Studying the Possibility of Using Treated Wastewater for Irrigation Purposes: Case Study in Babylon City, Iraq

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By

Nawras Ahmed Abbas Shaker

Supervised by

Asst.Prof. Dr. Nabaa Shaker Hadi

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بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

﴿يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ﴾

صدق الله العظيم

سورة المجادلة : 11

Supervisor's Certification

 I certify that this thesis (Studying the Possibility of using Treated Wastewater for Irrigation Purposes: Case study in Babylon City, Iraq) and submitted by the student (Nawras Ahmed Abbas) was prepared under my supervision at the Department of Environmental Engineer /College of Engineering /university of Babylon as a part of requirements for a   master degree of science in Environmental Engineering .

Signature:

Supervisor: Assit. prof. Dr. Nabaa Shakir Hadi

Date: /   /

I certify that this thesis mentioned above has been completed in Environmental Engineering in the College of Engineering /University of Babylon

Signature:

Head of Department: Assit. prof. Dr. Hussein A. M. Al-Zubaidi

Date :   /   /

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Thanks be to God for the insight that inspired me, and praise be to Him for the blessings He has bestowed upon me, and to Him is the credit for achieving what I aspire to in this research. Praise be to God, who by His praise opens every book and by His remembrance, every speech is issued, and by His praise, the people of blessings enjoy the abode of reward.

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Researcher

Nawras Ahmed Abbas

Dedication

To my kind father.... who taught me how to stand firmly above the earth, my role model, and my ideal in life; He is the one who taught me how to live with dignity and honor.

To my tender mother... the source of love, altruism, and generosity, I cannot find words that can give her her due, for she is the epic of love and the joy of a lifetime, and an example of dedication and giving she is the epic of love and the joy of a lifetime, and an example of dedication and giving.

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I dedicate to you, all, the summary of my scientific effort.

Abstract

Abstract

The current study was conducted to evaluate the efficiency Al-Muamirah treatment plant for the period from October 2020 to August 2021. This is done by measuring the removal efficiency of BOD_5, COD, TSS, T.N, PO_4, NH_3, SO_4, NO_3, Cl, and O&G. Moreover, to determine the effluent water quality from the Al-Muamirah treatment plant that disposed into Hilla drainage water (A1). The samples of water, sediment, and reed were collected monthly (from October 2021 to August 2022) from three stations along Hilla drainage water (A1) with distances of 0.5 km, 1.5 km, and 3.5 km from the Al-Muamirah treatment plant. Sixteen elements were collected from Hilla drainage water (A1) and measurd in the field and labrotory. These elements are air temperature, water temperature, pH, TDS, EC, salinity, turbidity, DO, COD, Nitrogen, Nitrate, TOC, TH. SO_4, Cl, Cu, and Pb.

The results showed that the removal efficiencies of the Al-Muamirah wastewater treatment plant for BOD_5, COD, TSS, T.N., PO_4, NH_3, SO_4, NO_3, Cl, and O&G were 92.6%, 78.9%, 94%, 62.6%, 81.8%, 83%, 8.7%, 61.5%, 12%, and 88.8%, respectively.

Based on the values of removal efficiency of the Al-Muamirah wastewater treatment plant, it has been found an acceptable efficiency in the removal of physicochemical parameters except for the efficiency of sulfates and chlorides.

Using cluster analysis as a multivariate statistical method on the data has been attempted (SPSS). Cluster analysis the first consists of two subgroups the months with similar removal efficiency (from Nov. 2020 to Jan 2021). The worst case was group No.3(from Oct 2020 to Mar 2021).

This research is to investigate the possibility of using water from the Drainage to irrigate land in the surrounding areas. The rates seasonal of the following physicochemical parameters at the study sites: air temperature (14.3 - 47.3 °C), water temperature (13.6 – 48.0 °C), pH (6.6 - 7.2), TDS (1670-3010 mg/L), EC (3360-6130 µs\cm), salinity (2.15 - 3.92 ppt), turbidity (1.05 - 5.2 NTU), DO (5.65 - 9.0 mg/L), COD (5.1 - 73.5 mg/L), Nitrogen (0.21 - 0.91 mg/L), Nitrate (0.01-1.5 mg/L), TOC

Abstract

(0.16-1.72%), TH (209-229 mg/L). in addition, SO_4 (1004-3824 mg/L) in water, (0.58-1.4 %) in sediment, and (51-69.75 mg/L) in reeds respectively, and for Cl (459-1345 mg/L) in water, (36-105.97 mg/L) in sediment, (21-30.61 mg/L) in reeds respectively. The rates seasonal of heavy metal concentrations in water were Cu (0.042 mg/L) and Pb (0.031 mg/L), in the dissolved phase and sediment (respectively) (as adry weight) were 0.48, and 1.59 mg/g, while in the residual phase and reeds (as adry weight) were (0.10, and 0.075) mg/g, respectively.

The physicochemical parameters were within the Iraqi standard limits except for TDS, EC, Cl & SO_4 in water. The heavy metals in water were within permissible limits of Iraqi standards but, the concentrations of heavy metals in sediment were outside permissible limits because it accumulates in the soil for several years. Rates of heavy metals in reeds plants were different between seasons and sites. The water is suitable for chlorine-tolerant plants with slight to moderate damage (High effect on sensitive crops).

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List of Abbreviations

Abbreviation	Definition
STP	Sewage Treatment Plant
WWTP	Waste-Water Treatment Plant
pH	Hydrogen ions
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
TSS	Total Suspended Solid
NH_3	Ammonia
PO_4	phosphate
TDS	Total Dissolved Solid
T	Temperature
Cl	Chloride ion
SO_4	Sulfate ions
H_2S	Hydrogen sulfide
O&G	Oil &Grease
NEQS	National Environmental Quality Standards
DO	Dissolved Oxygen
EC	Electrical Conductivity
TH	Total Hardness
TOC	Total Organic Carbon
Cu	Copper
Zn	Zinc ion
Cd	Cadmium
Cr	Chrome
Pb	Lead
Fe	Iron
Mn	Manganese
Ni	Nickel
Co	Cobalt
TN	Total Nitrogen
AAS	Atomic Absorption Spectrometry
APHA	American Public Health Association
NTU	Nephelometric Turbidity Unit
HCl	Hydraulic acid
ASTM	American Society for Testing and Materials
FAO	Food and Agriculture Organization
NO_3	Nitrate ions
N	Nitrogen
EPA	Environmental Protection Agency
WHO	World Health Organization

CHAPTER ONE

Introduction

CHAPTER ONE

INTRODUCTION

1.1 General Overview

Water scarcity is a concern in many nations, and Iraq is one of them; as a result, wastewater treatment plants have become essential for the country to alleviate some of the strain caused by this issue (Alanbari et al., 2015). The accessibility of water resources inside nations is one of the most important contributors to economic growth. As a result, it is essential to safeguard water supplies from the risks posed by pollution and to control how it is utilized (Cheepi, 2012; Ahmed and Kheder, 2009).

The majority of wastewater is composed of water (99.9%). Organic and inorganic pollutants both dissolved and suspended solids with microbes make up the remaining one percent. The elimination of these contaminants is the intended result of treating wastewater (Samer, 2015). Several factors including water usage, ecology, the economic and social circumstances of the community, and others influence the properties of wastewater (Henze et al., 1995).

Various sources generate sewage including residential institutional commercial and industrial. It is collected and transferred to a sewage treatment plant (STP) via a network of pipelines (Fikrat et al., 1997). This plant's primary objective is to remove contaminants from wastewater and reduce sediments, organic matter, and nutrients, so that treated effluent may be discharged into natural water bodies (Erbe et al., 2003). Due to the steady depletion of global water resources and the large amounts of polluted water in industrial cities give wastewater treatment operations play an important role in reducing water loss. Simultaneously, as cities become larger, the volume of chemical and physical loadings on existing plants will

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increase, demanding more effective wastewater treatment methods. After it has been used for a variety of reasons, wastewater becomes the community's water supply. When sewage water accumulates and is allowed into the septic system, the organic matter in it dissolved, producing noxious gases. (Qasim, 2009).

Because people are becoming more worried about the environment, they are paying more attention to how WWTP is run and controlled. Since the waste from STPs is discharged into a body of water, if they are not run correctly, they could cause serious environmental problems. Wastewater treatment plants are built and run to work like natural treatment systems. In this case, it's essential to pay extra attention to figure out how existing wastewater treatment plants affect the environment (Jamrah, 1999).

A performance evaluation of the existing treatment plant is needed for the reason of determining the quality of the existing effluent or meeting higher standards for treatment.

The levels of COD and suspended particles are significant indicators of the efficacy of wastewater treatment plant, which are forms of organic pollutants that are reduced. The treatment plant's performance depends not only on how well it was designed and built but also on how well it is run and cared for (Sundara et al., 2010).

The major constituents of wastewater collected from municipal, industrial, and residential sources are human feces, urine, food waste, household maintenance products, and shower/bath water, as well as a broad variety of other organic and inorganic chemicals in trace concentrations (Metcalf et al., 2014).

Conventionally, Wastewater Treatment plants (WWTP) are planned using empirical formulas and simplified design parameters that can be utilized for building and constructing treatment units by selecting wastewater parameters, operating conditions, and effluent requirements (Arif et al., 2018). Pollution is any change in

the quality and quantity of environmental components that cause an imbalance in the ecosystem and cannot be eliminated by natural processes (Okoro et al., 2013).

1.2 Statement of the Problem

The station serves the entire city of Hilla. Wastewater is an essential factor contributing to pollution and environmental diseases. Also, it has adverse effects on agricultural crops are damaged in terms of slow growth and low rates. After eating them, they can harm humans. It is essential for wastewater treatment plant work to treat and reuse it for different purposes such as for irrigation. Consequently, wastewater must be treated and its performance monitored before it is discharged into drainage or river, the wastewater is treated according to the Iraqi standards allowed for agricultural irrigation.

1.3 Objectives of the Present Work.

The main aims of this study are to evaluate the efficiency of the new Al-Muamirah wastewater treatment plant and to determine the validity of effluent water from the WWTP that drained into the Hilla drainage system (A1) for irrigation. This study has many objectives that need to be fulfilled as follows:

1. Assessment of the Al-Muamirah wastewater treatment plant.
2. Studying some physicochemical parameters of drainage water and monitoring seasonal changes.
3. Measurement of sulfate and chloride concentrations in water, sediment, and aquatic plants.
4. Measuring the levels of heavy metals like copper (Cu) and lead (Pb) in water, sediment, and aquatic plants.
5. Studying the correlation between physico-chemical parameters.

1.4 Thesis Structure

➢ **Chapter One:** "Introduction", includes the general overview, statement of the problem, and the main aim and objectives.

   Chapter Two: "Theoretical Concepts and Literature Review", discusses the essential concepts and some literature surveys that have been related to our proposed work.

➢ **Chapter Three:** "Field and Experimental works", includes the methods of collecting samples and preparing them for physical and chemical examinations inside the laboratory and some heavy metals.

➢ **Chapter Four:** "Results and Discussions" includes discussing the results of laboratory tests and comparing them with the permissible limits for agricultural irrigation.

➢ **Chapter Five:** "Conclusions and Recommendations", includes conclusions and future work to improve the quality of the treatment plant work.

CHAPTER TWO

Theoretical Concepts & Literature Review

CHAPTER TWO

THEORETICAL CONCEPTS & LITERATURE REVIEW

2.1 Introduction

WWTP plays a significant role in protecting the environment. Thus, it's essential to keep them operating effectively so that the concentrations of contaminants they release into rivers after being treated are within acceptable limits (Awad and Khudhair 2020).

Water pollution affects the environment of the water in many different ways; one of the most notable changes is the one that could represent changes in temperature, dissolved oxygen concentration, bottom characteristics, and water turbidity, in addition to changes in food value and excessive growth damages, and food enrichment that results in the accumulation of the degraded organic materials that contaminate the water and change the values of pH. The degree of the dangerous change is determined by the sort and amount of the pollutant, besides the water properties (Al- Adhamy, 1987).

water makes up most of our planet's surface, it is considered the most harmful type of pollution (Konar and Mullik, 1993).

Due to the rise in pollution from industrial, agricultural, and domestic sources, the contamination of water resources has become a significant problem worldwide. As a result, providing safe water for needs such as drinking, agriculture, and industry has gained more attention on a global scale (Al-Meini, 2010).

2.2 Composition and Characteristics of Wastewater.

Wastewater contains over 99.9 percent water; the remaining materials include suspended and dissolved organic and inorganic matter as well as microorganisms. These materials give physical, chemical, and biological qualities that are characteristics of residential and industrial wastewater (Hussain, 2011).

2.2.1 Physical Characteristics.

Temperature, color odor, density, turbidity, and density are all described as physical properties of municipal wastewater. The following physical parameters (Qasim, 2018):

1. Temperature: Temperature affects the solubility of gases, bacterial activity, and viscosity. It varies from 15 to 25 °C.
2. Color: The color of wastewater is light gray, and it can also be dark gray or black.
3. Odor: Wastewater may have a soapy or greasy odor, whereas the odor of residential wastewater is caused by gases released by organic matter decomposition. hydrogen sulfide (H_2S) and other decomposition products are the most odorous gas in septic wastewater.
4. Turbidity : is caused when small particles mix with the water stream and stay in suspension due to the motion of the water (colloids).
5. Density: ranges from 1.02 to 1.05 tons/m^3.

2.2.2 Chemical Characteristics.

The chemical characteristics of wastewater are represented in terms of inorganic and organic components. The organic components, total suspended particles, and inorganic proportion of wastewater are discussed in more detail (Qasim, 2009) as follows:

1. The pH ranges between 6 and 8.

2. Biochemical Oxygen Demand (BOD$_5$): It is the amount of dissolved oxygen that bacteria required to oxidize organic matter in wastewater, under typical incubation conditions of 20 ∘C for five days.

3. Chemical Oxygen Demand (COD): It is a measure of organic material that quantifies the amount of oxygen needed by a strong oxidizing chemical agent (potassium dichromate) to chemically stabilize all organic matter (bio-degradable and non-biodegradable) under acidic conditions.

4. Hydrogen sulfide (SO$_4^{-2}$): is a dense, colorless, strongly odorous toxic gas that corrodes infrastructures and impairs the performance of wastewater treatment operations.

5. Nitrogen (ammonia). It is measured in its different forms: nitrite, nitrate, ammonia, and organic nitrogen (which is the amount of nitrogen present in organic compounds).

6. Chlorides: The main chloride sources in water are industrial effluents, which usually contain high chloride concentration and are discharged from metal smelting, flue gas desulfurization and inland seawater desalination.

2.3 Literature Review.

2.3.1 Wastewater Treatment Plant.

According to **Al-Wardy et al. (2021),** Wastewater treatment is the process of altering the quality of wastewater, so it meets the standards for water discharged into surface waterways. In this study, the performance of the oxidation basin is examined. The work is associated with the Al-Muamirah WWTP in Hilla, Babylon governorate, Iraq. The samples were collected from the in and out of a plant. The plant's wastewater and treated water output are checked for contaminant factors. The monthly BOD$_5$, COD, TSS, NH$_3$, and PO$_4$ removal efficiencies are determined to be 91%, 78%, 93%, 69%, and 69%, respectively. Consequently, it is effective at

treating wastewater and producing water that conforms to Iraqi environmental guidelines for discharge to surface water.

Kumar et al. (2010) investigated how well a wastewater treatment plant works. For the case study, WWTP which uses the biological treatment method (Activated Sludge Process) and gets a rate of 23 (Million Liters per Day) of wastewater has been taken into account. The BOD_5, COD, TDS, and TSS were tested on wastewater samples collected at various stages of the treatment units. It is determined how effectively each unit treated pollution. The plant's overall performance has also been estimated. The results are useful for identifying and resolving operational and maintenance issues and planning the facility's future expansion to accommodate the increased hydraulic and organic loads.

Hadi (2014) evaluated the quality parameters of Al-Muamirah WWTP in Hilla. The plant is designed to serve 50,000 people and uses the activated sludge process, a biological treatment process. A daily average of 12,000 m^3/d of wastewater enters the plant. The Hilla Mayoralty collected wastewater data from the influent and discharge of the WWTP for significant water quality parameters including (BOD_5, COD, TSS, pH, T, and Cl) for six years. Each year, the plant's performance removal efficiency has been evaluated. Cluster analysis from the Statistical Package for the Social Sciences was used to test a multivariate statistical strategy on the data (SPSS). The outcome indicates that the existing's overall performance is acceptable. Cluster analysis demonstrates that 2009, 2010, 2011, and 2012 are all treated better than 2007 and 2008. Based on a six-year average, the effluent quality does not exceed the strict standards of Regulation 25 of the 1967 Iraqi National Standards. In total wastewater, the computed BOD_5/COD ratio of the influent is 0.49.

Alyaseri (2016) showed that due to improper design and/or implementation of the structural plan, a lack of operators, a power shortage, and inadequate

maintenance. In Al-Samawah WWTP is suffering considerable issues. The oil and grease, TSS, Cl^-, NH_3, COD, and H_2S data for the influent and effluent of Al-Samawah WWTP from 2012 to 2015 were collected, evaluated, and compared to national and international standards to evaluate the performance of this plant. The plant was unable to reduce the pollutants sufficiently and hence could not comply with the standards. The average concentrations (mg/L) of O&G, TSS, Cl, NH_3, COD, and H_2S in the effluent were (respectively) (42.0, 5.4, 3.5, 1.6, 1.2, and 1.2) greater than the local requirements. The untreated wastewater was released, making the plant the largest point source polluter in the region (about 20,000 m^3/day). In addition to the preliminary, primary, and tertiary treatment of the existing processes, which must be designed and implemented by professionals, it was suggested that the plant initiate a comprehensive maintenance program for its components to achieve an acceptable level of treatment.

Amjad et al. (2019) evaluated the treatment plants for National Environmental Quality Standards (NEQS) and to check the efficiency of functional components of the treatment plant. Water samples were collected from various points of the treatment plant to perform various onsite and laboratory tests (DO, BOD5, COD, Cl-, TSS, and pH) to check the efficiency of the wastewater treatment plant. The results obtained for each water quality parameter (physical, chemical, and biological) were compared with NEQS. The recommended value of DO was greater than 2 mg/L, and for BOD_5, COD, Cl, TSS, and pH by NEQS were less than 80 mg/L, 150 mg/L, 1000 mg/L, 150 mg/L, and 6.5 – 9, respectively. The measured values of DO, BOD_5, COD, Cl^-, TSS, and pH were 0.3 mg/L, 310 mg/L, 48 mg/L, 1760 mg/L, 204 mg/L, and 8.3 respectively. The values of DO, BOD_5, TSS, and Cl^- were over the recommended ranges of the NEQS. More facultative and anaerobic ponds should be constructed to treat the total wastewater generated in Pattoki (Pakistan), as the present plant treated almost one-fourth of the total wastewater

generated in Pattoki. Aerators should be provided at the aerobic ponds for improving the efficiency of the wastewater treatment plant.

2.3.2 Drainages and Rivers.

Alham et al. (2016) evaluated water in the northern and southern Kufa drainage systems. The study entailed the collection of eight samples per month for one year, with each season containing an average of three months. The data indicated that the EC of the two Kufa drainage water during the spring season was low compared to other seasons due to the low rainwater, whereas the electric conductivity increased during the summer season as a result of drainages progressing and the increased evaporation. The decrease in evaporation caused by the high level of drainage water and the restriction of the drainage process on agricultural land, led to EC decreasing slightly during winter, and autumn. In addition, the results indicated that the salinity of the southern drainage water was moderate according to the categorization system of the United States salinity lab since there is a treatment station named baraka that drains its pollutant.

Mohammed (2019) studied the irrigation and drainage projects in the Al-Kefel area giving a good idea of how water could be used and how to make the most of this valuable resource. This was especially important because the study area had a shortage of water discharge rates for different uses. Primarily the needs of agricultural land and crops planted with water for irrigation, problems, and losses, which called for the inadequacy of irrigation schedules and gave some solutions and proposals that would improve irrigation in the area. It also showed that the drainage varied in how well they served agricultural land by comparing the total length of the agricultural areas they serve.

Qahtan (2012) investigated whether or not the drainage water in the area to the north of Baghdad city (including the areas of Al-Rashidiya and Al-Husainiya)

was suitable for the irrigation of crops. Due to the high levels of salt and chemical characteristics (chlorides and magnesium), the results showed that drainage water was suitable for the irrigation of non-sensitive (very tolerant) crops. However, agricultural lands that used this water, need the drainage process.

Kizar (1999) evaluated the drainage water of the of Hilla-Kifil irrigation project to determine whether it is suitable for use in irrigation. In the project, samples of drainage water were collected at a variety of points along the main drain. To determine whether these samples of drainage water were suitable for use in irrigation, chemical analysis was performed on them. According to the findings of the study, drainage water from many different areas can be successfully used for the irrigation of a variety of crops, whereas drainage water from other locations can only be used for certain types of crops.

Mohammad & jassim (2014) studied the water quality in a particular region of the Al-Hussainia sector was evaluated it to see whether it can be used for irrigation. For the chemical evaluation of the Al-Hussainia main drain, the salinity problem's most significant indicators are (EC, TDS, sodium adsorption ratio, and sodium content). The findings demonstrated that sodium indicators did not harm crop output. All locations indicated that the water in the research region was suitable for irrigation.

Saleh & Afrah (2015) Investigated the Kifil Shinafiya project. Al-Shamia west drainage water is located 200 km to the south of Baghdad, between the two Euphrates River branches (Shatt Al-Kufa and Shatt Al-Shami). Nine locations were selected along the drainage (75 km) to evaluate water for irrigation from October 2013 to July 2014. Seven Chemical and physical parameters were collected (SO_4^{-2}, Cl^-, TH, Turbidity, TDS, pH, EC). Several mathematical relations were used to estimate Al-shamia west drainage water cation and anion concentrations. Using SPSS regression and correlation. The results of physical and chemical analyses of

water indicated that it was unsuitable for irrigation in the majority of sites and months, but could be utilized for the agriculture of salinity-tolerant crops on well-drained land in accordance with acceptable standards.

Rasheed et al. (2015) determined the physical and chemical properties of the Al-Shamya drainage. Four sampling locations on the Al-Shamyia drainage were chosen, and monthly samples were taken from Mar 2012 to Feb 2013. The results of the investigation indicated a consistent correlation between air and water temperatures at all locations. The pH values were in a narrow range in all study months. Turbidity values ranged from 0.15 - 51.5 NTU and TSS from 2 – 60 mg/L. EC recorded values ranged from 880-1300µs/cm, salinity 0.56 - 0.83 ppt, and TDS 475.2 – 702 mg/L. This study showed that the Al-Shamyia drainage water was well-oxygenated. A high percentage of oxygen saturation was recorded during the study period, while BOD_5 values did not exceed 5 mg/L. The study showed that Al-Shamyia drainage water was slightly alkaline, in which HCO_3 was dominant. The water in the study area was very hard. Sulfate was dominant among all ions, and chloride ion values ranged from 112.3 - 173.5 mg/L. NO_3 and reactive PO_4 were recorded in high concentrations in winter months.

Razzak et al. (2021) examined the levels of five different heavy metals in the water, sediments, and aquatic plants (reed plants) of the Euphrates River from Nov 2019 through Oct 2020. Three locations were selected, and samples were collected monthly in the morning to measure (air and water) temperature, pH, EC, TDS, turbidity, DO, BOD_5, TH, TOC, and soil texture. Moreover, examined dissolved heavy metals (Cu, Zn, Cd, Cr, Pb) in water, sediment as residual phase, and reeds plants. Air temperature (11 - 43 °C), water temperature (9 - 31 °C), pH (7.5 - 8.5), Turbidity (18.49 - 53.27 NTU), EC (950 - 1920 µs/cm), TDS (820 - 1450 mg/L), DO (5.2 - 10.3 mg/L), BOD (2 - 15 mg/L), TH (620 - 1250 mg/L), TOC (0.055 - 2.87%), and soil texture findings showed percentages (90% silt, 5% sand, and clay).

