) in S3 of the Winter and the highest concentration rate of (Cu) ($2083 \mu\text{g/l}$) so it is reached in S1 for the Autumn.

From the statistical analysis, it is showed that there are For dissolved Copper significant differences are found between for the four seasons at the significant 0.05 level except for S1 and S4 and S2 and S3 respectively for the Autumn so no significant differences are recorded. in summer significant differences are recorded in except S2 and S4 so no significant differences are recorded and the correlation

matrix for heavy metals in water showed that the dissolved Copper had a positive correlation with (Cr, Mg , Ca) at $p \leq 0.05$, $r = (0.93, 0.19, 0.40)$ respectively and positive relationship with the (water temperature , NO_2 , NO_3 , PO_4 ,TSS,TH) appendix (2). It is also clear that there is negative relationship with (DO,BOD₅,pH, Salinity , AT) at $p \leq 0.05$, $r = (-0.2, -0.4, -0.3, -0.3, -0.6)$ respectively.

For particulate Copper significant differences are found between for the four seasons at the significant 0.05 level except for S2 and S4 for the Autumn so no significant differences are recorded and the correlation matrix for heavy metals in water showed that the particulate Copper had a positive correlation with (Fe, Cr, Mg , Ca) at $p \leq 0.05$, $r = (0.96, 0.75, 0.48, 0.50)$ respectively and positive relationship with the (water temperature, NO_2 , NO_3 , PO_4 ,TSS,TH) Appendix(3) . It is also clear that there is negative relationship with (DO, BOD₅ , pH ,Salinity) at $p \leq 0.05$, $r = (-0.11, -0.38, -0.15, -0.02)$ respectively. Appendix (3).

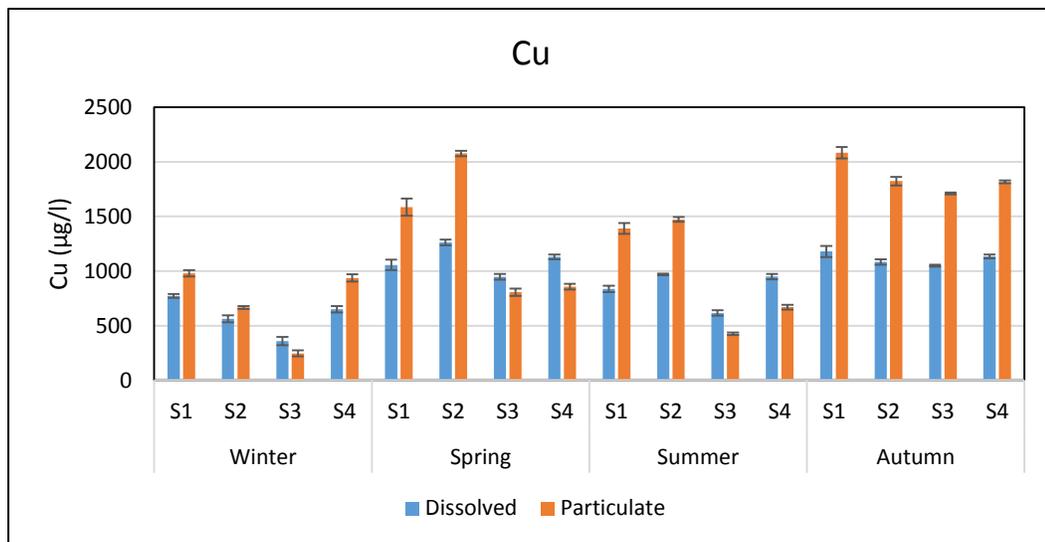


Figure (3-21) Copper Concentration rate µg /l of water in study site of Mashroo Al-Musayyib channel

Table (3-6) Copper Concentration rate $\mu\text{g/l}$ in water of water in study site of Mashroo Al-Musayyib channel

Sea. Sites	Heavy metal phase	Winter2021	Spring2021	Summer2021	Autumn2021
		Min-Max M($\mu\text{g/l}$) \pm SD			
S1	Dissolved	750-790 773.3 \pm 16.9	1000-1120 1056.6 \pm 49.2	800-870 836.7 \pm 28.7	1110-1230 1180 \pm 50.9
	Particulate	950-1020 980 \pm 29.4	1500-1690 1586.6 \pm 78.5	1330-1450 1390 \pm 48.9	2010-2130 2083.3 \pm 52.5
S2	Dissolved	520-600 563.3 \pm 32.9	1240-1300 1263.3 \pm 26.2	960-980 970 \pm 8.2	1050-1110 1083.3 \pm 24.9
	Particulate	650-680 666.7 \pm 12.4	2050-2110 2076.7 \pm 24.9	1450-1500 1473.3 \pm 20.5	1790-1880 1823.3 \pm 40.3
S3	Dissolved	320-410 360 \pm 37.4	910-970 946.7 \pm 26.2	590-650 616.7 \pm 24.9	1040-1060 1050 \pm 8.2
	Particulate	210-280 246.7 \pm 28.7	770-850 806.7 \pm 32.9	410-440 426.7 \pm 12.5	1700-1720 1710 \pm 8.2
S4	Dissolved	620-690 650 \pm 29.4	1100-1150 1130 \pm 21.6	920-980 950 \pm 24.5	1110-1150 1133.3 \pm 16.9
	Particulate	890-970 936.7 \pm 33.9	820-880 856.7 \pm 26.2	650-700 670 \pm 21.6	1800-1830 1816.7 \pm 12.5

3 - Zinc (Zn)

The results of Zinc (Zn) analysis concentration showed that in the waters (Table 3-7) (Figure 3-22) The results recorded the lowest average concentration of dissolved (Zn) ($8557\mu\text{g/l}$) in S3 for the Summer and the highest concentration rate if it reached ($30227\mu\text{g/l}$) in S2 for the Spring . as for (Zn) concentrations in particulate phase the lowest concentration rate is ($5820\mu\text{g/l}$) in S3 of the Winter and the highest concentration rate of($22287\mu\text{g/l}$) if it is reached in the for S2 the Spring .

From the statistical analysis, it is showed that there were For dissolved Zinc Significant differences are found all sites for the four season at the significant 0.05 level except for S1 and S4 for the Autumn and the S2 , S3 ,S4 respectively

so no significant differences are recorded. In Summer significant differences are found between all sites at the significant 0.05 except for S1 and S2 so no significant differences are recorded level and the correlation matrix for heavy metals in water showed that the dissolved Zinc had a positive correlation with (Cu,Fe,Cr,mg,Ca) at $p \leq 0.05$, $r=(0.72, 0.84, 0.66, 0.34, 0.36)$ respectively and positive relationship with the (water temperature, Salinity, NO_2 , NO_3 , PO_4 ,TSS,TH) It is also clear that there is negative relationship with(DO,BOD₅,pH,AT) at $p \leq 0.05$, $r= (-0.02,-0.24,-0.14,-0.35)$ respectively Appendix (2).

For particulate Zinc in Autumn significant differences are no found between all sites at the significant 0.05 level. The spring significant differences are found between all sites at the significant 0.05 level except S3 and S4 and significant differences are recorded in the summer except S1 and S2 and S3 and S4 respectively no record any significant differences . The winter significant differences are found between all sites at the significant 0.05 level except S1 and S3 Appendix (3). and the correlation matrix for heavy metals in water showed that the particulate Zinc had a positive correlation with (Cu, Fe, Cr ,Mg, Ca) at $p \leq 0.05$, $r =(0.84,0.91,0.66,0.34,0.10)$ respectively and positive relationship with the (Salinity, DO, BOD₅, NO_2 , NO_3 , PO_4 ,TSS,TH) Appendix(3).it is also clear that there is negative relationship with (water temperature ,AT) at $p \leq 0.05$, $r= (-0.10,-0.43)$ respectively Appendix (3).

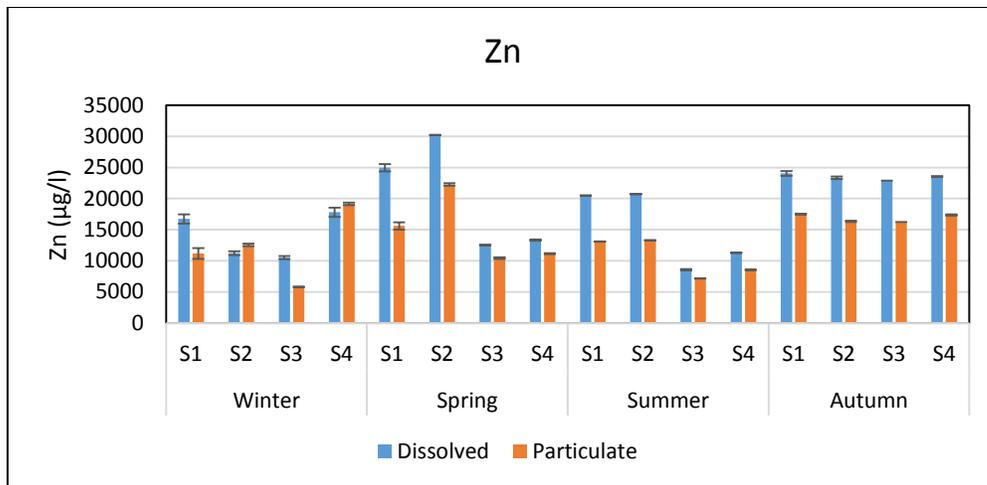


Figure (3-22) Zinc Concentration rate µg /l of water in study site of Mashroo Al-Musayyib channel

Table (3-7) Zinc Concentration rate µg /l of water in study site of Mashroo Al-Musayyib channel

Sea. Sites	Heavy metal phase	Winter2021	Spring2021	Summer2021	Autumn2021
		Min-Max M(µg/l) ±SD	Min-Max M(µg/l) ±SD	Min-Max M(µg/l) ±SD	Min-Max M(µg/l) ±SD
S1	Dissolved	15800-17600 16733.3 ±736.3	24500-25800 24966.7 ±590.7	20410-20550 20480 ±57.1	23650-24560 24040 ±382.7
	Particulate	10140-12050 11190 ±860	15000-16400 15600 ±588.8	13080-13140 13113.3 ±24.9	17460-17550 17496.7 ±38.6
S2	Dissolved	10800-11500 11233.3 ±309.1	30170-30260 30226.7 ±40.3	20690-20750 20710 ±28.3	23050-23420 23343.3 ±215.1
	Particulate	12300-12800 12533.3 ±205.5	22140-22580 22286.7 ±207.4	13260-13330 13286.7 ±30.9	16220-16480 16353.3 ±106.2
S3	Dissolved	10200-10800 10500 ±244.9	12480-12580 12536.7 ±41.9	8440-8660 8556.7 ±90.3	22870-22910 22890 ±16.3
	Particulate	5770-5890 5820 ±50.9	10250-10580 10423.3 ±135.2	7120-7230 7166.7 ±46.4	16220-16240 16230 ±8.2
S4	Dissolved	16920-18720 17816.7 ±734.9	13240-13470 13320 ±106.1	11250-11360 11290 ±49.7	23480-23600 23543.3 ±49.2
	Particulate	18980-19420 19130 ±205.1	11050-11240 11146.7 ± 77.6	8510-8560 8530 ±21.6	17250-17480 17353.3 ±95.3

4 - lead (Pb)

The results of Lead (pb) analysis concentration showed that in the waters (Table3-8) (Figure 3-23) if The results recorded the lowest average concentration of dissolved (pb) (0.2967 $\mu\text{g/l}$) in S3 for the winter and the highest concentration rate if it reached (3.593 $\mu\text{g/l}$) in S2 for the Spring . as for (pb) concentrations in particulate phase if the lowest concentration rate is (0.370 $\mu\text{g/l}$) in S3 of the Winter and the highest concentration rate of (1.263 $\mu\text{g/l}$) if it is reached in S2 for the Spring .From the statistical analysis, it is showed that there are For dissolved lead Significant differences are found between sites except for S2 and S4 for the Autumn at the significant 0.05 level .the spring significant differences are found between all site at the significant 0.05 level except S1 with S3 and S4 respectively but in the winter significant differences are no found between S4 with S1 and S2 respectively and the correlation matrix for heavy metals in water showed that the dissolved lead had a positive correlation with (Zn,Cu,Fe,Cr,Ca) at $p \leq 0.05$, $r=(0.60,0.84,0.76,0.79,0.14)$ respectively and positive relationship with the (water temperature , TSS) Appendix(2) .it is also clear that there is negative relationship with(DO,BOD₅,pH,Salinty , NO₂, NO₃, PO₄ ,TH, Mg ,AT) at $p \leq 0.05$, $r = (-0.31,-0.39, -0.55,-0.60,-0.24,-0.02,-0.02,-0.009,-0.14,-0.71)$ respectively Appendix(2) .

For particulate lead significant differences are found between sites except for S2 and S4 for the Autumn at the significant 0.05 level and significant differences are recorded in the summer in all sites except S2 and S3 . but in the winter significant differences are found between sites except S1 and S4 and the correlation matrix for heavy metals in water showed that the dissolved lead had a positive correlation with (Zn,Cu,Fe,Cr,) at $p \leq 0.05$, $r = (0.26, 0.26, 0.25,0.66)$ respectively and positive relationship with the (water temperature , TSS)

Appendix(3) .it is also clear that there is negative relationship with(DO,BOD₅,pH,Salinty , NO₂, NO₃, PO₄ ,TH, , Ca , Mg ,AT) at $p \leq 0.05$, $r=(-0.20,-0.17,-0.4,-0.5,-0.4,-0.2,-0.4,-0.3,-0.2,-0.3,-0.7)$ respectively Appendix(3)

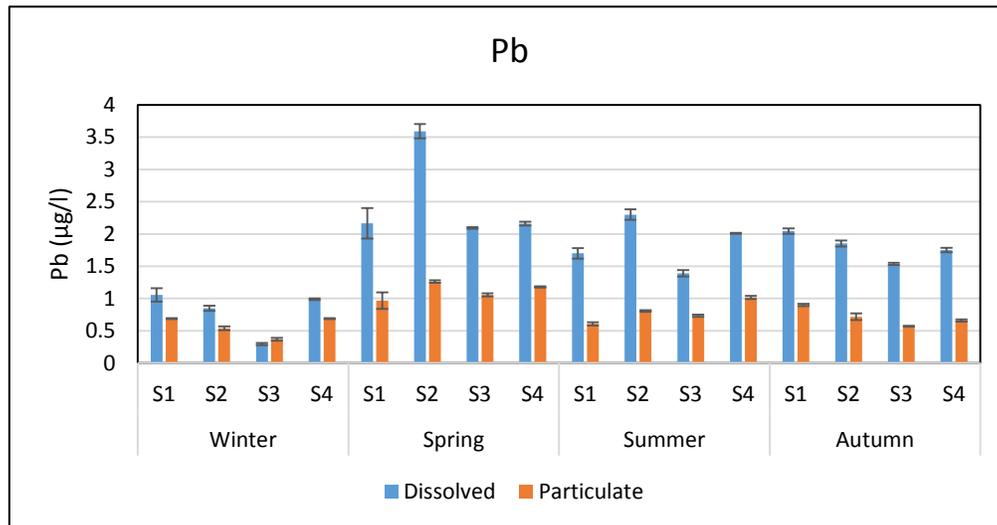


Figure (3-23) lead Concentration rate µg /l of water in study site of Mashroo Al-Musayyib channel

Table (3-8) lead Concentration rate $\mu\text{g/l}$ of water in study site of Mashroo Al-Musayyib channel

Sea. Sites	Heavy metal phase	Winter2021	Spring2021	Summer2021	Autumn2021
		Min-Max M($\mu\text{g/l}$) \pm SD			
S1	Dissolved	0.97-1.2 1.05667 \pm 0.102	2-2.5 2.16667 \pm 0.235	1.6-1.8 1.7 \pm 0.08	2-2.1 2.04667 \pm 0.04
	Particulate	0.68-0.7 0.69 \pm 0.008	0.8-1.11 0.97 \pm 0.1283	0.58-0.64 0.60667 \pm 0.02	0.88-0.9 0.9 \pm 0.01
S2	Dissolved	0.8-0.9 0.85 \pm 0.04	3.44-3.69 3.59333 \pm 0.109	2.2-2.4 2.3 \pm 0.08	1.79-1.9 1.85333 \pm 0.04
	Particulate	0.5-0.57 0.54 \pm 0.02	1.25-1.29 1.26333 \pm 0.01	0.79-0.82 0.80667 \pm 0.01	0.68-0.79 0.71667 \pm 0.05
S3	Dissolved	0.28-0.32 0.29 \pm 0.01	2.08-2.11 2.09667 \pm 0.01	1.33-1.45 1.39333 \pm 0.04	1.52-1.56 1.53667 \pm 0.01
	Particulate	0.35-0.4 0.37 \pm 0.02	1.04-1.09 1.05667 \pm 0.02	0.72-0.76 0.73333 \pm 0.01	0.56-0.58 0.57 \pm 0.008
S4	Dissolved	0.97-1 0.99 \pm 0.01	2.2-2.14 2.16 \pm 0.02	2-2.02 2.01 \pm 0.008	1.72-1.8 1.75333 \pm 0.03
	Particulate	0.68-0.7 0.69 \pm 0.008	1.17-1.19 1.18 \pm 0.008	1-1.05 1.01667 \pm 0.02	0.64-0.68 0.66 \pm 0.01

5 - Nickel (Ni)

The results of Nickel (Ni) analysis concentration showed that in the waters (Table 3-9) (Figure3-24). if The results recorded the lowest average concentration of dissolved (Ni) (0.1267 $\mu\text{g/l}$) in the S3 for the winter and the highest concentration rate if it reached (12.71 $\mu\text{g/l}$) in the S2 for the Spring . as for (Ni) concentrations in particulate phase if the lowest concentration rate is (0.217 $\mu\text{g/l}$) in S3 of the Winter and the highest concentration rate of (5.443 $\mu\text{g/l}$) so it is reached in S2 for the Spring .

From the statistical analysis, it is showed that there are For dissolved Nickel Significant differences between all sites for the four season at the significant 0.05

level except for S1 and S4 and S2 with S3 for the Autumn at the significant 0.05 level. but in the winter significant differences between all sites except for S1 and S4 and the correlation matrix for heavy metals in water showed that the dissolved lead had a positive correlation with (Pb,Zn,Cu,Fe,Cr,Mg, Ca) at $p \leq 0.05$, $r=(0.8,0.6,0.9,0.8,0.8,0.1,0.3)$ respectively and positive relationship with the (water temperature , NO, NO, P0 , TSS , TH) Appendix(2) it is also clear that there is negative relationship with (DO,BOD₅,pH,Salinty ,AT)at $p \leq 0.05$, $r= (-0.2,-0.4,-0.5,-0.4,-0.6)$ Appendix(2).

For particulate Nickel in Autumn Significant differences are found only between S1 and S3 at the significant 0.05. In spring significant differences are found between all sites except for S2 and S4. for the Summer significant differences are found between all sites except for S1 and S2. in Winter Significant differences are found between all sites except for S1 with S2 and S4 respectively and the correlation matrix for heavy metals in water showed that the particulate Nickel had a positive correlation with (Pb ,Zn, ,Cr,) at $p \leq 0.05$, $r=(0.7,0.2,0.2)$ respectively and positive relationship with the (DO,BOD₅,pH, TSS) Appendix(3) it is also clear that there is negative relationship with (water temperature , NO₂, NO₃, PO₄ , Salinity ,AT, TH, Cu, Fe , Mg, Ca) Appendix(3).

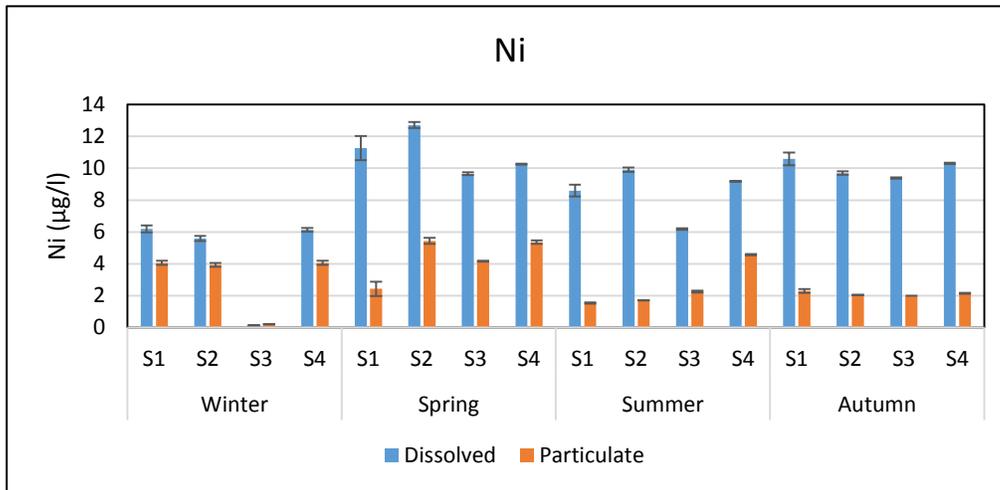


Figure (3-24) Nickel Concentration rate µg/l of water in study site of Mashroo Al-Musayyib channel

Table (3-9) Nickel Concentration rate µg/l of water in study site of Mashroo Al-Musayyib channel

Sea. Sites	Heavy metal phase	Winter2021	Spring2021	Summer2021	Autumn2021
		Min-Max M(µg/l) ±SD	Min-Max M(µg/l) ±SD	Min-Max M(µg/l) ±SD	Min-Max M(µg/l) ±SD
S1	Dissolved	6-6.5 6.2±0.2	10.2-11.8 11.27±0.75	8.2-9.1 8.6±0.4	10.11-11.08 10.59±0.396
	Particulate	3.9-4.2 4.06±0.1	1.9-3 2.43±0.44	1.5-1.58 1.543±0.03	2.13-2.4 2.296±0.11
S2	Dissolved	5.4-5.8 5.6±0.2	12.4-12.89 12.7±0.2	9.7-10.01 9.9033±0.1	9.58-9.85 9.6966±0.11
	Particulate	3.8-4.1 3.93±0.1	5.22-5.69 5.44±0.2	1.69-1.73 1.71±0.01	2.04-2.07 2.05±0.01
S3	Dissolved	0.12-0.14 0.126±0.009	9.55-9.78 9.656±0.09	6.14-6.25 6.19±0.04	9.33-9.42 9.383±0.038
	Particulate	0.2-0.24 0.216±0.01	4.12-4.2 4.166±0.03	2.2-2.33 2.26±0.05	2-2.01 2.0033±0.0047
S4	Dissolved	6-6.3 6.13±0.12	10.22-10.28 10.25±0.02	9.14-9.21 9.183±0.03	10.25-10.36 10.31±0.045
	Particulate	3.9-4.2 4.066±0.12	5.22-5.48 5.36±0.10	4.53-4.62 4.5766±0.03	2.11-2.17 2.1466±0.026

6- Cadmium (Cd)

The results of Cadmium (Cd) analysis concentration showed that in the waters (Table 3-10) (Figure 3-25) if The results recorded the lowest average concentration of dissolved (Cd) ($0.03\mu\text{g/l}$) in S3 for the Summer and the highest concentration rate if it reached ($0.88\mu\text{g/l}$) in S1 for the Spring . as for (Cd) concentrations in particulate phase if the lowest concentration rate is ($0.033\mu\text{g/l}$) in S3 of the Summer and the highest concentration rate of (Cd) ($0.985\mu\text{g/l}$) if it was reached in S4 for the Spring .

From the statistical analysis, it is showed that there are For dissolved Cadmium Significant differences are found between all sites for the four season at the significant 0.05 level except for S2 and S4 for the Autumn but in the winter significant differences are found between S2 and S3 and there are no differences Significantly between S1 with S2 and S4 respectively at the significant 0.05 level and the correlation matrix for heavy metals in water showed that the dissolved Cadmium had a positive correlation with (Ni,Zn,Cu,Fe,Cr,Mg,Ca) at $p\leq 0.05$, $r=(0.2,0.6,0.3,0.4,0.2,0.5,0.3)$ respectively and positive relationship with the (DO,BOD₅,pH, TSS , NO₂, NO₃, PO₄ , TH , salinity) Appendix(2) it is also clear that there is negative relationship with (water temperature ,Pb) at $p\leq 0.05$, $r=(-0.2,-0.02)$.

For particulate Cadmium Significant differences are found between all sites for the four season at the significant 0.05 level except for S1 and S4 for the winter and the correlation matrix for heavy metals in water showed that the particulate Cadmium had a positive correlation with (Ni, Pb,Zn,Cu,Fe,Cr,) at $p\leq 0.05$, $r=(0.7,0.6,0.2,0.1,0.1,0.5)$ respectively and positive relationship with the (DO,BOD₅,TSS) Appendix(3) it is also clear that there is negative relationship with (water temperature , PH, Salinity , Mg , Ca, TH,AT, NO₂, NO₃, PO₄) at $p\leq 0.05$, $r=(-0.04,-0.02,-0.01,-0.2,-0.3,-0.3,-0.5,-0.3,-0.1,-0.2)$ respectively.

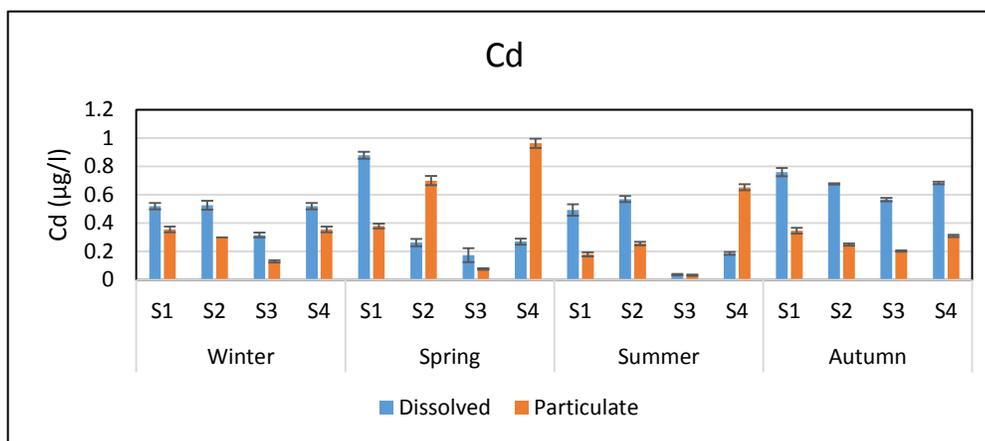


Figure (3-25) Cadmium Concentration rate µg /l of water in study site of Mashroo Al-Musayyib channel

Table (3-10) Cadmium Concentration rate µg /l of water in study site of Mashroo Al-Musayyib channel

Sea. Sites	Heavy metal phase	Winter2021	Spring2021	Summer2021	Autumn2021
		Min-Max M(µg/l) ±SD	Min-Max M(µg/l) ±SD	Min-Max M(µg/l) ±SD	Min-Max M(µg/l) ±SD
S1	Dissolved	0.5-0.55 0.52 ±0.02	0.85-0.91 0.88 ±0.02	0.46-0.55 0.4933 ±0.04	0.74-0.8 0.76 ±0.028
	Particulate	0.33-0.38 0.3566 ±0.02	0.36-0.4 0.38 ±0.01	0.17-0.2 0.18 ±0.01	0.32-0.37 0.3466 ±0.02
S2	Dissolved	0.5-0.57 0.52667 ±0.03	0.24-0.3 0.263 ±0.026	0.54-0.59 0.57 ±0.02	0.67-0.68 0.6766 ±0.004
	Particulate	0.3-0.31 0.3 ±0	0.66-0.74 0.7 ±0.03	0.24-0.27 0.25667 ±0.01	0.24-0.26 0.25 ±0.008
S3	Dissolved	0.3-0.34 0.316 ±0.017	0.11-0.23 0.17 ±0.049	0.03-0.04 0.036 ±0.0047	0.55-0.58 0.5666 ±0.01
	Particulate	0.12-0.14 0.13 ±0.008	0.07-0.08 0.0766 ±0.0047	0.03-0.04 0.0333 ±0.0047	0.2-0.21 0.2033 ±0.004
S4	Dissolved	0.5-0.55 0.52 ±0.02	0.24-0.29 0.27 ±0.021	0.18-0.2 0.1866 ±0.00943	0.67-0.69 0.6833 ±0.0094
	Particulate	0.33-0.38 0.35667 ±0.02	0.92-1 0.9633 ±0.03	0.63-0.68 0.6533 ±0.02	0.3-0.32 0.31 ±0.008

7- Chromium (Cr)

The results of chromium (Cr) analysis concentration showed that in the waters (Table 3-11) (Figure 3-26). if The results recorded the lowest average concentration of dissolved (Cr) ($0.103\mu\text{g/l}$) in the S2 for the Winter and the highest concentration rate if it reached ($1.153\mu\text{g/l}$) in S1 for the Autumn . as for (Cr) concentrations in particulate phase if the lowest concentration rate is ($0.136\mu\text{g/l}$) in S3 of the Summer and the highest concentration rate of (Cr) ($0.5367\mu\text{g/l}$) so it is reached in S2 for the Spring .From the statistical analysis it is showed that there are For dissolved chromium significant differences are found between all sites for the four season at the significant 0.05 level except for S2 and S4 for the Autumn but in the winter significant differences are no found between sites and the correlation matrix for heavy metals in water showed that the dissolved chromium had a positive correlation with (NO_2 , NO_3 , PO_4 , Mg , Ca) at $p \leq 0.05$, $r = (0.2, 0.4, 0.2, 0.1, 0.5)$ respectively and positive relationship with the (TH, TSS, water temperature) Appendix(1) it is also clear that there is negative relationship with (D0, BOD_5 , PH, Salinity, AT,) at $p \leq 0.05$, $r = (-0.4, -0.6, -0.4, -0.4, -0.6)$ Appendix(2).

For Particulate chromium Significant differences were found between all sites for the four season at the significant 0.05 level except for S4 with S1 and S2 for the Autumn but in spring Significant differences are found between all sites except for S1 with S2 and S4 and in summer Significant differences are found between all sites except for S1 with S4. in the winter significant differences were found between S3 with S1 and S4 respectively and the correlation matrix for heavy metals in water showed that the particulate chromium had a positive correlation with (water temperature, Mg, Ca) at $p \leq 0.05$, $r = (0.07, 0.07, 0.08)$ respectively and positive relationship with the (NO_2 , NO_3 , Po_4 , TH, TSS)

Appendix(3) it is also clear that there is negative relationship with (DO,BOD₅, PH, Salinity , AT,) at $p \leq 0.05$, $r=(-0.1,-0.2,-0.1,-0.1,-0.7)$ Appendix (3).

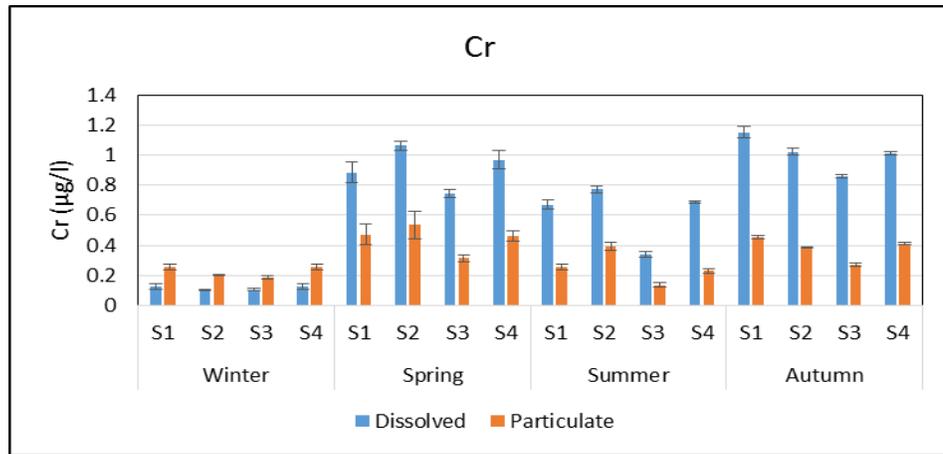


Figure (3-26) Chromium Concentration rate µg /l of water in study site of Mashroo Al-Musayyib channel

Table (3-11) Chromium Concentration rate µg /l of water in study site of Mashroo Al-Musayyib channel

Sea. Sites	Heavy metal phase	Winter2021	Spring2021	Summer2021	Autumn2021
		Min-Max M(µg/l) ±SD	Min-Max M(µg/l) ±SD	Min-Max M(µg/l) ±SD	Min-Max M(µg/l) ±SD
S1	Dissolved	0.11-0.15 0.1266 ±0.017	0.8-0.97 0.883 ±0.069	0.64-0.71 0.67 ±0.029	1.1-1.2 1.1533 ±0.04
	Particulate	0.24-0.28 0.2566 ±0.017	0.39-0.55 0.473 ±0.065	0.24-0.28 0.256 ±0.017	0.44-0.47 0.456 ±0.01
S2	Dissolved	0.1-0.11 0.10333 ±0.0047	1.02-1.09 1.0633 ±0.03	0.74-0.8 0.7733 ±0.02	1-1.05 1.0233 ±0.02
	Particulate	0.2-0.21 0.2033 ±0.0047	0.42-0.64 0.536 ±0.09	0.36-0.42 0.3966 ±0.026	0.38-0.39 0.3833 ±0.0047
S3	Dissolved	0.1-0.12 0.106667 ±0.009	0.71-0.77 0.746 ±0.026	0.32-0.36 0.34 ±0.016	0.85-0.87 0.86 ±0.008
	Particulate	0.17-0.2 0.18666 ±0.01	0.28-0.34 0.313 ±0.02	0.12-0.15 0.1366 ±0.012	0.25-0.28 0.27 ±0.01
S4	Dissolved	0.11-0.15 0.12333 ±0.018	0.89-1.04 0.9666 ±0.06	0.68-0.7 0.69 ±0.008	1-1.02 1.013 ±0.009
	Particulate	0.24-0.28 0.2566 ±0.017	0.42-0.5 0.463 ±0.03	0.22-0.25 0.23 ±0.01	0.4-0.42 0.41 ±0.008

3-4-2:Concentration of Heavy Metals in sediments

1- Iron (Fe)

The results showed a lowest average concentration of (Fe) (1533 $\mu\text{g/g}$) in S3 for the Winter and the highest concentration rate if it reached (8407 $\mu\text{g/g}$) in S1for the Autumn (Table 3-12) (Figure 3-27) .

From the statistical analysis, it was showed that there are For dissolved Iron Significant differences are found between all sites for the four season at the significant 0.05 level except for S2 andS4 for the Autumn and in the Summer significant differences are in found in all sites except S3 and S4 and the correlation matrix for heavy metals in sediments showed that the Iron had a positive correlation with (Cr,Mg,Ca, water temperature ,AT) at $p \leq 0.05$, $r = (0.6,0.3,0.6,0.3 ,0.3)$ respectively and positive relationship with the (NO₂, NO₃, PO₄ , TH, TSS) Appendix (4) it is also clear that there is negative relationship with(DO, BOD₅,pH,Salinity,AT) at $p \leq 0.05$, $r = (-0.4,-0.6,-0.2,-0.2,-0.4)$ Appendix (4).

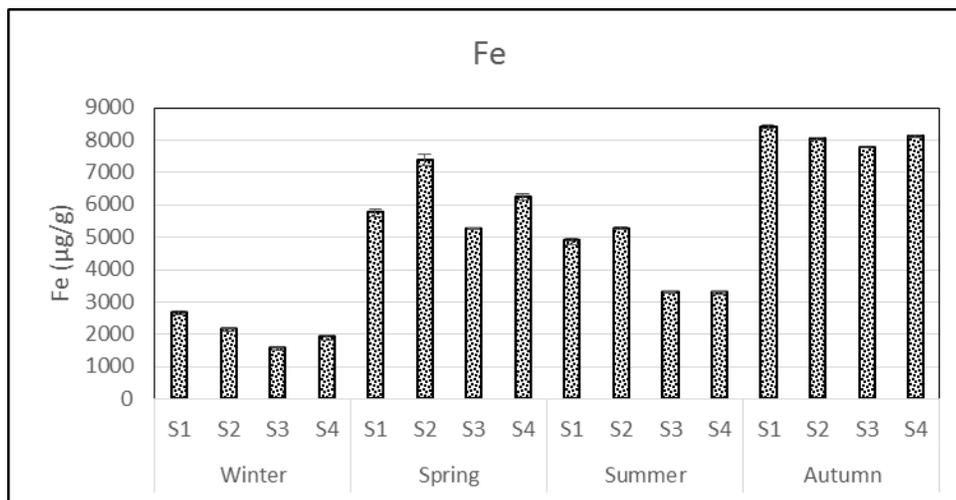


Figure (3-27) Iron Concentration rate $\mu\text{g/g}$ of sediments in study site of Mashroo Al-Musayyib channel

Table (3-12) Iron Concentration rate $\mu\text{g/g}$ of sediments in study site of Mashroo Al-Musayyib channel

Sea. Sites	Winter2021	Spring2021	Summer2021	Autumn2021
	Min-Max M($\mu\text{g/g}$) \pm SD			
S1	2580-2740 2666.67 \pm 65.99	5610-5880 5753.33 \pm 110.85	4770-5010 4883.3 \pm 98.43	8330-8450 8406.7 \pm 54.36
S2	2100-2200 2136.67 \pm 44.96	7150-7550 7393.3 \pm 174.4	5220-5310 5270 \pm 37.416	8020-8100 8046.7 \pm 37.7
S3	1490-1580 1533.33 \pm 36.81	5220-5300 5266.7 \pm 33.99	3250-3300 3276.7 \pm 20.54	7760-7790 7773.3 \pm 12.47
S4	1790-1990 1883.3 \pm 82.19	6140-6350 6253.3 \pm 86.53	3220-3350 3273.3 \pm 55.57	8100-8180 8133.3 \pm 33.99

2- Copper (Cu)

The results showed a lowest average concentration of (Cu) ($3250\mu\text{g/g}$) in S3 for the Winter and the highest concentration rate so it reached ($18207\mu\text{g/g}$) in S4 for the Autumn (Table 3-13) (Figure 3-28) .

From the statistical analysis, it is showed that there are For dissolved Copper Significant differences are found between all sites for the four season at the significant 0.05 level except for S1 with S2 and S4 for the Autumn and in the Spring significant differences are in found in all sites except S1 and S4. in the Summer significant differences are found between the sites except S1 with S4 and in the winter significant differences are in found between the sites except S3 with S4 and the correlation matrix for heavy metals in sediments showed that the

Copper had a positive correlation with (Fe ,Cr ,Mg ,Ca , water temperature) at $p \leq 0.05$, $r = (0.9,0.6,0.3,0.6,0.3)$ respectively and positive relationship with the (NO₂, NO₃, PO₄ , TH , TSS) Appendix (4) it is also clear that there is negative relationship with(DO, BOD₅,pH,Salinity,AT) at $p \leq 0.05$, $r = (-0.4,-0.7,-0.3,-0.2,-0.4)$ Appendix (4).

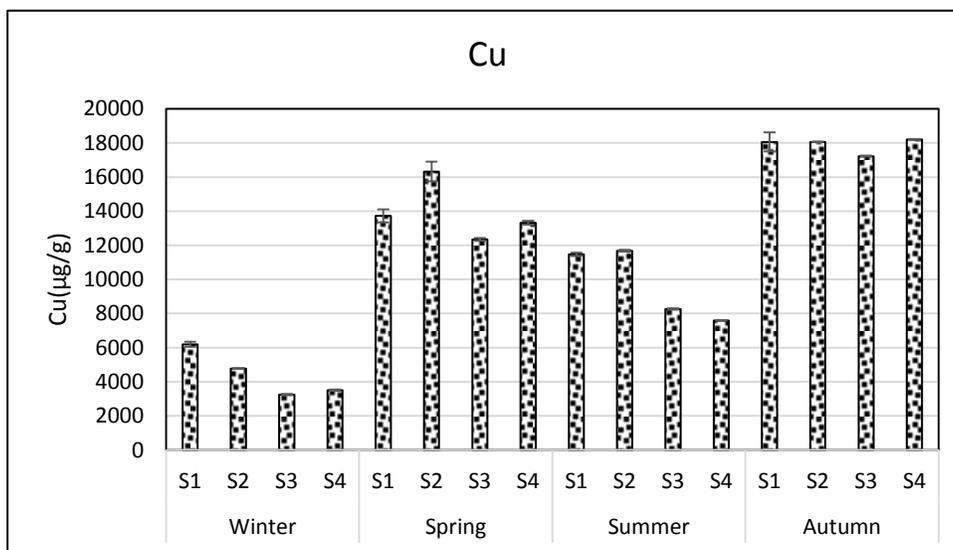


Figure (3-28) Copper Concentration rate µg/g of sediments in study site of Mashroo Al-Musayyib channel

Table (3-13) Copper Concentration rate µg/g of sediments in study site of Mashroo Al-Musayyib channel

Sea Sites	Winter2021	Spring2021	Summer2021	Autumn2021
	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD
S1	5980-6330 6196.67 ±154.56	13280-14220 13730 ±384.794	11350-11580 11470 ±94.163	17280-18460 18066.7±556.257
S2	4750-4800 4776.67 ±20.548	15580-16980 16333.3±576.50	11610-11740 11680 ±53.5413	18040-18080 18060±16.3299
S3	3220-3290 3250 ±29.4392	12.240-12440 12346.7±82.1922	8220-8300 8266.67 ±33.9935	17200-17260 17230±24.4949
S4	3470-3580 3506.67 ±51.8545	13220-13470 13323.3±106.562	7580-7630 7596.67 ± 23.5702	18170-18230 18206.7±26.2467

3 - Zinc (Zn)

The results showed the lowest average concentration of (Zn) (10593µg/g) in S3 for the Winter and the highest concentration rate if it reached (27497µg/g) in

the S2 for the Spring (Table 3-14) (Figure 3-29) . From the statistical analysis, it is showed that there are for dissolved Zinc Significant differences are found between all sites for the four season at the significant 0.05 level except for the S1 with S2 and S3 with S4 for the Autumn and in the Spring significant differences are in found in all sites except S3 and S4 . in the Summer significant differences are found between the sites except S1 with S2 and in the winter significant differences are found between the sites except S4 with S2 and S3 respectively and the correlation matrix for heavy metals in sediments showed that the Zinc had a positive correlation with (Cu, Fe, Cr, Mg, Ca , water temperature) at $p \leq 0.05$, $r = (0.9,0.9,0.5,0.3,0.4,0.2)$ respectively and Positive relationship with the (NO₂, NO₃, PO₄ , TH, TSS) Appendix (4) it is also clear that there is negative relationship with(DO, BOD₅,pH,Salinity,AT) at $p \leq 0.05$, $r = (-0.3,-0.5,-0.2,-0.1,-0.3)$ Appendix (4).

