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Statistical Analysis of Raw and Treated Water Quality for Hilla River, Iraq

A Thesis

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of Engineering in University of Babylon as Partial Fulfillment of the
Requirements for the degree of Master in Engineering /Environmental
Engineering**

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بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِیْمِ

وَاللّٰهُ أَنْزَلَ مِنَ السَّمَاءِ مَاءً فَأَحْيَا بِهِ الْأَرْضَ بَعْدَ

مَوْتِهَا أَنْ فِي ذَلِكَ لَآيَةٌ لِّقَوْمٍ يَسْمَعُونَ

صَدَقَ اللّٰهُ الْعَلِیُّ الْعَظِیْمُ

(٦٥ النحل)

Supervisors' Certificate

I certify that the thesis entitled " Statistical Analysis of Raw and Treated water quality for Hilla River, Iraq" was prepared by " Shahad Abd Al-Kareem ", under my supervision at the Environmental Engineering Department/ College of Engineering/ University of Babylon, as a partial fulfillment of the requirements for the degree of Master in Engineering/ Environmental Engineering.

Signature:

Name: Prof. Rasha Salah AL-Kizwini

Date: / /2022

DEDICATION

To

*How do I get the description and words that embody your struggle in life...? I dedicate this fruit to efforts that have given me strength and patience... To my dear **Father and Mother** ... I ask God to protect them for us.*

To

Those who have the hearts , always giving...

*To my husband **Emad Abbas Nayel***

*My Sisters and cousin, **Dr. Dhey Jawad Muhammad***

Shahad

2022

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"In the Name of Allah, the Most Gracious, the Most Merciful"

Praise be to Allah before anything and after anything and to the prophet "Mohammed and Ahl-Al-Bait" for the strength, courage, and wisdom that Allah gave me to complete this humble work and lengthy journey.

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ABSTRACT

In this study, water samples were collected from Shatt Al-Hilla River for both type of water raw and treated for three different stations new Hilla, Al-Hussein and Al –Hashimyah to study the physical and chemical parameters and compared them with the Iraqi standard specifications. The water quality index was determined using two models, which were the Weighted Arithmetic and Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI). Water samples were collected monthly from (October 2020 to June 2021), where twelve parameters of raw and treated water were examined, included temperature (Temp), total hardness (TH), electrical conductivity (EC), acidity (pH), total dissolved solids (TDS), sulfate (SO_4^{-2}), calcium (Ca^{+2}), magnesium (Mg^{+2}), sodium (Na^+), biological demand for oxygen (BOD_5), potassium (K^+) and turbidity. The results of water quality measurements and analysis showed that most of the measured water quality parameters along the river were within the standard limits except the (calcium, turbidity and electrical conductivity for raw water and temperature for treated water).

The spatial distribution of the water quality index along the river showed that the average values of the water quality index in three stations ranged between (87.246 to 109.006) for raw water and from (46.098 to 64.302) for treated water, which depends on a weighted calculation. While the water quality index based on Canadian method ranged from (79.307 to 81.232) for raw water and (94.620 to 94.718) for treated water. The weighted arithmetic model showed that the raw water quality has been rated " Severely polluted " to " Unfit and unsuitable for drinking " and for treatment water quality ranged from 'good water' to 'moderately polluted'. While, the CCME WQI method was classified The river water as "fair" and the water is treated as "good" for drinking. Comparison results between two

models showed that CCME WQI gave a water quality value greater than the value of the other method, or CCME WQI may have been considered more flexible.

Statistical analysis was carried out using the Statistical Program for Social Sciences (SPSS) Version (25) , which is one of the best software available for statistical analyzes for the period (October 2020 - June 2021). The ratio (R^2) of raw water was very good (0.89, 0.90, 0.88) for the stations (New Hilla, Al-Hussein, Al-Hashimyah),for treated water (0.92, 0.78, 0.88), respectively, indicating a strong relationship between water indices and water quality index.

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List of Abbreviations

Abbreviations	Definition
BOD	Biological Oxygen Demand
CCEM	Canadian Council of Ministers of the Environment
COD	Chemical Oxygen Demand
CWQI	Canadian Water Quality Index
DBP _s	Disinfection by Products
DO	Dissolved Oxygen
DWQI	Drinking Water Quality Index
GIS	Geographical Information System
HA	AL-Hashimyah
HE	AL- Hussein
IWQI	Irrigation Water Quality Index
K _r	Kelly's ratio
NH	New Hilla
NSF-WQI	National Sanitation Foundation- Water Quality Index
OWQI	Oregon Water Quality Index
PI	Permeability Index
PI _s	Pollution Indices
PLSR	Partial List Squares Regression
PPM	Part Per Million
RSC	Residual Sodium Carbonate
RWQI	Raw Water Quality Index
SAR	Sodium Absorption Ratio
SMLR	Stepwise Multiple Liner Regression
SPSS	Statistical Package for the Social Science

SSP	Soluble Sodium Percentage
TDS	Total dissolved solid
TP	Total Phosphorus
TrWQI	Tigris river Water Quality Index
TWQI	Treated Water Quality Index
WHO	World Health Organization
WQ	Water Quality
WQI	Water Quality Index

List of symbols

symbols	Definition
As	Arsenic
Ca(HCO ₃) ₂	Calcium Bicarbonate
Ca ⁺²	Calcium
CaCl ₂	Calcium Chloride
CaCO ₃	Calcium Carbonate
CO ₂	Carbon Dioxide
E%	Efficiency
EC	Electrical Conductivity
F ₁	is the factor that denotes the (%) of parameters which don't satisfy the goals (referential values) at the minimum once through the time (unsuccessful parameters).
F ₂	The factor that represents the (%) of individual tests which don't meet the goals at all (unsuccessful ests).
F ₃	The factor that denotes the quantity during which the values of the test didn't respect their guideline values.
Hg	Mercury
K	Constant of proportionality

K^+	Potassium
$Mg(HCO_3)_2$	Magnesium Bicarbonate
Mg^{+2}	Magnesium
$MgCl_2$	Magnesium Chloride
$MgCO_3$	Magnesium Carbonate
$MgSO_4$	Magnesium Sulfate
N_2	Nitrogen
Na	Sodium
NaCl	Sodium Chloride
P	Phosphorus
Pb	Lead
pH	Acidity of a Hydrogen
$So4^{-2}$	Sulfate
Temp	Temperature
TH	Total Hardness
Turb	Turbidity
V_a	The WQ variable value determined from the lab analysis.
V_o	The ideal value of variable meaning that the dissolves O_2 and pH are (14.6 mg/L) and (7.0), correspondingly and (0) for all other parameters (Călmuc et al., 2018).
V_s	The recommended standard value of the ith parameter.

W_i	A factor that calculates the parameter significance.
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List of Units

Units	Explanation
°C	Centigrade
μs	Microsemens
L	Litter
mg	Milligram
gm	Gram
cm	Centimeter
NTU	Nephelometric Turbidity unit
m	Meter
hr	hour

Chapter One

Introduction

Chapter One

Introduction

1.1 Introduction

Rivers are considered the most important natural resource for human development, but they are polluted by the indiscriminate disposal of sewage, industrial waste and a large number of human activities, which affects their physical, chemical and microbiological characteristics that are expressed as values, which expresses the possibility of their human use. It is essential to prevent and control river pollution and to have reliable water quality information for effective management, (Koklu et al., 2010).

Water quality depends on its biological, chemical and physical properties, while the insurance of this quality is very important for water usage such as agricultural or potable usage, (Alobaidy et al., 2010).

Iraqi rivers water is under growing threats because of the increasing of industrial and agricultural pollution, salinity, hardness, climate change (limited rains in the north), also the many dams which had been built in Turkey, Syria, Iran, and the bad planning used in irrigation,(Al-Ansari, 2013).

Water quality index (WQI) is one of the most effective tools to communicate information on the quality of water to the concern of citizens and policy makers. It becomes an important parameter for the assessment and management of surface water as a synthetic indicator. The concept of WQI are based on the comparison of the water quality parameters with respective regulatory standards and gives a single value to the water quality of a source, which translates the list of constituents and their concentrations present in a sample,(Alsaqqar et al., 2013).

The quality of water required to maintain ecosystem health is largely a function of natural background conditions. Some aquatic ecosystems are able to resist large changes in water quality without any detectable effects on ecosystem composition and function, whereas other ecosystems are sensitive to small changes in the physical and chemical makeup of the water body and this can lead to degradation of ecosystem services and loss of biological diversity,(Salman et al., 2015).

1.2 Problem statement

In the middle of Iraq, Babylon governorate, the main resource of the raw water is Shatt Al-Hilla river which supplies the raw water to the major water treatment plants which locate in the center of the Hilla city, which suffers greatly from pollution resulting from the discarding of various types of waste and the scarcity of water due to climatic changes, in addition to the construction of dams in upstream countries, especially since the Shatt Al-Hilla is one of the branches of the Euphrates river. During the entry of water in treatment plants, a series of successive processes such as coagulation, flocculation, sedimentation, filtration, ... etc. are carried out, the main objective of which is to get rid of suspended impurities and eliminate dangerous pathogens to make the water suitable for the consumer.

1.3 The objectives of the study

The aim of the study is to:

- 1- Evaluate the effective and important properties of water (total dissolved solids, pH, sodium, turbidity, electrical conductivity, sulfate, total hardness, calcium, magnesium, potassium, biological oxygen demand) at three water treatment plants in Babylon governorate (New Hilla, Al-Hussein, Al-Hashimyah).

- 2- Evaluate water quality index (WQI) by two methods: 1-Weighted arithmetic index method and 2- Canadian method (CCME).
- 3- Analyze the data statistically by using SPSS software version 25.

Chapter Two

**Theoretical Background and
Literature Review**

Chapter Two

Theoretical background and literatures review

2.1 Background

Surface water is an essential natural resource and a sensitive issue for human life in developing countries. The pollution of water resources has become one of the main environmental concerns in recent decades and is due to natural contamination processes and human practices, which have significantly degraded surface water quality and have led to serious health hazards for drinking use with local and regional implications, (Gad et al., 2020).

2.2 Water resources

Iraq is one of the countries in the middle east. The country is currently facing a serious water shortage problem. This problem is expected to be more severe in the future where the supply of water is predicted to be 43 and 17.61 Billion Cubic Meters (BCM) in 2015 and 2025 respectively while current demand is estimated to be between 66.8 and 77 BCM. It has been estimated that the Tigris and Euphrates river discharges will continue to decrease with time, and they will be completely dry by 2040. Serious, prudent and quick methods need to be taken to overcome this problem. The government should take methods to have a strategic water management vision, including regional coop-eration and coordination, research and development, improving agriculture and sanitation sector as well as public awareness program. These methods are required in order to address the following topics: Strategic Water Management Vision , Regional cooperation , coordination, Irrigation , Agriculture, Water Supply , Sanitation, , Research and Development,(Al-Ansari, 2013).

2.3 Water quality index (WQI)

The quality of water is the degree of its portability and is determined by the amount and level of physiochemical, and microbial parameters and metals (which included suspended and dissolved substances in the water). Determining water quality parameters is important to identify the quality, conditions and pollution level of surface waters. Related data must be processed and the results should be presented to specialists. One of the simplest methods to assess water quality conditions is by using water quality indices Horton(1965),when the first person used the concept of water quality, (Alobaidy et al., 2010) .

In Iraq, one of the main problems within the water quality management field is a lack of common understanding of water quality-related terminology relative to regulatory requirements and convenient evaluation of water quality. This lack of comprehension leads to over-regulation of wastewater discharges and storm water runoff-associated constituents for which there are water quality standards,(Al-Bayati, 2016) .

Water quality index (WQI) is valuable and unique rating to depict the overall water quality status in a single term that is helpful for the selection of appropriate treatment technique to meet the concerned issues. However, WQI depicts the composite influence of different water quality parameters and communicates water quality information to the public and legislative decision makers,(Tyagi et al., 2013).

Water is a prime natural resource and precious national asset, The main component of the ecosystem. Water sources may be mainly in the form of rivers, lakes, glaciers, rain water, ground water etc. Besides the need of water for drinking, water resources play a vital role in various sectors of economy such as

agriculture, livestock production, forestry, industrial activities, hydropower generation, fisheries and other creative activities. The availability and quality of water either surface or ground, have been deteriorated due to some important factors like increasing population, industrialization, urbanization etc. It can be defined in qualitative and/or quantitative terms. Parameters in defining water quality can be grouped into three board categories: physical, chemical, and biological. Physical factors include temperature, sediment and bed material, suspended sediments, turbidity, color, and odor. Chemical factors consist of the major and minor elements, and other chemical parameters such as pH, dissolved oxygen (DO), biological oxygen demand (BOD₅), and chemical oxygen demand (COD). The major elements include agro-nutrients such as Nitrogen and Phosphorus; and minor elements include elements such as arsenic (As), lead (Pb), and mercury (Hg), etc. Biological Constituents include Fecal Coli-form and E. coli. Conventionally water quality is expressed in terms of the measured value(s) of one or more of these parameters in relation to their accepted or implied limits. They are expressed in different units, and their magnitudes can vary significantly from one location to another and over time. For example, the temperature is expressed in degrees Celsius or degrees Fahrenheit, and coliforms in numbers, and most chemicals and nutrients in milligrams per liter (mg/l) or in parts per million (ppm). The values of these parameters are harmful for human health if they occurred more than defined limits,(EDITION, 2011).

2.4 Parameters selection for water quality assessment

The parameters choice to be comprised in a WQ evaluation has to be connected to the WQ evaluation program goals as well as the variables that rely upon it. The water quality parameters regarded with a concise explanation for everyone are as follows (Imran, 2016):

2.4.1 The temperature (°C)

Water temperature may not be important in pure water due to the wide range of temperature tolerances in aquatic life, but in polluted water, temperature can have profound effects on dissolved oxygen (DO) and biological oxygen demand (BOD₅) and on many of the elements present in the water. River water temperature usually depends on the season, geographical location, sampling time and inflow temperature of the stream, and the temperature is measured in situ with a thermometer or thermometer ,(Venkatesharaju et al., 2010).

2.4.2 Acidity of a Hydrogen (pH)

pH is an important ecological factor which affects the survival of aquatic organisms, solubility and toxicity of many metals in the waters. The acidity of waters increases the solubility of many metals that cause adverse effects on aquatic organisms,(Peterson, 2013).

Decreasing pH value during warm months may be due to elevation of temperature and water temperature due to increase the biological activity of microorganisms and increased the level of CO₂ in the water, while increased level of pH during cold months may be due to increase the density of phytoplankton and increased level of dissolved oxygen in the water and consumption of CO₂ which cause elevating the pH,(Sharma and Sharma, 2013).

2.4.3 The electrical conductivity (EC)

Electrical conductivity (EC) means the ability of water to conduct the electric current and expresses the amount of soluble salts in the water, it is influenced by the amount of total dissolved solids (TDS) in the water (Peterson, et al., 2013). Increasing their levels may be due to raised temperature and increased the rate of evaporation and decreased water levels which cause increasing the concentration of ions in the water (Thitame and Pondhe, 2010). While their decline

during winter months may be due to rain falls and increased water levels which cause dilution and hence decreasing their concentrations in the water (Ganie et al., 2012).

2.4.4 The sulfate (SO_4^{-2})

Sulfate is a constituent of TDS and may form salts with sodium, potassium, magnesium and other cations. The natural sources of sulfate are rocks, or may be derived from chemical fertilizers, detergents, pesticides, dyes, glass, paper, soaps, textiles and fungicides. The presence of sulfate in drinking water can cause noticeable taste, and at very high levels it may cause a laxative effect in unaccustomed consumers (Water and Organization, 2006).

2.4.5 The calcium (Ca^{+2})

Calcium, in the form of the Ca^{+2} ion, is one of the major inorganic cations, or positive ions, in saltwater and freshwater. It can originate from the dissociation of salts, such as calcium chloride or calcium sulphate, in water. Most calcium in surface water comes from streams flowing over limestone, CaCO_3 , gypsum, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ and other calcium-containing rocks and minerals. Calcium carbonate is relatively insoluble in water, but dissolves more readily in water containing significant levels of dissolved carbon dioxide. The concentration of calcium ions (Ca^{+2}) in freshwater is found in a range of 0 to 100 mg/L and usually has the highest concentration of any freshwater cations, (Abboud, 2014).

2.4.6 The total hardness (TH)

Hardness is most commonly associated with the ability of water to precipitate soap and usually divided into two categories: carbonate hardness (such as bicarbonate [$\text{Ca}(\text{HCO}_3)_2$ and $\text{Mg}(\text{HCO}_3)_2$] and carbonate (CaCO_3 and MgCO_3))

salts) and noncarbonated hardness (such as calcium chloride (CaCl_2), magnesium sulfate (MgSO_4), and magnesium chloride (MgCl_2)).

2.4.7 The sodium (Na^+) and potassium (K^+)

It is measured with the help of flame photometer. The instrument is standardized with the known concentration of sodium ion (1 to 100 mg/l) and concentration of potassium ion (1 to 5 mg/l). Relatively high concentrations may be found in brines and hard water softened by the sodium exchange process. The ratio of sodium to total cations is important in agriculture and human pathology. Soil permeability can be harmed by a high sodium ratio. Persons afflicted with certain diseases require water with low sodium concentration. Sodium can be removed by the hydrogen-exchange process or by distillation. Potassium is an essential element in both plant and human nutrition and occurs in groundwater as a result of mineral dissolution, (Federation and Association, 2005)

2.4.8 Biological oxygen demand (BOD_5)

BOD_5 is a measure of the dissolved oxygen consumed by microorganisms during the oxidation of reduced substances in waters and wastes. BOD_5 directly affects the amount of dissolved oxygen in rivers and streams. The greater the BOD_5 , the more rapidly oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life. The consequences of high BOD_5 are the same as those for low dissolved oxygen aquatic organisms which become stressed, suffocate and die. Sources of BOD_5 include leaves and woody debris; dead plants and animals; animal manure; effluents from pulp and paper mills, wastewater treatment plants, feedlots and food-processing plants; failing septic systems; and urban storm water runoff. The discharge of wastes with high levels of BOD_5 can cause water quality problems such as severe dissolved oxygen depletion and fish kills in the receiving water bodies, (Bhateria and Jain, 2016).

2.4.9 Total dissolved solid (TDS)

The TDS concentration in a body of water is affected by various factors . Fertilizers from fields and lawns can add a variety of ions to a stream. Increases in TDS can also result from runoff from roads that have been salted in the winter. Organic matter from wastewater treatment plants may contribute higher levels of nitrate or phosphate ions. If TDS levels are high, especially due to dissolved salts, many forms of aquatic life are affected. The salts act to dehydrate the skin of animals. TDS values in lakes and streams are typically found to be in the range of 50 to 250 mg/L. In areas of especially hard water or high salinity, TDS values may be as high as 500 mg/L,(Federation and Association, 2005).

2.5 Water treatment process

Water treatment plants should be able to produce a finished product of consistently high quality regardless of the demand. The selection of unit processes depends on the quality of the raw water entering the treatment plant and the quality of the finished water required. Raw water is pumped from the intake to the following stages:

2.5.1 Coagulation and flocculation

Coagulation is one of the most common phenomena in nature and artificially enhanced water treatment systems. Coagulation is a process in which small particles are combined into larger aggregates (flocs) and dissolved organic matter is adsorbed onto particulate aggregates so that these impurities can be removed in the subsequent solid/liquid separation processes(Jiang, 2015). The mechanism for the removal of organics by coagulation has three main aspects (Teh et al., 2016): (1) positively charged metal ions and negatively charged organic colloids are electrically neutralized, destabilized and aggregated; (2) metal ions and soluble organic matter molecules form insoluble complexes and precipitates; and (3)

physical and chemical adsorption of organics occurs on the surface of alum. As environmental pollution problems become more serious and water quality standards become more stringent, conventional coagulation technology has clearly failed to meet people's requirements for water quality safety, (Cui et al., 2020).

Coagulation and flocculation occurs in successive steps, allowing particle collision and growth of floc. This is then followed by sedimentation. If coagulation is incomplete, flocculation step will be unsuccessful, and if flocculation is incomplete, sedimentation will be unsuccessful. Flocculation, a gentle mixing stage, increases the particle size from submicroscopic Micro floc to visible suspended particles. Micro floc particles collide, causing them to bond to produce larger, visible flocs called pinflocs. Floc size continues to build with additional collisions and interaction with added inorganic polymers (coagulant) or organic polymers. Macro flocs are formed and high molecular weight polymers, called coagulant aids, may be added to help bridge, bind, and strengthen the floc, add weight, and increase settling rate. Once floc has reached its optimum size and strength, water is ready for sedimentation,(Prakash et al., 2014).

2.5.2 Sedimentation

Sedimentation is a physical process through which suspended solids removed by gravity. The process involves removing coarse suspended solids that might clog filters or reduce disinfection efficiency. Sedimentation tanks can be classified depend on the presence or absence of a sludge blanket, and shape (square ,circular and rectangular). Sedimentation most commonly takes place in horizontal-flow tanks, where water slowly moves from one end to the other, (APHA AWWA, 1998).

2.5.3 Filtration

Filtration is a physical method to remove suspended particles in any fluid such as water. These particles can be mud, color, organic matter, plankton, bacteria, and particles of the softening process and so on. Filters can be divided into two categories:

A) Deep Filters: The act of separating particulate matter from fluid is done in depth such as gravity filters or pressure filters.

B) Surface Filters: separating action of suspended particles from the liquid is done in a very low depth which is surface of the filter, such as Filtering paper.

Deep filters are used in water purification. Water containing suspended particles passes through the bed of a material that can be sand or anthracite coal. As the water passes through the pores between the material, suspended solids are trapped and water almost free of suspended solids,(Farzaneh and Mokshapathy, 2016).

2.5.4 Disinfection

The use of water disinfection as a public health measure reduces the spread of diseases. Various disinfection technologies can be used to meet the pathogen inactivation demand in water. Many of these chemical disinfectants if overdosed or used inappropriately can react with organic and inorganic precursors and bring the formation of disinfection by-products (DBPs) with adverse health effects,(Collivignarelli et al., 2018).

2.6 Literatures review

Khan et al., (2004) described the application of the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) as a communications tool for reporting the drinking water quality results. The CCME WQI simplified the communication of results while integrating local expert opinion, without challenging the integrity of the data. The NL Department of Environment and Conservation successfully tested the use of the CCME WQI on selected drinking water quality data sets, and developed a phased approach for its implementation as a practical means of presenting available physical, chemical, organic and microbiological results to communities. The CCME WQI index categorization schema was modified by adding a new ranking category to incorporate local expert opinion. This paper describes the development of the phased approach for calculating water quality indices, the testing methodology used, the rationale for modifying the existing CCME WQI index categorization schema, and the implementation of an automated CCME WQI calculator in the provincial drinking water quality database.

Shiow-mey Liou,(2004) studied the behavior and limitations of conventional methods for quality evaluation, a better overall index for water quality in Taiwan and its application in Keya river are proposed. The thirteen variables are employed for the quality assessment. Numerical scales relating to the degree of quality are established for each variable to assess variations in quality and to convey findings in a comprehensive manner to others. The employed variables are categorized into three aspects referred to the principal components analysis, which are ‘organics’, ‘particulates’ and ‘microorganisms’. The overall index consists of the geometric mean for the three defined aspects and multiplying by three coefficients, which reflect quality degrees of temperature, pH and toxicity, respectively. Finally, a

fresh, mixed aggregation function is developed for ensuring that the index score tells us something useful and does not hide important information.

Lumb et al.,(2006) presented an overall evaluation of the Mackenzie river basin to help local authorities in managing water quality in big Canadian cities. The researchers have used CCME WQI to summarize complex water quality data for five stations of Mackenzie River which length being 4241 km is the second largest river in North America. In their study, water quality parameters (temperature, pH, true color, turbidity, ammonia, nitrates, nitrites, total dissolved solids, chloride, sulphate, calcium and heavy metals) were examined. Based on CCME WQI model, the raw water quality in the basin was categorized as marginal to fair along the Mackenzie River for overall, drinking and aquatic water uses.

Moscuzza et al.,(2007) evaluated the application of Water Quality Index at 8 stations along Salado River in Buenos Aires Province (Argentina). The field work was conducted in winter and summer 2006. The water quality index WQI was calculated by choosing a set of parameters (pH, temperature, DO, EC, COD, total suspended solids, total dissolved solids, total Kjeldahl-nitrogen and total phosphorus). The obtained results showed that the status of the water body was unsuitable for the human uses and degraded during the period of study.

Hurley et al.,(2012) is found protecting drinking source water quality is a critical step in ensuring a safe supply of drinking water. Increasingly, drinking source water protection programs rely on the active participation of various stakeholders with differing degrees of water science knowledge. It has been tested the effectiveness of the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) in capturing expert assessments of drinking water quality. In cooperation with a panel of drinking water quality experts identified a core set of parameters to reflect common source water concerns. Drinking source water target values were drafted for use in the index corresponding to two basic

treatment levels. Index scores calculated using the core parameter set and associated source water target values were strongly correlated with expert assessments of water quality. It has been recommending a modified index calculation procedure to accommodate parameters measured at different frequencies within any particular study period.

Al-Bahrani et al.,(2012) examined 16 stations along the Euphrates river from its entrance to the Iraqi lands at Al-Qaim in Al – Anbar province up to meeting point with Tigris River at Qurna in Basrah province to assess the WQI for irrigation use. In this study fifteen water parameters (chlorides, sulfates, total dissolved solids, total nitrates, electrical conductivity, pH, sodium adsorption ratio, iron, lead, zinc, cadmium, copper, boron, chromium, and coliform bacteria) have been tested during the period from April, 2007 to December, 2010. Two mathematical methods (Canadian and Bhargava methods) were adopted to find WQI for irrigation use and the results according to Canadian method showed that river water was classified as good and fair but for Bhargava method, the river water classified as excellent, good, and acceptable.

Obais and Al-Fatlawi,(2012) studied water pollution for Shatt Al-Hilla river in Middle Euphrates region of Iraq (Babylon and Al-Diwaniya governorates) in both rural and urban areas. In rural areas, drinking water from natural sources such as rivers and streams is usually polluted by organic substances from upstream users who use water for agricultural activities. To evaluate the pollutant concentrations, regression models were obtained by Data Fit Software program (version 8.0). The results were compared with the Iraqi and WHO standards for domestic and irrigation purposes to determine pollution extend and suggest suitable solutions. The results of the program are verified with data of year 2008 which is not included in regression model. This verification showed a good agreement with coefficient of determination ranged between "0.927 to 0.996".

Mohebbi et al.,(2013) innovative the drinking water quality index (DWQI) based on the Canadian DWQI was developed as “modified DWQI” and applied for assessing the water quality in all of the groundwater resources that are used as the source of drinking water in urban areas of Iran in 2011. In development of the modified DWQI, twenty-three water quality parameters and relevant Iranian standards for drinking water quality were selected as input parameters, respectively. The modified DWQI is calculated for each sampling station over one year using three factors: the number of parameters that excure benchmarks, the number of measurements in a dataset that excure benchmarks and the magnitude of excursion from benchmarks in the violator measurements. The results of the case study revealed that the nationwide average scores of the modified DWQI in the groundwater resources were 85 and overall situation of water quality in the groundwater resources was described as good.

Al-Saleh,(2014) investigated the quality of Euphrates River for drinking purposes by determining the water quality index WQI. Fourteen physic-chemical water quality parameter from four water quality- monitoring stations along Euphrates river were monthly monitored during the study period (2007- 2013) to compute the WQI in order to assess the suitability of the river water for drinking and human consumption. The water quality index provides a simple method for estimating the water quality for different uses and it is very important for river quality monitoring. Water bodies are usually taken as the sink for dumping domestic, agriculture and industrial wastes, therefore, a regular monitoring for maintaining acceptable quality of these resources is of important human health and environmental concerns.

Abd Al-Hussein,(2015) studied some water treatment plants spreading in three districts (Al-Sadaa, Al-Hilla Al-Jaded, Al-Hashimyah) in Babylon

governorate were studied to evaluate water quality. The samples of raw and treated were taken from water treatment plants, eight parameters were considered during a period of one year (pH, turbidity, electric conductivity, total alkalinity, total hardness, Ca, Mg, Cl). starting from September 2013 until September 2014. The results showed that the maximum values of all physical and chemical parameters were within Iraqi standards except turbidity and conductivity, also the values of the MNE(Ministry of Nature and Environment of Mongolia)WQI at all water treatment plants were between(0.81-1.59) for raw water and the MNE WQI ranged between (0.49-0.87) for treated water and all values of MNE WQI indicated that the (raw and treated) water is clean, few of them can be referred as slightly polluted in raw water of Al-Sadaa WTP (1.59) and treated water of Al-Hashimyah WTP (0.9376). (AbdAL-Hussein, 2015).

Ewaid and Abed,(2017) investigated the water quality index has been developed mathematically to evaluate the water quality of Al-Gharraf River, the main branch of the Tigris River in the south of Iraq. Water samples were collected monthly from five sampling stations during 2015–2016, and 11 parameters were analyzed: biological oxygen demand, total dissolved solids, the concentration of hydrogen ions, dissolved oxygen, turbidity, phosphates, nitrates, chlorides, as well as turbidity, total hardness, electrical conductivity and alkalinity. The index classified the river water, without including turbidity as a parameter, as good for drinking at the first station, poor at stations 2, 3, 4 and very poor at station 5. When turbidity was included, the index classified the river water as unsuitable for drinking purposes in the entire river. The study highlights the importance of applying the water quality indices which indicate the total effect of the ecological factors on surface water quality and which give a simple interpretation of the monitoring data to help local people in improving water quality.

Fathi et al.,(2018) evaluated the water quality of the Beheshtabad River in Iran's Chaharmahal and Bakhtiari Province, using water quality index and multivariate statistical methods. Nitrate, temperature, phosphate, turbidity, dissolved oxygen, biological oxygen demand, electrical conductivity, total solids, and pH were measured at five selected stations along the river over 6 months using standard methods. Water quality index results demonstrated that water quality varied in the selected stations between average and good and that pollution in this section of the Beheshtabad river increases from upstream to downstream. Clustering and principal component analysis were also utilized. Multivariate statistical methods were used to analyze water conditions for efficient management of surface water quality. Agricultural fertilizers, upstream wastewater discharge, and fish farms constitute the main elements that decrease the water quality of the Beheshtabad River. To preserve this water resource against pollution, the implementation of stringent rules and guidelines are needed to enhance health and preserve water resources for future generations.

Gad et al.,(2020) studied the improve surface water quality assessments and their controlling mechanisms using the drinking water quality index (DWQI) and four pollution indices (PIs), which were supported by multivariate statistical analyses, such as principal component analysis, partial least squares regression (PLSR), and stepwise multiple linear regression (SMLR). Twenty-two physicochemical parameters are analyzed using standard analytical methods for 55 surface water sites in the northern Nile Delta, Egypt.

Abdullah,(2020) the study was conducted to explain the variations of ten variables of WQI in four stations at Al-Hilla River which is the major branch of the Euphrates River, and located in the middle of Babylon Province. It extends for 101 km long. Water samples were collected from the river from June 2016 to May 2017. Ten of the physicochemical parameters were analyzed; dissolved oxygen,

total dissolved solids, electrical conductivity, and the potential of hydrogen, calcium, magnesium, nitrates, phosphates, turbidity and total alkalinity. The range of water quality index values of Al-Hilla River is 48.63 was recorded at station 1, the values indicate good water quality to very poor (85.67) at station 4, according to weighted arithmetic. The results indicated that there were significant differences between the first and fourth stations. The results values of WQI were 56.61 and 82.81 at stations 2 and 3 which indicate poor at station 2 and very poor status at station 3, respectively. The values of water quality index within turbidity ranged from 133.7 at station 1 to 192.04 at station 4 and the results values of WQI were 206.39 and 156.30 at stations 2 and 3. Significant ($P < 0.05$) relationships were noted in the water quality index among the stations.

Makki et al.,(2021) investigated the groundwater quality in a region of central Iraq around Babylon city, covering an area of 5119 km². The data gathered for this study included maps, well locations and water quality data and was sourced from the relevant governmental departments. A base map of the focused region was initially prepared following data collection. The analyzed water quality parameters were used as an attribute database to produce thematic maps using a geographical information system (GIS) environment. In this study, the water quality index (WQI) and the irrigation water quality index (IWQI) were calculated for different groundwater samples using various parameters including the Electrical Conductivity (EC), Cl^- , HCO_3^- , Na^+ and pH. Moreover, the groundwater suitability for irrigation purposes has been assessed using indices such as Kelly's ratio (KR), sodium absorption ratio (SAR), residual sodium carbonate (RSC), soluble sodium percentage (SSP) and permeability index (PI). Water quality index maps have been developed using the GIS environment.

Abed et al.,(2021) aimed to assess the water quality of the Tigris River for drinking purposes. The Tigris River Water Quality Index (TrWQI) was developed

through the use of various tools and data, this includes; availability of water quality data, statistical correlations, water quality guidelines, and the experts' opinions. Ten water quality parameters were involved in the adopted index: turbidity, pH, water temperature, biochemical oxygen demand, dissolved oxygen, iron, sulfate, alkalinity and total coliform bacteria. Five sampling stations were selected to perform the TrWQI for the period of April 2019. Generally, the results of the index have manifested that the water quality was within “Fair” to “Poor” range. With considering the application of TrWQI, reasonable results have been achieved if compared with the raw data of the Tigris River. In fact, the index was capable to endow serviceable information for managers and decision-makers to sustain the quality of the river.

Through previous studies, it was noted that the study conducted by Abdullah (2020) is similar to the approved weighted arithmetic index method adopted in this study, and the study conducted by (Lomb et al., (2006)) is similar to the Canadian method.

Chapter Three

Field Work and Methodology

Chapter Three

Field work and methodology

3.1 Study area

The study area involved three stations along the Hilla River, which extended from the city of Hilla to Al Hashimyah town within the Babylon Governorate. These stations represented the water treatment plants of New Hilla, Al-Hussein, and Al Hashimyah. See Figure (3.1).

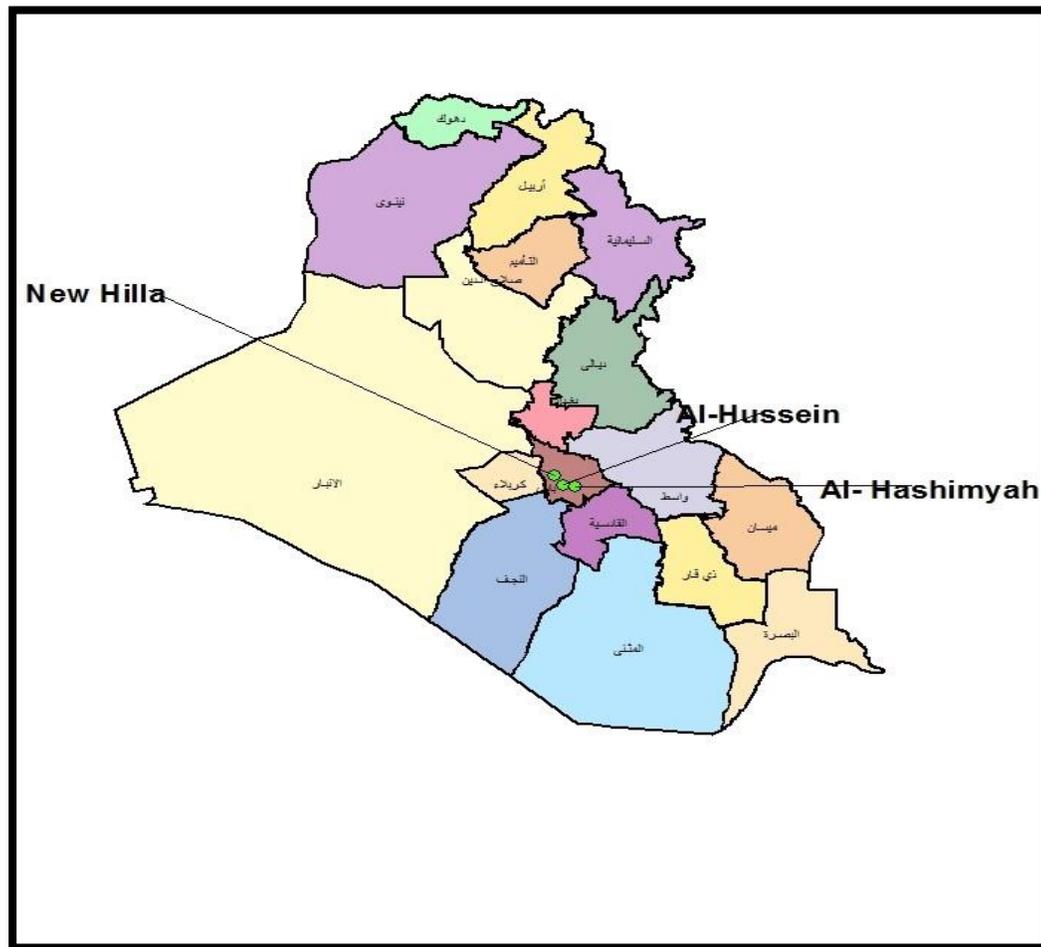


Figure (3.1) :The locations of the treatment plants (New Hilla, Al-Hussein, and Al Hashimyah) on the map of Iraq.