(Cu, Zn, Cd, Cr, and Pb) yearly mean levels in the water (dissolved phase) were (respectively) 1.75, 0.81, 1.23, 1.71, 0.81 µg/L, in the Sediment (residual phase) (respectively) 2.11, 4.78, 0.2, 2.93, 0.61 µg/g, dry weight, and in reeds plants (respectively) 3.18, 8.78, 0.14, 0.64, 1.83 µg/g, dry weight. Heavy metal concentrations in the water exceeded the standard limits for Iraqi and WHO, while sediment levels were within these limits.

Hassan et al. (2010) studied the changes in the environment along the Euphrates River in central Iraq, from the Al-Hindiya barrage to Al-Kufa city. Along the study area, seven locations were chosen for sampling from March 2004 to February 2005. The heavy metals concentrations in water and sediment (Pb, Mn, Cu, Fe, Zn, Cd, Ni, Co, and Cr), in addition, measured the pH, EC, TSS, TDS, DO, air, and water temperature. The results showed the TH in this part of the river was very hard and with a high level of BOD_5. The levels of nutrients changed a lot from one season to other.

Varol et al. (2010) studied the Tigris River of contamination in Turkey's Diyarbakir district. They observed that the Diyarbakir region negatively affected the water quality of the Tigris River, particularly after the discharge of (WWTP). Concentrations of COD, T.N., and PO_4 Significantly increased downstream of the Diyarbakir, Turkey WWTP discharge location.

Hussain (2009) studied some environmental parameters such as pH, temperature, turbidity, EC, Cl, TH, BOD_5, TSS, and TDS for the Tigris River from October 2002 to March 2003, and selected four stations. The results found that temperature ranged between (11.7 - 30 ºC) for four stations, and pH values ranged from 6.6 to 8.3. Al-Twetha station contained the highest BOD_5 concentration (7.5 mg/L). In October, the highest value of EC was 2069 µs/cm, and 800 mg/L of Cl in November. The highest TH value (225 mg/L) was recorded in November. The values

of TDS and TSS were (respectively) 2210 and 480 mg/L obtained during March and January.

Al-Khafji et al. (2011) found that the levels of manganese, cadmium, lead, and copper in the Euphrates River at Nasiriya were significantly elevated as a direct result of the presence of industrial activity in the surrounding area.

Alkam et al. (2012) found that the metals that accumulate in the water eventually reached the food chain. From 2012 (autumn) to 2013 (summer), samples were taken every month from three locations along the Diwaniyah River. In this study, copper, zinc, cadmium, and lead concentrations in water and sediments have been measured. Also, some of the physical and chemical properties of water were tested. Flame atomic absorption spectrometry was used to measure the concentrations of heavy metals. The results showed that samples of water and sediment had the most Pb and Zn than any other heavy metals. But the concentrations of heavy metals found in the water and sediments were lower than what WHO recommends. The study showed that the concentrations of heavy metals in the environment were going up. So, there is a need for serious warning about pollution from industry and people, which can harm ecosystems and the food chain.

Al-Obaidi (2009) examined the water hardness and turbidity in the Tigris River in Baghdad (from November 2005 to October 2006). He noticed an increase in turbidity values during the winter months as a result of the rainfall and the flow of the High River. Regarding the water's hardness, it has been discovered that the values of raw and treated water were the same and that the water's hardness remains within the range of (215 - 465) mg/L. The highest quantities were recorded in February at the Al-Dora and Al-Rasheed water treatment plants.

Mohammed et al. (2010) measured nitrate, phosphate, sulfate, and chloride in the Tigris River (in Mosul city) from September 2005 to June 2006. They found that the concentrations of nitrate and phosphate raised when the river flow increased

and decreased with reduced river flow (reached up to 1.05 mg/L in Jun. for NO_3 and 0.482 mg/L in Apr. for PO_4). The lowest concentrations were 0.285 mg/L in Dec. for NO_3 and 0.07mg/l in Jan. for PO_4). In general, the sulfate and chloride concentrations changed in the opposite direction of the river flow. The highest sulfate and chloride concentration was in January, and the lowest was in June. The highest sulfate concentration was 170 mg/L, and the highest chloride concentration was 33.4 mg/L. The lowest sulfate and chloride concentrations were 68 mg/liter and 15.6 mg/L consecutively.

2.4 Summary

In previous studies samples were taken from the treatment plant to evaluate the removal efficiency, then water, sediment, and reed samples were taken from the river and physical and chemical parameters were conducted on them.

In the current study, data were taken from the treatment plant to evaluate the removal efficiency, after which water, sediment, and reed samples were taken from the drainage, and physical and chemical parameters were performed and compared with the permissible parameters for agricultural irrigation.

CHAPTER THREE

Materials and Methods

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of Study Area.

3.1.1 Al Muamirah Wastewater Treatment Plant.

This plant was built in 2019 and designed to have a maximum bulk of 107000 cubic meters per day. This is enough to serve the whole city of Hilla, on together sides of the river, which has around 970000 people. But Hilla city's conveyor pipe and network the sewers are still being built, and at the moment, it gets wastewater of about 30000 m^3/day capacity. The small amount of input is because the pipes carrying the sewers of Hilla are not finished yet, which it transmits to the origin of the fine refineries and the facility for removing sand and fat. After removing sand from the sewage water, the water goes to the Aeration tank with two oxidation basins, which consists of two stages. The first stage is the removal of phosphorous and nitrogen, then the ventilation process to activate bacteria, and then the water goes to the origin of the distribution basin through A pipe diameter (2m). A ductile type distributes wastewater to four circular sedimentation basins, with a diameter of one basin (50 m). Alum is added during the distribution of water to the sedimentation basins to accelerate and increase the sedimentation efficiency, where the alum is injected through a special pump at the injection site. After the sedimentation process, the treated wastewater sends to the origin of the contact basin, where chlorine is added to the water for sterilization, and then sterilized chlorine water goes to a pumping station where the treated wastewater is poured into Hilla drainage system (A1). The sediments are extracted and they send to the drying beds. A complete outline of the plant units is shown in Fig (3.1).

1. Coarse screen
2. Fine screen
3. Flotation tanks
4. Primary sedimentation
5. Distribution basin
6. Sedimentation basins
7. Alum room
8. Contact basin
9. Chlorine room
10. Drying beds

Fig (3.1): Image plan of Al-Muamirah wastewater treatment plant, Hilla (Al-Muamirah project office, 2021).

3.1.2 Dimensions and Specifications of the Treatment Units.

The dimensions and specifications of Al-Muamirah project treatment units are explained as follows:

1. Coarse Screen.

It is the first step in the preliminary treatment stage and consists of three units that remove large items from the flow stream. In the beginning of the treatment plant, at the entry to the pumping plant, there are screens installed to protect the mechanical equipment that will be used in later stages of the processing (Fig. 3.2a).

2. Fine Screen.

It is another way to deal with the first stage physically. It has three parts that are used to remove fine solids and protect equipment that might be more sensitive to solids (Fig. 3.2b).

3. Flotation Tanks.

It is a closed tank with two entrances. One comes from the grit chamber, and the other is connected to the return pipe. These tanks have an anaerobic treatment

stage. In the first stage, anaerobic bacteria take out nitrates and some phosphorus (Fig 3.2c).

4. Primary Sedimentation Waste Basins with Activated Sludge.

It is divided into two parts the first is to remove nitrogen and phosphorus by anaerobic bacteria in the absence of oxygen. Second, in this stage oxidation is used in the presence of oxygen with aerobic bacteria (Fig. 3.2d).

5. Distribution Basin.

This tank has electrically controlled gates that let the water go into and out of the collection and distribution tank. Also, it has three arcs that move water to the sedimentation tanks, drain treated water to the contact tank, and move sludge to the return tank. Alum is also added to this tank to help it settle down more (Fig. 3.2e).

6. Secondary Sedimentation Basins.

Bridge skimming is done in four tanks that hold sediment. Each sedimentation tank is 45 meters in diameter and has two bridges. The sedimentation tank separates the treated water from the sludge. Also, solids that float to the top are thrown away, and clean water is sent to contact tanks and the last stage (Fig. 3.2f).

7. Alum Room.

In this stage, it is added to water before it reaches to contact basin (Fig. 3.2g).

8. Contact Basin.

This is the last stage, where the treated water goes to drainage (Fig. 3.2h).

9. Chlorine Room.

In the contact basins, the sterilization process takes place. Microorganisms and microbes are killed by adding chlorine to the water in these basins. According to the specifications and it is not clear after that the chlorine is removed or not (Fig. 3.2i).

10. Drying Beds.

There are 16 drying beds that use filters to separate sludge and let it dry in the sun (Fig. 3.2j).
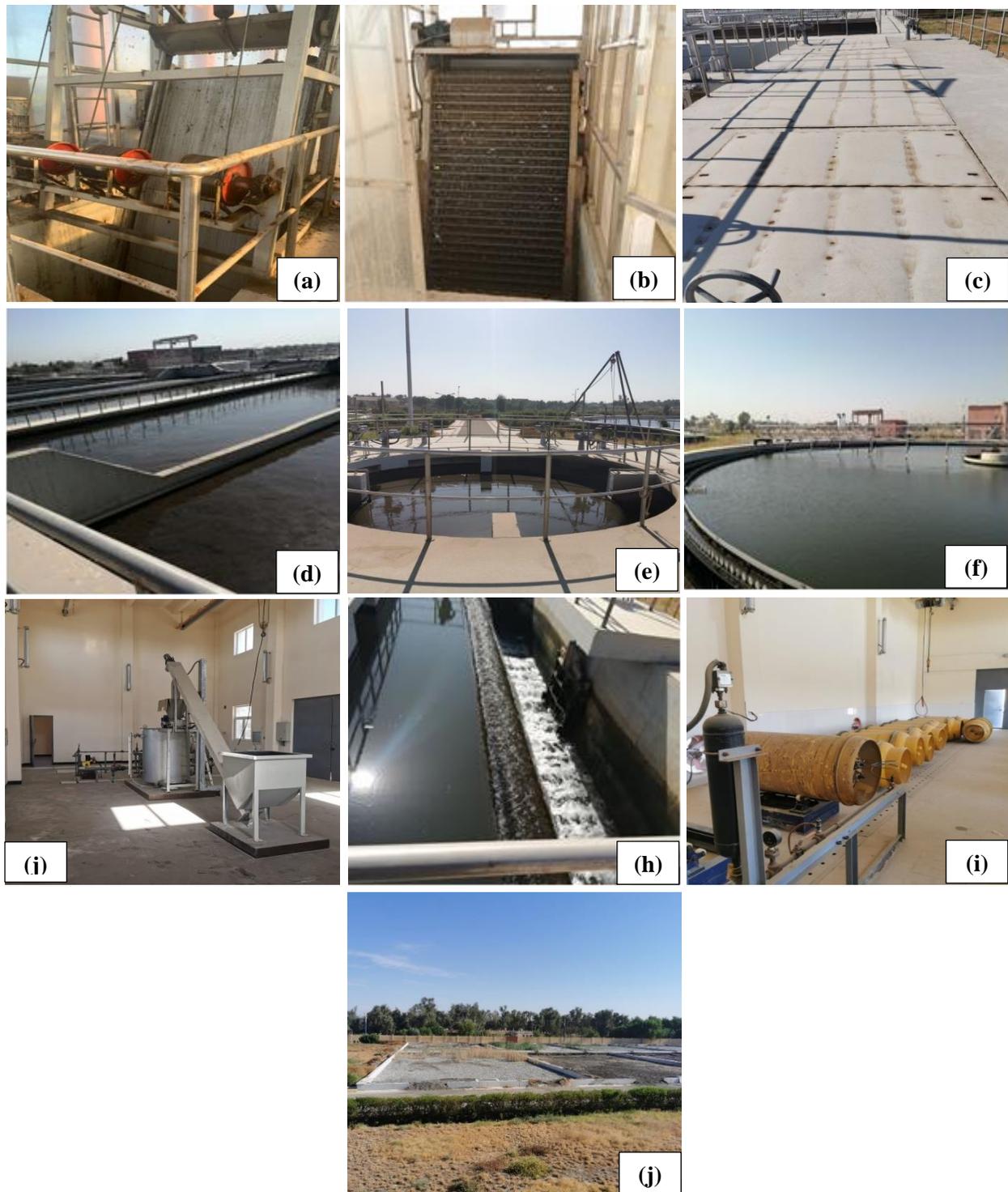
Fig. 3.2: Al-Muamirah treatment units, (a): coarse screen; (b): fine screen; (c): Flotation tanks; (d): Primary sedimentation basins; (e): distribution basin; (f): Secondary sedimentation basins; (g): alum room; (h): contact basins; (i): chlorine room; (j): drying beds.

3.1.3 Hilla Drainage System (A1).

The Hilla drainage system (A1) is one of the public utility wastewaters within the Hilla-Diwaniyah project (semi-reclaimed) and it crosses the drain parallel to Amer Katran road in the district of Hilla in the district of Al-Kifl. The number of families benefiting from the drainage is (140) and the design information of the drainage can be seen in Table (3.1).

Table (3.1): Design information for Al-Hilla drainage system (A1).

Drainage length (Km)	12.690
Design drain(m^3\sec)	1
The design water level at the beginning when pouring (m)	1.98
Bottom width(m)	0.80
Drainage depth(m)	4.48
Water depth(m)	0.80
Side slope	1/2
Longitudinal slope	37

The Hilla Drainage (A1) discharge the water to the Jahsh River, which is fed from the Shatt Al-Hilla River, to use the trough water to irrigate agricultural lands in the two streams of Dora and Al-Amir, as many secondary drainages pour into it, some of which are public and other are private, which are eight (A1A, A1B, A1C, A1D, A1E, A1F, A1G, A1H) and the length of each of them in kilometers (respectively) is as follows (0.830, 2.05, 0.890, 0.965, 1.270, 1.510, 1.670, 1.580). The Hilla Drainage (A1) pours into the drainage CDIIA trough at the kilometric site of the estuary (17.62 km), which eventually empties into the eastern Euphrates drainage as it is shown in Fig (3.3).
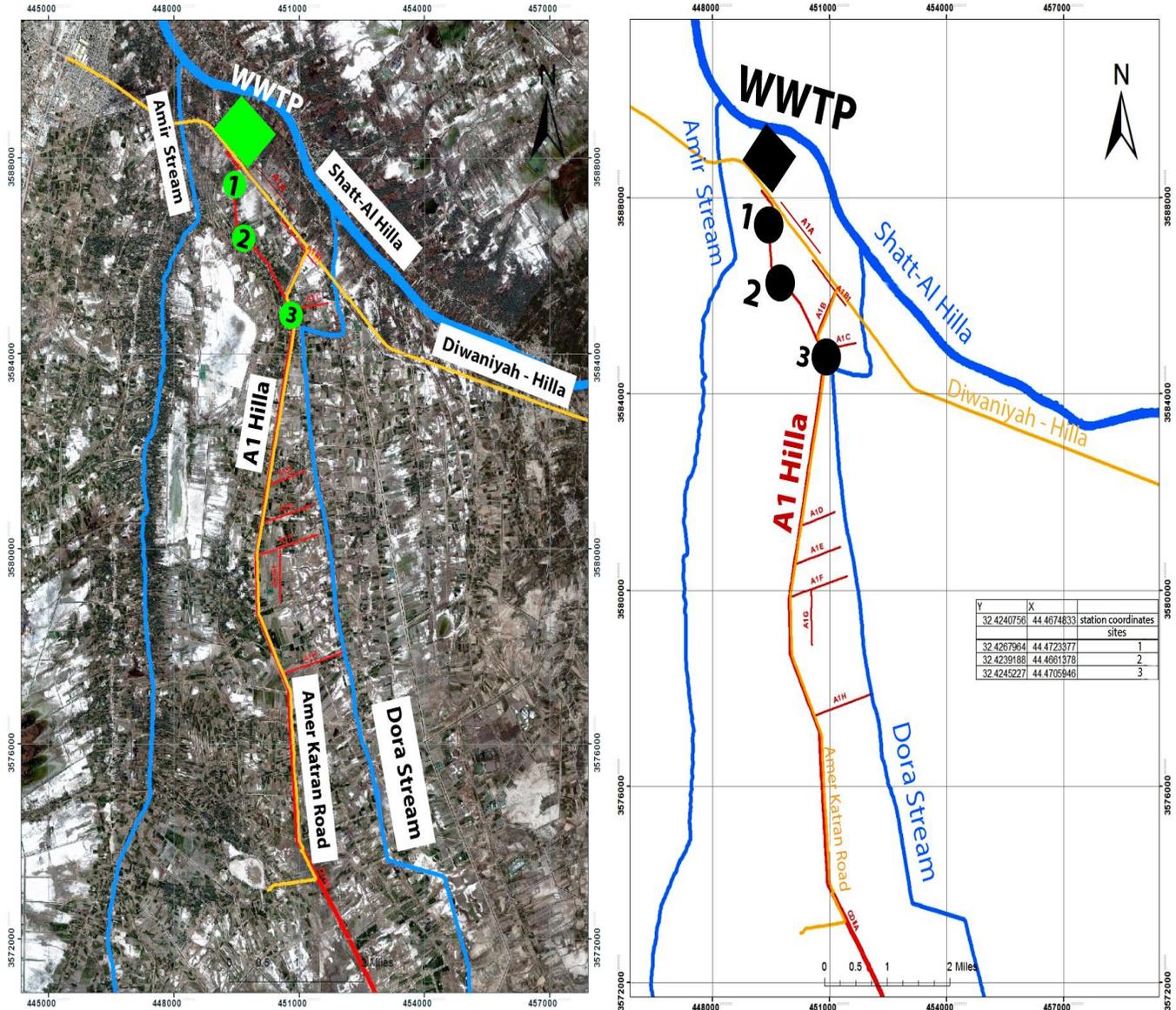
Fig (3.3): The Hilla drainage system (A1)(Babylon Resource Department)

3.2 Sampling Stations.

The study area was divided into three main stations along drainage between the latitude (44,4674833) and longitude (32,4240756), Three stations were taken from the drainage system (A1). The geographical coordinates of sampling sites were determined using the geographical position system GPS as shown in Table (3.2).

Tables (3.2): The coordinates of the three study locations established by GPS.

Study sites	The latitude	The longitude
Site 1	44.4723377	32,4267964
Site 2	44.4661378	32,4239188
Site 3	44.4705946	32,4245227

Three stations were taken for the study as shown in Figs (3.4, 3.5 & 3.6):

1. First Site.

The first station is located to the south of the WWTP about 500 m. The width of the drainage in this section is about 4 m, and its depth is 2.5m (Fig. 3.4).

Fig. (3.4): First site of study in drainage A1.

2. Second Site.

It is located at a distance of 1.5 km to the south of the WWTP, where the width of the drainage in this section is 3m and its depth about 2m as shown in Fig (3.5).

Fig. (3.5): Second site of study in drainage A1.

3. Third Site.

       This site is located to the southeast of the WWTP, about 3.5 km. The width of the drainage in this section is about 4 m, and its depth is 3 m (see Fig. 3.6).

Fig. (3.6): Third site of study in drainage A1.

3.3 Materials.

3.3.1 Apparatus and Instruments.

       The following apparatus and instruments were used in the experiments of the work as presented in Table (3.3).

Table (3.3): Apparatuses and types of equipment used in this study.

No.	Apparatus & Instruments	Purpose
1	Atomic Absorption Spectrometry (AAS).	Measuring of heavy metals
2	Burning furnace	Using for burning sample.
3	pH meter	Measuring of pH value.
4	Electrical conductivity meter	Measuring of EC.
5	Thermometer	Measuring of temperature.
6	TDS meter	Measuring of TDS.
7	Heater device	Using for heating sample.
8	Filter paper	Using filtration.
9	Turbidity meter	Measuring of turbidity.
10	Kjeldahl device	Measuring of Nitrogen.
11	UV device	Measuring of COD and Nitrate.

3.3.2 Chemical Materials.

Table (3.4) shows the list of all the chemicals used in this study's methods and protocols, as shown in.

Table (3.4): Chemicals materials used in the study.

No.	Chemical Materials	Chemical formula
1	Nitric acid	HNO_3
2	Hydrochloric acid	HCl
3	Perchloric acid	$HClO_4$
4	silver nitrate	$AgNo_3$
5	potassium chromate	$K_2Cr_2O_7$
6	Barium Chloride	$BaCl_2$
7	Sodium Thiosulfate	$Na_2S_2O_3.5H2O$
8	Sulfuric acid	H_2SO_4
9	Ammonia ferrous sulfate	$Fe(NH_4)_2(SO_4)_{2.6}H_2O$
10	Ammonium sulfate	$(NH_4)_2SO_4$

3.4 Methods.

3.4.1 Samples Collection.

A sampling of physical, and chemical parameters was performed from Three stations according to monthly basis from October 2021 to August 2022, to show all the seasons. Most of the time, sampling began at 11 a.m. and ended at 3 p.m.

❖ At a depth of 30 cm, water samples were taken from the middle of the drainage and put in 2-liter plastic bottles.

❖ Samples of sediment were taken with a Van Veen Grap sampler and kept in plastic bags with labels.

❖ Aquatic samples were collected (reed plant) and then transferred to the laboratory.

3.4.2 Field Measurement.

3.4.2.1 Air and Water Temperature (T).

The temperature of the air and water were measured in the field with a mercury thermometer that ranged from 0 to 50 °C with increments of 0.1. This was done at a depth of 20 cm. the measurement was taken after the temperature was stable for a few minutes according to APHA (2017) as shown in Figs (3.7). The results were expressed as ° C.

Fig (3.7): Air and water temperature.

3.4.2.2 Hydrogen Ions (pH).

According to Association of officiating Analytical chemists AOAC (2005), the portable pH-meter model was used to conduct the measurements immediately in the field (WTW pH. 720). Before each sample, the instrument was calibrated with a standard buffer solution (with pH values of 4, 7, and 9) (Fig. 3.8).

3.4.2.3 Electrical Conductivity (EC).

The conductivity of water was examined using a portable EC-meter in the field (WTW EC. 720). Automatic temperature adjustment was included with the device. The outcomes were presented as $\mu s.cm^{-1}$ by APHA (2017), (Fig. 3.8).

Fig (3.8): pH & Electrical Conductivity (EC).

3.4.3 Laboratory Measurement.

3.4.3.1 Salinity.

Salinity was calculated depending on EC value (Richards, 1954) according to the following Equation (3.1):

$$\text{Salinity (ppt)} = EC \times 0.64/1000 \qquad\qquad (3.1)$$

3.4.3.2 Turbidity.

The turbidity was measured with a turbidity meter (HACH.2100N.). Before taking each sample, the apparatus was adjusted using reference solutions. According to APHA (2017), the outcomes are presented as NTU (Nephelometric Turbidity Unit), (see Fig 3.9).

Fig (3.9): Turbidity meter.