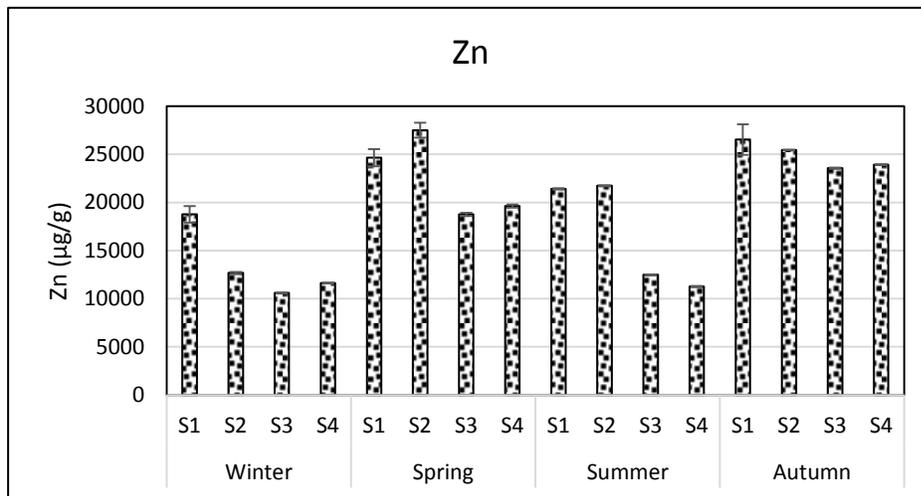


Figure (3-29) Zinc Concentration rate µg/g of sediments in study site of Mashroo Al-Musayyib channel

Table (3-14) Zinc Concentration rate $\mu\text{g/g}$ of sediments in study site of Mashroo Al-Musayyib channel

Sea. Sites	Winter2021	Spring2021	Summer2021	Autumn2021
	Min-Max M($\mu\text{g/g}$) \pm SD			
S1	17800-19900 18766.7 \pm 865.384	23470-25580 24646.7 \pm 878.42	21330-21470 21406.7 \pm 57.9272	24580-28470 26543.3 \pm 1588.3
S2	12500-12800 12666.7 \pm 124.722	26580-28470 27496.7 \pm 772.629	21670-21790 21733.3 \pm 49.2161	25400-25490 25443.3 \pm 36.8179
S3	10.540-10660 10593.3 \pm 49.8888	18590-18990 18773.3 \pm 164.992	12420-12550 12480 \pm 53.5413	23.490-23660 23563.3 \pm 71.3364
S4	11580-11690 11623.3 \pm 47.8423	19460-19870 19626.7 \pm 175.942	11200-11360 11260 \pm 71.1805	23880-23950 23910 \pm 29.4392

4 - lead (Pb)

The results showed a lowest average concentration of (Pb) (0.3500 $\mu\text{g/g}$) in S3 for the Winter and the highest concentration rate so it reached (7.5367 $\mu\text{g/g}$) in S2 for the Spring (Table 3-15) (Figure 3-30) .

From the statistical analysis, it is showed that there are For Lead Significant differences are found between all sites for the four season at the significant 0.05 level except for the Autumn are no recorded Significant differences between the sites . In the Spring significant differences are found in all sites except S1 and S4. in the Summer significant differences are found between the sites except S1 with S2. and in the winter significant differences are found except S1 and S4 and the correlation matrix for heavy metals in sediments showed that the lead had a positive correlation with (Zn, Cu, Fe, Cr, Ca , water temperature) at $p \leq 0.05$, $r = (0.7, 0.6, 0.6, 0.6, 0.04, 0.2)$ respectively and positive relationship with the (NO₃, TH, TSS) Appendix (4) it is also clear that there is negative relationship with(DO,

BOD₅,pH,Salinity, NO₂, PO₄ , Mg ,AT) at p≤ 0.05, r=(-0.2,-0.3,-0.4,-0.3,-0.1,-0.1,-0.03,-0.7) Appendix (4).

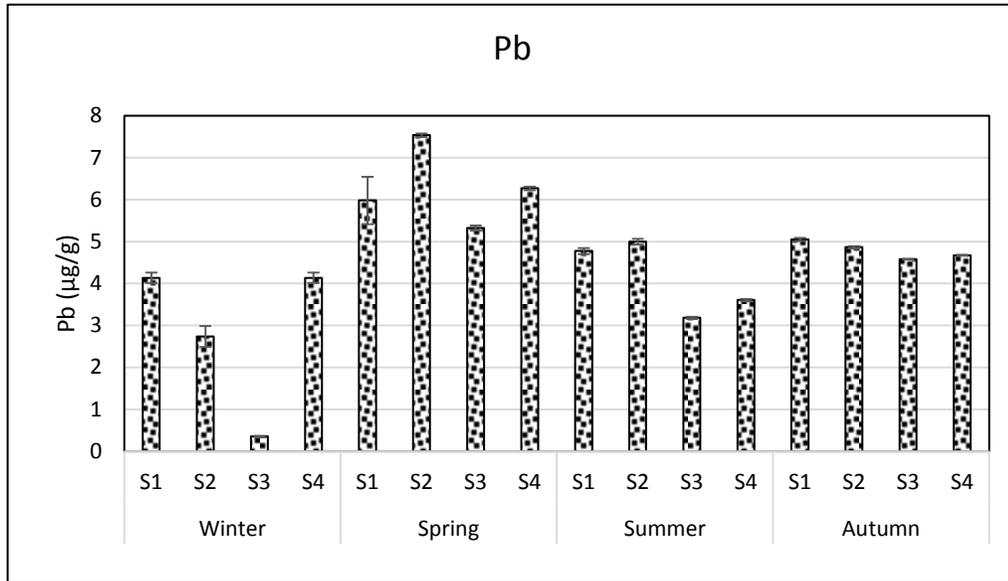


Figure (3-30) lead Concentration rate µg/g of sediments in study site of Mashroo Al-Musayyib channel

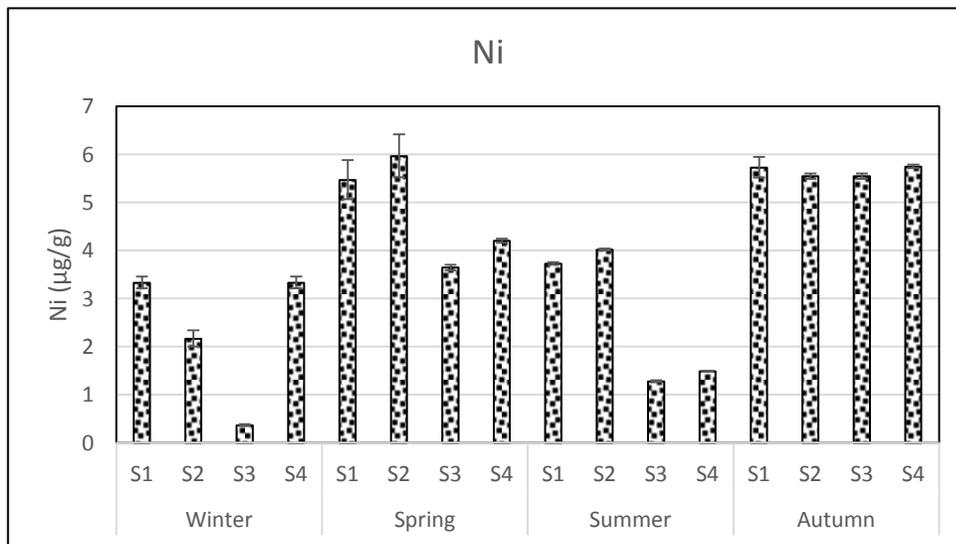
Table (3-15) lead Concentration rate µg/g of sediments in study site of Mashroo Al-Musayyib channel

Sea. Sites	Winter2021	Spring2021	Summer2021	Autumn2021
	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD
S1	4-4.3 4.1333 ±0.12	5.22-6.58 5.98 ±0.56	4.68-4.86 4.77333 ±0.07	5-5.1 5.05 ±0.04
S2	2.4-3 2.73333 ±0.25	7.48-7.58 7.53667 ±0.04	4.92-5.08 4.99667 ±0.065	4.83-4.89 4.86667 ±0.026
S3	0.33-0.37 0.35 ±0.02	5.26-5.41 5.32333 ±0.06	3.14-3.21 3.18 ±0.029	4.57-4.59 4.58 ±0.008
S4	4-4.3 4.1333 ± 0.12	6.24-6.33 6.27 ±0.04	3.58-3.64 3.60667 ±0.02	4.66-4.69 4.67333 ±0.01

5 - Nickel (Ni)

The results showed lowest average concentration of (Ni) (0.3633µg/g) in S3 for the Winter and the highest concentration rate so it reached (5.9700µg/g) in S2 for the Spring(Table 3-16) (Figure 3-31) .

From the statistical analysis, it is showed that there are for Nickel significant differences are found between all sites for the four seasons at the significant 0.05 level except for the Autumn are no recorded Significant differences between the sites . in the Spring significant differences were in found in all sites.in the Summer significant differences are found between the sites except S4 with S2 and S3 respectively and in the winter significant differences are found between the sites except for the S1 and S4 and the correlation matrix for heavy metals in sediments showed that the Nickel had a positive correlation with (Pb, Zn, Cu, Fe, Cr, Mg, Ca , water temperature) at $p \leq 0.05$, $r = (0.8, 0.9, 0.8, 0.8, 0.5, 0.3, 0.3, 0.07)$ respectively and positive relationship with the (NO₃, NO₂, PO₄ , TSS , TH , Salinity) Appendix (4) it is also clear that there is negative relationship with(DO, BOD₅, pH, AT) at $p \leq 0.05$, $r = (-0.1, -0.3, -0.1, -0.4)$ Appendix (4).



Figure(3-31) Nickel Concentration rate µg/g in sediments of sediments in study site of Mashroo Al-Musayyib channel

Table (3-16) Nickel Concentration rate $\mu\text{g/g}$ of sediments in study site of Mashroo Al-Musayyib channel

Sea. Sites	Winter2021	Spring2021	Summer2021	Autumn2021
	Min-Max M($\mu\text{g/g}$) $\pm\text{SD}$			
S1	3.2-3.5 3.33333 \pm 0.12	5.15-6.05 5.47333 \pm 0.4	3.69-3.75 3.72667 \pm 0.026	5.49-6.01 5.73 \pm 0.2
S2	2-2.4 2.16667 \pm 0.169	5.47-6.56 5.97 \pm 0.4	4-4.05 4.02 \pm 0.02	5.47-5.6 5.54667 \pm 0.055
S3	0.34-0.39 0.36333 \pm 0.02	3.57-3.69 3.6466 \pm 0.05	1.25-1.3 1.27667 \pm 0.02	5.47-5.6 5.54667 \pm 0.055
S4	3.2-3.5 3.33333 \pm 0.12	4.14-4.24 4.20333 \pm 0.04	1.47-1.5 1.48667 \pm 0.01	5.7-5.79 5.75 \pm 0.037

6- Cadmium (Cd)

The results showed the lowest average concentration of (Cd) (0.0733 $\mu\text{g/g}$) in S2 for the Winter and the highest concentration rate so it reached (1.6033 $\mu\text{g/g}$) in S1 for the Autumn (Table 3-17) (Figure 3-32). From the statistical analysis, it is showed that there are For Cadmium Significant differences are found between all sites for the four season at the significant 0.05 level except for the Autumn are recorded Significant differences in sites except S4 with S2. In the spring and the summer significant differences are found in all sites. and in the winter significant differences are no found between the sites and the correlation matrix for heavy metals in sediments showed that the Nickel had a positive correlation with (Pb, Zn, Cu, Fe, Cr, Mg, Ca, water temperature) at $p \leq 0.05$, $r = (0.7, 0.7, 0.8, 0.9, 0.9, 0.7, 0.1, 0.5, 0.5)$ respectively and positive relationship with the ($\text{NO}_3, \text{NO}_2, \text{PO}_4, \text{TH, TSS}$) Appendix (4) it is also clear that there is negative relationship with (DO, $\text{BOD}_5, \text{pH, AT, Salinity}$) at $p \leq 0.05$, $r = (-0.5, -0.7, -0.5, -0.4, -0.5)$ Appendix (4).

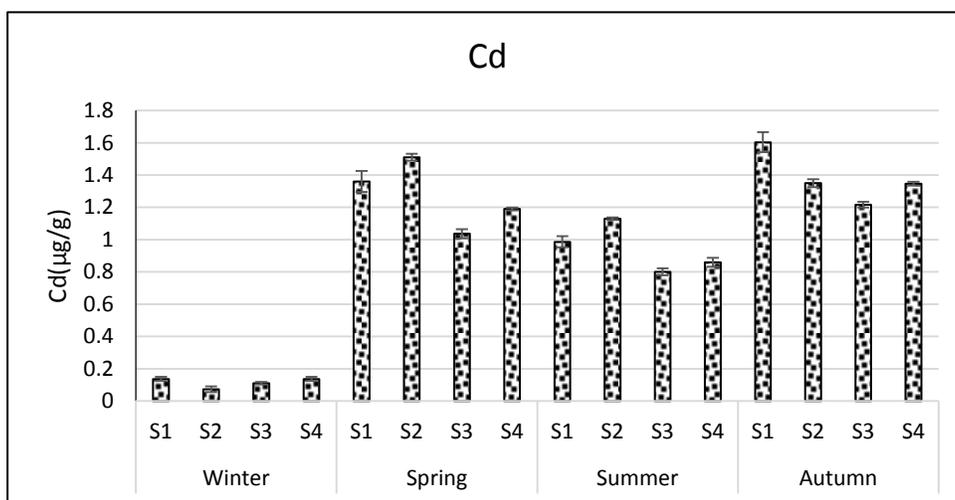


Figure (3-32) Cadmium Concentration rate µg/g of sediments in study site of Mashroo Al-Musayyib channel

Table (3-17) Cadmium Concentration rate µg/g of sediments in study site of Mashroo Al-Musayyib channel

Sea. Sites	Winter2021	Spring2021	Summer2021	Autumn2021
	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD
S1	0.12-0.15 0.13667±0.01	1.28-1.44 1.36±0.065	0.94-1.02 0.98667±0.03	1.55-1.69 1.60333±0.06
S2	0.05-0.09 0.07333±0.017	1.49-1.54 1.51±0.02	1.12-1.14 1.13±0.008	1.32-1.38 1.35±0.02
S3	0.1-0.12 0.11±0.008	1-1.07 1.03667±0.028	0.77-0.82 0.8±0.02	1.2-1.24 1.21667±0.017
S4	0.12-0.15 0.13667±0.01	1.18-1.2 1.19±0.008	0.84-0.9 0.86±0.028	1.33-1.36 1.34667±0.01

7- Chromium (Cr)

The results showed the lowest average concentration of (Cr) (0.1333 $\mu\text{g/g}$) in the S2 for the Winter and the highest concentration rate so it reached (1.24 $\mu\text{g/g}$) in S2 for the Spring (Table 3-18) (Figure 3-33) .

From the statistical analysis, it is showed that there is for chromium Significant differences are found between all sites for the four season at the significant 0.05 level except for the Autumn are recorded Significant differences in sites except S4 with S2. In the Spring significant differences are found in all sites .For the Summer significant differences are found in all sites except S3 with S4. and in the winter significant differences are found between the sites except S1 with S3and S4 respectively and the correlation matrix for heavy metals in sediments showed that the chromium had a positive correlation with (Pb, Zn, Cu, Fe ,Ni, Cd) at $p \leq 0.05$, $r = (0.6,0.5,0.6,0.6,0.5,0.7)$ respectively Appendix (4) and positive relationship with the(WT, AT, NO_3 ,TSS,TH,Ca) at $p \leq 0.05$, $r = (0.4,0.5,0.2,0.3,0.1,0.2)$ it is also clear that there is negative relationship with(DO, BOD₅,pH, AT ,EC,TDS, NO_2 , PO_4 ,Mg, AT) at $p \leq 0.05$, $r = (-0.4,-0.3,- 0.5,-0.7, - 0.5,- 0.5 ,-0.09,-0.07,-0.1,-0.7)$ Appendix (4).

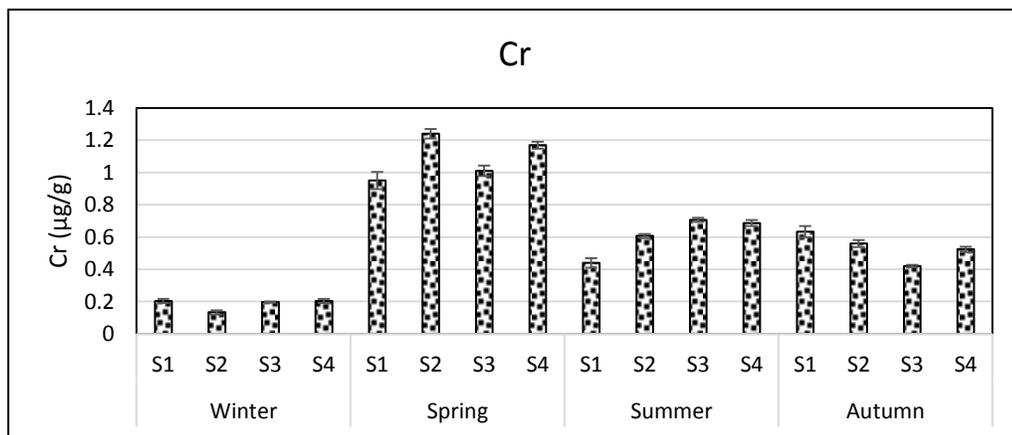


Figure (3-33) Chromium Concentration rate $\mu\text{g/g}$ of sediments in study site of Mashroo Al-Musayyib channel

Table (3-18) chromium Concentration rate $\mu\text{g/g}$ of sediments in study site of Mashroo Al-Musayyib channel

Sea. Sites	Winter2021	Spring2021	Summer2021	Autumn2021
	Min-Max M($\mu\text{g/g}$) \pm SD			
S1	0.19-0.22 0.20333 \pm 0.01	0.89-1.02 0.95 \pm 0.05	0.41-0.48 0.44 \pm 0.029	0.6-0.68 0.63333 \pm 0.03
S2	0.12-0.15 0.13333 \pm 0.01	1.2-1.27 1.24 \pm 0.029	0.59-0.62 0.60667 \pm 0.01	0.53-0.58 0.56 \pm 0.02
S3	0.19-0.2 0.19667 \pm 0.0047	0.97-1.05 1.01 \pm 0.03	0.69-0.72 0.70667 \pm 0.01	0.41-0.43 0.42 \pm 0.008
S4	0.19-0.22 0.20333 \pm 0.01	1.14-1.19 1.17 \pm 0.02	0.66-0.7 0.68667 \pm 0.018	0.5-0.54 0.52333 \pm 0.017

3-4-3: Concentration of Heavy Metals in aquatic plant

1- Iron (Fe)

The results showed the lowest average concentration of (Fe) in *C. demersum* ($4520\mu\text{g/g}$) in S2 and S3 for the Winter and the highest concentration rate so it reached ($12197\mu\text{g/g}$) in S2 for the Spring . as for (Fe) concentrations in *P. australis* so the lowest concentration rate is ($3497\mu\text{g/g}$) in S1 of the Winter and the highest concentration rate of (Fe) ($18133\mu\text{g/g}$) so it is reached in S2 for the Spring (Table 3-19) (Figure 3-34) .

From the statistical analysis, it is showed that there are In *C. demersum* Iron Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences in S1 with all site . In the Spring are recorded Significant differences in all sites and Summer Significant differences are found in site except S2 with S4. for in the winter significant differences are found in S4. with all sites and the correlation

matrix for heavy metals in *C. demersum* showed that the Iron had a positive correlation with (water temperature, Ca ,Cr) at $p \leq 0.05$, $r = (0.3, 0.03, 0.3)$ respectively Appendix (5) and positive relationship with (TSS , NO₃) it is also clear that there is negative relationship with (DO BOD₅, pH, Salinity ,NO₂, Mg, TH, PO₄ ,AT) at $p \leq 0.05$, $r = (-0.4, -0.4, -0.5, -0.5, -0.3, -0.3, -0.1, -0.2, -0.8,)$ Appendix (5).

In *P. australis* Iron Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences in S1 with all sites. In the spring are recorded Significant differences in sites except S1 with S3 and Summer Significant differences are found in S4 with all sites. for in the winter significant differences are found in S4 with all sites and the correlation matrix for heavy metals in *P. australis* showed that the Iron had a positive correlation with (water temperature, Ca ,Cr) at $p \leq 0.05$, $r = (0.4, 0.2, 0.6)$ respectively Appendix (6) and positive relationship with (TSS , TH, NO₃) it is also clear that there is negative relationship with (DO BOD₅, pH, Salinity ,NO₂, Mg, PO₄ ,AT) at $p \leq 0.05$, $r = (-0.4, -0.5, -0.5, -0.4, -0.07, -0.1, -0.05, -0.7)$ Appendix (6).

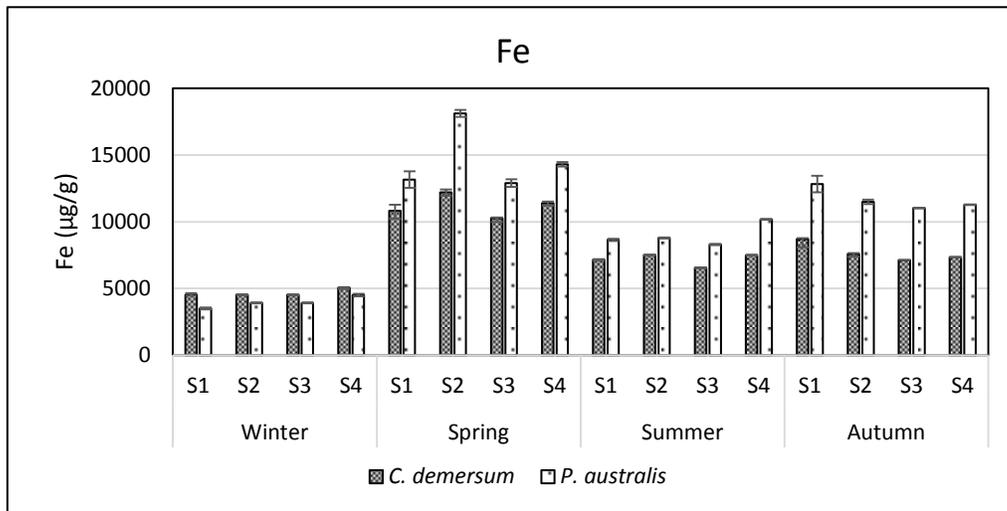


Figure (3-34) Iron Concentration rate µg/g of *P. australis* and *C. demersum* in study site of Mashroo Al-Musayyib channel

Table (3-19) Iron Concentration rate µg/ of *P. australis* and *C. demersum* in study site of Mashroo Al-Musayyib channel

Sea. Sites	aquatic plant	Winter2021	Spring2021	Summer2021	Autumn2021
		Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD
S1	<i>C.demersum</i>	4380-4650 4526.7±111.4	10300-11400 10833±449.6	7120-7200 7156.7±32.9	8590-8790 8690±81.6
	<i>P.australis</i>	3410-3580 3496.7±69.4	12400-13900 13167±612.8	8540-8740 8646.7±82.1	12250-13690 12830±620.3
S2	<i>C.demersum</i>	4500-4550 4520±21.6	11890-12400 12197±220.6	7470-7540 7496.7±30.9	7480-7690 7573.3±87.30
	<i>P.australis</i>	3880-3970 3913.3±40.27	17900-18500 18133±262.47	8740-8840 8790±40.8	11250-11650 11493.3±174.4
S3	<i>C.demersum</i>	4500-4550 4520±21.60	10250-10330 10277±37.7	6540-6580 6556.7±16.99	7120-7130 7123.33±4.7
	<i>P.australis</i>	3880-3970 3913.3±40.27	12550-13250 12893±285.9	8220-8340 8286.7±49.88	11020-11040 11030±8.16
S4	<i>C.demersum</i>	4970-5120 5046.7±61.28	11250-11480 11400±106.1	7440-7550 7483.3±47.8	7320-7360 7346.67±18.8
	<i>P.australis</i>	4380-4620 4493.3±98.4	14150-14550 14317±169.9	10140-10200 10170±24.49	11250-11300 11277±20.5

2- Copper (Cu)

The results of Copper (Cu) analysis concentration showed that in the aquatic plant if The results recorded the lowest average concentration of (Cu)in *C. demersum* (4143 μ g/g) in S3 for the Summer and the highest concentration rate if it reached (10367 μ g/g) in S2 for the Spring (Table3-20) (Figure 3-35) .

As for (Cu) concentrations in *P. australis* so the lowest concentration rate is (5150 μ g/g) in S3 of the Summer and the highest concentration rate of (Cu) (11567 μ g/g) so it is reached in S2 for the Spring .From the statistical analysis, it is showed that there are In *C. demersum* Copper Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences in S1 with all sites .

In the Spring are recorded Significant differences in all sites and in Summer Significant differences are found in site except S2 with S4 . For in the winter significant differences are found in S4 with all sites and the correlation matrix for heavy metals in *C. demersum* showed that the Copper had a positive correlation with (Fe,Cr) at $p \leq 0.05$, $r = (0.3,0.4)$ respectively Appendix (5) and positive relationship with (DO,BOD₅,pH,Salinity) it is also clear that there is negative relationship with (water temperature, Ca,NO₂, NO₃, Mg, PO₄ ,AT, TSS, TH) at $p \leq 0.05$, $r = (-0.6,-0.6,-0.3,-0.04,-0.3,-0.1,-0.5,-0.3,0.5)$ Appendix (5).

In *P. australis* Copper Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences in S1 with all sites . In the Spring are recorded Significant differences in S2 with all sites and Summer Significant differences are found in sites except S2 with S1. For in the winter significant differences are found site except S2 with S3.and the correlation matrix for heavy metals in *P. australis*

showed that the Copper had a positive correlation with (Fe,Cr) at $p \leq 0.05$, $r = (0.7,0.4)$ respectively Appendix (6) and positive relationship with (TSS , DO, NO_3) it is also clear that there is negative relationship with (BOD_5 ,pH,Salinity , NO_2 , Mg, PO_4 ,AT, water temperature, Ca) at $p \leq 0.05$, $r = (-0.01,-0.1,-0.08,-0.2,-0.3,-0.1,-0.8,-0.1,-0.2)$ Appendix (6)

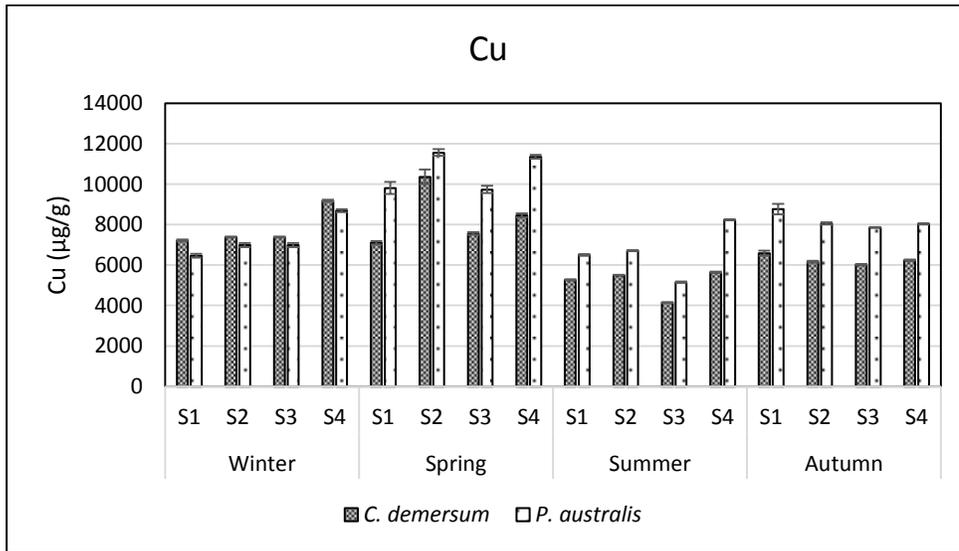


Figure (3-35) Copper Concentration rate µg/g of *P. australis* and *C. demersum* in study site of Mashroo Al-Musayyib channel

Table (3-20) Copper Concentration rate $\mu\text{g/g}$ of *P. australis* and *C. demersum* in study site of Mashroo Al-Musayyib channel

Sea. Sites	aquatic plant	Winter2021	Spring2021	Summer2021	Autumn2021
		Min-Max M($\mu\text{g/g}$) \pm SD			
S1	<i>C.demersum</i>	7150-7260 7216.7 \pm 47.8	7000-7210 7103.3 \pm 85.76	5220-5300 5266.7 \pm 33.99	6440-6750 6590 \pm 126.75
	<i>P.australis</i>	6380-6590 6463.3 \pm 91.04	9470-10200 9816.7 \pm 299.15	6470-6550 6496.7 \pm 37.71	8450-9080 8773.3 \pm 257.47
S2	<i>C.demersum</i>	7350-7410 7383.3 \pm 24.9	9900-10800 10367 \pm 368.18	5480-5520 5500 \pm 16.33	6130-6220 6163.3 \pm 40.27
	<i>P.australis</i>	6890-7120 6990 \pm 96.2	11400-11800 11567 \pm 169.97	6690-6740 6713.3 \pm 20.54	8000-8120 8060 \pm 48.99
S3	<i>C.demersum</i>	7350-7410 7383.3 \pm 24.9	7480-7640 7560 \pm 65.32	4120-4160 4143.3 \pm 16.99	6000-6050 6026.7 \pm 20.5
	<i>P.australis</i>	6890-7120 6990 \pm 96.26	9480-9880 9743.3 \pm 186.25	5120-5190 5150 \pm 29.43	7840-7890 7863.3 \pm 20.5
S4	<i>C.demersum</i>	9120-9240 9183.3 \pm 49.2	8330-8570 8463.3 \pm 99.77	5620-5690 5646.7 \pm 30.91	6220-6280 6246.7 \pm 24.9
	<i>P.australis</i>	8600-8790 8690 \pm 77.88	11250-11480 11363 \pm 93.92	8220-8260 8240 \pm 16.33	8000-8060 8036.7 \pm 26.24

3 - Zinc (Zn)

The results showed the lowest average concentration of (Zn) in *C. demersum* (7160 $\mu\text{g/g}$) in S3 for the Summer and the highest concentration rate so it reached (17493 $\mu\text{g/g}$) in S4 for the Winter (Table 3-21) (Figure 3-36) . as for (Zn) concentrations in *P. australis* so the lowest concentration rate is (10170 $\mu\text{g/g}$) in S3 of the Summer and the highest concentration rate of (Zn) (19067 $\mu\text{g/g}$) so it was reached in S2 for the Spring .

From the statistical analysis, it is showed that there are In *C. demersum* Zinc Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences in S1 with all sites . In the Spring are recorded Significant differences in sites except S1 with S4 and in Summer Significant differences in S4 with all sites. for in

the winter significant differences are found in sites except S2 with S3 and the correlation matrix for heavy metals in *C. demersum* showed that the Zinc had a positive correlation with (Fe,Cr,Cu) at $p \leq 0.05$, $r = (0.09,0.3,0.9)$ respectively Appendix (5) and positive relationship with (DO BOD₅,pH,Salinity) it is also clear that there is negative relationship with (water temperature, Ca , NO₂, NO₃, Mg, PO₄ ,AT, TSS , TH) at $p \leq 0.05$, $r = (-0.7,-0.7,-0.4,-0.1,-0.3,-0.2,-0.3,-0.4,0.6)$ Appendix (5). In *P. australis* Zinc Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences in S1 with all sites . In the Spring are recorded Significant differences in all sites and Summer Significant differences are found in sites except S2 with S1. for in the winter significant differences are found in S1 with all sites and the correlation matrix for heavy metals in *P. australis* showed that the Zink had a positive correlation with (Fe,Cr,Cu, Salinity) at $p \leq 0.05$, $r = (0.6,0.4,0.9,0.02)$ respectively Appendix (6) and positive relationship with (TSS , DO, BOD₅, NO₃) it is also clear that there is negative relationship with (pH, NO₂, Mg, PO₄ ,AT, TH, water temperature, Ca) at $p \leq 0.05$, $r = (-0.07,-0.2,-0.3,-0.1,-0.8,-0.3,-0.2,-0.3)$ Appendix (6)

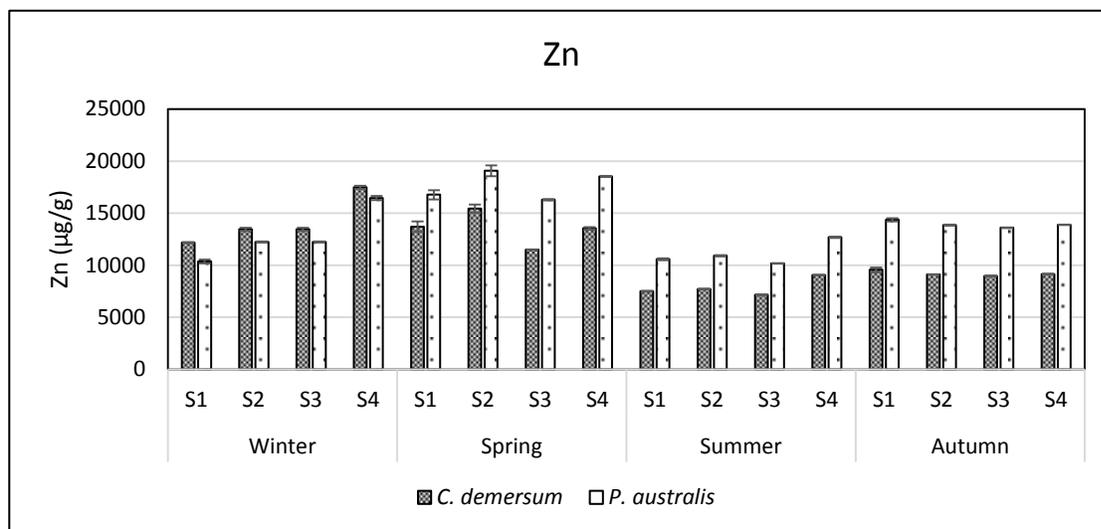


Figure (3-36) Zinc Concentration rate µg/g of *P. australis* and *C. demersum* in study site of Mashroo Al-Musayyib channel

Table (3-21) Zinc Concentration rate µg/g of *P. australis* and *C. demersum* in study site of Mashroo Al-Musayyib channel

Sea. Sites	aquatic plant	Winter2021	Spring2021	Summer2021	Autumn2021
		Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD
S1	<i>C.demersum</i>	12080-12230 12160±61.6	13000-14200 13700±509.9	7440-7540 7493.3±41.09	9250-9770 9553.3±220.9
	<i>P.australis</i>	10110-10580 10357±192.5	16400-17400 16767±449.6	10440-10690 10570±102.31	14250-14600 14367±164.9
S2	<i>C.demersum</i>	13250-13550 13447±139.12	14900-15800 15433±385.8	7690-7720 7703.3±12.47	9100-9150 9120±21.6
	<i>P.australis</i>	12180-12280 12230±40.825	18700-19800 19067±518.5	10850-10970 10910±48.99	13790-13890 13857±47.14
S3	<i>C.demersum</i>	13250-13550 13447±139.12	11470-11520 11493±20.548	7140-7200 7160±28.28	8950-8980 8966.7±12.47
	<i>P.australis</i>	12180-12280 12230±40.825	16220-16380 16293±65.99	10140-10190 10170±21.6	13580-13650 13610±29.4
S4	<i>C.demersum</i>	17280-17620 17493±151.7	13440-13690 13540±108.01	9020-9080 9050±24.49	9120-9170 9146.7±20.5
	<i>P.australis</i>	16280-16740 16457±202.37	18470-18590 18537±49.88	12600-12750 12670±61.64	13870-13890 13883±9.4

4 - lead (Pb)

The results showed the lowest average concentration of (pb)in *C. demersum* (0.040µg/g) in S4 for the Winter and the highest concentration rate so it reached (0.67µg/g) in S2 for the Spring (Table3-22) (Figure 3-37). as for (pb) concentrations in *P. australis* if the lowest concentration rate is (0.0633µg/g) in S4 of the Winter and the highest concentration rate of (pb) (10567µg/g) so it was reached in S1 for the Autumn .From the statistical analysis, it is showed that there are In *C. demersum* lead Significant differences are no found between all sites at the significant 0.05 level except in Summer Significant differences in S3 with S1 and S4 respectively and the correlation matrix for heavy metals in *C. demersum* showed that the lead had a positive correlation with (Fe, Cr, Ca , Mg) at $p \leq 0.05$, $r = (0.5,0.2,0.1,0.1)$ respectively Appendix (5) and positive relationship with (water temperature, TSS , TH) it is also clear that there is negative relationship with (NO₂, DO , BOD₅,pH,Salinity NO₃, PO₄ ,AT,) at $p \leq 0.05$, $r = (-0.05,-0.6,-0.6,-0.4,-0.5,-0.02 , -0.04,-0.1)$ Appendix (5).

In *P. australis* lead Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences in S3 with all sites . In the Spring are recorded Significant differences in sites except S2 with S4 and Summer Significant differences are found in sites except S1 with S4 . for in the winter significant differences were found in sites except S2 with S3 and the correlation matrix for heavy metals in *P. australis* showed that the lead had a positive correlation with (water temperature, Fe, Cr, Cu, Ca, Mg, Zn) at $p \leq 0.05$, $r = (0.4,0.7,0.7,0.4,0.6,0.2,0.3)$ respectively Appendix (6) and positive relationship with (TSS , TH, NO₃,NO₂, PO₄) it is also clear that there is negative relationship with (DO, BOD₅ , Salinity ,pH, ,AT) at $p \leq 0.05$, $r = (-0.4,-0.6,-0.2,-0.3,-0.4)$ Appendix (6).

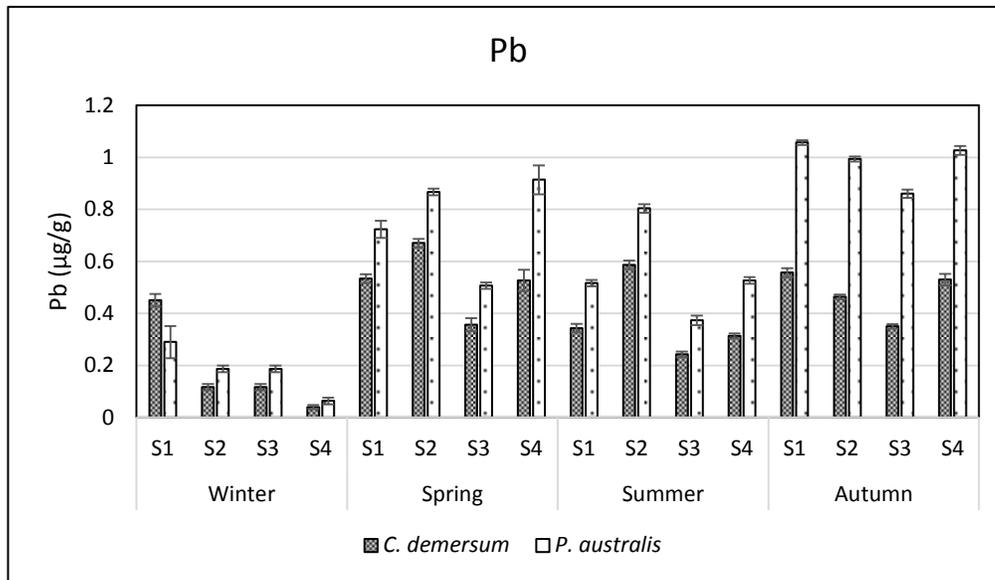


Figure (3-37) lead Concentration rate µg/g of *P. australis* and *C. demersum* in study site of Mashroo Al-Musayyib channel

Table (3-22) lead Concentration rate µg/g of *P. australis* and *C. demersum* in study site of Mashroo Al-Musayyib channel

Sea. Sites	aquatic plant	Winter2021	Spring2021	Summer2021	Autumn2021
		Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD
S1	<i>C.demersum</i>	0.42-0.48 0.45±0.02	0.51-0.55 0.5333±0.017	0.32-0.36 0.3433±0.017	0.54-0.58 0.556±0.017
	<i>P.australis</i>	0.21-0.36 0.29±0.06	0.7-0.77 0.7233±0.03	0.5-0.53 0.5167±0.01	1.05-1.07 1.056±0.009
S2	<i>C.demersum</i>	0.1-0.13 0.1167±0.01	0.65-0.69 0.67±0.016	0.57-0.61 0.5867±0.017	0.45-0.47 0.4633±0.009
	<i>P.australis</i>	0.17-0.2 0.1867±0.01	0.85-0.88 0.8667±0.01	0.78-0.82 0.8033±0.017	0.9-1 0.9933±0.009
S3	<i>C.demersum</i>	0.1-0.13 0.1167±0.01	0.33-0.39 0.3567±0.02	0.25-0.27 0.256±0.95	0.34-0.36 0.35±0.008
	<i>P.australis</i>	0.17-0.2 0.1867±0.01	0.49-0.52 0.5067±0.01	0.36-0.4 0.3733±0.018	0.84-0.88 0.86±0.016
S4	<i>C.demersum</i>	0.03-0.05 0.04±0.008	0.48-0.58 0.5267±0.04	0.3-0.32 0.3133±0.009	0.5-0.55 0.53±0.02
	<i>P.australis</i>	0.05-0.08 0.0633±0.01	0.86-0.99 0.9133±0.05	0.51-0.54 0.5267±0.01	1.01-1.07 1.0267±0.017

5 - Nickel (Ni)

The results recorded the lowest average concentration of (Ni) in *C. demersum* (0.1033µg/g) in S3 for the Winter and the highest concentration rate so it reached (0.4333µg/g) in S2 for the Spring (Table 3-23) (Figure 3-38) . as for (Ni) concentrations in *P. australis* so the lowest concentration rate is (0.1333µg/g) in S3 of the Summer and the highest concentration rate of (Ni) (0.5167µg/g) if it is reached in S2 for the Spring .