3.1.1 New Hilla water treatment plant.

The New Hilla water treatment plant station is considered one of the largest water treatment plants in Babylon Province. It is located directly on the southern side of Hilla River near the main northern entrance to the city of Hilla, which is 100 km south of Baghdad. Water at this plant is usually treated and stored before being pumped to consumers. (The number of sedimentation tanks is 6, the number of filters used is 32 filters, the number of pumps is 14 suction pumps and 14 push pumps) working every 24 hours, as shown in Figure(3.2),(Babylon Water Resources Directorate/Iraq).

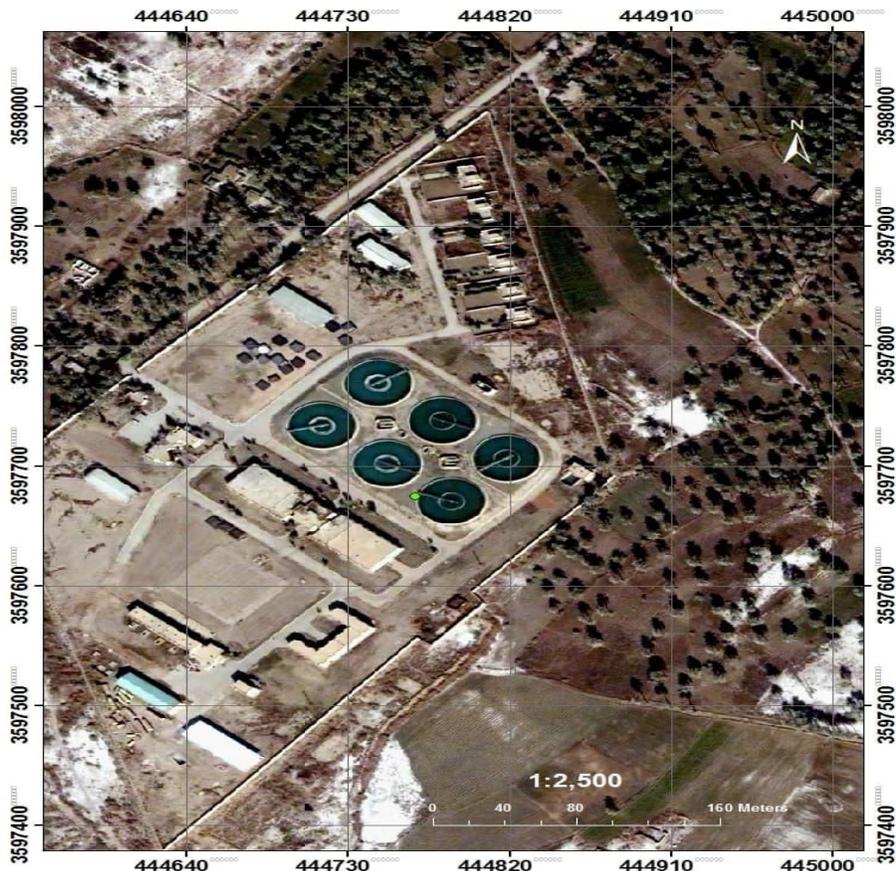


Figure (3.2): New Hilla Station (Babylon Water Resources Directorate/Iraq).

3.1.2 Al-Hussein water treatment plant

Al-Hussein water treatment plant is situated at Al-Hussein village. The plant started operation in (1976). (The number of sedimentation tanks is 2, the number of filters used is 6 filters, the number of pumps is 2 suction pumps and 6 push pumps working every 24 hours with production rate of 500 m³/h), as shown in Figure(3.3), (Babylon Water Resources Directorate/Iraq).



Figure (3.3) :Al-Hussein Station (Babylon Water Resources Directorate/Iraq).

3.1.3 Al-Hashimyah water treatment plant

Al-Hashimyah water treatment plant is the water treatment plant built at Al-Hashimyah city. It is located at a city center. The plant started operation in (1963) with capacity of (240 m³/h), Shatt Al-Hilla represents the main water resource for the raw water which drawn to the treatment system by main pumps where the pumped treated water is assist Al-Mazidiyia and Al-Hashimyah districts (The number of sedimentation tanks is 2, the number of filters used is 4 filters, the number of pumps is 3 suction pumps and 5 push pumps) working for 24 hours, as shown in Figure(3.4), (Babylon Water Resources Directorate/Iraq).



Figure (3.4) :AL- Hashimyah Station (Babylon Water Resources Directorate/Iraq).

3.2 Samples collection and experimental work

In this study, water samples were taken from the main three station in Hilla (New Hilla, Al-Hussein and Al-Hashimyah) and for two types of water (raw and drinking) for 9 months, starting from (October 2020 to June 2021). Three samples were taken monthly. The chemical and physical tests were characterized and the monthly average was found. The water quality index for both types of water was calculated using the weighted arithmetic index method and the Canadian method, then calculating the efficiency of the station based on the mathematical method, and then a comparison with previous years (2017-2018-2019) based on the data obtained from the Babylon Water Directorate.

3.3 Field measurements

From all sampling sites, the following chemical and physical parameters were measured: [Temperature, Na^+ , Turb, EC, pH, TDS, Ca^{+2} , TH, SO_4^{-2} , Mg^{+2} , K^+ and BOD_5]. The results of the measurements give an indication of the water quality and the total treatment plants efficiency.

3.4 Measurements facilities

3.4.1 Acidity of a Hydrogen (pH) and temperature (Temp)

pH is an important indicator of drinking water quality. The attention to pH monitoring is essential at all stages of the water chemical treatment to ensure that water is satisfactorily purified and sterilized. For sterilization with chlorine the pH must be less than (8).pH was measured using (pH Meter \ Brand: Adwa S.N:104344b\1077198) at the water sampling sites.

3.4.2 Turbidity (Turb)

Light rays are the major source for aquatic systems, influences the activity of photosynthesis. Transparency is a characteristic of water that varies with the

combined effect of turbidity and color. Turbidity is majorly caused because of silt, clay, planktons and colloidal organic matter which results into low transparency,(Patil et al., 2013),Turbidity was measured using a turbidity meter (Model AN HACH 2100N) to measure water turbidity.

3.4.3 Electrical conductivity(EC) and detection of total dissolved solids (TDS)

Electrical conductivity is measured using conductivity meter and it is expressed in units of ($\mu\text{S}/\text{cm}$) where the treated sample must be at a temperature of (25) °C, while the reading is corrected by the following equation,(Hayashi, 2004).

$$E. c 25 = \frac{(E.c t)}{[1+0.0191(t-25)]} \dots\dots\dots (3.1)$$

3.4.4 Mineral elements: potassium and sodium

The main important mineral elements are potassium (K^+) and sodium (Na^+) have been measured using (FLAME PHOTOMETER) device (model: JENWAY, PFP 7).

3.4.5 Sulphate (SO_4^{-2})

Sulfates are screened using(Gravimetric Method) and the examination method is described As following:

- 1- The ceramic bowl is thoroughly washed, dried and placed in the oven at a temperature of 800 °C for an hour, then cooled and carefully weighed.
- 2- A volume of (100 ml) is taken for dilution by adding (100 ml) of distilled water, adding several drops of methyl red reagent and slightly acidifying by adding (2-3) ml of hydrochloric acid (1:1). The solution is heated.
- 3- To the solution (before boiling), 10 ml of the barium chloride solution is slowly added with the constant stirring, so that the sulfate precipitates in the form of barium sulfate.

- 4- It is placed in a water bath for two hours to complete the sedimentation process, then filtered using filter paper (42 or 44) and washed with hot distilled water until the filter becomes free of chloride using silver nitrate solution as a guide.
- 5- The sediment is transferred with filter paper to the previously weighed container. Filter paper is burned in the container over a Petron lamp until it turns into a white precipitate.
- 6- Place it in the oven at a temperature of 800 °C for an hour until its weight stabilizes.
- 7- Cool the bowl and carefully weigh it.

$$(SO_4)^{-2} = \frac{[(A - B) \times 411.5 \times 1000]}{\text{Sample volume (ml)}} \dots\dots\dots (3.2)$$

A = Total weight of the bowl with the sediment.

B = weight of an empty bowl.

3.4.6 Total hardness (TH)

This property can be tested using EDTA titration method which can be described as:

Take 25 ml of a sample of water (or other suitable volume) and add to it (1 ml) of a buffer solution (pH = 10) until the medium is alkaline, then add a drop of aero chrome dye red-purple. We titration with EDTA until the color of the sample changes from red to blue, and the volume of standard solution used is recorded as:

$$\text{Total hardness in terms of } CaCO_3 \text{ (mg/L)} = \frac{A \times B \times 1000}{\text{Sample Volume (ml)}} \dots\dots\dots (3.3)$$

Where:

A: ml titrated sample

B: mg of CaCO₃ which equivalent to 1 ml EDTA titrant.

3.4.7 Calcium ion (Ca⁺²)

This property can be tested using EDTA titration method which can be described as:

This process achieved by measuring of 50 ml of test sample or other suitable amount and mixed with 2 ml of NaOH solution (1 N) and adequate amount of Murexes guide, where the final mixture is flushed directly with the EDAT solution gradually with constant stirring, where the color changes from the pale red to violet.

$$\text{Ca}^{+2} \text{ (mg/l)} = \frac{A \times B \times 400.8}{\text{Sample Volume (ml)}} \quad \dots\dots\dots(3.4)$$

Where:

A: ml testing sample titration.

B: mg of CaCO₃ which equivalent to 1 ml of EDTA titrant at the calcium pointer end point.

3.4.8 Magnesium ion (Mg⁺²)

The concentration of magnesium ion in water detected from the results of both total hardness and calcium, because magnesium is the product of calcium subtraction from total hardness,(Gombert et al., 2019).

$$\text{mg (Mg/l)} = [\text{T.H (as CaCO}_3) - (\text{Ca}_{\text{(as Ca)}}) \times 2.5] \times 0.244 \dots\dots\dots (3.5)$$

3.4.9 Biological oxygen demand (BOD₅)

100 ml of the sample was taken by a cylinder and placed in the dark bottle of the device, and a magnetic piece was placed inside it, after which a stopper containing potassium hydroxide is placed that absorbs the carbon dioxide produced by the decomposition process, the sensor is placed on the highest value it reads. Then the bottle is placed in an incubator for five days and we read.

3.5 WQI calculation methods

There are many ways to measure the water quality:

3.5.1 Weighted arithmetic index method

3.5.2 The CCME-WQI (Canadian Council of Ministers of the Environment Index)

3.5.3 OWQI (Oregon Water Quality Index)

3.5.4 NSF-WQI (National Sanitation Foundation-Water Quality Index)

In this study, the weighted arithmetic index technique and the CCME-WQI will be utilized to calculate the WQI.

3.5.1 Weighted arithmetic index method

WQI was calculated by weighted index method for irrigation purposes. This method used for transforming vast quantities of quality knowledge of water to single water level quality number. WQI was used as a guideline for the classification of surface water depending on the use of basic parameters of water characterization (Şener et al., 2017). In the present study, twelve water quality parameters, namely (Temp, pH, TH, EC, Ca⁺², Mg⁺², TDS, So₄⁻², Turb, K⁺, Na⁺, and BOD₅), were considered for computing WQI. And the unit weight W_i of each parameter was obtained depending upon its weight age, by adopting the following formula:

$$W_i = K / V_s \quad \dots\dots\dots (3.6)$$

$$K = [1 / \sum 1 / V_s] \dots\dots (3.7)$$

W_i : W_i is a factor that calculates parameter significance

K : proportionality constant, V Standard: world- widely accepted drinking water quality standard pre-scribed by Iraqi specification and WHO.

V_s : The recommended standard value of the i th parameter

$$\sum W_i = K \sum [1 / V_s] \dots\dots (3.8)$$

In the 2nd stage, the quality rating (Q_i) is computed as following formula:

$$Q_i = 100 [V_a - V_o] / [V_s - V_o] \dots\dots (3.9)$$

Where:

V_a : value of the water quality parameter obtained from the laboratory analysis.

V_s : The recommended standard value of the i th parameter

V_o : is an ideal value of parameter means that pH and dissolves oxygen 7.0 and 14.6 mg/L respectively and 0 for all other parameters, (Călmuc et al., 2018).

$$WQI = \sum q_i W_i / \sum W_i \dots (3.10)$$

Table (3.1): Standard specifications for raw water and drinking water (Iraqi standard limit) (Environment department of Karbala, 2010).

Parameter	Maximum limits (Raw Water)	Maximum limits (Drinking Water)
Temperature	30C°	25C°
pH	6.5 -8.5	6.5 -8.5
Total Hardness(TH)	500	500
Calcium(Ca ⁺²)	50	150
Magnesium(Mg ⁺²)	50	100
Sulfate (SO ₄ ⁻²)	400	400
Sodium (Na ⁺)	200	300
Electrical Conductivity(EC)	1000	2000
Potassium(K ⁺)	12	10
Total Dissolved Solids(TDS)	1500	1000
Turbidity	5	5
BOD ₅	5	

Table (3.2): WQ Rating as per weight arithmetic WQI method (Oni and Fasakin, 2016).

WQI Value	Water Quality
0 – 25	Excellent
26 – 50	Good Water
51 – 75	Moderately Polluted
76 – 100	Severely Polluted
> 100	Unfit and Unsuitable for Drinking

The mean efficiency (E%) was calculated by using the equation below(Al-Ridah et al., 2020)

$$E\% = (\text{Raw Water} - \text{Treated Water})/\text{Raw Water} \times 100 \dots\dots (3.11)$$

3.5.1.1 Advantages:

- Weighted arithmetic index method encompasses the values of various physio-chemical parameters of water quality into a mathematical equation, which indicates the water ecological state.
- It reflects the importance that each parameter has in the evaluation and management of water quality.
- It can be used to describe the suitability of both surface and underground water sources for human consumption.

3.5.1.2 Disadvantages:

- This index may not provide enough information about the real situation of the water quality.
- This index does not include all the parameters which can describe the quality of a body of water (Tyagi et al., 2013) and (Paun et al., 2016).
- This index only quantifies the direct effect of pollution on a body of water.

3.5.2 The Canadian council of ministers of the environment index (CCME-WQI)

This index was described by the Canadian Council of Ministers of the Environment Water Quality (Hurley et al., 2012) and (RANJBAR et al., 2016). The index scores are computed as:

$$\text{CCME WQI} = 100 - (F_1^2 + F_2^2 + F_3^2)^{0.5} / 1.732 \dots\dots (3.12)$$

Where, F_1 : is the factor which represents the percentage of variables which do not meet the objectives (referential values) at least once during the period (failed variables) and they are usually calculated by using equation (3.8)

$$F_1 = (\text{Number of failed variables} / \text{Total number of variables}) \times 100 \dots (3.13)$$

F_2 : is the factor representing the percentage of individual tests which do not meet the goals at all (failed tests).

$$F_2 = (\text{Number of failed tests} / \text{Total number of tests}) \times 100 \dots (3.14)$$

F_3 : is the factor which represents the amount through which the test values did not respect their guideline values. This is calculated in three steps:

a. When the test value must not exceed the objective:

$$\text{Excursion}_i = (\text{Failed test value}_i / \text{Objective}_j) - 1 \dots (3.15)$$

b. When the test value must not fall below the objective:

$$\text{Excursion}_i = (\text{Objective}_j / \text{Failed test value}_i) - 1 \dots (3.16)$$

c. The collective amount of excursions which are out of compliance is calculated according to the following formula:

$$nse \sum_{n=1}^i (\text{Excursion} / \text{Total number of tests}) \dots (3.17)$$

$$F_3 = nse / (nse \times 0.01 + 0.01) \dots (3.18)$$

After determining all these factors, the CCME-WQI may be calculated according to equation (3.14) (Lumb et al., 2006) , (Mahagamage and Manage, 2014).

$$CWQI = 100 - (F_1^2 + F_2^2 + F_3^2)^{0.5} / 1.732 \dots (3.19)$$

Table (3.3):The corresponding values of water quality in conformity with CCME-WQI index (Paun et al., 2016).

Value of CCME-WQI	Water Quality
Excellent	95 - 100
Good	80 - 94
Fair	65 - 79
Marginal	45 - 64
Poor	0 - 44

3.5.2.1 Advantages:

- The Canadian Council of Ministers of the Environment Index has a high adaptability to different water uses.
- Easy to calculate.
- It has a low level of sensibility to the case of missing data.
- It is appropriate for analyzing data coming from automated sampling.

3.5.2.2 Disadvantages

- All the variables have the same importance in the determination of the index.
- It cannot be mixed up with other indicators or with other biological data.
- The water quality gets described only partially.
- F_1 does not work appropriately when too few variables are taken into consideration (Tyagi et al., 2013) , (Paun et al., 2016).

3.6 Statistical analysis using SPSS software

The statistical analysis program SPSS (version 25) was used to analysis the correlation between the parameters (temperature, electrical conductivity, pH, TDS, sodium, magnesium, calcium, potassium, turbidity, total hardness, sulfate, and BOD₅) with the water quality index. The water quality index was considered a dependent variable resulting from multiple (independent) variables. Where the (normality test) was measured to see if the data are subject to a normal distribution and the (correlation matrix) was measured to find out the extent of the correlation of the parameters, and finally the model was built using (multiple linear regression analysis) and (analysis of variance) which shows how important it is to build a regression model Linear with respect to the constructed relationship between the independent variables (properties).

Chapter Four

Results and Discussion

Chapter Four

Results and discussion

4.1 Introduction

This chapter deals with three major parts:

- 1- Testing of samples collected from (New Hilla, Al-Hussein and Al-Hashimyah) Station and their comparison with the Iraqi Standard.
- 2- Calculating the values of the water quality index according to the theoretical methods (the arithmetic and the Canadian method) in different time periods and comparing them with the water quality index from data obtained from the Babylon Water Department for the previous years (2017-2018-2019) according to (Iraqi Standard Limit) (Environment Department of Karbala, 2010).
- 3- Perform statistical analysis using SPSS software.

4.2 Sampling dates

Samples were collected for physical and chemical testing at three locations along the Shatt al-Hilla River (New Hilla (NH), Al-Hussein(HE) and Al-Hashimyah (HA)), see Figure (4.1), for nine months during dry and wet weather through the period (October 2020 - June 2021). It was chosen to help understand the variability in water quality during the year as a result of wet and dry seasonal variations. Three samples were taken monthly, then their monthly average was found, from which the water quality coefficient was calculated, Appendix (A) shows the sampling dates for water quality parameters of raw and treated water.

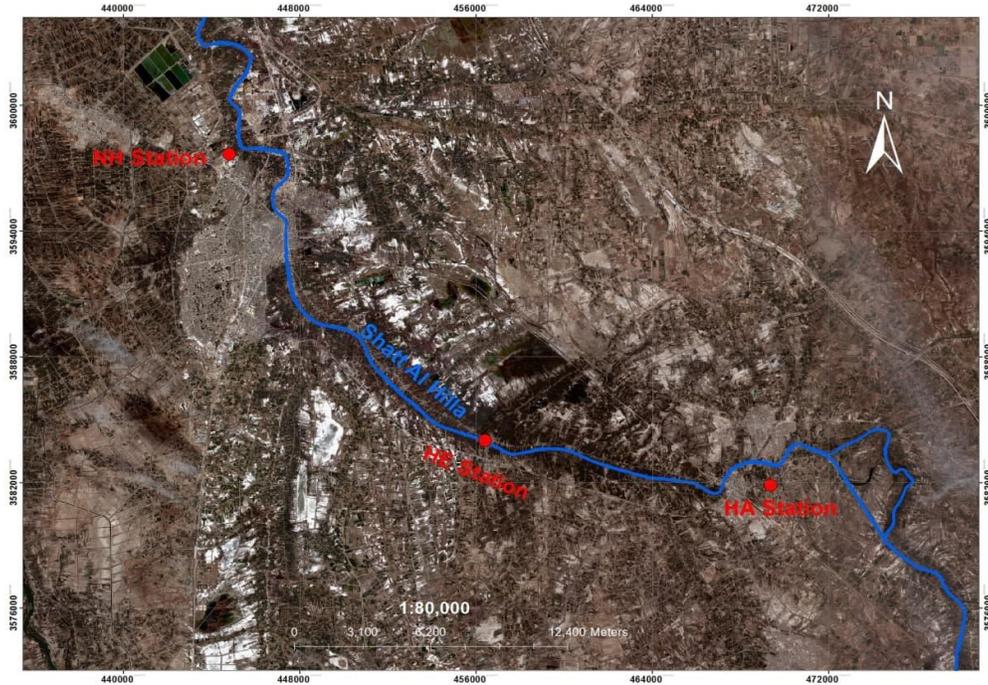


Figure (4.1): The location of the stations along the Shatt al-Hilla(Directorate of water resources in Babylon).

4.3 Physical and chemical parameters

4.3.1 Acidity of a Hydrogen (pH)

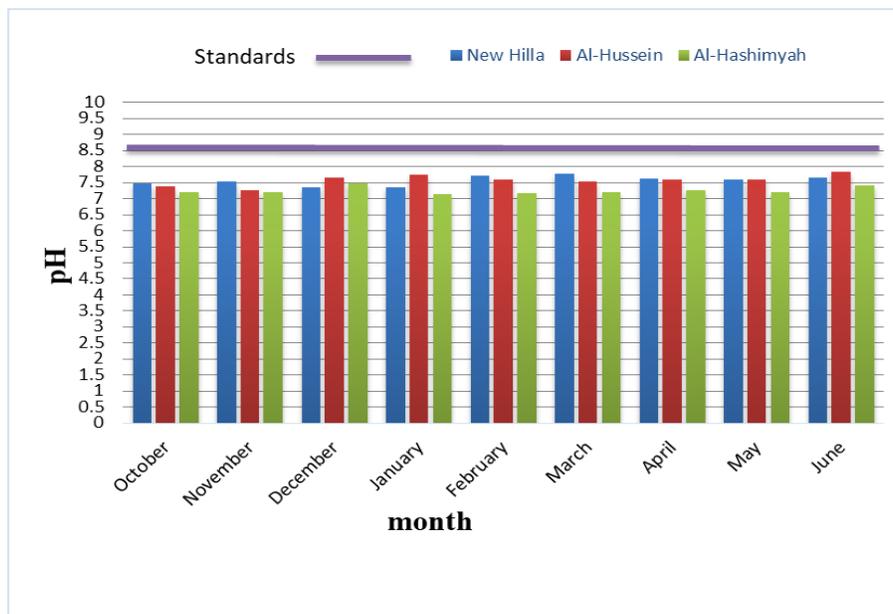


Figure (4.2): Temporal Variation in pH for Raw Water.

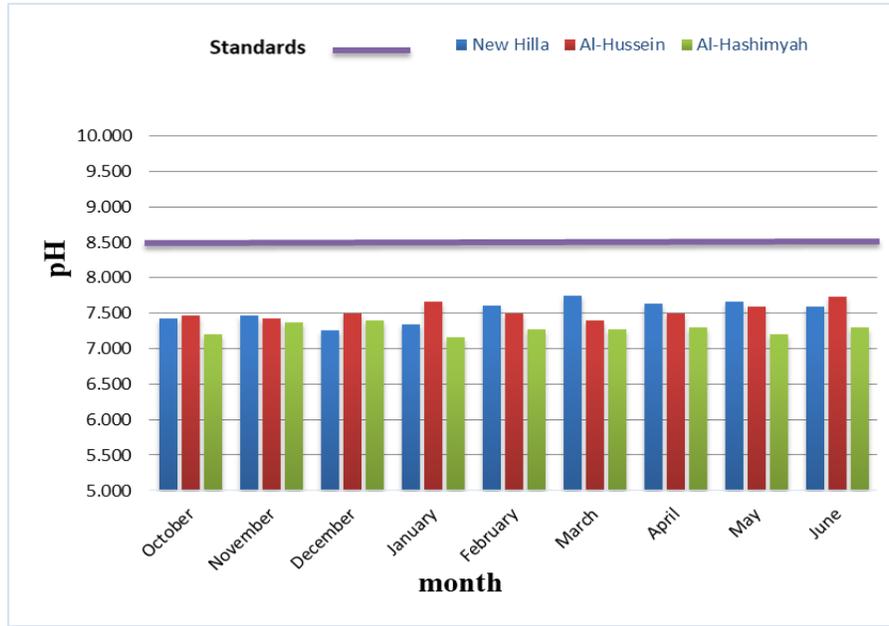


Figure (4.3): Temporal variation in pH from for treated water.

From Figures (4.2) and (4.3), the pH values were within the Iraqi standard limits. The above values of pH indicate that the water samples are almost neutral to sub-alkaline in nature,(Mokif, 2015).

4.3.2 Temperature (Temp)

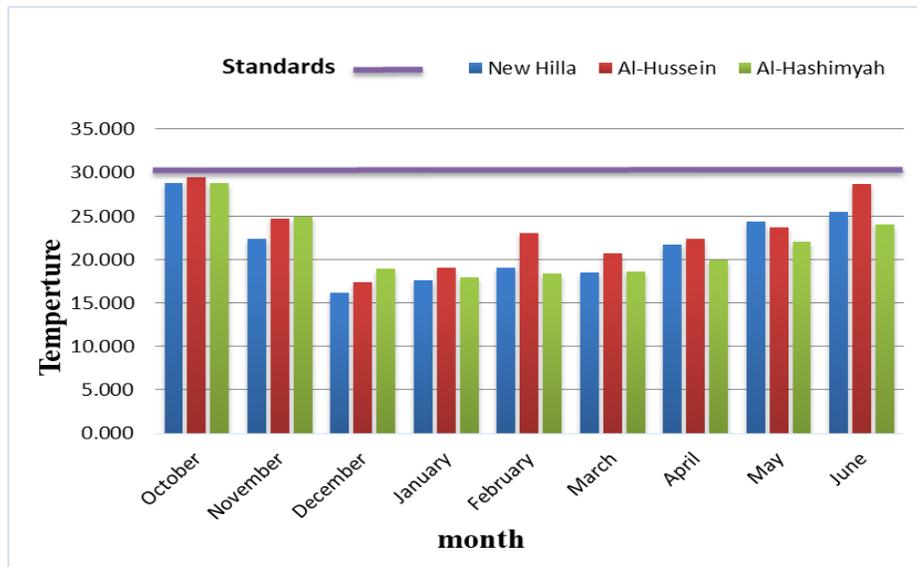


Figure (4.4): Temporal variation in temperature from for raw water.

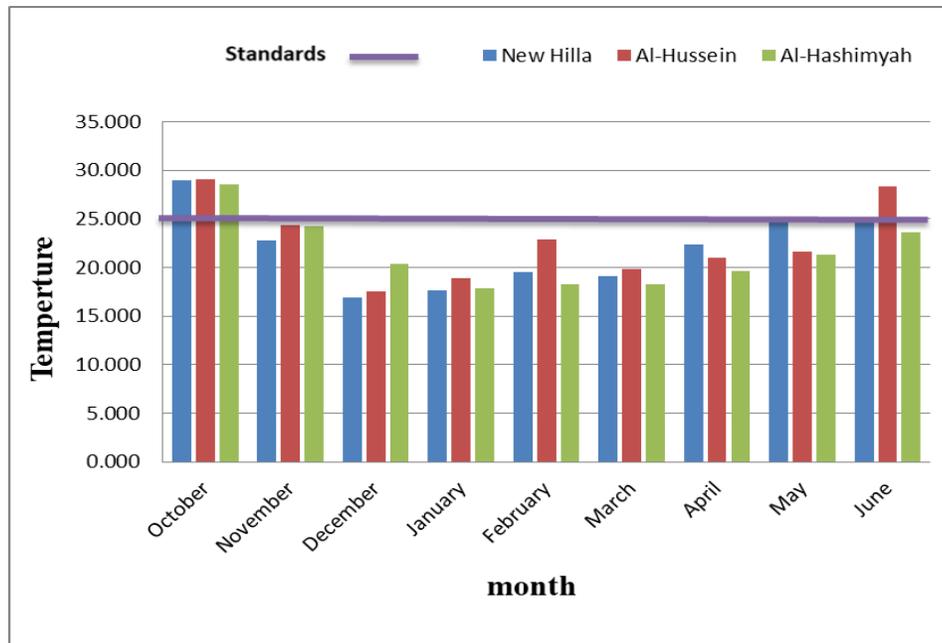


Figure (4.5): Temporal variation in temperature for treated water.

From Figures (4.4) and (4.5), it is noticed that the values of drinking water are higher than those of raw water. It was observed that warm days pass through cool seasons and vice versa and are not within the acceptable range indicating that the study areas are exposed to hot industrial waste. This relative increase in temperature will increase the activity of microorganisms in the water to carry out activities and the occurrence of many chemical reactions in the water and their survival for a longer period.

4.3.3 Turbidity (Turb)

Turbidity was one of the important factors that affected the WQI value. The drinking water was within the standards limits, while the turbidity values of the raw water exceeded the permissible limit. This is due to phytoplankton activities such as building and construction, which may lead to high levels of sedimentation, and water entry during rainstorms that lead to a rise in the water level. This leads to water dissolving, (Channar et al., 2014).



Figure (4.6): Temporal variation in turbidity for raw water.

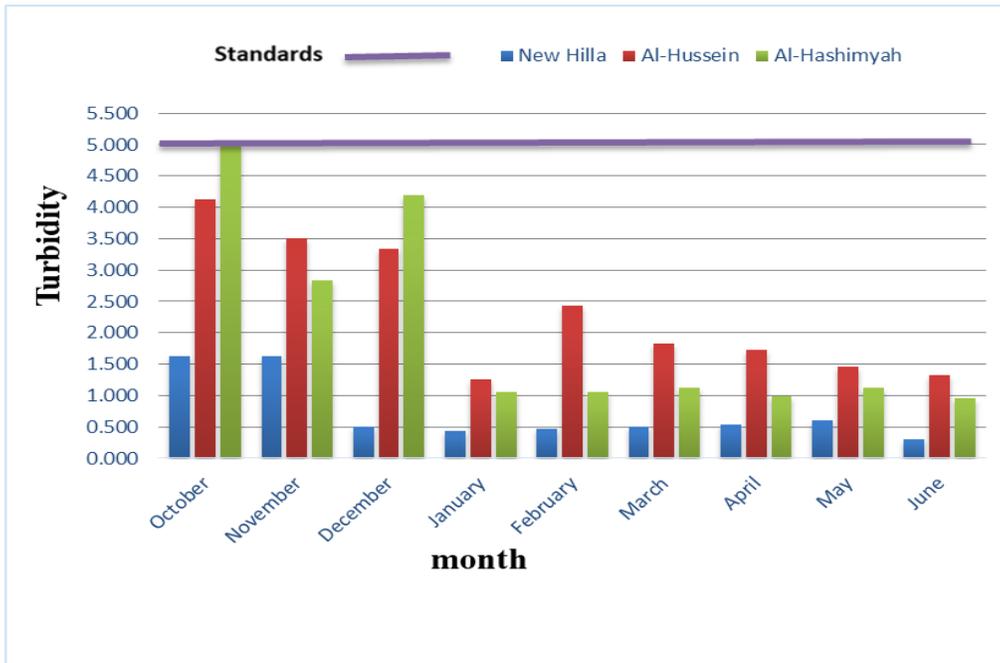


Figure (4.7): Temporal variation in turbidity for treated water.

4.3.4 Electrical Conductivity (EC)

From Figures (4.8) and (4.9), the electrical conductivity values of drinking water were within the standard specifications, while the electrical conductivity value of raw water for some months of the year exceeded the permissible limit. This is because the electrical conductivity values increase in the winter months due to the increase in the concentration of dissolved ions in this season. High EC values may occur due to human activities or runoff, which leads to an increase in dissolved salts in surface waters, (Tyagi et al., 2013).

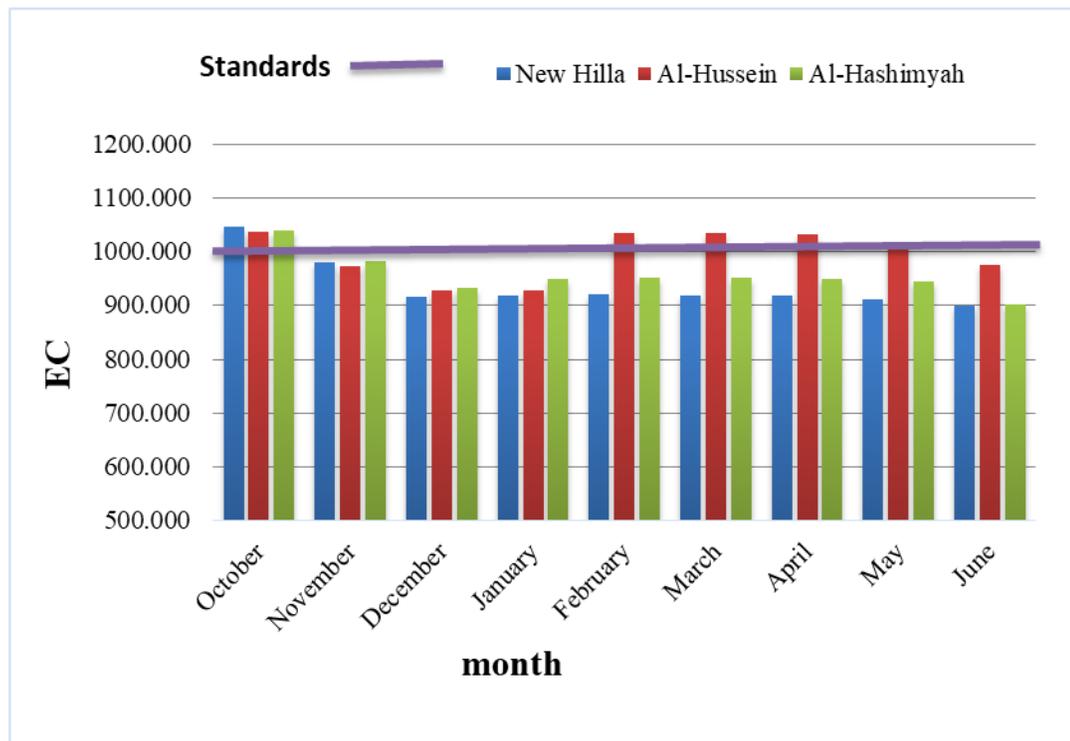


Figure (4.8): Temporal variation in EC for raw water.

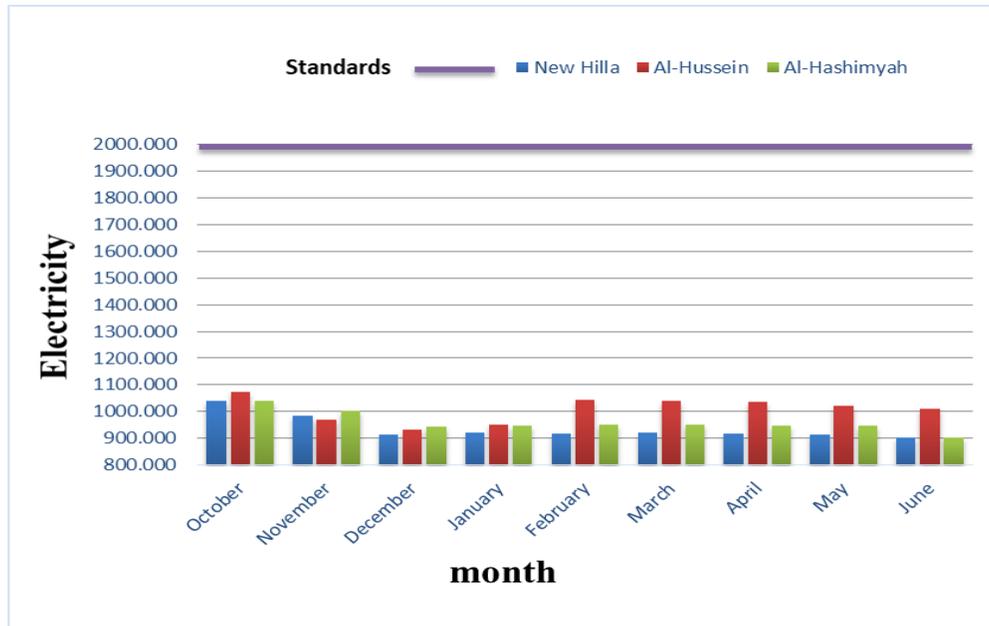


Figure (4.9) :Temporal variation in EC for treated water.

4.3.5 Total hardness (TH)

Figures (4.10) and (4.11) show that each of the drinking water and the values of raw water are within the permissible limits, that is, according to the Iraqi parameters are (500) for drinking and raw water. Full Difficulty due to the presence of calcium and magnesium, which are the two main factors causing stiffness are because of the weak effect it plays by the rest of the previous items. Hardness standard in hardness water should not exceed two parts per million. hardness coil the water should be semicircular between (500ppm),(Covington, 2018).



Figure (4.10): Temporal variation in total hardness for raw water.