3.4.3.3 Total Dissolved Solids (TDS).

This method explained by APHA (2005), involved the filtration of 50ml of the material using filter paper 42 - 44. The whole filtrate (with washings) was transferred to the weighted evaporation dish to evaporate until dry in the drying oven. Initially, dry the evaporated sample for at least 1 hour at 180 to 200 °C in an oven, then cool it in a desiccator to balance the temperature. Repeat the drying cycle that comprised drying, cooling, desiccating, and weighting for at least one additional hour to achieve a consistent weight or until the final weight is changed with no or more than 4% of the initial weight or 0.5 mg (whatever is less). Finally, the total dissolved solids were calculated as follows (see Equation 3.2):

$$\textbf{Mg total dissolved solids/L} = \frac{(\textbf{A} - \textbf{B}) \times \textbf{1000}}{\textbf{Sample volume, ml}} \qquad (3.2)$$

where, A is the weight of dried residue + dish, mg; B is the weight of the dish, mg.

3.4.3.4 Total Hardness (TH).

The sample of 10 ml was diluted to 50 ml with distilled water. Then, 1 ml of ammonia regulator solution with a pH of 10 was added to find the total hardness. This was done by adding a few dry indicators (Erichrom black T) as reagents and titrating against 0.02N EDTANa2 solution (APHA, 2012). The following equation (3.3) is usually used to calculate the total hardness:

$$\textbf{Total hardness as CaCO}_3 \textbf{ mg/L} = \textbf{A} \times \textbf{B} \times \textbf{1000/mL of sample} \qquad (3.3)$$

Where: A is the number of titrations; B is the amount of calcium carbonate needed to make 100 ml of EDTA titrated.

3.4.3.5 Dissolved Oxygen (DO).

Dissolved oxygen was determined by an acid modification of the Winkler method as described by (APHA, 2012), which was summarized by fixing oxygen

infield, and the bottle was shaken thoroughly to dissolve the precipitate. The sample was subsequently titrated against (0.0125 N) $Na_2S_2O_3.5H_2O$ (Sodium Thiosulphate Solution) using 2 ml of starch solution as an indicator. The results were expressed as mg. L^{-1}. DO values were calculated using Equation (3.4) as follows:

$$DO(mg/L) = (V_2 \times 8000 \times 0.0125)/(V_1 - 1.3) \qquad (3.4)$$

Where: V_2 is the volume of titrating; V_1 is the volume of the sample.

3.4.3.6 Chemical Oxygen Demand (COD).

The open reflux method was established by APHA, (2012) to measure the chemical oxygen requirement. This was done by adding 50 ml of concentrated sulfuric acid and adding 25 ml of 0.25N potassium dichromate. Then, the flask was connected to the condenser, and the remaining sulfuric acid of 70 ml was added. The device was heated to the boiling point for two hours, then left to be cooled and wiped with 0.25M ammonia ferrous sulfate solution. After that, add 2-3 drops of Veron reagent, where the color changed from bluish green to reddish_ brown all the previous steps were performed on a sample of distilled water, which represents the blank. the chemical requirement for oxygen was calculated using Equation (3.5) (Fig. 3.10).

$$COD \text{ as mg } O_2/L = \{(A - B) \times M \times 8000\}/ml \text{ of sample} \qquad (3.5)$$

Where: A is the volume of ammoniac ferrous sulfate with distilled water used as a corrector (ml); B is the volume of ammoniac ferrous sulfate used with the sample (ml); M is the molar ammonium ferrous sulfate; 8000 is the milli-equivalent weight of oxygen x 1000 Express the results in units of mg/L.

Fig (3.10): UV device used for COD.

3.4.3.7 Chloride (Cl⁻).

According to the APHA (2012), silver nitrate titration was utilized to evaluate the chloride ion content in water samples. 10 ml of the sample was diluted to 100 ml with water, and 1 ml of potassium chromate indicator solution was added, the sample was titrated against a 0.0141N solution of silver nitrate, causing the color to change from yellow to orange depicted in Fig. (3.11). The Cl concentrations (mg/L) were calculated using Equation (3.6) as follows:

$$Cl\left(\frac{mg}{L}\right) = ((A - B) * N * 35.450 * 1000)/V \qquad (3.6)$$

Where: A is represented the initial reading of the sample; B is the standard for the initial reading of the blank; N is the symbol for the normality of silver nitrate (0.0141); V is the sample size.

Fig (3.11): Chloride ion testing in the water.

3.4.3.8 Chloride in Soil.

A certain weight was taken from the crushed soil and a certain amount of distilled water was added to it, provided that the mixing ratio was 1:5. For example, if it was taken the weight of the soil 2.5g, and added 125ml distilled water to it (left for an hour), then filtered it on filter paper No 42. After filtering, 25 ml of the filtrate was taken, and dropped of potassium chromate guide was added to it. The color becomes yellow. The model was titrated with silver nitrate until the color changed to red-brown, and the volume was taken. The method was described according to Manali and Jeffrey (2016) (Fig. 3.12). Equation (3.7) is used to estimate the chloride in the soil as follows:

$$Cl\left(\frac{mg}{l}\right) = ((A - B) * N * 35.450 * 1000)/V \tag{3.7}$$

Where: A is the second size to clear; B is the first size to clear; N is the normality of $AgNO_3$; V is the sample weight.

Fig (3.12): Chloride testing in the soil.

3.4.3.9 Chloride in Reed Plant.

Chloride in the reed plant was analyzed in the lab according to Babalola et. (2001). The weight of 0.5 g of dried leaves was put in a beaker and added to it nitric acid 10 ml concentrated, left for 24 hours on a hot plate for heating to 70 C° and cool

it by adding distilled water. Then, washed the filter paper and its precipitate with hot water until reaching a volume of 25 ml. After that, the chloride in the reed plant was calculated similarly to the procedure of calculating the chlorides in the water.

3.4.3.10 Sulfates (SO$_4^{-2}$).

According to the procedure of calculating the sulfates by the APHA (2012), it was taken 100 ml of the water sample to be tested and added 5 ml of hydraulic acid. The mixture was heated to the stage of the start point of boiling. Then, 10 ml of barium chloride was added and left for two hours to be cooled. Next, the precipitate formed after filtering was filtered. The precipitate was washed with distilled water and transferred with filter paper to an alumina crucible. after that, it was burned in a burning oven at a temperature of 850 ° C. Finally, it was cooled and its weight was taken (see Fig. 3.13). The sulfate concentrations (mg/L) were calculated using Equation (3.8).

$$\mathbf{SO4\left(\frac{mg}{L}\right) = ((W1 - W2) * 411.5 * 1000)/V} \qquad (3.8)$$

Where: W1 is the weight of the lid before burning; W2 is the weight of the lid after burning; V is the sample size.
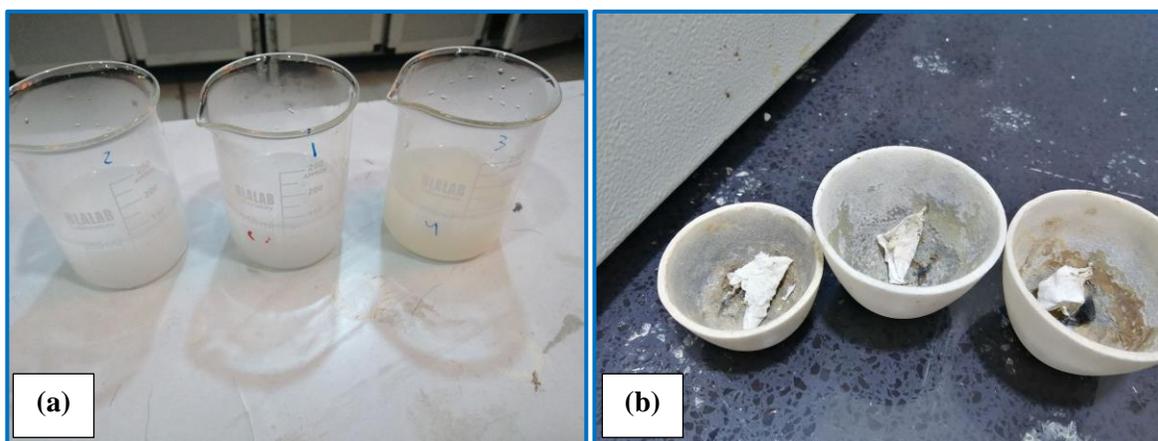
Fig (3.13): Sulfate testing in the water.

3.4.3.11 Sulfates in Soil.

According to Manali and Jeffrey (2016), a certain weight of the crushed soil to be examined was taken at 3g and added HCL to it with a concentration of 10%. The blend was placed on a heating device until it boils and then filtered on filter paper No 42. It was washed with hot distilled water and placed on a fire until it boils. It was removed from the fire and 7 ml of barium chloride was added, then left for the second day, filtered on filter paper 42, and the sediment is washed well with hot water until it becomes clean. The filter and precipitate were weighed and then placed in an alumina crucible. Then, the mixture was ignited at 850 °C, for a quarter of an hour, cooled in a desiccator, and then taken its weighting (Fig. 3.14). Equation (3.9) was used to calculate the Sulfates concentrations in the soil as follows:
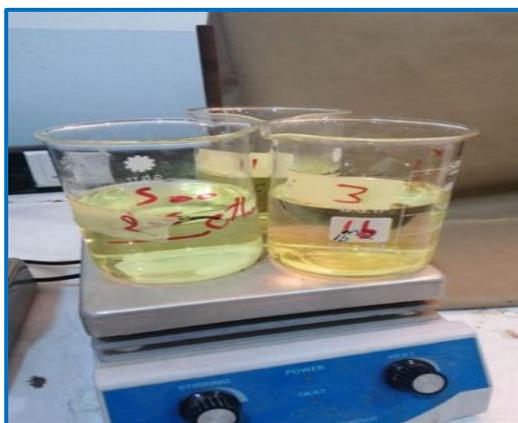
Fig (3.14): Sulfate testing in the soil.

$$\%SO3 = (W1 - W2) * 34.3/W \qquad (3.9)$$

Where: W1 is the weight of the lid before burning; W2 is the weight of the lid after burning; W is the sample weight.

3.4.3.12 Sulfates in Reed Plant.

Sulfates in the reed plant were analyzed according to Babalola et al. (2001). 0.5 g weight of dried leaves was taken in a beaker and added 10 ml of nitric acid to it concentrated, and left for 24 hours. it was heated to 70 ° C on a hot plate and then,

left for cooling. Next, 2 ml perchloric acid was added to it and heated for 15 minutes without drying. Following, the mixture was cooled by adding distilled water to it. After that, filter paper and precipitate were washed with hot water until reaching a volume of   25 ml. Finally, the sulfate was calculated by the same calculated processes for water.

3.4.3.13 Nitrate (NO_3^-).

According to APHA (2012), 2 ml of 1N HCl was added to a sample that has already been diluted (5ml of sample in 50ml of deionized water) and the nitrate ions were measured with a UV-spectrophotometer at 220nm, as shown in Fig (3.15). The results were written with the unit of mg/L.

Fig (3.15): UV device used for Nitrate.

3.4.3.14 Nitrogen

For Nitrogen analysis, a sample of sulfuric acid (H_2SO_4) was heated to 360 – 410 °C. By combining with oxygen, the organic sample broke down and released ammonium sulfate, a form of reduced nitrogen. Most of the time, ammonium sulfate was used as a catalyst. Selenium, and Hg_2SO_4, were added to speed up digestion, and Na_2SO_4 was added to make H_2SO_4 boil at a higher temperature. The digestion was done when the liquid was clear, and there were no more fumes, according to Kjeldahl (2022), (see Fig. 3.16).

Fig (3.16): Kjeldahl Device.

3.4.3.15 Total Organic Carbon Content in the Sediment.

A sample was taken from the dried soil at a temperature of 80 °C, which was passed on a sieve No. 40, and a sample was weighed before burning and entered into the oven at a temperature of 450 °C for 1.5 - 2 hours. Then, the weight was taken after burning (Fig. 3.17). Then divded the difference in weight by the original weight.The percentage of total organic carbon measured according to (ASTM-D7348- 2021).
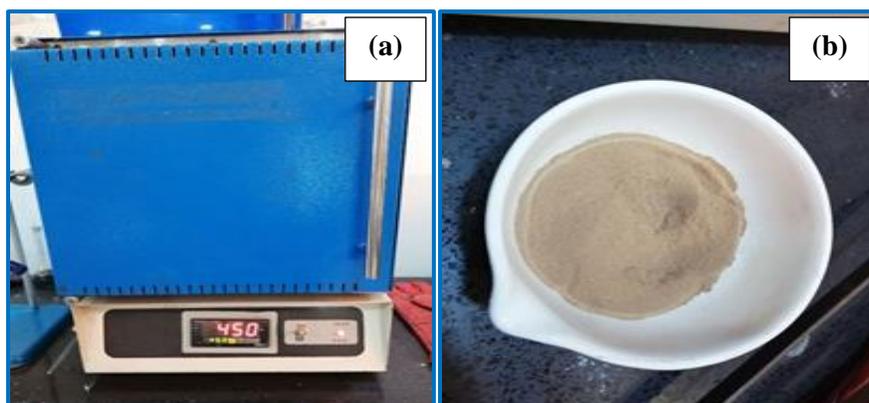

Fig (3.17): TOC Test.

3.4.3.16 Volumetric Analysis of Sediment Particles (Hydrometer).

The condensate method uses a hydrometer for estimating the percentage of sediment components as explained by (Bashour and Al-Sayegh, 2007). A weight of 50 g of dried and homogeneous soil was placed in the mixer. Then, added an amount

of distilled water and 10 ml of silicon-separated solution sodium (hexametaphosphate) and stirred the mixture for (3 – 4) minutes. Next, it was put in a graduated cylinder with a capacity of one liter and completed the volume to a liter, and mixed the mixture without creating a rotational movement. The capacitor was placed after 20 seconds and after 40 seconds the reading of the capacitor was taken with the temperature recorded to correct the reading (0.36 was added for each temperature above 20 mm and subtracted), where that 0.36 for each temperature less than 20 °C to determine the percentage of silt and clay. After that, the mixture was shaken again and left for two hours, after which the reading of the density was taken and the temperature was recorded to determine the percentage of clay, while the percentage of sand was determined by subtracting the percentage of silt and clay from (100).

3.4.4 Measurement of Heavy Metals.

3.4.4.1 Heavy Metals in Water.

Two elements chosen for examination copper and lead.Two litters of water samples from each site were filtered through Millipore filter paper (0.45 µm) after being washed with HNO_3 (0.5N), then with ion-free water, and dried at 60 °C for 12 hours. To keep the elements in their ionic form, 1.5 ml of concentrated HNO_3 was added to every 1 liter of the filtered water sample. Then, the water samples were focused by passing filtered water (2) liters over an ion exchange column of dimensions (2 x 50 cm) containing (telex-100) resin in the sodium form, the volume of 50 - 100 supplied by the Bio-Rad company quickly (no more than 5ml/min). 80 ml of dilute nitric acid (2N) was used to wash the heavy metal ions, then evaporated. The solution was at a temperature of 70 ºC to pre-drying, and (1ml) of concentrated HNO_3 acid and (10ml) of deionized water were left. Finally, the size was completed

to 25ml of ionic-free water, and ready samples were kept in labeled polyethylene until measuring in flame atomic absorption (APHA, 2003) (Fig. 3.18).
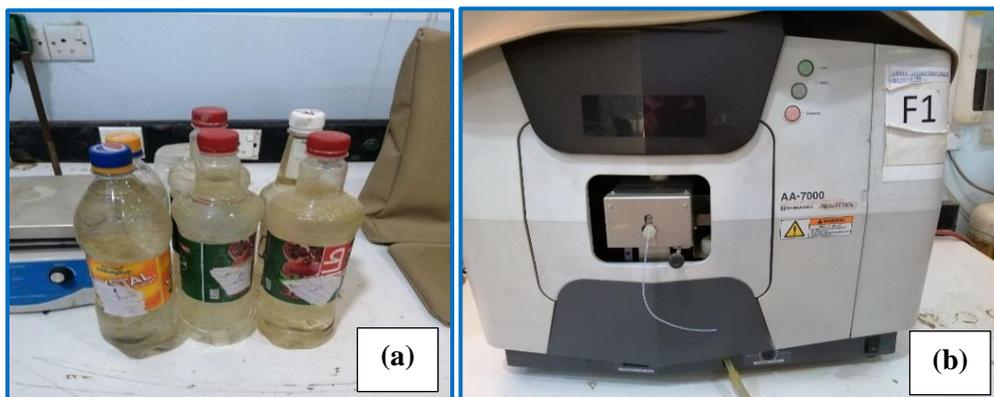
Fig (3.18): Heavy metals in water test.

3.4.4.2 Heavy Metals in Sediment.

Soil sediment samples were taken, dried at 80 °C, crushed, and passed on a sieve No. 40, as shown in Fig (3.19). Next, the weight of 1 g of sediment was taken, to which 1ml of HNO_3 and 4ml of HCL was added, left for two hours, passed on a normal filter paper, and the solution finished dissolving. Finally, the volume was finished to 100 ml of water with no free ions. The finished prepared samples were kept in clean plastic containers until the measurement was done in flame atomic absorption (APHA, 2003), and the unit was mg/g.
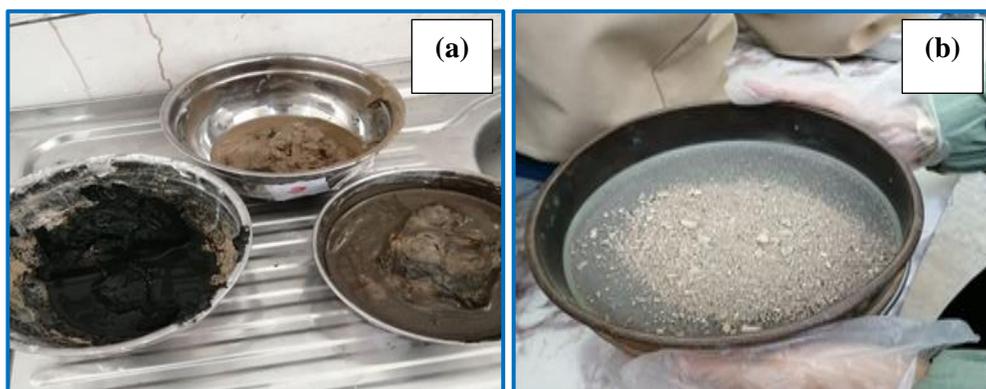
Fig (3.19): Heavy metals in sediment test.

3.4.4.3 Heavy Metals in Aquatic.

Wet acid digestion was followed according to the method described in (APHA, 2003), with a weight of 0.5 g of dried reed, which was passed through a sieve (NO 16 mesh) in a Teflon digestion beaker, then 2.5 ml of concentrated HNO_3 was added and left overnight. After covering it with a glass watch place the digestion pellets covered with a watch glass on a hot plate. For 1 hour, hydrophobic pellets covered with 1 hourglass were placed on a hot plate at 80 °C. After the samples had cooled, 2.5 ml of concentrated perchloric acid ($HClO_4$) was added to them. Then, the covered molds were heated at 180–200 °C for 2–3 h after the glass caps were removed and cooled. The samples reached a temperature of 100°C until the perchloric acid vapors dispersed. Then the samples were cooled down and the volume was completed to 25 ml so that the samples were ready for measurement using the atomic absorption technique (Fig. 3.20). The unit was mg/g.
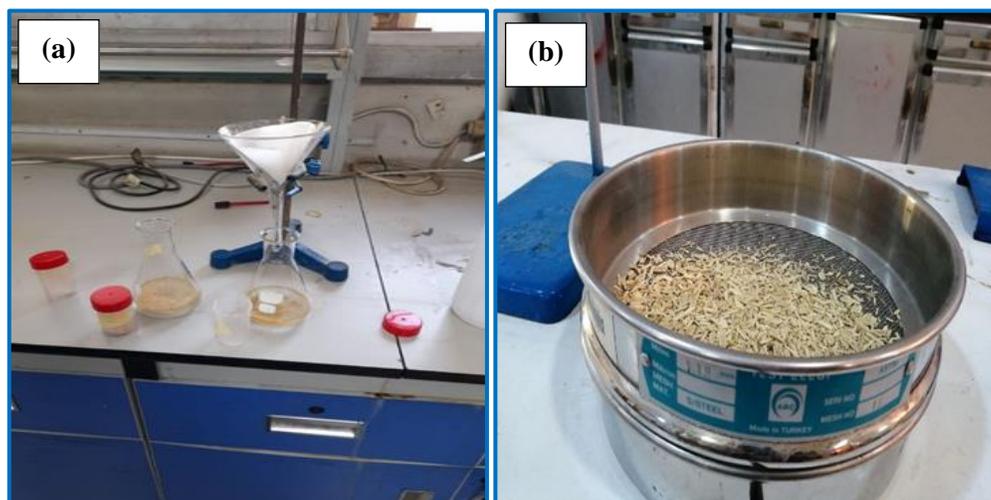
Fig (3.20): Heavy metals in Aquatic test.

CHAPTER FOUR

Results and Discussion

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Al-Muamirah Wastewater Treatment Plant.

Wastewater is the community's water supply after many different uses have polluted it. During its use, the water in a community picks up various chemicals. This means that the wastewater has the potential to pollute and becomes a health and environmental hazard (Kumar. et al., 2010).

In Hilla city, there is one main WWTP that was just built the Al-Muamirah Sewage Treatment Plant, which started running in 2019. The plant uses a system called "activated sludge" to get rid of the nitrogen and carbon compounds in raw wastewater in a biological way. The sewerage system is made to handle both industrial wastewater and wastewater from homes. The plant then sends the water that has been treated to (Drainage A1).

Comparing the concentrations of pollutants at the inlet and outlet of the treatment unit was used to assess its performance. samples were taken and examined according to the established methods for analyzing wastewater (APHA, AWWA, WPCF. 1998).

The evaluation of the plant's performance efficiency was carried out about the effluent quality. The assessment was conducted using operational data from the plant, which included BOD_5, COD, TSS, T.N, PO_4, NH_3, SO_4, NO_3, Cl, O&G, PH, and T measurements for the period of 11 months from Oct (2020) to Aug (2021).

The difference in the concentrations of influent and enffluent for the selected elements of by the wastewater treatment plant during the selected period can be seen in Figs. (4.1, 4.2, 4.3, 4.4). Table (4.1) described the statistics data of mean, standard deviations, maximum and minimum values for the selected parameters in the Al-Muamirah wastewater treatment plant.

Fig. (4.1): The values of the influent concentrations entered the WWTP and effluent concentrations after treating over 11 months for (a): BOD_5; (b): COD.