From the statistical analysis, it is showed that there are In *C. demersum* Nickel Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences in sites except S1 with S4 and in the Spring are recorded Significant differences in sites S2 with S1 and S3 respectively and in Summer Significant differences in S2 with all sites . for in the winter significant differences are no found in S1 with S4 and the S2 with S3 respectively and correlation matrix for heavy metals in *C. demersum* showed that the Nickel had a positive correlation with (Fe,Cr,Cu ,Zn, Pb) at $r = (0.09,0.3,0.9)$ respectively Appendix (5) and positive relationship with (water temperature, No₃, TSS) it is also clear that there is negative relationship with (, DO , BOD₅,pH,Salinity ,Ca,NO₂,Mg, PO₄ ,AT, TH) at $p \leq 0.05$, $r = (-0.07,-0.2,-0.1,-0.2,-0.06,-0.09,-0.04,-0.008,0.6,0.009)$ Appendix (5).

In *P. australis* Nickel Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences found in sites except S1 with S4. In the Spring are recorded Significant differences in sites except S2 with S4 and Summer Significant differences are found in all sites. for in the winter significant differences are no found in sites and the correlation matrix for heavy metals in *P. australis* showed that the Nickel had a positive correlation with (water

temperature ,Fe ,Cr, Cu, Ca, Zn , Pb) at $p \leq 0.05$, $r = (0.3,0.8,0.8,0.7,0.3,0.5,0.8)$ respectively Appendix (6) and positive relationship with (TSS , TH, NO_3 , NO_2 , PO_4) it is also clear that there is negative relationship with (DO, BOD_5 , Mg, Salinity, pH, ,AT, ,) at $p \leq 0.05$, $r =(-0.2,-0.4,-0.02,-0.3,-0.3,-0.7)$ Appendix (6)

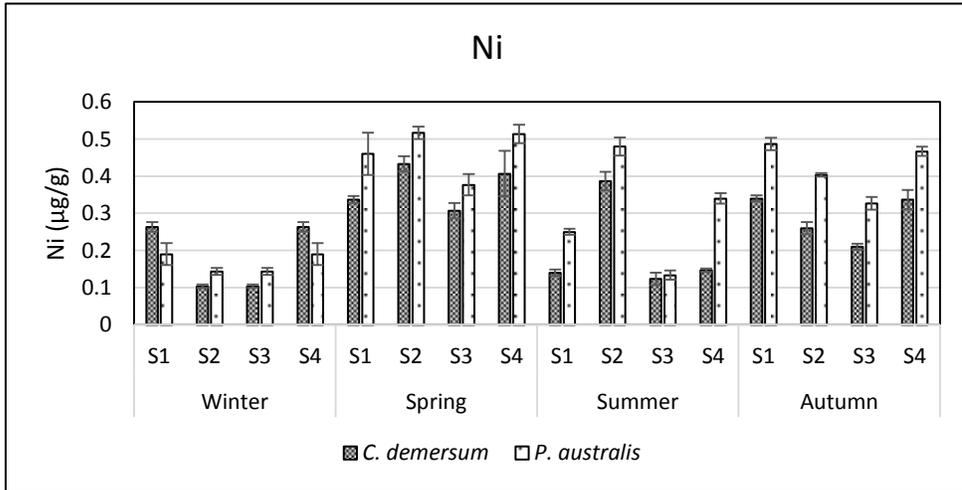


Figure (3-38) Nickel Concentration rate µg/g of *P. australis* and *C. demersum* in study site of Mashroo Al-Musayyib channel

Table (3-23) Nickel Concentration rate $\mu\text{g/g}$ of *P. australis* and *C. demersum* in study site of Mashroo Al-Musayyib channel

Sea. Sites	aquatic plant	Winter2021	Spring2021	Summer2021	Autumn2021
		min-max m \pm sd	min-max m \pm sd	min-max m \pm sd	min-max m \pm sd
S1	<i>C.demersum</i>	0.25-0.28 0.2633 \pm 0.01	0.33-0.35 0.3367 \pm 0.009	0.13-0.15 0.14 \pm 0.008	0.33-0.35 0.34 \pm 0.0082
	<i>P.australis</i>	0.16-0.23 0.19 \pm 0.029	0.41-0.54 0.46 \pm 0.057	0.24-0.26 0.25 \pm 0.008	0.47-0.51 0.4867 \pm 0.017
S2	<i>C.demersum</i>	0.1-0.11 0.1033 \pm 0.0047	0.41-0.46 0.4333 \pm 0.02	0.36-0.42 0.3867 \pm 0.02	0.24-0.28 0.26 \pm 0.016
	<i>P.australis</i>	0.13-0.15 0.1433 \pm 0.009	0.5-0.54 0.5167 \pm 0.017	0.45-0.51 0.48 \pm 0.02	0.4-0.41 0.4033 \pm 0.0047
S3	<i>C.demersum</i>	0.1-0.11 0.1033 \pm 0.0047	0.28-0.33 0.3067 \pm 0.02	0.1-0.14 0.1233 \pm 0.017	0.2-0.22 0.21 \pm 0.0082
	<i>P.australis</i>	0.13-0.15 0.1433 \pm 0.009	0.34-0.41 0.3767 \pm 0.028	0.12-0.15 0.1333 \pm 0.01	0.31-0.35 0.3267 \pm 0.017
S4	<i>C.demersum</i>	0.25-0.28 0.2633 \pm 0.01	0.33-0.48 0.4067 \pm 0.06	0.14-0.15 0.1467 \pm 0.0047	0.3-0.36 0.3367 \pm 0.026
	<i>P.australis</i>	0.16-0.23 0.19 \pm 0.029	0.48-0.52 0.5133 \pm 0.02	0.33-0.36 0.34 \pm 0.014	0.45-0.48 0.4667 \pm 0.01

6- Cadmium (Cd)

The results showed the lowest average concentration of (Cd) in *C. demersum* (0.0667 $\mu\text{g/g}$) in S3 for the Summer and the highest concentration rate so it reached (0.4200 $\mu\text{g/g}$) in S1 for the Autumn. as for (Cd) concentrations in *P. australis* so the lowest concentration rate is (0.2233 $\mu\text{g/g}$) in S3 of the Summer and the highest concentration rate of (Cd) (0.9000 $\mu\text{g/g}$) so it is reached in S1 for the Autumn (Table 3-24) (Figure 3-39).

From the statistical analysis, it is showed that there are In *C. demersum* Cadmium Significant differences are found between all sites for the four season at the significant 0.05 level. in the Autumn are recorded Significant differences

in sites except S2 with S4 and in the Spring are recorded Significant differences in all sites and in Summer Significant differences in sites except S1 with S4. for in the winter significant differences are found in sites except S1 with S4 and correlation matrix for heavy metals in *C. demersum* showed that the Cadmium had a positive correlation with (Fe ,Cr ,Cu ,Zn, Pb ,Ni) at $p \leq 0.05$, $r = (0.4,0.6,0.3,0.06,0.2,0.6)$ respectively Appendix (5) and positive relationship with (pH ,Salinity ,Ca,NO₂, DO , Mg, PO₄ , NO₃, TSS, TH) it is also clear that there is negative relationship with (water temperature, BOD₅, ,AT) at $p \leq 0.05$, $r = (-0.1,-0.2,-0.4)$ Appendix (5). In *P. australis* Cadmium Significant differences are found between all sites for the four season at the significant 0.05 level .In the Autumn are recorded Significant differences found in all sites . In the Spring are recorded Significant differences in S2 with S3 and S1 with S4 respectively. For Summer Significant differences are found in sites except S1 with S4 .

In the winter significant differences are found in S3 with all sites and the correlation matrix for heavy metals in *P. australis* showed that the had Cadmium a positive correlation with (water temperature,Fe,Cr,Cu, Ca, ,Zn,Pb ,Ni , Mg) at $p \leq 0.05$, $r = (0.08,0.6,0.8,0.4,0.4,0.4,0.8,0.7,0.4)$ respectively Appendix (6) and positive relationship with (TSS , Salinity ,pH , TH, NO₃,NO₂, PO₄) it is also clear that there is negative relationship with (DO, BOD₅ , AT) at $p \leq 0.05$, $r = (-0.1,-0.4,-0.3)$ Appendix (6).

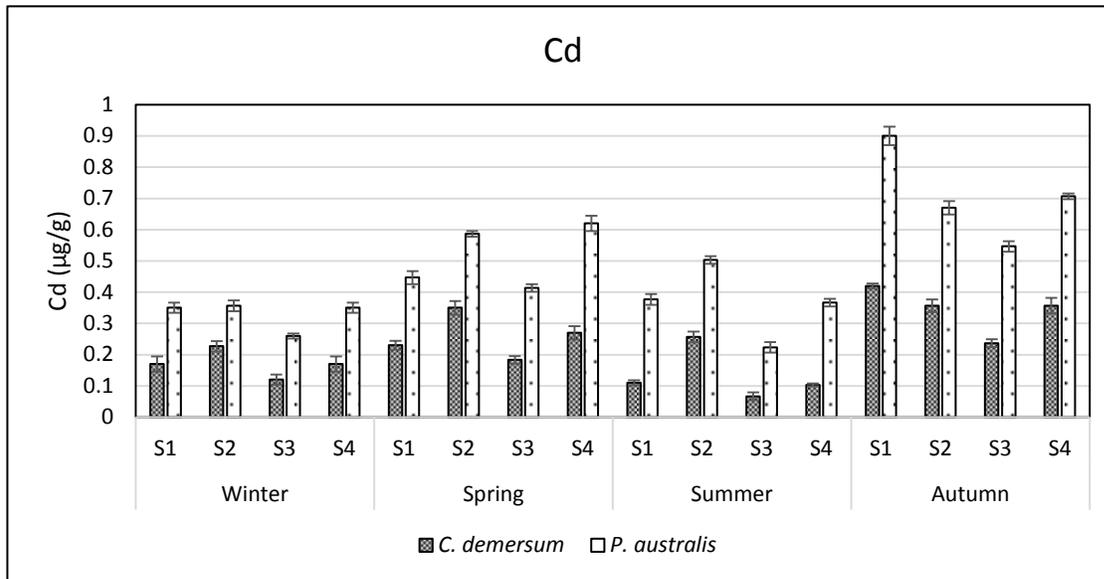


Figure (3-39) Cadmium Concentration rate $\mu\text{g/g}$ of *P. australis* and *C. demersum* in study site of Mashroo Al-Musayyib channel

Table (3-24) Cadmium Concentration rate $\mu\text{g/g}$ of *P. australis* and *C. demersum* in study site of Mashroo Al-Musayyib channel

Sea. Sites	aquatic plant	Winter2021	Spring2021	Summer2021	Autumn2021
		min-max m \pm sd	min-max m \pm sd	min-max m \pm sd	min-max m \pm sd
S1	<i>C. demersum</i>	0.14-0.2 0.17 \pm 0.02	0.21-0.24 0.23 \pm 0.01	0.1-0.12 0.11 \pm 0.008	0.41-0.43 0.42 \pm 0.008
	<i>P. australis</i>	0.33-0.37 0.35 \pm 0.016	0.42-0.47 0.4467 \pm 0.02	0.36-0.4 0.3767 \pm 0.017	0.87-0.94 0.9 \pm 0.029
S2	<i>C. demersum</i>	0.21-0.25 0.2267 \pm 0.017	0.33-0.38 0.35 \pm 0.02	0.24-0.28 0.2567 \pm 0.017	0.33-0.38 0.3567 \pm 0.02
	<i>P. australis</i>	0.34-0.38 0.3567 \pm 0.017	0.58-0.6 0.5867 \pm 0.009	0.49-0.52 0.5033 \pm 0.01	0.64-0.69 0.67 \pm 0.02
S3	<i>C. demersum</i>	0.1-0.14 0.12 \pm 0.016	0.17-0.2 0.183 \pm 0.0125	0.05-0.08 0.0667 \pm 0.01	0.22-0.25 0.2367 \pm 0.01
	<i>P. australis</i>	0.25-0.27 0.26 \pm 0.008	0.4-0.43 0.413 \pm 0.0125	0.2-0.24 0.2233 \pm 0.017	0.53-0.57 0.5467 \pm 0.017
S4	<i>C. demersum</i>	0.17-0.2 0.17 \pm 0.02	0.24-0.29 0.27 \pm 0.0216	0.1-0.11 0.1033 \pm 0.0047	0.33-0.39 0.3567 \pm 0.02
	<i>P. australis</i>	0.33-0.37 0.35 \pm 0.016	0.59-0.65 0.62 \pm 0.0245	0.35-0.38 0.3667 \pm 0.01	0.7-0.72 0.7067 \pm 0.009

7- chromium (Cr)

The results showed the lowest average concentration of (Cr) in *C. demersum* (0.0333 $\mu\text{g/g}$) in S3 and S4 for the Summer and the highest concentration rate so it reached (0.4800 $\mu\text{g/g}$) in S2 for the Spring. as for (Cr) concentrations in *P. australis* so the lowest concentration rate is (0.0700 $\mu\text{g/g}$) in S3 of the Summer and the highest concentration rate of (Cr) (0.3700 $\mu\text{g/g}$) So it is reached in S2 for the Spring (Table 3-25) (Figure 3-40).

From the statistical analysis, it is showed that there are In *C. demersum* chromium Significant differences are found between all sites for the four season at the significant 0.05 level. in the Autumn are recorded Significant differences in sites except S2 with S4 and in the Spring are recorded Significant differences in sites except S3 with S4 and in Summer Significant differences in sites except S3 with S4. for in the winter significant differences are found in sites except S1 with S4 and correlation matrix for heavy metals in *C. demersum* showed that the chromium had a positive correlation with (BOD₅, pH, Salinity, DO, Mg,) at $p \leq 0.05$, $r = (0.1, 0.08, 0.1, 0.2, 0.2)$ respectively Appendix (5) and positive relationship with (NO₂, PO₄, NO₃, TH) it is also clear that there is negative relationship with (water temperature, TSS, AT, Ca,) at $p \leq 0.05$, $r = (-0.2, -0.07, -0.2, -0.1)$ Appendix (5). In *P. australis* chromium Significant differences are found between all sites for the four season at the significant 0.05 level. in the Autumn are recorded Significant differences in sites except S2 with S4 and in the Spring are recorded Significant differences in sites except S1 with S4 and in Summer Significant differences in sites except S1 with S4. for in the winter significant differences are found in S3 with all sites and the correlation matrix for heavy metals in *P. australis* showed that the chromium had a positive correlation with (water temperature, Mg, Ca, TH) at $p \leq 0.05$, $r = (0.1, 0.2, 0.2, 0.2)$

respectively Appendix (6) and positive relationship with (NO₂, PO₄ , NO₃, TSS) it is also clear that there is negative relationship with (BOD₅, pH ,Salinity, DO ,AT) at p≤ 0.05, r =(-0.3,-0.07,-0.1,-0.05,-0.4) Appendix (6).

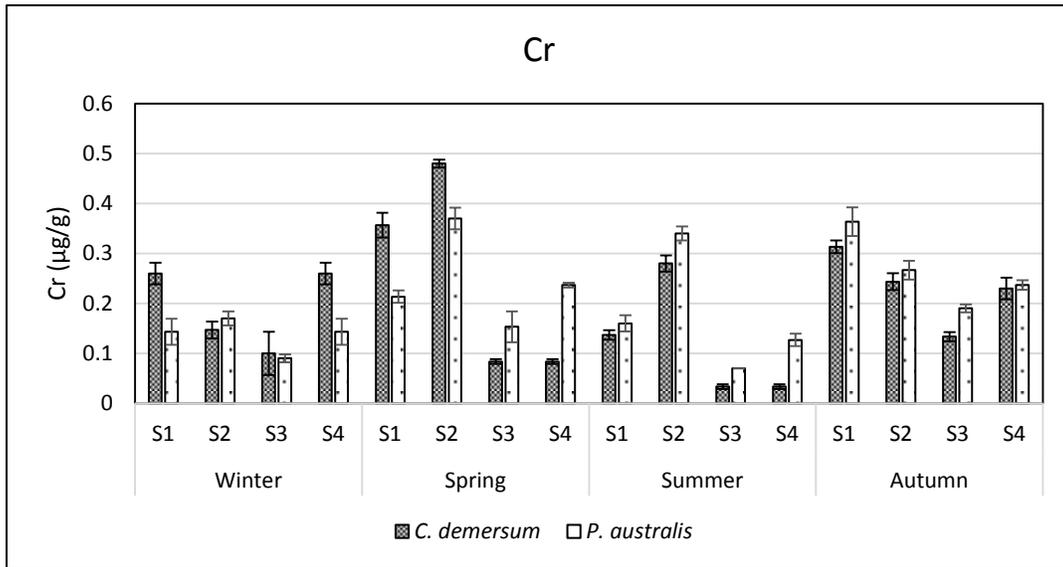


Figure (3-40) Chromium Concentration rate µg/g of *P. australis* and *C. demersum* in study site of Mashroo Al-Musayyib channel

Table (3-25)Chromium Concentration rate $\mu\text{g/g}$ of *P. australis* and *C. demersum* in study site of Mashroo Al-Musayyib channel

Sea. Sites	aquatic plant	Winter2021	Spring2021	Summer2021	Autumn2021
		min-max m \pm sd	min-max m \pm SD	min-max m \pm SD	min-max m \pm SD
S1	<i>C.demersum</i>	0.24-0.29 0.26 \pm 0.02	0.33-0.39 0.3567 \pm 0.02	0.13-0.15 0.1367 \pm 0.0094	0.3-0.33 0.3133 \pm 0.01
	<i>P.australis</i>	0.12-0.18 0.1433 \pm 0.026	0.2-0.23 0.2133 \pm 0.01	0.14-0.18 0.16 \pm 0.016	0.33-0.4 0.3633 \pm 0.028
S2	<i>C.demersum</i>	0.13-0.17 0.1467 \pm 0.017	0.47-0.49 0.48 \pm 0.008	0.26-0.3 0.28 \pm 0.016	0.22-0.26 0.2433 \pm 0.017
	<i>P.australis</i>	0.15-0.18 0.17 \pm 0.01	0.34-0.39 0.37 \pm 0.02	0.32-0.35 0.34 \pm 0.01	0.24-0.28 0.2667 \pm 0.018
S3	<i>C.demersum</i>	0.04-0.14 0.1 \pm 0.04	0.08-0.09 0.0833 \pm 0.0047	0.03-0.04 0.0333 \pm 0.004	0.12-0.14 0.1333 \pm 0.009
	<i>P.australis</i>	0.08-0.1 0.09 \pm 0.008	0.11-0.18 0.1533 \pm 0.03	0.07-0.07 0.07 \pm 0	0.18-0.2 0.19 \pm 0.008
S4	<i>C.demersum</i>	0.24-0.29 0.26 \pm 0.02	0.08-0.09 0.0833 \pm 0.0047	0.03-0.04 0.0333 \pm 0.004	0.2-0.25 0.23 \pm 0.02
	<i>P.australis</i>	0.12-0.18 0.1433 \pm 0.026	0.23-0.24 0.2367 \pm 0.0047	0.11-0.14 0.1267 \pm 0.012	0.23-0.25 0.2367 \pm 0.009

3-4- 4: Concentration of Heavy Metals in Clam

Pseudontopeses euphraticus

1-Iron (Fe)

The results recorded the lowest average concentration of (Fe) in *Pseudontopeses euphraticus* (5473µg/g) in S3 for the Summer and the highest concentration rate So it reached (13563µg/g) in S4 for the Winter (Table 3-26) (Figure 3-41) . From the statistical analysis, it is showed that there is For Iron significant differences are found between all sites for the four seasons at the significant 0.05 level except for the autumn are no recorded Significant differences in sites . In the Spring Significant differences are found between S2 with all sites. In the Summer significant differences are found in S3 with all sites and in the winter significant differences are found between S4 with all sites respectively and the correlation matrix for heavy metals in Clam showed that the Iron had a positive correlation with (DO, BOD₅,pH,Salinity Cr,) at $p \leq 0.05$, $r = (0.4,0.4,0.1,0.2,0.2)$ respectively and it is also clear that there is negative relationship with(Mg, Ca , water temperature,AT, NO₂, NO₃, PO₄ , TH, TSS) at $p \leq 0.05$, $r = (-0.4,-0.5,-0.4,-0.5,-0.3,-0.06,-0.2,-0.5,-0.1)$ Appendix (7).

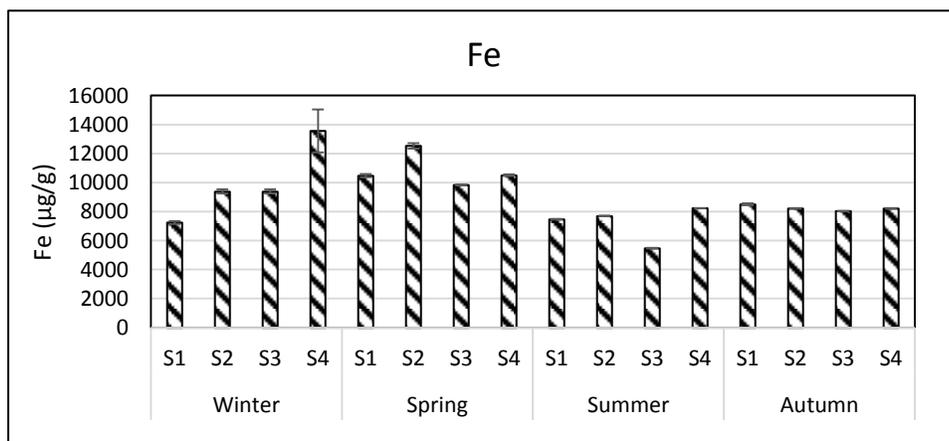


Figure (3-41) Iron Concentration rate µg/g of *P. euphraticus* in study site of Mashroo Al-Musayyib channel

Table (3-26) Iron Concentration rate $\mu\text{g/g}$ of *P. euphratics* in study site of Mashroo Al-Musayyib channel

Sea. Sites	Winter2021	Spring2021	Summer2021	Autumn2021
	min-max m \pm sd	min-max m \pm sd	min-max m \pm sd	min-max m \pm sd
S1	7120-7360 7250 \pm 98.99	10330-10580 10483.3 \pm 109.64	7440-7500 7473.33 \pm 24.94	8460-8590 8506.67 \pm 59.06
S2	9250-9580 9390 \pm 139.28	12400-12800 12533.3 \pm 188.56	7680-7710 7696.67 \pm 12.47	8200-8250 8223.33 \pm 20.54
S3	9250-9580 9390 \pm 139.28	9780-9880 9833.33 \pm 41.09	5440-5500 5473.33 \pm 24.94	8010-8050 8033.33 \pm 16.99
S4	12480-15650 13563.3 \pm 1475.86	10470-10580 10510 \pm 49.66	8220-8250 8236.67 \pm 12.47	8200-8240 8223.33 \pm 16.99

2-Copper (Cu)

The results recorded the lowest average concentration of (Cu) in *Pseudotapes euphratics* (3277 $\mu\text{g/g}$) in S3 for the Summer and the highest concentration rate So it reached (9500 $\mu\text{g/g}$) in S2 for the Spring(Table 3-27) (Figure 3-42) .

From the statistical analysis, it is showed that there are For Copper Significant differences are found between all sites for the four season at the significant 0.05 level .for the Autumn are recorded Significant differences in S1 with all sites . in the Spring Significant differences were found between sites except S1 with S4.in the Summer significant differences are found between sites except S1 with S2 and in the winter significant differences are found between sites except S2 with S3 respectively and the correlation matrix for heavy metals in Clam showed that the Copper had a positive correlation with (DO, BOD₅,pH,Salinity Cr, Fe) at $p \leq 0.05$, $r = (0.4,0.3,0.3,0.4,0.3,0.8)$ respectively and positive relationship with the (NO₃, PO₄ ,) Appendix (7) it is also clear that

there is negative relationship with (Mg, Ca , water temperature, AT ,TH, TSS ,NO₂) at $p \leq 0.05$, $r=(-0.1,-0.3,-0.6,-0.5,-0.3,-0.1,-0.08)$ Appendix (7).

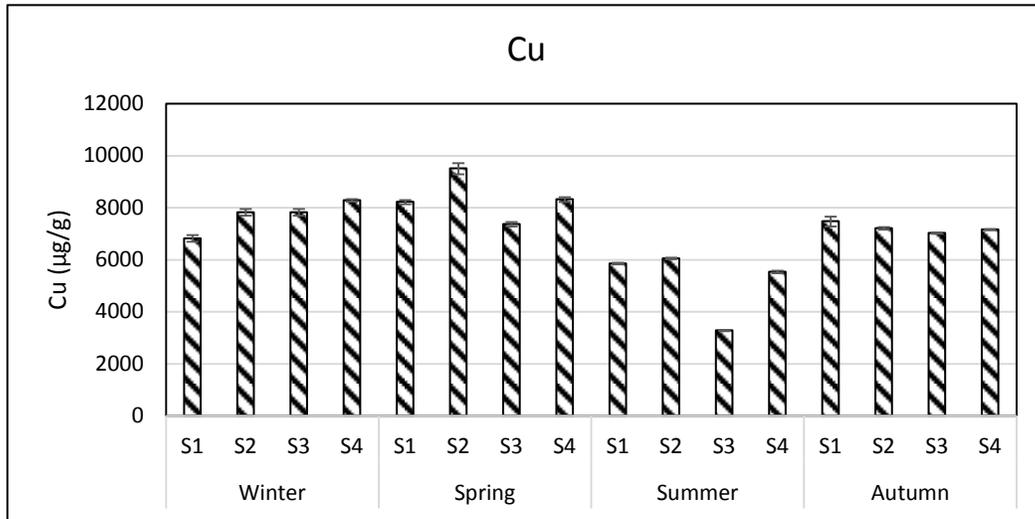


Figure (3-42) Copper Concentration rate µg/g of *P. euphraticus* in study site of Mashroo Al-Musayyib channel

Table (3-27)Copper Concentration rate µg/g of *P.euphraticus* in study site of Mashroo Al-Musayyib channel

Sea Sites	Winter2021	Spring2021	Summer2021	Autumn2021
	min-max m ±sd	min-max m ±sd	min-max m ±sd	min-max m ±sd
S1	6680-6990 6820±128.323	8140-8330 8220±80.4	5830-5890 5853.33±26.24	7440-7720 7470±193.04
S2	7640-7950 7823.33±132.749	9200-9700 9500±216.02	6010-6080 6046.67±28.67	7150-7260 7206.67±44.96
S3	7640-7950 7823.33±132.749	7280-7480 7363.33±84.98	3250-3300 3276.67±20.54	7000-7050 7020±21.60
S4	8230-8350 8286.67±49.216	8220-8440 8316.67±91.77	5470-5570 5530±43.20	7120-7180 7153.33±24.94

3 - Zinc (Zn)

The results recorded the lowest average concentration of (Zn) in *Psedontopeses euphratics* (11243 μ g/g) in S3 for the Summer and the highest concentration rate So it reached (19267 μ g/g) in S2 for the Spring (Table 3-28) (Figure 3-43) . From the statistical analysis, it is showed that there are for Zinc Significant differences are found between all sites for the four season at the significant 0.05 level .For the Autumn are recorded Significant differences in S1 with all sites respectively. in the Spring Significant differences are found between sites except S1 with S3.in the Summer significant differences are recorded Significant differences in S4 with all sites respectively. and in the winter significant differences are found between sites except S2 with S3 and the correlation matrix for heavy metals in Clam showed that the Zinc had a positive correlation with (DO, BOD₅,pH,Salinity Cr, Fe) at $p \leq 0.05$, $r = (0.2,0.2,0.2,0.2,0.3,0.8)$ respectively and positive relationship with the (NO₃, Cu,) Appendix (7) it is also clear that there is negative relationship with (Mg, Ca , water temperature ,AT ,TH, PO₄ , TSS ,NO₂,) at $p \leq 0.05$, $r = (-0.3,-0.5,-0.5,-0.6,-0.5,-0.1,-0.2,-0.3)$ Appendix (7).

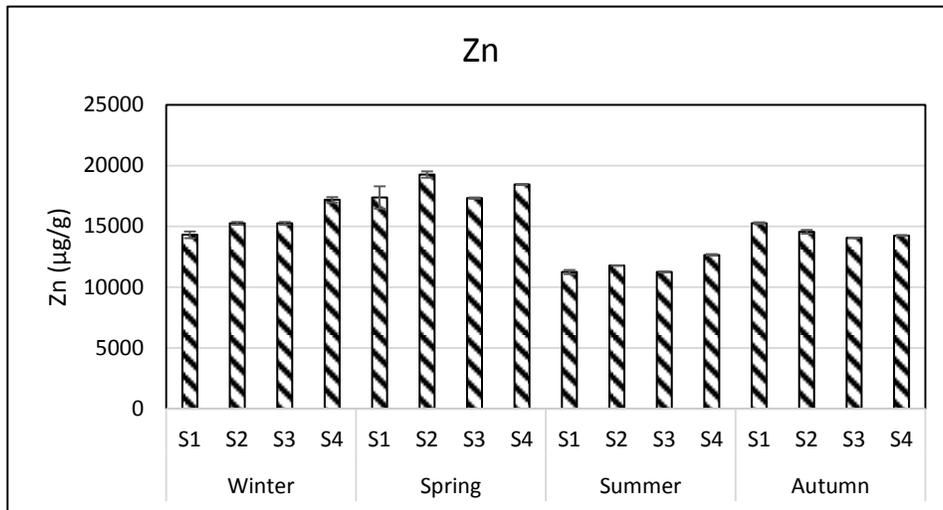


Figure (3-43) Zink Concentration rate µg/g of *P. euphratics* in study site of Mashroo Al-Musayyib channel

Table (3-28) Zink Concentration rate µg/g of *P. euphratics* in study site of Mashroo Al-Musayyib channel

Sea. / Sites	Winter2021	Spring2021	Summer2021	Autumn2021
	min-max m ±sd	min-max m ±sd	min-max m ±sd	min-max m ±sd
S1	13990-14650 14306.7±270.1	16240-18490 17390±919.2	11040-11470 11243.3±176.32	15200-15360 15266.7±67.98
S2	15100-15380 15256.7±116.7	18900-19500 19266.7±262.46	11740-11800 11773.3±24.94	14330-14700 14553.3±160.48
S3	15100-15380 15256.7±116.7	17280-17410 17340±53.54	11250-11300 11263.3±26.24	14020-14100 14060±32.65
S4	16920-17460 17193.3±220.5	18390-18490 18450±43.20	12550-12690 12643.3±65.99	14220-14300 14250±35.59

4 - lead (Pb)

The results of lead (Pb) analysis concentration showed that in the Clam if The results recorded the lowest average concentration of (Pb) in *Pseudontopeses euphratics* (0.5433µg/g) in S3 for the Summer and the highest concentration rate

So it reached (1.3167 $\mu\text{g/g}$) in S1 for the Autumn (Table 3-29) (Figure 3-44) . From the statistical analysis, it is showed that there were For lead Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences in sites except S1 with S2 . In the Spring Significant differences are found between sites except S2 with S4. In the Summer significant differences are recorded Significant differences in all sites . and in the winter significant differences are found in S1 and S2 and the correlation matrix for heavy metals in Clam showed that the lead had a positive correlation with (DO, BOD₅,pH,Salinity Cr, Fe, Cu, Zn) at $p \leq 0.05$, $r = (0.3,0.1,0.3,0.4,0.3,0.3,0.6,0.3)$ respectively and positive relationship with the (NO₃, Mg, Ca , TH, PO₄, TSS ,NO₂) Appendix (7) it is also clear that there is negative relationship with (water temperature, AT , at $p \leq 0.05$, $r = (-0.4,-0.1)$ Appendix (7).

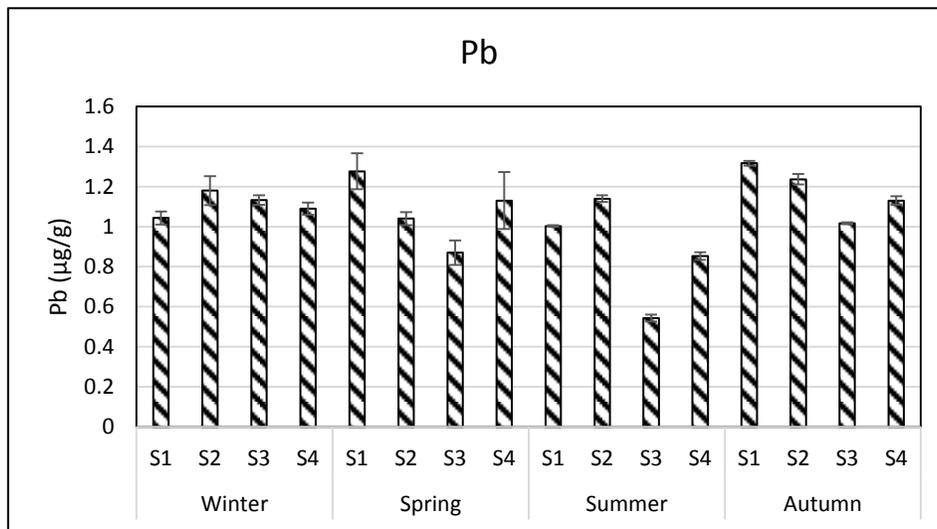


Figure (3-44)Lead Concentration rate $\mu\text{g/g}$ of *P. euphraticus* in study site of Mashroo Al-Musayyib channel

Table (3-29) Lead Concentration rate $\mu\text{g/g}$ of *P. euphratics* in study site of Mashroo Al-Musayyib channel

Sea. Sites	Winter2021	Spring2021	Summer2021	Autumn2021
	Min-Max M($\mu\text{g/g}$) \pm SD			
S1	1-1.08 1.04333 \pm 0.03	1.15-1.35 1.27667 \pm 0.089	1-1.01 1.00333 \pm 0.004	1.3-1.33 1.31667 \pm 0.012
S2	1.11-1.28 1.18 \pm 0.07	1-1.08 1.04 \pm 0.03	1.12-1.16 1.14 \pm 0.016	1.2-1.26 1.23667 \pm 0.026
S3	1.1-1.15 1.13333 \pm 0.02	0.79-0.94 0.87 \pm 0.06	0.52-0.56 0.54333 \pm 0.017	1.01-1.02 1.01667 \pm 0.0047
S4	1.1-1.12 1.09 \pm 0.029	1.01-1.33 1.13 \pm 0.14	0.84-0.88 0.85333 \pm 0.018	1.1-1.15 1.13 \pm 0.02

5 - Nickel (Ni)

The results recorded the lowest average concentration of (Ni) in *Pseudontopeses euphratics* ($0.32\mu\text{g/g}$) in S4 for the Winter and the highest concentration rate So it reached ($1.4633\mu\text{g/g}$) in S1 for the Spring (Table 3-30) (Figure 3-45). From the statistical analysis, it is showed that there are For Nickel Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences in sites except S3 with S4. In the Spring and Summer Significant differences are found in all site. and in the winter significant differences are found in sites except S2 with S3 and the correlation matrix for heavy metals in Clam showed that the Nickel had a positive correlation with (water temperature , NO_3 , Mg, Ca , TH, PO_4) at $p \leq 0.05$, $r = (0.2, 0.3, 0.3, 0.5, 0.4, 0.2)$ respectively and positive relationship with the (TSS , NO_2 , Cu ,Zn ,Pb) Appendix (7) it is also clear that there is negative relationship with (AT ,DO, BOD_5 , pH, Salinity ,Cr, Fe) at $p \leq 0.05$, $r = (-0.2, -0.3, -0.5, -0.2, -0.2, -0.1, -0.08)$ Appendix (7).

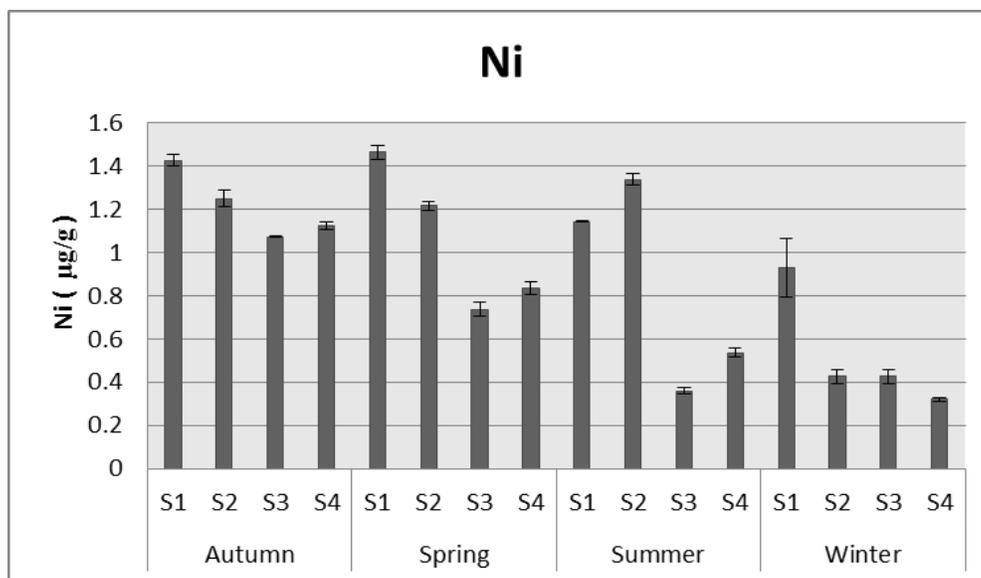


Figure (3-45) Nickel Concentration rate $\mu\text{g/g}$ of *P. euphraticus* in study site of Mashroo Al-Musayyib channel

Table (3-30) Nickel Concentration rate $\mu\text{g/g}$ of *P. euphraticus* in study site of Mashroo Al-Musayyib channel

Sea.	Winter2021	Spring2021	Summer2021	Autumn2021
Sites	Min-Max M($\mu\text{g/g}$) \pm SD			
S1	0.79-1.11 0.93 \pm 0.1	1.42-1.5 1.46333 \pm 0.03	1.14-1.15 1.14333 \pm 0.0047	1.4-1.46 1.42667 \pm 0.02
S2	0.39-0.47 0.42667 \pm 0.03	1.19-1.24 1.21667 \pm 0.02	1.3-1.36 1.33667 \pm 0.026	1.2-1.3 1.25 \pm 0.04
S3	0.39-0.47 0.42667 \pm 0.03	0.71-0.78 0.73667 \pm 0.03	0.34-0.38 0.36 \pm 0.016	1.07-1.08 1.07333 \pm 0.0047
S4	0.31-0.33 0.32 \pm 0.008	0.8-0.87 0.83667 \pm 0.028	0.51-0.56 0.53667 \pm 0.02	1.1-1.14 1.12333 \pm 0.017

6- Cadmium (Cd)

The results recorded the lowest average concentration of (Cd) in *Psedontopeses euphratics* (0.0133 μ g/g) in S3 for the Summer and the highest concentration rate so it reached (0.9067 μ g/g) in S4 for the Spring (Table 3-31) (Figure 3-46) .

From the statistical analysis, it is showed that there are For Cadmium Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences in sites except S2 with S4 . In the Spring are recorded Significant differences in sites except S2 with S3 and Summer Significant differences are found in all site. For in the winter significant differences are no found in sites and the correlation matrix for heavy metals in Clam showed that the Cadmium had a positive correlation with (water temperature , Cr, Fe ,TSS , ,Cu ,Zn ,Pb, Ni) at $p \leq 0.05$, $r = (0.1,0.4,0.09, 0.5,0.1,0.1,0.1,0.03)$ respectively Appendix (7) it is also clear that there is negative relationship with (NO₂,NO₃, Mg, Ca , TH, PO₄ ,AT ,DO, BOD₅,pH,Salinity ,) at $p \leq 0.05$, $r = (-0.1,-0.1,-0.2,-0.02,-0.1,-0.1, -0.3,-0.04,-0.1,-0.06,-0.1)$ Appendix (7).

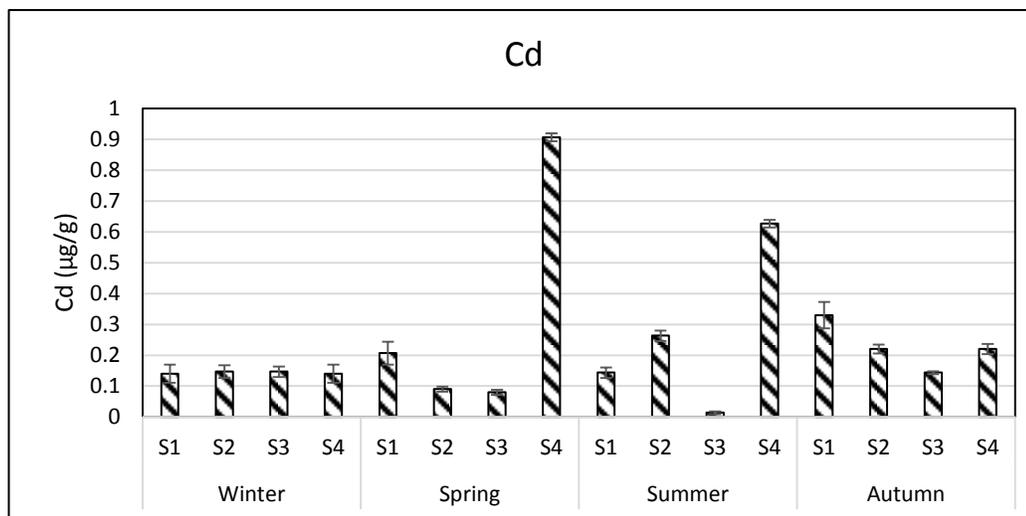


Figure (3-46) Cadmium Concentration rate µg/g of *P. euphraticus* in study site of Mashroo Al-Musayyib channel

Table (3-31) Cadmium Concentration rate µg/g of *Pseudontopeses euphraticus* in study site of Mashroo Al-Musayyib channel

Sea.	Winter2021	Spring2021	Summer2021	Autumn2021
Sites	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD	Min-Max M(µg/g) ±SD
S1	0.1-0.17 0.14±0.029	0.16-0.25 0.20667±0.036	0.12-0.16 0.14333±0.017	0.3-0.39 0.33±0.04
S2	0.12-0.17 0.14667±0.02	0.09-0.1 0.09±0.008	0.24-0.28 0.26333±0.017	0.21-0.24 0.22±0.01
S3	0.13-0.17 0.14667±0.01	0.07-0.09 0.08±0.008	0.01-0.02 0.01333±0.0047	0.14-0.15 0.14±0.0047
S4	0.1-0.17 0.14±0.029	0.89-0.92 0.90667±0.01	0.61-0.64 0.62667±0.01	0.2-0.24 0.22±0.016

7- chromium (Cr)

The results recorded the lowest average concentration of (Cr) in *Psedontopeses euphratics* (0.0047µg/g) in S3 for the Summer and the highest concentration rate so it reached (0.1733µg/g) in S3 for the Winter (Table 3-32) (Figure 3-47) .