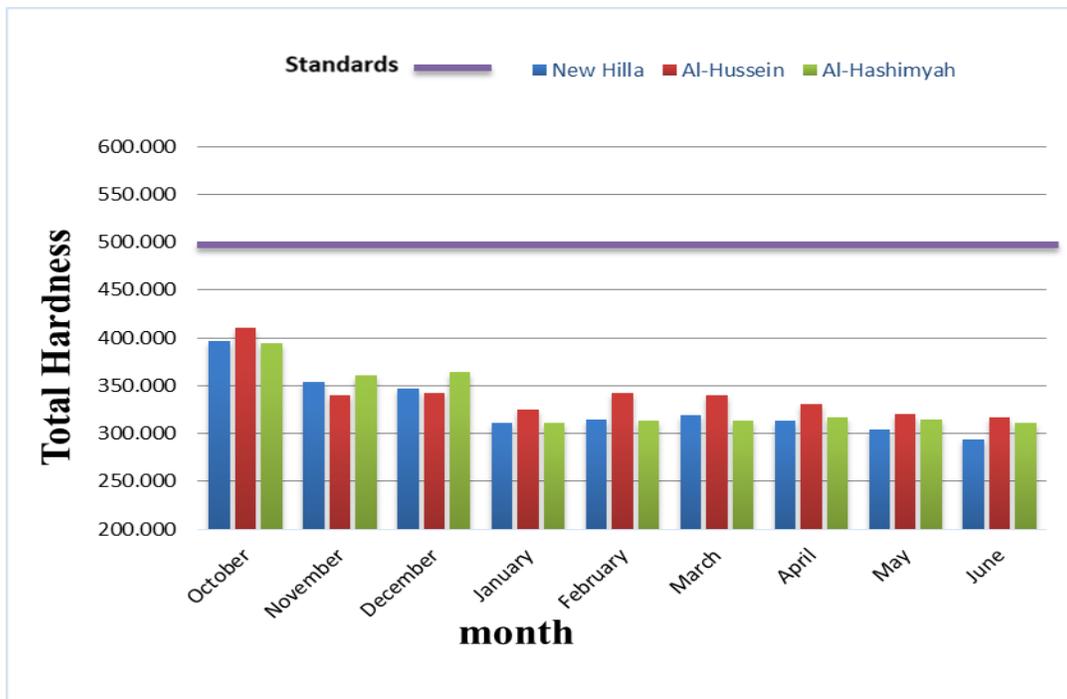


Figure (4.11): Temporal variation in total hardness for treated water.

4.3.6 Calcium (Ca^{+2})

Of the two Figures (4.12) and (4.13), the value of calcium was within the Iraqi standard specification for raw and drinking water. An excess of calcium ion is often due to the presence of other elements in higher than normal concentrations, (World Health Organization Hardness in Drinking - water, 2003).

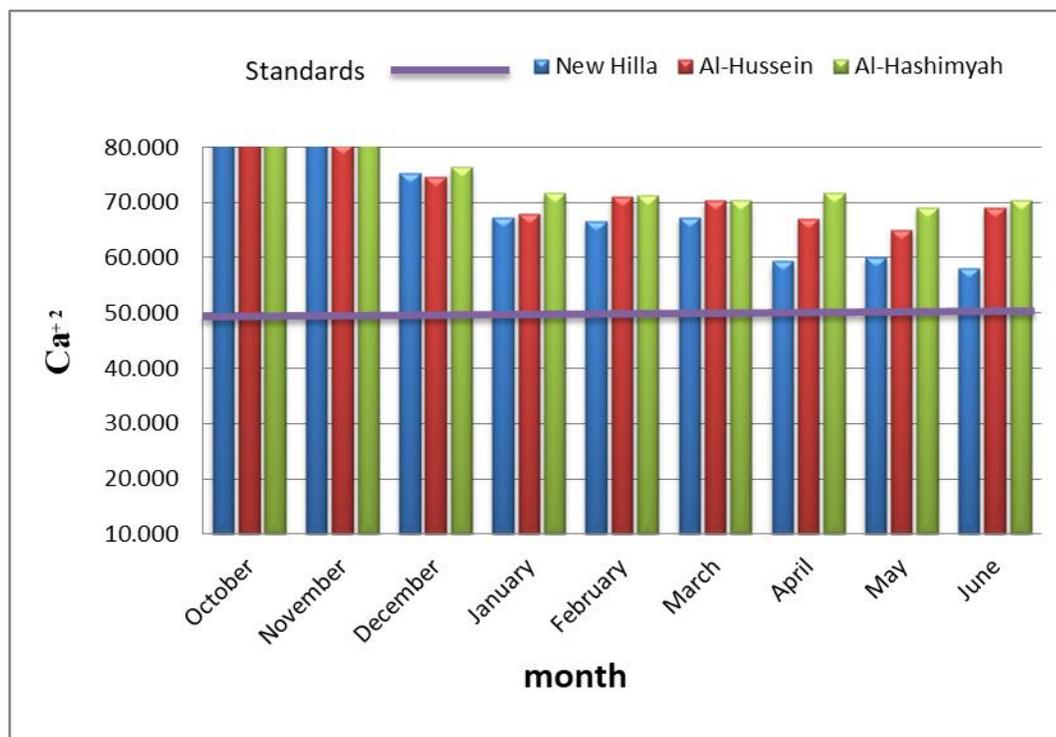


Figure (4.12): Temporal variation in Ca^{+2} for raw water.

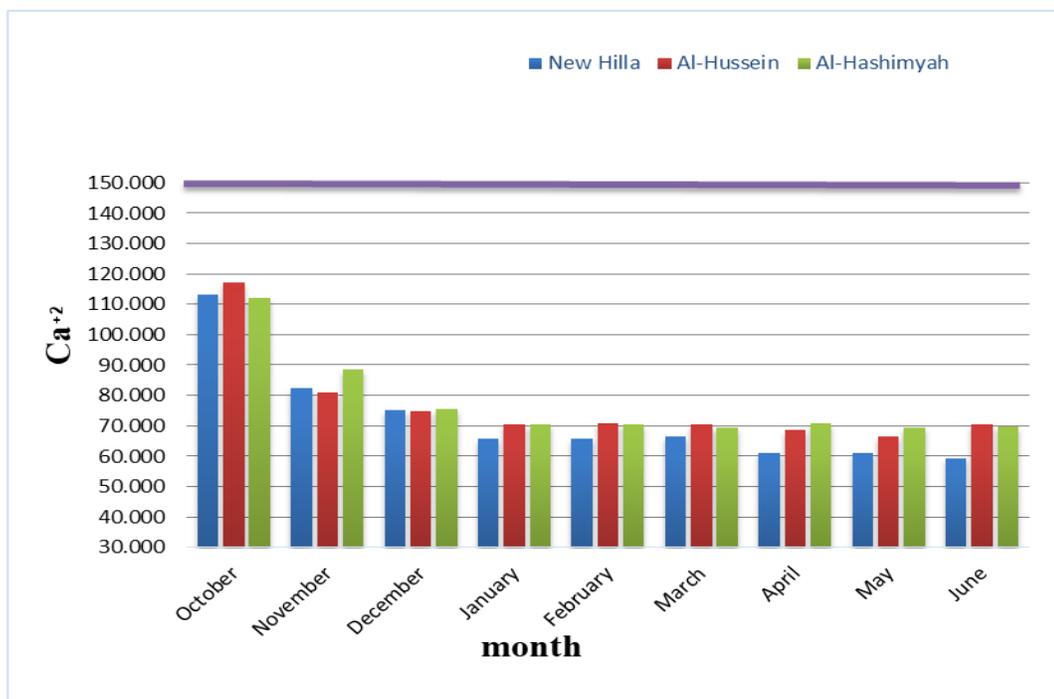


Figure (4.13): Temporal variation in Ca^{+2} for treated water.

4.3.7 Magnesium (Mg^{+2})

Magnesium values were within the Iraqi standard limits for the two types of raw and drinking water. It should be noted that the range of magnesium concentrations in natural waters is very large, and therefore it is difficult to reach a conclusion about the desired concentration of magnesium in drinking water, as clear differences can be observed in some studies in the level of risk even in the presence of one milligram of magnesium in a liter of water. . Based on the existing scientific knowledge from many researches on the effect of magnesium on health, it can be concluded that drinking water low or deficient in magnesium may lead to health risks, especially to increased morbidity and mortality from cardiovascular disease, (Suzuki-Kakisaka et al., 2013).



Figure (4.14): Temporal variation in Mg⁺² for raw water.

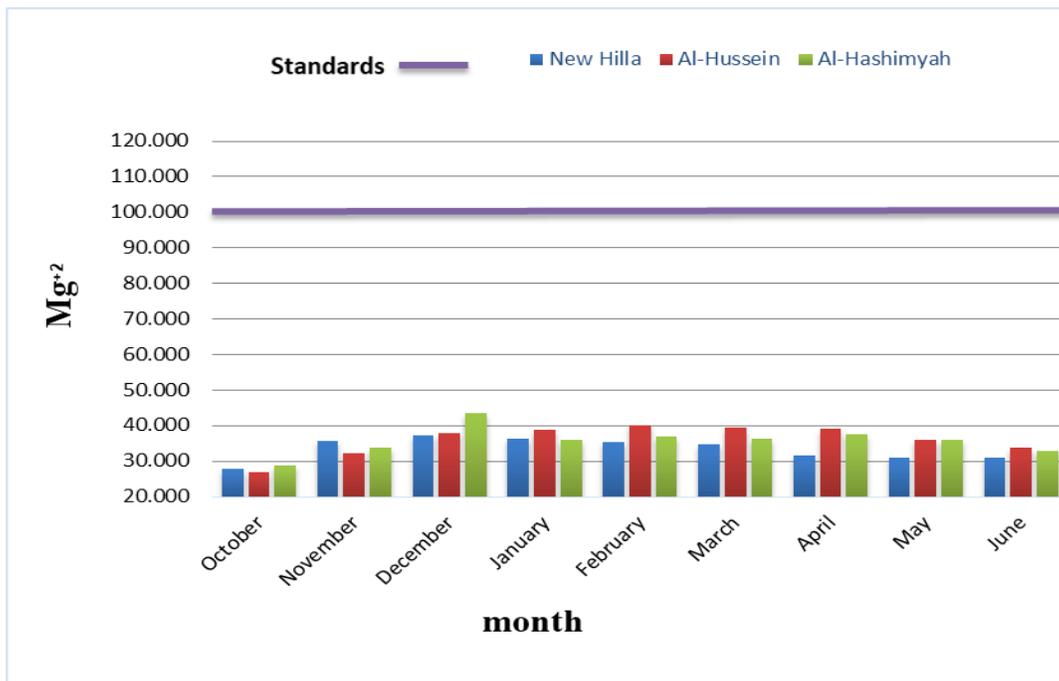


Figure (4.15): Temporal variation in Mg⁺² from for treated water.

4.3.8 Sulphate (SO_4^{-2})

From Figures (4.16) and (4.17), the values of sulfate in drinking water and raw water were within the permissible limits, that is, according to the Iraqi standards for drinking and raw water. The increase in sulfate values is due to the random addition of an excessive amount of alum, which leads to the accumulation and formation of sulfate salts and chlorides through the interaction of the increase in them with chlorine used in sterilization, which is one of the components of dissolved chlorides, where workers in stations use inaccurate and unscientific procedures to add alum ,(Alcom and Sarhan,2001).

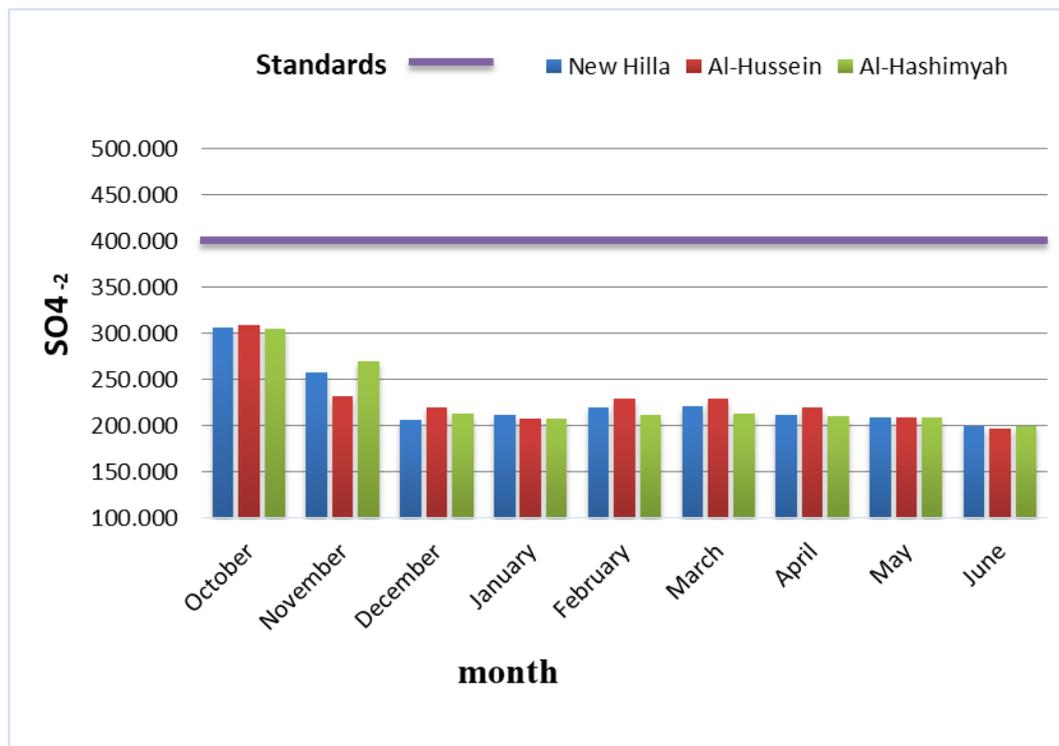


Figure (4.16): Temporal variation in SO_4^{-2} for raw water.

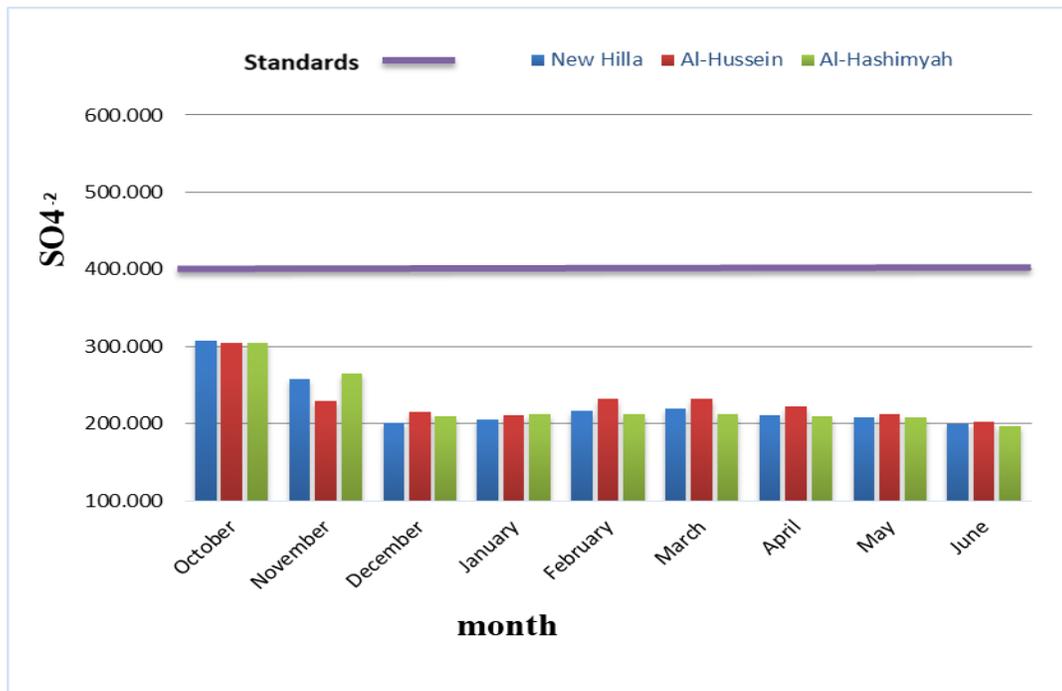


Figure (4.17): Temporal variation in SO_4^{2-} for treated water.

4.3.9 Total Dissolved Solids (TDS)

The results of the total value of dissolved solids were within the limits of the Iraqi standard for both types of water, raw and drinking. The amount of organic and inorganic substances in a liquid, whether suspended or ionic. The difference in values is due to monsoon rains, which carry salt with them during the colder months. The decrease in these values in drinking water is explained by the addition of alum in sufficient quantities and the quantities and time required for sedimentation basins of the sedimentation material, (Abdel-Tawwab et al., 2005).

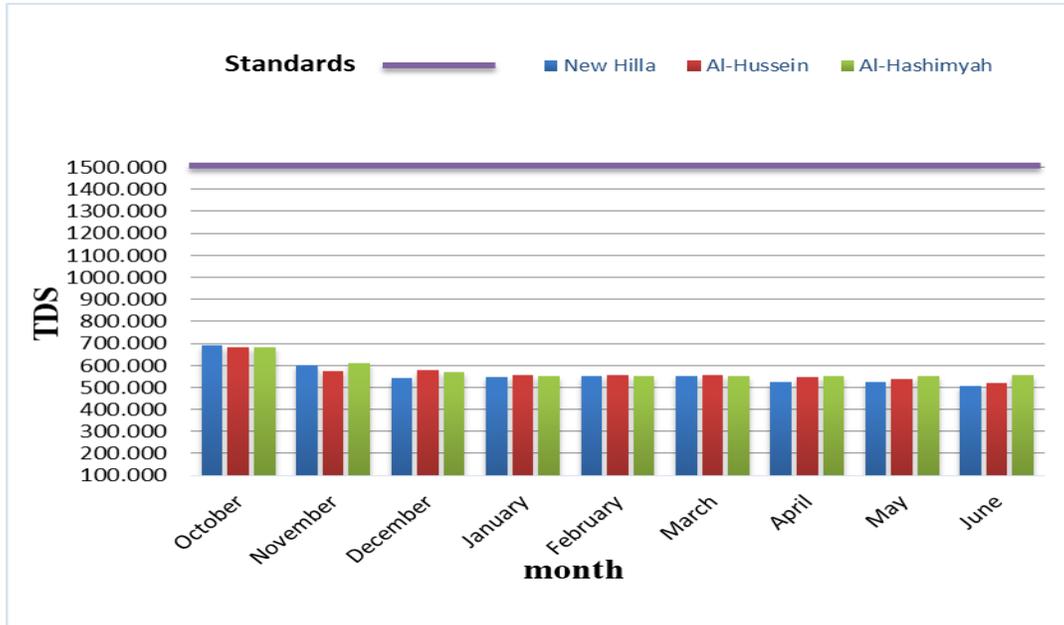


Figure (4.18): Temporal variation in TDS for raw water.



Figure (4.19): Temporal variation in TDS for treated water.

4.3.10 Sodium (Na^+)

From Figures (4.20) and (4.21), all values were according to the Iraqi specifications for drinking and raw water. The high sodium in raw water is due to the fact that sodium is one of the dissolved solid salts (TD5), according to the World Health Organization (WHO), there is no recommended limit for TDS associated with its health effect. . and attendance. In bottled drinking water, the consumption of water does not pose any health concerns to the consumer. Drinking Sodium Sources: Consider drinking more than 20 mg/L (20 parts per million) of water (health and disease risks related to salt and sodium).

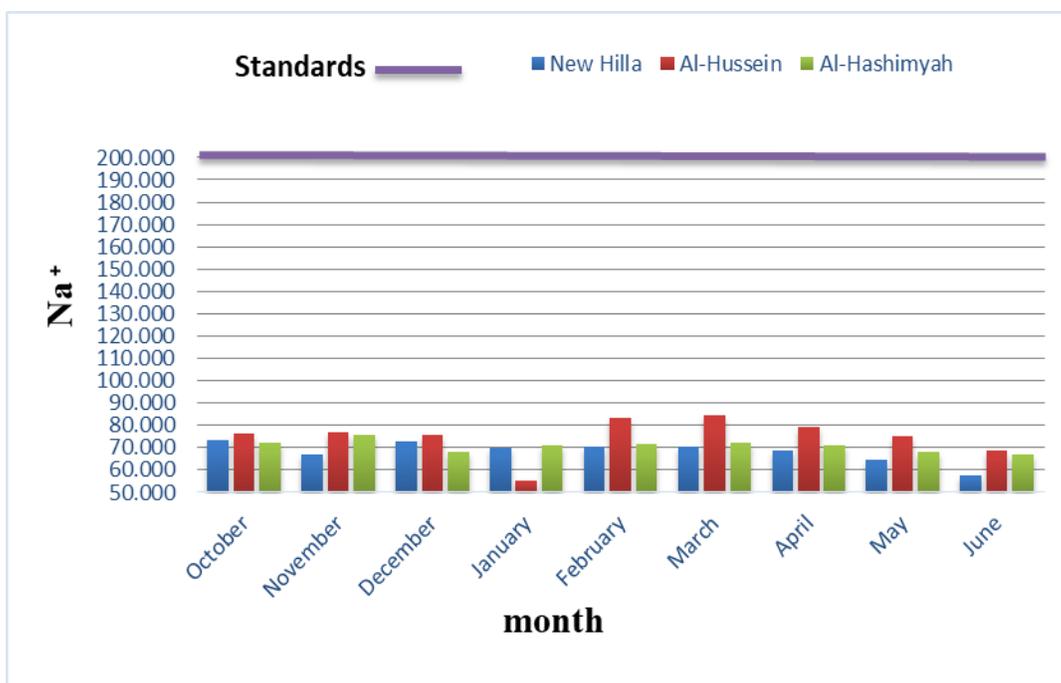


Figure (4.20): Temporal variation in Na^+ for raw water.

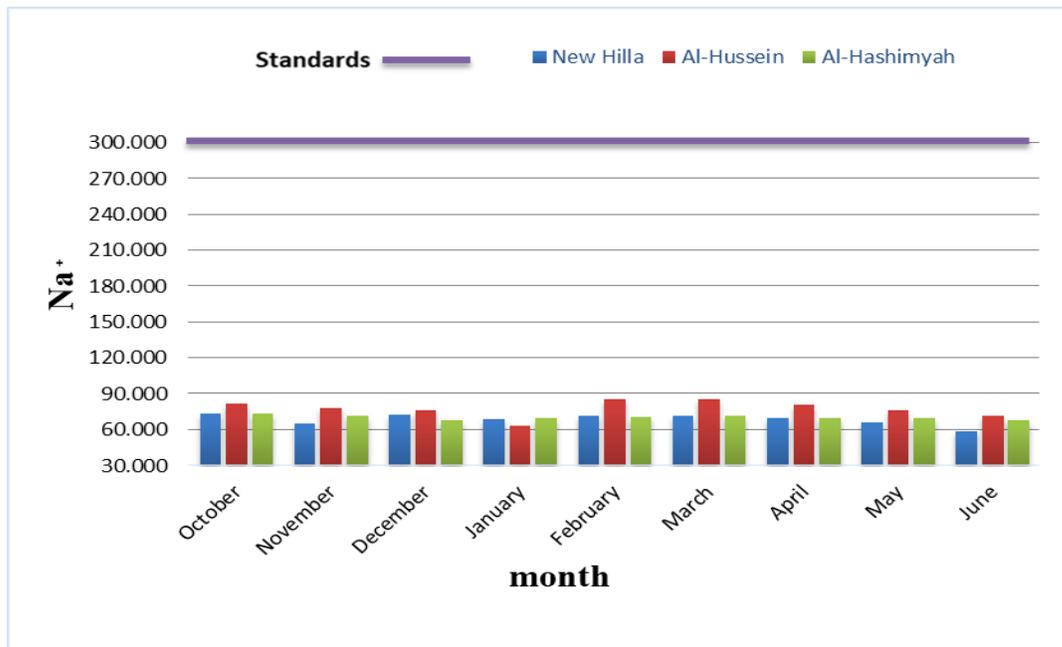


Figure (4.21): Temporal variation in Na^+ for treated water.

4.3.11 Potassium (k^+):

From Figures (4.22) and (4.23), the potassium values were within the Iraqi standard limits. Modern high-yield agriculture depends on the loss of potassium fertilizers. A & cropped. Most agricultural fertilizers contain potassium chloride, so As a result of weather factors, they displace soil in water, which leads to its appearance Potassium stagnation in water for many people with kidneys Their bodies are not able to get rid of excess amounts Potassium, which can be dangerous for them. ,(Smith et al., 1992).

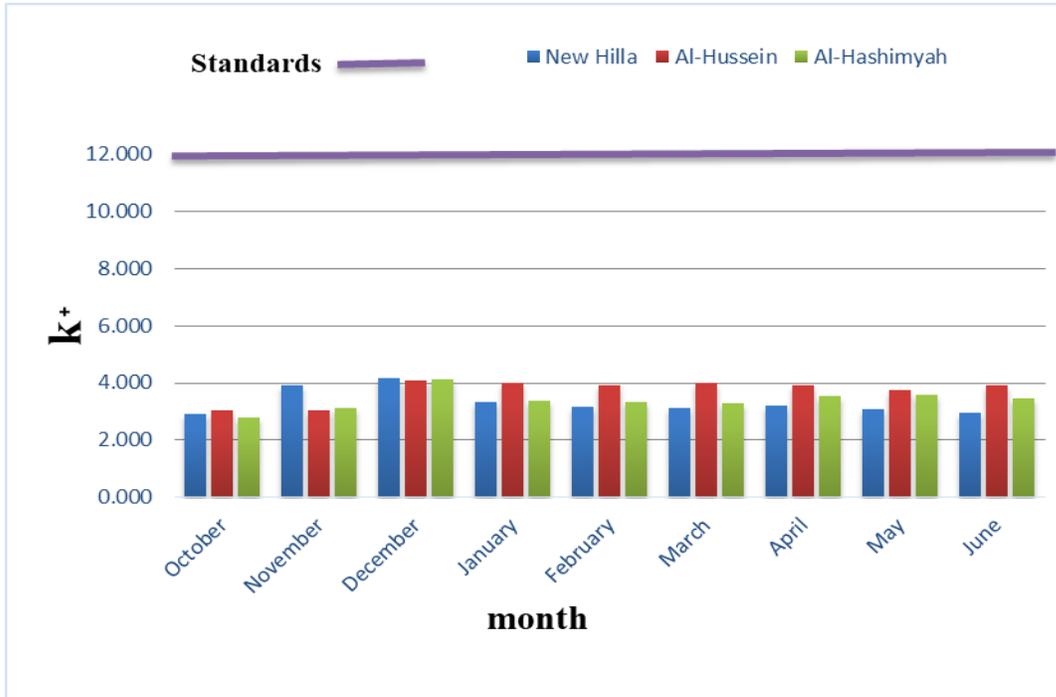


Figure (4.22): Temporal variation in K⁺ for raw water.



Figure (4.23): Temporal variation in K⁺ for treated water.

4.3.12 Biological oxygen demand (BOD)

BOD values in all Water Treatment Plants ranged between (0.25-0.87) mg/L for raw water (As shown in Appendix A). The highest value obtained was (0.87) mg/L in New Hilla Water Treatment Plant in January, while the lowest value obtained was (0.25) mg/L in the New Hilla Treatment Plant in October.

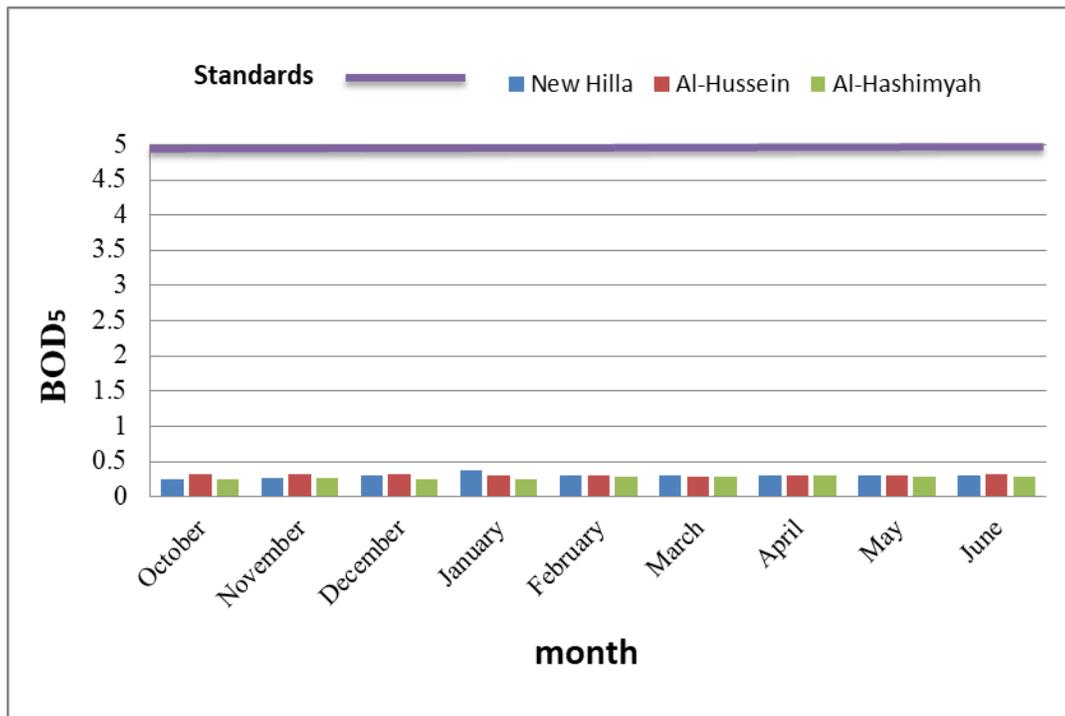


Figure (4.24): Temporal variation in BOD for raw water.

4.4 Water quality indexes calculation

4.4.1 Raw water quality index (RWQI) using weighted arithmetic index method

From Tables (4.1) to (4.3), were the results of the raw water quality index (RWQI) for all stations ranged between (53.977) in Hashimyah Station in January and (138.586) in Al-Hussein Station in October. In addition, the mean river WQI ranged from (87.246) in the Hashimyah Station to (109.006) in the Al-Hussein Station. From these WQI values and according to Table (3.2), the river water was classified as “Severely polluted” to “Unfit and unsuitable for drinking” for the studied stations during the study period for the year (2020 - 2021). Comparing with the water quality results for the previous years (2017, 2018 and 2019), As shown in Appendix C, it is noted find that the (RWQI) value ranged between (65.997) in the Al-Hussein Station in August and (374.304) in the Hashimyah Station in April. In addition, the mean river WQI ranged from (127.57) in the Al-Hussein Station to (131.59) in the Hashimyah Station. Among these WQI values and according to Table (3.2), water was classified as “moderately polluted” to “unfit for human consumption” for the studied stations during the study period of the year (2017), in (2018). The (RWQI) stations showed that the value ranged between (34.798) at Hashimyah Station in June and (239.031) at New Hilla Station in December. In addition, the mean river WQI ranged from (81.213) in the Al-Hussein station to (82.881) in the Hashimyah Station. From these WQI values and according to Table (3.2), the river water was classified as “good water” to “unfit for human consumption”, The value of (RWQI) in (2019) ranged between (53.234) in Hashimyah Station in March and (704.399) in Al-Hussein Station in August. The mean WQI of the river ranged from (151.255) in the Hashimyah Station to (275.539) in the Al-Hussein Station. From these WQI values and according to

Table (3.2), the river water was classified as “moderately polluted” to “unfit for human consumption”. The poor water quality of the Hilla River can be attributed to the presence of human activities, agricultural waste, organic matter pollution (Chauhan and Singh, 2010).

Table (4.1): Raw water for the New Hilla station.

Month	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	BOD ₅	ΣWi	ΣQI Wi= WQI
10	7.466	28.833	13.933	1044.666	406.333	116.333	28.333	307.000	690.666	73.666	2.900	0.25	1	115.289
11	7.533	22.366	9.666	980.333	354.000	84.333	34.666	258.333	600.000	67.000	3.933	0.27	1	92.031
12	7.350	16.200	10.933	914.333	351.666	75.333	39.666	207.333	543.333	72.666	4.166	0.3	1	91.456
1	7.340	17.633	9.333	917.333	316.000	67.333	37.000	213.000	547.333	70.000	3.333	0.87	1	83.969
2	7.700	19.067	8.867	919.000	314.667	66.667	35.000	220.000	551.000	70.667	3.167	0.3	1	91.670
3	7.767	18.533	9.167	918.333	321.333	67.333	34.667	221.667	551.000	70.667	3.100	0.303	1	95.819
4	7.633	21.666	9.167	917.333	311.666	59.333	32.000	212.333	526.333	68.666	3.200	0.31	1	90.725
5	7.600	24.333	9.166	911.666	303.666	60.000	31.333	209.333	523.666	64.666	3.066	0.303	1	89.694
6	7.666	25.500	11.166	898.000	292.666	58.000	29.666	200.333	508.000	57.666	2.933	0.296	1	103.376
Mean														94.892

Table (4.2): Raw water for Al-Hussein station.

Month	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	BOD ₅	∑Wi	∑QI Wi= WQI
10	7.366	29.433	18.600	1035.666	399.666	115.333	27.000	310.000	682.000	76.333	3.033	0.316	1	138.586
11	7.266	24.700	15.133	972.000	325.333	80.333	30.000	233.000	575.666	77.000	3.033	0.326	1	112.362
12	7.666	17.400	10.333	926.666	340.000	74.666	37.000	220.666	580.666	76.000	4.066	0.313	1	100.048
1	7.733	19.066	11.670	926.333	321.666	68.000	37.000	207.666	554.666	55.333	4.000	0.303	1	109.887
2	7.600	23.067	10.600	1034.667	335.333	71.000	37.667	229.333	556.000	83.667	3.933	0.303	1	99.645
3	7.533	20.667	11.000	1034.333	335.667	70.333	38.000	230.000	556.667	84.333	4.000	0.29	1	98.975
4	7.600	22.333	10.666	1031.333	324.000	67.000	37.666	220.333	548.000	79.333	3.900	0.296	1	99.573
5	7.600	23.666	11.000	1014.000	316.000	65.000	34.666	210.000	539.333	75.333	3.766	0.296	1	101.241
6	7.833	28.666	12.666	975.000	312.000	69.000	32.666	198.000	521.000	69.000	3.900	0.32	1	120.740
Mean														109.006

Table (4.3): Raw water for the Hashimyah station.

Month	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO4 ⁻²	TDS	Na ⁺	K ⁺	BOD ₅	∑Wi	∑QI Wi= WQI
10	7.200	28.800	14.000	1037.666	402.666	101.000	28.000	305.333	684.666	72.333	2.800	0.253	1	104.564
11	7.200	24.966	12.000	980.666	342.666	87.000	30.500	270.000	610.000	75.666	3.133	0.263	1	93.366
12	7.466	19.000	12.000	932.333	365.000	76.333	43.666	213.666	570.333	68.000	4.133	0.243	1	102.327
1	7.133	18.000	6.000	949.333	312.333	71.666	38.000	208.333	551.666	71.000	3.366	0.256	1	53.977
2	7.167	18.433	8.600	950.333	314.000	71.333	36.333	212.667	553.667	71.667	3.333	0.277	1	70.152
3	7.200	18.567	10.667	951.667	315.000	70.333	35.333	213.667	554.333	72.000	3.300	0.287	1	83.133
4	7.266	20.000	11.500	948.333	319.000	71.666	36.666	211.333	554.333	71.000	3.533	0.3	1	91.075
5	7.200	22.000	9.666	944.666	317.000	69.000	34.666	209.333	551.333	68.000	3.566	0.286	1	78.092
6	7.400	24.000	13.666	900.000	305.000	70.333	31.000	200.000	555.000	67.000	3.433	0.283	1	108.527
Mean														87.246

4.4.2 Treated water quality index (TWQI)

Tables (4.4) to (4.6), show the variance in the monthly values (WQI) of the treated water for the selected stations during the study period. The treated water quality index (TWQI) ranged between (34.237-58.271),(52.952-76.171) and (31.986-72.142) in New Hilla, Al-Hussein and Hashimyah Stations, respectively. According to Table (3.2), the treated water ranged from “moderately polluted ” to “good water” in the New Hilla Station, from “severely polluted” to “moderately polluted” in the Al-Hussein Station, and from “moderately polluted” to “good water” in the Hashimyah Station. Compared to previous years (2017, 2018, 2019), As shown in Appendix C, it is noted find that the treated water quality index (TWQI) ranged between (36.226 - 75.04), (31.613 - 78.453) and (47.154-97.479) in New Hilla, Al-Hussein and Hashimyah Stations, respectively.