Fig. (4.2): The values of the influent concentrations entered the WWTP and effluent concentrations after treating over 11 months for (a): SO_4; (b): TSS; (c): Cl.
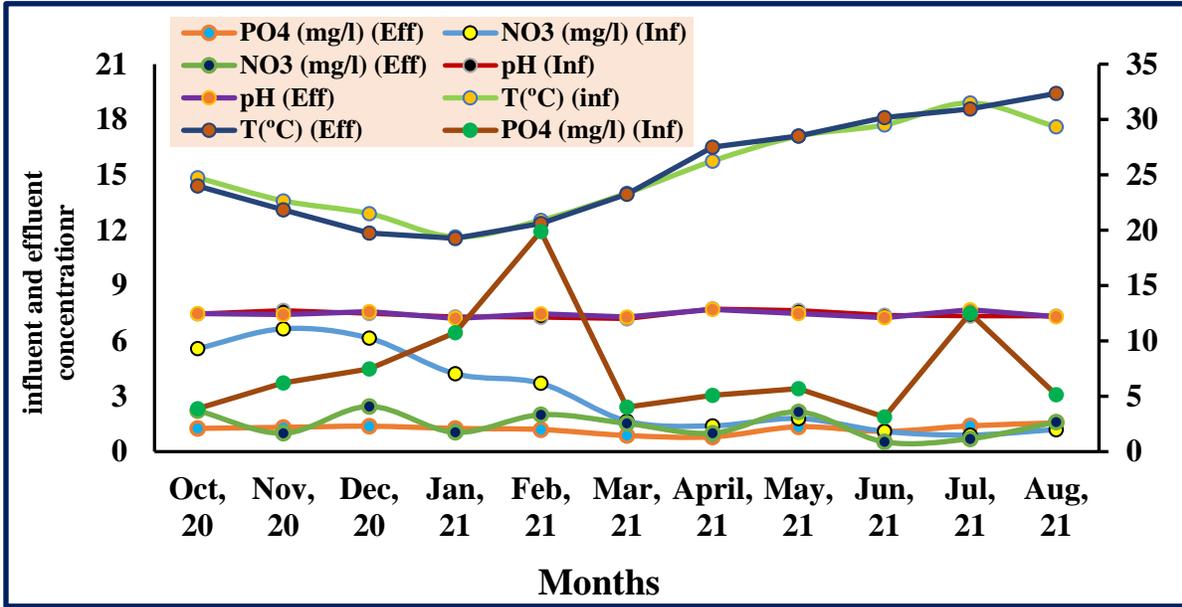
Fig. (4.3): The values of the influent concentrations entered the WWTP and effluent concentrations after treating over 11 months for (a): NO_3; (b): pH; (c): T; (d): PO_4.
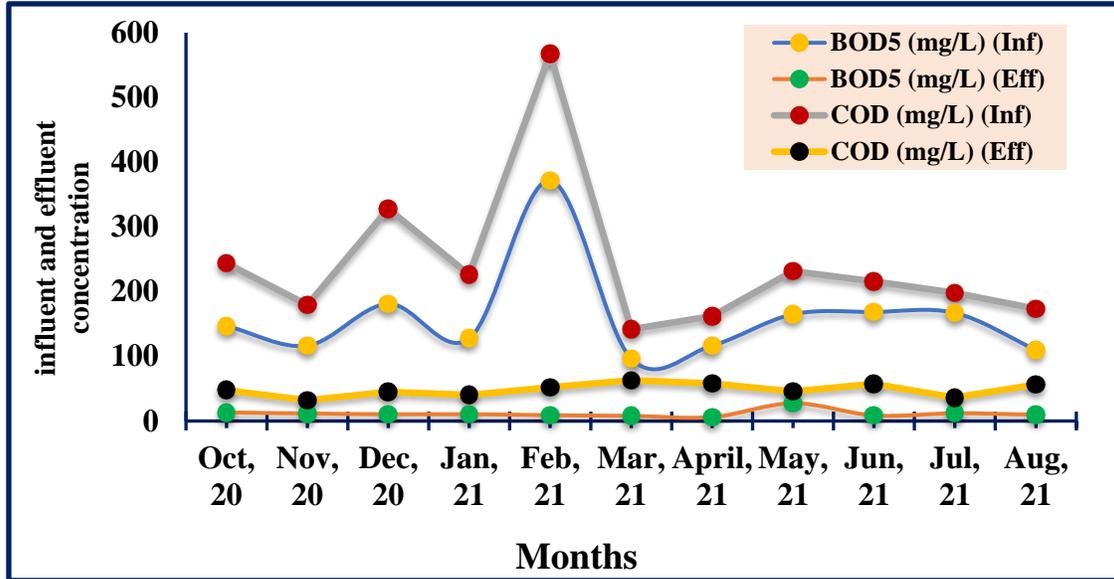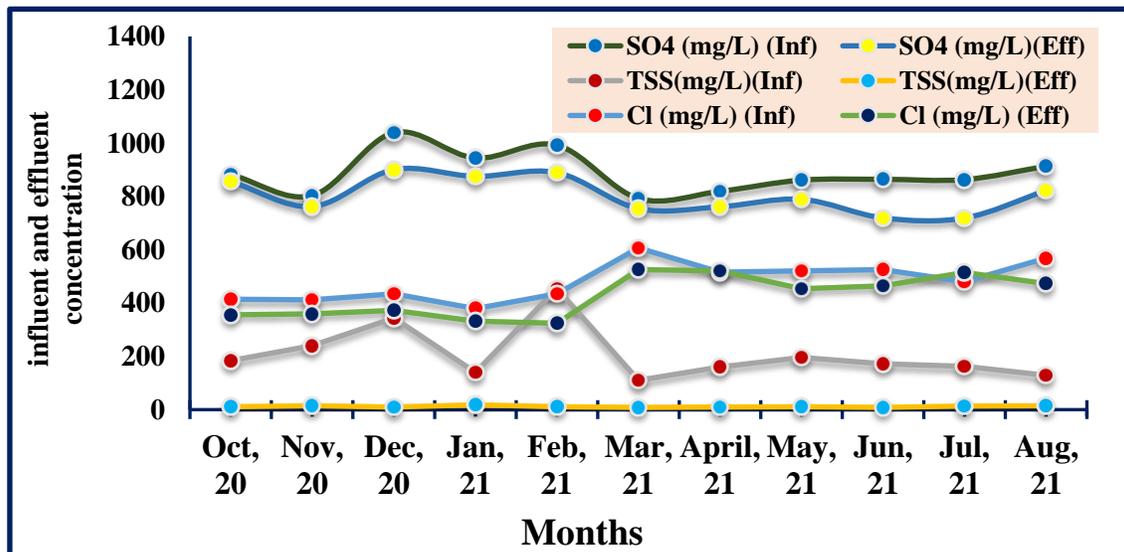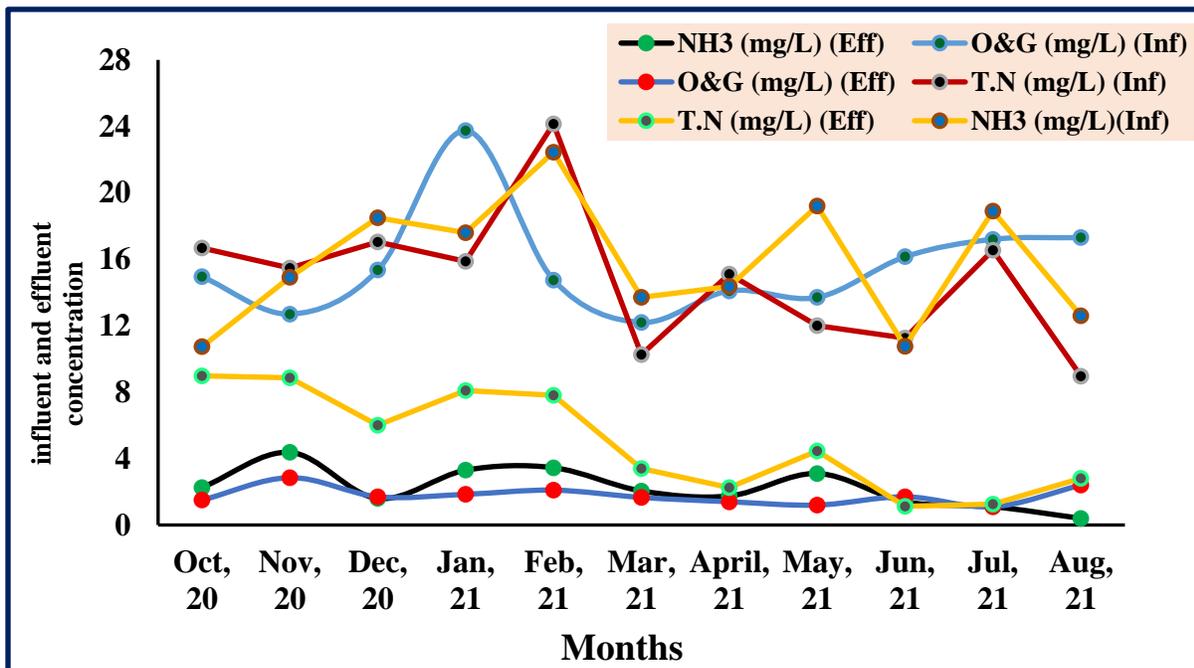

Fig. (4.4): The values of the influent concentrations entered the WWTP and effluent concentrations after treating over 11 months for (a): NO_3; (b): pH; (c): T; (d): PO_4.

Table (4.1): Statistics of selected parameters of Al- Muamirah WWTP (2020-2021).

Parameters	Influent				Effluent			
	Min	Max	Mean	StDv.	Min	Max	Mean	St.Dv.
BOD_5	75	573	149.79	92.42	4	49	10.95	6.75
COD	98	893	229.97	158.16	10	89	48.36	21.23
TSS	77	901	202.73	165.07	3	44	11.61	7.51
TN	2	30	14.71	5.74	0.1	14	5.5	4.09
PO_4	1.7	33.6	6.77	5.81	0.01	1.95	1.23	0.5
NH_3	0.7	28.2	14.87	5.34	0.4	5.1	2.48	1.43
SO_4	792	1106	899.46	87.33	719	910	821.07	62.66
NO_3	0.6	10.1	3.64	2.82	0.0002	6.4	1.40	1.33
Cl	354	715	483.22	87.1	301	560	423.8	79.54
O&G	6.3	28.2	15.57	7.88	0.1	3.1	1.73	0.8
pH	6.6	7.96	7.44	0.25	6.64	8.14	7.42	0.29
Temp.	18.4	32	24.92	3.86	18	32.7	45.1	127.76

The composition of wastewater effluent differs between facilities. depending on the level of treatment. This could be a big reason why pH levels vary so much (Morrison et al., 2001). The pH affects the suitability of a water system for various applications. It is well recognized that pH levels that are either extremely high or low can be harmful to aquatic life and can change the solubility of both other chemical pollutants and certain essential components found in water systems, which can have severe effects on the environment (Chapman., 1996).

TSS is one of the most factors in controlling the flow of wastewater, but it also messes up irrigation systems. The average TSS concentration of raw influent was 202.73 mg/L, but the average TSS concentration of treated effluent was only 11.61% (Table 4.1).

4.2 Removal Efficiency.

Utilizing the following formula, the removal efficiency of BOD$_5$, COD, TSS, T.N, PO$_4$, NH$_3$, SO$_4$, NO$_3$, Cl, and O&G was determined.

$$\textbf{Removal efficiency \% (P)} = \frac{\textbf{P}_{\textbf{inf}} - \textbf{P}_{\textbf{eff}}}{\textbf{P}_{\textbf{inf}}} \times \textbf{100} \tag{4.1}$$

Where: P is the selected parameter; P$_{inf}$ is the mean influent; P$_{eff}$ is the mean effluent.

Table (4.2) shows the removal efficiency for the above parameters from October (2020) to August (2021).

Table (4.2): Removal efficiency for the selected parameters.

Parameters	Mean Influent	Mean Effluent	Removal efficiency (%)
BOD$_5$	149.79	10.95	92.68
COD	229.97	48.36	78.97
TSS	202.73	11.61	94.27
T. N	14.71	5.5	62.61
PO$_4$	6.77	1.23	81.83
NH$_3$	14.87	2.48	83.32
SO$_4$	899.46	821.07	8.71
NO$_3$	3.64	1.40	61.53
Cl	483.22	423.8	12.29
O&G	15.57	1.73	88.88

The TSS removal efficiency in the Al-Muamirah WWTP was good, coming in at 94.27%. BOD and COD are two of the most important biochemical parameters used to assess the quality of wastewater (Huertasa et al., 2008).

COD is the amount of oxygen required by a strong oxidant (such as H$_2$SO$_4$) to decompose both organic and inorganic substances in a water system (Akan et al., 2008). Extreme oxygen depletion caused by elevated COD levels in water systems significantly affects aquatic life (Fatoki et al., 2003).

COD in the influent ranged from 98 mg/L to 893 mg/L, with an average of 229.97 mg/L. The average amount of COD left in the final effluent was 48.36 mg/L.

This ranged from 10 mg/L to 89 mg/L (Table 4.1).

The BOD in raw water ranged from 75 to 573 mg/L with an average of 149.79 mg/L. The BOD concentration in the treated effluent varied between 4 and 49 mg/L with a mean concentration of 10.95 mg/L (Table 4.1).

The efficiency of BOD_5 removal was 92.68 % while the efficiency of COD removal was 78.97% from OCT (2020) to Aug (2021), which are given in Table (4.2).

According to Metcalf and Eddy (1985), the BOD_5/COD ratio is a measure of biodegradation capacity, if the BOD_5/COD ratio is more than 0.5 biodegradation will happen quickly, if the ratio is between 0.2 and 0.4, biodegradation will occur only in a favorable thermal situation when the ratio is less than 0.2, biodegradation will not happen (Contreras et al., 2003). The BOD_5/COD ratio in the raw influent was 0.65, indicating the presence of biodegradable organic Materials.

The overall efficiency of the Muamirah WWTP for removing the BOD_5, COD, TSS, PO_4, NH_3, and O&G was considered good. Removal of more than 92.68%, 78.97%, 94.27%, 81.83%, 83.32%, and 88.88% was achieved in BOD_5, COD, TSS, PO_4, NH_3, and O&G respectively.

4.3 Cluster Analysis.

The outcome of cluster analysis was displayed as a tree diagram, Two major categories can be distinguished in (Fig. 4.5). the first consists of two subgroups the months with similar removal efficiency (from Nov 2020 to jan 2021). The worst case was group No.3(from Oct 2020 to Mar 2021), It could be attributed to several variables, such as operational factors like mechanical failure factor that led to a decrease in processing efficiency .
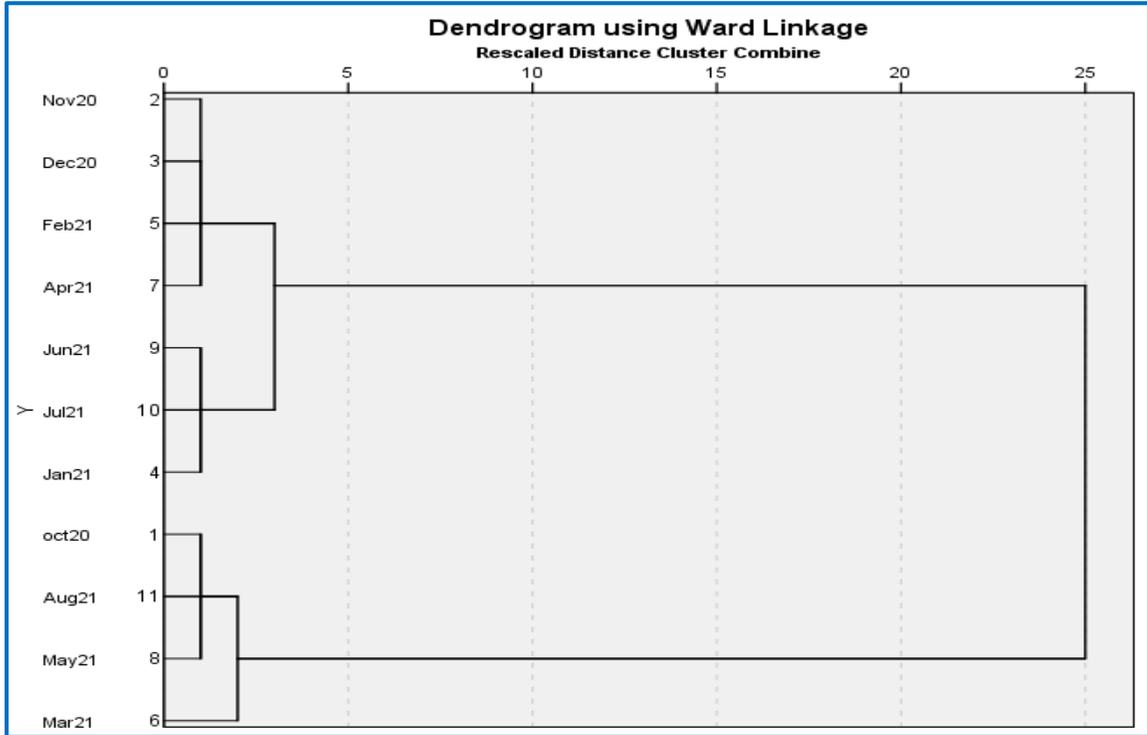
Fig (4.5): dendrogram of Clustering for monthly removal efficiency for all parameters at Al-Muamirah WWTP

The dendrogram demonstrates in Fig. (4.6) groups removal efficiency of all parameters into three statistically significant clusters: cluster I correspond to BOD_5, TSS, NH_3, and O&G; cluster II comprises COD, PO_4, and TN; and cluster III was linked to SO_4, Cl, and NO_3. from Fig. (4.6), there was a similarity between cluster I& cluster II in the removal efficiency of the elements. It was found that the worst efficiency of removing the elements in cluster III as it consistent with the results in Table 4.2.

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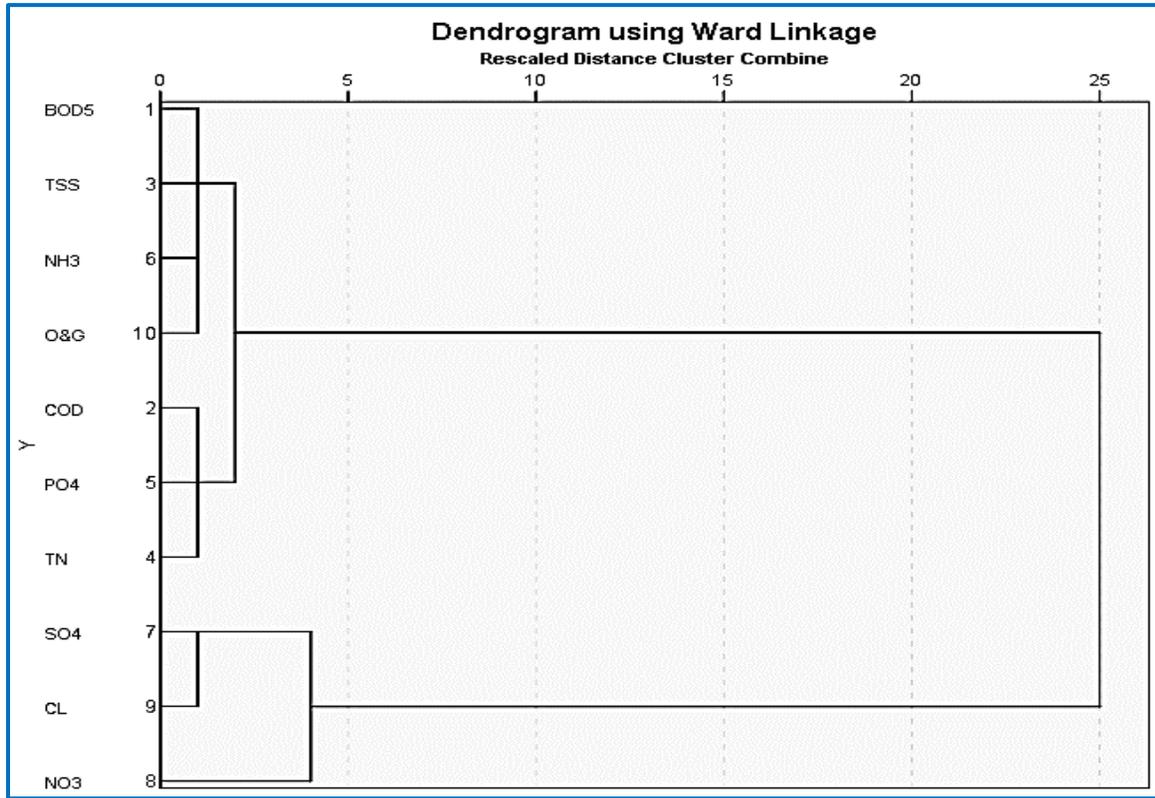
Fig (4.6): Dendrogram of clustering for wastewater removal efficiency
of Al-Muamirah WWTP.

4.4 Hilla Drainage System (A1).

4.4.1 Physical and Chemical Parameters.

4.4.1.1 Volumetric Analysis of Sediment Particles (Hydrometer).

Measuring the gradation for the soil distribution by sieve analysis was used. The selection of sieves is based on (ASTM D-422, 1985) standard details. The utilized soil was collected from study sites as shown in Fig. (4.7).
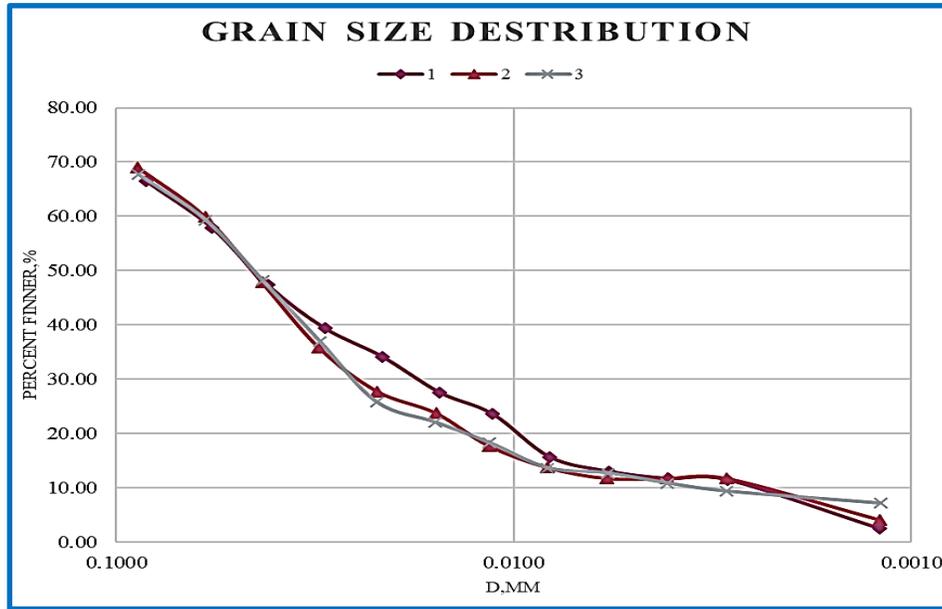
Fig (4.7): Grain size distribution soil of study sites.

Based on the results of the soil texture test according to classification (USDA), silt, and sand formed the largest percentage of the soil, while clay made up a lower percentage (Table 4.3). The composition of sediments affects their physical and chemical properties, as well as their storage ability for ions, salts, and organic materials (Al-Saadi, 2006).

Silt is a granular substance that is larger than clay but smaller than sand. It is typically composed of aluminum silicates ranging in size from 0.002 to 0.1 millimeters (Abdulwahhab et al., 2012).

Table (4.3): Percentage of soil components

Study Site	Sand%	Silt%	Clay%	Soil Type
S1	36	55	9	Silty loam
S2	37	54	9	Silty loam
S3	37	54	9	Silty loam

4.4.1.2 Air Temperature (T-Air) and Water Temperature (T-Water).

The air temperature has the most impact on the aquatic ecosystem. This is because changes in the properties of aquatic environments are dependent on

temperatures, such as levels of organic decomposition, electrical conductivity, and levels of dissolved oxygen. Temperature also influences the growth and reproduction of aquatic organisms (Duruibe et al., 2007). The temperature of the water has a significant influence on the diversity and density of aquatic organisms, as well as their cellular metabolic activities (Ranjbar et al., 2017).

The average air temperature at the study sites ranged from the highest (47.3 $^{\circ}$C) at the third site in summer to the lowest (14.5 $^{\circ}$C) at the second site in winter (Fig. 4.8), Appendix 1.