From the statistical analysis, it is showed that there is For chromium Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences in S1 with all site . In the Spring are recorded Significant differences in sites except S2 with S3 and Summer Significant differences are found in S3 with all sites . for in the winter significant differences are found in S3 with all site sand the correlation matrix for heavy metals in Clam showed that the Cadmium had a positive correlation with (BOD₅,pH,Salinity) at $p \leq 0.05$, $r = (0.01,0.2,0.1)$ respectively Appendix (7) it is also clear that there is negative relationship with (water temperature , TSS , NO₂,NO₃, Mg, Ca , TH, PO₄ ,AT ,DO)at $p \leq 0.05$, $r = (-0.2,-0.1,-0.2,-0.1,-0.4,-0.2,-0.3,-0.1,-0.04,-0.05)$ Appendix (7).

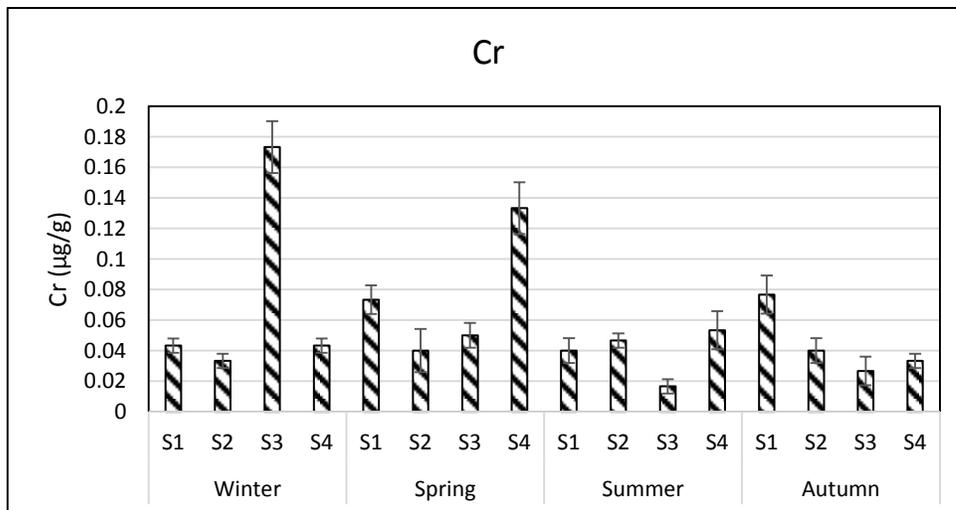


Figure (3-47) Chromium Concentration rate µg/g of *P. euphratics* in study site of Mashroo Al-Musayyib channel

Table (3-32)chromium Concentration rate $\mu\text{g/g}$ of *P. euphratics* in study site of Mashroo Al-Musayyib channel

Sea. Sites	Winter2021	Spring2021	Summer2021	Autumn2021
	Min-Max M($\mu\text{g/g}$) \pm SD			
S1	0.04-0.05 0.04333 \pm 0.00471	0.06-0.08 0.07333 \pm 0.00943	0.03-0.05 0.04 \pm 0.00816	0.06-0.09 0.07667 \pm 0.01
S2	0.03-0.04 0.03333 \pm 0.00471	0.02-0.05 0.04 \pm 0.014	0.04-0.05 0.04667 \pm 0.00471	0.03-0.05 0.04 \pm 0.008
S3	0.15-0.19 0.17333 \pm 0.017	0.04-0.06 0.05 \pm 0.00816	0.01-0.02 0.01667 \pm 0.00471	0.02-0.04 0.02667 \pm 0.009
S4	0.04-0.05 0.04333 \pm 0.00471	0.11-0.15 0.13333 \pm 0.017	0.04-0.07 0.05333 \pm 0.01	0.03-0.04 0.03333 \pm 0.00471

3-4-5 : Concentration of Heavy Metals in the Fish *Oreochromis aureas* and *Leuciscus vorax*

1- Iron (Fe)

The results recorded the lowest average concentration of (Fe)in *O. aureas* (3170 $\mu\text{g/g}$) in S3 for the Winter and the highest concentration rate so it reached (7817 $\mu\text{g/g}$) in S2 for the Spring (Table3-33) (Figure3-48) . as for (Fe) concentrations in *L. vorax* if the lowest concentration rate is (3293 $\mu\text{g/g}$) in S3 of the Summer and the highest concentration rate of (Fe) (8437 $\mu\text{g/g}$) so it is reached in S 4 for the Spring .From the statistical analysis, it is showed that there are in *Oreochromis aureas* Iron Significant differences are found between all sites for the four season at the significant 0.05 level . Significant differences are recorded in all sites for the spring, summer and winter except for the Autumn so significant differences are recorded between S1 and S3 , and no significant differences are

recorded between S2 with S4 . and correlation matrix for heavy metals in *Oreochromis aureas* showed that the Iron had a positive correlation with (water temperature, Mg, Ca ,Cr) at $p \leq 0.05$, $r = (0.1,0.03,0.1,0.5)$ respectively Appendix (8) and positive relationship with (NO₃, NO₂, PO₄ , TSS, TH) it is also clear that there is negative relationship with (AT, pH ,Salinity, DO , BOD₅) at $p \leq 0.05$, $r = (-0.7,-0.2,-0.2,-0.2,-0.3)$ Appendix (8).

In *Leuciscus vorax* Iron significant differences are found between all sites for the four season at the significant 0.05 level . In the Autumn are recorded Significant differences in sites except S3 with S4 respectively. In the Spring are recorded Significant differences in S4 with S1 and S3 respectively. For in Summer and winter Significant differences in all sites and correlation matrix for heavy metals in *Leuciscus vorax* showed that the Iron had a positive correlation with (water temperature, TSS ,Cr) at $p \leq 0.05$, $r = (0.08, 0.1, 0.7)$ respectively Appendix (9) and it is also clear that there is negative relationship with (AT, pH ,Salinity, DO, NO₃, Ca, Mg, NO₂, PO₄ , TH, BOD₅) at $p \leq 0.05$, $r = (-0.8,-0.3,-0.3,-0.1,-0.1,-0.1,-0.3,-0.4,-0.3,-0.3,-0.1)$ Appendix (9).

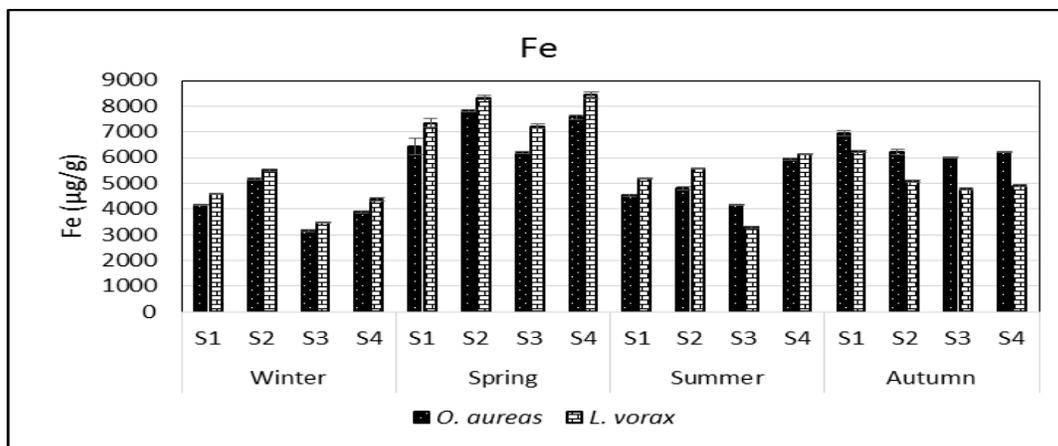


Figure (3-48) Iron Concentration rate µg/g of *O. aureas* and *L. vorax* in study site of Mashroo Al-Musayyib channel

Table (3-33) Iron Concentration rate $\mu\text{g/}$ of *O.aureas* and *L. vorax* in study site of Mashroo Al-Musayyib channel

Sea. Sites	Fish species	Winter2021	Spring2021	Summer2021	Autumn2021
		min-max m \pm sd	min-max m \pm sd	min-max m \pm sd	min-max m \pm sd
S1	<i>Oreochromis aureas</i>	4120-4200 4170 \pm 35.59	6140-6880 6423.3 \pm 326.02	4480-4570 4533.3 \pm 38.58	6880-7120 6963.3 \pm 110.86
	<i>Leuciscus vorax</i>	4550-4630 4596.7 \pm 33.99	7140-7550 7350 \pm 167.53	5150-5220 5190 \pm 29.43	6220-6300 6253.3 \pm 33.99
S2	<i>Oreochromis aureas</i>	5140-5210 5163.3 \pm 32.99	7770-7890 7816.7 \pm 52.49	4740-4880 4803.3 \pm 57.92	6120-6350 6223.3 \pm 95.336
	<i>Leuciscus vorax</i>	5470-5580 5523.3 \pm 4496	8250-8440 8320 \pm 85.24	5540-5600 5563.3 \pm 26.24	5000-5140 5086.7 \pm 61.824
S3	<i>Oreochromis aureas</i>	3120-3210 3170 \pm 37.41	6140-6220 6190 \pm 35.59	4120-4200 4170 \pm 35.59	6000-6030 6013.3 \pm 12.472
	<i>Leuciscus vorax</i>	3470-3520 3496.7 \pm 20.54	7140-7310 7223.3 \pm 69.44	3250-3330 3293.3 \pm 32.99	4730-4820 4780 \pm 37.417
S4	<i>Oreochromis aureas</i>	3850-3970 3900 \pm 50.99	7440-7690 7570 \pm 102.31	5890-6010 5950 \pm 48.99	6200-6250 6220 \pm 21.60
	<i>Leuciscus vorax</i>	4290-4470 4370 \pm 74.83	8280-8590 8436.7 \pm 126.58	6120-6180 6150 \pm 24.49	4880-4950 4906.7 \pm 30.91

2-Copper (Cu)

The results recorded the lowest average concentration of (Cu)in *O. aureas* (380 $\mu\text{g/g}$) in S3 for the Winter and the highest concentration rate so it reached (2067 $\mu\text{g/g}$) in S1 for the Autumn (Table3-34) (Figure 3-49) . as for (Cu) concentrations in *L. vorax* so the lowest concentration rate is (290 $\mu\text{g/g}$) in S3 of the Winter and the highest concentration rate of (Cu) (2463 $\mu\text{g/g}$) so it is reached in S2 for the Spring .

From the statistical analysis, it is showed that there are in *Oreochromis aureas* Copper Significant differences are found between all sites for the four season at the significant 0.05 level. Significant differences are recorded in all

sites for the Autumn , spring , summer s except for the winter so significant differences are recorded between the sites except S2 with S4 respectively and correlation matrix for heavy metals in *Oreochromis aureas* showed that the Copper had a positive correlation with (water temperature, Mg, Ca, Cr ,Fe) at $p \leq 0.05$, $r = (0.2,0.4,0.6,0.2,0.7)$ respectively Appendix (8) and positive relationship with (NO₂, PO₄ , NO₃, TSS, TH) it is also clear that there is negative relationship with (AT, pH ,Salinity, DO , BOD₅) at $p \leq 0.05$, $r =(-0.4,-0.1,-0.09,-0.2,-0.5)$ Appendix (8).

In *Leuciscus vorax* Copper Significant differences are found between all sites for the four season at the significant 0.05 level. Significant differences are recorded in all sites for the spring, summer and winter s except for the Autumn if significant differences are recorded between sites except S2 with S1 respectively and correlation matrix for heavy metals in *Oreochromis aureas* showed that the Copper had a positive correlation with (water temperature, TSS ,Cr, NO₃,Fe) at $p \leq 0.05$, $r = (0.1, 0.3, 0.8,0.1,0.8)$ respectively Appendix (9) and it is also clear that there is negative relationship with (AT, pH ,Salinity, DO, Ca, , Mg, NO₂, PO₄ , TH, BOD₅) at $p \leq 0.05$, $r =(-0.7,-0.1,-0.2,-0.08,-0.01,-0.1,-0.1,-0.04,-0.1,-0.2)$ Appendix (9).

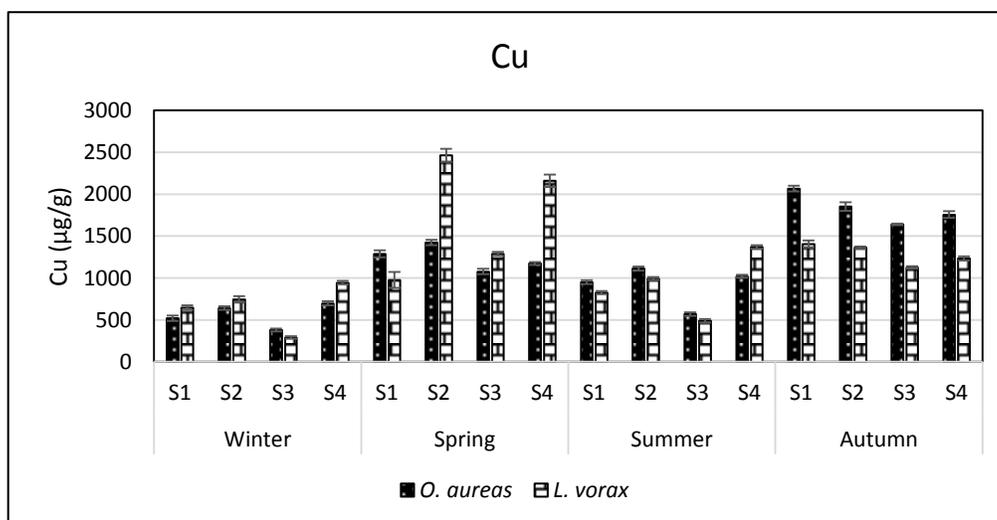


Figure (3-49) Copper Concentration rate µg/g of *O. aureas* and *L.vorax* in study site of Mashroo Al-Musayyib channel

Table (3-34) Copper Concentration rate µg/g of *O. aureas* and *L. vorax* in study site of Mashroo Al-Musayyib channel

Sea. Sites	Fish species	Winter2021	Spring2021	Summer2021	Autumn2021
		min-max m ±sd	min-max m ±sd	min-max m ±sd	min-max m ±sd
S1	<i>Oreochromis aureas</i>	480-560 520 ±32.66	1230-1330 1286.7 ±41.89	920-970 950 ±21.60	2020-2100 2066.7 ±33.99
	<i>Leuciscus vorax</i>	620-680 646.67 ±24.94	850-1080 976.67 ±95.336	800-840 826.67 ±18.85	1350-1450 1406.7 ±41.89
S2	<i>Oreochromis aureas</i>	620-670 640 ±21.60	1380-1450 1423.3 ±30.91	1080-1140 1113.3 ±24.94	1780-1890 1853.3 ±51.85
	<i>Leuciscus vorax</i>	700-790 746.67 ±36.81	2360-2550 2463.3 ±78.45	970-1010 993.33 ±16.99	1350-1380 1363.3 ±12.47
S3	<i>Oreochromis aureas</i>	360-400 380 ±16.33	1040-1120 1076.7 ±32.99	550-600 570 ±21.60	1630-1650 1640 ±8.16
	<i>Leuciscus vorax</i>	270-300 290 ±14.14	1260-1320 1286.7 ±24.94	470-520 490 ±21.60	1110-1140 1126.7 ±12.47
S4	<i>Oreochromis aureas</i>	670-730 696.67 ±24.94	1150-1190 1173.3 ±16.99	1000-1040 1020 ±16.33	1700-1790 1756.7 ±40.27
	<i>Leuciscus vorax</i>	920-970 943.33 ±20.54	2080-2260 2160 ±74.83	1350-1400 1370 ±21.60	1200-1260 1233.3 ±24.94

3 - Zinc (Zn)

The results recorded the lowest average concentration of (Zn)in *O. aureas* (1943 μ g/g) in S4 for the Summer and the highest concentration rate so it reached (4627 μ g/g) in S2 for the Spring (Table 3-35) (Figure 3-50) . as for (Zn) concentrations in *L. vorax* if the lowest concentration rate was (1900 μ g/g) in S3 of the Winter and the highest concentration rate of (Zn) (7943 μ g/g) so it is reached in S2 for the Spring .From the statistical analysis, it is showed that there are in *Oreochromis aureas* Zinc Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences in site except S3 with S4 .

In the spring and winter are recorded Significant differences in all sites. For in Summer Significant differences in sites except S3 with S4 and correlation matrix for heavy metals in *Oreochromis aureas* showed that the Zinc had a positive correlation with (Mg , Ca , Cr ,Fe ,Cu) at $p \leq 0.05$, $r = (0.3,0.1,0.2,0.7,0.7)$ respectively Appendix (8) and positive relationship with (NO₂, PO₄ , NO₃, TSS, , pH ,Salinity ,DO, TH) it is also clear that there is negative relationship with (water temperature ,AT, BOD₅) at $p \leq 0.05$, $r =(-0.1, -0.4,-0.2)$ Appendix (8).

In *Leuciscus vorax* Zinc Significant differences were found between all sites for the four season at the significant 0.05 level. In the Autumn are recorded Significant differences in sites except S3 with S4 and in the Spring and winter are recorded Significant differences in all site. For in Summer Significant differences in sites except S3 with S4 and correlation matrix for heavy metals in *Leuciscus vorax* showed that the Zinc had a positive correlation with (Cu,Cr, Ca, , Mg, ,Fe) at $p \leq 0.05$, $r = (0.7, 0.2, 0.1,0.3,0.7)$ respectively Appendix (9)

and positive relationship with (NO₂, PO₄, NO₃, TSS, pH, Salinity, DO, , TH) it is also clear that there is negative relationship with (water temperature, AT, BOD₅,) at p ≤ 0.05, r =(-0.1,-0.4,-0.2) Appendix (9).

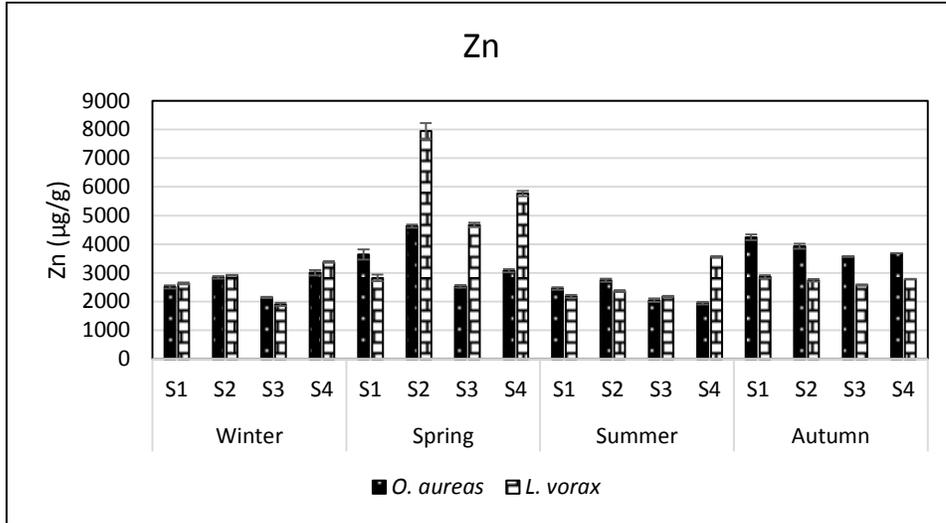


Figure (3-50) Zinc Concentration rate µg/g of *O. aureas* and *L. vorax* in study site of Mashroo Al-Musayyib channel

Table (3-35) Zinc Concentration rate $\mu\text{g/g}$ of *O. aureas* and *L.vorax* in study site of Mashroo Al-Musayyib channel

Sea. Sites	Fish species	Winter2021	Spring2021	Summer2021	Autumn2021
		min-max m \pm sd	min-max m \pm sd	min-max m \pm sd	min-max m \pm sd
S1	<i>Oreochromis aureas</i>	2440-2570 2513.3 \pm 54.36	3480-3890 3643.3 \pm 177.45	2400-2500 2456.7 \pm 41.89	4110-4360 4240 \pm 102.31
	<i>Leuciscus vorax</i>	2600-2680 2633.3 \pm 33.99	2700-2980 2823.3 \pm 116.71	2120-2240 2180 \pm 48.99	2790-2920 2863.3 \pm 54.36
S2	<i>Oreochromis aureas</i>	2790-2890 2843.3 \pm 41.09	4550-4690 4626.7 \pm 57.92	2660-2800 2743.3 \pm 60.18	3800-4000 3926.7 \pm 89.93
	<i>Leuciscus vorax</i>	2890-2940 2916.7 \pm 20.54	7580-8250 7943.3 \pm 276.45	2330-2410 2363.3 \pm 33.99	2680-2790 2740 \pm 45.46
S3	<i>Oreochromis aureas</i>	2110-2170 2143.3 \pm 24.94	2470-2580 2533.3 \pm 46.42	2000-2130 2046.7 \pm 59.06	3540-3590 3570 \pm 21.60
	<i>Leuciscus vorax</i>	1850-1980 1900 \pm 57.15	4580-4770 4670 \pm 77.88	2140-2200 2173.3 \pm 24.94	2550-2600 2573.3 \pm 20.54
S4	<i>Oreochromis aureas</i>	2920-3140 3006.7 \pm 95.68	3000-3140 3073.3 \pm 57.34	1890-2000 1943.3 \pm 44.96	3680-3690 3686.7 \pm 4.714
	<i>Leuciscus vorax</i>	3340-3410 3380 \pm 29.43	5670-5890 5766.7 \pm 91.77	3540-3590 3560 \pm 21.60	2780-2790 2783.3 \pm 4.714

4- lead (Pb)

The results recorded the lowest average concentration of (Pb)in *O. aureas* (0.2267 $\mu\text{g/g}$) in S2 for the Winter and the highest concentration rate so it reached (1.0667 $\mu\text{g/g}$) in S2 for the Spring(Table 3-36) (Figure 3-51). as for (Pb) concentrations in *L. vorax* so the lowest concentration rate is (0.2733 $\mu\text{g/g}$) in S1 of the Summer and the highest concentration rate of (Pb) (1.3903 $\mu\text{g/g}$) so it is reached in S2 for the Spring .

From the statistical analysis, it is showed that there are In *Oreochromis aureas* lead Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences

in site except S2 with S4 . In the Spring Significant differences in site except S1 with S3 and Summer are recorded Significant differences in all sites. for in winter Significant differences in sites except S1 with S4 and correlation matrix for heavy metals in *Oreochromis aureas* showed that the lead had a positive correlation with (water temperature, Cr ,Fe ,Cu ,Zn) at $p \leq 0.05$, $r = (0.1,0.5,0.7,0.5,0.6)$ respectively Appendix (8) and positive relationship with (NO₃, TSS,) it is also clear that there is negative relationship with (AT, NO₂, PO₄ , BOD₅, Mg , Ca, pH ,Salinity ,DO, TH) at $p \leq 0.05$, $r = (-0.7, -0.2,-0.1,0.3,-0.1,-0.001, -0.2,-0.3,-0.1,-0.07)$ Appendix (8) .

In *Leuciscus vorax* lead Significant differences are found between all sites for the four season at the significant 0.05 level . in the Autumn are no recorded Significant differences in sites and in spring Significant differences in S1 with all sites respectively and in Summer are recorded Significant differences in S4 with all sites. for in winter Significant differences in S2 with all sites respectively and correlation matrix for heavy metals in *Leuciscus vorax* showed that the lead had a positive correlation with (water temperature, Cr ,Fe ,Cu ,Zn) at $p \leq 0.05$, $r = (0.1,0.5,0.7,0.7,0.8)$ respectively Appendix (9) and positive relationship with (BOD₅ , TSS,) it is also clear that there is negative relationship with (AT, NO₃, NO₂, PO₄ , Mg , Ca, pH ,Salinity ,DO, TH) at $p \leq 0.05$, $r = (-0.7, -0.3,-0.6,0.5,-0.5,-0.4, -0.2,-0.4,-0.06,-0.5)$ Appendix.

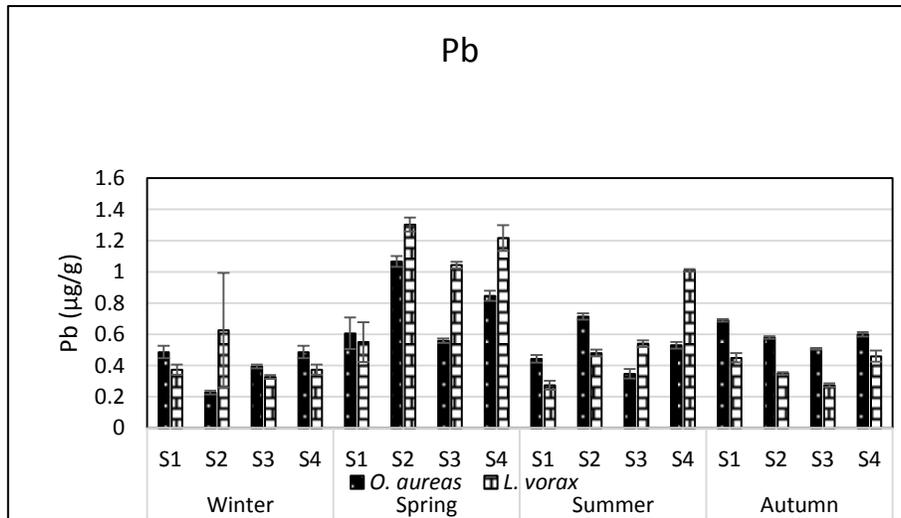


Figure (3-51) Lead Concentration rate µg/g of *O. aureas* and *L. vorax* in study site of Mashroo Al-Musayyib channel

Table (3-36) Lead Concentration rate µg/g of *O. aureas* and *L.vorax* in study site of Mashroo Al-Musayyib channel

Sea. Sites	Fish species	Winter2021	Spring2021	Summer2021	Autumn2021
		min-max m ±sd	min-max m ±sd	min-max m ±sd	min-max m ±sd
S1	<i>Oreochromis aureas</i>	0.43-0.52 0.4867±0.04	0.47-0.71 0.6067±0.1	0.41-0.47 0.4433±0.02	0.68-0.7 0.69±0.008
	<i>Leuciscus vorax</i>	0.33-0.41 0.3733±0.03	0.45-0.73 0.55±0.127	0.24-0.31 0.2733±0.028	0.41-0.48 0.45±0.029
S2	<i>Oreochromis aureas</i>	0.21-0.24 0.2267±0.01	1.02-1.1 1.0667±0.03	0.69-0.74 0.7133±0.02	0.57-0.59 0.58±0.008
	<i>Leuciscus vorax</i>	0.11-0.92 0.6267±0.36	1.25-1.36 1.3033±0.045	0.45-0.5 0.48±0.02	0.34-0.36 0.35±0.008
S3	<i>Oreochromis aureas</i>	0.38-0.41 0.3933±0.01	0.55-0.58 0.56±0.01	0.32-0.39 0.3467±0.03	0.5-0.51 0.5067±0.0047
	<i>Leuciscus vorax</i>	0.31-0.34 0.3267±0.01	1.02-1.07 1.0433±0.02	0.51-0.56 0.54±0.02	0.26-0.29 0.2733±0.01
S4	<i>Oreochromis aureas</i>	0.43-0.52 0.4867±0.04	0.8-0.87 0.8467±0.03	0.51-0.56 0.53±0.02	0.59-0.62 0.6±0.01
	<i>Leuciscus vorax</i>	0.33-0.41 0.3733±0.03	1.14-1.33 1.2167±0.08	1-1.02 1.01±0.008	0.41-0.49 0.46±0.035

5- Nickel (Ni)

The results recorded the lowest average concentration of (Ni) in *O. aureas* (0.0333 $\mu\text{g/g}$) in S3 for the Autumn and the highest concentration rate if it reached (0.2833 $\mu\text{g/g}$) in S2 for the Spring (Table 3-37) (Figure 3-52) as for (Ni) concentrations in *L. vorax* if the lowest concentration rate was (0.0133 $\mu\text{g/g}$) in S3 of the Autumn and the highest concentration rate of (Ni) (0.5633 $\mu\text{g/g}$) if it is reached in S4 for the Spring .

From the statistical analysis, it is showed that there are in *Oreochromis aureas* Nickel Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences in S1 with S3 and S4 respectively .

In the Spring Significant differences in site except S1 with S3 and in Summer are recorded Significant differences in S4 with S3 and S1 respectively . for in winter Significant differences in S1 with S2 and S4 respectively. and correlation matrix for heavy metals in *Oreochromis aureas* showed that the Nickel had a positive correlation with (Cr ,Fe ,Pb ,Zn) at $p \leq 0.05$, $r = (0.2, 0.1, 0.4, 0.1)$ Appendix (8) and positive relationship with (pH ,Salinity ,DO, BOD₅) it is also clear that there is negative relationship with (water temperature, AT, NO₂, PO₄ , Cu, Mg , Ca, TH ,NO₃, TSS) at $p \leq 0.05$, $r = (-0.5, -0.3, -0.6, 0.4, -0.3, -0.4, -0.7, -0.7, -0.4, -0.3)$ Appendix (8).

In *Leuciscus vorax* Nickel Significant differences are found between all sites for the four season at the significant 0.05 level . In the Autumn are recorded Significant differences in S1 with S3 respectively . In the Spring Significant differences in all site and in Summer are recorded Significant differences in sites except in S1 with S2. for in winter Significant differences in sites except in S3

with S4 and correlation matrix for heavy metals in *Leuciscus vorax* showed that the Nickel had a positive correlation with (Cr ,Fe ,Pb ,Zn, Cu) at $p \leq 0.05$, $r = (0.3,0.6,0.9,0.7,0.5)$ Appendix (9) and positive relationship with (pH,DO, BOD₅) it is also clear that there is negative relationship with (water temperature, Salinity ,AT, NO₃, PO₄ , Mg , Ca, TH , NO₂, TSS) at $p \leq 0.05$, $r = (-0.09, -0.2,-0.5,0.6,-0.5,-0.5, -0.5,-0.6,-0.4,-0.05)$ Appendix (9).

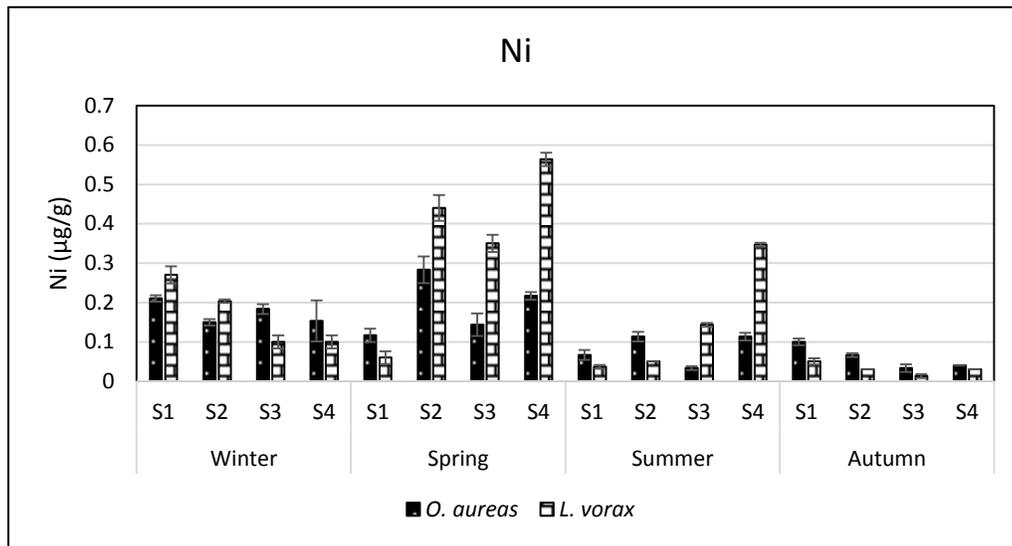


Figure (3-52) Nickel Concentration rate µg/g of *O. aureas* and *L. vorax* in study site of Mashroo Al-Musayyib channel

Table (3-37) Nickel Concentration rate $\mu\text{g/g}$ of *O. aureas* and *L. vorax* in study site of Mashroo Al-Musayyib channel

Sea. Sites	Fish species	Winter2021	Spring2021	Summer2021	Autumn2021
		min-max m \pm sd	min-max m \pm sd	min-max m \pm sd	min-max m \pm sd
S1	<i>Oreochromis aureas</i>	0.2-0.22 0.21 \pm 0.008	0.1-0.14 0.1167 \pm 0.017	0.05-0.08 0.0667 \pm 0.01	0.09-0.11 0.1 \pm 0.008
	<i>Leuciscus vorax</i>	0.24 -0.29 0.27 \pm 0.02	0.04-0.08 0.06 \pm 0.016	0.03-0.04 0.0367 \pm 0.004	0.04-0.06 0.05 \pm 0.008
S2	<i>Oreochromis aureas</i>	0.14-0.16 0.15 \pm 0.008	0.25-0.33 0.2833 \pm 0.03	0.1-0.13 0.1133 \pm 0.01	0.06-0.07 0.0667 \pm 0.0047
	<i>Leuciscus vorax</i>	0.2-0.21 0.2 \pm 0.004	0.4-0.48 0.44 \pm 0.03	0.05-0.05 0.05 \pm 0.008	0.03-0.03 0.03 \pm 0
S3	<i>Oreochromis aureas</i>	0.17-0.2 0.18 \pm 0.01	0.11-0.18 0.1433 \pm 0.028	0.03-0.04 0.0333 \pm 0.0047	0.02-0.04 0.0333 \pm 0.009
	<i>Leuciscus vorax</i>	0.08-0.12 0.1 \pm 0.016	0.33-0.38 0.35 \pm 0.02	0.14-0.15 0.1433 \pm 0.0047	0.01-0.02 0.01 \pm 0.0047
S4	<i>Oreochromis aureas</i>	0.08-0.2 0.153 \pm 0.05	0.21-0.23 0.2167 \pm 0.009	0.1-0.12 0.1133 \pm 0.009	0.04-0.04 0.04 \pm 0
	<i>Leuciscus vorax</i>	0.08-0.12 0.1 \pm 0.016	0.54-0.58 0.5633 \pm 0.017	0.34-0.35 0.3467 \pm 0.004	0.03-0.03 0.03 \pm 0

6- Cadmium (Cd)

The results recorded the lowest average concentration of (Cd) in *O. aureas* (0.0133 $\mu\text{g/g}$) in S3 and S1 for the Autumn ,Summer respectively and the highest concentration rate if it reached (0.3200 $\mu\text{g/g}$) in S3 for the Winter(Table 3-38) (Figure 3-53) . as for (Cd) concentrations in *L. vorax* if the lowest concentration rate is (0.0133 $\mu\text{g/g}$) in S3 and S1 of the Autumn , Summer respectively and the highest concentration rate of (Cd) (0.7000 $\mu\text{g/g}$) if it is reached in S2 for the Spring .

From the statistical analysis, it was showed that there are In *Oreochromis aureas* Cadmium Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant

differences in S1 with S3 and S4 respectively . in the Spring Significant differences in all site and in Summer are recorded Significant differences in sites except S2 with S3. for in winter Significant differences in S3 with all sites respectively and correlation matrix for heavy metals in *Oreochromis aureas* showed that the Cadmium had a Positive correlation with (Ni ,Cr ,Fe , Pb ,) at $p \leq 0.05$, $r = (0.6,0.3,0.002, 0.2)$ Appendix (8) and Positive relationship with (pH , ,DO, BOD₅) it is also clear that there is negative relationship with (water temperature, Salinity, AT, NO₂, PO₄ , Cu, Mg , Ca, Zn, TH ,NO₃, TSS) at $p \leq 0.05$, $r = (-0.2, -0.01,-0.1,0.4,-0.3,-0.3, -0.6,-0.3,-0.2,-0.5,-0.3,-0.1)$ Appendix (8).

In *Leuciscus vorax* Cadmium Significant differences are found between all sites for the four season at the significant 0.05 level . in the Autumn are no recorded Significant differences in site . in the Spring Significant differences in all site and in Summer are recorded Significant differences in S3 with S1 and S2 respectively .

For in winter Significant differences in S3 with all sites respectively and correlation matrix for heavy metals in *Leuciscus vorax* showed that the Cadmium had a Positive correlation with (water temperature, Cr ,Fe ,Pb ,Zn, Cu ,Ni) at $p \leq 0.05$, $r = (0.1,0.4,0.5,0.8,0.8,0.6,0.8)$ Appendix (9) it is also clear that there is negative relationship with (Salinity ,AT, NO₂, PO₄ , Mg , Ca, TH ,NO₃, TSS, pH,DO, BOD₅) at $p \leq 0.05$, $r = (-0.4, -0.5,-0.6,0.4,-0.5,-0.4, -0.5,-0.3,-0.1,-0.2,-0.1,-0.03)$ Appendix (9)

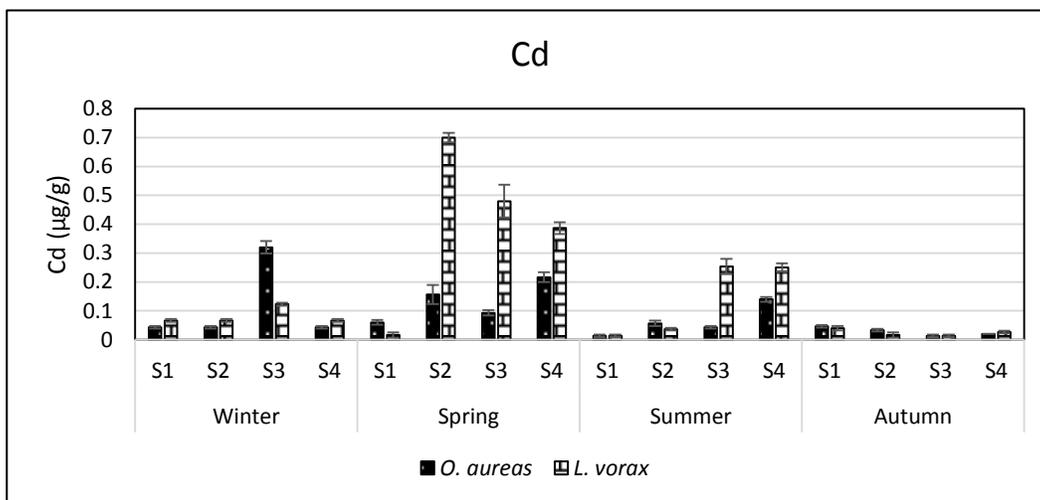


Figure (3-53) Cadmium Concentration rate µg/g of *O. aureas* and *L. vorax* in study site of Mashroo Al-Musayyib channel

Table (3-38) Cadmium Concentration rate µg/g of *O. aureas* and *L. vorax* in study site of Mashroo Al-Musayyib channel

Sea. Sites	Fish species	Winter2021	Spring2021	Summer2021	Autumn2021
		min-max m ±sd	min-max m ±sd	min-max m ±sd	min-max m ±sd
S1	<i>Oreochromis aureas</i>	0.04-0.05 0.0433 ±0.0047	0.05-0.07 0.06 ±0.008	0.01-0.02 0.0133±0.0047	0.04-0.05 0.0467±0.0047
	<i>Leuciscus vorax</i>	0.06-0.07 0.0667 ±0.0047	0.01-0.03 0.0167 ±0.009	0.01-0.02 0.0133±0.0047	0.03-0.05 0.04±0.008
S2	<i>Oreochromis aureas</i>	0.04-0.05 0.0433 ±0.0047	0.12-0.2 0.1567 ±0.03	0.05-0.07 0.0567±0.009	0.03-0.04 0.0333±0.0047
	<i>Leuciscus vorax</i>	0.06-0.07 0.0667 ±0.0047	0.68-0.72 0.7 ±0.016	0.03-0.04 0.0367±0.0047	0.01-0.03 0.0167 ±0.009
S3	<i>Oreochromis aureas</i>	0.3-0.35 0.32 ±0.02	0.08-0.1 0.0933 ±0.009	0.04-0.05 0.0433±0.0047	0.01-0.02 0.0133 ±0.0047
	<i>Leuciscus vorax</i>	0.12-0.13 0.1233 ±0.0047	0.41-0.55 0.48 ±0.057	0.23-0.29 0.2533±0.026	0.01-0.02 0.0133 ±0.0047
S4	<i>Oreochromis aureas</i>	0.04-0.05 0.0433 ±0.0047	0.2-0.24 0.2167 ±0.017	0.13-0.15 0.14±0.008	0.02-0.02 0.02 ±0
	<i>Leuciscus vorax</i>	0.06-0.07 0.0667 ±0.0047	0.39-0.41 0.3867 ±0.02	0.24-0.27 0.25 ±0.01	0.02-0.03 0.0267 ±0.0047

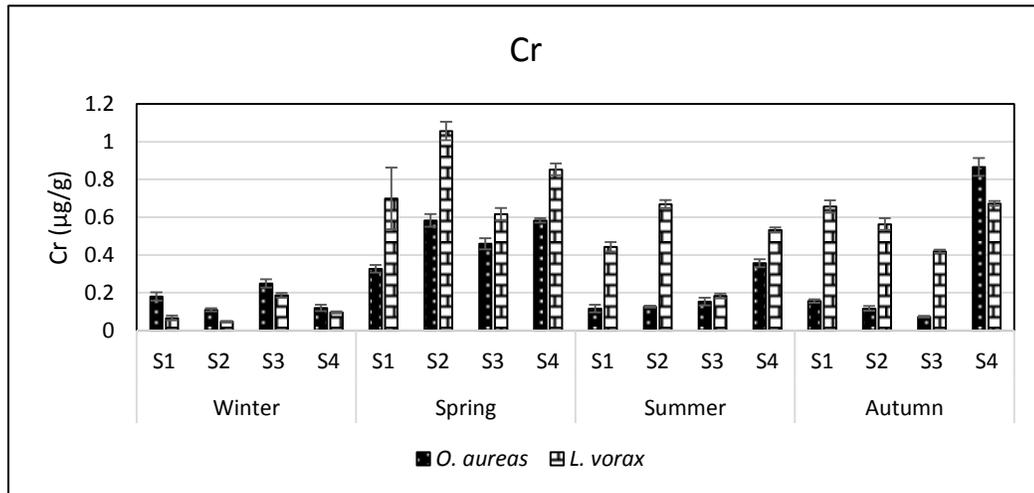
7- Chromium (Cr)

The results recorded the lowest average concentration of (Cr) in *O. aureas* (0.0733 $\mu\text{g/g}$) in S3 for the Autumn and the highest concentration rate if it reached (0.8667 $\mu\text{g/g}$) in S4 for the Autumn (Table3-39) (Figure 3-54). as for (Cr) concentrations in *L. vorax* if the lowest concentration rate is (0.0467 $\mu\text{g/g}$) in S2 of the Winter and the highest concentration rate of (Cr) (1.0567 $\mu\text{g/g}$) if it is reached in S2 for the Spring .