This means that the treated water ranged from “good” to “moderately polluted” at the New Hilla Station, from “good” to “extremely polluted” at the Al-Hussein Station, and from “good” to “extremely polluted” at the Hashimyah Station. According to Table (3.2) in (2017). In (2018) the value of the treated water quality index (TWQI) ranged between (3.188 - 79.021), (23.691 - 120.503) and (25.470 - 112.171) in New Hilla, Al-Hussein and Hashimyah Stations, respectively. This means that the treated water ranges from “excellent” to “extremely polluted” at the New Hilla Station, “excellent” to “unfit for human consumption” at the Al-Hussein Station, and “excellent” to “unfit for human consumption” at the Hashimyah Station According to Table (3.2).In (2019) (TWQI) ranged between (26.891 - 68.733), (45.722 – 318.363) and (33.863 – 437.461) in New Hilla, Al-Hussein and Hashimyah Stations, respectively.

Accordingly, the treated water ranges from “good water” to “moderately polluted” at the New Hilla Station, “good water” to “unfit for human consumption”

at the Al-Hussein Station, and “good water” to “unfit for human consumption” at the Hashimyah Station. According to Table (3.2). New Hilla Treatment Plant was effectively compared to other water treatment plants.

The quality of the treated water along the river (from the NH Station to the HA center) has been reduced due to lower raw water quality and lower water efficiency (E%) in the treatment plant,(Al-Ridah et al., 2020).

Table (4.4): Treated water for the New Hilla station.

Month	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	∑Wi	∑QI Wi=WQI
10	7.433	28.933	1.633	1039.000	396.666	113.333	27.666	307.000	678.666	73.333	2.866	1	53.832
11	7.466	22.766	1.633	986.000	353.666	82.333	35.666	257.333	602.666	65.333	3.833	1	55.307
12	7.266	16.933	0.500	913.666	346.666	75.333	37.000	200.666	544.666	72.666	4.166	1	34.237
1	7.350	17.666	0.433	919.666	311.666	65.666	36.333	205.333	546.666	69.333	3.366	1	36.690
2	7.610	19.500	0.467	919.000	315.000	65.667	35.333	216.333	550.000	71.667	3.267	1	51.240
3	7.743	19.067	0.500	919.667	319.333	66.667	34.667	220.000	551.667	71.333	3.167	1	58.271
4	7.633	22.333	0.533	918.333	313.000	61.000	31.333	211.666	528.000	70.000	3.266	1	53.765
5	7.666	25.000	0.600	914.000	304.666	61.000	31.000	207.666	527.000	66.333	3.166	1	56.692
6	7.600	25.000	0.300	901.333	294.333	59.333	31.000	200.333	506.666	59.000	3.000	1	50.378
mean													50.046

Table (4.5): Treated water for Al-Hussein station.

Month	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	∑Wi	∑QI Wi=WQI
10	7.466	29.033	4.133	1072.333	410.333	117.333	26.666	304.666	705.000	81.666	3.100	1	76.171
11	7.433	24.400	3.500	969.666	339.666	81.000	32.000	230.000	574.666	78.000	3.166	1	67.579
12	7.500	17.500	3.333	931.333	342.000	74.666	37.666	215.666	584.000	76.333	4.133	1	69.583
1	7.666	18.900	1.266	952.333	324.666	70.666	38.666	211.000	582.666	63.333	4.133	1	62.275
2	7.500	22.833	2.433	1044.333	342.333	71.000	40.000	232.000	583.667	85.333	4.000	1	63.876
3	7.400	19.833	1.833	1041.333	340.000	70.667	39.333	232.333	583.000	86.000	4.100	1	52.952
4	7.500	21.000	1.733	1037.666	330.333	68.666	39.000	222.000	562.333	81.333	3.900	1	57.404
5	7.600	21.666	1.466	1020.666	321.000	66.666	36.000	212.333	552.000	76.333	3.833	1	60.574
6	7.733	28.333	1.333	1011.000	316.666	70.333	33.666	202.000	526.000	71.666	3.633	1	68.300
mean													64.302

Table (4.6): Treated water for the Hashimyah station.

Month	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	∑Wi	∑QI Wi=WQI
10	7.200	28.566	5.000	1039.333	394.333	112.000	28.666	304.666	688.666	73.333	2.666	1	67.848
11	7.366	24.233	2.833	1002.000	360.666	88.666	33.666	265.333	660.000	71.666	3.133	1	58.706
12	7.400	20.333	4.200	942.333	364.000	75.666	43.333	209.000	581.000	68.000	4.100	1	72.142
1	7.166	17.866	1.066	947.666	311.000	70.333	36.000	213.000	583.000	69.666	3.333	1	31.986
2	7.267	18.267	1.067	949.333	313.333	70.333	36.666	213.000	576.000	71.000	3.300	1	37.467
3	7.267	18.267	1.133	950.333	313.667	69.333	36.333	212.333	577.000	71.333	3.300	1	37.981
4	7.300	19.666	1.000	949.000	317.000	71.000	37.333	210.000	560.333	70.333	3.500	1	39.556
5	7.200	21.333	1.133	946.666	315.000	69.333	36.000	208.333	557.000	69.666	3.500	1	35.767
6	7.300	23.666	0.966	902.666	311.000	69.666	32.666	197.333	558.333	67.666	3.533	1	33.430
mean													46.098

4.4.3 Treatment plants efficiency

The mean efficiency (E%) was calculated using equation (3.11). As shown in the Table(4.7),the efficiency of the water treatment plant for Al-Hilla and Al-Hashimyah plants was almost the same, while it decreased in Al-Hussein plant.

Table (4.7): Mean Efficiency (E %) of the Stations.

Year	(2020-2021)		
Station	NH	HE	HA
E %	47.130	40.780	47.038

While in previous years (2017, 2018 and 2019), the efficiency of the stations was shown in Table (4.8).

Table (4.8): Mean Efficiency (E %) of the Stations.

Year	2017			2018			2019		
Station	NH	HE	HA	NH	HE	HA	NH	HE	HA
E %	52.469	49.96	40.38	69.22	37.95	35.79	79.57	45.11	28.94

From the above Tables, the decrease in the efficiency of the stations as compared to previous years (2017, 2018 and 2019), because of some water difficulties in Iraq that occur naturally, such as seasonal floods and droughts. However, the most devastating problems are man-made as well as inefficient agricultural practices, in addition to the climate change.

4.4.4. Water quality index using the Canadian method

Tables (4.9) to (4.11), show the CCME WQI values where the raw water quality was (81.232), (79.307) and (80.931) for the three stations (New Hilla, Al-Hussein and Hashimyah Stations), respectively. This indicates that the water quality can be classified as 'good' for New Hilla, 'acceptable' for Al-Hussein and

'good' for Hashimyah. This is because some standards for raw water samples such as Turb, Ca and EC exceed water quality standards and human actions also affect water quality, with sewage and agricultural runoff contamination from lands near the river causing this to happen.

Table (4.9): Raw water for the New Hilla station.

Month	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	k ⁺	BOD ₅	CCMEWQI
10	7.466	28.833	13.933	1044.666	406.333	116.333	28.333	307.000	690.666	73.666	2.900	0.25	81.232
11	7.533	22.366	9.666	980.333	354.000	84.333	34.666	258.333	600.000	67.000	3.933	0.27	
12	7.350	16.200	10.933	914.333	351.666	75.333	39.666	207.333	543.333	72.666	4.166	0.3	
1	7.340	17.633	9.333	917.333	316.000	67.333	37.000	213.000	547.333	70.000	3.333	0.87	
2	7.700	19.067	8.867	919.000	314.667	66.667	35.000	220.000	551.000	70.667	3.167	0.3	
3	7.767	18.533	9.167	918.333	321.333	67.333	34.667	221.667	551.000	70.667	3.100	0.303	
4	7.633	21.666	9.167	917.333	311.666	59.333	32.000	212.333	526.333	68.666	3.200	0.31	
5	7.600	24.333	9.166	911.666	303.666	60.000	31.333	209.333	523.666	64.666	3.066	0.303	
6	7.666	25.500	11.166	898.000	292.666	58.000	29.666	200.333	508.000	57.666	2.933	0.296	
slandered	6.5-8.5	30	5	1000	500	50	50	400	1500	200	12	5	

Table (4.10): Raw water for Al-Hussein station.

Month	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	k ⁺	BOD ₅	CCMEWQI
10	7.366	29.433	18.600	1035.666	399.666	115.333	27.000	310.000	682.000	76.333	3.033	0.316	79.307
11	7.266	24.700	15.133	972.000	325.333	80.333	30.000	233.000	575.666	77.000	3.033	0.326	
12	7.666	17.400	10.333	926.666	340.000	74.666	37.000	220.666	580.666	76.000	4.066	0.313	
1	7.733	19.066	11.670	926.333	321.666	68.000	37.000	207.666	554.666	55.333	4.000	0.303	
2	7.600	23.067	10.600	1034.667	335.333	71.000	37.667	229.333	556.000	83.667	3.933	0.303	
3	7.533	20.667	11.000	1034.333	335.667	70.333	38.000	230.000	556.667	84.333	4.000	0.29	
4	7.600	22.333	10.666	1031.333	324.000	67.000	37.666	220.333	548.000	79.333	3.900	0.296	
5	7.600	23.666	11.000	1014.000	316.000	65.000	34.666	210.000	539.333	75.333	3.766	0.296	
6	7.833	28.666	12.666	975.000	312.000	69.000	32.666	198.000	521.000	69.000	3.900	0.32	
slandered	6.5-8.5	30	5	1000	500	50	50	400	1500	200	12	5	

Table (4.11): Raw water for the Hashimyah station.

Month	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	k ⁺	BOD ₅	CCMEWQI
10	7.200	28.800	14.000	1037.666	402.666	101.000	28.000	305.333	684.666	72.333	2.800	0.253	80.931
11	7.200	24.966	12.000	980.666	342.666	87.000	30.500	270.000	610.000	75.666	3.133	0.263	
12	7.466	19.000	12.000	932.333	365.000	76.333	43.666	213.666	570.333	68.000	4.133	0.243	
1	7.133	18.000	6.000	949.333	312.333	71.666	38.000	208.333	551.666	71.000	3.366	0.256	
2	7.167	18.433	8.600	950.333	314.000	71.333	36.333	212.667	553.667	71.667	3.333	0.277	
3	7.200	18.567	10.667	951.667	315.000	70.333	35.333	213.667	554.333	72.000	3.300	0.287	
4	7.266	20.000	11.500	948.333	319.000	71.666	36.666	211.333	554.333	71.000	3.533	0.3	
5	7.200	22.000	9.666	944.666	317.000	69.000	34.666	209.333	551.333	68.000	3.566	0.286	
6	7.400	24.000	13.666	900.000	305.000	70.333	31.000	200.000	555.000	67.000	3.433	0.283	
slanderred	6.5-8.5	30	5	1000	500	50	50	400	1500	200	12	5	

Tables (4.12) to (4.14), showed that drinking water was of high value, as the value of treated water ranged between 94.620 and 94.718, indicating that the quality of treated water in three plants was “good”. The higher concentration of parameters may be due to local sewage pollution or elevated presence due to river elevation or rain velocities and higher soil filtration.

In comparison with the CCME WQI values for all stations for the previous years (2017, 2018 and 2019) As shown in Appendix C, the CCME WQI results for raw water ranged between 68.116 and 79.933, indicating that the water quality can be classified as “fair” for drinking as per Table (2.3). The results showed that the WQI value in CCME for treated water ranged between 81.249 and 94.121 indicating that the quality of treated water in three plants during three years was “good”.

Table (4.12): Treated water for the New Hilla station.

Month	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO4 ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
10	7.433	28.933	1.633	1039.000	396.666	113.333	27.666	307.000	678.666	73.333	2.866	94.718
11	7.466	22.766	1.633	986.000	353.666	82.333	35.666	257.333	602.666	65.333	3.833	
12	7.266	16.933	0.500	913.666	346.666	75.333	37.000	200.666	544.666	72.666	4.166	
1	7.350	17.666	0.433	919.666	311.666	65.666	36.333	205.333	546.666	69.333	3.366	
2	7.610	19.500	0.467	919.000	315.000	65.667	35.333	216.333	550.000	71.667	3.267	
3	7.743	19.067	0.500	919.667	319.333	66.667	34.667	220.000	551.667	71.333	3.167	
4	7.633	22.333	0.533	918.333	313.000	61.000	31.333	211.666	528.000	70.000	3.266	
5	7.666	25.000	0.600	914.000	304.666	61.000	31.000	207.666	527.000	66.333	3.166	
6	7.600	25.000	0.300	901.333	294.333	59.333	31.000	200.333	506.666	59.000	3.000	
Standard	6.5-8.5	25	5	2000	500	150	100	400	1000	300	10	

Table (4.13): Treated water for Al-Hussein station.

Month	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
10	7.466	29.033	4.133	1072.333	410.333	117.333	26.666	304.666	705.000	81.666	3.100	94.620
11	7.433	24.400	3.500	969.666	339.666	81.000	32.000	230.000	574.666	78.000	3.166	
12	7.500	17.500	3.333	931.333	342.000	74.666	37.666	215.666	584.000	76.333	4.133	
1	7.666	18.900	1.266	952.333	324.666	70.666	38.666	211.000	582.666	63.333	4.133	
2	7.500	22.833	2.433	1044.333	342.333	71.000	40.000	232.000	583.667	85.333	4.000	
3	7.400	19.833	1.833	1041.333	340.000	70.667	39.333	232.333	583.000	86.000	4.100	
4	7.500	21.000	1.733	1037.666	330.333	68.666	39.000	222.000	562.333	81.333	3.900	
5	7.600	21.666	1.466	1020.666	321.000	66.666	36.000	212.333	552.000	76.333	3.833	
6	7.733	28.333	1.333	1011.000	316.666	70.333	33.666	202.000	526.000	71.666	3.633	
Standard	6.5-8.5	25	5	2000	500	150	100	400	1000	300	10	

Table (4.14): Treated water for the Hashimyah station.

Month	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO4 ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
10	7.200	28.566	5.000	1039.333	394.333	112.000	28.666	304.666	688.666	73.333	2.666	94.718
11	7.366	24.233	2.833	1002.000	360.666	88.666	33.666	265.333	660.000	71.666	3.133	
12	7.400	20.333	4.200	942.333	364.000	75.666	43.333	209.000	581.000	68.000	4.100	
1	7.166	17.866	1.066	947.666	311.000	70.333	36.000	213.000	583.000	69.666	3.333	
2	7.267	18.267	1.067	949.333	313.333	70.333	36.666	213.000	576.000	71.000	3.300	
3	7.267	18.267	1.133	950.333	313.667	69.333	36.333	212.333	577.000	71.333	3.300	
4	7.300	19.666	1.000	949.000	317.000	71.000	37.333	210.000	560.333	70.333	3.500	
5	7.200	21.333	1.133	946.666	315.000	69.333	36.000	208.333	557.000	69.666	3.500	
6	7.300	23.666	0.966	902.666	311.000	69.666	32.666	197.333	558.333	67.666	3.533	
Standard	6.5-8.5	25	5	2000	500	150	100	400	1000	300	10	

4.5 Score water quality comparing of the two indices

Table (4.15) summarizes the water quality at each specific station using the weighted calculation method and CCME water quality indicators. Meanwhile, the difference in points is clearly visible in the condition of raw water in all stations, so the water quality ranged from “highly polluted” to “unsafe for drinking” by the method of weighted calculation, while it was “good” to “fair”. Canadian style. The study thought that the difference in scores might be related to the index theory on which the standard was built and that CCME gave a higher level of water quality that could be considered and thus a more flexible weighted calculation method. Although indicators are used to determine water quality worldwide, no indicator has been accepted as universal.

Table (4.15): Drinking of water quality of each station and each index.

WQI	(2020-2021)					
	NH		HE		HA	
	RW	TW	RW	TW	RW	TW
Mean of weighted arithmetic	94.892 Severely polluted	50.046 Good water	109.006 Unfit and unsuitable for drinking	64.302 Moderately polluted	87.246 Severely polluted	47.028 Good water
CCME	81.232 Good	94.718 Good	79.307 Fair	94.620 Good	80.931 Good	94.718 Good

While in previous years, we note the convergence of treated water indicators for all stations for the years (2017, 2018 and 2019). At the same time, the difference in points is clearly visible in the case of raw water in all stations, and therefore the water quality is "inadequate", dangerous and "fair". As in the Table (4.16). This difference in the water quality index values for the mathematical

method and the Canadian method is similar to the study conducted by ((Al-Ridah et al., 2020)) where the raw water values for all stations were (New Hilla, Al-Hussein and Al-Hashimyah)(unfit and unsuitable for drinking) according to the weighted arithmetic index method while according to the Canadian method was (fair). The major reasons of deteriorating water quality are the discharge from drainage tributaries, city wastewater and other forms of intensives human activities which are increasing in trend from north to south. This comes in accordance with the findings of ,(Fulazzaky, 2009) and (Ouyang et al., 2006), who referred to these factors as main reasons for deteriorated water quality.

Table (4.16): Drinking of water quality of each station and each index.

WQI	2017						2018						2019					
	NH		HE		HA		NH		HE		HA		NH		HE		HA	
	RW	TW	RW	TW	RW	TW	RW	TW	RW	TW	RW	TW	RW	TW	RW	TW	RW	TW
Mean of weighted arithmetic	129.352 (Unfit)	52.506 (Moderately)	127.57 (Unfit)	55.69 (Moderately)	131.59 (Unfit)	68.25 (Moderately)	82.098 (Severely)	26.653 (Good)	81.213 (Severely)	47.79 (Good)	82.881 (Severely)	52.144 (Moderately)	252.79 (Unfit)	43.808 (Good)	275.539 (Unfit)	136.095 (Unfit)	151.255 (Unfit)	115.432 (Unfit)
CCME	79.933 (Fair)	94.119 (Good)	75.719 (Fair)	92.811 (Good)	75.112 (Fair)	94.121 (Good)	73.477 (Fair)	93.910 (Good)	74.375 (Fair)	89.057 (Good)	73.732 (Fair)	88.553 (Good)	8.116 (Fair)	93.492 (Good)	70.418 (Fair)	81.407 (Good)	71.543 (Fair)	81.249 (Good)

4.6 Statistical analysis

4.6.1 Raw water

4.6.1.1 Test of normality

Table(4.17) Test of normality of New Hilla station.

	Statistic	df	Sig.
WQI	0.81	8	0.45
pH	0.91	8	0.36
Temp	0.97	8	0.65
Turb	0.79	8	0.27
EC	0.71	8	0.42
TH	0.86	8	0.19
Ca ⁺²	0.79	8	0.23
Mg ⁺²	0.97	8	0.72
so ₄ ⁻²	0.73	8	0.36
TDS	0.79	8	0.26
Na ⁺	0.91	8	0.35
K ⁺	0.84	8	0.18
BOD ₅	0.51	8	0.53

Table(4.18) Test of normality of Al-Hussein station.

	Statistic	df	Sig.
WQI	0.784	9	0.34
pH	0.946	9	0.65
Temp	0.958	9	0.78
Turb	0.758	9	0.32
EC	0.818	9	0.12
TH	0.729	9	0.24
Ca ⁺²	0.649	9	0.29
Mg ⁺²	0.831	9	0.46
so ₄ ⁻²	0.734	9	0.34
TDS	0.758	9	0.27
Na ⁺	0.845	9	0.66
K ⁺	0.709	9	0.52
BOD ₅	0.949	9	0.68

Table(4.19) Test of normality of Al- Hashimyah station.

	Statistic	df	Sig.
WQI	.950	9	.690
pH	.811	9	.027
Temp	.875	9	.141
Turb	.946	9	.650
EC	.859	9	.093
TH	.782	9	.013
Ca ⁺²	.708	9	.002
Mg ⁺²	.961	9	.813
so ₄ ⁻²	.678	9	.001
TDS	.632	9	.000
Na ⁺	.928	9	.466
K ⁺	.933	9	.515
BOD ₅	.951	9	.702

From Tables (4.17, 4.18, 4.19) the Significant value was greater than 0.05 ,so acceptable the null hypothesis, therefore, all the data are subject to a normal distribution.

4.6.1.2 Correlation matrix

The following is a table of characteristics and a matrix of quality correlation using the Pearson correlation coefficient, which shows the extent of the relationship between each characteristic and its importance using the significance level of 0.05 to show the extent of the relationship between each characteristic and its importance.

Table: (4.20) Correlation matrix of the data of New Hilla station.

		WQI	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	so4 ⁻²	TDS	Na ⁺	K ⁺	BOD ₅
WQI	Pearson Correlation	1												
	Sig.													
pH	Pearson Correlation	.76*	1											
	Sig.	.043												
Temp	Pearson Correlation	.758	.169	1										
	Sig.	.018	.663											
Turb	Pearson Correlation	.875**	.361	.620	1									
	Sig.	.002	.340	.075										
EC	Pearson Correlation	.660	.267	.576	.702*	1								
	Sig.	.053	.487	.104	.035									
TH	Pearson Correlation	.582	.463	.308	.742*	.912**	1							
	Sig.	.100	.210	.420	.022	.001								
Ca ⁺²	Pearson Correlation	.676	.396	.446	.789*	.961**	.974**	1						
	Sig.	.045	.292	.229	.011	.000	.000							
Mg ⁺²	Pearson Correlation	.703	.405	.943**	.457	.392	.087	.238	1					
	Sig.	.035	.279	.000	.216	.297	.824	.537						
so4 ⁻²	Pearson Correlation	.678*	.191	.574	.679*	.995**	.893**	.952**	.410	1				
	Sig.	.045	.623	.106	.044	.000	.001	.000	.273					
TDS	Pearson Correlation	.650	.294	.472	.703*	.983**	.936**	.982**	.296	.986**	1			
	Sig.	.058	.443	.199	.035	.000	.000	.000	.439	.000				

Na ⁺	Pearson Correlation	.004	.371	.355	.157	.440	.644	.548	.413	.446	.550	1		
	Sig.	.993	.325	.349	.687	.237	.061	.127	.269	.229	.125			
K ⁺	Pearson Correlation	.444	.531	.571	.146	.045	.229	.055	.776*	.102	.040	.277	1	
	Sig.	.231	.141	.109	.708	.909	.553	.888	.014	.793	.918	.470		
BOD ₅	Pearson Correlation	.57*	.511	.414	.261	.239	.235	.202	.389	.253	.178	.096	.020	1
	Sig.	.032	.160	.268	.497	.535	.542	.603	.301	.510	.646	.805	.960	

Table: (4.21) Correlation matrix of the data of Al-Hussein station.

		WQI	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	so4 ⁻²	TDS	Na ⁺	K ⁺	BOD ₅
WQI	Pearson Correlation	1												
	Sig.													
pH	Pearson Correlation	.73*	1											
	Sig.	.041												
Temp	Pearson Correlation	.772	.258	1										
	Sig.	.015	.503											
Turb	Pearson Correlation	.916**	.635	.720*	1									
	Sig.	.001	.066	.029										
EC	Pearson Correlation	.038	.359	.450	.158	1								
	Sig.	.923	.343	.224	.686									
TH	Pearson Correlation	.638	.517	.342	.712*	.330	1							
	Sig.	.064	.154	.367	.031	.386								
Ca ⁺²	Pearson Correlation	.822	.606	.544	.903**	.232	.939**	1						
	Sig.	.007	.084	.130	.001	.548	.000							
Mg ⁺²	Pearson Correlation	.884	.568	.791*	.948**	.087	.549	.795*	1					
	Sig.	.002	.111	.011	.000	.825	.126	.010						
so4 ⁻²	Pearson Correlation	.662*	.683*	.453	.802**	.438	.968**	.956**	.650	1				

	Sig	.05	.043	.221	.009	.238	.000	.000	.058					
TDS	Pearson Correlation	.676	.626	.324	.795*	.192	.968**	.965**	.652	.963**	1			
	Sig.	.045	.071	.395	.011	.620	.000	.000	.057	.000				
Na ⁺	Pearson Correlation	.86**	.454	.091	-.063	.714	.234	.111	.069	.299	.129	1		
	Sig.	.005	.220	.816	.871	.031	.545	.776	.860	.434	.740			
K ⁺	Pearson Correlation	.690	.840**	.639	.906**	.212	.544	.762*	.908**	.704*	.677*	.116	1	
	Sig.	.040	.005	.064	.001	.584	.130	.017	.001	.034	.045	.767		
BOD ₅	Pearson Correlation	.622	.258	.469	.616	.422	.194	.461	.723*	.226	.322	.219	.599	1
	Sig.	.073	.503	.203	.078	.257	.617	.212	.028	.560	.398	.572	.088	

Table: (4.22) Correlation matrix of the data of Al- Hashimyah station.

		WQI	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	so4 ⁻²	TDS	Na ⁺	K ⁺	BOD ₅
WQI	Pearson Correlation	1												
	Sig.													
pH	Pearson Correlation	.711*	1											
	Sig.	.032												
Temp	Pearson Correlation	.631	.018	1										
	Sig.	.069	.964											
Turb	Pearson Correlation	.982**	.572	.719*	1									
	Sig.	.000	.108	.029										
EC	Pearson Correlation	.080	.505	.592	.205	1								
	Sig.	.838	.165	.093	.596									
TH	Pearson Correlation	.508	.146	.614	.530	.760*	1							
	Sig.	.163	.708	.079	.142	.018								
Ca ⁺²	Pearson Correlation	.446	.116	.800**	.526	.878*	.896**	1						
	Sig.	.229	.766	.010	.146	.002	.001							
Mg ⁺²	Pearson Correlation	.328	.338	.840**	.474	.502	.211	.562	1					
	Sig.	.389	.373	.005	.197	.168	.586	.115						
so4 ⁻²	Pearson Correlation	.68*	.261	.801*	.473	.922*	.826**	.980**	.638	1				

	Sig	.03	.498	.009	.198	.000	.006	.000	.065					
TDS	Pearson Correlation	.467	.121	.833**	.556	.881*	.893**	.992**	.608	.974**	1			
	Sig.	.205	.757	.005	.120	.002	.001	.000	.083	.000				
Na ⁺	Pearson Correlation	.174	.624	.212	.058	.669*	.244	.518	.380	.627	.457	1		
	Sig.	.655	.072	.585	.882	.049	.527	.153	.313	.071	.217			
K ⁺	Pearson Correlation	.028	.670	.614	.143	.712*	.244	.605	.863**	.695*	.634	.647	1	
	Sig.	.944	.048	.079	.713	.031	.527	.084	.003	.038	.067	.060		
BOD ₅	Pearson Correlation	.082	.162	.191	.019	.362	.672*	.556	.164	.451	.504	.117	.043	1
	Sig.	.833	.676	.622	.961	.339	.047	.120	.674	.223	.166	.765	.913	

4.6.1.3 Multiple linear regression analysis

Multiple linear regression analysis involves the necessity of an dependent factor and a set of independent factors, and therefore the necessity of a relationship between these factors. Here, the main dependent variable in the multi-line regression analysis model is the quality (WQI) resulting from the influence of multiple factors, namely (characteristics), regression analysis results, analysis of variance and multiplier values below for the period (October 2020-June 2021).

Table (4.23) :Estimated model of three stations.

Station	R ²	Std. Error of the Estimate
New Hilla	0.89	0.232
Al-Hussein	0.90	0.119
Al-Hashimyah	0.88	0.456

It is clear from the Table (4.23), which represent a summary of the multiple linear regression model of the effect of the characteristics on the quality of treated water for the stations (New Hilla, Al Hussein, Al Hashimyah), where we note that the value of R² was very good, which statistically indicates that the characteristics explained the effect in a very good degree, and this in itself represents A high level of measurement to generalize the results in the future depending on the accuracy of the measurement.

4.6.1.4 Variance analysis

It represents the analysis of variance table, which depends on the presence of differences between the independent factors (characteristics) that cause a change in the dependent factor quality (WQI). The analysis of variance table also gives the significance of constructing the linear regression model with regard to the relationship built between the independent variables (characteristics) for the period (October 2020-June 2021).

Table (4.24) :Analysis of Variance Schedule of three stations.

Station	Sum of Squares		df	Mean Square	F	Sig.
New Hilla	Regression	682.71	4	170.7	3178.32	0.00
	Residual	0.22	4	0.054		
	Total	682.93	8			
Al-Hussein	Regression	1442.5	4	360.62	25622.2	0.001
	Residual	0.06	4	0.014		
	Total	1442.5	8			
Al-Hashimyah	Regression	2531.1	3	843.7	4056.14	0.002
	Residual	1.04	5	0.21		
	Total	2532.11	8			

Table(4.24), there were significant values obtained as a result of the analysis of variance that did not exceed the default level of significance 0.05, which indicates the importance of building a multiple linear regression model.

4.6.1.5 Table of influence coefficients for multiple linear regression model

Table of multiple linear regression coefficients represents the values of the indicators of the independent variables (characteristics) and their effect on the WQI of the dependent variable, i.e. when the quality index changes, which factors have

the greatest influence and which caused a change in the water quality index and whether it is statistically significant or not.

Table (4.25) :Influence coefficients for the regression line of three stations.

Station	Model
New Hilla	$WQI = -225.5 + 5.74Turb + 33.6pH + 0.03So_4^{-2} + 3.26BOD_5$
Al-Hussein	$WQI = -296.4 + 6.05Turb + 42.68 pH + 0.05Na^{+1} + 0.013So_4^{-2}$
Al-Hashimyah	$WQI = -290.2 + 5.65Turb + 42.67 pH + 0.03 So_4^{-2}$

4.6.2 Treated water

4.6.2.1 Test of normality

Table(4.26) Test of normality of New Hilla station.

Statistic	df	Sig.	
WQI	0.8	9	0.20
pH	0.94	9	0.65
Temp	0.94	9	0.67
Turb	0.67	9	0.61
EC	0.68	9	0.41
TH	0.86	9	0.97
Ca ⁺²	0.74	9	0.34
Mg ⁺²	0.90	9	0.26
so ₄ ⁻²	0.72	9	0.64
TDS	0.8	9	0.21
Na ⁺	0.87	9	0.44
K ⁺	0.88	9	0.56

Table(4.27) Test of normality of Al-Hussein station.

	Statistic	df	Sig.
WQI	0.8	9	0.25
pH	0.94	9	0.65
Temp	0.94	9	0.66
Turb	0.67	9	0.61
EC	0.68	9	0.71
TH	0.86	9	0.97
Ca ⁺²	0.74	9	0.34
Mg ⁺²	0.90	9	0.26
so ₄ ⁻²	0.72	9	0.83
TDS	0.80	9	0.21
Na ⁺	0.87	9	0.44
K ⁺	0.88	9	0.56

Table(4.28) Test of normality of Al- Hashimyah station.

	Statistic	df	Sig.
WQI	0.82	9	0.38
pH	0.95	9	0.69
Temp	0.88	9	0.92
Turb	0.71	9	0.25
EC	0.82	9	0.38
TH	0.74	9	0.84
Ca ⁺²	0.64	9	0.25
Mg ⁺²	0.92	9	0.45
so ₄ ⁻²	0.68	9	0.91
TDS	0.74	9	0.45
Na ⁺	0.96	9	0.87
K ⁺	0.92	9	0.41

From Tables (4.26, 4.27, 4.28) the Significant value was greater than 0.05 ,so acceptable the null hypothesis, therefore, all the data are subject to a normal distribution.

4.6.2.2 Correlation matrix

The following is a table of characteristics and a matrix of quality correlation using the Pearson correlation coefficient, which shows the extent of the relationship between each characteristic and its importance using the significance level of 0.05 to show the extent of the relationship between each characteristic and its importance.

Table: (4.29) Correlation matrix of the data of New Hilla station.

		WQI	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	so4 ⁻²	TDS	Na ⁺	K ⁺
WQI	Pearson Correlation	1											
	Sig.												
pH	Pearson Correlation	.823**	1										
	Sig.	.006											
Temp	Pearson Correlation	.595	.243	1									
	Sig.	.091	.529										
Turb	Pearson Correlation	.83**	.258	.548	1								
	Sig.	.004	.502	.126									
EC	Pearson Correlation	.270	.286	.592	.949**	1							
	Sig.	.482	.456	.093	.000								
TH	Pearson Correlation	.004	.500	.350	.847**	.909**	1						
	Sig.	.991	.170	.356	.004	.001							
Ca ⁺²	Pearson Correlation	.062	.441	.483	.845**	.948**	.974**	1					
	Sig.	.874	.235	.188	.004	.000	.000						
Mg ⁺²	Pearson Correlation	.536	.335	.919**	.295	.422	.228	.367	1				
	Sig.	.137	.378	.000	.440	.257	.556	.331					
so4 ⁻²	Pearson Correlation	.371	.163	.633	.917**	.989**	.881**	.933**	.488	1			
	Sig.	.326	.676	.067	.000	.000	.002	.000	.183				
TDS	Pearson Correlation	.184	.333	.469	.894**	.979**	.941**	.972**	.331	.972**	1		
	Sig.	.636	.381	.203	.001	.000	.000	.000	.385	.000			

Na ⁺	Pearson Correlation	.191	.253	.305	.153	.292	.513	.430	.150	.301	.445	1	
	Sig.	.622	.511	.424	.695	.447	.158	.249	.701	.432	.230		
K ⁺	Pearson Correlation	.554	.590	.622	.037	.149	.136	.063	.762*	.257	.117	.159	1
	Sig.	.122	.095	.073	.926	.702	.728	.873	.017	.504	.765	.682	

Table: (4.30) Correlation matrix of the data of Al-Hussein station.

		WQI	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	so4 ⁻²	TDS	Na ⁺	K ⁺
WQI	Pearson Correlation	1											
	Sig.												
pH	Pearson Correlation	.119	1										
	Sig.	.760											
Temp	Pearson Correlation	.588	.159	1									
	Sig.	.096	.683										
Turb	Pearson Correlation	.698	.623	.292	1								
	Sig.	.036	.073	.446									
EC	Pearson Correlation	.108	.250	.536	.022	1							
	Sig.	.781	.516	.137	.955								
TH	Pearson Correlation	.591	.508	.447	.802**	.446	1						
	Sig.	.094	.163	.228	.009	.228							
Ca ⁺²	Pearson Correlation	.723	.329	.600	.780*	.359	.956**	1					
	Sig.	.028	.387	.087	.013	.343	.000						
Mg ⁺²	Pearson Correlation	.774*	.047	.796*	.623	.230	.672*	.845**	1				
	Sig.	.014	.904	.010	.073	.552	.047	.004					
so4 ⁻²	Pearson Correlation	.492	.522	.503	.727*	.572	.981**	.938**	.673*	1			
	Sig	.178	.149	.168	.027	.107	.000	.000	.047				
TDS	Pearson Correlation	.527	.463	.316	.728*	.370	.973**	.923**	.592	.955**	1		

	Sig.	.145	.210	.407	.026	.328	.000	.000	.093	.000			
Na ⁺	Pearson Correlation	.181	.787*	.114	.381	.658	.409	.203	.018	.459	.285	1	
	Sig.	.642	.012	.771	.311	.054	.274	.601	.964	.213	.457		
K ⁺	Pearson Correlation	.639	.177	.820**	.607	.293	.568	.732*	.924**	.612	.463	.126	1
	Sig.	.064	.648	.007	.083	.445	.110	.025	.000	.080	.210	.748	

Table: (4.31) Correlation matrix of the data of Al- Hashimyah station.

		WQI	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	so4 ⁻²	TDS	Na ⁺	K ⁺
WQI	Pearson Correlation	1											
	Sig.												
pH	Pearson Correlation	.59*	1										
	Sig.	.043											
Temp	Pearson Correlation	.629*	.018	1									
	Sig.	.05	.963										
Turb	Pearson Correlation	.955**	.262	.669*	1								
	Sig.	.000	.496	.049									
EC	Pearson Correlation	.56*	.145	.632	.701*	1							
	Sig.	.023	.709	.068	.035								
TH	Pearson Correlation	.934	.253	.749*	.979**	.799**	1						
	Sig.	.021	.512	.020	.000	.010							
Ca ⁺²	Pearson Correlation	.713	.072	.852**	.833**	.910**	.904**	1					
	Sig.	.031	.854	.004	.005	.001	.001						
Mg ⁺²	Pearson Correlation	.005	.485	.713*	.130	.521	.257	.621	1				
	Sig.	.990	.186	.031	.740	.150	.505	.074					
so4 ⁻²	Pearson Correlation	.609	.119	.786*	.740*	.966**	.840**	.974**	.657	1			
	Sig.	.082	.761	.012	.023	.000	.005	.000	.055				
TDS	Pearson Correlation	.659	.007	.748*	.762*	.935**	.857**	.947**	.592	.979**	1		
	Sig.	.054	.986	.020	.017	.000	.003	.000	.093	.000			

Na ⁺	Pearson Correlation	.65*	.317	.371	.331	.869**	.451	.683*	.577	.797*	.736*	1	
	Sig.	.023	.406	.325	.385	.002	.223	.043	.104	.010	.024		
K ⁺	Pearson Correlation	.011	.529	.536	.200	.749*	.333	.688*	.885**	.782*	.720*	.871**	1
	Sig.	.977	.143	.137	.607	.020	.382	.041	.002	.013	.029	.002	

4.6.2.3 Multiple linear regression analysis

Multiple linear regression analysis involves the necessity of an dependent factor and a set of independent factors, and therefore the necessity of a relationship between these factors. Here, the main dependent variable in the multi-line regression analysis model is the quality (WQI) resulting from the influence of multiple factors, namely (characteristics), regression analysis results, analysis of variance and multiplier values below for the period (October 2020-June 2021).