The average water temperature at the study sites ranged from the highest (48.0 °C) at the third site in summer to the lowest (13.6 °C) at the second site in winter (Fig. 4.9), Appendix 1.
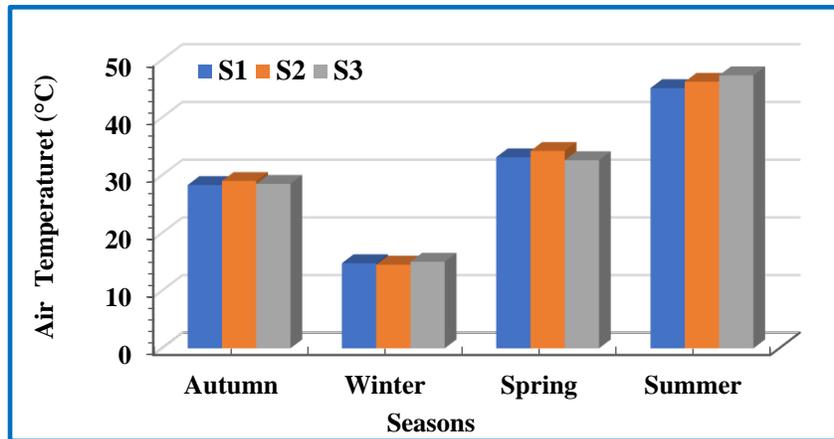

Fig (4.8): Seasonal variations for mean air temperature value in the sites.
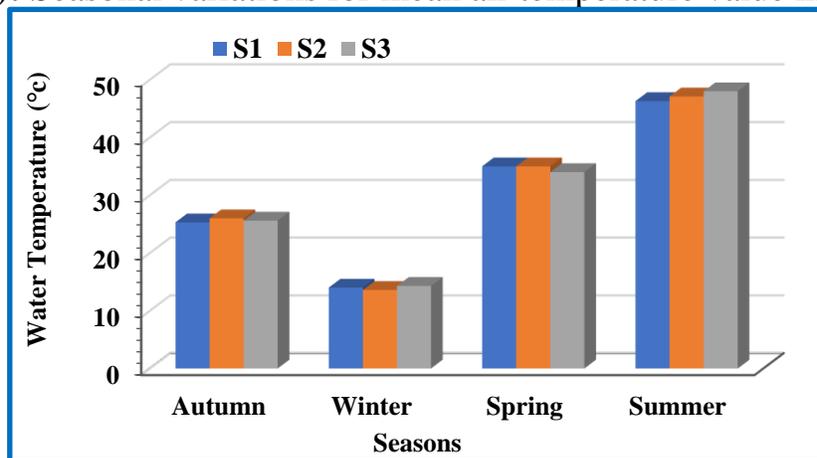
Fig (4.9): Seasonal variations for mean water temperature value in the sites.

4.4.1.3 pH

The pH value is a measure of the activity of hydrogen ions, which affects biological and chemical reactions in a body of water (Friedl et al., 2004; Lawson, 2011). The rise in pH in rivers might have something to do with photosynthesis and the growth of aquatic plants. Since photosynthesis uses up CO_2 the pH levels rise (Yousry et al., 2009). pH plays a major role in the survival of aquatic organisms and affects their distribution in water because many proteins and enzymes are affected by the high and low pH. Most aquatic organisms require a pH within the range of 5 to 8.5 for optimal growth and reproduction, although they may survive for a time at pH values outside this range. The toxicity of many pollutants is dependent on pH (Al-Zubaidi, 2011). The first site had the highest mean of pH (7.2) in autumn and the lowest mean of pH (6.6) in the first site during spring (Fig. 4.10), Appendix 1. The results showed pH in drainage water values in all sites within limits of Iraqi standard NO.3 of 2012.
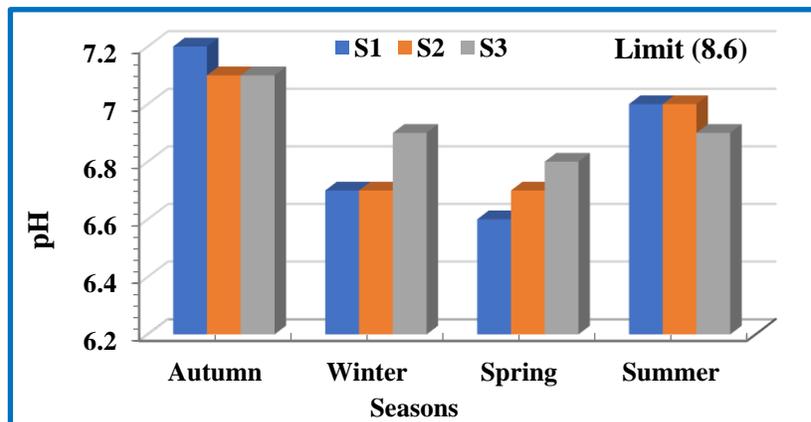
Fig (4.10): Seasonal variations for mean pH value in the sites.

4.4.1.4 Total Dissolved Solids (TDS).

TDS is used to describe the inorganic salts and organic material concentrations dissolved in water (WHO, 1996). The concentration and content of total dissolved solids (TDS) in natural waters are governed by drainage geology, atmospheric precipitation, and the water balance (evaporation-precipitation) (Phyllis

and Lawrence, 2007). TDS ranged from the highest mean value (3010 mg/L) in the third location during Autumn to the lowest mean value (1670 mg/L) in the first location during Spring (Fig. 4.11), Appendix 1. The average valueof TDS was 2088.61 mg/L. The results showed the high value of TDS in drainage water was at the third site which was above the Iraqi standard NO.3 of 2012 for TDS >2000 mg/L.
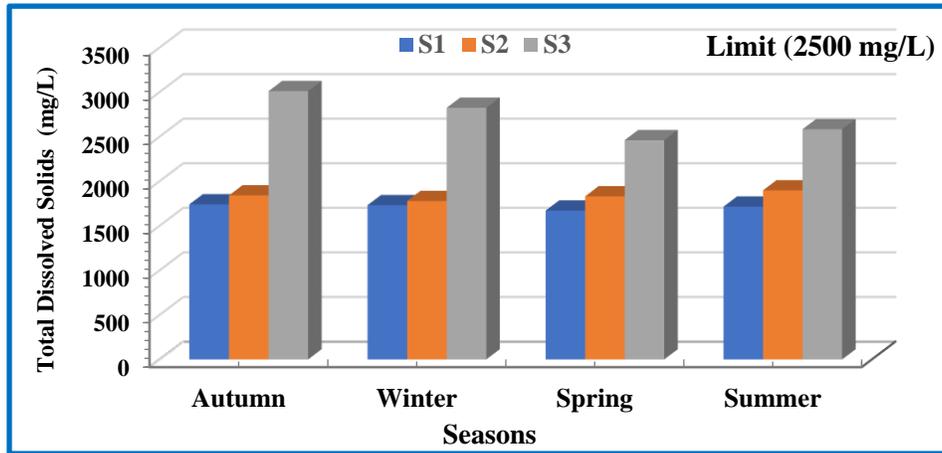
Fig (4.11): Seasonal variations for mean TDS value in the sites.

4.4.1.5 Electrical Conductivity (EC).

It is defined as the ability to transfer electrical current and is one of the most important factors in the environment for determining water quality, is affected by temperature, the amount of total dissolved solids in water, and the organic materials that are present in water (Jayalakshmi et al., 2011). Electrical conductivity was highest in the third site during Autumn (6130 µs\cm) and lowest in the first site during Spring (3360 µs\cm) (Fig. 4.12), Appendix 1. The increase may have been caused by a lack of rainfall throughout the autumn season, which led to a rise in salt concentrations and an increase in EC values, studies agree with this (Al-Seedi and Al-Auboody, 2011; Al-Sharifi, 2014). Electrical conductivity is directly related to salinity and thus damages agricultural crops (FAO, 2012). The Results showed electrical conductivity in drainage water values in all sites exceeding the permissible limit (FAO, 2003).
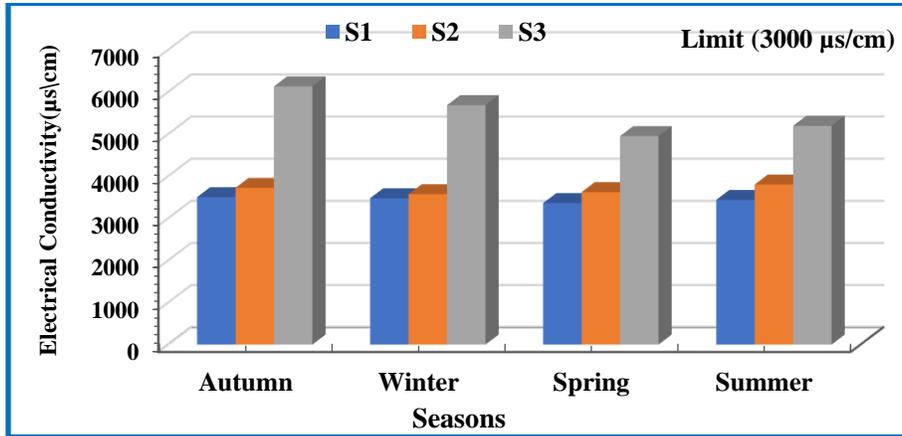
Fig (4.12): Seasonal variations for mean EC value in the sites.

4.4.1.6 Salinity.

It is a dynamic indicator of the exchange system's character. It is expressed in parts per thousand as the total concentration of electrically charged ions in water (UNESCO&WHO, 1992). Salinity was highest (3.92 ppt) in the third site in the Autumn and lowest (2.15 ppt) in the first site in spring (Fig. 4.13), Appendix 1. The results showed salinity in drainage water values in all sites exceeding the permissible limits (FAO, 2003).
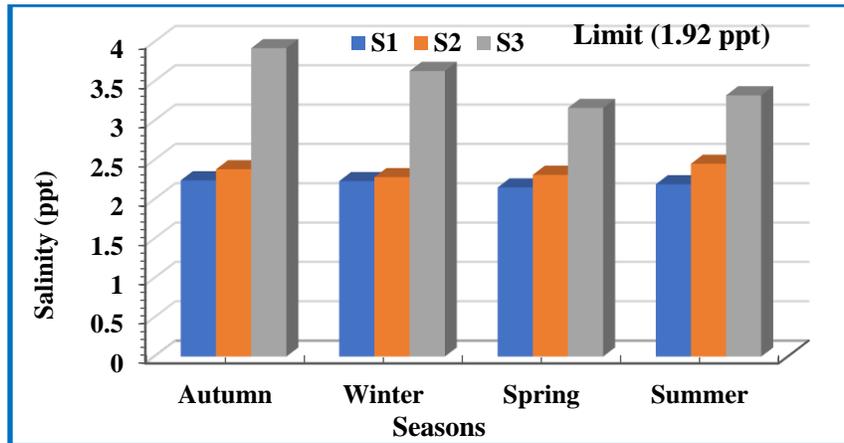
Fig (4.13): Seasonal variations for mean salinity value in the sites.

4.4.1.7 Turbidity.

Water turbidity is the measurement of fine suspended matter in water, typically including clay, silt, sand, non-living organic particulates, plankton, and

other microorganisms (Siliem, 1995; Lako et al., 2012). Turbidity hinders water treatment (filtration) and affects aquatic life (UNEP, 2008). Turbidity was highest (5.2 NTU) in the third site in Autumn and lowest (1.05 NTU) in the first site in winter (Fig. 4.14), Appendix 1. The outcomes showed turbidity in drainage water in third site values in all seasons exceeding the permissible limit except for the winter (FAO, 2003). The value of turbidity in the winter season was within the permissible limits compared to other seasons due to rain that leads to soil washing and the flow velocity (Mushtaq et al., 2013). The turbidity in the third site was high due to the presence of suspended particles and sand because it sand and gravel factories, which may have caused an increase in turbidity values compared to other sites (Mustafa, 2006).
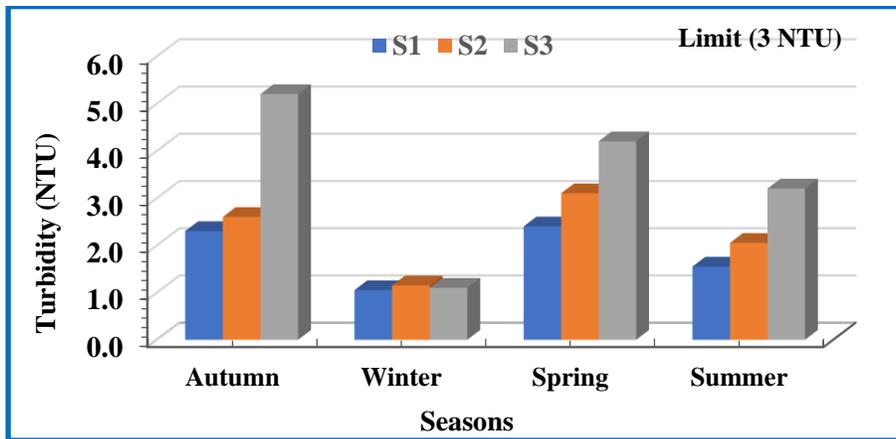
Fig (4.14): Seasonal variations for mean turbidity value in the sites.

4.4.1.8 Dissolved Oxygen (DO).

DO is one of the most critical elements in stream and drainage systems. Due to bioaccumulation and biomagnification, a DO deficiency has a direct impact on the environment of a river or drainage due to its detrimental effects on aquatic life (Venkatesharaju et al., 2010). When its average concentration falls below 5 mg/L, it impacts the function of living organisms, and below 2 mg/l, it destroys aquatic organisms, including the death of the majority of fish (UNESCO/WHO/UNEP,

1996). Dissolved oxygen was the highest (9.0 mg/L) in the third location in spring and the lowest (5.65 mg/L) in the first location in summer (Fig. 4.15), Appendix 1. Good aeration was observed in drainage water due to levels of dissolved oxygen (> 5 mg/L). Dissolved oxygen levels decreased during summer due to the solubility of gases decreasing with increasing temperature, which has a significant effect on the solubility of carbon dioxide and oxygen (Al-Ghanmi, and Al-Shawat 2015). It might be attributable to an increase in chemical and biological processes that occur in aquatic systems and are associated with temperature rise, which agrees with (Al-Hejuje, 2014). The results showed dissolved oxygen in drainage water values in all sites within the permissible limit (FAO, 2003).
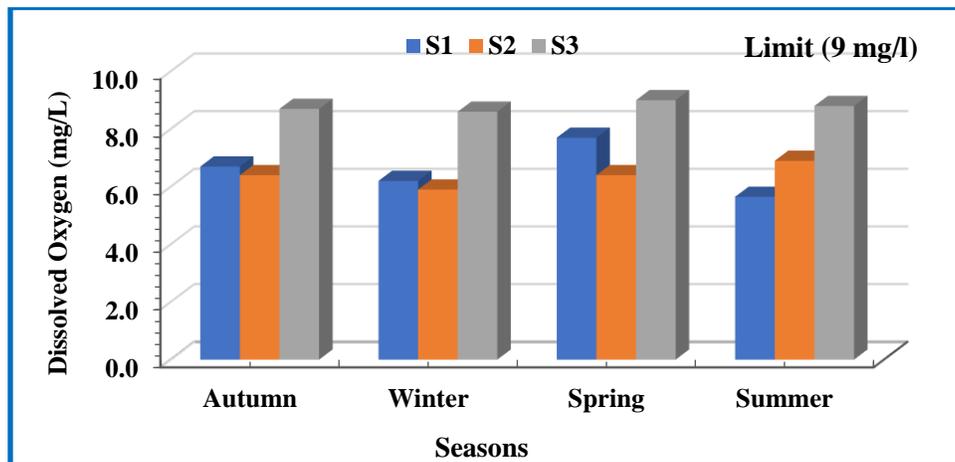
Fig (4.15): Seasonal variations for mean DO value in the sites.

4.4.1.9 Chemical Oxygen Demand (COD).

COD was highest (73.5 mg/L) in the third location in Autumn and the lowest (5.1 mg/L) in the first location in spring (Fig. 4.16), Appendix 1. Wastewater contains many non-biodegradable materials that contribute to raising the value of the chemical oxygen demand. The results of the study showed an increase in the values of the chemical oxygen demand during the Autumn season in the third location. This is due to a high content of organic matter (Maiti, 2004). The results

showed the COD in drainage water values in all sites within limits of Iraqi standard NO.3 of 2012.
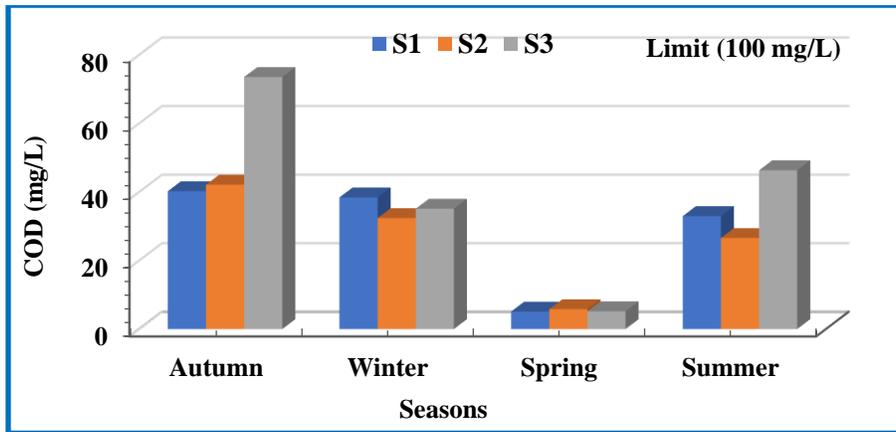
Fig (4.16): Seasonal variations for mean COD value in the sites.

4.4.1.10 Nitrogen (N).

For Nitrogen, the highest value was (0.91 mg/L) in the first site in summer, and the lowest value was (0.21 mg/L) in the third site in spring (Fig. 4.17), Appendix 1. The decrease in nitrogen concentration was attributed to an increase in its consumption by plankton and aquatic plants (WHO,1997), or it may be attributed to the high temperatures and increased nitrogen reduction due to a decrease in the concentration of dissolved oxygen (Shrimali and Singh, 2001). The results showed nitrogen values in drainage water in all sites were within limits of Iraqi standard NO.3 of 2012.
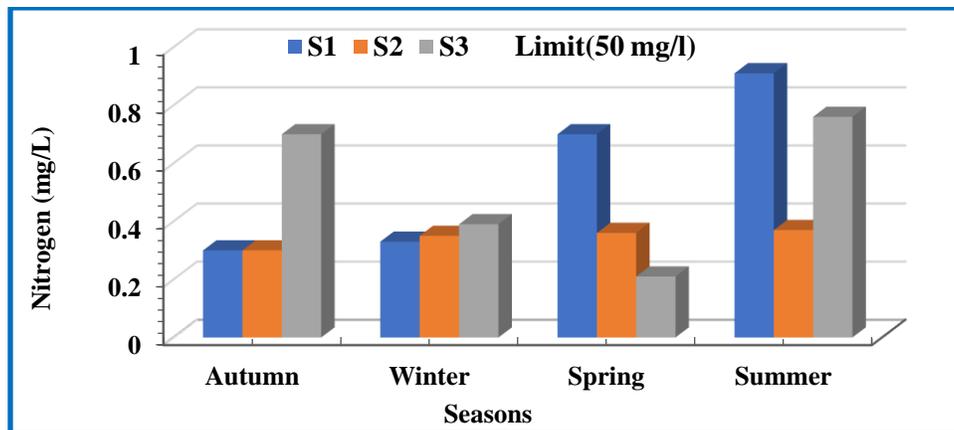
Fig (4.17): Seasonal variations for mean nitrogen value in the sites.

4.4.1.11 Nitrate (NO_3).

Nitrate is a form of nitrogen compound found in natural waters and is the most oxidized. Chemical fertilizers, decaying plant and animal matter, household effluents, discharge wastewater on land, industrial discharge, leachates from trash, and are all major sources of nitrate. These sources can pollute rivers, lakes, streams, and groundwater. Small amounts of nitrate are found in unpolluted natural water (Foglar, 2013). Nitrate was highest (1.5 mg\L) in the third site in Autumn and lowest (0.01 mg\l) in the first site in Spring (Fig. 4.18), Appendix 1. The results showed high concentrations of Nitrates during the winter months. This may be caused by the availability of oxygen for nitrite oxidation to nitrate (Lunsford, 2003), as well as nitrogen sources coming from agricultural lands also contributes to increasing their concentrations in water (Al-Saad et al., 2008). The obvious decrease in nitrate concentrations during the spring and summer months returns to increase consumption by phytoplankton or may return to higher temperatures and increased operations of organic decomposition, and reduction of nitrate to nitrite (Hussein et al.,2000). The results showed nitrate in drainage water values in all sites within limits of Iraqi standard NO.3 of 2012.
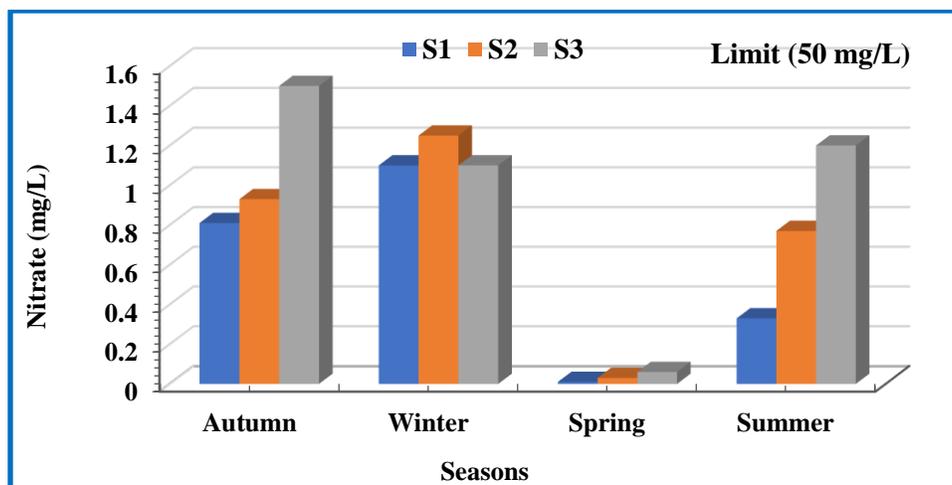
Fig (4.18): Seasonal variations for mean nitrate value in the sites.

4.4.1.12 Total Organic Carbon (TOC) Content in Sediment.

Total organic carbon was the highest (1.72%) in the third site in Summer and the lowest (0.16%) in the first site in Winter, as demonstrated in Fig(4.19) Appendix 1. Summer was shown to have the highest amounts of the TOC, this may be attributed to the movement of benthic sediment, as well as changes in air currents and soil particles, increased mean values of evaporation, and the temperature-induced decomposition of chemical compounds. These levels of TOC are in accordance with the research by Al-Sharifi (2014). The results showed total organic carbon in drainage water values in all sites within limits (ASTM D5268_02).
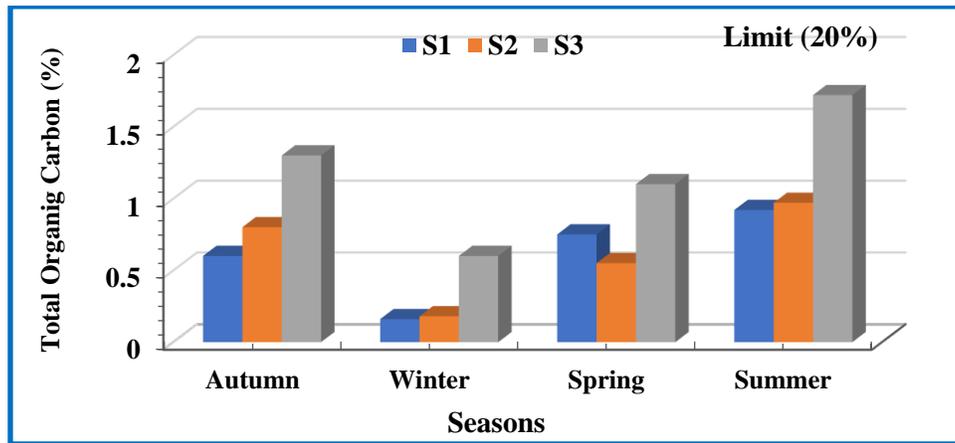
Fig (4.19): Seasonal variations for mean TOC value in the sites.