From the statistical analysis, it is showed that there are In *Oreochromis aureas* chromium Significant differences are found between all sites for the four season at the significant 0.05 level .in the Autumn are recorded Significant differences in S4 with all sites respectively in the Spring are recorded Significant differences in sites except S2 with S4 and in Summer Significant differences in S4 with all sites . for in the winter significant differences were found in sites except S2 with S4 and correlation matrix for heavy metals in *Oreochromis aureas* showed that the chromium had a Positive correlation with (water temperature, NO_3 , TSS , BOD_5) at $p \leq 0.05$, $r = (0.03, 0.2, 0.3, 0.03)$ respectively Appendix (8) and it is also clear that there is negative relationship with (,AT, Ca, , pH ,Salinity, DO , Mg, NO_2 , PO_4 , TH) at $p \leq 0.05$, $r = (-0.7, -0.07, -0.1, -0.2, -0.07, -0.2, -0.1, -0.03, -0.1)$ Appendix (8).

In *Leuciscus vorax* chromium Significant differences are found between all sites for the four season at the significant 0.05 level . in the Autumn are recorded Significant differences in S3 with all sites respectively. in the Spring are recorded Significant differences in sites except S1 with S3 and in Summer Significant differences in sites except S1 with S4. for in the winter significant differences are found in S3 with S1 and S2 respectively and correlation matrix for heavy metals in *Leuciscus vorax* showed that the chromium had a Positive correlation

with (water temperature, NO₃, Ca, TSS , TH) at $p \leq 0.05$, $r = (0.4, 0.1, 0.2, 0.4, 0.02)$ respectively Appendix (9) and it is also clear that there is negative relationship with (AT, pH ,Salinity, DO , Mg, NO₂, PO₄, BOD₅) at $p \leq 0.05$, $r = (-0.7, -0.4, -0.5, -0.3, -0.2, -0.1, -0.08, -0.4)$ Appendix (9)



Figure(3-54) Chromium Concentration rate µg/g of *O.aureas* and *L.vorax* in study site of Mashroo Al-Musayyib channel

Table (3-39) Chromium Concentration rate $\mu\text{g/g}$ of *O. aureas* and *L. vorax* in study site of Mashroo Al-Musayyib channel

Sea. Sites	Fish species	Winter2021	Spring2021	Summer2021	Autumn2021
		min-max m \pm sd	min-max m \pm sd	min-max m \pm sd	min-max m \pm sd
SI	<i>Oreochromis aureas</i>	0.16-0.21 0.18 \pm 0.02	0.3-0.35 0.3267 \pm 0.02	0.09-0.14 0.1167 \pm 0.02	0.15-0.17 0.1567 \pm 0.009
	<i>Leuciscus vorax</i>	0.05-0.08 0.0667 \pm 0.01	0.5-0.9 0.7 \pm 0.16	0.41-0.47 0.4433 \pm 0.02	0.62-0.7 0.6567 \pm 0.033
S2	<i>Oreochromis aureas</i>	0.1-0.12 0.11 \pm 0.008	0.55-0.63 0.5833 \pm 0.03	0.12-0.13 0.1267 \pm 0.0047	0.1-0.13 0.1167 \pm 0.0125
	<i>Leuciscus vorax</i>	0.04-0.05 0.046 \pm 0.0047	1-1.12 1.0567 \pm 0.04	0.65-0.7 0.67 \pm 0.02	0.52-0.59 0.5633 \pm 0.03
S3	<i>Oreochromis aureas</i>	0.23-0.28 0.25 \pm 0.02	0.42-0.49 0.46 \pm 0.029	0.13-0.18 0.1533 \pm 0.02	0.07-0.08 0.0733 \pm 0.0047
	<i>Leuciscus vorax</i>	0.17-0.2 0.1867 \pm 0.01	0.58-0.66 0.6167 \pm 0.033	0.17-0.2 0.1833 \pm 0.01	0.41-0.43 0.42 \pm 0.0082
S4	<i>Oreochromis aureas</i>	0.1-0.14 0.12 \pm 0.016	0.57-0.6 0.5833 \pm 0.0125	0.33-0.38 0.3567 \pm 0.02	0.8-0.9 0.8667 \pm 0.0471
	<i>Leuciscus vorax</i>	0.09-0.1 0.0967 \pm 0.0047	0.81-0.88 0.8533 \pm 0.03	0.52-0.55 0.5333 \pm 0.01	0.66-0.69 0.6733 \pm 0.0125

3-5: Water Quality index (Canadian Model) (CWQI)

The current study deal with to determine its suitability for the maintenance of rivers are depended on(13) Total parameter each (Table 3-41). The results showed the Canadian model of water quality index (CWQI) value for the maintenance of rivers ranging between (24.901-39.600) at the fourth site of the autumn and the third site for the winter respectively Fig.(3-55) and when compared with the standard values of water conservation it turns out that (poor) Water is always subject to pollution and is far values ideal at all times (Table 3-40).

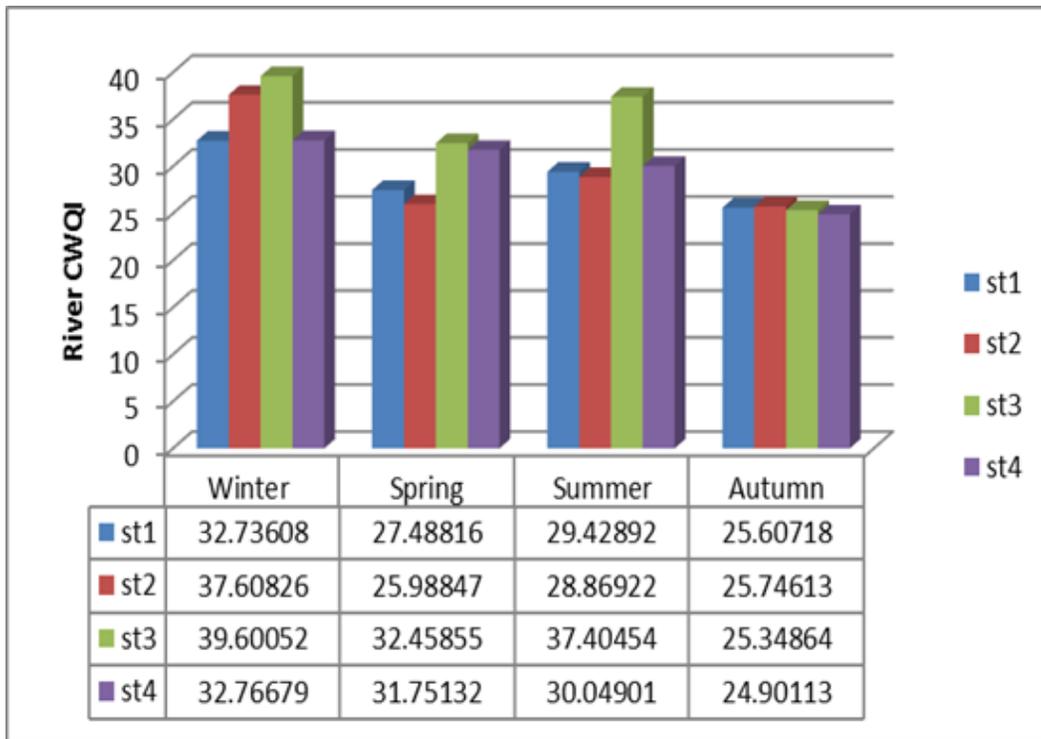


Figure (3-55) :- Value of Mashroo Al-Musayyib channel Rivers Maintenance CWQI for study site area

As for determining the suitability the river for aquatic environment (GWQI) are depended on(14) parameter each (Table 3-41). The results showed the CWQI value for the determine its suitability for aquatic environment ranging between (8.279- 19.474) at the first site of the Autumn and the fourth site for the spring respectively (Fig 3-56) and when compared with the standard values of water conservation it turns out that (poor)Water is always prone to pollution and is far from ideal at all times (Table 3-40).

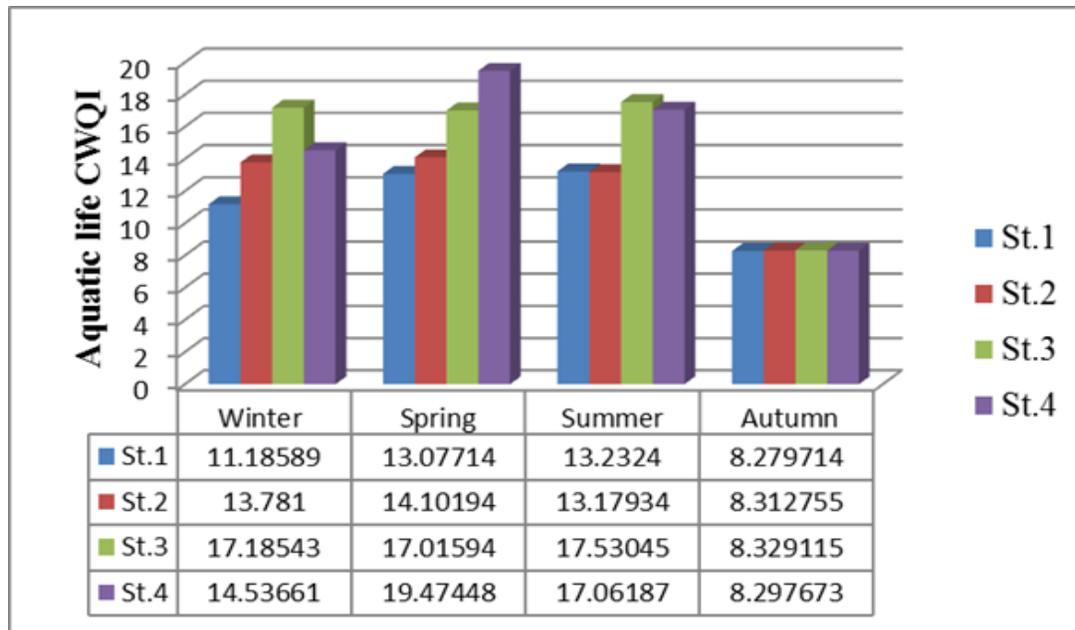


Figure (3-56):- Water quality index for the aquatic life(GWQI) for Mashroo Al-Musayyib channel between Winter 2021 to Autumn 2021 on the study site

As for determining the suitability of the river for irrigation, it depended on (11) parameter each (Table 3-41) the results showed the CWQI value ranging between (43.044-61-422) at the first site of the Autumn and the third site for the winter respectively(Fig 3-57) , and when compared with the standard values 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 subject to pollution and is far from ideal at all times (Table 3-40).

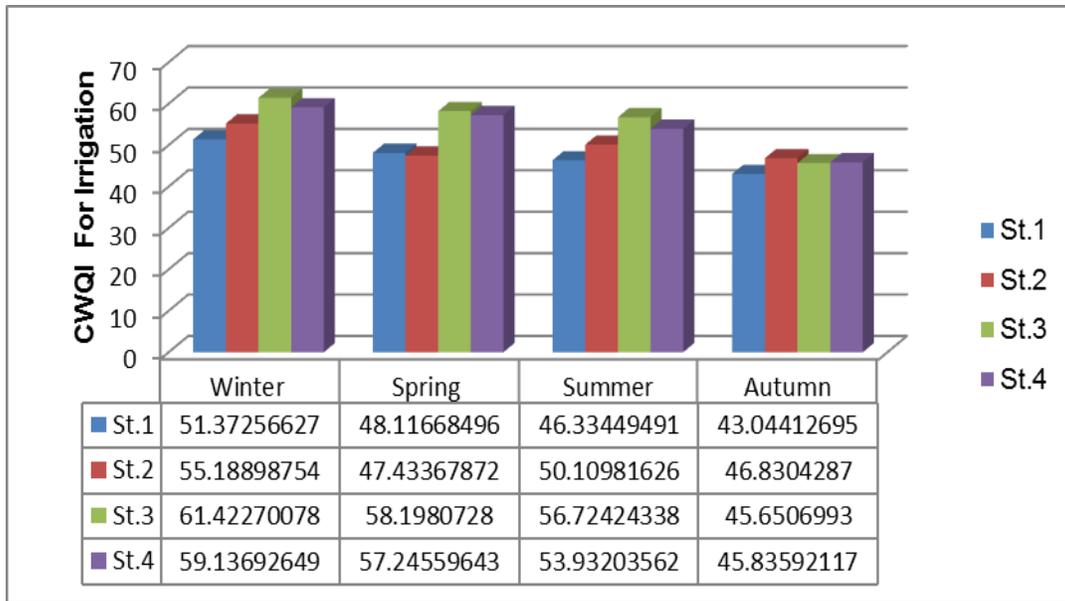


Figure (3-57):- Irrigation water quality index(IWQI) for study sites between in Musayyib river .

3-6: pollution index

The Index of pollution including two types of were index studied to determine the extent of pollution of the river it is heavy Pollution Index (HPI) and the contamination index (C_d). The HPI values which are noticed are recorded greater than the Critical Pollution Index of (100) average value ranged between (74.38388 - 238 .5592) in S3 for Winter and S2 for spring (Fig 3-58) . As for the contamination index (C_d) The values of (C_d) ranged from (23.061-84.070) in site three in winter and site two in spring (Fig ,3-59) that $C_d >3$ the pollution is high.

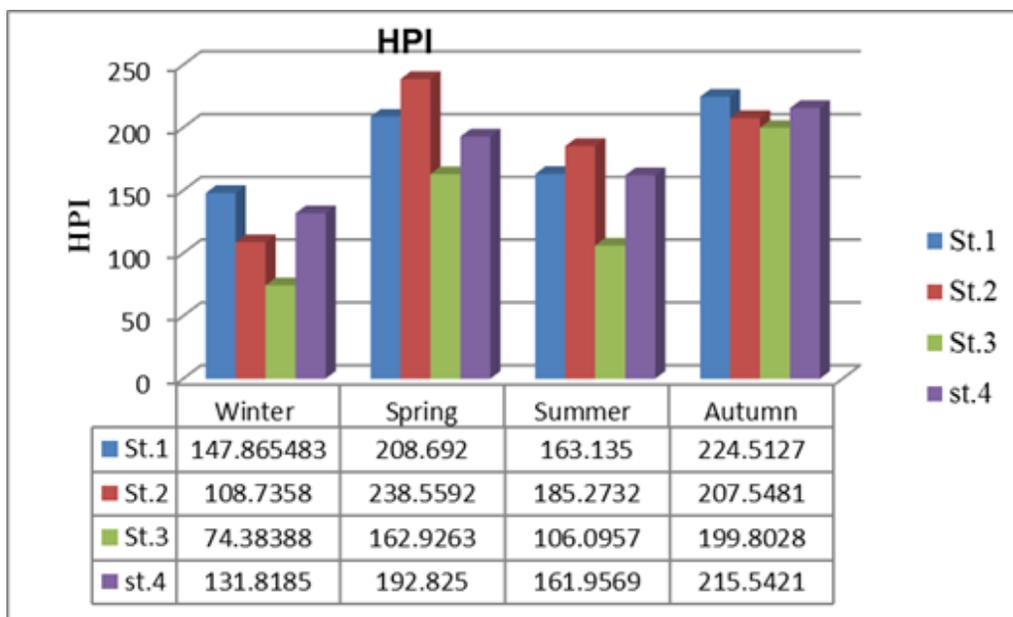


Figure (3-58) :- Heavy metals index (HPI) on study sites of Mashroo Al-Musayyib channel

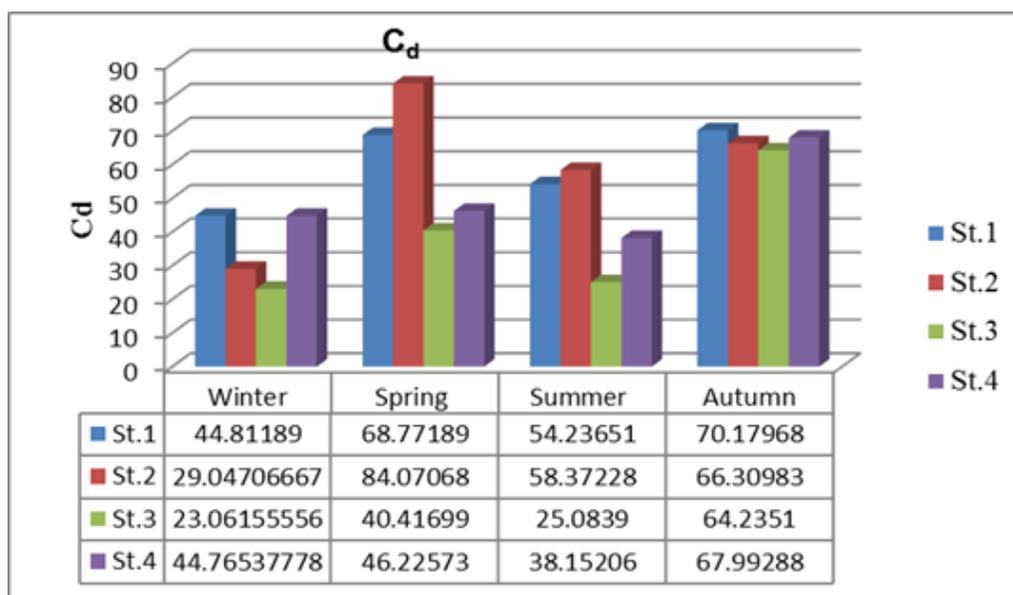


Figure (3-59):- Contamination index(C_d) for study sites of Mashroo Al-Musayyib channel

Table (3-40) Water Quality Guide Scale (Canadian Model) CWQI

Water quality statues	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 (3-41) Iraqi and international standards used to calculate the water quality index.

Parameters	Rivers Maintenance system (1967)	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***	-
NO ₃	15*	13***	-
NO ₂	-	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 ^{###}

- : Non found

***CCME (2007)

^{###} CCME (2005)

**FAO (1994)

[#] Ayers and Westcot (1985)

*New Determinants of the Pollution Rivers Maintenance Law No. (35) of 1967 and the Instructions AtAir temperatureched thereto

3-7: Bio concentration factor(BCF) and Bio sedimentation factor (BSF)

The current results showed that *Pseudontopeses euphratic* recorded the value of the Bio concentration factor of the copper element and is very high (21.7) as well as the Bio sedimentation factor is high for the element itself (2.41) in site three in winter while the value of the bio concentration factor of the iron element is recorded the value (17.5) in site three in winter and is higher than the Bio sedimentation factor (Table 3-42).

In *Ceratophyllum demersum* recorded the value of the bio concentration factor of the copper element and is very high (20.5) in site three in winter and is higher than the Bio sedimentation factor (2.27) while the value of the bio concentration factor of the iron element is recorded the value (10.6) in site three in spring and is higher than the Bio sedimentation factor (1.95) (Table 3-44).

As for as in *Phragmites australis* recorded the value of the Bio concentration factor of the copper element and is very high (19) in site three in winter and is higher than the Bio sedimentation factor (2.2) while the value of the bio concentration factor of the Iron element is recorded the value (13.3) in site three in spring and is higher than the Bio sedimentation factor(2.45) (Table 3-46) and recorded the value of the Bio concentration factor of the cadmium element and is high (6.1) in site three in summer and was higher than the Bio sedimentation factor (0.28) Table(3-47).

As for as in *Oreochromis aureas* recorded the value of the Bio concentration factor of the Iron element and is high (8.07) in site three in winter and is higher than the Bio sedimentation factor(2.42) (Table 3-48).

In *Leuciscus vorax* recorded the value of the Bio concentration factor of the Iron element and is high (8.63) in site two in winter and is higher than the Bio

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sedimentation factor (2.59) Table (3-50) recorded the value of the Bio concentration factor of the cadmium element and was high (6.91) in site three in summer and is higher than the Bio sedimentation factor (0.317) (Table 5).

Table (3-42) Bio concentration factor (BCF) and Bio sedimentation factor (BSF) for Clam *Pseudontopetes euphratic* in the study site of Mashroo Al-Musayyib channel

<i>Pseudontopetes euphratic</i>																					
Season	Site	Cr					Fe					Cu					Zn				
		Water	sed.	con.	BCF	BSF	Water	Sed	Con	BCF	BSF	Water	sed.	con.	BCF	BSF	Water	Sed	con.	BCF	BSF
Winter	S1	0.13	0.2	0.04	0.34	0.21	806.7	2667	7250	8.99	2.72	773.333	6197	6820	8.82	1.1	16733	18767	14307	0.85	0.76
	S2	0.1	0.13	0.03	0.32	0.25	640	2137	9390	14.7	4.39	563.333	4777	7823.3	13.9	1.64	11233	12667	15257	1.36	1.2
	S3	0.11	0.2	0.17	1.63	0.88	536.7	1533	9390	17.5	6.12	360	3250	7823.3	21.7	2.41	10500	10593	15257	1.45	1.44
	S4	0.12	0.2	0.04	0.35	0.21	883.3	1883	13563	15.4	7.2	650	3507	8286.7	12.7	2.36	17817	11623	17193	0.97	1.48
Spring	S1	0.88	0.95	0.07	0.08	0.08	1307	5753	10483	8.02	1.82	1056.67	13730	8220	7.78	0.6	24967	24647	17390	0.7	0.71
	S2	1.06	1.24	0.04	0.04	0.03	1523	7393	12533	8.23	1.7	1263.33	16333	9500	7.52	0.58	30227	27497	19267	0.64	0.7
	S3	0.75	1.01	0.05	0.07	0.05	966.7	5267	9833	10.2	1.87	946.667	12347	7363.3	7.78	0.6	12537	18773	17340	1.38	0.92
	S4	0.97	1.17	0.13	0.14	0.11	1130	6253	10510	9.3	1.68	1130	13323	8316.7	7.36	0.62	13320	19627	18450	1.39	0.94
Summer	S1	0.67	0.44	0.04	0.06	0.09	993.3	4883	7473	7.52	1.53	836.667	11470	5853.3	7	0.51	20480	21407	11243	0.55	0.53
	S2	0.77	0.61	0.05	0.06	0.08	1283	5270	7697	6	1.46	970	11680	6046.7	6.23	0.52	20710	21733	11773	0.57	0.54
	S3	0.34	0.71	0.02	0.05	0.02	760	3277	5473	7.2	1.67	616.667	8267	3276.7	5.31	0.4	8556.7	12480	11263	1.32	0.9
	S4	0.69	0.69	0.05	0.08	0.08	1017	3273	8237	8.1	2.52	950	7597	5530	5.82	0.73	11290	11260	12643	1.12	1.12
Autumn	S1	1.15	0.63	0.08	0.07	0.12	1553	8407	8507	5.48	1.01	1180	18067	7470	6.33	0.41	24040	26543	15267	0.64	0.58
	S2	1.02	0.56	0.04	0.04	0.07	1400	8047	8223	5.87	1.02	1083.33	18060	7206.7	6.65	0.4	23343	25443	14553	0.62	0.57
	S3	0.86	0.42	0.03	0.03	0.06	1260	7773	8033	6.38	1.03	1050	17230	7020	6.69	0.41	22890	23563	14060	0.61	0.6
	S4	1.01	0.52	0.03	0.03	0.06	1483	8133	8223	5.54	1.01	1133.33	18207	7153.3	6.31	0.39	23543	23910	14250	0.61	0.6

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Table (3-43) Bio concentration factor (BCF) and Bio sedimentation factor (BSF) for Clam *Pseudontopetes euphratic* in the study site of Mashroo Al-Musayyib channel

<i>Pseudontopetes euphratic</i>																
Season	Site	Pb					Ni					Cd				
		Water	sed.	con.	BCF	BSF	Water	Sed	Con	BCF	BSF	Water	sed.	con.	BCF	BSF
Winter	S1	1.06	4.133	1.04	0.99	0.25	6.2	3.33	0.93	0.15	0.28	0.52	0.137	0.14	0.27	1.02
	S2	0.85	2.733	1.18	1.39	0.43	5.6	2.17	0.42	0.08	0.2	0.5267	0.073	0.147	0.28	2
	S3	0.3	0.35	1.13	3.82	3.24	0.127	0.36	0.42	3.37	1.17	0.3167	0.11	0.147	0.46	1.33
	S4	0.99	4.133	1.09	1.1	0.26	6.133	3.33	0.32	0.05	0.1	0.52	0.137	0.14	0.27	1.02
Spring	S1	2.17	5.98	1.28	0.59	0.21	11.27	5.47	1.46	0.13	0.27	0.88	1.36	0.207	0.23	0.15
	S2	3.59	7.537	1.04	0.29	0.14	12.71	5.97	1.21	0.1	0.2	0.2633	1.51	0.09	0.34	0.06
	S3	2.1	5.323	0.87	0.41	0.16	9.657	3.65	0.737	0.08	0.2	0.1733	1.037	0.08	0.46	0.08
	S4	2.16	6.27	1.13	0.52	0.18	10.25	4.2	0.83	0.08	0.2	0.27	1.19	0.907	3.36	0.76
Summer	S1	1.7	4.773	1	0.59	0.21	8.6	3.73	1.14	0.13	0.31	0.4933	0.987	0.143	0.29	0.15
	S2	2.3	4.997	1.14	0.5	0.23	9.903	4.02	1.33	0.13	0.33	0.57	1.13	0.263	0.46	0.23
	S3	1.39	3.18	0.54	0.39	0.17	6.19	1.28	0.36	0.06	0.28	0.0367	0.8	0.013	0.36	0.02
	S4	2.01	3.607	0.85	0.42	0.24	9.183	1.49	0.53	0.06	0.36	0.1867	0.86	0.627	3.36	0.73
Autumn	S1	2.05	5.05	1.32	0.64	0.26	10.59	5.73	1.42	0.13	0.25	0.76	1.603	0.33	0.43	0.21
	S2	1.85	4.867	1.24	0.67	0.25	9.697	5.55	1.25	0.13	0.23	0.6767	1.35	0.22	0.33	0.16
	S3	1.54	4.58	1.02	0.66	0.22	9.383	5.55	1.07	0.11	0.19	0.5667	1.217	0.143	0.25	0.12
	S4	1.75	4.673	1.13	0.64	0.24	10.31	5.75	1.12	0.11	0.2	0.6833	1.347	0.22	0.32	0.16

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Table (3-44) Bio concentration factor (BCF) and Bio sedimentation factor (BSF) for aquatic plant *Ceratophyllum demersum* in the study site of Mashroo Al-Musayyib channel

<i>Ceratophyllum demersum</i>																					
Season	Site	Cr					Fe					Cu					Zn				
		Water	sed.	con.	BCF	BSF	Water	Sed	Con	BCF	BSF	Water	sed.	con.	BCF	BSF	Water	Sed	con.	BCF	BSF
Winter	S1	0.13	0.2	0.26	2.05	1.28	806.7	2667	4527	5.61	1.7	773.3	6196.7	7217	9.33	1.16	16733	18767	12160	0.73	0.6
	S2	0.1	0.13	0.15	1.42	1.1	640	2137	4520	7.06	2.12	563.3	4776.7	7383	13.1	1.55	11233	12667	13447	1.2	1.1
	S3	0.11	0.2	0.1	0.94	0.51	536.7	1533	4520	8.42	2.95	360	3250	7383	20.5	2.27	10500	10593	13447	1.28	1.3
	S4	0.12	0.2	0.26	2.11	1.28	883.3	1883	5047	5.71	2.68	650	3506.7	9183	14.1	2.62	17817	11623	17493	0.98	1.5
Spring	S1	0.88	0.95	0.36	0.4	0.38	1307	5753	10833	8.29	1.88	1057	13730	7103	6.72	0.52	24967	24647	13700	0.55	0.6
	S2	1.06	1.24	0.48	0.45	0.39	1523	7393	12197	8.01	1.65	1263	16333	1036	8.21	0.63	30227	27497	15433	0.51	0.6
	S3	0.75	1.01	0.08	0.11	0.08	966.7	5267	10277	10.6	1.95	946.7	12347	7560	7.99	0.61	12537	18773	11493	0.92	0.6
	S4	0.97	1.17	0.08	0.09	0.07	1130	6253	11400	10.1	1.82	1130	13323	8463	7.49	0.64	13320	19627	13540	1.02	0.7
Summer	S1	0.67	0.44	0.14	0.2	0.31	993.3	4883	7157	7.2	1.47	836.7	11470	5267	6.29	0.46	20480	21407	7493	0.37	0.4
	S2	0.77	0.61	0.28	0.36	0.46	1283	5270	7497	5.84	1.42	970	11680	5500	5.67	0.47	20710	21733	7703	0.37	0.4
	S3	0.34	0.71	0.03	0.1	0.05	760	3277	6557	8.63	2	616.7	8266.7	4143	6.72	0.5	8557	12480	7160	0.84	0.6
	S4	0.69	0.69	0.03	0.05	0.05	1017	3273	7483	7.36	2.29	950	7596.7	5647	5.94	0.74	11290	11260	9050	0.8	0.8
Autumn	S1	1.15	0.63	0.31	0.27	0.49	1553	8407	8690	5.59	1.03	1180	18067	6590	5.58	0.36	24040	26543	9553	0.4	0.4
	S2	1.02	0.56	0.24	0.24	0.43	1400	8047	7573	5.41	0.94	1083	18060	6163	5.69	0.34	23343	25443	9120	0.39	0.4
	S3	0.86	0.42	0.13	0.16	0.32	1260	7773	7123	5.65	0.92	1050	17230	6027	5.74	0.35	22890	23563	8967	0.39	0.4
	S4	1.01	0.52	0.23	0.23	0.44	1483	8133	7347	4.95	0.9	1133	18207	6247	5.51	0.34	23543	23910	9147	0.39	0.4

Chapter Three..... Results

Table (3-45) Bio concentration factor (BCF) and Bio sedimentation factor (BSF) for aquatic plant *Ceratophyllum demersum* in the study site of Mashroo Al-Musayyib channel

<i>Ceratophyllum demersum</i>																
Season	Site	Pb					Ni					Cd				
		Water	sed.	con.	BCF	BSF	Water	Sed	Con	BCF	BSF	Water	sed.	con.	BCF	BSF
Winter	S1	1.06	4.133	0.45	0.43	0.11	6.2	3.333	0.263	0.04	0.1	0.52	0.14	0.2	0.33	1.24
	S2	0.85	2.733	0.12	0.14	0.04	5.6	2.167	0.103	0.02	0	0.5267	0.07	0.2	0.43	3.09
	S3	0.3	0.35	0.12	0.39	0.33	0.127	0.363	0.103	0.82	0.3	0.3167	0.11	0.1	0.38	1.09
	S4	0.99	4.133	0.04	0.04	0.01	6.133	3.333	0.263	0.04	0.1	0.52	0.14	0.2	0.33	1.24
Spring	S1	2.17	5.98	0.53	0.25	0.09	11.27	5.473	0.337	0.03	0.1	0.88	1.36	0.2	0.26	0.17
	S2	3.59	7.537	0.67	0.19	0.09	12.71	5.97	0.433	0.03	0.1	0.2633	1.51	0.4	1.33	0.23
	S3	2.1	5.323	0.36	0.17	0.07	9.657	3.647	0.307	0.03	0.1	0.1733	1.04	0.2	1.06	0.18
	S4	2.16	6.27	0.53	0.24	0.08	10.25	4.203	0.407	0.04	0.1	0.27	1.19	0.3	1	0.23
Summer	S1	1.7	4.773	0.34	0.2	0.07	8.6	3.727	0.14	0.02	0	0.4933	0.99	0.1	0.22	0.11
	S2	2.3	4.997	0.59	0.26	0.12	9.903	4.02	0.387	0.04	0.1	0.57	1.13	0.3	0.45	0.23
	S3	1.39	3.18	0.92	0.66	0.29	6.19	1.277	0.123	0.02	0.1	0.0367	0.8	0.1	1.82	0.08
	S4	2.01	3.607	0.31	0.16	0.09	9.183	1.487	0.147	0.02	0.1	0.1867	0.86	0.1	0.55	0.12
Autumn	S1	2.05	5.05	0.56	0.27	0.11	10.59	5.73	0.34	0.03	0.1	0.76	1.6	0.4	0.55	0.26
	S2	1.85	4.867	0.46	0.25	0.1	9.697	5.547	0.26	0.03	0	0.6767	1.35	0.4	0.53	0.26
	S3	1.54	4.58	0.35	0.23	0.08	9.383	5.547	0.21	0.02	0	0.5667	1.22	0.2	0.42	0.19
	S4	1.75	4.673	0.53	0.3	0.11	10.31	5.75	0.337	0.03	0.1	0.6833	1.35	0.4	0.52	0.26

Chapter Three..... Results

Table (3-46) Bio concentration factor (BCF) and Bio sedimentation factor (BSF) for aquatic plant *Phragmites australis* in the study site of Mashroo Al-Musayyib channel

<i>Phragmites australis</i>																					
Season	Site	Cr					Fe					Cu					Zn				
		Water	sed.	con.	BCF	BSF	Water	Sed	Con	BCF	BSF	Water	sed.	con.	BCF	BSF	Water	Sed	con.	BCF	BSF
Winter	S1	0.13	0.2	0.14	1.13	0.7	807	2667	3497	4.33	1.31	773.3	6197	6463	8.4	1	16733	18767	10357	0.62	0.6
	S2	0.1	0.13	0.17	1.65	1.28	640	2137	3913	6.11	1.83	563.3	4777	6990	12	1.5	11233	12667	12230	1.09	1
	S3	0.11	0.2	0.09	0.84	0.46	537	1533	3913	7.29	2.55	360	3250	6990	19	2.2	10500	10593	12230	1.16	1.2
	S4	0.12	0.2	0.14	1.16	0.7	883	1883	4493	5.09	2.39	650	3507	8690	13	2.5	17817	11623	16457	0.92	1.4
Spring	S1	0.88	0.95	0.21	0.24	0.22	1307	5753	13167	10.1	2.29	1057	13730	9817	9.3	0.7	24967	24647	16767	0.67	0.7
	S2	1.06	1.24	0.37	0.35	0.3	1523	7393	18133	11.9	2.45	1263	16333	11567	9.2	0.7	30227	27497	19067	0.63	0.7
	S3	0.75	1.01	0.15	0.21	0.15	967	5267	12893	13.3	2.45	946.7	12347	9743	10	0.8	12537	18773	16293	1.3	0.9
	S4	0.97	1.17	0.24	0.24	0.2	1130	6253	14317	12.7	2.29	1130	13323	11363	10	0.9	13320	19627	18537	1.39	0.9
Summer	S1	0.67	0.44	0.16	0.24	0.36	993	4883	8647	8.7	1.77	836.7	11470	6497	7.8	0.6	20480	21407	10570	0.52	0.5
	S2	0.77	0.61	0.34	0.44	0.56	1283	5270	8790	6.85	1.67	970	11680	6713	6.9	0.6	20710	21733	10910	0.53	0.5
	S3	0.34	0.71	0.07	0.21	0.1	760	3277	8287	10.9	2.53	616.7	8267	5150	8.4	0.6	8557	12480	10170	1.19	0.8
	S4	0.69	0.69	0.13	0.18	0.18	1017	3273	10170	10	3.11	950	7597	8240	8.7	1.1	11290	11260	12670	1.12	1.1
Autumn	S1	1.15	0.63	0.36	0.32	0.57	1553	8407	12830	8.26	1.53	1180	18067	8773	7.4	0.5	24040	26543	14367	0.6	0.5
	S2	1.02	0.56	0.27	0.26	0.48	1400	8047	11493	8.21	1.43	1083	18060	8060	7.4	0.4	23343	25443	13857	0.59	0.5
	S3	0.86	0.42	0.19	0.22	0.45	1260	7773	11030	8.75	1.42	1050	17230	7863	7.5	0.5	22890	23563	13610	0.59	0.6
	S4	1.01	0.52	0.24	0.23	0.45	1483	8133	11277	7.6	1.39	1133	18207	8037	7.1	0.4	23543	23910	13883	0.59	0.6

Chapter Three..... Results

Table(3-47) Bio concentration factor (BCF) and Bio sedimentation factor (BSF) for aquatic plant *Phragmitus australis* in the study site of Mashroo Al-Musayyib channel

<i>Phragmitus australis</i>																
Season	Site	Pb					Ni					Cd				
		Water	sed.	con.	BCF	BSF	Water	Sed	Con	BCF	BSF	Water	sed.	con.	BCF	BSF
Winter	S1	1.06	4.133	0.29	0.27	0.07	6.2	3.33	0.19	0.03	0.06	0.52	0.14	0.35	0.7	2.56
	S2	0.85	2.733	0.19	0.22	0.07	5.6	2.17	0.14	0.03	0.07	0.53	0.07	0.36	0.7	4.86
	S3	0.3	0.35	0.19	0.63	0.53	0.127	0.36	0.14	1.13	0.39	0.32	0.11	0.26	0.8	2.36
	S4	0.99	4.133	0.06	0.06	0.02	6.133	3.33	0.19	0.03	0.06	0.52	0.14	0.35	0.7	2.56
Spring	S1	2.17	5.98	0.72	0.33	0.12	11.27	5.47	0.46	0.04	0.08	0.88	1.36	0.45	0.5	0.33
	S2	3.59	7.537	0.87	0.24	0.11	12.71	5.97	0.52	0.04	0.09	0.26	1.51	0.59	2.2	0.39
	S3	2.1	5.323	0.51	0.24	0.1	9.657	3.65	0.38	0.04	0.1	0.17	1.04	0.41	2.4	0.4
	S4	2.16	6.27	0.91	0.42	0.15	10.25	4.2	0.51	0.05	0.12	0.27	1.19	0.62	2.3	0.52
Summer	S1	1.7	4.773	0.52	0.3	0.11	8.6	3.73	0.25	0.03	0.07	0.49	0.99	0.38	0.8	0.38
	S2	2.3	4.997	0.8	0.35	0.16	9.903	4.02	0.48	0.05	0.12	0.57	1.13	0.5	0.9	0.45
	S3	1.39	3.18	0.37	0.27	0.12	6.19	1.28	0.13	0.02	0.1	0.04	0.8	0.22	6.1	0.28
	S4	2.01	3.607	0.53	0.26	0.15	9.183	1.49	0.34	0.04	0.23	0.19	0.86	0.37	2	0.43
Autumn	S1	2.05	5.05	1.06	0.52	0.21	10.59	5.73	0.49	0.05	0.08	0.76	1.6	0.9	1.2	0.56
	S2	1.85	4.867	0.99	0.54	0.2	9.697	5.55	0.4	0.04	0.07	0.68	1.35	0.67	1	0.5
	S3	1.54	4.58	0.86	0.56	0.19	9.383	5.55	0.33	0.03	0.06	0.57	1.22	0.55	1	0.45
	S4	1.75	4.673	1.03	0.59	0.22	10.31	5.75	0.47	0.05	0.08	0.68	1.35	0.71	1	0.52

Chapter Three..... Results

Table(3-48) Bio concentration factor (BCF) and Bio sedimentation factor (BSF) for Fish *Oreochromis aureas* in the study site of Mashroo Al-Musayyib channel