Table (4.32) :Estimated model of three stations.

Station	R ²	Std. Error of the Estimate
New Hilla	0.92	0.72
Al-Hussein	0.78	0.98
Al-Hashimyah	0.88	0.79

It is clear from the Table (4.32), which represent a summary of the multiple linear regression model of the effect of the characteristics on the quality of treated water for the stations (New Hilla, Al Hussein, Al Hashimyah), where we note that the value of R² was very good, which statistically indicates that the characteristics explained the effect in a very good degree, and this in itself represents A high level of measurement to generalize the results in the future depending on the accuracy of the measurement.

4.6.2.4 Variance analysis

It represents the analysis of variance table, which depends on the presence of differences between the independent factors (characteristics) that cause a change in the dependent factor quality (WQI). The analysis of variance table also gives the significance of constructing the linear regression model with regard to the

relationship built between the independent variables (characteristics) for the period (October 2020-June 2021).

Table (4.33) :Analysis of Variance Schedule of three stations.

Station	Sum of Squares		df	Mean Square	F	Sig.
New Hilla	Regression	594.3	2	297.2	563.7	0.003
	Residual	3.2	6	0.53		
	Total	597.5	8			
Al-Hussein	Regression	233.9	1	233.9	10.5	0.008
	Residual	156.2	7	22.32		
	Total	390.1	8			
Al-Hashimyah	Regression	1810.03	5	362.01	58185.3	0.005
	Residual	0.02	3	0.1		
	Total	1810.1	8			

Table(4.33), there were significant values obtained as a result of the analysis of variance that did not exceed the default level of significance 0.05, which indicates the importance of building a multiple linear regression model.

4.6.2.5 Table of influence coefficients for multiple linear regression model

Table of multiple linear regression coefficients represents the values of the indicators of the independent variables (characteristics) and their effect on the WQI of the dependent variable, i.e. when the quality index changes, which factors have the greatest influence and which caused a change in the water quality index and whether it is statistically significant or not.

Table (4.34) :Influence coefficients for the regression line of three stations.

Station	Model
New Hilla	$WQI = -356.5 + 53.04pH + 9.75Turb$
Al-Hussein	$WQI = 108.5 - 1.231Mg^{+2}$
Al-Hashimyah	$WQI = -355.7 + 8.19Turb + 56.01pH + 0.35Temp - .014EC - 0.22Na^{+}$

Chapter Five

Conclusion and Recommendations

Chapter Five

Conclusions and Recommendations

5.1 Conclusions

Based on the overall results analysis of this study, the following conclusions are extracted:

- 1- Most of the water quality parameters measured along the river were within the acceptable Iraqi standard limits with the exception of (calcium, turbidity, electrical conductivity of raw water and temperature of treated water.
- 2- The values of the raw water parameters for the three stations (New Hilla, Al-Hussein, AL-Hashimyah) range from (7.133-7.833) with respect to pH,(16.2- 29.433) for temperature,(6- 18.6) for turbidity,(898- 1044.666) for electricity,(292.666- 406.333) for total hardness,(58- 116.333) for calcium ,(27- 43.666) for magnesium,(198- 310) for sulfate,(508- 690.666) for total dissolved solid, (55.333- 84.333) for sodium,(2.8- 4.166) for potassium and (0.243- 0.870) for biological oxygen demand .
- 3- The values of the treated water parameters for the three stations(New Hilla, Al-Hussein, AL-Hashimyah) range from (7.166-7.743) with respect to pH,(16.933- 29.033)for temperature,(0.3- 5) for turbidity,(901.333- 1072.333) for electricity,(294.333- 410.333) for total hardness,(59.333- 117.333) for calcium,(26.666- 43.333) for magnesium,(197.333- 307) for sulfate,(506.666- 705) for total dissolved solid,(59-86) for sodium and (2.666- 4.166) for potassium .
- 4- The mathematical method shows that the water quality index for the three stations (New Hilla, Al-Hussein, AL-Hashimyah) range from (87.246 to 109.006) for raw water and from (47.028 to 64.302) for treated water.

Accordingly, water quality has been rated "severely polluted" to "unfit and unsuitable for drinking" for raw water and 'good water' to 'moderately polluted' for treated Water.

- 5- The results of the water quality index were ranged from (79.307 to 81.232) for raw water and (94.620 to 94.718) for treated water according to the Canadian method. Accordingly, the CCME WQI method was classified The river water is "fair" and the water is treated as "good" for drinking.
- 6- Most of the water quality index results were good. In the case of the Canadian method, CCME WQI is more flexible compared to other methods used to calculate quality.
- 7- The removal efficiency of the New Hilla Treatment Plant (47.13) and Al-Hashimyah(47.04) was effective compared to that of Al-Hussein Station (40.78). The quality of treated water decreased along the river (from Al-Hussein Station to Al-Hashimyah Station) due to the low quality of raw water and low water efficiency (E%).
- 8- Statistical analysis was carried out using (SPSS) version 25, and the result of the analysis was that there is a strong relationship between water indicators and the water quality indicator.
- 9- (R^2) of raw water was very good (0.89, 0.90, 0.88) for the stations (New Hilla, Al-Hussein, Al-Hashimyah). (0.92, 0.78, 0.88) for treated water, respectively, indicating a strong relationship between water indices and water quality index.
- 10- There is a strong correlation between chemical and physical parameters with water quality.

5.2 Recommendations

The following recommendations are suggested for future studies:

- 1- Study the effect of other parameters such as Cl, P.....,etc., and study more physical and chemical measures are to be tested.
- 2- Use other types of international indices to explain more carefully the water quality index and parameters affected.
- 3- Extend the study from upstream to downstream at all seasons to include other parameters such as microbial studies in an exhaustive view of the functioning of the river.
- 4- Use other types of statistical analysis methods to explain the relationship between parameters and the water quality.

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Table (A.1): Raw and Treated water data for the New Hilla Station

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	October	1	7.3	7.466	7.3	7.433
		2	7.2		7.1	
		3	7.9		7.9	
Temp		1	28	28.833	28	28.933
		2	29.1		29.6	
		3	29.4		29.2	
Turb		1	13	13.933	1.3	1.633
		2	9.3		0.9	
		3	19.5		2.7	
EC		1	1032	1044.666	1031	1039
		2	1044		1034	
		3	1058		1052	
TH		1	400	406.333	393	396.666
		2	404		393	
		3	415		404	
Ca ⁺²		1	113	116.333	113	113.333
		2	117		113	
		3	119		114	
Mg ⁺²		1	29	28.333	27	27.666
		2	27		27	
		3	29		29	
So4 ⁻²		1	298	307	295	307
		2	304		302	
		3	319		324	
TDS		1	668	690.666	652	678.666
		2	714		688	
		3	690		696	
Na ⁺		1	73	73.666	74	73.333
		2	68		67	
		3	80		79	
K ⁺		1	2.6	2.9	2.6	2.866
		2	2.9		2.9	
		3	3.2		3.1	
BOD ₅		1	0.25	0.25	0	0
		2	0.21		0	
		3	0.29		0	

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	November	1	7.4	7.533	7.3	7.466
		2	7.7		7.7	
		3	7.5		7.4	
Temp		1	24.1	22.366	24	22.766
		2	23		23.8	
		3	20		20.5	
Turb		1	12	9.666	1.5	1.633
		2	8		2.4	
		3	9		1	
EC		1	1032	980.333	1040	986
		2	951		958	
		3	958		960	
TH		1	398	354	392	353.666
		2	327		335	
		3	337		334	
Ca ⁺²		1	102	84.333	101	82.333
		2	77		76	
		3	74		70	
Mg ⁺²		1	35	34.666	35	35.666
		2	32		34	
		3	37		38	
So4 ⁻²		1	306	258.333	303	257.333
		2	225		230	
		3	244		239	
TDS		1	648	600	648	602.666
		2	570		581	
		3	582		579	
Na ⁺		1	77	67	74	65.333
		2	61		61	
		3	63		61	
K ⁺		1	3.3	3.933	3.3	3.833
		2	4.5		4.3	
		3	4		3.9	
BOD ₅		1	0.21	0.27	0	0
		2	0.29		0	
		3	0.31		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	December	1	7.65	7.35	7.5	7.266
		2	7.2		7.2	
		3	7.2		7.1	
Temp		1	18.6	16.2	18.5	16.933
		2	15		16	
		3	15		16.3	
Turb		1	8.8	10.933	0.6	0.5
		2	10		0.4	
		3	14		0.5	
EC		1	901	914.333	900	913.666
		2	915		917	
		3	927		924	
TH		1	350	351.666	343	346.666
		2	350		344	
		3	355		353	
Ca ⁺²		1	74	75.333	74	75.333
		2	75		75	
		3	77		77	
Mg ⁺²		1	40	39.666	37	37
		2	40		36	
		3	39		38	
So ₄ ⁻²		1	205	207.333	196	200.666
		2	192		194	
		3	225		212	
TDS		1	530	543.333	529	544.666
		2	545		545	
		3	555		560	
Na ⁺		1	70	72.666	70	72.666
		2	75		75	
		3	73		73	
K ⁺		1	4.1	4.166	4.1	4.166
		2	4.4		4.4	
		3	4		4	
BOD ₅		1	0.31	0.3	0	0
		2	0.3		0	
		3	0.29		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	January	1	7.5	7.34	7.56	7.35
		2	7.25		7.2	
		3	7.27		7.3	
Temp		1	17.9	17.633	17.9	17.666
		2	17.4		17.4	
		3	17.6		17.7	
Turb		1	6.1	9.333	0.4	0.433
		2	11.5		0.4	
		3	10.4		0.5	
EC		1	909	917.333	910	919.666
		2	923		927	
		3	920		922	
TH		1	304	316	304	311.666
		2	324		314	
		3	320		317	
Ca ⁺²		1	65	67.333	64	65.666
		2	69		66	
		3	68		67	
Mg ⁺²		1	35	37	35	36.333
		2	37		36	
		3	39		38	
So4 ⁻²		1	211	213	199	205.333
		2	213		207	
		3	215		210	
TDS		1	540	547.333	538	546.666
		2	550		552	
		3	552		550	
Na ⁺		1	71	70	73	69.333
		2	69		66	
		3	70		69	
K ⁺		1	3.3	3.333	3.4	3.366
		2	3.3		3.3	
		3	3.4		3.4	
BOD ₅		1	0.29	0.87	0	0
		2	0.3		0	
		3	0.28		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	February	1	7.6	7.7	7.62	7.61
		2	7.8		7.5	
		3	7.7		7.7	
Temp		1	18.8	19.067	19	19.5
		2	19		20	
		3	19.4		19.5	
Turb		1	9	8.867	0.4	0.467
		2	7.5		0.5	
		3	10.1		0.5	
EC		1	912	919	915	919
		2	926		922	
		3	919		920	
TH		1	320	314.667	318	315
		2	305		308	
		3	319		319	
Ca ⁺²		1	65	66.667	63	65.667
		2	66		66	
		3	69		68	
Mg ⁺²		1	34	35	34	35.333
		2	33		35	
		3	38		37	
So4 ⁻²		1	217	220	215	216.333
		2	222		214	
		3	221		220	
TDS		1	548	551	551	550
		2	555		550	
		3	550		549	
Na ⁺		1	68	70.667	69	71.667
		2	73		73	
		3	71		73	
K ⁺		1	3	3.167	3.2	3.267
		2	3.2		3.3	
		3	3.3		3.3	
BOD ₅		1	0.3	0.3	0	0
		2	0.31		0	
		3	0.29		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	March	1	7.7	7.767	7.72	7.743
		2	7.8		7.7	
		3	7.8		7.81	
Temp		1	18	18.533	18.5	19.067
		2	18.6		19	
		3	19		19.7	
Turb		1	10	9.167	0.6	0.5
		2	8		0.4	
		3	9.5		0.5	
EC		1	912	918.333	915	919.667
		2	923		920	
		3	920		924	
TH		1	330	321.333	328	319.333
		2	310		310	
		3	324		320	
Ca ⁺²		1	66	67.333	65	66.667
		2	67		67	
		3	69		68	
Mg ⁺²		1	33	34.667	34	34.667
		2	34		33	
		3	37		37	
So4 ⁻²		1	219	221.667	217	220
		2	224		222	
		3	222		221	
TDS		1	545	551	547	551.667
		2	556		555	
		3	552		553	
Na ⁺		1	69	70.667	70	71.333
		2	73		74	
		3	70		70	
K ⁺		1	3	3.1	3.1	3.167
		2	3.1		3.2	
		3	3.2		3.2	
BOD ₅		1	0.31	0.303	0	0
		2	0.3		0	
		3	0.3		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	April	1	7.5	7.633	7.5	7.633
		2	7.8		7.7	
		3	7.6		7.7	
Temp		1	20	21.666	21	22.333
		2	22		22	
		3	23		24	
Turb		1	9	9.166	0.7	0.533
		2	10		0.5	
		3	8.5		0.4	
EC		1	910	917.333	912	918.333
		2	920		919	
		3	922		924	
TH		1	320	311.666	319	313
		2	300		302	
		3	315		318	
Ca ⁺²		1	56	59.333	58	61
		2	60		60	
		3	62		65	
Mg ⁺²		1	32	32	33	31.333
		2	30		30	
		3	34		31	
So4 ⁻²		1	209	212.333	208	211.666
		2	212		211	
		3	216		216	
TDS		1	535	526.333	540	528
		2	545		544	
		3	499		500	
Na ⁺		1	66	68.666	68	70
		2	70		70	
		3	70		72	
K ⁺		1	3.1	3.2	3.2	3.266
		2	3.3		3.3	
		3	3.2		3.3	
BOD ₅		1	0.32	0.31	0	0
		2	0.31		0	
		3	0.3		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	May	1	7.6	7.6	7.7	7.633
		2	7.7		7.6	
		3	7.5		7.6	
Temp		1	23	24.333	24	25
		2	24		26	
		3	26		25	
Turb		1	8.5	9.166	0.6	0.6
		2	9		0.8	
		3	10		0.4	
EC		1	905	911.666	908	914
		2	910		913	
		3	920		921	
TH		1	316	303.666	315	304.666
		2	295		300	
		3	300		299	
Ca ⁺²		1	59	60	60	61
		2	60		61	
		3	61		62	
Mg ⁺²		1	30	31.333	32	31
		2	31		31	
		3	33		30	
So4 ⁻²		1	205	209.333	204	207.666
		2	210		209	
		3	213		210	
TDS		1	530	523.666	531	527
		2	541		544	
		3	500		506	
Na ⁺		1	60	64.666	64	66.333
		2	65		65	
		3	69		70	
K ⁺		1	3	3.066	3.3	3.166
		2	3.1		3.2	
		3	3.1		3	
BOD ₅		1	0.31	0.303	0	0
		2	0.3		0	
		3	0.3		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	June	1	7.7	7.666	7.8	7.666
		2	7.8		7.7	
		3	7.5		7.5	
Temp		1	23.5	25.5	24	25
		2	26		25	
		3	27		26	
Turb		1	10	11.166	0.4	0.3
		2	9.5		0.3	
		3	14		0.2	
EC		1	889	898	890	901.333
		2	900		905	
		3	905		909	
TH		1	301	292.666	300	294.333
		2	287		290	
		3	290		293	
Ca ⁺²		1	55	58	56	59.333
		2	59		60	
		3	60		62	
Mg ⁺²		1	29	29.666	30	31
		2	30		29	
		3	30		34	
So4 ⁻²		1	198	200.333	199	200.333
		2	200		202	
		3	203		200	
TDS		1	512	508	515	506.666
		2	522		520	
		3	490		485	
Na ⁺		1	58	57.666	60	59
		2	60		61	
		3	55		56	
K ⁺		1	3.1	2.933	3.1	3
		2	2.7		2.9	
		3	3		3	
BOD ₅		1	0.28	0.296	0	0
		2	0.31		0	
		3	0.3		0	

Table (A.2): Raw water and Treated water data for the Al-Hussein Station

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	October	1	7.1	7.366	7.2	7.466
		2	7.2		7.3	
		3	7.8		7.9	
Temp		1	31.7	29.433	31.1	29.033
		2	29.2		29	
		3	27.4		27	
Turb		1	19	18.6	5	4.133
		2	18		4.3	
		3	18.8		3.1	
EC		1	1021	1035.666	1097	1072.333
		2	1030		1065	
		3	1056		1055	
TH		1	389	399.666	411	410.333
		2	400		409	
		3	410		411	
Ca ⁺²		1	112	115.333	113	117.333
		2	114		118	
		3	120		121	
Mg ⁺²		1	27	27	26	26.666
		2	27		27	
		3	27		27	
So4 ⁻²		1	298	310	295	304.666
		2	300		298	
		3	332		321	
TDS		1	676	682	724	705
		2	680		700	
		3	690		691	
Na ⁺		1	78	76.333	85	81.666
		2	75		81	
		3	76		79	
K ⁺		1	3	3.033	3	3.1
		2	3		3.1	
		3	3.1		3.2	
BOD ₅		1	0.3	0.316	0	0
		2	0.32		0	
		3	0.33		0	

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	November	1	7.1	7.266	7.3	7.433
		2	7.3		7.4	
		3	7.4		7.6	
Temp		1	24.4	24.7	24.3	24.4
		2	25		24.7	
		3	24.7		24.2	
Turb		1	14.3	15.133	3	3.5
		2	16		5	
		3	15.1		2.5	
EC		1	970	972	967	969.666
		2	974		972	
		3	972		970	
TH		1	322	325.333	336	339.666
		2	326		340	
		3	328		343	
Ca ⁺²		1	79	80.333	80	81
		2	81		81	
		3	81		82	
Mg ⁺²		1	29	30	29	32
		2	30		34	
		3	31		33	
So ₄ ⁻²		1	230	233	229	230
		2	234		230	
		3	235		231	
TDS		1	577	575.666	576	574.666
		2	576		574	
		3	574		574	
Na ⁺		1	79	77	80	78
		2	77		78	
		3	75		76	
K ⁺		1	3.1	3.033	3.1	3.166
		2	3		3.2	
		3	3		3.2	
BOD ₅		1	0.31	0.326	0	0
		2	0.35		0	
		3	0.32		0	

pH	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
Temp	December	1	7.6	7.666	7.4	7.5
		2	7.7		7.5	
		3	7.7		7.6	
Turb		1	17.2	17.4	17	17.5
		2	17		18	
		3	18		17.5	
EC		1	9.5	10.333	3	3.333
		2	10		3	
		3	11.5		4	
TH		1	925	926.666	930	931.333
		2	927		932	
		3	928		932	
Ca ²⁺		1	339	340	340	342
		2	340		343	
		3	341		343	
Mg ²⁺		1	74	74.666	76	74.666
		2	75		73	
		3	75		75	
So4 ⁻²		1	36	37	36	37.666
		2	37		38	
		3	38		39	
TDS		1	221	220.666	223	215.666
		2	221		213	
		3	220		211	
Na ⁺		1	580	580.666	583	584
		2	581		585	
		3	581		584	
K ⁺		1	75	76	76	76.333
		2	76		76	
		3	77		77	
BOD ₅		1	4	4.066	4.1	4.133
		2	4.1		4.1	
		3	4.1		4.2	
		1	0.33	0.313	0	0
		2	0.3		0	
		3	0.31		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	January	1	7.7	7.733	7.7	7.666
		2	7.8		7.7	
		3	7.7		7.6	
Temp		1	19	19.066	19.1	18.9
		2	19.3		19	
		3	18.9		18.6	
Turb		1	10.8	11.67	0.8	1.266
		2	11		1.8	
		3	11.7		1.2	
EC		1	920	926.333	949	952.333
		2	929		954	
		3	930		954	
TH		1	319	321.666	322	324.666
		2	321		324	
		3	325		328	
Ca ⁺²		1	66	68	70	70.666
		2	68		70	
		3	70		72	
Mg ⁺²		1	35	37	38	38.666
		2	37		38	
		3	39		40	
So ₄ ⁻²		1	206	207.666	210	211
		2	207		211	
		3	210		212	
TDS		1	550	554.666	570	582.666
		2	554		588	
		3	560		590	
Na ⁺		1	52	55.333	60	63.333
		2	55		64	
		3	59		66	
K ⁺		1	3.9	4	3.9	4.133
		2	4		4.1	
		3	4.1		4.4	
BOD ₅		1	0.3	0.303	0	0
		2	0.33		0	
		3	0.28		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	February	1	7.6	7.6	7.5	7.5
		2	7.5		7.3	
		3	7.7		7.7	
Temp		1	22	23.067	21	22.833
		2	24		24.5	
		3	23.2		23	
Turb		1	10	10.6	1.9	2.433
		2	11.1		3	
		3	10.7		2.4	
EC		1	1028	1034.667	1038	1044.333
		2	1037		1045	
		3	1039		1050	
TH		1	330	335.333	339	342.333
		2	337		343	
		3	339		345	
Ca ⁺²		1	69	71	70	71
		2	72		70	
		3	72		73	
Mg ⁺²		1	34	37.667	38	40
		2	39		40	
		3	40		42	
So4 ⁻²		1	227	229.333	230	232
		2	230		233	
		3	231		233	
TDS		1	551	556	573	583.667
		2	557		590	
		3	560		588	
Na ⁺		1	78	83.667	80	85.333
		2	85		86	
		3	88		90	
K ⁺		1	3.8	3.933	3.9	4
		2	4		4	
		3	4		4.1	
BOD ₅		1	0.29	0.303	0	0
		2	0.32		0	
		3	0.3		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	March	1	7.5	7.533	7.4	7.4
		2	7.5		7.3	
		3	7.6		7.5	
Temp		1	20	20.667	19	19.833
		2	22		21	
		3	20		19.5	
Turb		1	10	11	1.4	1.833
		2	10.5		2.3	
		3	12.5		1.8	
EC		1	1025	1034.333	1030	1041.333
		2	1038		1043	
		3	1040		1051	
TH		1	329	335.667	335	340
		2	338		340	
		3	340		345	
Ca ⁺²		1	70	70.333	71	70.667
		2	69		70	
		3	72		71	
Mg ⁺²		1	35	38	37	39.333
		2	40		41	
		3	39		40	
So4 ⁻²		1	228	230	230	232.333
		2	225		229	
		3	237		238	
TDS		1	553	556.667	570	583
		2	556		588	
		3	561		591	
Na ⁺		1	77	84.333	79	86
		2	86		88	
		3	90		91	
K ⁺		1	3.9	4	4	4.1
		2	4.1		4.2	
		3	4		4.1	
BOD ₅		1	0.28	0.29	0	0
		2	0.3		0	
		3	0.29		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	April	1	7.6	7.6	7.5	7.5
		2	7.5		7.4	
		3	7.7		7.6	
Temp		1	22	22.333	21	21
		2	24		22	
		3	21		20	
Turb		1	10	10.166	1.3	1.733
		2	9.5		2	
		3	11		1.9	
EC		1	1020	1031.333	1029	1037.666
		2	1035		1040	
		3	1039		1044	
TH		1	300	324	310	330.333
		2	335		340	
		3	337		341	
Ca ⁺²		1	65	67	66	68.666
		2	66		70	
		3	70		70	
Mg ⁺²		1	35	37.666	37	39
		2	38		38	
		3	40		42	
So4 ⁻²		1	219	220.333	220	222
		2	220		221	
		3	222		225	
TDS		1	545	548	560	562.333
		2	549		562	
		3	550		565	
Na ⁺		1	70	79.333	71	81.333
		2	80		83	
		3	88		90	
K ⁺		1	3.8	3.9	3.9	3.9
		2	4		4	
		3	3.9		3.8	
BOD ₅		1	0.29	0.296	0	0
		2	0.3		0	
		3	0.3		0	

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	May	1	7.5	7.6	7.5	7.6
		2	7.6		7.7	
		3	7.7		7.6	
Temp		1	24	23.666	23	21.666
		2	25		22	
		3	22		20	
Turb		1	11	11	1.4	1.466
		2	10		1.8	
		3	12		1.2	
EC		1	1000	1014	1010	1020.666
		2	1020		1022	
		3	1022		1030	
TH		1	290	316	299	321
		2	328		330	
		3	330		334	
Ca ⁺²		1	62	65	64	66.666
		2	64		66	
		3	69		70	
Mg ⁺²		1	33	34.666	33	36
		2	35		37	
		3	36		38	
So4 ⁻²		1	211	210	212	212.333
		2	210		214	
		3	209		211	
TDS		1	533	539.333	545	552
		2	540		550	
		3	545		561	
Na ⁺		1	69	75.333	70	76.333
		2	77		77	
		3	80		82	
K ⁺		1	3.5	3.766	3.6	3.833
		2	4		4.1	
		3	3.8		3.8	
BOD ₅		1	0.3	0.296	0	0
		2	0.28		0	
		3	0.31		0	

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	June	1	7.8	7.833	7.7	7.733
		2	7.7		7.6	
		3	8		7.9	
Temp		1	27	28.666	26	28.333
		2	29		28	
		3	30		31	
Turb		1	13	12.666	1.2	1.333
		2	11		1.5	
		3	14		1.3	
EC		1	902	975	1000	1011
		2	1009		1010	
		3	1014		1023	
TH		1	289	312	293	316.666
		2	322		327	
		3	325		330	
Ca ⁺²		1	65	69	66	70.333
		2	63		65	
		3	79		80	
Mg ⁺²		1	31	32.666	32	33.666
		2	33		34	
		3	34		35	
So4 ⁻²		1	200	198	204	202
		2	195		200	
		3	199		202	
TDS		1	504	521	513	526
		2	532		535	
		3	527		530	
Na ⁺		1	58	69	60	71.666
		2	69		71	
		3	80		84	
K ⁺		1	3.7	3.9	3.5	3.633
		2	4.5		4.1	
		3	3.5		3.3	
BOD ₅		1	0.31	0.32	0	0
		2	0.24		0	
		3	0.41		0	

Table (A.3): Raw water and Treated water data for the Hashimyah Station

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	October	1	7.2	7.2	7.3	7.266
		2	7		7.1	
		3	7.4		7.4	
Temp		1	29	28.8	28.2	28.566
		2	28.9		28.5	
		3	28.5		29	
Turb		1	12	14	4.3	5
		2	10		5.1	
		3	20		5.6	
EC		1	1025	1037.666	1026	1039.333
		2	1038		1040	
		3	1050		1052	
TH		1	398	402.666	390	394.333
		2	400		393	
		3	410		400	
Ca ⁺²		1	100	101	110	112
		2	98.1		113	
		3	104.9		113	
Mg ⁺²		1	28	28	28	28.666
		2	27		29	
		3	29		29	
So4 ⁻²		1	296	305.333	294	304.666
		2	302		300	
		3	318		320	
TDS		1	664	684.666	665	688.666
		2	700		702	
		3	690		699	
Na ⁺		1	71	72.333	73	73.333
		2	66		66	
		3	80		81	
K ⁺		1	2.5	2.8	2.5	2.666
		2	2.8		2.8	
		3	3.1		2.7	
BOD ₅		1	0.26	0.253	0	0
		2	0.23		0	
		3	0.27		0	

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	November	1	7.2	7.2	7.4	7.366
		2	7.1		7.3	
		3	7.3		7.4	
Temp		1	24.8	24.966	24	24.233
		2	25		24.3	
		3	25.1		24.4	
Turb		1	11.5	12	2.4	2.833
		2	13		3.1	
		3	11.5		3	
EC		1	979	980.666	1001	1002
		2	983		1005	
		3	980		1000	
TH		1	345	342.666	363	360.666
		2	340		359	
		3	343		360	
Ca ⁺²		1	85	87	88	88.666
		2	87		89	
		3	89		89	
Mg ⁺²		1	30	30.5	35	33.666
		2	31		34	
		3	30.5		32	
So4 ⁻²		1	269	270	265	265.33
		2	270		264	
		3	271		267	
TDS		1	627	610	661	660
		2	553		659	
		3	650		660	
Na ⁺		1	77	75.666	74	71.666
		2	76		71	
		3	74		70	
K ⁺		1	3.3	3.133	3.3	3.133
		2	3.1		3.1	
		3	3		3	
BOD ₅		1	0.24	0.263	0	0
		2	0.27		0	
		3	0.28		0	

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	December	1	7.3	7.466	7.3	7.4
		2	7.6		7.5	
		3	7.5		7.4	
Temp		1	18	19	18	20.333
		2	19		21	
		3	20		22	
Turb		1	11	12	3.1	4.2
		2	13		4.4	
		3	12		5.1	
EC		1	932	932.333	942	942.333
		2	935		945	
		3	930		940	
TH		1	362	365	360	364
		2	366		366	
		3	367		366	
Ca ⁺²		1	77	76.333	75	75.666
		2	75		75	
		3	77		77	
Mg ⁺²		1	44	43.666	43	43.333
		2	43		43	
		3	44		44	
So4 ⁻²		1	211	213.666	209	209
		2	214		208	
		3	216		210	
TDS		1	565	570.333	579	581
		2	571		581	
		3	575		583	
Na ⁺		1	68	68	67	68
		2	67		68	
		3	69		69	
K ⁺		1	4.3	4.133	4.2	4.1
		2	4.1		4.1	
		3	4		4	
BOD ₅		1	0.23	0.243	0	0
		2	0.26		0	
		3	0.24		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	January	1	7.1	7.133	7.2	7.166
		2	7.1		7.1	
		3	7.2		7.2	
Temp		1	18	18	17.9	17.866
		2	17.9		17.7	
		3	18.1		18	
Turb		1	7	6	0.9	1.066
		2	6		1.1	
		3	5		1.2	
EC		1	947	949.333	946	947.666
		2	950		947	
		3	951		950	
TH		1	313	312.333	310	311
		2	314		314	
		3	310		309	
Ca ⁺²		1	72	71.666	70	70.333
		2	69		69	
		3	74		72	
Mg ⁺²		1	39	38	35	36
		2	35		35	
		3	40		38	
So4 ⁻²		1	210	208.333	209	213
		2	206		214	
		3	209		216	
TDS		1	551	551.666	580	583
		2	555		587	
		3	549		582	
Na ⁺		1	70	71	69	69.666
		2	71		70	
		3	72		70	
K ⁺		1	3.4	3.366	3.3	3.333
		2	3.3		3.3	
		3	3.4		3.4	
BOD ₅		1	0.27	0.256	0	0
		2	0.26		0	
		3	0.24		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	February	1	7.1	7.167	7.2	7.267
		2	7.2		7.2	
		3	7.2		7.4	
Temp		1	19	18.433	18.9	18.267
		2	18		17.9	
		3	18.3		18	
Turb		1	7.8	8.6	0.8	1.067
		2	8		1.3	
		3	10		1.1	
EC		1	949	950.333	947	949.333
		2	952		950	
		3	950		951	
TH		1	319	314	318	313.333
		2	313		313	
		3	310		309	
Ca ⁺²		1	71	71.333	70	70.333
		2	70		69	
		3	73		72	
Mg ⁺²		1	38	36.333	38	36.666
		2	32		34	
		3	39		38	
So4 ⁻²		1	214	212.667	213	213
		2	213		215	
		3	211		211	
TDS		1	554	553.667	570	576
		2	557		578	
		3	550		580	
Na ⁺		1	71	71.667	70	71
		2	73		72	
		3	71		71	
K ⁺		1	3.3	3.333	3.2	3.3
		2	3.3		3.3	
		3	3.4		3.4	
BOD ₅		1	0.3	0.277	0	0
		2	0.27		0	
		3	0.26		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	March	1	7.2	7.2	7.3	7.267
		2	7.1		7.2	
		3	7.3		7.3	
Temp		1	18.4	18.567	18	18.267
		2	19		18.8	
		3	18.3		18	
Turb		1	9	10.667	0.7	1.133
		2	10		1.2	
		3	13		1.5	
EC		1	950	951.667	949	950.333
		2	952		951	
		3	953		951	
TH		1	320	315	319	313.667
		2	315		312	
		3	310		310	
Ca ⁺²		1	70	70.333	69	69.333
		2	69		68	
		3	72		71	
Mg ⁺²		1	38	35.333	37	36.333
		2	31		34	
		3	37		38	
So4 ⁻²		1	215	213.667	214	212.333
		2	214		211	
		3	212		212	
TDS		1	555	554.333	572	577
		2	557		579	
		3	551		580	
Na ⁺		1	72	72	71	71.333
		2	71		71	
		3	73		72	
K ⁺		1	3.4	3.3	3.3	3.3
		2	3.3		3.3	
		3	3.2		3.3	
BOD ₅		1	0.31	0.287	0	0
		2	0.28		0	
		3	0.27		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	April	1	7.3	7.266	7.3	7.3
		2	7.4		7.4	
		3	7.1		7.2	
Temp		1	20	20	19	19.666
		2	19		20	
		3	21		20	
Turb		1	8.5	11.5	0.6	1
		2	12		1.3	
		3	14		1.1	
EC		1	947	948.333	946	949
		2	948		950	
		3	950		951	
TH		1	322	319	320	317
		2	320		319	
		3	315		312	
Ca ⁺²		1	73	71.666	72	71
		2	70		70	
		3	72		71	
Mg ⁺²		1	39	36.666	40	37.333
		2	33		34	
		3	38		38	
So4 ⁻²		1	213	211.333	211	210
		2	211		210	
		3	210		209	
TDS		1	556	554.333	560	560.333
		2	555		558	
		3	552		563	
Na ⁺		1	70	71	70	70.333
		2	72		71	
		3	71		70	
K ⁺		1	3.8	3.533	3.6	3.5
		2	3.5		3.5	
		3	3.3		3.4	
BOD ₅		1	0.32	0.3	0	0
		2	0.3		0	
		3	0.28		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	May	1	7.2	7.2	7.3	7.2
		2	7.3		7.2	
		3	7.1		7.1	
Temp		1	22	22	21	21.333
		2	20		20	
		3	24		23	
Turb		1	8	9.666	0.8	1.1333
		2	10		1.2	
		3	11		1.4	
EC		1	945	944.666	948	946.666
		2	946		950	
		3	943		942	
TH		1	320	317	319	315
		2	316		314	
		3	315		312	
Ca ⁺²		1	70	69	69	69.333
		2	66		66	
		3	71		70	
Mg ⁺²		1	35	34.666	36	36
		2	33		35	
		3	36		37	
So ₄ ⁻²		1	209	209.333	207	208.333
		2	208		208	
		3	211		210	
TDS		1	553	551.333	558	557
		2	550		553	
		3	551		560	
Na ⁺		1	65	68	68	69.666
		2	70		70	
		3	69		71	
K ⁺		1	3.5	3.533	3.4	3.5
		2	3.7		3.6	
		3	3.4		3.5	
BOD ₅		1	0.31	0.3	0	0
		2	0.3		0	
		3	0.29		0	

parameters	Month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	June	1	7.3	7.4	7.4	7.3
		2	7.4		7.3	
		3	7.5		7.2	
Temp		1	25	24	24	23.666
		2	23		22	
		3	24		25	
Turb		1	11	13.666	0.7	0.966
		2	16		1	
		3	14		1.2	
EC		1	882	900	890	902.666
		2	904		908	
		3	914		910	
TH		1	315	305	300	311
		2	301		297	
		3	299		336	
Ca ⁺²		1	69	70.333	68	69.666
		2	70		71	
		3	72		70	
Mg ⁺²		1	32	31	33	32.666
		2	30		31	
		3	31		34	
So4 ⁻²		1	195	200	192	197.333
		2	200		199	
		3	205		201	
TDS		1	558	555	560	558.333
		2	555		559	
		3	552		556	
Na ⁺		1	62	67	63	67.666
		2	69		70	
		3	70		70	
K ⁺		1	3.4	3.433	3.5	3.533
		2	3.6		3.7	
		3	3.3		3.4	
BOD ₅		1	0.29	0.283	0	0
		2	0.3		0	
		3	0.26		0	

Table (B.1) :(Raw and Treated water data for the new Hilla Station for 2017)

Parameters	month	the week	Raw water Raw water weekly rate	Raw water Raw water monthly rate	Weekly rate Weekly rate of Treated water	Monthly rate Monthly rate of Treated water
pH	January	1	7.74	7.7475	7.6	7.6
		2	7.78		7.6	
		3	7.78		7.6	
		4	7.69		7.6	
Temp		1	14.7	15.35	14.9	15.3
		2	16.1		16.1	
		3	16.1		16.1	
		4	14.5		14.1	
Turb		1	8.3	6.325	1.1	0.775
		2	5.2		0.7	
		3	5.2		0.7	
		4	6.6		0.6	
EC		1	1281	1200.5	1253	1203.5
		2	1205		1224	
		3	1205		1224	
		4	1111		1113	
TH		1	396	387.5	403	387.75
		2	409		400	
		3	387		387	
		4	358		361	
Ca ⁺²		1	95	84.75	98	85.75
		2	91		92	
		3	84		84	
		4	69		69	
Mg ⁺²		1	39	42.75	38	42
		2	44		41	
		3	43		43	
		4	45		46	
So4 ⁻²		1	330	292.5	313	283.75
		2	320		320	
		3	281		267	
		4	239		235	
TDS		1	768	696.5	700	682.5
		2	670		680	
		3	768		770	
		4	580		580	
Na ⁺		1	98	96.75	101	98.5
		2	97		98	
		3	95		97	