4.4.1.13 Total Hardness (TH).

Total Hardness is an indication of the amount of water that contains calcium and magnesium ions, in addition to alkaline salts such as barium. The presence of dissolved calcium and magnesium sulfate and chlorides, in addition to inorganic acids, is what causes permanent hardness. Calcium and magnesium bicarbonate is converted to carbonate, and part of this carbonate precipitation is what causes Temporary hardness (Hassan et al., 2014). During Winter, the second location had the highest mean value of total hardness (229 mg/L), whereas the first location had the lowest mean total hardness (209 mg/L) during Spring (Fig. 4.20), Appendix 1.

It dropped to a low level during the months of Spring, which may be related to the rise in water levels and the growth of aquatic plants, both of which lead to increase consumption of salts (Mahmood, 2008). The Results showed Total hardness in drainage water values in all sites within limits of Iraqi standard NO.3 of 2012.
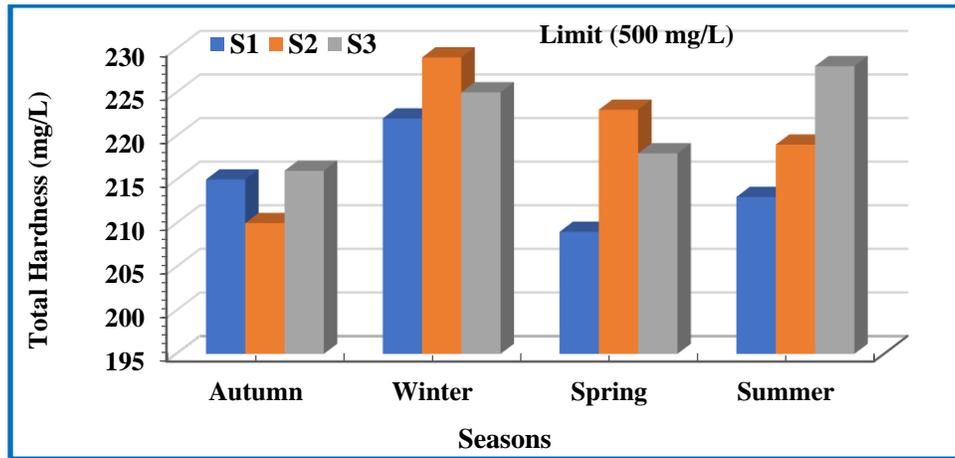
Fig (4.20): Seasonal variations for mean TH value in the sites.

4.4.2 Sulfate & Chloride (Water, Sediment, and Reeds).

4.4.2.1 Sulfate (SO₄) in Water.

Sulfates are found in almost all natural waters, but the amounts vary depending on the type of land they flow through. They are often derived from the sulfides of heavy metals (iron, nickel, copper, and lead). Iron sulfates are found in sedimentary rocks, where they can be oxidized into sulfate in humid climates. Sulfate can then leach into waterways, making groundwater too high with sulfates. As magnesium and sodium are found in many types of water, the effect of their combination with sulfate will be bigger or smaller depending on the concentration (EPA, 2001). The highest value of Sulfate (SO_4) in water was (3824 mg/L) in the third site in Autumn, and the lowest value was (1004 mg/L) in the first site (Fig. 4.21), Appendix 2. The results of sulfates in drainage water in all sites were outside the Iraq standard limit (1967). Sulfate concentrations raised in autumn and decreased in the summer due to the discharge of domestic sewage and agricultural runoff; these

ions can be formed by the decomposition of organic materials or the use of chemical fertilizers in agriculture (Imarah and Munther, 1993; Grasby et al., 1997). The decomposition of the many different sulfur-containing compounds that are present in bodies of water results in the formation of sulfates. The increase in sulfate concentrations has a negative role on the use of water for irrigation and increasing its concentrations works on Calcium sulfate precipitation, which in turn affects the sodium ions dissolved in water (Al-Obaidi, 2010)
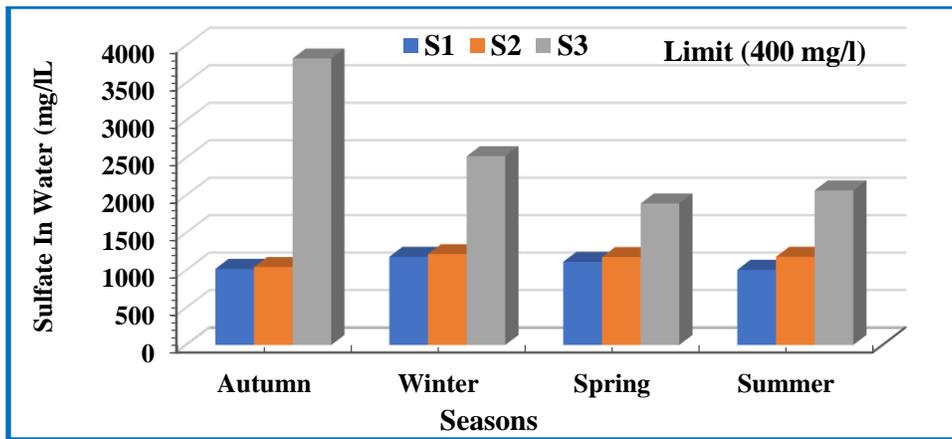
Fig (4.21): Seasonal variations for mean SO_4 value (in water) in the sites.

4.4.2.2 Sulfate (SO4) in Sediment.

The highest sulfate value in sediment was (1.4%) at the third site in winter, and the lowest value was (0.58%) at the first site in summer (Fig. 4.22), Appendix 2. The increase in its concentration led to an increase in the salinity of the soil (Al-Obaidi, 2010). The results of sulfates in sediment for all sites were within the standard limits of ASTMD5268-02.
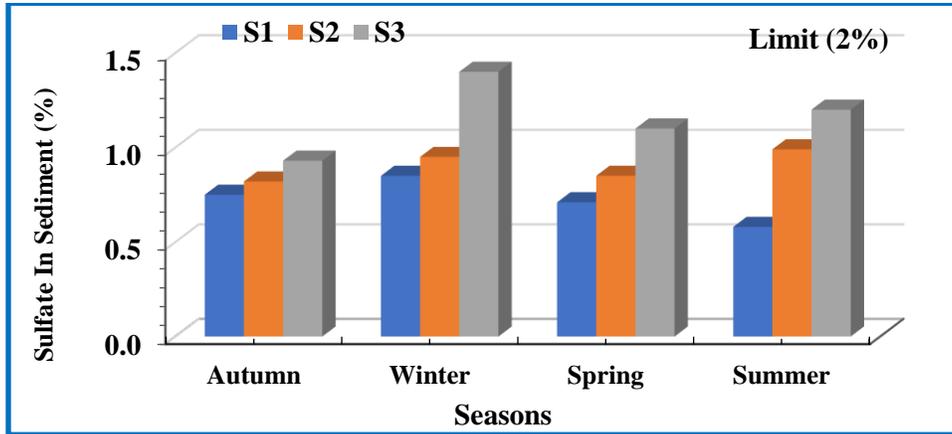
Fig (4.22): Seasonal variations for mean SO_4 value (in sediment) in the sites.

4.4.2.3 Sulfate (SO_4) in Reeds.

Sulfate concentrations in reeds ranged from the highest (69.75 mg/L) in the first location in summer to the lowest (51mg /L) in the third site in Spring (Fig. 4.23), Appendix 2. The increase in sulfate concentrations in plants impedes plant growth and the appearance of spots on its leaves (Al-Obaidi, 2010).
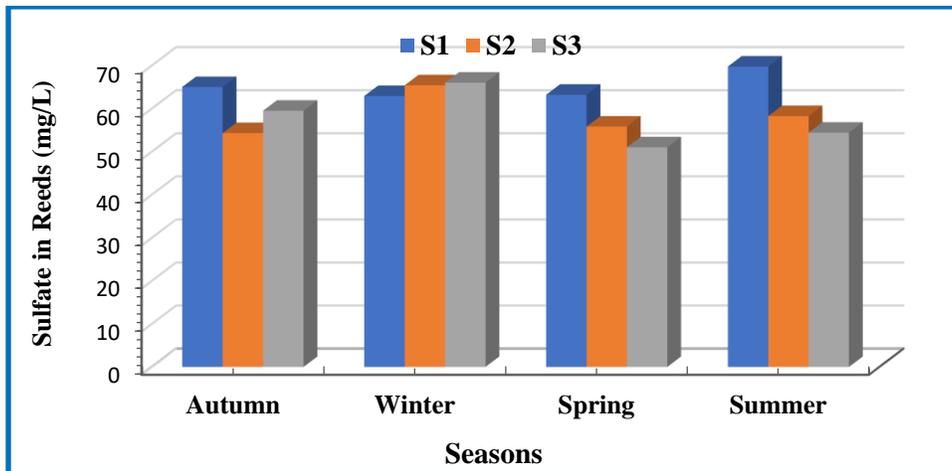
Fig (4.23): Seasonal variations for mean SO_4 value (in reeds) in the sites.

4.4.2.4 Chloride (Cl) in Water.

Chloride is found in all natural waters, but the concentrations vary a lot. Sources of pollution in freshwater include soil and rock formations, and wastewater.

A lot of chlorides are found in sewage and some industrial wastewater (Ezeribe et al., 2012). Its permissible limit for agricultural irrigation is 600 mg/L, and the lack or excess of chloride affects the productivity of agriculture (Cheepi, 2012). The highest value of chloride (Cl) in water (1345 mg/L) was recorded at the third location in autumn, and the lowest value was (459 mg/L) in the first location in autumn (Fig. 4.24), Appendix 2. Chlorides in drainage water in the third site were outside the permissible Iraq standard limits (1967). The chloride salts are characterized by their high solubility in water, and the presence of large quantities of them in water may cause a toxic effect on some sensitive agricultural crops such as fruit trees (Wessal et al, 2011). Classification of irrigation water and the effect of chlorides on plant growth have a high effect on sensitive crops, where the water is suitable for chlorine-tolerant plants with slight to moderate damage (USA, 1987) (Table 4.4).
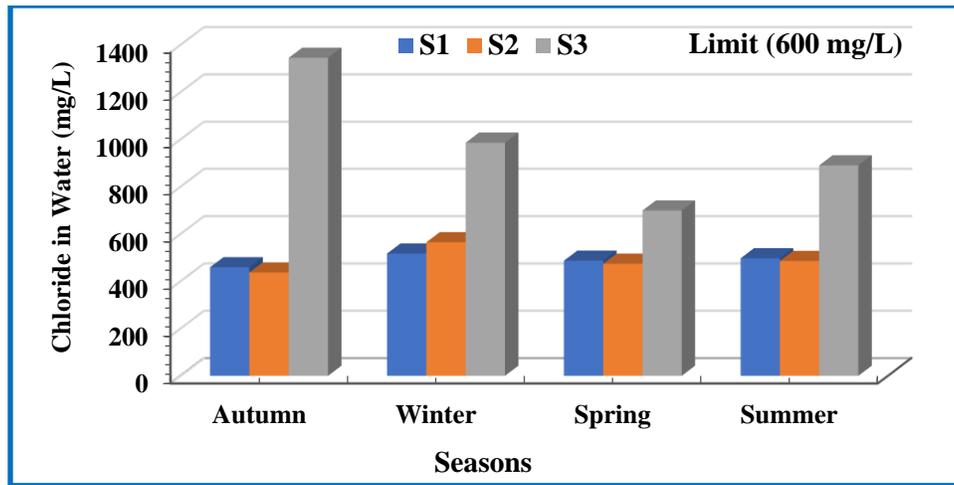
Fig (4.24): Seasonal variations for mean Cl value (in water) in the sites.

Table (4.4): Classification of irrigation water and the effect of chlorides on plant growth (USA, 1987).

Effect degree	Chloride concentration (mg/l)
Little effect on plants	< 71
Acceptable effect on plants	71 - 142
Medium effect on sensitive crops	142 - 284
High effect on sensitive crops	> 284

4.4.2.5 Chloride (Cl) in Sediment.

The quantity of chlorine in natural water varies considerably. This is due to the contamination by wastewater and the leaching of saline residues from the soil, an abnormally high quantity of chloride may be produced (Cheepi, 2012). Chloride in sediment was highest (105.97 mg/L) in the third location in spring and lowest (36 mg/L) in the first location in Autumn (Fig. 4.25), Appendix 2. The presence of chlorides is common in the soils of dry areas, and their concentration varies in the soil according to the quality soil and the degree of its salinity (Wessel et al, 2011).
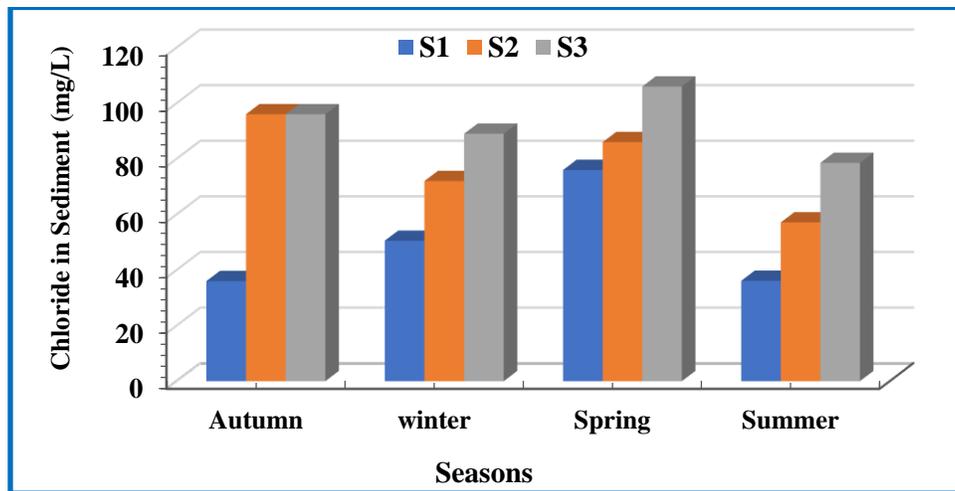
Fig (4.25): Seasonal variations for mean Cl value (in sediment) in the sites.

4.4.2.6 Chloride (Cl) in Reeds.

Chloride in reeds was 30.61 mg/L (the highest value) in the third location in Winter, and the lowest value was (21 mg/L) in the first location in Autumn (Fig. 4.26), Appendix 2. Classification of irrigation water and the effect of chlorides on plant growth have a high effect on sensitive crops (The water is suitable for chlorine-tolerant plants with slight to moderate damage) (USA, 1987) (see Appendix 4).
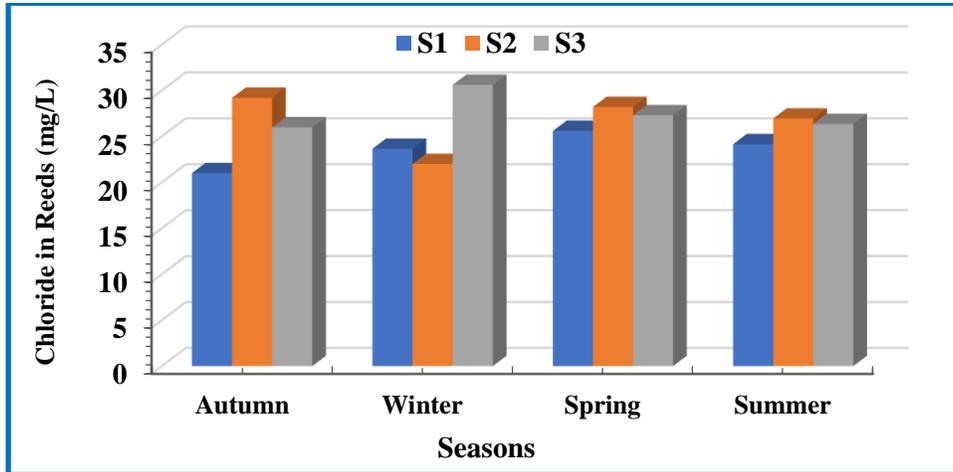
Fig (4.26): Seasonal variations for mean Cl value (in reeds) in the sites.

4.4.3 Heavy Metals.

4.4.3.1 Heavy Metals in Water.

Two elements chosen for examination copper and lead .The concentration of heavy metals is influenced by water quality and physicochemical qualities. The concentration of heavy metals is also affected by the rise and decrease in temperature, which causes evaporation, the increase in salinity, the rise and decrease in water depth, and the change in conductivity (Al-Taher et al., 2020). In water, heavy metals were found in a variety of different forms, including dissolved, and particulate, these forms can pass between different layers of water and can enter all levels of the food chain, where they can accumulate and present a risk to all of life, including humans (Kobielska et al., 2018). Heavy metals in water concentrate in aquatic plants and animals (Wang et al., 2019). The turbidity, total dissolved solids, and pH of the water are all factors that have an impact on the ease with which sediment and plankton are able to become mixed together. When there is an increased quantity of organic matter, it is oxidized, which results in the production of carbon dioxide (CO_2). This CO_2 then dissolves in water to create carbonate, which results in a lower pH, increased solubility, and the release of heavy metals (Fawzy et al., 2012).

A. Copper (Cu) in Water.

Seasonal changes of Cu in the dissolved phase of water revealed that had the highest value of it (0.09 mg/L) in the second location in the autumn, and the lowest value (0.01 mg/L) in the first location in the spring (Fig. 4.27) Appendix 3, and the annual mean was (0.042 mg/L).
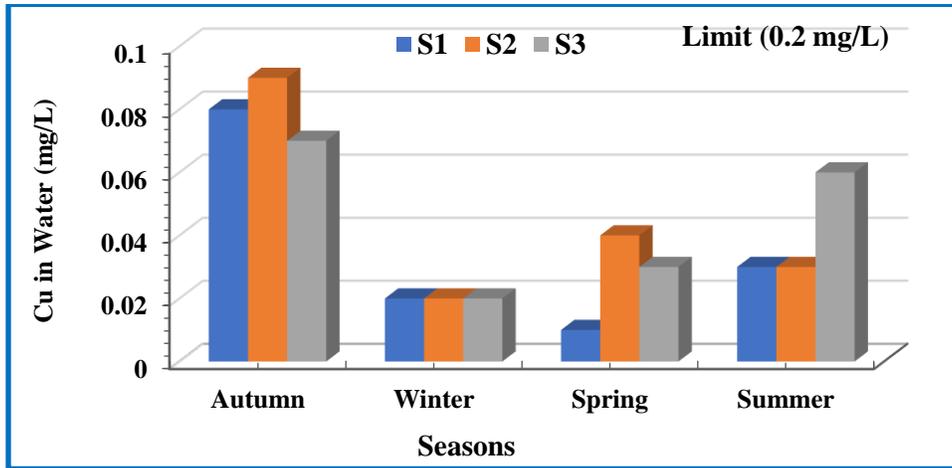
Fig (4.27): Seasonal variations for copper in water (dissolved phase) in the sites.

B. Lead (Pb) in Water.

Seasonal variation of the Pb in the dissolved phase water demonstrated that the highest value was (0.05 mg/L) in the second location in autumn and the lowest value (0.01 mg/L) in first & third locations in spring (Fig. 4.28), Appendix 3. The annual mean was 0.031 mg/L.
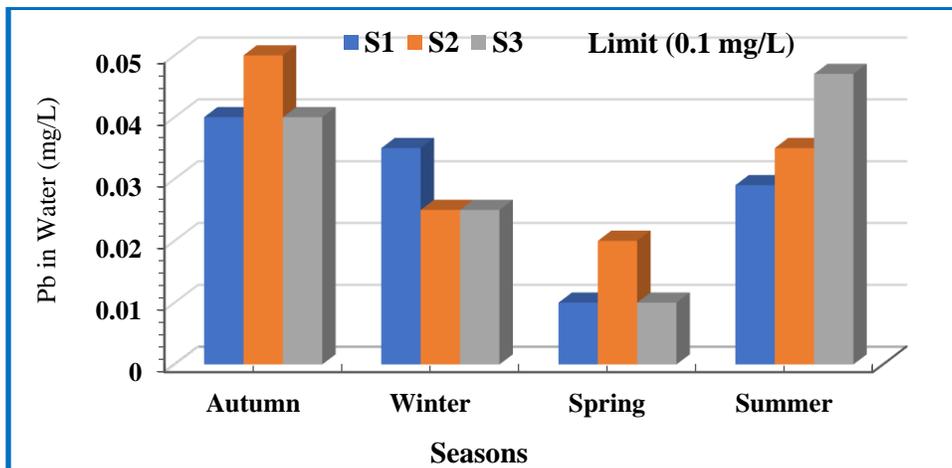
Fig (4.28): Seasonal variations for lead in water (dissolved phase) in the sites.

The Cu and Pb concentrations in water were found to be within the allowed limits of Iraqi standard NO.3 of 2012. However, there was a notable increase in the Pb, which may be related to the burning of rubbish and tires near the second site during autumn (Al-Hassen et al., 2012). Lower Pb concentrations may be attributed to its capacity to rapidly absorb high amounts of organic compounds (El-Khatib et al., 2014). Because they adsorb with sediment or mix with organic molecules, elements don't stay dissolved phase for long (Nafea & Zyada, 2015). Its decline may be due to element accumulation in aquatic plants, adsorption by sediments, or the formation of complexes with organic materials (Al-Jaberi et al., 2016). The order of examined elements in the dissolved phase was Cu > Pb; a considerable increase in element concentrations, especially in autumn, can be attributed to drainage-induced soil washing (Kar et al., 2008).

Seasonal differences in heavy element concentrations can be ascribed to water characteristics, organic and inorganic contaminants, and the activity of microbes, algae, and aquatic plants (Salman et al., 2015).

4.4.3.2 Heavy Metals in Sediment.

Sediment is thought to be a potential source of pollution from heavy metals, and when we examine the sediment's uppermost layer, we find a lot of pollutants that can contaminate the water. Heavy metals do not remain in the dissolved phase for long; they either transform into suspended colloids or are taken up by organic plankton, where they form dissolved ketones of heavy metals that are easily absorbed and stored by clay minerals or organic compounds, and subsequently accumulate on sediment (Okoro et al., 2013). When conditions or biological activity are proper, sediments play an important role in bringing heavy metals back into water systems. These metals are then taken up by aquatic food chains (Salman et al., 2015). Due to the progressive accumulation of pollutants in sediments over time,

sediments and their constituents serve as an indicator of the quality and quantity of pollution and the nature of their source (Goher & Ali, 2009).

A. Copper (Cu) in Sediment.

Seasonal variations of Cu in the residual phase demonstrated that the highest value was (0.74 mg/g) in the third location in Winter and the lowest value was (0.03 mg/g) in the third location in Spring (Fig 4.29) Appendix 3, the annual mean was 0.48 mg/g.
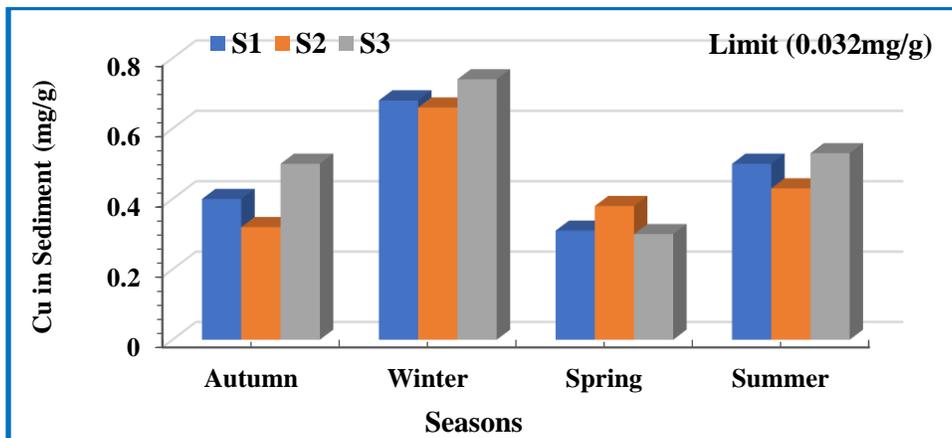
Fig (4.29): Seasonal variations for copper (residual phase) in the sites.