<i>Oreochromis aureas</i>																					
Season	Site	Cr					Fe					Cu					Zn				
		Water	sed.	con.	BCF	BSF	Water	Sed	Con	BCF	BSF	Water	sed.	con.	BCF	BSF	Water	Sed	con.	BCF	BSF
Winter	S1	0.13	0.2	0.18	1.42	0.89	807	2667	4170	5.17	1.56	773.3	6197	520	0.67	0.08	16733	18767	2513	0.15	0.13
	S2	0.1	0.13	0.11	1.06	0.83	640	2137	5163	8.07	2.42	563.3	4777	640	1.14	0.13	11233	12667	2843	0.25	0.22
	S3	0.11	0.2	0.25	2.34	1.27	537	1533	3170	5.91	2.07	360	3250	380	1.06	0.12	10500	10593	2143	0.2	0.2
	S4	0.12	0.2	0.12	0.97	0.59	883	1883	3900	4.42	2.07	650	3507	696.7	1.07	0.2	17817	11623	3007	0.17	0.26
Spring	S1	0.88	0.95	0.33	0.37	0.34	1307	5753	6423	4.92	1.12	1057	13730	1287	1.22	0.09	24967	24647	3643	0.15	0.15
	S2	1.06	1.24	0.58	0.55	0.47	1523	7393	7817	5.13	1.06	1263	16333	1423	1.13	0.09	30227	27497	4627	0.15	0.17
	S3	0.75	1.01	0.46	0.62	0.46	967	5267	6190	6.4	1.18	946.7	12347	1077	1.14	0.09	12537	18773	2533	0.2	0.13
	S4	0.97	1.17	0.58	0.6	0.5	1130	6253	7570	6.7	1.21	1130	13323	1173	1.04	0.09	13320	19627	3073	0.23	0.16
Summer	S1	0.67	0.44	0.12	0.17	0.27	993	4883	4533	4.56	0.93	836.7	11470	950	1.14	0.08	20480	21407	2457	0.12	0.11
	S2	0.77	0.61	0.13	0.16	0.21	1283	5270	4803	3.74	0.91	970	11680	1113	1.15	0.1	20710	21733	2743	0.13	0.13
	S3	0.34	0.71	0.15	0.45	0.22	760	3277	4170	5.49	1.27	616.7	8267	570	0.92	0.07	8557	12480	2047	0.24	0.16
	S4	0.69	0.69	0.36	0.52	0.52	1017	3273	5950	5.85	1.82	950	7597	1020	1.07	0.13	11290	11260	1943	0.17	0.17
Autumn	S1	1.15	0.63	0.16	0.14	0.25	1553	8407	6963	4.48	0.83	1180	18067	2067	1.75	0.11	24040	26543	4240	0.18	0.16
	S2	1.02	0.56	0.12	0.11	0.21	1400	8047	6223	4.45	0.77	1083	18060	1853	1.71	0.1	23343	25443	3927	0.17	0.15
	S3	0.86	0.42	0.07	0.09	0.17	1260	7773	6013	4.77	0.77	1050	17230	1640	1.56	0.1	22890	23563	3570	0.16	0.15
	S4	1.01	0.52	0.87	0.86	1.66	1483	8133	6220	4.19	0.76	1133	18207	1757	1.55	0.1	23543	23910	3687	0.16	0.15

Chapter Three..... Results

Table (3-49) Bio concentration factor (BCF) and Bio sedimentation factor (BSF) for Fish *Oreochromis aureas* in the study site of Mashroo Al-Musayyib channel

<i>Oreochromis aureas</i>																
Season	Site	Pb					Ni					Cd				
		Water	sed.	con.	BCF	BSF	Water	Sed	Con	BCF	BSF	Water	sed.	con.	BCF	BSF
Winter	S1	1.06	4.133	0.49	0.46	0.12	6.2	3.3	0.21	0.03	0.06	0.52	0.1	0.04	0.08	0.32
	S2	0.85	2.733	0.23	0.27	0.08	5.6	2.2	0.15	0.03	0.07	0.527	0.1	0.04	0.08	0.59
	S3	0.3	0.35	0.39	1.33	1.12	0.127	0.4	0.183	1.45	0.5	0.317	0.1	0.32	1.01	2.91
	S4	0.99	4.133	0.49	0.49	0.12	6.133	3.3	0.153	0.03	0.05	0.52	0.1	0.04	0.08	0.32
Spring	S1	2.17	5.98	0.61	0.28	0.1	11.27	5.5	0.117	0.01	0.02	0.88	1.4	0.06	0.07	0.04
	S2	3.59	7.537	1.07	0.3	0.14	12.71	6	0.283	0.02	0.05	0.263	1.5	0.16	0.59	0.1
	S3	2.1	5.323	0.56	0.27	0.11	9.657	3.6	0.143	0.01	0.04	0.173	1	0.09	0.54	0.09
	S4	2.16	6.27	0.85	0.39	0.14	10.25	4.2	0.217	0.02	0.05	0.27	1.2	0.22	0.8	0.18
Summer	S1	1.7	4.773	0.44	0.26	0.09	8.6	3.7	0.067	0.01	0.02	0.493	1	0.01	0.03	0.01
	S2	2.3	4.997	0.71	0.31	0.14	9.903	4	0.113	0.01	0.03	0.57	1.1	0.06	0.1	0.05
	S3	1.39	3.18	0.35	0.25	0.11	6.19	1.3	0.033	0.01	0.03	0.037	0.8	0.04	1.18	0.05
	S4	2.01	3.607	0.53	0.26	0.15	9.183	1.5	0.113	0.01	0.08	0.187	0.9	0.14	0.75	0.16
Autumn	S1	2.05	5.05	0.69	0.34	0.14	10.59	5.7	0.1	0.01	0.02	0.76	1.6	0.05	0.06	0.03
	S2	1.85	4.867	0.58	0.31	0.12	9.697	5.5	0.067	0.01	0.01	0.677	1.4	0.03	0.05	0.02
	S3	1.54	4.58	0.51	0.33	0.11	9.383	5.5	0.033	0	0.01	0.567	1.2	0.01	0.02	0.01
	S4	1.75	4.673	0.6	0.34	0.13	10.31	5.8	0.04	0	0.01	0.683	1.3	0.02	0.03	0.01

Chapter Three..... Results

Table (3-50) Bio concentration factor (BCF) and Bio sedimentation factor (BSF) for Fish *Leuciscus vorax* in the study site of Mashroo Al-Musayyib channel

<i>Leuciscus vorax</i>																					
Season	Site	Cr					Fe					Cu					Zn				
		Water	sed.	con.	BCF	BSF	Water	Sed	Con	BCF	BSF	Water	sed.	con.	BCF	BSF	Water	Sed	con.	BCF	BSF
Winter	S1	0.13	0.2	0.07	0.53	0.33	806.7	2667	4597	5.7	1.72	773	6197	646.7	0.84	0.1	16733	18767	2633	0.16	0.14
	S2	0.1	0.13	0.05	0.45	0.35	640	2137	5523	8.63	2.59	563	4777	746.7	1.33	0.16	11233	12667	2917	0.26	0.23
	S3	0.11	0.2	0.19	1.75	0.95	536.7	1533	3497	6.52	2.28	360	3250	290	0.81	0.09	10500	10593	1900	0.18	0.18
	S4	0.12	0.2	0.1	0.78	0.48	883.3	1883	4370	4.95	2.32	650	3507	943.3	1.45	0.27	17817	11623	3380	0.19	0.29
Spring	S1	0.88	0.95	0.7	0.79	0.74	1307	5753	7350	5.63	1.28	1057	13730	976.7	0.92	0.07	24967	24647	2823	0.11	0.11
	S2	1.06	1.24	1.06	0.99	0.85	1523	7393	8320	5.46	1.13	1263	16333	2463	1.95	0.15	30227	27497	7943	0.26	0.29
	S3	0.75	1.01	0.62	0.83	0.61	966.7	5267	7223	7.47	1.37	947	12347	1287	1.36	0.1	12537	18773	4670	0.37	0.25
	S4	0.97	1.17	0.85	0.88	0.73	1130	6253	8437	7.47	1.35	1130	13323	2160	1.91	0.16	13320	19627	5767	0.43	0.29
Summer	S1	0.67	0.44	0.44	0.66	1.01	993.3	4883	5190	5.22	1.06	837	11470	826.7	0.99	0.07	20480	21407	2180	0.11	0.1
	S2	0.77	0.61	0.67	0.87	1.1	1283	5270	5563	4.34	1.06	970	11680	993.3	1.02	0.09	20710	21733	2363	0.11	0.11
	S3	0.34	0.71	0.18	0.54	0.26	760	3277	3293	4.33	1.01	617	8267	490	0.79	0.06	8557	12480	2173	0.25	0.17
	S4	0.69	0.69	0.53	0.77	0.78	1017	3273	6150	6.05	1.88	950	7597	1370	1.44	0.18	11290	11260	3560	0.32	0.32
Autumn	S1	1.15	0.63	0.66	0.57	1.04	1553	8407	6253	4.03	0.74	1180	18067	1407	1.19	0.08	24040	26543	2863	0.12	0.11
	S2	1.02	0.56	0.56	0.55	1.01	1400	8047	5087	3.63	0.63	1083	18060	1363	1.26	0.08	23343	25443	2740	0.12	0.11
	S3	0.86	0.42	0.42	0.49	1	1260	7773	4780	3.79	0.61	1050	17230	1127	1.07	0.07	22890	23563	2573	0.11	0.11
	S4	1.01	0.52	0.67	0.66	1.29	1483	8133	4907	3.31	0.6	1133	18207	1233	1.09	0.07	23543	23910	2783	0.12	0.12

Table (3-51) Bio concentration factor (BCF) and Bio sedimentation factor (BSF) for Fish *Leuciscus vorax* in the study site of Mashroo Al-Musayyib channel

<i>Leuciscus vorax</i>																
Season	Site	Pb					Ni					Cd				
		Water	sed.	con.	BCF	BSF	Water	Sed	Con	BCF	BSF	Water	sed.	con.	BCF	BSF
Winter	S1	1.057	4.133	0.3733	0.353	0.09	6.2	3.3333	0.27	0.044	0.081	0.52	0.137	0.07	0.13	0.488
	S2	0.85	2.733	0.6267	0.737	0.229	5.6	2.1667	0.2033	0.036	0.094	0.527	0.073	0.07	0.13	0.909
	S3	0.297	0.35	0.3267	1.101	0.933	0.127	0.3633	0.1	0.789	0.275	0.317	0.11	0.12	0.39	1.121
	S4	0.99	4.133	0.3733	0.377	0.09	6.133	3.3333	0.1	0.016	0.03	0.52	0.137	0.07	0.13	0.488
Spring	S1	2.167	5.98	0.55	0.254	0.092	11.27	5.4733	0.06	0.005	0.011	0.88	1.36	0.02	0.02	0.012
	S2	3.593	7.537	1.3033	0.363	0.173	12.71	5.97	0.44	0.035	0.074	0.263	1.51	0.7	2.66	0.464
	S3	2.097	5.323	1.0433	0.498	0.196	9.657	3.6467	0.35	0.036	0.096	0.173	1.037	0.48	2.77	0.463
	S4	2.16	6.27	1.2167	0.563	0.194	10.25	4.2033	0.5633	0.055	0.134	0.27	1.19	0.39	1.43	0.325
Summer	S1	1.7	4.773	0.2733	0.161	0.057	8.6	3.7267	0.0367	0.004	0.01	0.493	0.987	0.01	0.03	0.014
	S2	2.3	4.997	0.48	0.209	0.096	9.903	4.02	0.05	0.005	0.012	0.57	1.13	0.04	0.06	0.032
	S3	1.393	3.18	0.54	0.388	0.17	6.19	1.2767	0.1433	0.023	0.112	0.037	0.8	0.25	6.91	0.317
	S4	2.01	3.607	1.01	0.502	0.28	9.183	1.4867	0.3467	0.038	0.233	0.187	0.86	0.25	1.34	0.291
Autumn	S1	2.047	5.05	0.45	0.22	0.089	10.59	5.73	0.05	0.005	0.009	0.76	1.603	0.04	0.05	0.025
	S2	1.853	4.867	0.35	0.189	0.072	9.697	5.5467	0.03	0.003	0.005	0.677	1.35	0.02	0.02	0.012
	S3	1.537	4.58	0.2733	0.178	0.06	9.383	5.5467	0.0133	0.001	0.002	0.567	1.217	0.01	0.02	0.011
	S4	1.753	4.673	0.46	0.262	0.098	10.31	5.75	0.03	0.003	0.005	0.683	1.347	0.03	0.04	0.02

Chapter Four

Discussion

4: Discussion

4-1: Physical and Chemical Properties

The physical and chemical properties are important evidence by which the quality of water is inferred and thus the determination of its suitability for various uses (Peterson *et al.*, 2013). Temperature is one of the most important factors influencing the aquatic environment because most physical and chemical factors depend on temperature in their changes as well as the degree of their impact on aquatic organisms and the characteristics of the aquatic medium in terms of the level of dissolved oxygen and variability in pH values, salinity and electrical conductivity. The air temperature ranged between (12.5 - 46) C° in site two in February and sites three in July respectively, while the water temperature ranged between (13.6 – 38) C°. It increased during hot months and decreased during cold months. These results corresponded with other Iraqi studies (Hassan *et al.*,2017 ; Al-khafaji and Al-Taee 2020 ; Qadoori andTawash,2021).

It is noted through the results of the statistical analysis that there are clear monthly changes in the temperature of the air and water that occurred as are caused by several factors: the most important of which are differences according to the weather of the region, the time of taking measurements, the intensity of brightness of sunlight, and the differences in daylight hours between the months of the year. The results of the current study showed a Positive correlation relationship between air temperature and water temperature during the duration of the study ($r = (0.94)$ Appendix (1)). This study agree with the researchers' studies (Salman ,2006 ; Al-Qarooni ,2011 ; Al-Sharifi, 2014 ; Habeeb,2015) .

The pH values ranged between (6.6 – 8.34) in site one in May 2021 and January respectively, this refer to sub alkaline in nature (Pal *et al.*, 2016).. The pH

values are affected by many factors such as CO₂ concentration (Nashaat and Al-Bahathy, 2022) and nature of climate (Maulood and Hassan, 2021). Electrical conductivity values ranged between (369-594) $\mu\text{S}/\text{cm}$ in site two in August and site four in December respectively. EC is a numerical expression of positive and negative ions in water (APHA, 2003) and is an indicator of dissolved salts present in water. Statistical analysis showed that there is a positive correlation relationship with each of pH, dissolved oxygen, Salinity and TDS at $p \leq 0.05$ ($r=1.00, 0.9$ respectively).

Salinity values ranged (0.2- 0.4)%_o in April, July, August and December respectively. The water of river in studied sites is classified as oligosaline. TDS values range was (250-420) mg/l in site two in August and site four in December respectively. There are many factors affect the TDS values such as rainfall, water level, soil erosion and waste disposal into the river (Abbas and Hassan, 2018). TSS values range was (3.667 – 46.667) mg/l in site two in February and site four in September respectively. Runoff water from agriculture and anthropogenic activities could be the causes of high TSS concentration in the river (Nguyen, 2020).

Dissolved oxygen (DO) Values of these parameters ranged from (1.4-6.3) mg/l in site one in September and site one in March respectively. The low level of dissolved oxygen recorded can be attributed to low density of hydrophyte and phytoplankton or the sewage discharges from the catchment area are gradually affecting the aquatic life (Salman and Hussain, 2012).

BOD₅ values ranged between (0.3 – 3.9) mg/l in site four in May and January respectively. The result showed low levels of BOD₅ may be due to the activity of microorganism and self purification in surface water systems.

From statistical analysis it became clear that there is inverse significant correlation relationship between dissolved oxygen and both air temperature at $r = (-0.54)$ and water temperature at $r = (-0.59)$ and there is also a positive inverse correlation between dissolved oxygen and pH and this study agreed with (Al-Atbee, 2018).

Total alkalinity values showed clear changes between months and site and ranged total alkalinity values ranges between (1.000 -50.667) mg/l in the fourth site for the month of November and the third site for the month of January respectively. The alkaline properties of Iraqi water are noticed by other authors (Hassan *et al.* , 2007). This alkaline properties might be due to the bicarbonate and carbonate contents in the aquatic systems which these ions are the main responsible ions of water alkalinity (Abbas and Hassan ,2018). The higher concentrations of total alkalinity may be due to sewage wastes (Walli *et al.* , 2018).

Total Hardness is defined as a digital expression of the concentration of Ca^{+2} , Mg^{+2} in water as well as other alkaline salts and their levels vary in water environments influenced by the geological structure of rivers and the melting of rocks in the case of the availability of oxygen and carbonic acid in the water (Salman *et al.* , 2012, Al-Sharifi, 2014).

The results of the current study showed the total hardness values clear changes between months and its sites and ranged was (295.000 -900.000) mg/l in the fourth site in May and the first site in October respectively. Ca values ranged (193.33 and 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 September respectively. Calcium and magnesium are the main cause of hardness in most water, as calcium works to reduce the buffering capacity as a result of its

ability to reduce the solubility of carbon dioxide in water, as well as is one of the important elements for plants and other aquatic organisms as it works to regulate the osmotic pressure inside their bodies by ensuring that some necessary elements such as potassium and sodium are not lost, while magnesium is an essential component in chlorophyll in hydrophyte but it is found in the aquatic environment smaller amounts of calcium dissolved because of its deposition in large quantities (Wilson, 2009 ; Al – Ghanemi,2011). NO_3 values ranged (0.213-7.827) mg/l in site three in August and site four in November respectively

Nitrite is an intermediate phase of oxidation and reduction of both ammonia and nitrate their concentrations are very low in natural water systems (Philips *et al* ., 2002).Its concentration is ranged from (0.01-0.13) (mg/l) in site four in February and November respectively . PO_4 values ranged (0 -1.087) mg/l in site four in march month and site two in September month respectively. The higher content of Po_4 in site two in September month in Musayyib River indicates contamination of water by domestic, sewage and detergents. If the content of phosphate in water is high it indicates that water is highly polluted (Walli *et al* ., 2018).

4-2 :Total organic carbon in sediments (TOC)

Total organic carbon (TOC) are important parameter for the environmental status estimation of terrestrial and aquatic ecosystem . TOC considered a measure of organic pollution in water and sediments .The soil and sediments organic carbon are mainly derived by decomposition of the plants and animals or plankton or anthropogenic sources such as chemical contaminants, fertilizers or organic rich waste(Avramidis *et al* ., 2015).

The results of the study showed that the highest values of total organic carbon content are at the third and fourth site s during the Winter season that they reached

(33.6%) $\mu\text{g/g}$ while the lowest value was (4.8%) $\mu\text{g/g}$ recorded at the third site in Spring.

4-3: Grain size analysis of Sediment

The results of the current study showed that sediment in Al- Musayyib River consists of a mixture of sand, silt and clay if the percentage of these components is (72.5 , 20, 7.5) % in first site and (80, 15, 5)% in second site and (65, 27.5,7.5) % in third site and (60,30,10) %in fourth site . The percentage of sediments plays an important role in determining the quality of sediment and its physical and chemical properties, that it affects the ability of sediments to retain the ions of elements, salts and organic matter (Al-Saadi, 2006), It is noted through the results of the study that the deposits of the study sites are Sandy loam.

4 – 4: Heavy metals

4-4-1: Concentration of heavy metals in water

Several studies have indicated that rivers are exposed to pollution with heavy metals from various sources such as household waste, mining activities, and agricultural activities such as adding fertilizers and pesticides which negatively affects the balance of the aquatic ecosystem (Ameen *et al* ., 2021).The results of the current study showed that the rates of heavy metals concentrations in water for the four studied sites are in the following order in dissolved phase:- Zn> Fe > Cu> Ni>Pb> Cr > Cd. In particulate phase:- Zn> Cu >Fe > Ni>Pb> Cr >Cd, The zinc element recorded the highest rate among the of concentration of the studied elements in the dissolved water and particulate matter while cadmium recorded the lowest rate . The reason for the rise of 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 caused by the 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 (El Sheekh *et al.* , 2022) . The reason of the low concentrations of some elements such as cadmium may be due to the tendency accumulation of these elements in the bodies of plankton and hydrophyte with filter feeding and its adsorption by sediments and this agreed with (Almamory and Salman,2022 ; Hassan *et al.* , 2010). As for the higher concentrations of some elements (iron and copper) in the particulate phase than the dissolved ones this is attributed to the tendency of most elements to adsorption and bonding the water column contains clay and organic matter on the surfaces of suspended particulate matter, because when it dissolves in water it forms suspended colloids and is fixed before organo plankton or cations easily attracted by clay minerals or organic materials.

4-4-2: Concentration of heavy metals in sediment

The sediments at the bottom of different water bodies represent a basin for the collection or storage of various water pollutants that have the ability to precipitate and adsorption on the surface of the particles that make up these sediments (clay, silt, and sand grains) and go down to the bottom area in the water medium. As a result, heavy metals are among the most significant pollutants in the aquatic environment (Juned *et al.* , 2018). Sediments play an important role in returning these pollutants to water systems (Peng *et al.* , 2008). If these elements are released again to the water column when mixing occurs or they transport through the food chain, then the quality of the sediment and its components are evidence of the quality and quantity of this pollution and the nature of its source tends to accumulate these pollutants gradually over time in the sediments (Bai *et al.* , 2018).

The average concentrations of heavy elements in the sediments were for the four studied site Zn > Cu > Fe > Pb > Ni > Cd > Cr, the zinc recorded the highest rate of concentration of the studied elements in the sediment while the chromium element recorded the lowest rate. Tannery is a major cause of Cr pollution in sediments. (Skorbiłowicz *et al.* , 2021). Organic substances, Cr salts, chloride ions, sulfides, sulfates, and nitrogen are present in untreated tannery effluent (Zeng *et al.* , 2022). In addition, a significant amount of domestic and industrial wastewater is discharged into rivers which may explain the high level of Zn and Cu accumulation in sediments (Wang *et al.* , 2018) .

4-4-3: Concentration of heavy metals in Aquatic plant

Hydrophyte can accumulate biogenic elements, toxic substances, including heavy metals so use of plants as a good indicator of heavy metals pollution due to absorb heavy metals from soils and sediments and accumulate them in their tissue , and they not only have a high assimilation potential. An issue of global concern is the presence of toxic heavy metal ions in aquatic systems. Heavy metals can accumulate along the food chain and have toxic effects even at low concentrations leading to significant ecological and health issues. They are hazards due to their solubility and mobility (Nag *et al.* , 2022).

Heavy metal absorption varies in plant species and is influenced by the metals' bioavailability ,the pH, and the content of organic matter in the sediments , the extent of their survival in the water(Aljanabi *et al.* , 2021).

The average concentrations of heavy elements in the aquatic plant are for the four studied sites . In *C. demersum* recorded the following Zn > Fe > Cu > Pb > Cr > Ni > Cd and in *P. australis* Zn > Fe > Cu > Pb > Cd > Ni > Cr , The result

showed that the *P. australis* has the highest concentration of heavy metal than *C. demersum* .

Many factors affect the concentration of heavy metal in the plant, such as soil texture, and depend on the evaluation of the plant, the zinc element recorded the highest rate of concentration of the studied elements in the aquatic plant while the cadmium and chromium element recorded the lowest rate respectively in *C. demersum* and *P. australis* because sediments are a major sink for heavy metals in water and are crucial for aquatic organisms' uptake of heavy metals. Depending on the distribution of heavy metals in sediments and where the organisms are caught, the heavy metal concentrations in aquatic organisms in the three areas varied greatly (Nag *et al* .,2022) .

Salman *et al.*, (2013) a studied on *Ceratophyllum demersum*, *Phragmitus australis*, *Typha domingensis* and *Potamogeton pectinatus* through Euphrates river and he found that those plants had the ability to accumulate heavy metals due to rates of concentrations which are higher in the studied plants more than sediments and water, this susceptibility varies with the variability of the source of contamination and different plant type. Al-Edani *et al.*, (2019) studied the ability of three plants to accumulate some heavy metals (Fe, Cd, Cu, and Pb) in two locations along the Shatt Al-Arab River, they found that rates of elements are high in *C. demersum* that reflected good efficiency in removing element pollutants followed by *P. australis* and finally in *Cyperus rotundus*.

4-4-4 :Concentration of heavy metals in Clam

The wide range of heavy metal accumulation in bivalve with filter feeding and from different food sources give an indication that they can use it as a guide or key to determine pollution levels in the environment (Saeed *et al* .,2021) and

mentioning Kadeem *et al.* ,(2021) that there are numerous factors that influence the concentration of heavy metals in bivalve tissues including, element readiness, sampling time, and hydrochemical factors of ecosystem such as size, gender , reproductive cycle and variations in the tissue composition of the organism's body. The average concentrations of heavy elements in clam were for S4, : Zn> Fe > Cu> Ni >Pb> Cd > Cr ,the concentration of heavy metals in bivalves is closely related to and indicative of the concentration of heavy metals in the sediment (El Nemr *et al.* , 2016) .

Heavy metals in aquatic habitats tend to accumulate in biomes and biomagnify through the food chain due to their stability and persistence, and they are frequently regarded as highly potentially toxic contaminants (Gao *et al.* ,2021). There are many studies about clam on the Euphrates River, such as(Mirza and Nashaat,2019; Merza,2021) that study fresh water clam as a heavy metal bioaccumulation indicator organism and diversity of molluska in the Euphrates River, Iraq. The concentration of heavy metals in this study in Clam ranged between (0.1733 –19267 $\mu\text{g} / \text{g}$) for each of Cr in S3 in Winter and Zn in S2 in Spring , respectively. Their concentrations were as follows: Zn> Fe > Cu> Ni >Pb> Cd > Cr.

Zn is an essential trace element that can be toxic to aquatic biota (Yap *et al.* , 2021) thus is present in all organisms for metabolic processes (Cheng and Yap,2015) Clams filter water to obtain food particles and this could facilitate entry of Zn in its body. The chemical property of Zn to oxidize easily helps in its easy absorption into soft tissues (Ong and Ibrahim , 2017). Cr in clams ranged from (0.004-0.17) $\mu\text{g}/\text{g}$ for all study areas with the lowest value observed in Summer in S3. The highest was recorded in S3 during the Winter .Cr as a nonessential metal, Cr is an element required in small quantity for the biological processes of organisms (Sow *et al.* ,2019).

Iron and copper are essential for human health (Hossen *et al* .,2015) The range of Fe was (5473-13563) $\mu\text{g/g}$ in clam, with the lowest value observed in Summer in S3. The highest was recorded in S4 during the winter.

The Fe levels in the clams of this study are found to be higher than those reported by many previous studies These differences in Fe accumulation might be due to differences in habitats. However, even species that are closely related, or even the same species, may have differences in metal concentrations in different types of tissues (Yap *et al* ., 2021).

The range of Cu is (3277-9500) $\mu\text{g/g}$ in clam, with the lowest value observed in Summer in S3. The highest is recorded in S2 during the Spring.

The mean concentration of Pb (1.31 μg) in this study is low when compared to Zn, Fe, Cu, and Ni. However, it is still higher than Cd and Cr. Pb is an element which can produce toxic effects even in low concentration. Pb may enter water from the combustion of fossil fuels during boating activities, as well as the use of diesel fuel and leaded aviation gasoline (Bonvalot *et al.*, 2016). (Jalal *et al.*, 2009).

Besides that, combustion of fossil fuels from vehicles nearby might also contribute to release of Pb into aquatic environment where it accumulates in the sediments and organisms. Continuous exposure of humans to Pb might cause mental retardation and kidney disease (WHO, 2000), and disruption of blood flow (Arnich *et al.*, 2012).

The mean concentration of Cd (0.9) $\mu\text{g/g}$ in S4 in Spring Cadmium is a carcinogenic chemical (Rahman *et al.*, 2012). Cadmium unlike other metals, has a strong retention ability, allowing it to stay longer in the clam tissues .The concentration of Cd in the clam is low, within permissible limits. However, a continuous monitoring is necessary in view of highly toxic and carciogenic effects of this heavy metal. Nickel normally occurs at very low concentrations in the

environment. It is observed that the range of Ni was(0.3-1.46) $\mu\text{g/g}$ in clam the lowest value is observed in Winter in S4 The highest is observed in S1 in Spring.

4-4-5 : Concentration of heavy metals in Fish

The average concentrations of heavy elements in Fish are for the four study site s: Fe > Zn > Cu>Pb> Cr > Cd >Ni Non-essential metals may accumulate in fish organs while essential metals are required for normal metabolism (Canli and Atli , 2003) . Essential metals include Fe, Cu, Zn and manganese (Mn), whereas nonessential metals are Hg, Pb, Ni and Cd (Türkmen *et al.*, 2005). As a result, levels in fish typically reflect levels found in the sediment and water of the specific aquatic environment from which they are sourced, as well as the time of exposure. fish have the ability to accumulate heavy metals in their tissues at higher levels than environmental concentrations due to absorption along the gill surface and the kidney, liver, and gut tract wall(Al-Kazaghly *et al* 2021).

Heavy metal accumulation by organisms can be passive or selective, and differences in heavy metal accumulation by organisms can be due to differences in assimilation, egestion, or both (Rajeshkumar and Li , 2018). Many studies estimated the concentration of some heavy metals (cadmium, lead, zinc, iron, manganese, selenium and nickel) in the mussels of fish species and other aquatic biota collected from Euphrates river / middle of Iraq (Alshkarchy *et al.*, 2021; Alasadiy,2019 ; Athab *et al* ., 2022; . Aziz andRasheed,2017 ; Rasheed,2012).

Fishes and clam are well-known indicators of heavy metal pollution Examining the metal concentration in fish and clam meat is especially important to ensure compliance with food safety regulations and consumer protection, because once metal assimilates in biota, it tends to biomagnify in the food chain and

becomes difficult to break down into less dangerous compounds(Malhotra *et al* ,2020). It is shown that the average concentrations of heavy metals in in *Oreochromis aureas* at less than in *Leuciscus vorax*.

Relatively concentrations mean of heavy metals were identified in *Oreochromis aureas* (7817 µg /g for Fe , 4627 µg /g for Zn ,2067 µg/g for Cu ,1.06 µg/g for pb ,0.86 µg/g for Cr ,0.3 µg/g for Cd, 0.28 µg/g for Ni While relatively high metal concentrations were identified in *Leuciscus vorax* (8437 µg/g for Fe,7943 µg/g for Zn ,2463 µg/g for Cu,1.39 µg/g for pb,1.05 µg/g for Cr , 0.7 µg/g for Cd ,0.5 µg/g for Ni).

The study also revealed that high concentrations of studied heavy metals can be attributed to the presence of various human activities such as heavy traffic for modes of transportation to and subtraction agricultural waste in the same place on a continuous basis location as well as the possibility of Pollutant transportation from upstream (Al-Sultany, 2014).

In addition to the density of hydrophyte at this site, which allows to provide living adequate for the fish, resulting in the accumulation of elements in their tissues. Salman (2006).

4-5 :Water Quality index (Canadian Model) (CWQI)

The current study is done on Mashroo 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 system, 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 are computed to calculate water quality index (Canadian Model) CWQI value. The current study is built up with seventeen

physicochemical parameters (WT, pH, DO, BOD₅, TDS, NO₃, NO₂, Ca, Mg, PO₄, Cr, Fe, Cu, Zn, Pb, Ni, Cd).

The findings of the present study demonstrated that the rates of heavy metals concentrations in water for the four studied 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.

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.*, 2020; Tripathi and Shukla., 2018). The rapid rise in heavy metal levels has created a risk of bio magnification of these heavy metals through the entry of noxious elements into the food chain (Kumar *et al.*., 2020). 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 disposal (Paul ., 2017).

The findings of the current study showed that the concentrations of both Fe, Cu, Zn exceeded the World Health Organization's permissible limit for water (WHO, 2006) While Pb, Ni, Cd was within the desirable limit.

The heavy metals' relative abundance is in the following order: in dissolved phase Zn > 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 is calculated using the mean concentration values of the selected metals (Zn, Fe, Cu, Ni, Pb, Cr, and Cd).

In the current study in the river to determine its suitability for rivers maintenance are depended on(13) total parameter each season .the results showed the CWQI value for the maintenance of rivers ranging from (24.9 to -39.6) at the fourth site of the autumn and the third site for the Winter respectively and when compared with the standard values of water conservation it turns out that (poor) Water is always subject to pollution and is far from ideal at all times 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 PO_4,NO_2 , Zinc, Copper and Iron.

The reason for the rise of the element zinc may be attributed to the variation 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 of the 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 (El-Sheekh *et al.*, (2022).

As for determining the suitability the river for aquatic environment (GWQI) were depended on(14) parameter each season .The results showed the CWQI value for the determine 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 and when compared with the standard values of water conservation it turns out that (poor)Water is always subject to pollution and is far from ideal at all times 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 PO_4,NO_2 , Zn, Cu ,Fe ,Cd.(Wang *et al.*, 2015) stated that among the

six metal concentrations in the water, sediments, and aquatic organisms in the rural rivers, Zn concentration is highest and Cd concentration is lowest .

In addition to total heavy metal concentrations in water and sediments, metal speciation concentrations in sediments are also correlated with heavy metal accumulation in aquatic organisms and the greatest ecological risk to the environment came from cadmium in sediments .

(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 sites 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).

As for determining the suitability of the river for irrigation(IWQI) , it depended on (11) parameters each season .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. and when compared with the standard values 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 subject to pollution and is far from ideal at all times 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.

4-6: pollution index

As for the Index of pollution, two types of are Index studied to determine the extent of pollution of the river heavy Pollution Index (HPI) and the contamination index (C_d). The heavy metal pollution index for the study area is calculated using the mean concentration values of the selected metals Zn, Cr, Cd, Ni, Pb, Fe. the mean HPI was found to be 238.55 in S2 for Spring which exceeds the critical pollution index value of 100. This implies that the study is critically polluted with very high concentrations of heavy metals. HPI for all sampling point were found to be greater than acceptable ($HPI > 950$) with the highest value (238.55) recorded at in S2 for Spring and the lowest value (74.38) recorded at S3 for Winter.

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 water. Under most environmental conditions iron is relatively immobile, owing to the extremely low solubility of iron (III) hydroxide in its various forms. Its solubility is strongly influenced by redox conditions; his findings revealed the highest concentrations of iron in regions with low buffering capacity, and he speculated that the non-degradable nature and possible slow rate of dispersion may be responsible for higher levels observed near the shore (Addey *et al* .,2018).

The relatively higher concentrations of Cu from municipal waste waters and landfill leachate and The relatively higher concentrations Zn resulted by the general waste landfill. (Milivojević *et al* ., 2016)

The findings are in agreement with research by (Addey *et al* .,2018) in which heavy metals pollution index of surface water from Commodore channel, Lagos, Nigeria. The study revealed the sources of the heavy metals are primarily from anthropogenic source attributed to the untreated industrial discharge, and

municipal solid waste disposed in the area. Prompt enforcement of environmental protection laws is needed to prevent continuous pollution of the area.

In his study El-Ameir (2017) his referred to results that were Compatibility with the current results. Total HPIs (367.35) are higher than the critical threshold pollution index, indicating significant contamination of water in the Damietta branch of Nile River with minerals that may be attributed to over drainage of wastewater originating from various anthropogenic activities.

This findings is higher than index values research by (Al-Atbee *et al.* , 2020) in which The results indicated that mean HPI values are found to be below the critical pollution index value of 100 , HPI values are ranged from 4.39 to 12.51 referred to unpolluted water according to the permissible values of dissolved elements.

As for the contamination index (C_d) The contamination degree is defined as the sum of all concentration factors (Rahman *et al.* 2014). The values of (C_d) ranged from (23.061-84.070) in site three in Winter and site two in Spring. $C_d > 3$ the pollution is high.

The HPI and(C_d) models indicated a high degree of heavy metal pollution in the study area which could be traced to primarily anthropogenic sources from untreated industrial discharge, refuse dumping, municipal waste and processing activities in the area. The greatest risk of contamination by HMs is likely to be in the Euphrates food web complexes. This alarming concentration can also lead to uncomfortable conditions for people living near this river. Therefore, strict measures to protect the sustainability of the environment of this Euphrates should be taken into account (Kamel *et al.*, 2022).

Pb, followed by Fe and Ni, was the most important elements that contributed to the rise of both indices (PI, MI), whose levels consistently exceeded the permitted limits. a rise in the amount of heavy metals in the Tigris River, which

receives waste effluents from several industrial sites on its bank, as well as the direct discharge of sewage from public facilities. (Aljanabi *et al.*,2022).

4-7: Bio concentration factor (BCF) and Bio sedimentation factor (BSF)

The concentration of elements in aquatic biota is defined by several terms. Thus, bio concentration is the intake of an element into biota when the element's source is water. It is expressed as a bio concentration factor (BCF), which represents the ratio of the ratio of an element's concentration in the aquatic biota to the element's concentration in water Bio concentration describes how much a certain element's concentration is higher in biota. BCF is defined in relation to the concentration of that element in the environment, i.e. contaminant uptake from the dissolved phase Krivokapić (2021). The bio-sedimentation factor is defined as the ratio of heavy metal concentration in the body of organisms to that in the sediment. It makes it possible to evaluate the effectiveness of the bioaccumulation of heavy metals in the organism and give an idea of the speed of substance absorption and excretion by a living organism (Coulibaly, 2013; Elwasify *et al.*, 2021).

The results show that the bioconcentration factor (B.C.F) values are more than Biosedimentation (B.S.F) values. These results agreed with (Zahraw *et al.*,2019 ; Aljanabi *et al.* ,2021) which indicates that the heavy elements in the water are more effective on the aquatic species because they are bioavailable and because the bio concentration factor of copper and iron elements in the studied species is higher than the Bio sedimentation factor so it is a good biological evidence for evaluating bioaccumulation with the above two elements.

The BCF of Cu is the highest in S3 in Winter of the seven metals for Clam *Pseudontopeses euphratic* indicating the strong capability of *Pseudontopeses euphratic* to enrich Cu and *Pseudontopeses euphratic* suggesting that is suitable for treating Cu-polluted rivers. The BCF of other metals for *Pseudontopeses euphratic*

displayed the order of $Zn < Cr < Cd < Ni < Pb < Fe$. The BCF of Cu is the highest in S3 in Winter whereas the BCF of Pb is the lowest for *Ceratophyllum demersum* while in *Phragmites australis* the BCF of Cu is the highest in S3 in Winter whereas the BCF of Pb is the lowest in S3 in winter.

The high levels of Cu could be due to a large amount of domestic sewage and industrial wastewater is discharged into rivers (Dummee *et al.*, 2012). Interactions among dissolved oxygen, temperature, salinity, and detritus may have had a significant effect on heavy metal accumulation and their potential ecological risks (Karadede-Akin and Ünlü, 2007). The BCF of Fe is the highest in S2 in Winter of the seven metals for Fish *Oreochromis aureas*. The BCF of other metals for *Oreochromis aureas* displayed the order of $Zn < Cd < Pb < Ni < Cu < Cr$. While in *Leuciscus vorax* the BCF of Fe is the highest in S2 in Winter whereas the BCF of Zn was the lowest in S4 in Spring.

Fish may become a vector of heavy metal contamination to humans by the food chain (Das *et al.*, 2017; Ullah *et al.*, 2017). Indeed, fish raised in heavy metal-contaminated waters are likely to have heavy metals in their flesh (Benzer *et al.* 2013; Junianto *et al.*, 2017) because they can accumulate large amounts of heavy metals (El-Nemaki *et al.*, 2008). Thus, when the fish's living environment is contaminated with heavy metals, it not only endangers the fish but also poses serious hazards to public health (Vieira *et al.*, 2011; Junejo *et al.*, 2019). As a result, humans face a serious threat (El-Shafei, 2015). To determine the amount of heavy metals in fish organs (liver, gills, muscles, kidneys, gut, stomach, skin, bone, and spleen), several investigations have been conducted (Abdel-Baki *et al.*, 2011; Chahid, 2016; Alvarado *et al.*, 2020). However, due to the effects of its consumption and health hazards, muscle—the primary edible component of fish (El-Korashy *et al.*, 2018)—remains the most studied organ (Chahid, 2016).

**Conclusions
and
Recommendations**

Conclusions and Recommendations

5: Conclusions and Recommendations

5-1: Conclusions

1. Variation of physical and chemical properties of water according to variation of seasons and study sites .
2. High concentration of heavy metals in food chains through Mashroo Al-Musayyib channel .
3. Spatial and temporal fluctuation in heavy metal concentration specially Cu, Zn, and Fe.
4. Clear transportation of heavy metals through within lotic ecosystem in study area and bioaccumulation of these heavy metals in river biota such as aquatic plants ,Clam and Fish .
5. Water Quality Index (WQI) varied according to seasons and study sites and refer to poor –marginal for several purposes for irrigation, aquatic life .
6. River is high polluted by heavy metals according to heavy metal index (HPI) and contamination index(C_d)

5-2: Recommendations

- 1- Use the aquatic biota in the environmental monitoring of rivers and other aquatic systems quality .
- 2- Use the clam and aquatic plants as bio indicator to River pollution by heavy metals .
- 3- Application of water quality index and pollution index to assessments of River water quality .

Conclusions and Recommendations

- 4- Study concentration and accumulation of other types of pollutants in study sites such as PAH_s and pesticides .
- 5- Use other aquatic biota as bio indicator of pollution in study area such as phytoplankton and Zooplankton.

References

References

References

- **Abbas, A. A. A., & Hassan, F. M. (2018).** Water quality assessment of Euphrates river in Qadisiyah province (Diwaniyah river), Iraq. *The Iraqi Journal of Agricultural Science*, 49(2), 251-261.
- **Abbasnia, A., Yousefi, N., Mahvi, A. H., Nabizadeh, R., Radfard, M., Yousefi, M., & Alimohammadi, M. (2019).** Evaluation of groundwater quality using water quality index and its suitability for assessing water for drinking and irrigation purposes: case study of Sistan and Baluchistan province (Iran). *Human and Ecological Risk Assessment: An International Journal*, 25(4), 988-1005.
Abbassa Int. J. Aqua., Vol.11 No.(1) 2018.
- **Abdel-Baki, A. S., Dkhil, M. A., & Al-Quraishy, S. (2011).** Bioaccumulation of some heavy metals in tilapia fish relevant to their concentration in water and sediment of Wadi Hanifah, Saudi Arabia. *African Journal of Biotechnology*, 10(13), 2541-2547.
- **Abdel-Satar, A. M., Ali, M. H., & Goher, M. E. (2017).** Indices of water quality and metal pollution of Nile River, Egypt. *The Egyptian Journal of Aquatic Research*, 43(1), 21-29..
- **Afrous, A., Goudarzi, S., & Liaghat, A. (2011).** Phytoremediation by some species of aquatic plants for As and Hg removal (case study: Dezful, Iran). *Advances in Environmental Biology*, 5(11), 3629-3635.
- **Al Naggar, Y., Khalil, M. S., & Ghorab, M. A. (2018).** Environmental pollution by heavy metals in the aquatic ecosystems of Egypt. *Open Acc. J. Toxicol*, 3, 555603.
- **Al Qarooni, I. H. M. (2011).** Estimation of some heavy metals concentrations in water, sediment and bioaccumulation in some invertebrates

References

- of Shatt Al-Arab River and Shatt Al-Basrah canal, southern Iraq (Doctoral dissertation, Ph. D. Thesis, Education College, Basrah University).
- **Al -Rawi, I.K. (1977).** Sedimentological study of the alluvial plain deposits in Diwaniya – Hilla area. M.Sc. Thesis, Baghdad Univ., 138pp.
 - **Al Zughaiiby H H S, Jawad H J, Al Awadi J H H .(2020).** The relationship between concentrations of some trace elements in the Euphrates River of Iraq. AIP Conf Proc; 2290: 020044 . <https://doi.org/10.1063/5.0028128>.
 - **Al-Ansari, N., Jawad, S., Adamo, N., & Sissakian, V. (2019).** Water Quality and its Environmental Implications within Tigris and Euphrates Rivers. *Journal of Earth Sciences and Geotechnical Engineering*, 9(4), 57-108.
 - **Alasadiy Y D K (2019).** Evaluation of parasitic infection in two species of fishes from Euphrates river passing through Al-Muthanna Province. J. Phys. Conf. Ser .; 1279 :012030. doi:10.1088/1742-6596/1279/1/012030
 - **Al-Atbee , R. S. K. (2018) .** Assessment Of Some Heavy Elements and Hydrocarbons in the Water, Sediments and Dominant Aquatic Plants at Al-Chibayish marshes. M.Sc. Thesis, College of Science, University of Basrah , 208.
 - **Al-Atbee, R. S., Al-Hejuje, M. M., & Al-Saad, H. T. (2020).** Applied heavy elements pollution index (HPI) as a water pollution indicator at Al-Chibayish marsh in Thi-Qar province, southern Iraq. *Mesopotamia Environmental Journal (mesop. environ. j) ISSN: 2410-2598*, 5(4), 58-71.
 - **Al-Dehaimi M.H.M . (2010).** Study of some heavy metals in common carp, *Cyprinus carpio*, collected from the Euphrates River. *Euphrates Journal of Agriculture Science*, 2(3).