Appendix B *Data obtained from the Babylon Water Department (2017, 2018 and 2019)*

		4	97		98	
K⁺		1	3.2	3.175	3.2	3.175
		2	3.2		3.2	
		3	3.1		3.1	
		4	3.2		3.2	

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	February	1	8.01	7.937	7.82	7.8
		2	7.9		7.78	
		3	7.9		7.8	
Temp		1	17.9	16.06	18.2	17.233
		2	16.3		16.3	
		3	17		17.2	
Turb		1	5.8	8.2	0.6	0.8
		2	10.9		1.3	
		3	7.9		0.5	
EC		1	997	937	999	938.667
		2	920		922	
		3	894		895	
TH		1	330	305	336	311.33
		2	294		307	
		3	291		291	
Ca ⁺²		1	68	70.667	68	70.333
		2	70		70	
		3	74		73	
Mg ⁺²		1	39	31.333	40	32.666
		2	29		32	
		3	26		26	
So4 ⁻²		1	243	213.333	244	216.333
		2	202		208	
		3	195		197	
TDS		1	560	583.333	562	585.333
		2	594		596	
		3	596		598	
Na ⁺		1	91	89.333	93	90.333
		2	91		93	
		3	86		85	
K ⁺		1	3	9.2	3	9.1
		2	3.1		3.1	
		3	3.1		3	

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	March	1	7.95	7.95	7.79	7.79
Temp		1	24.1	24.1	24.2	24.2
Turb		1	5.5	5.5	0.7	0.7
EC		1	915	915	911	911
TH		1	301	301	294	294
Ca⁺²		1	63	63	63	63
Mg⁺²		1	35	35	33	33
SO4⁻²		1	210	210	209	209
TDS		1	524	524	520	520
Na⁺		1	84	84	87	87
K⁺		1	3.1	3.1	3.1	3.1

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	April	1	7.7	7.766	7.7	7.633
		2	7.9		7.7	
		3	7.7		7.5	
Temp		1	20.2	23.633	20.2	24.133
		2	24		24.9	
		3	26.7		27.3	
Turb		1	18.5	12.166	2.7	1.233
		2	11		0.5	
		3	7		0.5	
EC		1	1055	963.666	1036	960.666
		2	948		956	
		3	888		890	
TH		1	350	319	350	326.666
		2	307		323	
		3	300		307	
Ca ⁺²		1	83	74.666	83	74.666
		2	73		73	
		3	68		68	
Mg ⁺²		1	35	46.666	35	47
		2	73		73	
		3	32		33	
So4 ⁻²		1	250	214	249	213.333
		2	198		198	
		3	194		193	
TDS		1	694	634.666	678	627.333
		2	644		646	
		3	566		558	
Na ⁺		1	86	80.666	86	81
		2	76		76	
		3	80		81	
K ⁺		1	3.3	3.133	3.3	3.1
		2	3		2.9	
		3	3.1		3.1	

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	May	1	7.7	7.7	7.3	7.3
Temp		1	24.9	24.9	27.4	27.4
Turb		1	36.9	36.9	0.5	0.5
EC		1	909	909	885	885
TH		1	313	313	384	384
Ca⁺²		1	69	69	70	70
Mg⁺²		1	34	34	31	31
SO₄⁻²		1	181	181	190	190
TDS		1	642	642	620	620
Na⁺		1	70	70	70	70
K⁺		1	3	3	3	3

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	June	1	7.5	7.4	7.5	7.433
		2	7.1		7.5	
		3	7.6		7.3	
Temp		1	33.3	28.433	30.3	27.8
		2	21.1		23.3	
		3	30.9		29.8	
Turb		1	4.5	5.033	0.4	1.4
		2	6		0.8	
		3	4.6		0.2	
EC		1	974	942.333	969	943.666
		2	944		947	
		3	909		915	
TH		1	366	364	363	361.666
		2	346		350	
		3	380		372	
Ca⁺²		1	88	91.333	88	92
		2	93		94	
		3	93		94	
Mg⁺²		1	36	33.333	35	32
		2	28		28	
		3	36		33	
So4⁻²		1	258	251	258	247.666
		2	258		255	
		3	237		230	
TDS		1	592	609.333	576	607.333
		2	636		636	
		3	600		610	
Na⁺		1	81	71	81	71.666
		2	67		68	
		3	65		66	
K⁺		1	3	2.933	3	2.993
		2	2.9		2.9	
		3	2.9		2.9	

Appendix B Data obtained from the Babylon Water Department(2017,2018and 2019)

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	July	1	7.6	7.7	7.3	7.366
		2	7.8		7.4	
		3	7.7		7.4	
Temp		1	32.2	30.033	31.1	29.933
		2	29.5		29.7	
		3	28.4		29	
Turb		1	22.5	8.833	0.3	0.266
		2	2.1		0.3	
		3	1.9		0.2	
EC		1	1003	994	988	992
		2	995		998	
		3	984		990	
TH		1	350	346	350	351
		2	350		354	
		3	338		349	
Ca ⁺²		1	85	87	84	87
		2	86		86	
		3	90		91	
Mg ⁺²		1	34	31.666	34	32.666
		2	33		34	
		3	28		30	
So4 ⁻²		1	264	259	259	254
		2	260		254	
		3	253		249	
TDS		1	632	633.333	630	632.666
		2	646		638	
		3	622		630	
Na ⁺		1	75	78.666	76	80
		2	77		81	
		3	84		83	
K ⁺		1	3	3.033	3	3.066
		2	3		3.1	
		3	3.1		3.1	

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	August	1	7.5	7.4	7.3	7.3
		2	7.3		7.3	
Temp		1	29.4	29.2	30.4	30.25
		2	29		30.1	
Turb		1	4.3	6.35	0.3	0.3
		2	8.4		0.3	
EC		1	986	973	964	963.5
		2	961		963	
TH		1	309	307.5	304	305
		2	306		306	
Ca ⁺²		1	71	73	71	73
		2	75		75	
Mg ⁺²		1	29	27.5	28	27
		2	26		26	
So4 ⁻²		1	259	257	254	254.5
		2	255		255	
TDS		1	652	648	630	638
		2	644		646	
Na ⁺		1	77	76.5	77	77
		2	76		77	
K ⁺		1	2.9	2.95	2.9	3
		2	3		3.1	

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	September	1	7.5	7.55	7.6	7.55
		2	7.6		7.5	
Temp		1	29.9	29.65	29.2	29.5
		2	29.4		29.8	
Turb		1	3.5	3.75	0.4	0.4
		2	4		0.4	
EC		1	959	959.5	958	957
		2	960		956	
TH		1	303	306	306	306
		2	309		306	
Ca⁺²		1	69	69.5	69	70
		2	70		71	
Mg⁺²		1	30	30	30	29.5
		2	30		29	
So4⁻²		1	237	235.5	238	237.5
		2	234		237	
TDS		1	612	621	610	616
		2	630		622	
Na⁺		1	75	73	75	74.5
		2	71		74	
K⁺		1	3	2.9	3	2.9
		2	2.8		2.8	

Appendix B Data obtained from the Babylon Water Department(2017,2018and 2019)

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	October	1	7.7	7.7	7.6	7.6
Temp		1	27.1	27.1	27.2	27.2
Turb		1	7	7	0.6	0.6
EC		1	1000	1000	995	995
TH		1	309	309	306	306
Ca ⁺²		1	75	75	75	75
Mg ⁺²		1	27	27	26	26
SO ₄ ⁻²		1	262	262	256	256
TDS		1	666	666	664	664
Na ⁺		1	67	67	70	70
K ⁺		1	2.8	2.8	2.8	2.8

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	November	1	7.8	7.8	7.7	7.7
Temp		1	21.9	21.9	21.9	21.9
Turb		1	2.9	2.9	0.4	0.4
EC		1	1079	1079	1082	1082
TH		1	340	340	337	337
Ca ⁺²		1	84	84	84	84
Mg ⁺²		1	29	29	28	28
SO ₄ ⁻²		1	282	282	282	282
TDS		1	726	726	730	730
Na ⁺		1	78	78	80	80
K ⁺		1	2.8	2.8	2.8	2.8

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	December	1	7.8	7.85	7.7	7.75
		2	7.9		7.8	
Temp		1	17.9	17.5	18	17.6
		2	17.1		17.2	
Turb		1	5.1	4.55	0.3	0.25
		2	4		0.2	
EC		1	1149	1180	1144	1173
		2	1211		1202	
TH		1	333	337.5	333	336
		2	342		339	
Ca⁺²		1	78	81	78	81
		2	84		84	
Mg⁺²		1	31	30.5	31	30
		2	30		29	
So4⁻²		1	261	267	258	264.5
		2	273		271	
TDS		1	700	718	690	710
		2	736		730	
Na⁺		1	83	83.5	82	82.5
		2	84		83	
K⁺		1	2.7	2.8	2.7	2.8
		2	2.9		2.9	

Table (B.2) :(Raw water and Treated water data for the Al-Hussein Station for the year 2017)

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	January	1	7.67	7.67	7.61	7.61
Temp		1	18.1	18.1	18.7	18.7
Turb		1	4.67	4.67	1.8	1.8
EC		1	1198	1198	1202	1202
TH		1	413	413	400	400
Ca ⁺²		1	91	91	91	91
Mg ⁺²		1	45	45	42	42
SO4 ⁻²		1	303	303	291	291
TDS		1	762	762	770	770
Na ⁺		1	90	90	90	90
K ⁺		1	3.2	3.2	3.2	3.2

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	February	1	8.08	8.08	7.99	7.99
Temp		1	19.2	19.2	19	19
Turb		1	3.9	3.9	1.4	1.4
EC		1	902	902	906	906
TH		1	298	298	298	298
Ca ⁺²		1	68	68	68	68
Mg ⁺²		1	31	31	31	31
SO4 ⁻²		1	198	198	195	195
TDS		1	614	614	616	616
Na ⁺		1	88	88	87	87
K ⁺		1	3.1	3.1	3.1	3.1

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

Parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	March	1	7.9	7.9	7.5	7.5
Temp		1	22.5	22.5	22.5	22.5
Turb		1	33.8	33.8	1.9	1.9
EC		1	916	916	921	921
TH		1	304	304	317	317
Ca ⁺²		1	63	63	65	65
Mg ⁺²		1	36	36	38	38
SO4 ⁻²		1	213	213	210	210
TDS		1	582	582	584	584
Na ⁺		1	85	85	84	84
K ⁺		1	3	3	3	3

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	April	1	7.8	7.8	7.6	7.6
Temp		1	24	24	24.8	24.8
Turb		1	7.4	7.4	2.5	2.5
EC		1	912	912	898	898
TH		1	304	304	304	304
Ca ⁺²		1	68	68	69	69
Mg ⁺²		1	33	33	34	34
SO4 ⁻²		1	193	193	192	192
TDS		1	536	536	520	520
Na ⁺		1	78	78	78	78
K ⁺		1	3	3	3.1	3.1

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	May	1	7.7	7.7	7.4	7.4
Temp		1	25.6	25.6	25.6	25.6
Turb		1	15.9	15.9	3.8	3.8
EC		1	877	877	887	887
TH		1	307	307	310	310
Ca⁺²		1	70	70	71	71
Mg⁺²		1	32	32	32	32
SO4⁻²		1	199	199	200	200
TDS		1	588	588	592	592
Na⁺		1	74	74	76	76
K⁺		1	3	3	3	3

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	June	1	7.4	7.4	7.29	7.29
Temp		1	28.2	28.2	28.2	28.2
Turb		1	5.9	5.9	1.3	1.3
EC		1	928	928	928	928
TH		1	361	361	353	353
Ca⁺²		1	93	93	92	92
Mg⁺²		1	31	31	30	30
SO4⁻²		1	235	235	239	239
TDS		1	612	612	614	614
Na⁺		1	69	69	71	71
K⁺		1	2.9	2.9	2.9	2.9

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	July	1	7.5	7.5	7.2	7.2
Temp		1	32	32	32	32
Turb		1	12	12	1	1
EC		1	990	990	992	992
TH		1	343	343	343	343
Ca ⁺²		1	88	88	88	88
Mg ⁺²		1	30	30	30	30
SO4 ⁻²		1	252	252	251	251
TDS		1	650	650	656	656
Na ⁺		1	79	79	79	79
K ⁺		1	3.1	3.1	3.1	3.1

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	August	1	7.3	7.3	7.2	7.2
Temp		1	23.6	23.6	23.9	23.9
Turb		1	3.8	3.8	0.6	0.6
EC		1	985	985	986	986
TH		1	335	335	335	335
Ca ⁺²		1	84	84	84	84
Mg ⁺²		1	28	28	28	28
SO4 ⁻²		1	254	254	260	260
TDS		1	656	656	648	648
Na ⁺		1	80	80	80	80
K ⁺		1	3.1	3.1	3.1	3.1

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	September	1	7.6	7.6	7.6	7.6
Temp		1	28.2	28.2	27.6	27.6
Turb		1	4.6	4.6	0.8	0.8
EC		1	964	964	965	965
TH		1	309	309	313	313
Ca⁺²		1	73	73	75	75
Mg⁺²		1	28	28	28	28
SO4⁻²		1	265	265	260	260
TDS		1	636	636	634	634
Na⁺		1	87	87	87	87
K⁺		1	3.2	3.2	3.2	3.2

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	October	1	7.6	7.6	7.7	7.7
Temp		1	29.7	29.7	29.3	29.3
Turb		1	7	7	1.4	1.4
EC		1	994	994	994	994
TH		1	316	316	320	320
Ca⁺²		1	78	78	78	78
Mg⁺²		1	27	27	27	27
SO4⁻²		1	270	270	267	267
TDS		1	660	660	660	660
Na⁺		1	76	76	77	77
K⁺		1	2.8	2.8	2.9	2.9

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	November	1	7.8	7.8	7.5	7.5
Temp		1	24.2	24.2	24.4	24.4
Turb		1	6.6	6.6	1.8	1.8
EC		1	1050	1050	1056	1056
TH		1	326	326	326	326
Ca⁺²		1	80	80	80	80
Mg⁺²		1	28	28	28	28
SO4⁻²		1	284	284	282	282
TDS		1	702	702	708	708
Na⁺		1	74	74	76	76
K⁺		1	2.8	2.8	2.8	2.8

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	December	1	7.5	7.5	7.3	7.3
Temp		1	16.7	16.7	16.9	16.9
Turb		1	4.5	4.5	1.7	1.7
EC		1	1151	1151	1155	1155
TH		1	357	357	354	354
Ca⁺²		1	80	80	80	80
Mg⁺²		1	35	35	35	35
SO4⁻²		1	267	267	267	267
TDS		1	708	708	710	710
Na⁺		1	79	79	79	79
K⁺		1	2.8	2.8	2.8	2.8

Table (B.3): Raw water and Treated water data for the Hashimyah Station for the year 2017

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	January	1	7.78	7.78	7.5	7.5
Temp		1	16.6	16.6	16.6	16.6
Turb		1	7.7	7.7	3.7	3.7
EC		1	1206	1206	1198	1198
TH		1	396	396	396	396
Ca ⁺²		1	91	91	91	91
Mg ⁺²		1	41	41	41	41
SO4 ⁻²		1	321	321	310	310
TDS		1	800	800	792	792
Na ⁺		1	99	99	98	98
K ⁺		1	3.2	3.2	3.2	3.2

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	February	1	8.04	8.04	7.79	7.79
Temp		1	14.8	14.8	14.8	14.8
Turb		1	5	5	3.1	3.1
EC		1	1031	1031	1031	1031
TH		1	335	335	345	345
Ca ⁺²		1	73	73	74	74
Mg ⁺²		1	37	37	38	38
SO4 ⁻²		1	259	259	250	250
TDS		1	662	662	660	660
Na ⁺		1	100	100	98	98
K ⁺		1	3.2	3.2	3.1	3.1

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	March	1	7.45	7.45	7.6	7.6
Temp		1	19.1	19.1	19.4	19.4
Turb		1	4	4	2	2
EC		1	933	933	935	935
TH		1	310	310	301	301
Ca⁺²		1	60	60	63	63
Mg⁺²		1	39	39	35	35
SO₄⁻²		1	214	214	217	217
TDS		1	540	540	542	542
Na⁺		1	89	89	89	89
K⁺		1	3.2	3.2	3.2	3.2

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	April	1	7.8	7.8	7.5	7.5
Temp		1	21.4	21.4	21.2	21.2
Turb		1	39	39	6.8	6.8
EC		1	1076	1076	1044	1044
TH		1	360	360	360	360
Ca⁺²		1	84	84	84	84
Mg⁺²		1	37	37	37	37
SO₄⁻²		1	268	268	264	264
TDS		1	726	726	706	706
Na⁺		1	90	90	90	90
K⁺		1	3.4	3.4	3.5	3.5

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	May	1	7.5	7.5	7.5	7.5
Temp		1	25.8	25.8	25.6	25.6
Turb		1	5.8	5.8	3.8	3.8
EC		1	885	885	885	885
TH		1	304	304	310	310
Ca⁺²		1	69	69	69	69
Mg⁺²		1	34	34	34	34
SO4⁻²		1	198	198	190	190
TDS		1	550	550	550	550
Na⁺		1	76	76	77	77
K⁺		1	3	3	3	3

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	June	1	7.9	7.9	7.4	7.4
Temp		1	27.1	27.1	27.1	27.1
Turb		1	6.5	6.5	2.5	2.5
EC		1	989	989	989	989
TH		1	366	366	363	363
Ca⁺²		1	89	89	89	89
Mg⁺²		1	35	35	34	34
SO4⁻²		1	250	250	252	252
TDS		1	560	560	558	558
Na⁺		1	83	83	83	83
K⁺		1	3	3	3	3

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	July	1	7.5	7.5	7.3	7.3
Temp		1	30.2	30.2	29.3	29.3
Turb		1	15.8	15.8	2.4	2.4
EC		1	995	995	994	994
TH		1	357	357	354	354
Ca⁺²		1	90	90	91	91
Mg⁺²		1	32	32	31	31
SO4⁻²		1	265	265	262	262
TDS		1	630	630	632	632
Na⁺		1	82	82	81	81
K⁺		1	3.1	3.1	3.1	3.1

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	August	1	7.5	7.5	7.5	7.5
Temp		1	32.1	32.1	32.1	32.1
Turb		1	4.9	4.9	1.5	1.5
EC		1	960	960	966	966
TH		1	306	306	306	306
Ca⁺²		1	71	71	72	72
Mg⁺²		1	29	29	28	28
SO4⁻²		1	256	256	264	264
TDS		1	616	616	618	618
Na⁺		1	76	76	78	78
K⁺		1	3	3	3	3

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	September	1	7.6	7.6	7.5	7.5
Temp		1	29.4	29.4	29.8	29.8
Turb		1	4	4	0.4	0.4
EC		1	960	960	956	956
TH		1	309	309	306	306
Ca ⁺²		1	70	70	71	71
Mg ⁺²		1	30	30	29	29
SO4 ⁻²		1	234	234	237	237
TDS		1	630	630	622	622
Na ⁺		1	71	71	74	74
K ⁺		1	2.8	2.8	2.8	2.8

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	October	1	7.7	7.7	7.6	7.6
Temp		1	26.6	26.6	26.9	26.9
Turb		1	4.8	4.8	1.8	1.8
EC		1	985	985	995	995
TH		1	309	309	309	309
Ca ⁺²		1	71	71	71	71
Mg ⁺²		1	29	29	29	29
SO4 ⁻²		1	252	252	256	256
TDS		1	644	644	652	652
Na ⁺		1	69	69	71	71
K ⁺		1	2.9	2.9	2.9	2.9

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	November	1	7.8	7.8	7.6	7.6
Temp		1	23.2	23.2	23.1	23.1
Turb		1	7	7	2.9	2.9
EC		1	1065	1065	1055	1055
TH		1	337	337	337	337
Ca ⁺²		1	83	83	84	84
Mg ⁺²		1	29	29	28	28
SO4 ⁻²		1	294	294	280	280
TDS		1	716	716	706	706
Na ⁺		1	78	78	75	75
K ⁺		1	2.9	2.9	2.9	2.9

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	December	1	7.7	7.7	7.5	7.5
Temp		1	19.4	19.4	19.7	19.7
Turb		1	8.7	8.7	5.4	5.4
EC		1	1136	1136	1144	1144
TH		1	343	343	347	347
Ca ⁺²		1	78	78	79	79
Mg ⁺²		1	33	33	33	33
SO4 ⁻²		1	270	270	267	267
TDS		1	706	706	710	710
Na ⁺		1	84	84	85	85
K ⁺		1	2.8	2.8	2.8	2.8

Table (B.4) :(Raw and Treated water data for the new Hilla Station for 2018)

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	January	1	7.76	7.53	7.6	7.45
		2	7.26		7.2	
		3	7.8		7.7	
		4	7.3		7.3	
Temp		1	17	17.525	17.2	17.65
		2	17.4		17.5	
		3	16.2		16.3	
		4	19.5		19.6	
Turb		1	7.3	5.1	0.5	0.325
		2	4		0.2	
		3	4.1		0.3	
		4	5		0.3	
EC		1	1188	1082.25	1193	1086.75
		2	1103		1116	
		3	1020		1019	
		4	1018		1019	
TH		1	350	322.75	350	320.25
		2	324		320	
		3	307		304	
		4	310		307	
Ca ⁺²		1	81	78.5	81	78.5
		2	77		77	
		3	80		80	
		4	76		76	
Mg ⁺²		1	36	30.75	36	30
		2	32		31	
		3	26		25	
		4	29		28	
So4 ⁻²		1	236	218.75	261	223.5
		2	229		224	
		3	202		205	
		4	208		204	
TDS		1	746	652	748	656.5
		2	636		648	
		3	594		596	
		4	632		634	

Appendix B *Data obtained from the Babylon Water Department (2017, 2018 and 2019)*

Na⁺		1	84	73.75	84	73.75
		2	68		69	
		3	70		67	
		4	73		75	
K⁺		1	2.8	2.7	2.8	2.675
		2	2.7		2.7	
		3	2.6		2.5	
		4	2.7		2.7	

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	February	1	6.8	7.1925	6.7	7.025
		2	7.7		7.6	
		3	7.1		6.9	
		4	7.17		6.9	
Temp		1	17.2	18.375	17.8	18.8
		2	18.5		19.4	
		3	18.7		18.8	
		4	19.1		19.2	
Turb		1	2.7	3.575	0.3	0.5
		2	2.7		0.7	
		3	4.9		0.3	
		4	4		0.7	
EC		1	1029	1030	1027	1034.5
		2	1012		1015	
		3	993		1009	
		4	1086		1087	
TH		1	311	317	311	316.25
		2	311		308	
		3	308		308	
		4	338		338	
Ca⁺²		1	71	71	71	70.75
		2	70		69	
		3	68		68	
		4	75		75	
Mg⁺²		1	33	34.25	33	34.75
		2	33		35	
		3	34		34	
		4	37		37	
So4⁻²		1	202	197.25	201	199.25
		2	212		216	
		3	204		206	
		4	171		174	
TDS		1	626	627.5	624	613
		2	666		620	
		3	558		570	
		4	660		638	
Na⁺		1	79	77.75	79	79.5
		2	82		84	
		3	72		77	
		4	78		78	
K⁺		1	2.9	2.975	2.9	2.975
		2	2.9		2.9	
		3	2.7		2.8	

Appendix B Data obtained from the Babylon Water Department(2017,2018and 2019)

		4	3.4		3.3	
parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	March	1	7	6.9	7	6.766
		2	6.4		6.4	
		3	7.3		6.9	
Temp		1	21	24.233	22	24.466
		2	24.5		24.5	
		3	27.2		26.9	
Turb		1	10.3	5.866	0.2	0.233
		2	3.3		0.2	
		3	4		0.3	
EC		1	1025	1038	1031	1038.33
		2	1005		996	
		3	1084		1088	
TH		1	321	315	321	315
		2	295		295	
		3	329		329	
Ca⁺²		1	81	75.666	82	76
		2	65		65	
		3	81		81	
Mg⁺²		1	29	30.666	28	30.333
		2	32		32	
		3	31		31	
So4⁻²		1	189	215.333	192	216
		2	190		191	
		3	267		265	
TDS		1	556	600	570	604
		2	574		568	
		3	670		674	
Na⁺		1	75	76.666	75	76.666
		2	80		80	
		3	75		75	
K⁺		1	3.1	3	3.1	3
		2	3		3	
		3	2.9		2.9	

Appendix B Data obtained from the Babylon Water Department(2017,2018and 2019)

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	April	1	7	6.933	6.9	6.7
		2	7		6.7	
		3	6.8		6.5	
Temp		1	23.7	24.866	24.2	25.5
		2	25		26	
		3	25.9		26.3	
Turb		1	2.8	3.166	0.4	0.333
		2	4.1		0.4	
		3	2.6		0.2	
EC		1	1007	1080	1006	1065.666
		2	1112		1075	
		3	1121		1116	
TH		1	310	356.333	310	352
		2	377		371	
		3	382		375	
Ca ⁺²		1	86	91	86	91
		2	95		95	
		3	92		92	
Mg ⁺²		1	23	31.333	23	30.333
		2	34		33	
		3	37		35	
So4 ⁻²		1	220	288.666	221	257.666
		2	353		255	
		3	293		297	
TDS		1	588	648	588	625.333
		2	652		606	
		3	704		682	
Na ⁺		1	58	72.666	60	73
		2	79		77	
		3	81		82	
K ⁺		1	2.8	3.033	2.8	3
		2	3		2.9	
		3	3.3		3.3	

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	May	1	7.2	7.2	7.16	7.16
Temp		1	26.9	26.9	27.2	27.2
Turb		1	2.2	2.2	0.6	0.6
EC		1	1119	1119	1114	1114
TH		1	352	352	352	352
Ca ⁺²		1	87	87	87	87
Mg ⁺²		1	33	33	33	33
SO ₄ ⁻²		1	246	246	241	241
TDS		1	676	676	648	648
Na ⁺		1	88	88	94	94
K ⁺		1	2.8	2.8	2.7	2.7

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	June	1	6.8	6.8	6.8	6.8
Temp		1	29.6	29.6	29.4	29.4
Turb		1	6	6	1.7	1.7
EC		1	1228	1228	1234	1234
TH		1	368	368	368	368
Ca ⁺²		1	93	93	93	93
Mg ⁺²		1	33	33	33	33
SO ₄ ⁻²		1	299	299	284	284
TDS		1	700	700	718	718
Na ⁺		1	99	99	103	103
K ⁺		1	2.5	2.5	2.5	2.5

Appendix B Data obtained from the Babylon Water Department(2017,2018and 2019)

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	July	1	6.3	6.775	6.4	6.725
		2	7.4		7.3	
		3	6.9		6.7	
		4	6.5		6.5	
Temp		1	29	29.15	29.5	28.775
		2	29.3		28.6	
		3	28.2		27.1	
		4	30.1		29.9	
Turb		1	4.3	5.2	0.14	0.275
		2	7.4		0.3	
		3	4.3		0.16	
		4	4.8		0.5	
EC		1	1178	1200.75	1175	1200.75
		2	1225		1230	
		3	1228		1224	
		4	1172		1174	
TH		1	346	375.5	346	374.75
		2	378		378	
		3	401		398	
		4	377		377	
Ca ⁺²		1	83	87.5	83	87.5
		2	93		93	
		3	92		92	
		4	82		82	
Mg ⁺²		1	34	38.5	34	38.25
		2	36		36	
		3	42		41	
		4	42		42	
So4 ⁻²		1	295	311.5	275	309
		2	329		341	
		3	327		321	
		4	295		299	
TDS		1	774	747.5	766	742
		2	734		734	
		3	774		772	
		4	708		696	
Na ⁺		1	106	99.75	107	100.25
		2	96		95	

Appendix B *Data obtained from the Babylon Water Department (2017, 2018 and 2019)*

		3	111		111	
		4	86		88	
K⁺		1	2.8	3.625	2.8	3.65
		2	3.6		3.7	
		3	4		4	
		4	4.1		4.1	

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	August	1	7.3	7.1	7.4	7.1
		2	6.9		6.8	
Temp		1	27.2	29.5	27.8	29.85
		2	31.8		31.9	
Turb		1	5	5.2	0.3	0.275
		2	5.4		0.25	
EC		1	1216	1220	1215	1219.5
		2	1224		1224	
TH		1	391	391	391	391
		2	391		391	
Ca⁺²		1	90	89	89	88.5
		2	88		88	
Mg⁺²		1	41	41.5	41	41.5
		2	42		42	
So4⁻²		1	313	312.5	303	308.5
		2	312		314	
TDS		1	704	723	704	730
		2	742		756	
Na⁺		1	88	89	91	95
		2	90		99	
K⁺		1	3.8	3.7	3.8	3.8
		2	3.6		3.8	

Appendix B Data obtained from the Babylon Water Department(2017,2018and 2019)

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	September	1	7.6	7.075	7.4	7
		2	6.7		6.6	
		3	7.1		7.1	
		4	6.9		6.9	
Temp		1	30.4	30.4	30.9	30.05
		2	31		30.4	
		3	30.8		29.7	
		4	29.4		29.2	
Turb		1	8.2	8.175	0.7	0.53
		2	10.9		0.4	
		3	7		0.42	
		4	6.6		0.6	
EC		1	1193	1205.25	1190	1202
		2	1201		1201	
		3	1219		1213	
		4	1208		1204	
TH		1	375	381.25	375	378.75
		2	386		386	
		3	389		379	
		4	375		375	
Ca ⁺²		1	85	86.75	85	86.75
		2	89		89	
		3	89		89	
		4	84		84	
Mg ⁺²		1	40	40	40	39.5
		2	40		40	
		3	40		38	
		4	40		40	
So4 ⁻²		1	294	296.5	291	293.5
		2	301		298	
		3	297		300	
		4	294		285	
TDS		1	714	738	710	734.5
		2	764		762	
		3	774		766	
		4	700		700	
Na ⁺		1	105	100.5	103	100.75
		2	101		103	
		3	101		101	
		4	95		96	
K ⁺		1	3.7	3.9	3.6	3.875
		2	4		4	

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

		3	3.8		3.8	
		4	4.1		4.1	

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	October	1	7.1	6.75	7	6.7
		2	6.4		6.4	
Temp		1	27.9	25.9	27.4	27.8
		2	23.9		28.2	
Turb		1	8.2	7.9	0.8	0.65
		2	7.6		0.5	
EC		1	1199	1191.5	1204	1196
		2	1184		1188	
TH		1	368	375	368	371.5
		2	382		375	
Ca⁺²		1	85	85	85	85
		2	85		85	
Mg⁺²		1	38	39.5	38	78
		2	41		40	
So4⁻²		1	283	284	283	282
		2	285		281	
TDS		1	774	747	780	754
		2	720		728	
Na⁺		1	104	98.5	106	99
		2	93		92	
K⁺		1	4.3	4.25	4.3	4.2
		2	4.2		4.1	

Appendix B Data obtained from the Babylon Water Department(2017,2018and 2019)

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	November	1	6.8	7.133	6.9	7.133
		2	7.4		7.4	
		3	7.2		7.1	
Temp		1	20.7	20.666	20.9	20.866
		2	18.8		18.9	
		3	22.5		22.8	
Turb		1	11.1	9.4	9.1	3.866
		2	3.4		2	
		3	13.7		0.5	
EC		1	1059	1171.666	1071	1170.333
		2	1124		1075	
		3	1332		1365	
TH		1	354	385.666	361	383.666
		2	368		347	
		3	435		443	
Ca ⁺²		1	77	91.666	77	91.333
		2	88		83	
		3	110		114	
Mg ⁺²		1	39	40	41	38
		2	36		34	
		3	45		39	
So4 ⁻²		1	228	253.666	222	252.333
		2	244		238	
		3	289		297	
TDS		1	646	718.666	658	712
		2	688		648	
		3	822		830	
Na ⁺		1	88	101	95	100.666
		2	115		106	
		3	100		101	
K ⁺		1	3.8	3.633	3.9	3.666
		2	3.4		3.3	
		3	3.7		3.8	

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	December	1	7.1	7.5	7.2	7.45
		2	7.9		7.7	
Temp		1	18.8	16.45	19.1	16.65
		2	14.1		14.2	
Turb		1	26.4	24.05	8.6	4.9
		2	21.7		1.2	
EC		1	1088	1143.5	1117	1169
		2	1199		1221	
TH		1	354	375	457	413
		2	396		396	
Ca⁺²		1	85	88	85	91
		2	91		97	
Mg⁺²		1	36	38.5	35	36
		2	41		37	
So4⁻²		1	231	244.5	224	238.5
		2	258		253	
TDS		1	670	705	692	719
		2	740		746	
Na⁺		1	110	100.5	112	102.5
		2	91		93	
K⁺		1	3.6	3.85	3.8	3.9
		2	4.1		4	

Table (B-5) :(Raw water and Treated water data for the Al-Hussein Station for the year 2018)

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	January	1	7.5	7.5	7.5	7.5
Temp		1	13.7	13.7	13.9	13.9
Turb		1	4	4	0.9	0.9
EC		1	1224	1224	1214	1214
TH		1	353	353	353	353
Ca ⁺²		1	81	81	81	81
Mg ⁺²		1	37	37	37	37
SO4 ⁻²		1	262	262	261	261
TDS		1	776	776	770	770
Na ⁺		1	87	87	91	91
K ⁺		1	2.9	2.9	2.9	2.9

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	February	1	7.6	7.6	7.3	7.3
Temp		1	17.9	17.9	17.9	17.9
Turb		1	3	3	0.8	0.8
EC		1	1149	1149	1159	1159
TH		1	384	384	384	384
Ca ⁺²		1	81	81	82	82
Mg ⁺²		1	44	44	44	44
SO4 ⁻²		1	196	196	210	210
TDS		1	694	694	702	702
Na ⁺		1	82	82	82	82
K ⁺		1	3.3	3.3	3.4	3.4

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	March	1	7	7	7	7
Temp		1	20.7	20.7	21	21
Turb		1	5.2	5.2	2.7	2.7
EC		1	1225	1225	1239	1239
TH		1	382	382	382	382
Ca ⁺²		1	89	89	90	90
Mg ⁺²		1	39	39	38	38
SO ₄ ⁻²		1	270	270	277	277
TDS		1	736	736	764	764
Na ⁺		1	87	87	89	89
K ⁺		1	3.4	3.4	3.4	3.4

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	April	1	7.2	7.2	7.5	7.5
Temp		1	25	25	25	25
Turb		1	2.6	2.6	0.9	0.9
EC		1	988	988	988	988
TH		1	347	347	347	347
Ca ⁺²		1	87	87	87	87
Mg ⁺²		1	32	32	32	32
SO ₄ ⁻²		1	237	237	232	232
TDS		1	588	588	592	592
Na ⁺		1	64	64	66	66
K ⁺		1	2.8	2.8	2.8	2.8

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	May	1	7.1	7.1	7.1	7.1
Temp		1	27.8	27.8	27.6	27.6
Turb		1	1.2	1.2	0.7	0.7
EC		1	1155	1155	1168	1168
TH		1	378	378	382	382
Ca ⁺²		1	98	98	98	98
Mg ⁺²		1	32	32	33	33
SO4 ⁻²		1	275	275	274	274
TDS		1	730	730	738	738
Na ⁺		1	75	75	76	76
K ⁺		1	3.5	3.5	3.5	3.5

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	June	1	7	7	7	7
Temp		1	27	27	27	27
Turb		1	1.8	1.8	0.9	0.9
EC		1	1234	1234	1235	1235
TH		1	368	368	368	368
Ca ⁺²		1	94	94	93	93
Mg ⁺²		1	32	32	33	33
SO4 ⁻²		1	315	315	330	330
TDS		1	694	694	696	696
Na ⁺		1	101	101	101	101
K ⁺		1	2.5	2.5	2.6	2.6

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	July	1	7.2	7.2	7.2	7.2
Temp		1	30.4	30.4	30.4	30.4
Turb		1	4.6	4.6	0.9	0.9
EC		1	1245	1245	1247	1247
TH		1	408	408	408	408
Ca ⁺²		1	102	102	102	102
Mg ⁺²		1	37	37	37	37
SO ₄ ⁻²		1	314	314	308	308
TDS		1	766	766	768	768
Na ⁺		1	104	104	105	105
K ⁺		1	3.7	3.7	3.8	3.8

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	August	1	7	7	7.1	7.1
Temp		1	34	34	33.9	33.9
Turb		1	4.8	4.8	3.8	3.8
EC		1	1205	1205	1209	1209
TH		1	384	384	384	384
Ca ⁺²		1	88	88	85	85
Mg ⁺²		1	40	40	42	42
SO ₄ ⁻²		1	302	302	313	313
TDS		1	728	728	730	730
Na ⁺		1	82	82	85	85
K ⁺		1	3.4	3.4	3.2	3.2