B. Lead (Pb) in Sediment.

Seasonal variations of pb in the residual phase demonstrated that the highest value was (2.6 mg/g) in the third location in autumn, and the lowest value was (1 mg/g) in the second location in spring (Fig. 4.30) Appendix 3, the annual mean was 1.59 mg/g.
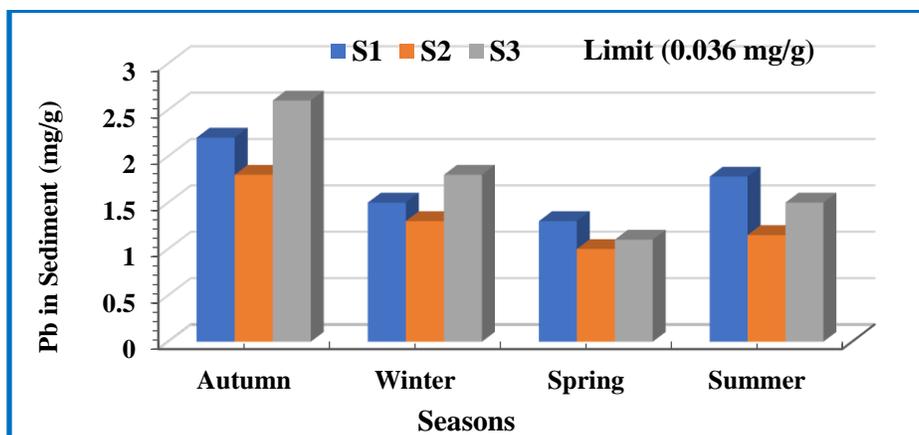
Fig (4.30): Seasonal variations for lead (residual phase) in the sites.

The results revealed a considerable rise in concentrations of studied elements in sediment compared to water, levels that exceeded allowable limits in sediment (CBSQG, 2003), and an elemental arrangement of Pb > Cu in the residual phase.

Cu values in the residual phase may have increased throughout the winter as a result of human activities such as changing automobile oil in streams, metal plating, dyes, glues, automobile and truck cleaning, and pesticide container washing (Al-Afify & Abdel-Satar, 2020).

The Pb levels were high in the soil in the autumn, which may have been caused by the burning of Pb-containing fuel, heavy traffic and vehicle emissions, and the disposal of corroded batteries in drainage systems (Rabee et al., 2009).

4.4.3.3 Heavy Metals in Reeds.

Due to their ability to extract heavy toxic components from the water, gather them in their tissues, store them in non-sensitive specific plants, or change them into non-toxic forms, several plant families are utilized as indicators of pollution in the aquatic environment (Memon, 2001).

As the reeds plant is more tolerant of environmental conditions and more likely to grow in polluted soils, as it is used in phytoremediation.

A. Copper (Cu) in Reeds.

Seasonal changes of Cu in reeds plant demonstrate that the maximum value (0.35 mg/g) in the first location in spring, and the minimum value was (0.01 mg/g) in the second location in autumn (Fig. 4.31), Appendix 3, and the annual mean was (0.10 mg/g).
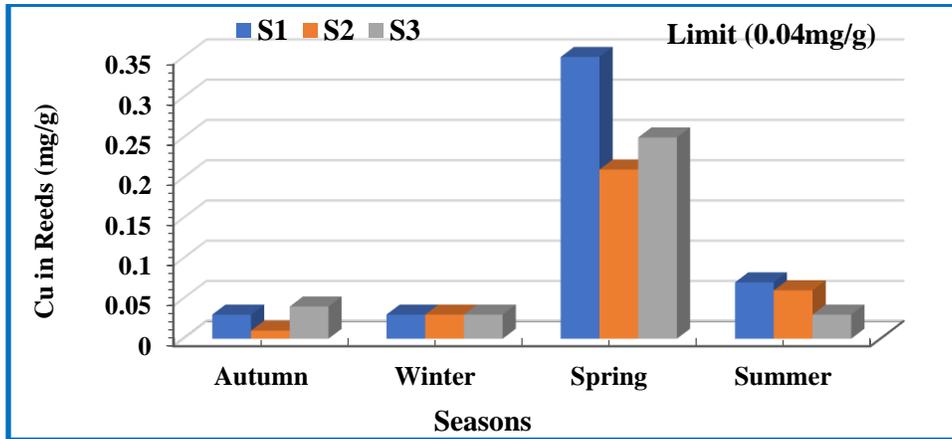
Fig (4.31): Seasonal variations for copper in reeds in the sites.

B. Lead (pb) in Reeds.

Seasonal changes of the pb in reeds demonstrated that the highest value was (0.13 mg/g) recorded in the third location in summer, and the lowest value was (0.04 mg/g) in the first location in winter (Fig. 4.32), Appendix 3. The annual mean was (0.075 mg/g).
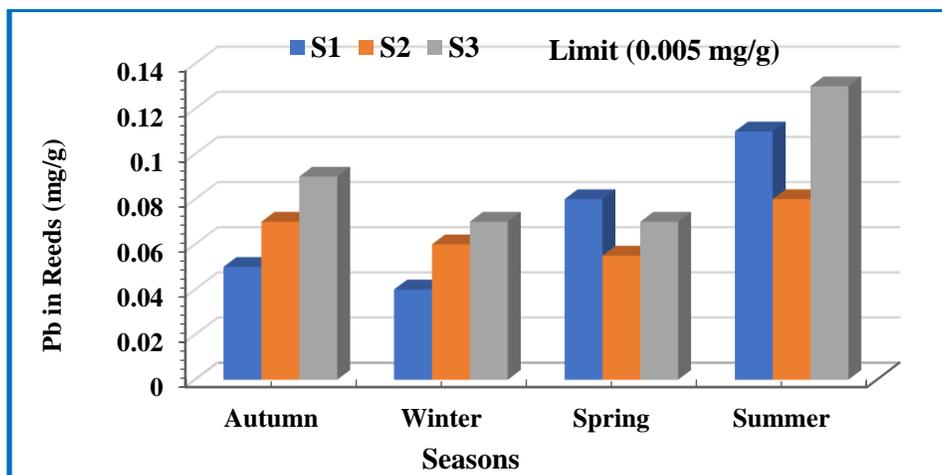

Fig (4.32): Seasonal variations for lead in reeds in the sites.

The Cu was found to be more than the Pb in the reeds that were studied. The higher rates in summer and spring were caused by low water levels, high temperatures, and evaporation during the study period, as well as an increase in the amount of sewage that was discharged into the trocars or an increase in the amount of the nutrient in the drainage which led to more hydrophyte growth and increased heavy metal absorption (Majid et al., 2014). The rise in the Pb rate throughout the summertime concurs compatible with Sabri et al. (2020). Differences in heavy metal concentrations in reeds between seasons and locales may be attributable to environmental conditions, the availability of components in water or sediments, the depth of the water, and plant growth rates all influence aquatic ecosystems (Batty and Younger et al., 2004). The concentrations of copper in spring and summer were outside permitted limits in the plant but the concentrations of lead in all seasons were outside permitted limits according to WHO/FAO (2007).

4.4.4 The Results of the Correlation

In the Table (4.5), the statistical analysis demonstrated significant differences at ($P < 0.01$), The results showed a strong positive correlation between air temperature and water temperature ($r = 0.992$), and between EC and TDS ($r = 1.00$); and between Salinity and each of TDS and EC ($r = 1.00$). Nitrate showed a positive correlation with (COD) ($r = 0.626$), These results are consistent with the logical relationship discussed previously for these variables.

Table 4.5: The correlation (r) Among Some Physico-Chemical Parameters.

	Twater	Tair	PH	TDS	EC	Salinity	Turbidity	DO	COD	N	NO3	TOC	hardness
Twater	1.000												
Tair	.992**	1.000											
PH	0.016	0.032	1.000										
TDS	0.046	0.061	0.286	1.000									
EC	0.046	0.061	0.286	1.000**	1.000								
Salinity	0.046	0.061	0.286	1.000**	1.000**	1.000							
Turbidity	0.290	0.303	0.191	0.333	0.333	0.333	1.000						
DO	0.215	0.198	0.016	.504*	.504*	.504*	0.412	1.000					
COD	-0.046	-0.030	.477*	0.303	0.303	0.303	0.061	0.046	1.000				
N	0.326	0.308	-0.032	0.062	0.062	0.062	0.000	0.109	0.031	1.000			
NO3	-0.338	-0.321	0.240	0.382	0.382	0.382	-0.046	0.000	.626**	0.109	1.000		
TOC	.523*	.504*	0.272	.443*	.443*	.443*	.534*	.492*	0.137	0.295	0.000	1.000	
hardness	-0.123	-0.107	-0.304	0.260	0.260	0.260	-0.168	0.062	0.046	0.047	0.369	-0.123	1.000

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

CHAPTER FIVE

Conclusions and Recommendations

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CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions.

1. It is found in the Al-Muamirah plant that the worst efficiency of removing the elements chloride and sulfate, the reason is that a company did not equip the plant with chloride for this period and that the plant does not treat sulfates.

2. Physical and chemical parameters for the Hilla drainage system (A1) results showed that they were within permissible limits except for TDS, EC, salinity, sulfate & chloride.

3. It was found that the results of most of the physical and chemical elements for the Hilla drainage system (A1) were high in the third site, and the reason was its proximity to the sand and gravel factories, as well as the presence of the water cycle near it.

4. Levels of studied heavy metals of Cu and pb in water were within permissible limits but, the concentrations of heavy metals in sediment were outside permissible limits. This was to accumulate them in the soil for years.

5. The average of the TDS was (2088.61 mg/l) in all sites of the drainage, where the values of TDS were >2000 mg/l. This meant that the salinity had severe drainage water.

6. The results of sulfates in water in all sites were outside the permissible limits, but in sediment in all sites were within permissible limits, where plants absorbed it from the soil for their need for these nutrients.

7. Differences between seasons and sites in the concentrations of heavy metals in reeds plants may be attributable to environmental factors, availability of elements in water or sediments, and growing rates of the plant. The concentrations of copper in spring and summer are outside permitted limits in the plant, but the concentrations of lead in all seasons were outside permitted limits.

8. Classification of the effect of chlorides on plant growth was the high effect on sensitive crops, where the water was suitable for chlorine-tolerant plants with slight to moderate damage.

9. The reuse of treated wastewater for agricultural purposes eliminated the needing to use chemical fertilizers due to the presence of nutrients in it.

5.2 Recommendations.

1. Treatment removal efficiency for the Al-Muamirah plant should be improved to remove chloride and sulfate pollutants.

2. Selecting additional physical, chemical, biological, and heavy metal elements especially BOD_5 to evaluate water in the Hilla drainage system (A1).

3. Establishment of agricultural projects to get benefit from this water in areas close to drains with the availability of soil that is suitable for this type of water and to determine the type of crops suitable for this water.

4. Follow-up the qualitative characteristics of the drainage water on a continuous and comprehensive basis to monitor the variables of this water

5. Carrying out periodic washing and drainage of agricultural lands irrigated with that water to preserve the soil from salinization and pollution.

6. Follows the recommendations of the Ministry of Environment, the Ministry of Water Resources, and other destinations to prevent factories and wastewater treatment plants from draining their untreated water into the drainage.

REFERENCES

Refrences

❖ Aggrawal., M., and Rohrer. J. (2016). Determination of Chloride and Sulfate in Water and Soil. *Thermo Fisher Scientific, Sunnyvale, CA, USA /AN-1113.*

❖ Ahmed, M.R., and Kheder, N.K. (2009). Assessment Drinking Water of Dohuk City. *J. Duhok Univ. Vol.12 (1) pp: 28-34.*

❖ Akan, J.C., Abdulrahman, F.I., Dimari, G.A. & Ogugbuaja, V.O. (2008). Physicochemical determination of pollutants in wastewater and vegetable samples along the Jakara wastewater channel in Kano Metropolis, Kano State, Nigeria. *European Journal of Scientific Research, 23(1), 122–133.*

❖ Al-Hassen, S., Al-Rubaiay, D., and Al-Saad, H. (2012). Levels of heavy metals in the aquatic environment of Basra City, Iraq. 4th, Environ. Confer, Babylon Uni, 5-6 Dec, -Iraq.

❖ Al-Aadhamy, H. A. (1987). The Effect of Heavy Metals Pollution. The Second Symposium in the Collage of Girls Education, Baghdad University. p198. (In Arabic).

❖ Al-Afify, A.D., & Abdel-Satar, A.M. (2020). Risk assessment of heavy metal pollution in water, sediment and plants in the Nile River in the Cairo region, Egypt. *Oceanological and Hydrobiological Studies, 49(1), 1-12.*

❖ Alanbari, A.A., & Knutsson, S. (2015). Environmental Assessment of Al-Hilla City Wastewater Treatment Plants. *Journal of Civil Engineering and Architecture 9 (749-755).*

❖ Al-Ghanmi, H. A., & Shawat, A. A. (2015). Environmental study for the four wells in Al-Salahiya district Northwest AL-Diwaniya city and determine their algal content. *Al-Qadisiyah Journal Of Pure Science, 20(1), 38-50.*

❖ Alham, A., Hasson, A.H., Fedel, S., Guhe, L.Q. Qualitative Estimation For Northern and Southern Kufa Drainage Water of Najaf. *journal of Madenat*

References

Alelem University College 8, no.1(June 30, 2016): pages 48-59. Accessed July 9, 2022. https://journal.mauc.edu.iq/index.php/jmauc/article/view/130.

❖ Al-Hejuje, M.M. (2014). Application of Water Quality and Pollution Indices to Evaluate the Water and Sediments Status in the Middle Part of Shatt AlArab River. Ph.D. Thesis. University of Basrah, College of Science, Biology Department. 240 pp

❖ Al-Jaberi, M.H., Al-Dabbas, M.A., & Al-Khafaji, R. (2016). Assessment of Heavy Metals Concentration and Sediment Quality in Shatt Al-Arab River, Iraq. *The Iraqi Geological Journal, 88-97*.

❖ Alkam, F.M., Mohamed J.S., Al-Haidarey, K.K. (2012). Astudy of some physicochemical parameters and Heavy Metals in the Diwaniyah River / Euphrates, Iraq. *International Journal of science and Research ISSN (2319-7064)*.

❖ Al-khafaji, B.Y., Awad, N.A., Fahad, K.K., and Afrah, A.M. (2011). Trace Metals Content in the Ecosystem of Al-Garaf River in Al-Nassiriya City, South of Iraq. *jour. of al-Qadisiya for pure Sci ,16(1):1-13*.

❖ Al-Meini, A.K. (2010). A Proposed Index of Water Quality Assessment for Irrigation. *Eng. & Tech. J. Vol. 28. (22) pp: 6557-6571*

❖ Al-Obaidi, A.H. (2009). Evaluation of Tigris River Quality in Baghdad for the period between (November 2005- October2006). Eng & Tech. Journal. 27: 9.

❖ Al-Obaidi, S.H. (2010). Groundwater in Hawija District and its Investments, previous source, p. 93.(In Arabic)

❖ Al-Saad, H.T., Al-Hello, M., Kareem, S., and DouAbul, A. (2008). Water quality of Iraqi Southern Marshes. Mar. Meso., 22(1):10-28.

❖ Al-Saadi, H.A. (2006). Fundamentals of ecology and pollution. Al-Yazuri House. Amman Jordan.

References

❖ Al-Sayegh, E., and Al-Sayegh, B. (2007). Methods of loading the soil of dry and semi-arid areas, Food and Agriculture Organization (FAO). United Nations.

❖ Al-Seedi, S.N., and Al-Auboody, F.J. (2011). Ecological study on some physical and chemical properties of Al-Gharaf river water in Thi-Qar governorate. *College of Education journal, 4(1):44-51.*

❖ Al-Sharifi, A.A. (2014). Possible contamination with heavy elements and some ecological parameters of water Bani- Hassan stream in the province of Karbala-Iraq. M.Sc. Thesis. University of Karbala. (In Arabic)

❖ Al-Taher, Q.M., Akbar, M.M., & Al-Qarooni, I.H. (2020). Estimation of Heavy Metals in Water, Sediment and bioaccumulation in Pseudodontopsis euphraticus and Bellamya bengalensis in Euphrates Riverin Al-Nassiriyah City/South of Iraq. *Plant Archives, 20(2), 1454- 1460.*

❖ Al-Wardy, A.H., Al-Saadi, R.J., and Alquzweeni, S.S. Performance Evaluation of Al-Muamirah Wastewater Treatment Plant. In IOP Conference Series: *Earth and Environmental Science, 2021, vol. 877, no. 1, p. 12027.*

❖ Alyaseri, I. (2016). Wastewater Treatment in Developing Countries: Case Study from Al-Muthanna, Iraq. *International Journal of Research in Engineering and Science (IJRES) ISSN (Online): 2320-9364, ISSN (Print): 2320-9356 www.ijres.org Volume 6 Issue PP. 59-69.*

❖ Al-Zubaidi, A.N. (2011). A study of Al-Kut and Al-Karama water treatment plants efficiency to purify the drinking water in Al-Kut city. M.Sc. Thesis. Baghdad Univ. Iraq.

❖ AOAC. (2005). Official Methods of Analysis, 18th edition, edited by Horwitz, W. And G. W. Latimer, AOAC International.

❖ APHA (American Public Health Association). (1985). *Standard Method for Examination Water and Wastewater, 16th Ed. New York.*

References

❖ APHA (American Public Health Association). (1998). *Standard Methods for the Examination of Water and Wastewater, 20th Ed. Washington, D.C*.

❖ APHA (American Public Health Association). (1999). Standard methods for the examination of water and wastewater, American Water Works Association, Water Environmental Federation.

❖ APHA. (1998). Standard Methods for the Examination of Water and Wastewater. 20th edition, American Public Health Association, Washington, DC, New York, USA.

❖ APHA. (2005). Standard Methods for the Examination of Water and wastewater, 21st ed., edited by Eaton, A. D. American Water Work Association and Water Environment Federation, USA.

❖ APHA (American Public Health Association). (2003). Standard methods for the examination of water and wastewater. 20th ed. Washington DC, USA.

❖ Arif, A.U., Sorour, M.T., & Aly, S.A. (2018). Design and comparison of wastewater treatment plant types (activated sludge and membrane bioreactor), using GPS-X simulation program: case Study of Tikrit WWTP (Middle Iraq). *Journal of Environmental Protection, 9(6), 636-651.*

❖ ASTM (American Society for Testing and Materials). (1985). *Standard test method for particle-size analysis of soils D. 442-63.*

❖ ASTM-D7348. (2021). Standard Test Methods for Loss on Ignition (LOI) of Solid Combustion Residues.

❖ Babalola, S.O., Babalola, A.O and Aworh, O.C. (2001).*"Quantitative Estimation of Chlorides and Sulphates plant Tissue Fluides" The Journal of Food Technology in Africa, Vol.6, No.4,Oct-Dec, pp.133-134.*

❖ Batty, L.C., Younger, P.L. (2004). Growth of Phragmites australis (Cav.) Trin ex. Steudel in mine water treatment wetlands: effects of metal and nutrient uptake. Environmental Pollution, 132: 85–93.

References

❖ Chapman D. (1996). Water quality assessments: A guide to the use of biota, sediments and water in environmental monitoring (2nd ed.), London: UNESCO, World Health Organization, United Nations Environment Programme.

❖ Cheepi, P. (2012). Musi River Pollution Its Impact on Health and Economic Conditions of Down Stream Villages-A Study. *Journal of Environmental Science, Toxicology and Food Technology, Vol.1 (4) pp: 40-51.*

❖ Contreras, S., Rodriguez, M., Al-Momani, F., Sans, C., and Esplugas, S. (2003). Contribution of the ozonation pre-treatment to the biodegradation of aqueous solutions of 2,4-dichlorophenol. *Water Res., 37: 3164-3171.*

❖ Duruibe, J.O., Ogwuegbu, M.O., & Egwurugwu, J.N. (2007). Heavy metal pollution and human biotoxic effects. *International Journal of physical sciences, 2 (5), 112-118.*

❖ El-Khatib, A.A., Hegazy, A.K., & Abo-El-Kassem, A.M. (2014). Bioaccumulation potential and physiological responses of aquatic macrophytes to Pb pollution. *International Journal of Phytoremediation, 16(1), 29-45.*

❖ EPA (Environmental Protection Agency). (2001). Parameters of Water Quality : Interpretation and Standards.Ireland.

❖ Erbe, V., Rosholt , L.P., Schilling, W., and London g.J. (2003). Integrated Modeling for Analysis and Optimization of Wasewater Systems. The Odenthal case. *Urban Water, Vol.4, No.1.pp63-71.*

❖ Ezeribe, A.I.; Oshieke, K.C., and Jauro, A. (2012). Physico-chemical properties of well water samples from some Villages in Nigeria with cases of stained and mottle teeth. *Sci. World J. Vol. 7 (1): ISSN 1597- 6343.*

❖ FAO. (2003). User's manual for irrigation with treated wastewater. Food and Agriculture Organization (FAO) of the United Nations, FAO Regional Office of the Near East. FAO, Cairo.

References

❖ FAO. (2012). Coping with water scarcity. An action framework for agri culture and food security. FAO Water Reports. Food and Agriculture Organization of the United Nations (FAO). FAO, Rome.

❖ Fatoki S.O., Gogwana P., & Ogunfowokan A.O. (2003). Pollution assessment in the Keiskamma River and the impoundment downstream. *Water South Africa, 29(3), 183–187.*

❖ Fawzy, M.A., Badr, N.E.S., El-Khatib, A., & Abo-El-Kassem, A. (2012). Heavy metal biomonitoring and phytoremediation potentialities of aquatic macrophytes in River Nile. *Environmental monitoring and Assessment, 184(3), 1753-1771.*

❖ Fikrat, M.H., Al-Yaseen B.M., And Abbas, A.N. (2020). Use of Epipelic Algae AS A Bioindicator to Determine Water Quality of Al-Diwaniya River, Diwanyai (Iraq).

❖ Foglar, L. (2013). Nitrate removal in continuous-flow stirred reactor. Chem. Biochem. *Eng. Q. 27 (1) pp: 7-13.*

❖ Food and agriculture organization (FAO). (1985). Water Quality for Agriculture.

❖ Friedl, G., Teodoru, C., and Wehrli, B. (2004). Is the iron gate I reservoir on the Danube River a sink for dissolved silica. Biogeochemistry, Vol.68: 21-32.