References

- **Al-Edani, T. Y., Al-Tameemi, H. J., & Jasim, Z. F. (2019).** Phytoremediation of heavy metals (Cd, Cu, Fe, and Pb) by using aquatic plants in Shatt Al-Arab River. *Engineering and Technology Journal*, 37(3), 365-369..
- **Al-Fahdawi, M. Q., Rasedee, A., & Al-Qubaisi, M. S. (2015).** Cytotoxicity and physicochemical characterization of iron–manganese-doped sulfated zirconia nanoparticles [Corrigendum]. *International Journal of Nanomedicine*, 10(1), 6657-6658.
- **Al-Ghanemi, H. (2011).** Use Aquatic Plants as Bioindicators of Heavy Metals Pollution in Euphrates River, Iraq (Doctoral dissertation, MS thesis, Dept. Biology, College of Science, University of Babylon, Iraq).
- **Algül, F., & Beyhan, M. (2020).** Concentrations and sources of heavy metals in shallow sediments in Lake Bafa, Turkey. *Scientific reports*, 10(1), 1-12.
- **Ali, H., & Khan, E. & Ilahi, I. (2019).** Environmental chemistry and ecotoxicology of hazardous heavy metals: Environmental persistence, toxicity, and bioaccumulation. *Journal of Chemistry*, 6730305. <https://doi.org/10.1155/2019/6730305>.
- **Ali, H., & Khan, E. (2018).** Bioaccumulation of non-essential hazardous heavy metals and metalloids in freshwater fish. Risk to human health. *Environmental chemistry letters*, 16(3), 903-917. <https://doi.org/10.1007/s10311-018-0734-7>.
- **Ali, M. M., Ali, M. L., Islam, M. S., & Rahman, M. Z. (2016).** Preliminary assessment of heavy metals in water and sediment of Karnaphuli River, Bangladesh. *Environmental Nanotechnology, Monitoring & Management*, 5, 27-35.

References

- **Aljanabi, Z. Z., Al-Obaidy, A. H. M. J., & Hassan, F. M. (2021).** A brief review of water quality indices and their applications. In *IOP Conference Series: Earth and Environmental Science* (Vol. 779, No. 1, p. 012088). IOP Publishing..
- **Aljanabi, Z. Z., Hassan, F. M., & Al-Obaidy, A. H. M. J. (2022).** Heavy metals pollution profiles in Tigris River within Baghdad city. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1088, No. 1, p. 012008). IOP Publishing.
- **Aljanabi, Z. Z., Maktoof, A. A., Al-Khairalla, R. J., & Al-Aboody, B. A. (2021).** Levels of some heavy elements in water, sediments and two aquatic plants in Al-Garrafriver at Shatra district/southern Iraq. In *IOP Conference Series: Earth and Environmental Science* (Vol. 779, No. 1, p. 012055). IOP Publishing.
- **Al-Kazaghly R F, Hamid M, Ighwela KA (2021)** .Bioaccumulation of some Heavy Metals in Red mullet (*Mullus barbatus*) and Common pandora (*Pagellus erythrinus*) in Zliten Coast, Libya. *J. Kelaut. Perikan. Terap.* 13(1):81–86. <http://doi.org/10.20473/jipk.v13i1.2203750>.
- **Al-Khafaji, A. S., & Al-Taee, I. A. (2020)** . Study of some physical and chemical parameters in Euphrates river in Samawah city, Iraq.
- **Al-khafaji, B. Y. (2011).** Trace Metals Content in the Ecosystem of Al-Garaf River in Al-Nassiriya City, South of Iraq. *Al-Qadisiyah Journal of pure science*, 16(1).1-13.
- **Almamory, A. M. J & Salman, J. M.(2022)** . Molecular Markers in Molluscs as Biomonitoring Species . In: Research Aspects in *Biological Science* ;3, 1 : 118-123. <https://doi.org/10.9734/bpi/rabs/v3/15748D>

References

- **Almeida, C.A. (2007):** Influence of Urbanization and Tourist Activities on the Water Quality of the Potrero De Los Funes River (San Luis – Argentina). *Environmental Monitoring and Assessment*, Vol.133(1-3): 459-465.
- **Al-Obaidy, A. H. M., Khalaf, S. M., & Hassan, F. M. (2022).** Application of CCME Index to Assess the Water Quality of Tigris River within Baghdad City, Iraq. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1088, No. 1, p. 012004). IOP Publishing.
- **Al-Saadi, H.A. (2005).** The Aquatic Environment, Yazurdy Scientific House for Publishing and Distribution, Amman, Jordan, 308 pp.
- **Al-Saadi, H.A. (2006).** Fundamentals of ecology and pollution. Dar Al-Bazuri Al-Alamia for Publishing and Distribution, Amman, Jordan, pg. 411.
- **Al-Sareji, O. J., Grmasha, R. A., Salman, J. M., & Hashim, K. S. (2021).** Street dust contamination by heavy metals in Babylon governorate, Iraq. *Journal of Engineering Science and Technology*, 16(1), 455-469. <https://jestec.taylors.edu.my/V16Issue1.htm>
- **Al-Sharifi , A . A .H (2014).** Possible contamination with heavy elements and some ecological parameters of water Bani- Hassan stream in the province of Karbala- Iraq.
- **Alshkarchy, S. S., Raesen, A. K., & Najim, S. M. (2021).** Effect of heavy metals on physiological and histological status in liver of common carp *Cyprinus carpio*, reared in cages and wild in the Euphrates River, Babil/Iraq. *IOP Conference Series: Earth and Environmental Science* (Vol. 779, No. 1, p. 012066). IOP Publishing.

References

- **Al-Shujairi, S. O. H. (2013).** Develop and apply water quality index to evaluate water quality of Tigris and Euphrates Rivers in Iraq. *International Journal of Modern Engineering Research*, 3(4), 2119-2126.
- **Al-Sultany, D. A. (2014).** Estimate the concentration of some heavy metals in the muscles of hamri fish *barbus luteus* (heckel) collected in the euphrates river/middle of Iraq. *Euphrates Journal of Agriculture science*, 6(4).
- **Al-Tae ,M. M (1999).** Some metals in water, sediments, fishes and plants of Shatt Al-Hilla river, Ph.D. Thesis. Univ. of Babylon. Iraq 128 pp. (In Arabic).
- **Al-Taher, Q. M., Akbar, M. M., & Al-Qarooni, I. H. (2020).** Estimation of heavy metals in water, sediments and bioaccumulation in *Pseudodontopsis euphraticus* and *bellamya bengalensis* in Euphrates river in Al-Nassiriyah city/south of Iraq. *plant archives*, 20(2), 1454-1460.
- **Alvarado, C., Ramírez, J. M., Herrera-López, E. J., Cortez-Valladolid, D., & Ramírez, G. (2020).** Bioaccumulation of Metals in Cultured Carp (*Cyprinus carpio*) from Lake Chapala, Mexico. *Biological trace element research*, 195(1), 226-238.
- **Al-Zughaiby, H. H. S., Jawad, H. J., & Al-Awadi, J. H. H. (2020).** The relationship between concentrations of some trace elements in the Euphrates River of Iraq. *AIP Conference Proceedings* (Vol. 2290, No. 1, p. 020044). AIP Publishing LLC. <https://doi.org/10.1063/5.0028128>.
- **Ameen F, Albueajee A I , Hassan F M , Steven L. Stephenson S L, Douabul A A Z(2021).** Controlling Factors of Phytoplankton Productivity in Marshes in a Hot Climate with High Seasonal Variation. *J. Mar. Sci. Eng* .; 9, 811. <https://doi.org/10.3390/jmse9080811>.

References

- **Ameen, H. A. (2019).** Spring water quality assessment using water quality index in villages of BarwariBala, Duhok, Kurdistan Region, Iraq. *Applied Water Science*, 9(8), 1-12.
- **Anbuselvan, N. D. S. N., & Sridharan, M. (2018).** Heavy metal assessment in surface sediments off Coromandel Coast of India: Implication on marine pollution. *Marine Pollution Bulletin*, 131, 712-726. <https://doi.org/10.1016/j.marpolbul.2018.04.074>.
- **Aoki, I. (2012).** Entropy principle for the development of complex biotic systems: organisms, ecosystems, the Earth. Elsevier.
- **APHA American Public Health Association. (2003).** Standard methods for the examination of water and wastewater. 20th ed. Washington DC, USA https://www.academia.edu/42904639/Standard_Methods_for_the_Examination_of_Water_and_Wastewater_23RD_Edition
- **APHA American Public Health Association.(2017).** Standard Methods for the Examination of Water and Wastewater 23th Edition, 800 I Street, NW, Washington DC, USA,. <https://www.pdfdrive.com/apha-standard-methods-for-the-examination-of-water-and-wastewater-d184521100.html>
- **APHA American Public Health Association (1995).** Standard methods for examination of water and wastewater, Washington, DC . 1193P.
- **Arnich, N., Sirot, V., Rivière, G., Jean, J., Noël, L., Guérin, T., & Leblanc, J. C. (2012).** Dietary exposure to trace elements and health risk assessment in the 2nd French Total Diet Study. *Food and Chemical Toxicology*, 50(7), 2432-2449.
- **Arora, P. (2017).** Physical, Chemical and Biological Characteristics of Water (e Content Module). Central University of Punjab, 2018, 1-16.

References

- **Arroyo P, Molinos-Senante M (2018).** Selecting Appropriate wastewater treatment technologies using a choosing-by advantages approach. *Sci. Total Environ.*; 625(1): 819–827. <http://dx.doi.org/10.1016/j.scitotenv.2017.12.331>
- **Arroyo, P., & Molinos-Senante, M. (2018).** Selecting appropriate wastewater treatment technologies using a choosing-by-advantages approach. *Science of the Total Environment*, 625, 819-827. <http://dx.doi.org/10.1016/j.scitotenv.2017.12.331>.
- **Athab ZH, Halbus AF, Abbas, AS, Salman J M ,Lafta ,AJ.(2022).** Enhanced Macroporous Cationic Chitosan Hydrogel by Freezing and Thawing Method with Superadsorption Capacity for Anionic Dyes. *J Polym Environ* , <https://doi.org/10.1007/s10924-022-02462-w>
- **Avram, S., Croitoru, a., George, c., & manta, n. (2018).** Cartarea ecosistemelor naturale și seminaturale degradate.
- **Avramidis, P., Nikolaou, K., & Bekiari, V. (2015).** Total organic carbon and total nitrogen in sediments and soils: a comparison of the wet oxidation–titration method with the combustion-infrared method. *Agriculture and Agricultural Science Procedia*, 4, 425-430.
- **Ayers, R. S. and Westcot DW(1985).** *Water Quality for Agricultura* FAO 29. FAO Irrigation and Drainage, Paper 29, Food and Agriculture Organization, Rome.; p. 174.
- **Aziz F H & Rasheed R O (2017).** Heavy metals in water, fishes and sediments in Derbendikhan reservoir, Kurdistan Region-Iraq. *Zanco j. pure appl. sci*; 29 (3): 19-27 <http://dx.doi.org/10.21271/ZJPAS.29.3.3>

References

- **Backman,B.,Bodis,D.,Lahermo,P.,Rapant,S.,(1997).**Application of aground water contamination index in Finland and Slovakia. *Environ .Geol.*36(1-2),55-64.
- **Bai L , Liu X,Hu J(2018).** Heavy metal accumulation in common aquatic plants in rivers and lake in the Taihu basin . *Int. J. Environ. Res. Public Health.*; 14; 15(12):2857. <https://doi.org/10.3390/ijerph15122857> .
- **Barange M, Field JG, Harris RP, Eileen E, Hofmann EE, Perry RI, Werner F (2010)** .Marine ecosystems and global change. Oxford University Press, Oxford, p 464.
- **Barchiesi, F., Branciarì, R., Latini, M., Roila, R., Lediani, G., Filippini, G., ... & Ranucci, D. (2020).** Heavy metals contamination in shellfish: benefit-risk evaluation in Central Italy. *Foods*, 9(11), 1720.
- **Bawuro, A. A., Voegborlo, R. B., & Adimado, A. A. (2018).** Bioaccumulation of heavy metals in some tissues of fish in Lake Geriyo, Adamawa State, Nigeria. *Journal of Environmental and Public Health.*Volume 2018, Article ID 1854892 , 7 pages. <https://doi.org/10.1155/2018/1854892>.
- **Begum, A. & HariKrishna, S. (2010).** Bioaccumulation of Trace metals by aquatic plants . *International Journal of ChemTech Research* , 2 (1) : 250-254
- **Benzer, S., Arslan, H. A. L. İ. T., Uzel, N. U. R. C. A. N., Gul, A., & Yilmaz, M. (2013).** Concentrations of metals in water, sediment and tissues of *Cyprinus carpio* L., 1758 from Mogan Lake (Turkey).
- **Bilton, D. T., Freeland, J. R., & Okamura, B. (2001).** Dispersal in freshwater invertebrates. *Annual review of ecology and systematics*, 159-181.

References

- **Bo, L., Wang, D., Li, T., Li, Y., Zhang, G., Wang, C., & Zhang, S. (2015).** Accumulation and risk assessment of heavy metals in water, sediments, and aquatic organisms in rural rivers in the Taihu Lake region, China. *Environmental Science and Pollution Research*, 22(9), 6721-6731.
- **Bonvalot, L., Tuna, T., Fagault, Y., Jaffrezo, J. L., Jacob, V., Chevrier, F., & Bard, E. (2016).** Estimating contributions from biomass burning, fossil fuel combustion, and biogenic carbon to carbonaceous aerosols in the Valley of Chamonix: a dual approach based on radiocarbon and levoglucosan. *Atmospheric Chemistry and Physics*, 16(21), 13753-13772.
- **Briffa, J., Sinagra, E., & Blundell, R. (2020).** Heavy metal pollution in the environment and their toxicological effects on humans. *Heliyon*, 6(9), e04691.
- **Brodin M, Vallejos M, Opedal MT, Area MC, Carrasco GC.(2017) .** Lignocelluloses as sustainable resources for production of Bioplastics -A Review . J. Clean. Prod; 162:646-664. <https://doi.org/10.54112/bcsrj.v2021i1.71>
- **Butu, A. W., & Iguisi, E. O. (2013).** Concentration of heavy metals in sediment of river Kubanni, Zaria, Nigeria. *Compr J Environ Earth Sci*, 2(1), 10-17.
- **Canli M & Atli G.(2003).**The relationships between heavy metal (Cd, Cr, Cu, Fe, Pb& Zn) levels and the size of six Mediter ranean fish species. *Environ. Pollut.*;121:129–136. [https://doi.org/10.1016/s0269-7491\(02\)00194-x](https://doi.org/10.1016/s0269-7491(02)00194-x).
- **Canli, M. A. Y. O., Ay, Ö., & Kalay, M. (1998).** Levels of Heavy Metals (Cd, Pb, Cu, Cr and Ni) in Tissue of *Cyprinus carpio*, *Barbus capito* and

References

- Chondrostoma regium from the Seyhan River, Turkey. *Turkish journal of zoology*, 22(2), 149-158.
- **Carrillo, J. A., McCann, R. J., & Villani, C. (2006).** Contractions in the 2-Wasserstein length space and their malization of granular media. *Archive for Rational Mechanics and Analysis*, 179(2), 217-263.
 - **CCME (Canadian Council of Ministers of the Environment, (2001).** Canadian water quality guidelines for the protection of aquatic life: CCME Water Quality Index 1.0, User's Manual. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.
 - **CCME, Canadian Council of Ministers of the Environment (2007).** Canadian Water Quality Guidelines for the Protection of Aquatic. Excerpt from publication No. 1299, 9pp.
 - **Chahid, A. (2016).** Quantification des éléments traces métalliques (cadmium, plomb et mercure total) de certains produits de la pêche débarqués dans la zone Essaouira-Dakhla: Evaluation des risques sanitaires.
 - **Charles, I. A., Nubi, O. A., Adelopo, A. O., & Oginni, E. T. (2018).** Heavy metals pollution index of surface water from Commodore channel, Lagos, Nigeria. *African Journal of Environmental Science and Technology*, 12(6), 191-197.
 - **Cheng, W. H., & Yap, C. K. (2015).** Potential human health risks from toxic metals via mangrove snail consumption and their ecological risk assessments in the habitat sediment from Peninsular Malaysia. *Chemosphere*, 135, 156-165.

References

- **Chowdhury, R. M., Muntasir, S. Y., & Hossain, M. M. (2012).** Water quality index of water bodies along Faridpur-Barisal road in Bangladesh. *Glob Eng Tech Rev*, 2(3), 1-8.
- **CMME (2005.)** CC of M of the E. Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses. *Environment Canada*.
- **Coulibaly, S. (2013).** *Bioaccumulation des métaux lourds et effets biologiques induits chez Saratherodon melanotheron rüppell, 1852 pêché dans la Baie de Bietri en Lagune Ebrié (Côte d'Ivoire)* (Doctoral dissertation, Thèse de Doctorat, Université Felix Houphouët Boigny (Abidjan, Côte d'Ivoire).
- **Dallinger, R., Prosi, F., Segner, H., & Back, H. (1987).** Contaminated food and uptake of heavy metals by fish: a review and a proposal for further research. *Oecologia*, 73(1), 91-98.
- **Das, P. R., Hossain, M. K., Sarker, B. S., Parvin, A., Das, S. S., Moniruzzaman, M., & Saha, B. (2017).** Heavy metals in farm sediments, feeds and bioaccumulation of some selected heavy metals in various tissues of farmed *Pangasius hypophthalmus* in Bangladesh. *Fisheries and Aquaculture Journal*, 8(3), 1-9.
- **Day, P. R. (1965).** Particle fractionation and particle-size analysis. *Methods of Soil Analysis: Part Physical and Mineralogical Properties, Including Statistics of Measurement and Sampling*, 9 :545 -567 .
- **De Meester, L., Gómez, A., Okamura, B., & Schwenk, K. (2002).** The Monopolization Hypothesis and the dispersal–gene flow paradox in aquatic organisms. *Acta oecologica*, 23(3), 121-135.
- **Demirak A, Yilmaz F, Tuna AL, Ozdemir N (2006) .** Heavy metals in water, sediment and tissues of *Leuciscus cephalus* from a stream in

References

- southwestern Turkey. *Chemosphere* 63:1451–1458.
<https://doi.org/10.1016/j.chemosphere.2005.09.033>.
- **Dorne, J. L., Kass, G. E., Bordajandi, L. R., Amzal, B., Bertelsen, U., Castoldi, A. F., ... & Verger, P. (2011).** Human risk assessment of heavy metals: principles and applications. *Met Ions Life Sci*, 8(4), 27-60.
 - **Drever, J. I. (1988).** The geochemistry of natural waters (Vol. 437). Englewood Cliffs: Prentice hall.
 - **Dumme, V., Kruatrachue, M., Trinachartvanit, W., Tanhan, P., Pokethitiyook, P., & Damrongphol, P. (2012).** Bioaccumulation of heavy metals in water, sediments, aquatic plant and histopathological effects on the golden apple snail in Beung Boraphet reservoir, Thailand. *Ecotoxicology and Environmental Safety*, 86, 204-212.
 - **El Nemr A ,El-Said GF, Ragab S, Khaled A, El-Sikaily A.(2016) .** The distribution, contamination and risk assessment of heavy metals in sediment and shellfish from the Red Sea coast, Egypt .*Chemosphere*, 165, : 369-380.
<https://doi.org/10.1016/j.chemosphere.2016.09.048>
 - **El Sheekh M M, Salman J M, GrmashaR A, Abdul Adel,E , Saleh M M, Al sareji O J.(2022)** Influence of Fe+2 on the Biomass, Pigments, and Essential Fatty Acids of *Arthrospiraplatensis*. *Biomass Conversion and Biorefnery*.
 - **El-Ameir, Y. A. (2017).** Evaluation of heavy metal pollution in Damietta branch of Nile River, Egypt using metal indices and phyto-accumulators. *Journal of Environmental Sciences*, 46(2), 89-102.
 - **El-Korashy, S. A., Ali, N. A., Al-Kenawy, D. A., & Mousa, I. M. (2018).** Some heavy metals concentrations in water and tilapia (*Oreochromis niloticus*) muscles of fish farms supplied by three different water sources.

References

- **El-Nemaki, F. A., Ali, N. A., Zeinhom, M. M., & Radwan, O. A. (2008).** Impacts of different water resources on the ecological parameters and the quality of tilapia production at El-Abbassa fish farms in Egypt. In *8th international symposium on tilapia in aquaculture* (Vol. 491, pp. 491-512).
- **El-Shafei, H. M. (2015).** Some heavy metals concentration in water, muscles and gills of tilapia niloticus as biological indicator of Manzala Lake pollution. *Journal of Aquaculture Research and Development*, 6(9).
- **Fagan, W. F. (2002).** Connectivity, fragmentation, and extinction risk in dendritic metapopulations. *Ecology*, 83(12), 3243-3249.
- **FAO (1994).** Water Quality for Agriculture. Irrigation and Drainage; *Food and Agriculture Organization: Rome, Italy.*
- **Farkas, A., Salanki, J., & Varanka, I. (2000).** Heavy metal concentrations in fish of Lake Balaton. *Lakes & Reservoirs: Research & Management*, 5(4), 271-279.
- **Fernandes, C., Fontainhas-Fernandes, A., Peixoto, F., & Salgado, M. A. (2007).** Bioaccumulation of heavy metals in *Liza saliens* from the Esmoriz–Paramos coastal lagoon, Portugal. *Ecotoxicology and environmental safety*, 66(3), 426-431.
- **Ferrey, M. L., Hamilton, M. C., Backe, W. J., & Anderson, K. E. (2018).** Pharmaceuticals and other anthropogenic chemicals in atmospheric particulates and precipitation. *Science of the Total Environment*, 612, 1488-1497.
- **Forstner, U. & Wittmann, G. T. W. (1981).** Metal Pollution In The Aquatic Environment. Springer-Verlag, New York.
- **Förstner, U., & Wittmann, G. T. (2012).** Metal pollution in the aquatic environment. Springer Science & Business Media.

References

- **France, K. E., & Duffy, J. E. (2006).** Diversity and dispersal interactively affect predictability of ecosystem function. *Nature*, 441(7097), 1139-1143.
- **Galczyńska, M., Mańkowska, N., Milke, J., & Buśko, M. (2019).** Possibilities and limitations of using *Lemna minor*, *Hydrocharis morsus-ranae* and *Ceratophyllum demersum* in removing metals with contaminated water. *Journal of Water and Land Development*. No. 40 (I–III): 161–173.
- **GaoY,Wang R ,Li XuebinY,Yueming D, GJian J, Feng L (2021)** .Trophic transfer of heavy metals in the marine food web based on tissue residuals. *Sci. Total Environ.*; 10; 772:145064. <https://doi.org/10.1016/j.scitotenv.2021.145064>
- **García-Ávila, F., Zhindón-Arévalo, C., Valdiviezo-Gonzales, L., Cadme-Galabay, M., Gutiérrez-Ortega, H., & del Pino, L. F. (2022).** A comparative study of water quality using two quality indices and a risk index in a drinking water distribution network. *Environmental Technology Reviews*, 11(1), 49-61.
- **Gaudette, H.E. ; Flight, W. R. ; Toner, L. & Folger, D.W. (1974)** . An inexpensive titration method for the determination of organic carbon in recent sediments. *J. of Sedimentary Petrology*,44 (1): 249-253 .
Guidelines for drinking water. (3rd edn.) World Health Organization of
- **Habeeb, M. A., Al-Bermani, A., & Salman, J. M. (2015).** Environmental study of water quality and some heavy metals in water, sediment and aquatic macrophytas in lotic ecosystem, Iraq. *Mesopotamia Environmental Journal*, 1(2), 66-84.
- **Hall, K. D., Ayuketah, A., Brychta, R., Cai, H., Cassimatis, T., Chen, K. Y., ... & Zhou, M. (2019).** Ultra-processed diets cause excess calorie intake

References

and weight gain: an inpatient randomized controlled trial of ad libitum food intake. *Cell metabolism*, 30(1), 67-77.

- **Hall, L. W., Anderson, R. D., & Alden Iii, R. W. (2002).** A ten year summary of concurrent ambient water column and sediment toxicity tests in the Chesapeake Bay watershed: 1990–1999. *Environmental monitoring and assessment*, 76(3), 311-352.
- **Hashim, R., Song, T. H., Muslim, N. Z. M., & Yen, T. P. (2014).** Determination of heavy metal levels in fishes from the lower reach of the Kelantan River, Kelantan, Malaysia. *Tropical life sciences research*, 25(2), 21.
- **Hassan F.M. Salman, J.M., Al-Nasrawi, S. (2017)** .Community Structure of Benthic Algae in a Lotic Ecosystem, Karbala Province Iraq, *Baghdad Sci J*; 14(4): 692-706. <http://dx.doi.org/10.21123/bsj.2017.14.4.0692>
- **Hassan, F. M., Salah. M. M., and J. M. Salman (2007).** Quantitative and qualitative variability of Epiphytic algae on three aquatic plants on Euphrates river, Iraq. *Iraqi J.of Aqua*. 4(1):1:16.
- **Hassan, F. M., Saleh, M. M., & Salman, J. M. (2010).** A study of physicochemical parameters and nine heavy metals in the Euphrates River, Iraq. *E-Journal of Chemistry*, 7(3), 685-692.. <http://www.hindawi.com>.
- **Havens, K., & Jeppesen, E. (2018).** Ecological responses of lakes to climate change. *Water*, 10(7), 917.
- **Hossen, M., Hamdan, S., & Rahman, M. (2015).** Review on the risk assessment of heavy metals in Malaysian clams. *The Scientific World Journal*, 2015.
<https://doi.org/10.1155/2019/1615298>.

References

- **Hussien, B. M., Lattoofi, N. F., Abd-alghafour, N. M., Muslim, R. F., Zaidan, T., & Mahmood, M. (2021).** Space-time hydrochemical variations and water quality of Euphrates river. *Arabian Journal of Geosciences*, 14(15), 1-19.
- **Iqbal, F., Ali, M., Salam, A., Khan, B. A., Ahmad, S., Qamar, M., & Umer, K. (2004).** Seasonal variations of physico-chemical characteristics of River Soan water at Dhoak Pathan Bridge (Chakwal), Pakistan. *International Journal of Agriculture and Biology*, 6(1), 89-92.
- **Irabii, D. S. (2001).** Mercury pollution by industrial waste and seiment the south of Iraq. Ph.D. Thesis, coll.of Scin. Univ. of Basrah, Iraq. 145p.
- **Jalal, K. C. A., Faizul, H. N., Kamaruzzaman, B. Y., Shahbudin, S., Alam, M. Z., & Irwandi, J. (2009).** Studies on physico-chemical characteristics and sediment environment along the coastal waters in Pulau Tuba, Langkawi, Malaysia. *Aquatic Ecosystem Health & Management*, 12(4), 350-357.
- **Jawad, S. T., Al-Taher, Q. M., & Shihab, A. F. (2022).** Melanoides tuberculata as Bioindicator of the Heavy Metal Contamination in Water and Sediment Pollution of Euphrates River at Thi-Qar province, Iraq. *Health Education and Health Promotion*, 10(2), 247-253.
- **Jayalakshmi ¹, M. K. M., Mahesh, M. K., & R¹, S. B.(2014).** CCME Water Quality Index and Assessment of Physico-Chemical Parameters of Chikkakere, Periyapatna, Mysore District, Karnataka State, India. *International Journal of Innovative Research in Science, Engineering and Technology*, 3(8), 15343-15347.

References

- **Jena, V.; Gupta, G. and Matic, N. (2013).** Assessment of Kharoon River Water Quality at Raipur By Physico -Chemical Parameters Analysis, *Asian J. Exp. Biol. Sci.* 4 (1):79-83.
- **Juned S ,Nagargoje B N ,Bhosle A B , Yannawar V B (2018).** Monitoring of Heavy Metals and Physico-Chemical Parameters of Soil, Near Sudha Dam Bhokar, Maharashtra. *Am. J. Sci.* 14 (5): 35- 39. DOI:10.7537/marsjas140518.07.
- **Junejo, S. H., Baig, J. A., Kazi, T. G., & Afridi, H. I. (2019).** Cadmium and lead hazardous impact assessment of pond fish species. *Biological trace element research*, 191(2), 502-511.
- **Junianto, Z., & Apriliani, I. M. (2017).** Evaluation of heavy metal contamination in various fish meat from Cirata Dam, West Java, Indonesia. *AAFL Bioflux*, 10(2), 241-246.
- **Kadarsah, A., Salim, D., Husain, S., & Dinata, M. (2020).** Species Density and Lead (Pb) Pollution in Mangrove Ecosystem, South Kalimantan. *Jurnal Biodjati*, 5(1), 70-81.
- **Kadeem ZJ , Hassan FM , Al Obaidy AHMJ (2021).** Monitoring of Phytoplankton in the Artificial Lake: Comparison Study. *IOP Conf. Ser.: Earth Environ. Sci.*; 779: 012125. doi:10.1088/1755-1315/779/1/012125
- **Kadhun, S. A., Abed, S. A., Ewaid, S. H., Chabuk, A., Al-Ansari, N., & Jassim, A. K. (2020).** Multivariate analysis and geochemical assessment of heavy metals pollution in surface sediment from euphrates river, Iraq. *Pollution Research*, 39(November Suppl. Issue), S262-S267.
- **Kamel, L. H., Al-Zurfi, S. K. L., & Mahmood, M. B. (2022).** Investigation of Heavy Metals Pollution in Euphrates River (Iraq) By Using Heavy Metal

References

- Pollution Index Model. In IOP Conference Series: *Earth and Environmental Science* (Vol. 1029, No. 1, p. 012034). IOP Publishing.
- **Kara, Y. (2005).** Bioaccumulation of Cu, Zn and Ni from the wastewater by treated *Nasturtium officinale*. *International Journal of Environmental Science & Technology*, 2(1), 63-67.
 - **Karadede-Akin, H., & Ünlü, E. (2007).** Heavy metal concentrations in water, sediment, fish and some benthic organisms from Tigris River, Turkey. *Environmental Monitoring and Assessment*, 131(1), 323-337
 - **Khaleefa, O., & Kamel, A. H. (2021).** On The evaluation of water quality index: case study of Euphrates River, Iraq. *Knowledge-Based Engineering and Sciences*, 2(2), 35-43.
 - **Khlaif, A. T., Mohammed, S. S., & Al-Sultany, D. A. (2021).** Detection of contamination by some trace elements in the muscles of *Carassius auratus* (Linnaeus) collected from the Euphrates River/Central Iraq. *Research Square*, DOI: <https://doi.org/10.21203/rs.3.rs-1097301/v2>.
 - **Khoshnam, Z., Sarikhani, R., Ghassemi Dehnavi, A., & Ahmadnejad, Z. (2017).** Evaluation of water quality using heavy metal index and multivariate statistical analysis in Lorestan province, Iran. *Journal of Advances in Environmental Health Research*, 5(1), 29-37.
 - **Krivokapić, M. (2021).** Study on the evaluation of (Heavy) metals in water and sediment of skadar lake (montenegro), with bcf assessment and translocation ability (ta) by *trapa natans* and a review of sdgs. *Water*, 13(6), 876.
 - **Kumar, A., & Dua, A. (2009).** Water quality index for assessment of water quality of river Ravi at Madhopur (India). *Global journal of environmental sciences*, 8(1).

References

- **Kumar, A., Kumar, A., Cabral-Pinto, M., Chaturvedi, A. K., Shabnam, A. A., Subrahmanyam, G., Mondal, R., Gupta, D. K., Malyan, S. K., Kumar, S. S., Khan, A. S., & Yadav, K. K. (2020).** Lead toxicity: Health hazards, influence on food chain, and sustainable remediation approaches. *International Journal of Environmental Research and Public Health*, 17(7), 2179.
- **Kwak, Ihn-Sil & PARK, Young-Seuk (2020)** Food chains and food webs in aquatic ecosystems. *Applied Sciences*, 10.14: 5012.
- **Lampert, W., & Sommer, U. (2007).** Limnoecology: the ecology of lakes and streams. Oxford university press.
- **Lateef, Z. Q., Al-Madhhachi, A. S. T., & Sachit, D. E. (2020).** Evaluation of water quality parameters in Shatt Al-Arab, Southern Iraq, using spatial analysis. *Hydrology*, 7(4), 79.
- **Li, H.; Shi, A.; Li, M. and Zhang, X. i, H.; Shi, A.; Li, M. and Zhang, X. (2013):** Effect of PH, Temperature and Flow Rate of Overlying Water on Heavy Metals Release from Storm Sewer *Sediments. Journal of Chemistry.* Article ID 434012, 11pages.
- **Li, Y., Zhao, B., Duan, K., Cai, J., Niu, W., & Dong, X. (2020).** Assessments of water-soluble inorganic ions and heavy metals in atmospheric dustfall and topsoil in Lanzhou, China. *International journal of environmental research and public health*, 17(8), 2970. [https://doi: 10.3390/ijerph17082970](https://doi.org/10.3390/ijerph17082970)
- **Lind, G. T. (1979).** Handbook of common methods in Limnology, 2 nd ed., London.
- **Liu J, Gao M, Liang JN, Chen J (2019)** . Characteristics and assessment of heavy metal pollution in spring atmospheric dust of an industrial park in

References

- Shaanxi Province. *Res. J. Environ. Sci.* ; 32: 1195–1203. doi: 10.13198/j.issn.1001-6929.2019.02.06.
- **Mackereth J H, Heron J, Talliny J F (1978).** Water analysis. some revised method for limnologists, *Int Rev ges Hydrobiol Hydrogr.* 36 :1-120 .
 - **Mahmood, B. A., & Hadi, S. H. (2022) .** Estimation of the concentrations of some heavy metals in water in anbar province, *Iraq Biochem. Cell. Arch.* 22(1) 3387-3399
 - **Majed, A . M, Mahmoud, A, H and Hassan, M.A (2002).** Heavy metal contents of some Molluscs and Crustaceans Along Al - Hodedah Sea . *Bull . Nat . of Oceanogr and fish*, 28: 331-319.
 - **Makki, I. M., & Manii, J. K. (2020).** Water Quality Index of Euphrates River Near Al-Musayyab Power Plant. *Iraqi Journal of Science*, 3002-3008.
 - **Malhotra, N., Ger, T. R., Uapipatanakul, B., Huang, J. C., Chen, K. H. C., & Hsiao, C. D. (2020).** Review of copper and copper nanoparticle toxicity in fish. *Nanomaterials*, 10(6), 1126.
 - **Maliki, A. A., Chabuk, A., Sultan, M. A., Hashim, B. M., Hussain, H. M., & Al-Ansari, N. (2022).** Estimation of total dissolved solids in water bodies by spectral indices Case Study: Shatt al-Arab River. *Water, Air, & Soil Pollution*, 231(9), 1-11.
 - **Mason, H. D., Martikainen, H., Beard, R. W., Anyaoku, V., & Franks, S. (1990).** Direct gonadotrophic effect of growth hormone on oestradiol production by human granulosa cells in vitro. *Journal of Endocrinology*, 126(3), R1-R4.
 - **Mateo-Sagasta, J., Zadeh, S. M., Turrall, H., & Burke, J. (2017).** Water pollution from agriculture: a global review. Executive summary.

References

- **Matlob , T.H. (2011)** . Monthly Variations of some physical and chemical characteristics and Concentrations of some Heavy elements in the water of AL-Husseiniya River- Karbala. *Journal of Karbala University*, ,9 (4) , 289 – 298 .
- **Maulood B K & Hassan F M.(2021)**. Physical and Chemical Characters of Mesopotamian Marshes: A Short Review . Chapter In book: Southern Iraq's Marshes , ; (pp.95-112) Springer -Nature Switzerland AG .
https://doi.org/10.1007/978-3-030-66238-7_6
- **Mellina, E., Moore, R. D., Hinch, S. G., Macdonald, J. S., & Pearson, G. (2002)**. Stream temperature responses to clearcut logging in British Columbia: the moderating influences of groundwater and headwater lakes. *Canadian Journal of Fisheries and Aquatic Sciences*, 59(12), 1886-1900.
- **Merza F A(2021)**. Diversity of Mollusca in some sites of Euphrates River. *J. Phys. Conf. Ser.*;1879 : 022049. doi:10.1088/1742-6596/1879/2/022049
- **Milivojević, J., Krstić, D., Šmit, B., & Djekić, V. (2016)**. Assessment of heavy metal contamination and calculation of its pollution index for Uglješnica River, Serbia. *Bulletin of environmental contamination and toxicology*, 97(5), 737-742.
- **Mirza NNA , Nashaat MR.(2019)**. Abundance, Diversity and Distribution of Mollusca in the Gharaf River, Southern Iraq . *Iraqi J. Sci* ,; 60 (3): 469-485. DOI: 10.24996/ijsc.2019.60.3.7
- **Mkadmi, Y., Benabbi, O., Fekhaoui, M., Benakkam, R., Bjjou, W., Elazzouzi, M., ... & Chetouani, A. (2018)**. Study of the impact of heavy metals and physico-chemical parameters on the quality of the wells and waters of the Holcim area (Oriental region of Morocco). *J Mater Environ Sci*, 9(2), 672-679. <https://doi.org/10.26872/jmes.9.2.74>.