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	September	1	7.1	7.1	7.1	7.1
Temp		1	30.6	30.6	30.3	30.3
Turb		1	4.9	4.9	4.6	4.6
EC		1	1228	1228	1224	1224
TH		1	382	382	382	382
Ca ⁺²		1	89	89	89	89
Mg ⁺²		1	39	39	39	39
SO ₄ ⁻²		1	295	295	304	304
TDS		1	688	688	678	678
Na ⁺		1	110	110	110	110
K ⁺		1	4	4	4	4

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	October	1	7.1	7.1	7	7
Temp		1	26	26	25.6	25.6
Turb		1	10.5	10.5	2.7	2.7
EC		1	1209	1209	1232	1232
TH		1	372	372	382	382
Ca ⁺²		1	58	58	92	92
Mg ⁺²		1	39	39	37	37
SO ₄ ⁻²		1	277	277	270	270
TDS		1	726	726	756	756
Na ⁺		1	107	107	111	111
K ⁺		1	4.9	4.9	4.5	4.5

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	November	1	7	7	7	7
Temp		1	21.7	21.7	21.7	21.7
Turb		1	12.7	12.7	4.3	4.3
EC		1	1260	1260	1319	1319
TH		1	411	411	432	432
Ca ⁺²		1	96	96	108	108
Mg ⁺²		1	42	42	40	40
SO ₄ ⁻²		1	284	284	287	287
TDS		1	790	790	862	862
Na ⁺		1	107	107	104	104
K ⁺		1	3.6	3.6	3.6	3.6

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	December	1	7.6	7.6	7.49	7.49
Temp		1	16.2	16.2	16	16
Turb		1	18	18	9.8	9.8
EC		1	1238	1238	1269	1269
TH		1	419	419	429	429
Ca ⁺²		1	99	99	102	102
Mg ⁺²		1	42	42	42	42
SO ₄ ⁻²		1	290	290	297	297
TDS		1	758	758	780	780
Na ⁺		1	93	93	94	94
K ⁺		1	3.8	3.8	3.9	3.9

Table (B.6): Raw water and Treated water data for the Hashimyah Station for the year 2018

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	January	1	7.6	7.6	7.4	7.4
Temp		1	17.1	17.1	16.8	16.8
Turb		1	3.5	3.5	2.5	2.5
EC		1	1131	1131	1149	1149
TH		1	324	324	324	324
Ca ⁺²		1	81	81	81	81
Mg ⁺²		1	30	30	30	30
SO ₄ ⁻²		1	227	227	232	232
TDS		1	732	732	744	744
Na ⁺		1	80	80	79	79
K ⁺		1	2.8	2.8	2.8	2.8

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	February	1	7	7	7.1	7.1
Temp		1	18.2	18.2	17.8	17.8
Turb		1	3	3	1.8	1.8
EC		1	1032	1032	1038	1038
TH		1	321	321	316	316
Ca ⁺²		1	71	71	71	71
Mg ⁺²		1	35	35	34	34
SO ₄ ⁻²		1	202	202	203	203
TDS		1	582	582	586	586
Na ⁺		1	84	84	84	84
K ⁺		1	2.8	2.8	2.8	2.8

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	March	1	7.1	7.1	7	7
Temp		1	24	24	23	23
Turb		1	8.6	8.6	2.7	2.7
EC		1	1051	1051	1020	1020
TH		1	331	331	328	328
Ca ⁺²		1	74	74	74	74
Mg ⁺²		1	36	36	35	35
SO ₄ ⁻²		1	187	187	187	187
TDS		1	600	600	572	572
Na ⁺		1	81	81	76	76
K ⁺		1	3	3	3	3

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	April	1	7.4	7.4	7	7
Temp		1	25.6	25.6	26	26
Turb		1	1.5	1.5	2	2
EC		1	1043	1043	1036	1036
TH		1	360	360	360	360
Ca ⁺²		1	92	92	95	95
Mg ⁺²		1	32	32	30	30
SO ₄ ⁻²		1	250	250	248	248
TDS		1	632	632	638	638
Na ⁺		1	60	60	63	63
K ⁺		1	2.8	2.8	2.8	2.8

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	May	1	7	7	7	7
Temp		1	26.9	26.9	28.9	28.9
Turb		1	2.7	2.7	1.6	1.6
EC		1	1149	1149	1096	1096
TH		1	352	352	332	332
Ca ⁺²		1	86	86	85	85
Mg ⁺²		1	33	33	29	29
SO ₄ ⁻²		1	255	255	252	252
TDS		1	686	686	654	654
Na ⁺		1	104	104	100	100
K ⁺		1	2.8	2.8	2.8	2.8

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	June	1	7	7	7	7
Temp		1	31.4	31.4	31.4	31.4
Turb		1	1.8	1.8	1.1	1.1
EC		1	114	114	113	113
TH		1	346	346	355	355
Ca ⁺²		1	91	91	91	91
Mg ⁺²		1	29	29	31	31
SO ₄ ⁻²		1	283	283	279	279
TDS		1	680	680	680	680
Na ⁺		1	82	82	83	83
K ⁺		1	2	2	2.1	2.1

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	July	1	7	7	7	7
Temp		1	32.8	32.8	32.8	32.8
Turb		1	10.5	10.5	1.4	1.4
EC		1	1257	1257	1230	1230
TH		1	365	365	365	365
Ca ⁺²		1	93	93	93	93
Mg ⁺²		1	32	32	32	32
SO ₄ ⁻²		1	325	325	326	326
TDS		1	772	772	772	772
Na ⁺		1	98	98	98	98
K ⁺		1	3.6	3.6	3.7	3.7

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	August	1	7.66	7.66	7.22	7.22
Temp		1	33.6	33.6	33.6	33.6
Turb		1	4.2	4.2	2.5	2.5
EC		1	1234	1234	1182	1182
TH		1	374	374	374	374
Ca ⁺²		1	84	84	84	84
Mg ⁺²		1	40	40	40	40
SO ₄ ⁻²		1	286	286	296	296
TDS		1	744	744	778	778
Na ⁺		1	95	95	94	94
K ⁺		1	4	4	3.7	3.7

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	September	1	7.3	7.3	7.1	7.1
Temp		1	28.4	28.4	28.4	28.4
Turb		1	10	10	10.8	10.8
EC		1	1204	1204	1200	1200
TH		1	372	372	368	368
Ca ⁺²		1	83	83	84	84
Mg ⁺²		1	40	40	39	39
SO ₄ ⁻²		1	288	288	284	284
TDS		1	702	702	698	698
Na ⁺		1	103	103	101	101
K ⁺		1	4.3	4.3	4.3	4.3

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	October	1	7.2	7.2	7.3	7.3
Temp		1	32.1	32.1	32.1	32.1
Turb		1	108	10.8	5.2	5.2
EC		1	1233	1233	1233	1233
TH		1	379	379	379	379
Ca ⁺²		1	89	89	85	85
Mg ⁺²		1	38	38	41	41
SO ₄ ⁻²		1	288	288	284	284
TDS		1	730	730	730	730
Na ⁺		1	101	101	103	103
K ⁺		1	4.2	4.2	4.1	4.1

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	November	1	7.1	7.1	7.2	7.2
Temp		1	22.3	22.3	22.3	22.3
Turb		1	9.5	9.5	4.5	4.5
EC		1	1252	1252	1274	1274
TH		1	389	389	393	393
Ca ⁺²		1	85	85	84	84
Mg ⁺²		1	43	43	45	45
SO ₄ ⁻²		1	254	254	256	256
TDS		1	796	796	806	806
Na ⁺		1	101	101	106	106
K ⁺		1	4.9	4.9	4.9	4.9

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	December	1	7	7	7	7
Temp		1	19	19	19	19
Turb		1	10.2	10.2	6.6	6.6
EC		1	1261	1261	1168	1168
TH		1	391	391	381	381
Ca ⁺²		1	88	88	87	87
Mg ⁺²		1	42	42	40	40
SO ₄ ⁻²		1	275	275	265	265
TDS		1	778	778	714	714
Na ⁺		1	147	147	123	123
K ⁺		1	5.5	5.5	4.7	4.7

Table (B.7): (Raw and Treated water data for the new Hilla Station for 2019)

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	January	1	7.8	7.56	7.7	7.516
		2	7.18		7.15	
		3	7.7		7.7	
Temp		1	16	15.966	15.7	15.833
		2	15.5		15.6	
		3	16.4		16.2	
Turb		1	14.6	12.9	1	0.9
		2	10.6		0.8	
		3	13.5		0.9	
EC		1	1252	1303	1224	1292
		2	1337		1333	
		3	1320		1319	
TH		1	409	434.333	396	425.666
		2	442		442	
		3	452		439	
Ca ⁺²		1	99	111.666	96	111
		2	118		119	
		3	118		118	
Mg ⁺²		1	39	37.666	38	36
		2	36		35	
		3	38		35	
So ₄ ⁻²		1	298	350	299	349.666
		2	383		388	
		3	369		362	
TDS		1	770	826	730	801.333
		2	822		814	
		3	886		860	
Na ⁺		1	92	93	92	91.666
		2	97		93	
		3	90		90	
K ⁺		1	3.7	4.166	3.8	4.2
		2	4.6		4.5	
		3	4.2		4.3	

Appendix B Data obtained from the Babylon Water Department(2017,2018and 2019)

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	February	1	7.3	7.166	7.2	7.166
		2	6.5		6.6	
		3	7.7		7.7	
Temp		1	16.1	16.333	16.1	16.266
		2	17.6		17.5	
		3	15.3		15.2	
Turb		1	3.2	12.666	0.7	0.8
		2	17.8		0.8	
		3	17		0.9	
EC		1	1440	1367.333	1401	1355.666
		2	1339		1333	
		3	1323		1333	
TH		1	452	447.333	433	443.333
		2	449		449	
		3	441		448	
Ca ⁺²		1	114	117.666	109	116.666
		2	119		119	
		3	120		122	
Mg ⁺²		1	41	37.333	39	37
		2	37		37	
		3	34		35	
So4 ⁻²		1	351	346.333	346	349
		2	342		351	
		3	346		350	
TDS		1	840	835.333	812	834.666
		2	828		838	
		3	838		854	
Na ⁺		1	118	112.666	115	111.666
		2	117		115	
		3	103		105	
K ⁺		1	6.5	5.166	6.7	5.2
		2	4.7		4.7	
		3	4.3		4.2	

Appendix B Data obtained from the Babylon Water Department(2017,2018and 2019)

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	March	1	6.4	6.566	7.1	7.1
		2	7		6.98	
		3	6.3		7.1	
Temp		1	20.7	20.066	19.7	19.2
		2	20		19	
		3	19.5		18.9	
Turb		1	23.1	15.166	0.8	0.683
		2	9.6		0.5	
		3	12.8		0.75	
EC		1	1350	1331.666	1344	1322
		2	1303		1280	
		3	1342		1342	
TH		1	458	459.333	461	459.666
		2	448		442	
		3	472		476	
Ca ⁺²		1	128	128	127	123.666
		2	124		118	
		3	132		126	
Mg ⁺²		1	34	34.333	35	36.666
		2	34		36	
		3	35		39	
So4 ⁻²		1	399	395	389	388.666
		2	394		382	
		3	392		395	
TDS		1	900	875.333	876	848.333
		2	842		798	
		3	884		856	
Na ⁺		1	104	99	101	97.333
		2	89		89	
		3	104		102	
K ⁺		1	3.8	3.833	3.8	3.766
		2	2.7		2.7	
		3	5		4.8	

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	April	1	7.5	7.4	7.2	7.166
		2	7.4		7.2	
		3	7.3		7	
Temp		1	15	22.333	24.5	25.133
		2	23.2		23.3	
		3	28.8		27.6	
Turb		1	2.8	5.766	0.2	0.3
		2	5.5		0.4	
		3	9		0.3	
EC		1	1285	1146	1270	1143.666
		2	1099		1106	
		3	1054		1055	
TH		1	419	407.666	419	407.666
		2	395		395	
		3	409		409	
Ca ⁺²		1	32	87.666	32	87.666
		2	119		119	
		3	112		112	
Mg ⁺²		1	32	29	32	29
		2	24		24	
		3	31		31	
So4 ⁻²		1	351	339.666	347	336
		2	387		381	
		3	281		280	
TDS		1	852	746.666	840	743.333
		2	724		728	
		3	664		662	
Na ⁺		1	103	81.333	101	79.333
		2	70		67	
		3	71		70	
K ⁺		1	4.3	3.633	4.4	3.6
		2	3.6		3.4	
		3	3		3	

Appendix B Data obtained from the Babylon Water Department (2017,2018and 2019)

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	May	1	7.1	7.475	7	7.3
		2	7.5		7.4	
		3	7.3		7.1	
		4	8		7.7	
Temp		1	27.6	30.45	23.9	28.625
		2	31.3		29.2	
		3	28.6		28	
		4	34.3		33.4	
Turb		1	65	30.8	0.4	0.425
		2	13.7		0.6	
		3	19		0.3	
		4	25.5		0.4	
EC		1	995	973	998	987.25
		2	1015		1067	
		3	983		982	
		4	899		902	
TH		1	384	363.75	384	364.75
		2	366		369	
		3	367		371	
		4	338		335	
Ca ⁺²		1	104	99	104	98.75
		2	101		101	
		3	101		101	
		4	90		89	
Mg ⁺²		1	30	28.5	30	28.5
		2	28		28	
		3	28		29	
		4	28		27	
So ₄ ⁻²		1	272	241.25	203	225.75
		2	241		253	
		3	239		234	
		4	213		213	
TDS		1	600	596.5	596	592.5
		2	620		612	
		3	600		594	
		4	566		568	
Na ⁺		1	64	55.75	62	55

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

		2	59		59	
		3	56		54	
		4	44		45	
K⁺		1	3	2.825	2.9	2.8
		2	2.8		2.8	
		3	2.7		2.7	
		4	2.8		2.8	

Appendix B Data obtained from the Babylon Water Department(2017,2018and 2019)

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	June	1	7.3	7.45	7.3	7.4
		2	6.9		6.9	
		3	7.5		7.5	
		4	8.1		7.9	
Temp		1	29.4	29.4	28.5	29.175
		2	28.6		29.2	
		3	29.9		29	
		4	29.7		30	
Turb		1	28	33.65	0.56	1.94
		2	22		1.5	
		3	39		1.9	
		4	45.6		3.8	
EC		1	880	859.75	878	856.25
		2	845		842	
		3	868		857	
		4	846		848	
TH		1	360	344.5	360	340
		2	326		326	
		3	344		337	
		4	348		337	
Ca ⁺²		1	101	96.75	97	95.25
		2	96		93	
		3	97		96	
		4	93		95	
Mg ⁺²		1	26	24.5	29	25
		2	21		23	
		3	25		24	
		4	28		24	
So4 ⁻²		1	226	229	214	221.25
		2	223		213	
		3	238		235	
		4	229		223	
TDS		1	542	521	544	522.5
		2	498		490	
		3	522		524	
		4	522		532	
Na ⁺		1	36	36.75	37	35.75
		2	36		36	

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

		3	40		36	
		4	35		34	
K⁺		1	2.6	2.425	2.6	2.425
		2	2.3		2.4	
		3	2.5		2.4	
		4	2.3		2.3	

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	July	1	7.7	7.7	7.6	7.6
Temp		1	30.5	30.5	29.8	29.8
Turb		1	57.7	57.7	2.6	2.6
EC		1	824	824	834	834
TH		1	328	328	328	328
Ca⁺²		1	87	87	89	89
Mg⁺²		1	27	27	26	26
SO4⁻²		1	215	215	211	211
TDS		1	506	506	512	521
Na⁺		1	54	54	55	55
K⁺		1	2.1	2.1	2.1	2.1

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	August	1	7.1	7.433	7.2	7.5
		2	7.8		7.8	
		3	7.4		7.5	
Temp		1	30.6	30.7	31	30.6
		2	31.1		30.3	
		3	30.4		30.5	
Turb		1	55	52.6	4.6	2.4
		2	49.8		1.6	
		3	53		1	
EC		1	862	864.666	858	696.333
		2	864		863	
		3	868		868	
TH		1	345	357	338	342.333
		2	345		338	
		3	381		351	
Ca ⁺²		1	94	95.333	94	94
		2	95		92	
		3	97		96	
Mg ⁺²		1	27	26.333	25	26
		2	26		26	
		3	26		27	
So4 ⁻²		1	245	247.333	240	245.666
		2	248		252	
		3	249		245	
TDS		1	552	554	550	550.666
		2	548		540	
		3	562		562	
Na ⁺		1	49	48.333	48	48.333
		2	49		49	
		3	47		48	
K ⁺		1	2.2	2.166	2.2	2.2
		2	2.1		2.1	
		3	2.2		2.3	

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	September	1	8.2	7.5	8	7.45
		2	6.8		6.9	
Temp		1	30.9	30.15	30.2	29.25
		2	29.4		28.3	
Turb		1	43.7	42.35	3	2.3
		2	41		1.6	
EC		1	862	866	866	867
		2	870		868	
TH		1	351	349.5	348	349.5
		2	348		351	
Ca⁺²		1	99	97	99	96
		2	95		93	
Mg⁺²		1	25	26	25	27
		2	27		29	
So4⁻²		1	253	251	247	244
		2	249		241	
TDS		1	544	561	558	569
		2	578		580	
Na⁺		1	40	48	41	48.5
		2	56		56	
K⁺		1	2.1	2.3	2.2	2.35
		2	2.5		2.5	

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	October	1	6.5	6.5	6.6	6.6
		2	6.5		6.6	
Temp		1	31.9	29.6	28.5	27.55
		2	27.3		26.6	
Turb		1	21	21	3	4
		2	21		5	
EC		1	862	813	857	812.5
		2	764		768	
TH		1	302	297.5	298	295.5
		2	293		293	
Ca⁺²		1	70	70	70	73
		2	70		76	
Mg⁺²		1	31	30	30	30.5
		2	29		31	
So4⁻²		1	193	173.5	195	171
		2	154		147	
TDS		1	532	498	524	502
		2	464		480	
Na⁺		1	46	54.5	45	55
		2	63		65	
K⁺		1	2.9	2.65	2.9	2.7
		2	2.4		2.5	

Appendix B *Data obtained from the Babylon Water Department(2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	November	1	7.3	7.3	7.29	7.145
		2	7.3		7	
Temp		1	23.2	26	23.2	25.4
		2	28.8		27.6	
Turb		1	18.4	13.7	1.8	1.05
		2	9		0.3	
EC		1	937	995.5	929	992
		2	1054		1055	
TH		1	342	375.5	333	371
		2	409		409	
Ca⁺²		1	77	94.5	70	91
		2	112		112	
Mg⁺²		1	36	33.5	39	35
		2	31		31	
So4⁻²		1	217	249	217	248.5
		2	281		280	
TDS		1	562	613	558	610
		2	664		662	
Na⁺		1	68	69.5	71	70.5
		2	71		70	
K⁺		1	3.9	3.45	3.9	3.45
		2	3		3	

Table (B.8): (Raw water and Treated water data for the Al-Hussein Station for the year 2019)

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	January	1	7.65	7.65	7.65	7.65
Temp		1	15	15	15	15
Turb		1	8.6	8.6	4.2	4.2
EC		1	1316	1316	1320	1320
TH		1	446	446	442	442
Ca ⁺²		1	119	119	119	119
Mg ⁺²		1	36	36	35	35
SO ₄ ⁻²		1	371	371	366	366
TDS		1	816	816	822	822
Na ⁺		1	91	91	90	90
K ⁺		1	4.1	4.1	4.1	4.1

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	February	1	7	7	6.8	6.8
Temp		1	19	19	19	19
Turb		1	8.5	8.5	4.8	4.8
EC		1	1311	1311	1317	1317
TH		1	449	449	445	445
Ca ⁺²		1	117	117	119	119
Mg ⁺²		1	38	38	36	36
SO ₄ ⁻²		1	349	349	350	350
TDS		1	814	814	818	818
Na ⁺		1	113	113	111	111
K ⁺		1	4.5	4.5	4.4	4.4

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	March	1	7.1	7.1	6.5	6.5
Temp		1	21	21	20.9	20.9
Turb		1	13	13	15.4	15.4
EC		1	1362	1362	1372	1372
TH		1	467	467	467	467
Ca⁺²		1	129	129	131	131
Mg⁺²		1	35	35	34	34
SO₄⁻²		1	410	410	401	401
TDS		1	906	906	912	912
Na⁺		1	92	92	93	93
K⁺		1	4.3	4.3	4.1	4.1

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	April	1	7.7	7.7	7.2	7.2
Temp		1	23	23	22.9	22.9
Turb		1	10	10	3.8	3.8
EC		1	1059	1059	1065	1065
TH		1	420	420	409	409
Ca⁺²		1	112	112	112	112
Mg⁺²		1	34	34	31	31
SO₄⁻²		1	279	279	271	271
TDS		1	674	674	674	674
Na⁺		1	70	70	68	68
K⁺		1	3.2	3.2	3.2	3.2

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	May	1	7.1	7.1	7.3	7.3
Temp		1	27.3	27.3	27.3	27.3
Turb		1	12.5	12.5	4	4
EC		1	986	986	989	989
TH		1	367	367	364	364
Ca ⁺²		1	97	97	97	97
Mg ⁺²		1	30	30	30	30
SO4 ⁻²		1	245	245	239	239
TDS		1	606	606	616	616
Na ⁺		1	53	53	53	53
K ⁺		1	3.1	3.1	3.2	3.2

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	June	1	8.7	8.7	8.5	8.5
Temp		1	36.9	36.9	37.6	37.6
Turb		1	19.3	19.3	8.5	8.5
EC		1	881	881	884	884
TH		1	351	351	348	348
Ca ⁺²		1	96	96	96	96
Mg ⁺²		1	27	27	27	27
SO4 ⁻²		1	217	217	232	232
TDS		1	542	542	546	546
Na ⁺		1	34	34	37	37
K ⁺		1	2.5	2.5	2.6	2.6

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	July	1	7.3	7.3	7.4	7.4
Temp		1	31	31	30	30
Turb		1	60	60	35	35
EC		1	859	859	861	861
TH		1	338	338	342	342
Ca ⁺²		1	92	92	92	92
Mg ⁺²		1	26	26	27	27
SO ₄ ⁻²		1	231	231	239	239
TDS		1	544	544	550	550
Na ⁺		1	54	54	55	55
K ⁺		1	2.3	2.3	2.4	2.4

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	August	1	7.7	7.7	7.7	7.7
Temp		1	24.2	24.2	24.2	24.2
Turb		1	81.2	81.2	25.8	25.8
EC		1	851	851	856	856
TH		1	342	342	345	345
Ca ⁺²		1	92	92	92	92
Mg ⁺²		1	27	27	28	28
SO ₄ ⁻²		1	233	233	231	231
TDS		1	528	528	540	540
Na ⁺		1	47	47	46	46
K ⁺		1	2.3	2.3	2.2	2.2

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	September	1	7.86	7.86	7.77	7.77
Temp		1	28.9	28.9	28.5	28.5
Turb		1	57	57	14.3	14.3
EC		1	937	937	947	947
TH		1	370	370	366	366
Ca ⁺²		1	99	99	99	99
Mg ⁺²		1	30	30	29	29
SO4 ⁻²		1	266	266	269	269
TDS		1	578	578	594	594
Na ⁺		1	50	50	50	50
K ⁺		1	2.5	2.5	2.5	2.5

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	October	1	6.8	6.8	6.7	6.7
Temp		1	27.6	27.6	27.2	27.2
Turb		1	15	15	9.5	9.5
EC		1	797	797	801	801
TH		1	302	302	307	307
Ca ⁺²		1	74	74	74	74
Mg ⁺²		1	29	29	30	30
SO4 ⁻²		1	193	193	190	190
TDS		1	496	496	500	500
Na ⁺		1	64	64	64	64
K ⁺		1	2.7	2.7	2.8	2.8

Appendix B *Data obtained from the Babylon Water Department (2017,2018and 2019)*

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	November December		Protests	Protests	Protests	Protests
Temp						
Turb						
EC						
TH						
Ca⁺²						
Mg⁺²						
SO₄⁻²						
TDS						
Na⁺						
K⁺						

Table (B.9): Raw water and Treated water data for the Hashimyah Station for the year 2019

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	January	1	7.4	7.4	7.24	7.24
Temp		1	15	15	15	15
Turb		1	7.6	7.6	5	5
EC		1	1337	1337	1355	1355
TH		1	445	445	448	448
Ca ⁺²		1	119	119	119	119
Mg ⁺²		1	36	36	36	36
SO ₄ ⁻²		1	379	379	385	385
TDS		1	842	842	896	896
Na ⁺		1	87	87	91	91
K ⁺		1	4.3	4.3	4.5	4.5

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	February	1	7.5	7.5	6.6	6.6
Temp		1	19.6	19.6	20.5	20.5
Turb		1	10.1	10.1	4.7	4.7
EC		1	1445	1445	1316	1316
TH		1	418	418	407	407
Ca ⁺²		1	114	114	106	106
Mg ⁺²		1	32	32	35	35
SO ₄ ⁻²		1	297	297	304	304
TDS		1	816	816	744	744
Na ⁺		1	125	125	108	108
K ⁺		1	7.4	7.4	5.2	5.2

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	March	1	6.8	6.8	6.8	6.8
Temp		1	22.5	22.5	22.5	22.5
Turb		1	5.2	5.2	5.6	5.6
EC		1	1324	1324	1327	1327
TH		1	445	445	451	451
Ca ⁺²		1	127	127	133	133
Mg ⁺²		1	31	31	29	29
SO ₄ ⁻²		1	418	418	411	411
TDS		1	854	854	850	850
Na ⁺		1	102	102	106	106
K ⁺		1	2.2	2.2	2.2	2.2

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	April	1	7.3	7.3	6.9	6.9
Temp		1	27.5	27.5	26.5	26.5
Turb		1	5.2	5.2	3.7	3.7
EC		1	1316	1316	1284	1284
TH		1	473	473	484	484
Ca ⁺²		1	183	183	118	118
Mg ⁺²		1	40	40	49	49
SO ₄ ⁻²		1	353	353	312	312
TDS		1	860	860	840	840
Na ⁺		1	109	109	110	110
K ⁺		1	4.8	4.8	5.1	5.1

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	May	1	7.2	7.2	7	7
Temp		1	25.5	25.5	26	26
Turb		1	2.9	2.9	2.1	2.1
EC		1	1048	1048	1052	1052
TH		1	388	388	391	391
Ca ⁺²		1	101	101	101	101
Mg ⁺²		1	32	32	32	32
SO ₄ ⁻²		1	244	244	251	251
TDS		1	630	630	680	680
Na ⁺		1	66	66	65	65
K ⁺		1	3.1	3.1	3.1	3.1

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	June	1	7.5	7.5	7	7
Temp		1	28.1	28.1	27.9	27.9
Turb		1	11	11	13	13
EC		1	873	873	878	878
TH		1	349	349	349	349
Ca ⁺²		1	97	97	97	97
Mg ⁺²		1	26	26	26	26
SO ₄ ⁻²		1	236	236	228	228
TDS		1	554	554	560	560
Na ⁺		1	41	41	41	41
K ⁺		1	2.8	2.8	2.7	2.7

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	July August		Protests	Protests	Protests	Protests
Temp						
Turb						
EC						
TH						
Ca ⁺²						
Mg ⁺²						
SO ₄ ⁻²						
TDS						
Na ⁺						
K ⁺						

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	September	1	7.4	7.4	7.6	7.6
Temp		1	30	30	29	29
Turb		1	55	55	50	50
EC		1	867	867	867	867
TH		1	355	355	355	355
Ca ⁺²		1	99	99	97	97
Mg ⁺²		1	26	26	27	27
SO ₄ ⁻²		1	256	256	263	263
TDS		1	572	572	576	576
Na ⁺		1	41	41	41	41
K ⁺		1	2.1	2.1	2	2

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	October	1	6.5	6.5	7.9	7.9
Temp		1	26.8	26.8	26.8	26.8
Turb		1	15.1	15.1	17.6	17.6
EC		1	767	767	767	767
TH		1	302	302	302	302
Ca ⁺²		1	70	70	70	70
Mg ⁺²		1	31	31	32	32
SO ₄ ⁻²		1	151	151	160	160
TDS		1	464	464	462	462
Na ⁺		1	62	62	63	63
K ⁺		1	2.6	2.6	2.7	2.7

parameters	month	the week	Raw water weekly rate	Raw water monthly rate	Weekly rate of Treated water	Monthly rate of Treated water
pH	November		Protests	Protests	Protests	Protests
Temp	December					
Turb						
EC						
TH						
Ca ⁺²						
Mg ⁺²						
SO ₄ ⁻²						
TDS						
Na ⁺						
K ⁺						

(1) Calculation of water quality for all stations using Weighted arithmetic index method

In this method, W_i is calculated from equation (3.6)

K from equation (3.7)

Calculate $\sum W_i$ from the equation (3.8)

Q_i from equation (3.9)

EX: In the first month (January)

the W_i Q_i is calculated for each indicator and then the water quality coefficient is found according to the equation (3.10) as follows:

$Q_i = 100 [V_a - V_o] / [V_s - V_o]$ ($V_{o\text{pH}} = 7$, $V_o = 0$ for the other parameters)

$$Q_i = 100 [7.748 - 7] / [7.5 - 7] = 149.6$$

$$K = [1 / \sum 1 / V_s]$$

$$K = [1 / 0.501167] = 1.995$$

$$W_i = K / S$$

$$W_i = 1.995 / 7.5 = 0.266$$

$$\sum W_i = K \sum [1 / V_s] = 1.995 \times 0.501167 = 1$$

$$Q_i W_i = 149.6 \times 0.266 = 39.7936$$

Then

$$WQI = \sum q_i W_i / \sum W_i$$

$$WQI = (39.7936 + 3.403 + 50.482 + 0.240 + 0.309 + 6.764 + 3.412 + 0.365 + 0.062 + 0.483 + 4.399) / 1 = 109.7126$$

(This process is repeated for the remaining months.)

Table (C.1):Raw water for the New Hilla Station (2017)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	∑W _i	∑Q _i W _i	WQI
1	7.748	15.350	6.325	1200.500	387.500	84.750	42.750	292.500	696.500	96.750	3.175	1	109.712 6	109.712 6
2	7.937	16.060	8.200	937.000	305.000	70.667	31.333	213.333	583.333	89.333	9.200	1	140.948	140.948
3	7.950	24.100	5.500	915.000	301.000	63.000	35.000	210.000	524.000	84.000	3.100	1	113.057	113.057
4	7.766	23.633	12.166	963.666	319.000	74.666	46.666	214.000	634.666	80.666	3.133	1	158.297	158.297
5	7.700	24.900	36.900	909.000	313.000	69.000	34.000	181.000	642.000	70.000	3.000	1	350.721	350.721
6	7.400	28.433	5.033	942.333	364.000	91.333	33.333	251.000	609.333	71.000	2.933	1	82.972	82.972
7	7.700	30.033	8.833	994.000	346.000	87.000	31.666	259.000	633.333	78.666	3.033	1	129.324	129.324
8	7.400	29.200	6.350	973.000	307.500	73.000	27.500	257.000	648.000	76.500	2.950	1	91.747	91.747
9	7.550	29.650	3.750	959.500	306.000	69.500	30.000	235.500	621.000	73.000	2.900	1	78.877	78.877

Appendix C

Water quality calculation

10	7.700	27.100	7.000	1000.000	309.000	75.000	27.000	262.000	666.000	67.000	2.800	1	112.311	112.311
11	7.800	21.900	2.900	1079.000	340.000	84.000	29.000	282.000	726.000	78.000	2.800	1	84.759	84.759
12	7.850	17.500	4.550	1180.000	337.500	81.000	30.500	267.000	718.000	83.500	2.800	1	99.520	99.520
mean														129.352

Table (C.2): Treated water for the New Hilla Station (2017)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	ΣW _i	ΣQ _i W _i	WQI
1	7.600	15.300	0.775	1203.500	387.750	85.750	42.000	283.750	682.500	98.500	3.175	1	52.198	52.198
2	7.800	17.233	0.800	938.667	311.330	70.333	32.666	216.333	585.333	90.333	9.100	1	75.044	75.044
3	7.790	24.200	0.700	911.000	294.000	63.000	33.000	209.000	520.000	87.000	3.100	1	63.822	63.822
4	7.633	24.133	1.233	960.666	326.666	74.666	47.000	213.333	627.333	81.000	3.100	1	60.112	60.112
5	7.300	27.400	0.500	885.000	384.000	70.000	31.000	190.000	620.000	70.000	3.000	1	36.928	36.928
6	7.433	27.800	1.400	943.666	361.666	92.000	32.000	247.666	607.333	71.666	2.993	1	51.629	51.629
7	7.366	29.933	0.266	992.000	351.000	87.000	32.666	254.000	632.666	80.000	3.066	1	39.790	39.790
8	7.300	30.250	0.300	963.500	305.000	73.000	27.000	254.500	638.000	77.000	3.000	1	36.226	36.226
9	7.550	29.500	0.400	957.000	306.000	70.000	29.500	237.500	616.000	74.500	2.900	1	49.930	49.930
10	7.600	27.200	0.600	995.000	306.000	75.000	26.000	256.000	664.000	70.000	2.800	1	53.265	53.265
11	7.700	21.900	0.400	1082.000	337.000	84.000	28.000	282.000	730.000	80.000	2.800	1	55.522	55.522
12	7.750	17.600	0.250	1173.000	336.000	81.000	30.000	264.500	710.000	82.500	2.800	1	55.610	55.610
mean														52.506

Table (C.3):Raw Water for Al-Hussein Station (2017)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	ΣW _i	ΣQ _i W _i	WQI
1	7.670	18.100	4.670	1198.000	413.000	91.000	45.000	303.000	762.000	90.000	3.200	1	93.688	93.688
2	8.080	19.200	3.900	902.000	298.000	68.000	31.000	198.000	614.000	88.000	3.100	1	106.205	106.205
3	7.900	22.500	33.800	916.000	304.000	63.000	36.000	213.000	582.000	85.000	3.000	1	335.872	335.872
4	7.800	24.000	7.400	912.000	304.000	68.000	33.000	193.000	536.000	78.000	3.000	1	120.271	120.271
5	7.700	25.600	15.900	877.000	307.000	70.000	32.000	199.000	588.000	74.000	3.000	1	183.213	183.213
6	7.400	28.200	5.900	928.000	361.000	93.000	31.000	235.000	612.000	69.000	2.900	1	89.706	89.706
7	7.500	32.000	12.000	990.000	343.000	88.000	30.000	252.000	650.000	79.000	3.100	1	144.427	144.427
8	7.300	23.600	3.800	985.000	335.000	84.000	28.000	254.000	656.000	80.000	3.100	1	65.997	65.997
9	7.600	28.200	4.600	964.000	309.000	73.000	28.000	265.000	636.000	87.000	3.200	1	88.647	88.647
10	7.600	29.700	7.000	994.000	316.000	78.000	27.000	270.000	660.000	76.000	2.800	1	107.865	107.865
11	7.800	24.200	6.600	1050.000	326.000	80.000	28.000	284.000	702.000	74.000	2.800	1	114.365	114.365
12	7.500	16.700	4.500	1151.000	357.000	80.000	35.000	267.000	708.000	79.000	2.800	1	80.586	80.586
mean														127.57

Table (C.4): Treated Water for Al-Hussein Station (2017)														
Time	pH	Temp	Turb	EC	TH	Ca⁺²	Mg⁺²	SO₄⁻²	TDS	Na⁺	K⁺	∑W_i	∑Q_i W_i	WQI
1	7.610	18.700	1.800	1202.000	400.000	91.000	42.000	291.000	770.000	90.000	3.200	1	62.147	62.147
2	7.990	19.000	1.400	906.000	298.000	68.000	31.000	195.000	616.000	87.000	3.100	1	78.453	78.453
3	7.500	22.500	1.900	921.000	317.000	65.000	38.000	210.000	584.000	84.000	3.000	1	57.347	57.347
4	7.600	24.800	2.500	898.000	304.000	69.000	34.000	192.000	520.000	78.000	3.100	1	68.326	68.326
5	7.400	25.600	3.800	887.000	310.000	71.000	32.000	200.000	592.000	76.000	3.000	1	68.117	68.117
6	7.290	28.200	1.300	928.000	353.000	92.000	30.000	239.000	614.000	71.000	2.900	1	43.074	43.074
7	7.200	32.000	1.000	992.000	343.000	88.000	30.000	251.000	656.000	79.000	3.100	1	37.483	37.483
8	7.200	23.900	0.600	986.000	335.000	84.000	28.000	260.000	648.000	80.000	3.100	1	31.613	31.613
9	7.600	27.600	0.800	965.000	313.000	75.000	28.000	260.000	634.000	87.000	3.200	1	55.877	55.877
10	7.700	29.300	1.400	994.000	320.000	78.000	27.000	267.000	660.000	77.000	2.900	1	65.973	65.973
11	7.500	24.400	1.800	1056.000	326.000	80.000	28.000	282.000	708.000	76.000	2.800	1	56.798	56.798
12	7.300	16.900	1.700	1155.000	354.000	80.000	35.000	267.000	710.000	79.000	2.800	1	43.069	43.069
mean														55.69