❖ Goher, M.E, Ali, M.H. (2009). Monitoring of water quality characteristics and some heavy metals in water, sediment and macrophytes in Main Khors of Lake Nasser Egypt. *J. Egypt. Acad. Soc. Environ. Develop. 10 (4), 109– 122.*

❖ Grasby, S.E., Hutcheon, I., and Krouse, H.R. (1997). Application of the stable isotope composition of SO_4^{2-} to tracing anomalous TDS in Nose Creek, southern Alberta, Canada, *Applied Geochemistry,Vol.12(5) pp:567-575.*

References

❖ Hadi, N. S. (2014). Statistical Analaysis of Quality parameters of Maamera Sewage Treatment plant. *Muthanna Journal of Engineering and Technology , 3(1).*

❖ Hagen , E. (1987). Irrigation of Agricultural Land " *Agronomy Series , No.11, pp. 10-14, USA.*

❖ Hassan, A., Hamid, S., Niaz, Y., Ashraf, M., Yasir, U., Chaudhary, A., Arsalan, A., and Waqar, M. (2019). Efficiency Assessment of Wastewater Treatment Plant: A Case Study of Pattoki, District Kasur, Pakistan. *Earth Sciences Pakistan* 3: 1–4.

❖ Hassan, F.M., Salman, J.M., Alkam, F.A., & Jawad, H.J. (2014). Ecological observations on epipelic algae in Euphrates river at Hindiya and Manathira, Iraq. *International Journal of Advanced Research, 2(4), 1183-1194.*

❖ Hassan, F.M., Salem, M.M., and Salman, J.M. (2010). A study of physicochemical parameters and nine heavy hetals in the Euphrates River, Iraq. *E-J. Chem. Vol. 7(3) pp: 685-692.* http://www.e-journals.net.

❖ Henze, M., Gujer, W., Mino, T., Matsuo, T., Wentzel, M., Marais, G. (1995). Wastewater and biomass characterization for the activated sludge model No. 2: biological phosphorus removal. *Water Science and Technology. 31 13-23*.

❖ Huertasa, E., Salgota, M., Hollenderb, J.,Weberb, S., and Dottb, W. (2008). Key objectives for water reuse concepts. *Desalination, 218: 120-131.*

❖ Hussain, A.A. (2009). Monthly Changes of Some Physiochemical Parameters for Tigris River- Baghdad between 2002-2003.*Technology and Engineering J.Vol.2 (27) pp: 64-70.*

❖ Hussein, S.A., Al-Essa, S.A., and Al-Manshad, H.N. (2000). Limnological investigations to the lower reaches of Saddam River. Environmental characteristics. *Basrah J. Agric., 13(2): 25-37.*

References

❖ Hussein, F. (2011). Desigen of Wastewater Treatment Plant. Thiess Department of Construction Engineering, University of Technology.

❖ Imarah, F.J. and Munther, E.A. (1993). Pollution and Arabian Gulf Conference, Basrah University, Basrah, 28-30.

❖ *Iraq standard wastewater discharged (1967).*

❖ Iraqi standard specification for treated wastewater in Agricultural irrigation law NO.27 of 2009 and its amendments NO.3 of 2012.*Events J.vol.4260* .(In Arabic)

❖ Jamrah A.I. (1999). Assessment of characteristics and biological treatment technologies of Jordanian wastewater. *Bioprocess Engineering, Vol. 21, pp 331- 340.*

❖ Jayalakshmi, V. Lakshmi, N. Singara C.M.A. (2011). Assessment of physicochemical parameters of water and waste waters in and around Vijayawada. *Int J Res Pharm Biomed Sci 2(3):1040–1046.*

❖ Kar, D., Sur, P., Mandai, S.K., Saha, T., Kole, R.K., (2008). Assessment of heavy metal pollution in surface water. *Int J Environ Sci Technol 5(1):119– 124.*

❖ Khassaf, S.I., and Jaber, A.A. (2015). Assessing the validity of the western Shamiya drainage water for irrigation purposes. *Babylon University Journal/ Engineering Sciences Issue (1) Volume 23*.(In Arabic)

❖ Kizer, F.M. (1999). Evaluation of Suitability of Drainage Water of Hilla -Kifil project for Irrigaion. M.Sc. Thesis, College of engineering, Babylon University.

❖ Kjeldahl, J. (1883). Kjeldahl Method For Measuring Nitrogen. https://www.chemistrysources.com/

❖ Kobielska, P.A., Howarth, A.J., Farha, O.K., & Nayak, S. (2018). Metal–organic frameworks for heavy metal removal from water. *Coordination Chemistry Reviews, 358, 92-107.*

References

❖ Konar, S.K. & Mullick, S. (1993). Pollution Hazards of coastal water by petroleum products, Detergents and metals. *Env. Ecol., Vol. 11 (3) pp: 688-690.*

❖ Kumar, K., Kumar, P., Babu, M. (2010)."Performance Evaluation of Wastewater Treatment Plant "International Journal of Engineering Science and Technology *Vol. 2(12), 7785-7796.*

❖ Lako, V., Zhuri, E., Babani, F., and Karaja, T. (2012). Characterization of turbidity of some water ecosystems in southwestern Albania (Vlora region).

❖ Lawson, E.O. (2011). Physicochemical parameters and heavy metal contents of water from the mangrove swamps of Lagos Lagoon, Nigeria. Advan. Biol. *Res. Vol.5 (1) pp: 08-21.*

❖ Lind, G.T. (1979). Handbook of Common Method in Limnology, *2nd.Ed, London. pp 1991.*

❖ Lunsford, A. (2003). Compartion of the fate of dissolved organic matter in two coastal systems; Hog island Bay, VA(USA) and plum, island sound, MA(USA). M.Sc. Thesis, College of William and Mary, Virgnia, USA.

❖ Mahmood, A.A. (2008). Concentrations of pollutants in water, sedimentsand aquatic plants in some wetlands in south of Iraq. Ph.D. Thesis. *College of Science, University of Basrah.160 pp.*

❖ Maiti, S.K. (2004). Handbook of methods in environmental studies*, Vol. 1. ABD publisher, India.*

❖ Majid, S.N., Khwa al-saadm, A.I., Rasul, G.A.M., & Ahmed, Z.H. (2014). Bioaccumulation, enrichment and translocation factors of some heavy metals in Typha angustifolia and Phragmites australis species growing along Qalyasan Stream in Sulaimani City/IKR. *Journal of Zankoy Sulaimani-Part A, 16(4), 93-109.*

References

❖ Memon, A. (2001). Heavy Metals Accumulation and Detoxification Mechanisms in Plants. *Turk. J. Bot., Vol. 25, pp.111-121.*

❖ Metcalf and Eddy INC. (1985). Wastewater Engineering Treatment, Disposal, and Reuse, 3rd Ed., McGraw-Hill, New York, USA.

❖ Metcalf, Eddy, Abu-Orf, M., Bowden, G., Burton, F.L., Pfrang, W., ..., Aecom. (2014). Wastewater engineering: treatment and resource recovery: McGraw Hill Education.

❖ Mohammad, O.I., & Jassim, L.A. (2014). Evaluation of Suitability of Drainage Water of Al-Hussainia Sector (Kut-Iraq) For Irrigation. *Wasit Journal of Engineering Sciences, 2(1), 30–45.*

❖ Mohammed, M. H., Kharrufa, S. N., and Shihab, M. S. (2010). Comparison and Assessment for Major Anions in Tigris River at Mosul District. *Tikrit J. Eng. Sci.Vol. 17(2) pp: 36-50.*

❖ Mohammed, R.I. (2019). Evaluation of the efficiency of irrigation and drainage projects in Al-kefel area. *Jour.of the college of Basic education and Human sciences,University of Babylon,42 pp:916-956.*

❖ Morrison, G., Fatoki, O.S., Persson, L., & Ekberg, A. (2001). Assessment of the impact of point source pollution from the Keiskammahoek sewage treatment plant on the Keiskamma River-pH, electrical conductivity, oxygen demanding substance(COD) and nutrients. Water South Africa,27(4),475–480.

❖ Mushtaq, B., Raina, R., Yaseen, T., Wanganeo, A., and Yousuf, A. R. (2013). Variations in the physico-chemical properties of Dal Lake, Srinagar, Kashmir. *African J. Sci and Tec. 7(7):624-633.*

❖ Mustafa, O.M. (2006). Impact of sewage wastewater on the environment of Tanjero river and its basin within Sulaimani City/ NE- Iraq. M.sc. thesis. Sci. coll- Baghdad Uni.

References

❖ Nafea, E.M.A., & Zyada, M.A. (2015). Biomonitoring of heavy metals pollution in Lake Burrullas, Northern Delta, Egypt. *African Journal of Environmental Science and Technology, 9(1), 1-7.*

❖ Nkegbe, E., Emongor, V., and Koorapetsi, I. (2005). Assessment of Effluent quality at Glen Valley Wastewater Treatment Plant. *Journal of Applied Sciences 5 (4): 647-650.*

❖ Okoro, H.K., Fatoki, O.S., Adekola, F.A., Ximba, B.J., Snyman, R.G. (2013). Physocochemical characteristics and 1-year monitoring of heavy metal pollution and its seasonal variation in seawater of cape town harbour, South Africa. Fresenius Environ.

❖ Phyllis, K.W., and Lawrence K.D. (2007). Effects of total dissolved solids on aquatic organisms:A review of literature and recommendation for Salmonid Species.*Am. J. Environ. Sci.Vol.3 (1) pp: 1-6,ISSN 1553- 345X.*

❖ Qahtan, M.S., (2012). Evaluation of the drainge water quality at the north part of Baghdad city and suitability for irrigation. *journal of Techniques 25(3).*

❖ Qasim, S.R. (2018). Wastewater Treatment and Reuse Theory and Design Examples. Vol.2, Taylor & Francis Group.

❖ Qasim., S.R. (2009). Wastewater treatment plant Planning, Design, and Operation. Second edition, libarary of congress in publication Data.

❖ Rabee, A.M., Al-Fatlawy, Y.F., and Abd own, A. N. (2009). Seasonal Variation and assessment of heavy metals pollution in sediments from selected stations in Tigris and Euphrates Rivers , central Iraq. *Iraqi J. Sci., 50(4):466-475.*

❖ Ranjbar, J.A., Riyahi, B.A., Shadmehri, T.A., Catherine, J. (2017). Spatial distribution, ecological and health risk assessment of heavy metals in marine surface sediments and coastal seawaters of fringing coral reefs of the Persian Gulf, *Iran. Chemosphere 185, 1090–1111.*

References

❖ Rasheed, K.A., Nashaat, M.R., and Hassan, H. A. (2015). Study of physico-Chemical Properties of Al-Shamyia River in Iraq. *Iraqi Journal of Biotechnology 14 (2):339-355.*

❖ Razzak, W.S., Al-taee, A., and Al-Fanharawi, A.A. (2021). Determination of Some Heavy Metals Bioaccumulation in Water, Sediments, and Phragmites Australis and Ceratophyllum Demersum Plant in Euphrates River in Al-Samawa City/ Iraq. Removal from water. *Environ. Pollut. 112(3):9-351.*

❖ Richards, L.A. (1954). Diagnosis and improvement of saline and alkali soil. Handbook, No. 60. Washington D.C.

❖ Salman, M.A., Al-Bermani, A.K. and Salman, J.M. (2015). Environmental study of water quality and some heavy metals in water, sediment and aquatic macrophytes in lotic ecosystem, Iraq. *Mesop. Environ. J., 1(2): 66- 84.*

❖ Salman, M.A., Al-Bermani, A.K. and Salman, J.M. (2015). Environmental study of water quality and some heavy metals in water, sediment and aquatic macrophytes in lotic ecosystem, Iraq. *Mesop. Environ. J., 1(2): 66- 84.*

❖ Samer, M. (2015). Wastewater treatment engineering. *BoD–Books on Demand.*

❖ Shrimali, M., and Singh, K.P. (2001). New methods of nitrate removal from water. *Environ. Pollut. 112(3):9-351.*

❖ Siliem, T.A.E. (1995). Primary productivity of the Nile in barrage area. Menofiya *J. Agric. Res. Vol. 20(4) pp: 1687-1701.*

❖ Sundara K.K., Sundara K.P., Ratnakanth B.M.J. (2010). Performance evaluation of wastewater treatment plant. *International Journal of Engineering Science and Technology Vol.2(12), 7785-7796.*

❖ UNEP (United Nations Environment Programme). (2008). Water Quality for Ecosystem and Human Health, 2nd Edition. ISBN 92-95039- 51-7.

❖ UNESCO. (1992). Water Quality Assessment. A Guide to use of Biota, Sediments and Water in Environment Monitoring. 2nd Edn., pp: 306.

References

❖ USEPA (United State Environmental Protection Agency). (1986). Methods for chemical of water and wast analysis.

❖ USEPA (United State Environmental Protection Agency). (2000). Methods for measuring the toxicity and bioaccumulation of sedimentassociated contaminants with freshwater invertebrates. 2nd Edition. Washington. 600/R-99/064.

❖ Varol, M., Gökot, B., and Bekleyen, A. (2010). Assesment of Water Pollution in the Tigris River in Diyarbakır, Turkey. *Water Practice & Tech. Vol 5(1) pp: 1- 13.*

❖ Venkatesharaju, K., Ravikumar, P., Somaskekar, R.K., and Prakash, K.L. (2010). Physico-chemical and bacteriological investigation on the river Cauvery of Kollegal stretch in Karnataka. *Kathmandu University J. Sci. Eng. Tech.Vol.6 (1) pp: 50-59.*

❖ Wang, X., Liu, L., Zhao, L., Xu, H., & Zhang, X. (2019). Assessment of dissolved heavy metals in the Laoshan Bay, China. Marine Pollution Bulletin, 149, 110608.

❖ Wessal, F.H. (2011), Irrigation water quality in Al-Faw district", Basra governorate, *Basra Research Journal, Al-Olayyat Center. Marine Sciences, University of Basra, Issue thirty-seven, Part One, p. 38*(in Arabic).

❖ WHO (World Health Organization). (1996). *Guideline for Drinking Water Quality Health Criteria and Other Supporting Information 2nd. Ed. Vol. 20.Geneva.*

❖ WHO (2007). Food Standard Programme Codex Alimentarius Commission 13th Session. Report of the Thirty Eight Session of the Codex Committee on Food Hygiene. Houston, United States of America, ALINORM 07/30/13.

❖ WHO (world health organization). (1997). Guidelines for drinking water quality. Vol. 2. 2ed ed. Amman, Jordan.

References

❖ WHO. (1996). Water Quality Assessment - A guide to Use of Biota, Sediment and Water in Environmental Monitoring. 2nd Edition Edited by Chapman, D. Published on behalf of United Nations educational Scientific and Cultural Organization; World Health organization and United Nations Environment Programme. Published by E & FN Spon, an imprint of Chapman & Hall. London.

❖ Yousry, M., El-Sherbini, A., Heikal, M., and Salem, T. (2009). Suitability of water quality status of Rosetta branch for west Delta water conservation and irrigation rehabilitation project. *Water Sci.Vol.46 : 47- 60.*

APPENDIXES

Appendixes

Appendix 1: Physical & chemical parameters in study sites (2021 –2022).

Parameters	Site 1 Range	Site 1 Average & Stadv.	Site 2 Range	Site 2 Average & Stadv.	Site 3 Range	Site 3 Average & Stadv.
Air temp. (Cº)	9.3-45.1	29.3±13.1	9-46.5	29.9±13.8	9.5-47.3	30.2±13.9
Water temp. (Cº)	13-47.5	29.6±14.1	12.9-49.3	29.9±14.9	13.4-48.7	30.0±14.5
pH	6.5-7.2	6.85±0.29	6.5-7.1	6.85±0.23	6.8-7.1	6.97±0.12
Turbidity (NTU)	1.0-2.4	1.65±0.61	1.3-3.1	2.07±0.72	1.0-5.2	2.9±1.69
EC (μs\cm)	3270-3680	3447±141	3480-3840	3680±125	4950-6130	5473±491
TDS (mg/l)	1630-1830	1716±69	1735-1915	1836±61	2460-3010	2713±231
DO (mg/l)	5.4-7.7	6.35±0.79	5.8-7.1	6.4±0.47	8.5-9.1	8.75±0.22
COD (mg/l)	5.1-46.7	31±14	5.8-42.1	27.62±12.4	5.2-73.5	40.3±22.7
Salinity (ppt)	2.09-2.36	2.2±0.09	2.22-2.45	2.35±0.08	3.16-3.92	3.5±0.31
TH (mg /l)	205-223	215±7	210-230	222±7	216-230	216±5
N (mg/l)	0.3-1.0	0.58±0.30	0.29-0.46	0.35±0.06	0.21-0.76	0.54±0.24
NO₃ (mg/l)	0.01-1.6	0.61±0.56	0.03-2.1	0.83±0.70	0.06-1.5	1.01±0.51
TOC (%)	0.15-0.95	0.58±0.39	0.15-1.22	0.605±0.40	0.56-1.76	1.171±0.51

Appendix 2: Chemical parameters in study sites (2021 –2022).

Elements		Site 1 Range	Site 1 Average & Stadv.	Site 2 Range	Site 2 Average & Stadv.	Site 3 Range	Site 3 Average & Stadv.
SO₄	Dissolved phase water (mg/l)	965-1220	1081±92	1041-1235	1166±71	1890-3824	2480±721
	Residual phase sediment (%)	0.5-0.9	0.7±0.1	0.82-1.1	0.93±0.1	0.93-1.5	1.20±0.2
	Aquatic (mg/L)	55.7-74.3	65.6±6.3	53.1-67.5	59.6±5.9	50.0-7.0	58.3±7.8
Cl	Dissolved phase water (mg/L)	459-524	496±23	437-574	502±53	699-1345	966±213
	Residual phase sediment (mg/L)	31.5-75.9	47.5±16.2	47.9-96	73.4±16.8	70.2-105.9	73.4±12.6
	Aquatic (mg/L)	21-27.1	23.7±2.54	19.7-30.4	26±4.03	23.5-32.1	27.88±2.98

Appendixes

Appendix 3: Heavy metals concentrations in study sites (2021 –2022).

Elements		Site 1		Site 2		Site 3	
		Range	Average & Stadv.	Range	Average & Stadv.	Range	Average & Stadv.
Pb	Dissolved phase water (mg/L)	0.01-0.04	0.030±0.011	0.02-0.05	0.032±0.012	0.01-0.05	0.033±0.015
	Residual phase sediment (mg/g)	1.3-2.2	1.69±0.37	0.96-1.8	1.28±0.32	1.1-2.6	1.69±0.52
	Aquatic (mg/g)	0.02-0.20	0.072±0.066	0.02-0.1	0.068±0.030	0.01-0.25	0.093±0.075
Cu	Dissolved phase water (mg/L)	0.01-0.08	0.033±0.025	0.01-0.09	0.038±0.027	0.01-0.09	0.043±0.030
	Residual phase sediment (mg/g)	0.31-0.73	0.51±0.15	0.32-0.72	0.48±0.15	0.3-0.79	0.55±0.17
	Aquatic (mg/g)	0.01-0.35	0.095±0.13	0.01-0.21	0.065±0.074	0.01-0.25	0.068±0.09

الخلاصة

أجريت الدراسة الحالية لتقييم كفاءة محطة معالجة المعميرة للفترة من شهر تشرين الأول 2020 الى اب 2021 وتم ذلك عن طريق قياس كفاءة الازالة لل Bod5,COD,TSS, T.N, PO4,NH3,SO4, NO3, Cl ,O&G علاوة على ذلك لتحديد نوعية المياه المتدفقة من محطة معالجة مياه الصرف الصحي المعميرة والتي يتم تخلص منها في مبزل الحله A1. جمعت عينات المياه والرواسب والقصب شهريا من شهر تشرين الأول (2021) الى شهر اب (2022) من ثلاث مواقع على المبزل وكانت المواقع تبعد عن المحطة المعميرة 3.5 km, 1.5km، 500m تم جمع العناصر ستة عشر من المياه المبزل الحلة A1 وتم قياسها في الحقل والمختبر .وهذه العناصر هي درجة حرارة الهواء ,درجة حرارة الماء ,درجة الحموضة , المواد الصلبة الذائبة , توصيلية الكهربائية , الملوحة, العكارة , المتطلب الكيميائي للاوكسجين، الاوكسجين المذاب ,النتروجين ,النترات ,الكبريتات ,العسرة الكلية, الكاربون العضوي الكلي ,الكلوريدات ,نحاس و رصاص. اظهرت النتائج ان كفاءة الازالة لمحطة معالجة مياه الصرف الصحي المعميرة لل Bod5,COD,TSS, T.N, PO4,NH3,SO4, NO3, Cl ,O&G كانت 92.6% 78.9% 94% 62.6% 81.8% 83% 8.7% 61.5% 12% 88.8 % على توالي .

بناءا على قيم كفاءة الازالة محطة معالجة مياه الصرف الصحي المعميرة فقد وجد كفاءة مقبولة في إزالة المتغيرات الفيزيائية والكيميائية باستثناء كفاءة الكبريتات والكلوريدات.

تمت محاولة استخدام التحليل العنقودي SPSS للبيانات وان هذا التحليل يتكون من مجموعتين فرعيتين حيث كان هناك تشابه في كفاءة الازالة للاشهر من (تشرين الثاني2020 الى كانون الثاني 2021) .وكان اسوء مجموعة رقم 3 من(تشرين الأول 2020 الى اذار 2021).

يهدف هذا البحث الى دراسة إمكانية استخدام مياه الصرف لري الأراضي في المناطق المحيطة. المعدلات الموسمية للعناصر الفيزيائية والكيميائية في مواقع الدراسة : درجة حرارة الهواء (47.3 - 14.3 ^oC), درجة حرارة الماء (48.0 ^oC – 13.6), الاس الهيدروجيني (7.2-6.6) , المواد الصلبة الذائبة الكلية (1670-3010 ملغم/لتر) , التوصيلية الكهربائية (3360-6130 مايكروسيمنز/سم), الملوحة (2.15-3.92 جزء في الالف) العكورة (1.05 -NTU5.2) , الاوكسجين المذاب (5.65-9.0 ملغم/لتر) المتطلب الحيوي للأوكسجين (5.1-73.5 ملغم/لتر) , النتروجين (0.21-0.91 ملغم/لتر), النترات (0.01-1.5 ملغم/لتر) ,المحتوى الكاربون العضوي (0.16-1.72%) , العسرة الكلية(209-229ملغم/لتر) ,الكبريتات في المياه (1004-3824 ملغم /لتر) في الرواسب (0.58-1.4%) في القصب (51-69.75 ملغم/لتر) على التوالي .الكلوريد في الماء (459-1345 ملغم/لتر) في الرواسب (36-105.97 ملغم /لتر) في القصب (21-30.61 ملغم /لتر) على التوالي , وتراكيز العناصر الثقيلة (النحاس والرصاص) في المياه (0.042, 0.031) ملغم/لتر

على التوالي في الحالة الذائبة وفي الرواسب (0.48-1.59) ملي غرام/ غرام وزنا جاف على التوالي في الحالة المتبقية وفي القصب (0.10-0.075) ملي غرام /غرام وزنا جاف على التوالي .

كانت المعلمات الفيزيائية والكيميائية ضمن المحددات العراقية ماعدا المواد الصلبة الذائبة والتوصيلية الكهربائية والملوحة والكلوريدات والكبريتات في المياه. العناصر الثقيلة في المياه كانت ضمن المحددات المسموح بها لكنها في الرواسب تجاوزت الحدود المسموح بها لانها تتراكم في التربة لسنوات عديدة. ومعدلات التراكيز العناصر الثقيلة في القصب تختلف بين المواسم والمواقع.ان المياه مناسبة للنباتات التي تتحمل الكلور مع اضرار طفيفة الى متوسطة (عالي تاثير على المحاصيل الحساسة).

دراسة إمكانية استخدام مياه الصرف المعالج لغرض الري : حالة الدراسة في مدينة بابل .العراق

من قبل

نورس احمد عباس شاكر

اشراف

أ.م د. نبأ شاكر هادي