References

- **Mohan SV, Nithila P, Reddy SJ. (1996).** Estimation of heavy metals in drinking water and development of heavy metal pollution index. *Journal of Environmental Science and Health Part A*; 31(2): 283-89.
- **Mouloud, B. K, & Al Saadi, H. A. & Al Azami, H .A.S (1990).** Environment and Practical Pollution. Ministry of Higher Education and Scientific Research, House of Wisdom, University of Baghdad.
- **Murphy, J. & Riley, J. R. (1962).**A modificational signal solution method for determination of phosphate in natural water. *Chem. Acta.*, 27: 31-36.
- **Nag R, O'Rourke SM, Cummins E (2022) .**A GIS study to rank Irish agricultural lands with background and anthropogenic concentrations of metal(loid)s in soil. *Chemosphere* 286(Pt 3):131928. <https://doi.org/10.1016/j.chemosphere.2021.131928>
- **Nashaat M R & Al-Bahathy I A A.(2022).** Impact of Hindiya Dam on the Limnological Features of Euphrates River to the North of Babil Governorate, Iraq .*Baghdad Sci.J.* 19(3): 447-459 . <http://dx.doi.org/10.21123/bsj.2022.19.3.0447>
- **Nguyen, G. T. (2020).** Evaluating current water quality monitoring system on Hau River, Mekong Delta, Vietnam using multivariate statistical techniques. *Applied Environmental Research*, 42(1), 14-25.
- **Noor, A. R., Hassan, F. M., & Al-Obaidy, A. H. M. J. (2022).** Water Quality Status of Tigris River Using Index Analysis. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1088, No. 1, p. 012011). IOP Publishing.
- **O Rasheed, R., H Khudor, M., H Issa, A., L Jassim, F., K Al-Wiswasy, M., T Al-Hadithi, H., ... & K Saleh, H. (2012).** Assessment of some Heavy

References

- Metals in Muscle Tissue of *Silurus triostegus* from Derbendikhan Reservoir, Kurdistan Region–Iraq. *Rafidain Journal of Science*, 23(1), 11-18..
- **Ogoyi, D. O., Mwita, C. J., Nguu, E. K., & Shiundu, P. M. (2011).** Determination of heavy metal content in water, sediment and microalgae from Lake Victoria, East Africa. *Environmental Engineering Journal*, 4, 156 – 161.
 - **Oh, H. J., Jeong, H. G., Nam, G. S., Oda, Y., Dai, W., Lee, E. H., ... & Chang, K. H. (2017).** Comparison of taxon-based and trophi-based response patterns of rotifer community to water quality: applicability of the rotifer functional group as an indicator of water quality. *Animal Cells and Systems*, 21(2), 133-140.
 - **Olaifa, F. E., Olaifa, A. K., Adelaja, A. A., & Owolabi, A. G. (2004).** Heavy metal contamination of *Clarias gariepinus* from a lake and fish farm in Ibadan, Nigeria. *African Journal of Biomedical Research*, 7(3).
 - **Ong, M. C., & Ibrahim, A. (2017).** Determination of selected metallic elements in marsh clam, *Polymesoda expansa*, collected from Tanjung Lumpur Mangrove Forest, Kuantan, *Pahang*. *Borneo Journal of Marine Science and Aquaculture (BJoMSA)*.
 - **Otchere, F. A. (2003).** Heavy metals concentrations and burden in the bivalves (*Anadara (Senilia) senilis*, *Crassostrea tulipa* and *Perna perna*) from lagoons in Ghana: Model to describe mechanism of accumulation/excretion. *African Journal of Biotechnology*, 2(9), 280-287.
 - **Pandiyan, J., Mahboob, S., Govindarajan, M., Al-Ghanim, K. A., Ahmed, Z., Al-Mulhm, N., ... & Krishnappa, K. (2021).** An assessment of level of heavy metals pollution in the water, sediment and aquatic

References

- organisms: A perspective of tackling environmental threats for food security. *Saudi Journal of Biological Sciences*, 28(2), 1218-1225.
- **Papafilippaki, A. K., Kotti, M. E., & Stavroulakis, G. G. (2008).** Seasonal variations in dissolved heavy metals in the Keritis River, Chania, Greece. *Global nest. The international journal*, 10(3), 320-325..
 - **Papagiannis, I.; Kagalou, I.; leonardos, J.; Petridis, D. and kalfa, k. (2004)** . Copper and zinc in four fresh water fish species from Lake Pamvotis (Greece). *Environ. Int* . 30: 357- 362.
 - **Parson, T.R.; Mait, Y. &Laulli, C.M. (1984).** A manual of chemical and biological methods for sea water analysis pergamone press Oxford.
 - **Paul, D. (2017).** Research on heavy metal pollution of river Ganga: A review. *Annals of Agrarian Science*, 15(2), 278– 286.
 - **Peng K, Luo C, Lou L, Li X, Shen Z. (2008)** . Bioaccumulation of heavy metals by the aquatic plants *Potamogeton pectinatus* L. and *Potamogeton malaianus* Miq. and their potential use for contamination indicators and in wastewater treatment. *Sci. Total Environ.*; 392(1):22-9. <https://doi.org/10.1016/j.scitotenv.2007.11.032> .
 - **Perumal, K., Antony, J., & Muthuramalingam, S. (2021).** Heavy metal pollutants and their spatial distribution in surface sediments from Thondi coast, Palk Bay, South India. *Environmental Sciences Europe*, 33(1), 1-20. <https://doi.org/10.1186/s12302-021-00501-2>.
 - **Peterson, D. P., Wenger, S. J., Rieman, B. E., & Isaak, D. J. (2013).** Linking climate change and fish conservation efforts using spatially explicit decision support tools. *Fisheries*, 38(3), 112-127.
 - **Pham, T. L. (2020).** Accumulation, depuration and risk assessment of cadmium (Cd) and lead (Pb) in clam *Corbicula fluminea* (OF Müller, 1774)

References

- under laboratory conditions. *Iranian Journal of Fisheries Sciences*, 19(3), 1062-1072.
- **Philips, S., Laanbroek, H. J., & Verstraete, W. (2002).** Origin, causes and effects of increased nitrite concentrations in aquatic environments. *Reviews in environmental science and biotechnology*, 1(2), 115-141.
 - **Prasad, B., & Bose, J. (2001).** Evaluation of the heavy metal pollution index for surface and spring water near a limestone mining area of the lower Himalayas. *Environmental Geology*, 41(1), 183-188.
 - **Prasad, N. R., & Patil, J. M. (2008).** A study of physico-chemical parameters of Krishna River water particularly in Western Maharashtra. *Rasayan J. Chem*, 1(4), 943-958.
 - **Qadoori A H , Al –Tawash B S. (2021).** Assessment of Some Heavy Metals in Water and Sediments Using Bio -Concentration Method of Al-Ma’ail River in Al - Kahla’a District, Maysan, Southern Iraq .; *Iraqi Geol J.* 2021; 54 (1D): 82 – 92 . <https://doi.org/10.46717/igj.54.1D.7Ms-2021-04-27>
 - **Qingjie, G., Jun, D., Yunchuan, X., Qingfei, W., & Liqiang, Y. (2008).** Calculating pollution indices by heavy metals in ecological geochemistry assessment and a case study in parks of Beijing. *Journal of China university of geosciences*, 19(3), 230-241.
 - **Rahman, M. S., Molla, A. H., Saha, N., & Rahman, A. (2012).** Study on heavy metals levels and its risk assessment in some edible fishes from Bangshi River, Savar, Dhaka, Bangladesh. *Food chemistry*, 134(4), 1847-1854.
 - **Rahman, M. S., Saha, N., & Molla, A. H. (2014).** Potential ecological risk assessment of heavy metal contamination in sediment and water body

References

- around Dhaka export processing zone, Bangladesh. *Environmental earth sciences*, 71(5), 2293-2308.
- **Rajeshkumar, S., & Li, X. (2018).** Bioaccumulation of heavy metals in fish species from the Meiliang Bay, Taihu Lake, China. *Toxicology reports*, 5, 288-295.
 - **Rashed, M. N. (2001).** Cadmium and lead levels in fish (*Tilapia nilotica*) Tissues As Biological indicator for lake water pollution. *Environ. Monitor and Assess.* 68:75-89.
 - **Remoudaki, E., Hatzikioseyan, A., Kousi, P., & Tsezos, M. (2003).** The mechanism of metals precipitation by biologically generated alkalinity in biofilm reactors. *Water Research*, 37(16), 3843-3854.
 - **Ribeiro, C. O., Vollaire, Y., Sanchez-Chardi, A., & Roche, H. É. L. È. N. E. (2005).** Bioaccumulation and the effects of organochlorine pesticides, PAH and heavy metals in the Eel (*Anguilla anguilla*) at the Camargue Nature Reserve, France. *Aquatic Toxicology*, 74(1), 53-69.
 - **Richmond, A. (2004).** Biological principles of mass cultivation. *Handbook of microalgal culture: Biotechnology and applied phycology*, 125-177.
 - **Saeed S I, Ahmed RZT, Grmasha R A, Alenezi S M, Salman J M, Al-Sareji O J, (2021).** Heavy metal pollution removal from water using a cost-effective bio-adsorbent. *IOP Conf. Ser.: Mater. Sci. Eng.*; 1058(10) : 012013. doi:10.1088/1757-899X/1058/1/012013
 - **Saeed, S. M., & Shaker, I. M. (2008).** Assessment of heavy metals pollution in water and sediments and their effect on *Oreochromis niloticus* in the northern delta lakes, Egypt. In 8th international symposium on Tilapia in Aquaculture (Vol. 2008, pp. 475-490). Central Laboratory for Aquaculture Research, Agricultural Research Center. Limnology Department.

References

- **Salman J M & Al-Shammary AAS .(2020) .** Monitoring Lotic Ecosystem by the Application of Water Quality Index (CCMEWQI), *Baghdad Sci. J.*; 17(1): 23-27. <https://doi.org/10.21123/bsj.2020.17.1.0023>
- **Salman, H. M., Jasim, M. N., & Salman, J.M. (2015).** A GIS assessment of water quality in Euphrates River/Iraq. *Journal of Babylon University/Engineering Sciences*, 23, 1-8.
- **Salman, J. M. (2006).** An environmental study of potential pollution in the Euphrates River between the Hindaa Dam and Kufaa City–Iraq (Doctoral dissertation, Ph. D. Thesis, College of Science, University of Babylon.
- **Salman, J. M., & Al-Shammary, A. A.S (2020).** Monitoring Lotic Ecosystem by the Application of Water Quality Index (CCMEWQI). *Baghdad Science Journal*, 17(1). 23-27): <https://doi.org/10.21123/bsj.17.1.0023>.
- **Salman, J. M., & Hussain, H. A. (2012).** Water quality and some heavy metals in water and sediments of Euphrates River, Iraq. *Journal of Environmental Science and Engineering*. A, 1(9A), 1088.
- **Salman, J. M., Alkam, F. M., & Al-Fatlawi, H. J. (2012).** A Biodiversity of phytoplankton in Euphrates river, middle of Iraq. *Iraqi Journal of Science, Special*, (1), 277-293.
- **Salman, J. M., Hassan J, J., Ahmmed J, N., & Fikrat M, H. (2013).** A study of phytoplankton communities and related environmental factors in Euphrates River (between two cities: Al-Musayyab and Hindiya), Iraq. *Journal of Environmental protection*, 2013.
- **Salman, J. M., Hassan, F. M., & Abdulameer, S. H. (2015).** A study on the fate of some heavy metals in water and sediments in lotic ecosystems. *Int. J. Chem. Phy. Sci*, 4(2), 36-45. www.ijcps.org.

References

- **Salman, J. M., Fikrat M, H&Baiee ,M.A.(2017).** Practical Methods in Environmental and Pollution Laboratory. University of Babylon ,Environmental research &Studies Center. Al-shaima press. Baghdad, Iraq.
- **Sangpal, R. R., Kulkarni, U. D., & Nandurkar, Y. M. (2011).** An assessment of the physico-chemical properties to study the pollution potential of Ujjani Reservoir, Solapur District, India. *ARNP Journal of Agricultural and Biological Science*, 6(3), 34-38.
- **Sankhla, M. S., Kumari, M., Nandan, M., Kumar, R., & Agrawal, P. (2016).** Heavy metals contamination in water and their hazardous effect on human health-a review. *Int. J. Curr. Microbiol. App. Sci* (2016), 5(10), 759-766.
- **Saad, W. M., Yosif, Y. M., Abdulrahman, M. F., & Mohammed, A. H. (2021).** Water quality index along the Euphrates between the cities of Al-Qaim and Falluja: A comparative study. In *IOP Conference Series: Earth and Environmental Science* (Vol. 779, No. 1, p. 012058). IOP Publishing.
- **Schulz, U. H., & Martins-Junior, H. (2001).** *Astyanax fasciatus* as bioindicator of water pollution of Rio dos Sinos, RS, Brazil. *Brazilian Journal of Biology*, 61, 615-622.
- **Shukla, S., Khan, R., & Hussain, C. M. (2020).** Chapter 16. Nanoremediation. *The Handbook of Environmental Remediation* (pp. 443– 467). Royal Society of Chemistry.
- **Skorbiłowicz E , Skorbiłowicz M , Tarasiuk U , Magdalena Korzińska M. (2021) .** Cadmium, Chromium, and Cobalt in the Organs of *Glyceria maxima* and Bottom Sediments of the Pisa River and Its Tributaries (Poland) . *Int. J. Environ. Res. Public Health*; 28;18(19):10193 .
<https://doi.org/10.3390/ijerph181910193>

References

- **Smalinskienė, A., & Abrachmanovas, O. (2001).** Investigation of concentrations of trace elements by patients, infirmed with renal deficiency. *Biomedicine*, 1, 93-97.
- **Smith, R. (2004).** Current methods in aquatic science. University of Waterloo Canada,96 p.
- **Solheim, A. L., Globevnik, L., Austnes, K., Kristensen, P., Moe, S. J., Persson, J., & Birk, S. (2019).** A new broad typology for rivers and lakes in Europe: Development and application for large-scale environmental assessments. *Science of the Total Environment*, 697, 134043. <https://doi.org/10.1016/j.scitotenv>.
- **Sow, A. Y., Dee, K. H., Lee, S. W., & Eh Rak, A. A. (2019).** An Assessment of Heavy Metals Toxicity in Asian Clam, *Corbicula fluminea*, from Mekong River, Pa Sak River, and Lopburi River, Thailand. *The Scientific World Journal*,. Volume 2019, Article ID 1615298, 5 pages.
- **Starzomski, B. M., & Srivastava, D. S. (2007).** Landscape geometry determines community response to disturbance. *Oikos*, 116(4), 690-699.
- **Stewart, B. D., Jenkins, S. R., Boig, C., Sinfield, C., Kennington, K., Brand, A. R., ... & Kröger, R. (2021).** Metal pollution as a potential threat to shell strength and survival in marine bivalves. *Science of the Total Environment*, 755, 143019.
- **Strayer, D. L. (2010).** Alien species in fresh waters: ecological effects, interactions with other stressors, and prospects for the future. *Freshwater biology*, 55, 152-174.
- **Suresh, G., Sutharsan, P., Ramasamy, V., & Venkatachalapathy, R. (2012).** Assessment of spatial distribution and potential ecological risk of the

References

- heavy metals in relation to granulometric contents of Veeranam lake sediments, India. *Ecotoxicology and environmental safety*, 84, 117-124.
- the United Nations, Rome, Italy. 1:68.
- **Tripathi, A., & Shukla, S. (2018).** Phytoremediation of lead and copper using ficusvirens and azadirachtaindica in Bareilly, Uttar Pradesh, India. *Pollution Research*, 37(4), 1109– 1116.
 - **Turek A, Wieczorek K , Wolf W M (2019).** Digestion Procedure and Determination of Heavy Metals in Sewage Sludge—An Analytical Problem. *Sustain.*; 11, 1753. <http://dx.doi.org/10.3390/su11061753>.
 - **Türkmen A, Türkmen M , Tepe Y and Akyurt İ (2005)** .Heavy metals in three commercially valuable fish species from İskenderun Bay, Northern East Mediterranean Sea, Turkey. *Food Chem.* 2005; 91(1): 167–172. <http://dx.doi.org/10.1016/j.foodchem..08.008>
 - **Uddin, M. M., Zakeel, M. C. M., Zavahir, J. S., Marikar, F. M., & Jahan, I. (2021).** Heavy metal accumulation in rice and aquatic plants used as human food: A general review. *Toxics*, 9(12), 360.
 - **Ullah, A. K. M. A.; Maksud, M. A.; Khan S. R.; Lutfu, L. N. and Quraishi S. B. (2017).** Dietary intake of heavy metals from eight highly consumed species of cultured fish and possible human health risk implications in Bangladesh. *Toxicology Reports*, 4: 574–579. doi:10.1016/j.toxrep.2017.10.002.
 - **UNEP (1993)** .Guidelines of monitoring chemical contamination in the sea using marine organisms .Reference methods for marine pollution studies.United Nation Environmental program . Nairobi,

References

- **UNEP,(2008)** Water Quality for Ecosystem and Human Health . United Nations Environment Monitoring System (GEMS) / Water Programme, 2nd edition , Canada.
- **Van den Broek, J.L., K.S. Gledhill and D.G. Morgan, (2002).** Heavy metal concentrations in the mosquito fish, *Gambusia holbrooki*, in the manly lagoon catchment. UTS Freshwater Ecology Report, Department of Environmental Sciences, University of Technology, Sydney, Australia, pp: 25.
- **Varol, M. (2011).** Assessment of heavy metal contamination in sediments of the Tigris River (Turkey) using pollution indices and multivariate statistical techniques. *Journal of hazardous materials*, 195, 355-364. doi: 10.1016/j.jhazmat.2011.08.051. . doi: 10.1016/j.jhazmat.2011.08.051.
- **Venkatesharaju, K., Ravikumar, P., Somashekar, R. K., & Prakash, K. L. (2010).** Physico-chemical and bacteriological investigation on the river Cauvery of Kollegal stretch in Karnataka. *Kathmandu University Journal of Science, Engineering and Technology*, 6(1), 50-59.
- **Vieira, C., Morais, S., Ramos, S., Delerue-Matos, C., & Oliveira, M. B. P. P. (2011).** Mercury, cadmium, lead and arsenic levels in three pelagic fish species from the Atlantic Ocean: intra-and inter-specific variability and human health risks for consumption. *Food and Chemical Toxicology*, 49(4), 923-932.
- **Wahab, H. R. & Al-Zubaidi, F. (2012).**Investigation of lead and chromium in phytoplankton and zooplankton at a Section of Tigris River at Baghdad City. Ist. Sci.Confer. March., - Bagh.Univ- Iraq.

References

- **Walli, H. A., Abed, S. A., Hossain, L. I., & Kadam, Z. M. (2018).** Water quality assessment of some rivers in Al-Qadisiyah province, middle euphrates/Iraq. *Journal of Global Pharma Technology*, 10(11), 883-891.
- **Wang J, Liu G, Wu H, Zhang T, Liu X, Li W(2018).**Temporal-spatial variation and partitioning of dissolved and particulate heavy metal(loid)s in a river affected by mining activities in Southern China. *Environ. Sci. Pollut. Res.*; 25(10): 9828-9839. <https://doi.org/10.1007/s11356-018-1322-x>
- **Wang, T., Zaar, M., Arvedsen, S., Vedel-Smith, C., & Overgaard, J. (2002).** Effects of temperature on the metabolic response to feeding in *Python molurus*. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology*, 133(3), 519-527.
- **WHO World Health Organization (2011).** Guidelines for drinking water quality, fourth ed. Geneva: WHO, 564p. ISBN: 978 92 4 154815 1.
- **Widmeyer, J. R., Crozier, E. D., Moore, M. M., Jurgensen, A., & Bendell-Young, L. I. (2004).** Role of *Leptothrix discophora* in mediating metal uptake in the filter-feeding bivalve *Mytilus trossulus (edulis)*. *Environmental science & technology*, 38(3), 769-774.
- **Wilson , A. (2009).** Houshold water quality , water hardness. Verginia Cooperative Extension , USA , pp: 356- 490.
- **World Health Organization (WHO) (2006).** World Health Organization
- **Yap, C. K., Wong, K. W., Al-Shami, S. A., Nulit, R., Cheng, W. H., Aris, A. Z., ... & Al-Mutairi, K. A. (2021).** Human Health risk assessments of trace metals on the clam *Corbicula javanica* in a tropical river in Peninsular Malaysia. *International journal of environmental research and public health*, 18(1), 195.

References

- **Yedjou, C. G., Patlolla, A. K., & Sutton, D. J. (2012).** Heavy Metals Toxicity and the Environment Paul B Tchounwou. *Published in final edited form as: EXS*, 101, 133-164.
- **YH, Elwasify (2021).** Effect of bioaccumulation and biosedimentation of some heavy metals on histological features in the cichlid fish, *Tilapia zillii* inhabiting Lake Qarun, Egypt. *Egyptian Journal of Aquatic Biology and Fisheries*, 25(3), 695-711.
- **Yi, Y. J., & Zhang, S. H. (2012).** The relationships between fish heavy metal concentrations and fish size in the upper and middle reach of Yangtze River. *Procedia Environmental Sciences*, 13, 1699-1707.
- **Yilmaz, A. B., Sangün, M. K., Yağlıoğlu, D., & Turan, C. (2010).** Metals (major, essential to non-essential) composition of the different tissues of three demersal fish species from Iskenderun Bay, Turkey. *Food chemistry*, 123(2), 410-415.
- **Yin, H., Gao, Y., & Fan, C. (2011).** Distribution, sources and ecological risk assessment of heavy metals in surface sediments from Lake Taihu, China. *Environmental Research Letters*, 6(4), 044012.
- **Zahraw, Z., Abd Maktoof, A., Al-Obaidy, A. H. M., Kareem, L. M. A., Shakir, E., & Hassan, S. M. (2019).** Estimation of Heavy Metal Concentration for Sediments of Shatt Al-Basrah Canal by using Ecological Indices. *Indian J Public Health Res. Dev*, 10(1), 970.
- **Zeng J, Han G, Zhang S, Zhang Q.(2022).** Suspended Sediments Quality Assessment in a Coastal River: *Identification of Potentially Toxic Elements. Int. J. Environ. Res. Public Health*; 3; 19(7): 4293. <https://doi.org/10.3390/ijerph19074293>

References

- **Zhang JJ, Tong L, Huang Z W, Zhang H L, He MM, Dai XR.,(2018).** Seasonal variation and size distributions of water-soluble inorganic ions and carbonaceous aerosols at a coastal site in Ningbo, China. *Sci. Total Environ.* 2018; 639: 793–803. doi: 10.1016/j.scitotenv.05.183.

Appendices

Appendix

Appendix (1) Correlation between Physiochemical parameters

parameter	WT	AT	DO	BOD ₅	pH	EC	Salinity	TDS	NO ₂	NO ₃	PO ₄	TSS	T.H	Ca	Mg	TA
WT	1.00															
AT	0.94	1.00														
DO	-0.59	-0.54	1.00													
BOD₅	-0.54	-0.46	0.68	1.00												
Ph	-0.60	-0.60	0.38	0.33	1.00											
EC	-0.51	-0.45	0.31	0.20	0.53	1.00										
Salinity	-0.51	-0.45	0.31	0.20	0.53	1.00	1.00									
TDS	-0.54	-0.48	0.25	0.16	0.54	0.98	0.98	1.00								
NO₂	-0.07	-0.05	0.02	-0.16	0.17	0.59	0.59	0.57	1.00							
NO₃	-0.27	-0.26	0.31	-0.06	0.21	0.17	0.17	0.17	0.59	1.00						
PO₄	-0.12	-0.14	-0.04	-0.12	0.30	0.48	0.48	0.49	0.76	0.48	1.00					
TSS	0.46	0.45	-0.37	-0.25	-0.13	-0.21	-0.21	-0.22	0.10	0.09	0.27	1.00				
T.H	0.22	0.22	-0.03	-0.21	0.21	0.33	0.33	0.31	0.42	0.17	0.58	0.25	1.00			
Ca	0.08	0.09	0.36	-0.14	0.08	0.27	0.27	0.21	0.24	0.25	0.11	-0.17	0.58	1.00		
Mg	0.16	0.16	-0.32	-0.06	0.16	0.15	0.15	0.17	0.25	-0.07	0.56	0.45	0.62	-0.25	1.00	
TA	0.00	0.02	-0.09	0.07	0.13	0.22	0.22	0.20	-0.06	-0.36	-0.01	-0.07	0.33	0.14	0.30	1.00

Appendix

Appendix (2) Correlation between physiochemical parameters and *dissolved* HMs

HM Parameter	Cr	Fe	Cu	Zn	Pb	Ni	Cd
WT	0.494	0.352	0.359	0.089	0.495	0.458	-0.236
DO	-0.474	-0.231	-0.267	-0.024	-0.318	-0.288	0.192
BOD5	-0.662	-0.479	-0.481	-0.246	-0.395	-0.415	0.019
pH	-0.440	-0.306	-0.355	-0.148	-0.554	-0.532	0.166
Salinity	-0.420	-0.219	-0.336	0.044	-0.608	-0.462	0.451
NO2	0.265	0.374	0.184	0.314	-0.245	0.027	0.556
NO3	0.436	0.507	0.401	0.448	-0.021	0.227	0.494
PO4	0.240	0.364	0.210	0.342	-0.201	0.029	0.519
TSS	0.598	0.5406	0.558	0.267	0.344	0.488	0.164
T.H	0.407	0.515	0.352	0.431	-0.009	0.241	0.515
Ca	0.563	0.501	0.400	0.363	0.142	0.307	0.322
Mg	0.132	0.334	0.197	0.344	-0.146	0.118	0.548
TA	-0.606	-0.534	-0.654	-0.356	-0.718	-0.691	0.039
Cr	1.000	0.923	0.938	0.663	0.795	0.867	0.281
Fe		1.000	0.935	0.849	0.767	0.869	0.480
Cu			1.000	0.723	0.849	0.948	0.303
Zn				1.000	0.607	0.675	0.636
Pb					1.000	0.896	-0.028
Ni						1.000	0.256
Cd							1.000

Appendix

Appendix (3) Correlation between physiochemical parameters and *Particulate* HMS

HM Parameter	Cr	Fe	Cu	Zn	Pb	Ni	Cd
WT	0.073	0.112	0.189	-0.108	0.293	-0.178	-0.042
DO	-0.143	0.002	-0.119	0.230	-0.209	0.325	0.193
BOD5	-0.280	-0.231	-0.388	0.010	-0.172	0.345	0.115
pH	-0.185	-0.162	-0.158	0.000	-0.400	0.033	-0.020
Salinity	-0.156	0.058	-0.025	0.219	-0.520	-0.084	-0.019
NO2	0.006	0.395	0.464	0.295	-0.495	-0.504	-0.350
NO3	0.256	0.474	0.544	0.438	-0.242	-0.266	-0.157
PO4	0.083	0.377	0.453	0.326	-0.408	-0.349	-0.224
TSS	0.269	0.315	0.379	0.166	0.232	0.020	0.371
T.H	0.084	0.491	0.589	0.283	-0.331	-0.497	-0.328
Ca	0.084	0.371	0.508	0.100	-0.232	-0.586	-0.317
Mg	0.007	0.438	0.481	0.349	-0.330	-0.228	-0.245
TA	-0.721	-0.366	-0.335	-0.434	-0.772	-0.551	-0.583
Cr	1.000	0.746	0.759	0.665	0.665	0.260	0.542
Fe		1.000	0.965	0.914	0.254	-0.015	0.159
Cu			1.000	0.842	0.263	-0.064	0.144
Zn				1.000	0.261	0.209	0.245
Pb					1.000	0.714	0.671
Ni						1.000	0.711
Cd							1.000

Appendix

Appendix (4) Correlation between physiochemical parameters and Sediment HMS

HM Parameter	Cr Sed.	Fe Sed	Cu Sed	Zn Sed	Pb Sed	Ni Sed	Cd Sed
<i>WT</i>	0.46	0.34	0.38	0.20	0.27	0.07	0.59
<i>AT</i>	0.50	0.39	0.43	0.25	0.40	0.14	0.65
<i>DO</i>	-0.40	-0.43	-0.47	-0.33	-0.24	-0.14	-0.59
<i>BOD₅</i>	-0.31	-0.68	-0.70	-0.54	-0.33	-0.38	-0.72
<i>pH</i>	-0.59	-0.27	-0.32	-0.21	-0.41	-0.15	-0.55
<i>EC</i>	-0.56	-0.22	-0.26	-0.16	-0.37	0.00	-0.49
<i>Salinity</i>	-0.56	-0.22	-0.26	-0.16	-0.37	0.00	-0.49
<i>TDS</i>	-0.57	-0.20	-0.24	-0.13	-0.34	0.02	-0.48
<i>NO₂</i>	-0.09	0.48	0.46	0.32	-0.17	0.38	0.23
<i>NO₃</i>	0.21	0.65	0.63	0.48	0.08	0.59	0.38
<i>PO₄</i>	-0.07	0.46	0.44	0.35	-0.10	0.41	0.18
<i>TSS</i>	0.37	0.48	0.48	0.27	0.23	0.30	0.53
<i>T.H</i>	0.10	0.58	0.59	0.49	0.02	0.46	0.42
<i>Ca</i>	0.21	0.63	0.64	0.48	0.04	0.38	0.57
<i>Mg</i>	-0.10	0.35	0.34	0.34	-0.03	0.38	0.14
<i>TA</i>	-0.73	-0.46	-0.45	-0.39	-0.73	-0.50	-0.55
<i>Cr Sed.</i>	1.00	0.61	0.64	0.55	0.63	0.51	0.75
<i>Fe Sed</i>		1.00	1.00	0.90	0.68	0.88	0.92
<i>Cu Sed</i>			1.00	0.91	0.68	0.87	0.94
<i>Zn Sed</i>				1.00	0.76	0.94	0.83
<i>Pb Sed</i>					1.00	0.80	0.73
<i>Ni Sed</i>						1.00	0.77

Appendix

Appendix (5) Correlation between physiochemical parameters and *C. demersuim* HMS

HM Parameter	Cr	Fe	Cu	Zn	Pb	Ni	Cd
WT	-0.207	0.364	-0.621	-0.739	0.577	0.027	-0.129
DO	0.244	-0.479	0.483	0.578	-0.662	-0.071	0.043
BOD5	0.119	-0.446	0.464	0.664	-0.612	-0.206	-0.257
pH	0.086	-0.542	0.359	0.408	-0.479	-0.142	0.182
Salinity	0.197	-0.533	0.338	0.514	-0.510	-0.208	0.168
NO2	0.046	-0.330	-0.364	-0.416	-0.058	-0.090	0.494
NO3	0.151	0.000	-0.044	-0.160	-0.029	0.173	0.619
PO4	0.144	-0.288	-0.191	-0.258	-0.042	-0.008	0.544
TSS	-0.072	0.240	-0.309	-0.430	0.134	0.107	0.256
T.H	0.123	-0.184	-0.566	-0.663	0.292	-0.004	0.434
Ca	-0.104	0.037	-0.643	-0.797	0.197	-0.062	0.260
Mg	0.253	-0.338	-0.324	-0.346	0.171	-0.049	0.440
TA	-0.297	-0.821	-0.520	-0.336	-0.172	-0.699	-0.415
Cr.	1.000	0.331	0.497	0.371	0.203	0.652	0.645
Fe.		1.000	0.325	0.094	0.501	0.721	0.434
Cu			1.000	0.914	-0.302	0.478	0.313
Zn				1.000	-0.446	0.237	0.068
Pb					1.000	0.415	0.236
Ni						1.000	0.694
Cd							1.000

Appendix

Appendix(6) Correlation between physiochemical parameters and *P. australis* HMS

HM Parameter	Cr	Fe	Cu	Zn	Pb	Ni	Cd
WT	0.133	0.444	-0.130	-0.206	0.418	0.324	0.085
DO	-0.053	-0.490	0.025	0.048	-0.438	-0.267	-0.139
BOD5	-0.328	-0.554	-0.017	0.034	-0.692	-0.440	-0.439
pH	-0.077	-0.522	-0.111	-0.079	-0.308	-0.364	0.058
Salinity	-0.147	-0.499	-0.083	0.028	-0.295	-0.389	0.035
NO2	0.202	-0.079	-0.287	-0.254	0.414	0.067	0.560
NO3	0.264	0.221	0.108	0.150	0.547	0.295	0.620
PO4	0.206	-0.054	-0.179	-0.147	0.399	0.081	0.537
TSS	0.220	0.404	0.163	0.051	0.572	0.477	0.471
T.H	0.278	0.070	-0.367	-0.386	0.547	0.178	0.556
Ca	0.234	0.261	-0.246	-0.322	0.616	0.305	0.455
Mg	0.228	-0.130	-0.355	-0.345	0.286	-0.026	0.462
TA	-0.435	-0.759	-0.859	-0.831	-0.460	-0.735	-0.398
Cr	1.000	0.630	0.493	0.412	0.762	0.822	0.824
Fe		1.000	0.745	0.675	0.795	0.856	0.625
Cu			1.000	0.966	0.432	0.700	0.475
Zn				1.000	0.339	0.594	0.410
Pb					1.000	0.881	0.878
Ni						1.000	0.792
Cd							1.000

Appendix

Appendix (7) Correlation between physiochemical parameters and Clam HMS

HM Parameter	Cr Clam	Fe Clam	Cu Clam	Zn Clam	Pb Clam	Ni Clam	Cd Clam
WT	-0.299	-0.466	-0.635	-0.551	-0.454	0.276	0.154
DO	-0.053	0.460	0.432	0.248	0.321	-0.319	-0.043
BOD5	0.018	0.471	0.326	0.267	0.109	-0.508	-0.132
pH	0.281	0.153	0.361	0.232	0.389	-0.264	-0.066
Salinity	0.179	0.277	0.429	0.274	0.488	-0.203	-0.143
NO2	-0.216	-0.341	-0.087	-0.302	0.344	0.286	-0.141
NO3	-0.157	-0.061	0.237	0.096	0.364	0.347	-0.108
PO4	-0.189	-0.242	0.047	-0.141	0.381	0.275	-0.125
TSS	-0.116	-0.179	-0.164	-0.244	0.070	0.315	0.526
T.H	-0.398	-0.572	-0.330	-0.504	0.163	0.493	-0.157
Ca	-0.219	-0.561	-0.350	-0.547	0.070	0.524	-0.020
Mg	-0.472	-0.411	-0.174	-0.312	0.229	0.316	-0.239
TA	-0.049	-0.590	-0.515	-0.645	-0.149	-0.277	-0.370
Cr	1.000	0.247	0.365	0.350	0.342	-0.115	0.455
Fe		1.000	0.835	0.849	0.372	-0.082	0.094
Cu			1.000	0.879	0.693	0.231	0.111
Zn				1.000	0.386	0.052	0.163
Pb					1.000	0.544	0.189
Ni						1.000	0.036
Cd							1.000

Appendix

Appendix (8) Correlation between physiochemical parameters and *O. aureas* HMS

HM Parameter	Cr	Fe	Cu	Zn	Pb	Ni	Cd
WT	0.034	0.194	0.280	-0.123	0.195	-0.506	-0.201
DO	-0.072	-0.231	-0.254	0.010	-0.152	0.400	0.019
BOD5	0.035	-0.365	-0.547	-0.229	-0.303	0.441	0.107
pH	-0.198	-0.279	-0.172	0.055	-0.226	0.352	0.174
Salinity	-0.223	-0.258	-0.095	0.220	-0.329	0.131	-0.016
NO2	-0.133	0.023	0.601	0.373	-0.203	-0.633	-0.452
NO3	0.253	0.321	0.695	0.569	0.055	-0.421	-0.300
PO4	-0.035	0.073	0.559	0.433	-0.108	-0.433	-0.363
TSS	0.354	0.433	0.582	0.175	0.249	-0.387	-0.129
T.H	-0.126	0.085	0.642	0.353	-0.077	-0.705	-0.597
Ca	-0.071	0.162	0.641	0.191	-0.001	-0.735	-0.356
Mg	-0.246	0.036	0.458	0.386	-0.190	-0.454	-0.657
TA	-0.778	-0.749	-0.406	-0.444	-0.702	-0.316	-0.159
Cr	1.000	0.536	0.263	0.254	0.524	0.256	0.304
Fe		1.000	0.751	0.704	0.740	0.172	0.002
Cu			1.000	0.797	0.531	-0.317	-0.324
Zn				1.000	0.635	0.106	-0.215
Pb					1.000	0.473	0.238
Ni						1.000	0.607
Cd							1.000

Appendix

Appendix(9) Correlation between physiochemical parameters and *L. vorax* HMS

HM Parameter	Cr	Fe	Cu	Zn	Pb	Ni	Cd
WT	0.433	0.086	0.163	-0.043	0.128	-0.098	0.100
DO	-0.396	-0.125	-0.083	0.042	-0.063	0.062	-0.145
BOD5	-0.487	-0.118	-0.253	0.027	0.028	0.153	-0.035
pH	-0.495	-0.312	-0.197	-0.119	-0.274	0.004	-0.206
Salinity	-0.534	-0.362	-0.281	-0.245	-0.464	-0.260	-0.448
NO2	-0.118	-0.436	-0.154	-0.488	-0.620	-0.670	-0.620
NO3	0.156	-0.118	0.138	-0.125	-0.305	-0.407	-0.308
PO4	-0.089	-0.365	-0.048	-0.333	-0.510	-0.506	-0.495
TSS	0.444	0.174	0.375	0.011	0.103	-0.058	-0.126
T.H	0.025	-0.375	-0.111	-0.478	-0.579	-0.655	-0.569
Ca	0.258	-0.190	-0.018	-0.397	-0.402	-0.567	-0.411
Mg	-0.225	-0.363	-0.162	-0.403	-0.536	-0.516	-0.544
TA	-0.793	-0.819	-0.788	-0.758	-0.731	-0.500	-0.578
Cr	1.000	0.793	0.835	0.644	0.593	0.319	0.486
Fe		1.000	0.829	0.790	0.792	0.638	0.591
Cu			1.000	0.876	0.750	0.597	0.641
Zn				1.000	0.879	0.794	0.880
Pb					1.000	0.900	0.893
Ni						1.000	0.825
Cd							1.000

الخلاصة

هدفت الدراسة الحالية إلى تقييم نوعية المياه والتحري عن مصير ونقل بعض العناصر الثقيلة في السلاسل الغذائية داخل قناة المسيب (المتفرعة من نهر الفرات وسط العراق) كنظام مائي جاري للفترة من كانون الثاني ٢٠٢١ ولغاية كانون الاول ٢٠٢١ في اربعة مواقع (٤،٣،٢،١).

تضمنت هذه الدراسة قياس بعض الخصائص الفيزيائية والكيميائية لمياه القناة ، مثل درجة حرارة الماء (WT) ودرجة حرارة الهواء (AT) والاس الهيدروجيني (pH) والتوصيلية الكهربائية (EC) والملوحة و المواد الصلبة الذائبة الكلية (TDS) و المواد الصلبة العالقة الكلية (TSS) والأوكسجين المذاب (DO) والمتطلب الاحيائي للأوكسجين (BOD₅).

تناولت هذه الدراسة تقدير سبعة عناصر ثقيلة (الحديد والنحاس والزنك والرصاص والنيكل والكاديوم والكروم) في الماء (الطور الذائب والدقائق) والرواسب وبعض الكائنات الحية المائية بما في ذلك نوعان من النباتات المائية (*Ceratophyllum demersum* and *Phragmites australis*) و نوع واحد من المحار (*Pseudontopeses euphraticus*) ونوعان من الأسماك (*Leuciscus vorax* and *Oreochromis aureus*) في أربعة مواقع داخل قناة مشروع المسيب / فرع من نهر الفرات ، بابل ، وسط العراق. وكان الترتيب للعناصر المدروسة في الطور الذائب من الماء هو: Zn < Fe < Cu < Ni < Pb < Cr < Cd اذ سجل عنصر الزنك أعلى معدل في الموقع الثاني لموسم الربيع بينما سجل عنصر الكاديوم أقل معدل في الموقع الأول لموسم الربيع. وفي الطور الدقائق منه ترتبت العناصر بالشكل الاتي: Zn < Cu < Fe < Ni < Pb < Cr < Cd والتي سجل فيها عنصر الزنك أعلى معدل في الموقع الثاني لموسم الربيع بينما سجل عنصر الكاديوم أقل معدل في الموقع الرابع لموسم الربيع وترتبت العناصر تحت الدراسة في الرواسب بالصيغة الاتية : Zn < Cu < Fe < Pb < Ni < Cd < Cr وسجل عنصر الزنك أعلى معدل في الموقع الثاني لموسم الربيع بينما سجل عنصر الكروم أقل معدل في الموقع الثاني للربيع وفي النبات المائي *C. demersum* كان تدرجها اخذ الشكل الاتي: Zn < Fe < Cu < Pb < Cr < Ni < Cd سجل عنصر الزنك أعلى معدل في الموقع الرابع لموسم الشتاء بينما سجل عنصر الكاديوم أقل معدل في الموقع الأول لموسم الخريف وفي نبات القصب *P. australis* تدرجت العناصر في الصيغة: Zn < Fe < Cu < Pb < Cd < Cr < Ni سجل عنصر الزنك أعلى معدل في الموقع الثاني لموسم الربيع بينما سجل عنصر الكروم أقل معدل في الموقع الثاني لموسم الربيع. اما في المحار فقد كان ترتيبها كالاتي: Zn < Fe < Cu < Ni < Pb < Cd < Cr ، سجل عنصر الزنك أعلى معدل في الموقع الثاني لموسم

الربيع بينما سجل الكروم أدنى قيمة في الموقع ٣ خلال شتاء ٢٠٢١ وفي أنواع الأسماك (O. aureus) كان ترتيب $Ni < Cd < Cr < Pb < Cu < Zn < Fe$ سجل عنصر الحديد أعلى معدل في الموقع ٢ في ربيع عام ٢٠٢١ بينما سجل عنصر النيكل Ni أقل معدل كان في الموقع ٢ للربيع وفي (L.vorax) سجل عنصر الحديد أعلى معدل في الموقع الأول لموسم الصيف بينما سجل النيكل قيم منخفضة في الموقع الرابع في ربيع ٢٠٢١.

إضافة إلى ذلك، هدفت الدراسة الحالية إلى تقييم نوعية المياه الحالية لنهر المسيب الذي يمثل منه مشروع المسيب الكبير ويقع في الشمال الشرقي من محافظة بابل، إلى الشرق من مديرتي محاويل والمسيب. إلى مدينة جبلة من خلال العديد من التحليلات الفيزيائية والكيميائية باستخدام مؤشرات جودة المياه (WQI) وتلوث المعادن الثقيلة (HPI) والتلوث (C_d).

مؤشر جودة المياه (WQI) هو أداة تستخدم لتحديد ما إذا كانت المياه مناسبة للحياة المائية والأنهار المستخدمة في الري (IWQI). الهدف من هذه الدراسة هو تقييم نوعية المياه في نهر المسيب. تم اختيار العديد من المواقع في منطقة الدراسة وتم تطبيق سبعة عشر معلماً فيزيائياً كيميائياً ومؤشر حساب تلوث العناصر الثقيلة (HPI) ومؤشر التلوث (C_d) لتقييم صلاحية المياه للاستخدام المختلف من كانون الثاني ٢٠٢١ إلى كانون الأول ٢٠٢١ ، وتم تقسيم الفترة المدروسة إلى أربعة فصول (الشتاء ، الربيع ، الصيف ، الخريف) . كانت هذه المعلمة (درجة حرارة الماء ، درجة الحموضة ، DO ، BOD5 ، TDS ، NO3 ، NO2 ، Ca ، Mg ، PO4 ، Cu ، Fe ، Cr ، Zn ، Pb ، Ni ، Cd).

ظهرت نتائج الدراسة الحالية أن قيم HPI التي كانت أعلى من متوسط قيمة مؤشر التلوث الحرج (١٠٠) ، حيث تراوحت بين ٧٤,٣٨٣٨٨ إلى ٢٣٨,٥٥٩٢ في St.3 لفصل الشتاء و St.2 للربيع. قد تكون القيمة العالية للمؤشر بسبب ارتفاع العناصر Fe ؛ Cu و Zn أكثر من الحد المسموح به للمياه المحمولة وتركيز المعادن الثقيلة. أما بالنسبة لمؤشر التلوث (C_d) فقد تراوحت قيم (C_d) بين (٢٣,٠٦١-٨٤,٠٧٠) في الموقع الثالث في فصل الشتاء والموقع الثاني في الربيع الشكل $Cd > 3$ ويكون التلوث عالي .

كانت حالة نوعية المياه (حافي - فقير) وتأثرت بشكل كبير بالخصائص الفيزيائية والكيميائية للنهر.



جمهورية العراق
وزارة التعليم العالي والبحث العلمي
جامعة بابل / كلية العلوم /
قسم علوم الحياة

توزيع ومصير بعض العناصر الثقيلة ونوعية المياه للنظام البيئي الجاري
في جدول مشروع المسيب / فرع نهر الفرات ، بابل ، العراق

اطروحة مقدمة الى

مجلس كلية العلوم / جامعة بابل

كجزء من متطلبات دكتوراه فلسفة في العلوم / علوم الحياة

من قبل

اشواق فالح خزعل فليح العجيلي

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