Table (C.5): Raw Water for the Hashimyah Station (2017)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	ΣW _i	ΣQ _i W _i	WQI
1	7.780	16.600	7.700	1206.000	396.000	91.000	41.000	321.000	800.000	99.000	3.200	1	123.131	123.131
2	8.040	14.800	5.000	1031.000	335.000	73.000	37.000	259.000	662.000	100.000	3.200	1	113.093	113.093
3	7.450	19.100	4.000	933.000	310.000	60.000	39.000	214.000	540.000	89.000	3.200	1	73.632	73.632
4	7.800	21.400	39.000	1076.000	360.000	84.000	37.000	268.000	726.000	90.000	3.400	1	374.304	374.304
5	7.500	25.800	5.800	885.000	304.000	69.000	34.000	198.000	550.000	76.000	3.000	1	92.088	92.088
6	7.900	27.100	6.500	989.000	366.000	89.000	35.000	250.000	560.000	83.000	3.000	1	121.094	121.094
7	7.500	30.200	15.800	995.000	357.000	90.000	32.000	265.000	630.000	82.000	3.100	1	174.718	174.718
8	7.500	32.100	4.900	960.000	306.000	71.000	29.000	256.000	616.000	76.000	3.000	1	86.157	86.157
9	7.600	29.400	4.000	960.000	309.000	70.000	30.000	234.000	630.000	71.000	2.800	1	83.370	83.370
10	7.700	26.600	4.800	985.000	309.000	71.000	29.000	252.000	644.000	69.000	2.900	1	94.613	94.613
11	7.800	23.200	7.000	1065.000	337.000	83.000	29.000	294.000	716.000	78.000	2.900	1	117.839	117.839
12	7.700	19.400	8.700	1136.000	343.000	78.000	33.000	270.000	706.000	84.000	2.800	1	125.043	125.043
mean														131.59

Table (C.6): Treated Water for the Hashimyah Station (2017)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	ΣW _i	ΣQi W _i	WQI
1	7.500	16.600	3.700	1198.000	396.000	91.000	41.000	310.000	792.000	98.000	3.200	1	70.842	70.842
2	7.790	14.800	3.100	1031.000	345.000	74.000	38.000	250.000	660.000	98.000	3.100	1	80.384	80.384
3	7.600	19.400	2.000	935.000	301.000	63.000	35.000	217.000	542.000	89.000	3.200	1	62.817	62.817
4	7.500	21.200	6.800	1044.000	360.000	84.000	37.000	264.000	706.000	90.000	3.500	1	97.479	97.479
5	7.500	25.600	3.800	885.000	310.000	69.000	34.000	190.000	550.000	77.000	3.000	1	73.461	73.461
6	7.400	27.100	2.500	989.000	363.000	89.000	34.000	252.000	558.000	83.000	3.000	1	58.505	58.505
7	7.300	29.300	2.400	99.400	354.000	91.000	31.000	262.000	632.000	81.000	3.100	1	53.198	53.198
8	7.500	32.100	1.500	966.000	306.000	72.000	28.000	264.000	618.000	78.000	3.000	1	57.135	57.135
9	7.500	29.800	0.400	956.000	306.000	71.000	29.000	237.000	622.000	74.000	2.800	1	47.154	47.154
10	7.600	26.900	1.800	995.000	309.000	71.000	29.000	256.000	652.000	71.000	2.900	1	63.008	63.008
11	7.600	23.100	2.900	1055.000	337.000	84.000	28.000	280.000	706.000	75.000	2.900	1	70.773	70.773
12	7.500	19.700	5.400	1144.000	347.000	79.000	33.000	267.000	710.000	85.000	2.800	1	84.245	84.245
mean														68.25

Table (C.7): Raw water for the New Hilla Station (2018)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	∑W _i	∑Qi W _i	WQI
1	7.530	17.525	5.100	1082.250	322.750	78.500	30.750	218.750	652.000	73.750	2.700	1	86.424	86.424
2	7.193	18.375	3.575	1030.000	317.000	71.000	34.250	197.250	627.500	77.750	2.975	1	56.521	56.521
3	6.900	24.233	5.866	1038.000	315.000	75.666	30.666	215.333	600.000	76.666	3.000	1	60.677	60.677
4	6.933	24.866	3.166	1080.000	356.333	91.000	31.333	288.666	648.000	72.666	3.033	1	42.463	42.463
5	7.200	26.900	2.200	1119.000	352.000	87.000	33.000	246.000	676.000	88.000	2.800	1	48.932	48.932
6	6.800	29.600	6.000	1228.000	368.000	93.000	33.000	299.000	700.000	99.000	2.500	1	58.797	58.797
7	6.775	29.150	5.200	1200.750	375.500	87.500	38.500	311.500	747.500	99.750	3.625	1	52.565	52.565
8	7.100	29.500	5.200	1220.000	391.000	89.000	41.500	312.500	723.000	89.000	3.700	1	70.360	70.360
9	7.075	30.400	8.175	1205.250	381.250	86.750	40.000	296.500	738.000	100.500	3.900	1	92.980	92.980
10	6.750	25.900	7.900	1191.500	375.000	85.000	39.500	284.000	747.000	98.500	4.250	1	72.767	72.767
11	7.133	20.666	9.400	1171.666	385.666	91.666	40.000	253.666	718.666	101.000	3.633	1	103.652	103.652
12	7.500	16.450	24.050	1143.500	375.000	88.000	38.500	244.500	705.000	100.500	3.850	1	239.031	239.031
mean														82.098

Table (C.8): Treated water for the New Hilla Station (2018)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	ΣW _i	ΣQi W _i	WQI
1	7.450	17.650	0.325	1086.750	320.250	78.500	30.000	223.500	656.500	73.750	2.675	1	39.834	39.834
2	7.025	18.800	0.500	1034.500	316.250	70.750	34.750	199.250	613.000	79.500	2.975	1	19.502	19.502
3	6.766	24.466	0.233	1038.330	315.000	76.000	30.333	216.000	604.000	76.666	3.000	1	5.368	5.368
4	6.700	25.500	0.333	1065.666	352.000	91.000	30.333	257.666	625.333	73.000	3.000	1	3.188	3.188
5	7.160	27.200	0.600	1114.000	352.000	87.000	33.000	241.000	648.000	94.000	2.700	1	29.888	29.888
6	6.800	29.400	1.700	1234.000	368.000	93.000	33.000	284.000	718.000	103.000	2.500	1	19.938	19.938
7	6.725	28.775	0.275	1200.750	374.750	87.500	38.250	309.000	742.000	100.250	3.650	1	6.710	6.710
8	7.100	29.850	0.275	1219.500	391.000	88.500	41.500	308.500	730.000	95.000	3.800	1	27.455	27.455
9	7.000	30.050	0.530	1202.000	378.750	86.750	39.500	293.500	734.500	100.750	3.875	1	24.300	24.300
10	6.700	27.800	0.650	1196.000	371.500	85.000	78.000	282.000	754.000	99.000	4.200	1	9.905	9.905
11	7.133	20.866	3.866	1170.333	383.666	91.333	38.000	252.333	712.000	100.666	3.666	1	54.722	54.722
12	7.450	16.650	4.900	1169.000	413.000	91.000	36.000	238.500	719.000	102.500	3.900	1	79.021	79.021
mean														26.653

Table (C.9): Raw Water for Al-Hussein Station (2018)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	∑W _i	∑Q _i W _i	WQI
1	7.500	13.700	4.000	1224.000	353.000	81.000	37.000	262.000	776.000	87.000	2.900	1	76.359	76.359
2	7.600	17.900	3.000	1149.000	384.000	81.000	44.000	196.000	694.000	82.000	3.300	1	75.638	75.638
3	7.000	20.700	5.200	1225.000	382.000	89.000	39.000	270.000	736.000	87.000	4.400	1	63.791	63.791
4	7.200	25.000	2.600	988.000	347.000	87.000	32.000	237.000	588.000	64.000	2.800	1	51.455	51.455
5	7.100	27.800	1.200	1155.000	378.000	98.000	32.000	275.000	730.000	75.000	3.500	1	37.602	37.602
6	7.000	27.000	1.800	1234.000	368.000	94.000	32.000	315.000	694.000	101.000	2.500	1	35.371	35.371
7	7.200	30.400	4.600	1245.000	408.000	102.000	37.000	314.000	766.000	104.000	3.700	1	71.869	71.869
8	7.000	34.000	4.800	1205.000	384.000	88.000	40.000	302.000	728.000	82.000	3.400	1	62.173	62.173
9	7.100	30.600	4.900	1228.000	382.000	89.000	39.000	295.000	688.000	110.000	4.000	1	68.500	68.500
10	7.100	26.000	10.500	1209.000	372.000	58.000	39.000	277.000	726.000	107.000	4.900	1	110.903	110.903
11	7.000	21.700	12.700	1260.000	411.000	96.000	42.000	284.000	790.000	107.000	3.600	1	123.715	123.715
12	7.600	16.200	18.000	1238.000	419.000	99.000	42.000	290.000	758.000	93.000	3.800	1	197.175	197.175
mean														81.213

Table (C.10): Treated Water for Al-Hussein Station (2018)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	∑W _i	∑Q _i W _i	WQI
1	7.500	13.900	0.900	1214.000	353.000	81.000	37.000	261.000	770.000	91.000	2.900	1	46.662	46.662
2	7.300	17.900	0.800	1159.000	384.000	82.000	44.000	210.000	702.000	82.000	3.400	1	37.537	37.537
3	7.000	21.000	2.700	1239.000	382.000	90.000	38.000	277.000	764.000	89.000	3.400	1	37.795	37.795
4	7.500	25.000	0.900	988.000	347.000	87.000	32.000	232.000	592.000	66.000	2.800	1	28.467	28.467
5	7.100	27.600	0.700	1168.000	382.000	98.000	33.000	274.000	738.000	76.000	3.500	1	29.359	29.359
6	7.000	27.000	0.900	1235.000	368.000	93.000	33.000	330.000	696.000	101.000	2.600	1	23.691	23.691
7	7.200	30.400	0.900	1247.000	408.000	102.000	37.000	308.000	768.000	105.000	3.800	1	38.053	38.053
8	7.100	33.900	3.800	1209.000	384.000	85.000	42.000	313.000	730.000	85.000	3.200	1	55.745	55.745
9	7.100	30.300	4.600	1224.000	382.000	89.000	39.000	304.000	678.000	110.000	4.000	1	62.611	62.611
10	7.000	25.600	2.700	1232.000	382.000	92.000	37.000	270.000	756.000	111.000	4.500	1	41.508	41.508
11	7.000	21.700	4.300	1319.000	432.000	108.000	40.000	287.000	862.000	104.000	3.600	1	51.547	51.547
12	7.490	16.000	9.800	1269.000	429.000	102.000	42.000	297.000	780.000	94.000	3.900	1	120.503	120.503
mean														47.79

Table (C.11): Raw Water for the Hashimyah Station (2018)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	∑W _i	∑Q _i W _i	WQI
1	7.600	17.100	3.500	1131.000	324.000	81.000	30.000	227.000	732.000	80.000	2.800	1	77.622	77.622
2	7.000	18.200	3.000	1032.000	321.000	71.000	35.000	202.000	582.000	84.000	2.800	1	41.504	41.504
3	7.100	24.000	8.600	1051.000	331.000	74.000	36.000	187.000	600.000	81.000	3.000	1	93.383	93.383
4	7.400	25.600	1.500	1043.000	360.000	92.000	32.000	250.000	632.000	60.000	2.800	1	53.871	53.871
5	7.000	26.900	2.700	1149.000	352.000	86.000	33.000	255.000	686.000	104.000	2.800	1	42.299	42.299
6	7.000	31.400	1.800	114.000	346.000	91.000	29.000	283.000	680.000	82.000	2.000	1	34.798	34.798
7	7.000	32.800	10.500	1257.000	365.000	93.000	32.000	325.000	772.000	98.000	3.600	1	107.546	107.546
8	7.660	33.600	4.200	1234.000	374.000	84.000	40.000	286.000	744.000	95.000	4.000	1	92.970	92.970
9	7.300	28.400	10.000	1204.000	372.000	83.000	40.000	288.000	702.000	103.000	4.300	1	119.321	119.321
10	7.200	32.100	10.800	1233.000	379.000	89.000	38.000	288.000	730.000	101.000	4.200	1	121.390	121.390
11	7.100	22.300	9.500	1252.000	389.000	85.000	43.000	254.000	796.000	101.000	4.900	1	104.545	104.545
12	7.000	19.000	10.200	1261.000	391.000	88.000	42.000	275.000	778.000	147.000	5.500	1	105.328	105.328
mean														82.881

Table (C.12): Treated Water for the Hashimyah Station (2018)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	∑W _i	∑Q _i W _i	WQI
1	7.400	16.800	2.500	1149.000	324.000	81.000	30.000	232.000	744.000	79.000	2.800	1	54.633	54.633
2	7.100	17.800	1.800	1038.000	316.000	71.000	34.000	203.000	586.000	84.000	2.800	1	33.247	33.247
3	7.000	23.000	2.700	1020.000	328.000	74.000	35.000	187.000	572.000	76.000	3.000	1	37.198	37.198
4	7.000	26.000	2.000	1036.000	360.000	95.000	30.000	248.000	638.000	63.000	2.800	1	32.325	32.325
5	7.000	28.900	1.600	1096.000	332.000	85.000	29.000	252.000	654.000	100.000	2.800	1	30.012	30.012
6	7.000	31.400	1.100	113.000	355.000	91.000	31.000	279.000	680.000	83.000	2.100	1	25.470	25.470
7	7.000	32.800	1.400	1230.000	365.000	93.000	32.000	326.000	772.000	98.000	3.700	1	31.738	31.738
8	7.220	33.600	2.500	1182.000	374.000	84.000	40.000	296.000	778.000	94.000	3.700	1	52.595	52.595
9	7.100	28.400	10.800	1200.000	368.000	84.000	39.000	284.000	698.000	101.000	4.300	1	112.171	112.171
10	7.300	32.100	5.200	1233.000	379.000	85.000	41.000	284.000	730.000	103.000	4.100	1	78.847	78.847
11	7.200	22.300	4.500	1274.000	393.000	84.000	45.000	256.000	806.000	106.000	4.900	1	66.433	66.433
12	7.000	19.000	6.600	1168.000	381.000	87.000	40.000	265.000	714.000	123.000	4.700	1	71.059	71.059
mean														52.144

Table (C.13):Raw water for the New Hilla Station (2019)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	∑W _i	∑Q _i W _i	WQI
1	7.560	15.966	12.900	1303.000	434.333	111.666	37.666	350.000	826.000	93.000	4.166	1	155.568	155.568
2	7.166	16.333	12.666	1367.333	447.333	117.666	37.333	346.333	835.333	112.666	5.166	1	134.773	134.773
3	6.566	20.066	15.166	1331.666	459.333	128.000	34.333	395.000	875.333	99.000	3.833	1	122.366	122.366
4	7.400	22.333	5.766	1146.000	407.666	87.666	29.000	339.666	746.666	81.333	3.633	1	88.051	88.051
5	7.475	30.450	30.800	973.000	363.750	99.000	28.500	241.250	596.500	55.750	2.825	1	293.059	293.059
6	7.450	29.400	33.650	859.750	344.500	96.750	24.500	229.000	521.000	36.750	2.425	1	313.035	313.035
7	7.700	30.500	57.700	824.000	328.000	87.000	27.000	215.000	506.000	54.000	2.100	1	517.551	517.551
8	7.433	30.700	52.600	864.666	357.000	95.333	26.333	247.333	554.000	48.333	2.166	1	463.434	463.434
9	7.500	30.150	42.350	866.000	349.500	97.000	26.000	251.000	561.000	48.000	2.300	1	385.358	385.358
10	6.500	29.600	21.000	813.000	297.500	70.000	30.000	173.500	498.000	54.500	2.650	1	160.152	160.152
11	7.300	26.000	13.700	995.500	475.500	94.500	33.500	249.000	613.000	69.500	3.450	1	147.358	147.358
12	Protests													
mean														252.791

Table (C.14): Treated water for the New Hilla Station (2019)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	∑W _i	∑Q _i W _i	WQI
1	7.516	15.833	0.900	1292.000	425.666	111.000	36.000	349.666	801.333	91.666	4.200	1	51.168	51.168
2	7.166	16.266	0.800	1355.666	443.333	116.666	37.000	349.000	834.666	111.666	5.200	1	33.955	33.955
3	7.100	19.200	0.683	1322.000	459.666	123.666	36.666	388.666	843.333	79.333	3.766	1	27.607	27.607
4	7.166	25.133	0.300	1143.666	407.666	87.666	29.000	336.000	743.333	79.333	3.600	1	29.022	29.022
5	7.300	28.625	0.425	987.250	364.750	98.750	28.500	225.750	592.500	55.000	2.800	1	36.521	36.521
6	7.400	29.175	1.940	856.250	340.000	95.250	25.000	221.250	522.500	35.750	2.425	1	53.232	53.232
7	7.600	29.800	2.600	834.000	328.000	89.000	26.000	211.000	521.000	55.000	2.100	1	68.733	68.733
8	7.500	30.600	2.400	696.333	342.333	94.000	26.000	245.666	550.666	48.333	2.200	1	62.331	62.331
9	7.450	29.250	2.300	867.000	349.500	96.000	27.000	244.000	569.000	48.500	2.350	1	58.781	58.781
10	6.600	27.550	4.000	812.500	295.500	73.000	30.500	171.000	502.000	55.000	2.700	1	26.891	26.891
11	7.145	25.400	1.050	992.000	371.000	91.000	35.000	248.500	610.000	70.500	3.450	1	33.651	33.651
12	Protests													
mean														43.808

Table (C.15): Raw Water for Al-Hussein Station (2019)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	∑W _i	∑Q _i W _i	WQI
1	7.650	15.000	8.600	1316.000	446.000	113.000	36.000	371.000	316.000	91.000	4.100	1	125.688	125.688
2	7.000	19.000	8.500	1311.000	449.000	117.000	38.000	349.000	814.000	113.000	4.500	1	92.352	92.352
3	7.100	21.000	13.000	1362.000	467.000	129.000	35.000	410.000	906.000	92.000	4.300	1	134.477	134.477
4	7.700	23.000	10.000	159.000	420.000	112.000	34.000	279.000	674.000	70.000	3.200	1	139.370	139.370
5	7.100	27.300	12.500	986.000	367.000	97.000	30.000	245.000	606.000	53.000	3.100	1	126.686	126.686
6	8.700	36.900	19.300	881.000	351.000	96.000	27.000	217.000	542.000	34.000	2.500	1	266.903	266.903
7	7.300	31.000	60.000	859.000	338.000	92.000	26.000	231.000	544.000	54.000	2.300	1	515.370	515.370
8	7.700	24.200	81.200	851.000	342.000	92.000	27.000	233.000	528.000	47.000	2.300	1	704.399	704.399
9	7.860	28.900	57.000	937.000	370.000	99.000	30.000	266.000	578.000	50.000	2.500	1	521.980	521.980
10	6.800	27.600	15.000	797.000	302.000	74.000	29.000	193.000	496.000	64.000	2.700	1	128.164	128.164
11	Protests													
12														
mean														275.539

Table (C.16): Treated Water for Al-Hussein Station (2019)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	ΣW _i	ΣQ _i W _i	WQI
1	7.650	15.000	4.200	1320.000	442.000	119.000	35.000	366.000	822.000	90.000	4.100	1	84.378	84.378
2	6.800	19.000	4.800	1317.000	445.000	119.000	36.000	350.000	818.000	111.000	4.400	1	45.722	45.722
3	6.500	20.900	15.400	1372.000	467.000	131.000	34.000	401.000	912.000	93.000	4.100	1	114.751	114.751
4	7.200	22.900	3.800	1065.000	409.000	112.000	31.000	271.000	674.000	68.000	3.200	1	57.492	57.492
5	7.300	27.300	4.000	989.000	364.000	97.000	30.000	239.000	616.000	53.000	3.200	1	65.566	65.566
6	8.500	37.600	8.500	884.000	348.000	96.000	27.000	232.000	546.000	37.000	2.600	1	167.653	167.653
7	7.400	30.000	35.000	861.000	342.000	92.000	27.000	239.000	550.000	55.000	2.400	1	318.363	318.363
8	7.700	24.200	25.800	856.000	345.000	92.000	28.000	231.000	540.000	46.000	2.200	1	258.417	258.417
9	7.770	28.500	14.300	947.000	366.000	99.000	29.000	269.000	594.000	50.000	2.500	1	172.183	172.183
10	6.700	27.200	9.500	801.000	307.000	74.000	30.000	190.000	500.000	64.000	2.800	1	76.429	76.429
11	Protests													
12														
mean														136.095

Table (C.17):Raw Water for the Hashimyah Station (2019)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	∑W _i	∑Q _i W _i	WQI
1	7.400	15.000	7.600	1337.000	445.000	119.000	36.000	379.000	842.000	87.000	4.300	1	105.200	105.200
2	7.500	19.600	10.100	1445.000	418.000	114.000	32.000	297.000	816.000	125.000	7.400	1	135.157	135.157
3	6.800	22.500	5.200	1324.000	445.000	127.000	31.000	418.000	854.000	102.000	2.200	1	53.234	53.234
4	7.300	27.500	5.200	1316.000	473.000	183.000	40.000	353.000	860.000	109.000	4.800	1	89.713	89.713
5	7.200	25.500	2.900	1048.000	388.000	101.000	32.000	244.000	630.000	66.000	3.100	1	55.560	55.560
6	7.500	28.100	11.000	873.000	349.000	97.000	26.000	236.000	554.000	41.000	2.800	1	135.327	135.327
7	Protests													
8	Protests													
9	7.400	30.000	55.000	867.000	355.000	99.000	26.000	256.000	572.000	41.000	2.100	1	496.791	496.791
10	6.500	26.800	15.100	767.000	302.000	70.000	31.000	151.000	464.000	62.000	2.600	1	139.057	139.057
11	Protests													
12	Protests													
mean														151.255

Table (C.18): Treated Water for the Hashimyah Station (2019)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	∑W _i	∑Q _i W _i	WQI
1	7.240	15.000	5.000	1355.000	448.000	119.000	36.000	385.000	896.000	91.000	4.500	1	69.760	69.760
2	6.600	20.500	4.700	1316.000	407.000	106.000	35.000	304.000	744.000	180.000	5.200	1	36.237	36.237
3	6.800	22.500	5.600	1327.000	451.000	133.000	29.000	411.000	850.000	106.000	2.200	1	48.907	48.907
4	6.900	26.500	3.700	1284.000	484.000	118.000	49.000	312.000	840.000	110.000	5.100	1	46.291	46.291
5	7.000	26.000	2.100	1052.000	391.000	101.000	32.000	251.000	680.000	65.000	3.100	1	33.863	33.863
6	7.000	27.900	13.000	878.000	349.000	97.000	26.000	228.000	560.000	41.000	2.700	1	120.682	120.682
7	Protests													
8	Protests													
9	7.600	29.000	50.000	867.000	355.000	97.000	27.000	263.000	576.000	41.000	2.000	1	437.461	437.461
10	7.900	26.800	17.600	767.000	302.000	70.000	32.000	160.000	462.000	63.000	2.700	1	130.258	130.258
11	Protests													
12	Protests													
mean													115.432	

(2) Calculation of water quality for all stations using the Canadian method

In this method, the value of f_1 is calculated from the equation (3.13), f_2 from the equation (3.14), f_3 from the equation (3.18).

Excursion, it is calculated from equation (3.15) when the test value does not exceed the target, and (3.16) when the test value is not less than the target. and **nse** is found from the equation (3.17).

Then equation (3.19) is applied to find the water quality index.

EX:

Finding raw water quality standards for the New Hilla Station.

$$F_1 = (3/11) \times 100 = 27.2727$$

$$F_2 = (24/132) \times 100 = 18.1818$$

$$\text{Excursion for turbidity} = (6.325/5-1) + (8.2/5-1) + (5.5/5-1) + (12.166/5-1) + (36.9/5-1) + (5.4/5-1) + (8.833/5-1) + (6.35/5-1) + (7/5-1) = 10.3348$$

$$\text{Excursion for electricity} = (1200.5/1000-1) + (1079/1000-1) + (1180/1000-1) = 0.4595$$

$$\text{Excursion for calcium} = (84.75/50-1) + (70.667/50-1) + (63/50-1) + (74.666/50-1) + (69/50-1) + (91.333/50-1) + (87/50-1) + (73/50-1) + (69.5/50-1) + (75/50-1) + (84/50-1) + (81/50-1) = 6.45832$$

$$\text{and upon it } nse = (10.3348 + 0.4595 + 6.45832) / 132 = 0.13070$$

$$F_3 = 0.13070 / (0.13070 \times 0.01 + 0.01) = 11.5592$$

$$\text{CCMEWQI} = 100 - \frac{(27.2727^2 + 18.1818^2 + 11.5592^2)^{0.5}}{1.732} = 79.9329$$

(These operations are repeated for the remaining months)

Table (C.19): Raw water for the New Hilla Station (2017)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.7475	15.35	6.325	1200.5	387.5	84.75	42.75	292.5	696.5	96.75	3.175	79.9329
2	7.937	16.06	8.2	937	305	70.667	31.333	213.333	583.333	89.333	9.2	
3	7.95	24.1	5.5	915	301	63	35	210	524	84	3.1	
4	7.766	23.633	12.166	963.666	319	74.666	46.666	214	634.666	80.666	3.133	
5	7.7	24.9	36.9	909	313	69	34	181	642	70	3	
6	7.4	28.433	5.4	942.333	364	91.333	33.333	251	609.333	71	2.933	
7	7.7	30.033	8.833	994	346	87	31.666	259	633.333	78.666	3.033	
8	7.4	29.2	6.35	973	307.5	73	27.5	257	648	76.5	2.95	
9	7.55	29.65	3.75	959.5	306	69.5	30	235.5	621	73	2.9	
10	7.7	27.1	7	1000	309	75	27	262	666	67	2.8	
11	7.8	21.9	2.9	1079	340	84	29	282	726	78	2.8	
12	7.85	17.5	4.55	1180	337.5	81	30.5	267	718	83.5	2.8	
slandered	6.5-8.5	30	5	1000	500	50	50	400	1500	200	12	

Table (C.20): Treated water for the New Hilla Station (2017)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.6	15.3	0.775	1203.5	387.75	85.75	42	283.75	682.5	98.5	3.175	94.1191
2	7.8	17.233	0.8	938.667	311.33	70.333	32.666	216.333	585.333	90.333	9.1	
3	7.79	24.2	0.7	911	294	63	33	209	520	87	3.1	
4	7.633	24.133	1.233	960.666	326.666	74.666	47	213.333	627.333	81	3.1	
5	7.3	27.4	0.5	885	384	70	31	190	620	70	3	
6	7.433	27.8	1.4	943.666	361.666	92	32	247.666	607.333	71.666	2.993	
7	7.366	29.933	0.266	992	351	87	32.666	254	632.666	80	3.066	
8	7.3	30.25	0.3	963.5	305	73	27	254.5	638	77	3	
9	7.55	29.5	0.4	957	306	70	29.5	237.5	616	74.5	2.9	
10	7.6	27.2	0.6	995	306	75	26	256	664	70	2.8	
11	7.7	21.9	0.4	1082	337	84	28	282	730	80	2.8	
12	7.75	17.6	0.25	1173	336	81	30	264.5	710	82.5	2.8	
Standard	6.5-8.5	25	5	2000	500	150	100	400	1000	300	10	

Table (C.21): Raw Water for Al-Hussein Station (2017)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.67	18.1	4.67	1198	413	91	45	303	762	90	3.2	75.7190
2	8.08	19.2	3.9	902	298	68	31	198	614	88	3.1	
3	7.9	22.5	33.8	916	304	63	36	213	582	85	3	
4	7.8	24	7.4	912	304	68	33	193	536	78	3	
5	7.7	25.6	15.9	877	307	70	32	199	588	74	3	
6	7.4	28.2	5.9	928	361	93	31	235	612	69	2.9	
7	7.5	32	12	990	343	88	30	252	650	79	3.1	
8	7.3	23.6	3.8	985	335	84	28	254	656	80	3.1	
9	7.6	28.2	4.6	964	309	73	28	265	636	87	3.2	
10	7.6	29.7	7	994	316	78	27	270	660	76	2.8	
11	7.8	24.2	6.6	1050	326	80	28	284	702	74	2.8	
12	7.5	16.7	4.5	1151	357	80	35	267	708	79	2.8	
slandered	6.5-8.5	30	5	1000	500	50	50	400	1500	200	12	

Table (C.22): Treated Water for Al-Hussein Station (2017)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.61	18.7	1.8	1202	400	91	42	291	770	90	3.2	92.8112
2	7.99	19	1.4	906	298	68	31	195	616	87	3.1	
3	7.5	22.5	1.9	921	317	65	38	210	584	84	3	
4	7.6	24.8	2.5	898	304	69	34	192	520	78	3.1	
5	7.4	25.6	3.8	887	310	71	32	200	592	76	3	
6	7.29	28.2	1.3	928	353	92	30	239	614	71	2.9	
7	7.2	32	1	992	343	88	30	251	656	79	3.1	
8	7.2	23.9	0.6	986	335	84	28	260	648	80	3.1	
9	7.6	27.6	0.8	965	313	75	28	260	634	87	3.2	
10	7.7	29.3	1.4	994	320	78	27	267	660	77	2.9	
11	7.5	24.4	1.8	1056	326	80	28	282	708	76	2.8	
12	7.3	16.9	1.7	1155	354	80	35	267	710	79	2.8	
Standard	6.5-8.5	25	5	2000	500	150	100	400	1000	300	10	

Table (C.23): Raw Water for the Hashimyah Station (2017)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.78	16.6	7.7	1206	396	91	41	321	800	99	3.2	75.1120
2	8.04	14.8	5	1031	335	73	37	259	662	100	3.2	
3	7.45	19.1	4	933	310	60	39	214	540	89	3.2	
4	7.8	21.4	39	1076	360	84	37	268	726	90	3.4	
5	7.5	25.8	5.8	885	304	69	34	198	550	76	3	
6	7.9	27.1	6.5	989	366	89	35	250	560	83	3	
7	7.5	30.2	15.8	995	357	90	32	265	630	82	3.1	
8	7.5	32.1	4.9	960	306	71	29	256	616	76	3	
9	7.6	29.4	4	960	309	70	30	234	630	71	2.8	
10	7.7	26.6	4.8	985	309	71	29	252	644	69	2.9	
11	7.8	23.2	7	1065	337	83	29	294	716	78	2.9	
12	7.7	19.4	8.7	1136	343	78	33	270	706	84	2.8	
slandered	6.5-8.5	30	5	1000	500	50	50	400	1500	200	12	

Table (C.24): Treated Water for the Hashimyah Station (2017)												
Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.5	16.6	3.7	1198	396	91	41	310	792	98	3.2	94.1205
2	7.79	14.8	3.1	1031	345	74	38	250	660	98	3.1	
3	6.65	19.4	2.8	935	301	63	35	217	542	89	3.2	
4	7.5	21.2	6.8	1044	360	84	37	264	706	90	3.5	
5	7.5	25.6	3.8	885	310	69	34	190	550	77	3	
6	7.4	27.1	2.5	989	363	89	34	252	558	83	3	
7	7.3	29.3	2.4	99.4	354	91	31	262	632	81	3.1	
8	7.5	32.1	1.5	966	306	72	28	264	618	78	3	
9	7.5	29.8	0.4	956	306	71	29	237	622	74	2.8	
10	7.6	26.9	1.8	995	309	71	29	256	652	71	2.9	
11	7.6	23.1	2.9	1055	337	84	28	280	706	75	2.9	
12	7.5	19.7	5.4	1144	347	79	33	267	710	85	2.8	
Standard	6.5-8.5	25	5	2000	500	150	100	400	1000	300	10	

Table (C.25):Raw water for the New Hilla Station (2018)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.53	17.525	5.1	1082.25	322.75	78.5	30.75	218.75	652	73.75	2.7	73.4767
2	7.1925	18.375	3.575	1030	317	71	34.25	197.25	627.5	77.75	2.975	
3	6.9	24.233	5.866	1038	315	75.666	30.666	215.333	600	76.666	3	
4	6.933	24.866	3.166	1080	356.333	91	31.333	288.666	648	72.666	3.033	
5	7.2	26.9	2.2	1119	352	87	33	246	676	88	2.8	
6	6.8	29.6	6	1228	368	93	33	299	700	99	2.5	
7	6.775	29.15	5.2	1200.75	375.5	87.5	38.5	311.5	747.5	99.75	3.625	
8	7.1	29.5	5.2	1220	391	89	41.5	312.5	723	89	3.7	
9	7.075	30.4	8.175	1205.25	381.25	86.75	40	296.5	738	100.5	3.9	
10	6.75	25.9	7.9	1191.5	375	85	39.5	284	747	98.5	4.25	
11	7.133	20.666	9.4	1171.666	385.666	91.666	40	253.666	718.666	101	3.633	
12	7.5	16.45	24.05	1143.5	375	88	38.5	244.5	705	100.5	3.85	
slandered	6.5-8.5	30	5	1000	500	50	50	400	1500	200	12	

Table (C.26):Treated water for the New Hilla Station (2018)												
Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.45	17.65	0.325	1086.75	320.25	78.5	30	223.5	656.5	73.75	2.675	93.9096
2	7.025	18.8	0.5	1034.5	316.25	70.75	34.75	199.25	613	79.5	2.975	
3	6.766	24.466	0.233	1038.33	315	76	30.333	216	604	76.666	3	
4	6.7	25.5	0.333	1065.666	352	91	30.333	257.666	625.333	73	3	
5	7.16	27.2	0.6	1114	352	87	33	241	648	94	2.7	
6	6.8	29.4	1.7	1234	368	93	33	284	718	103	2.5	
7	6.725	28.775	0.275	1200.75	374.75	87.5	38.25	309	742	100.25	3.65	
8	7.1	29.85	0.275	1219.5	391	88.5	41.5	308.5	730	95	3.8	
9	7	30.05	0.53	1202	378.75	86.75	39.5	293.5	734.5	100.75	3.875	
10	6.7	27.8	0.65	1196	371.5	85	78	282	754	99	4.2	
11	7.133	20.866	3.866	1170.333	383.666	91.333	38	252.333	712	100.666	3.666	
12	7.45	16.65	4.9	1169	413	91	36	238.5	719	102.5	3.9	
Standard	6.5-8.5	25	5	2000	500	150	100	400	1000	300	10	

Table (C.27):Raw Water for Al-Hussein Station (2018)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.5	13.7	4	1224	353	81	37	262	776	87	2.9	74.3749
2	7.6	17.9	3	1149	384	81	44	196	694	82	3.3	
3	6.8	20.7	5.2	1225	382	89	39	270	736	87	4.4	
4	6.6	25	2.6	988	347	87	32	237	588	64	2.8	
5	7.1	27.8	1.2	1155	378	98	32	275	730	75	3.5	
6	7	27	1.8	1234	368	94	32	315	694	101	2.5	
7	6.5	30.4	4.6	1245	408	102	37	314	766	104	3.7	
8	6.8	34	4.8	1205	384	88	40	302	728	82	3.4	
9	7.1	30.6	4.9	1228	382	89	39	295	688	110	4	
10	6.7	26	10.5	1209	372	58	39	277	726	107	4.9	
11	7	21.7	12.7	1260	411	96	42	284	790	107	3.6	
12	7.6	16.2	18	1238	419	99	42	290	758	93	3.8	
slandered	6.5-8.5	30	5	1000	500	50	50	400	1500	200	12	

Table (C.28): Treated Water for Al-Hussein Station (2018)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.5	13.9	0.9	1214	353	81	37	261	770	91	2.9	89.0565
2	7.3	17.9	0.8	1159	384	82	44	210	702	82	3.4	
3	6.6	21	2.7	1239	382	90	38	277	764	89	3.4	
4	6.4	25	0.9	988	347	87	32	232	592	66	2.8	
5	7.1	27.6	0.7	1168	382	98	33	274	738	76	3.5	
6	7	27	0.9	1235	368	93	33	330	696	101	2.6	
7	6.5	30.4	0.9	1247	408	102	37	308	768	105	3.8	
8	6.7	33.9	3.8	1209	384	85	42	313	730	85	3.2	
9	7.1	30.3	4.6	1224	382	89	39	304	678	110	4	
10	7	25.6	2.7	1232	382	92	37	270	756	111	4.5	
11	7	21.7	4.3	1319	432	108	40	287	862	104	3.6	
12	7.49	16	9.8	1269	429	102	42	297	780	94	3.9	
Standard	6.5-8.5	25	5	2000	500	150	100	400	1000	300	10	

Table (C.29):Raw Water for the Hashimyah Station (2018)												
Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.6	17.1	3.5	1131	324	81	30	227	732	80	2.8	73.7317
2	6.9	18.2	3	1032	321	71	35	202	582	84	2.8	
3	6.3	24	8.6	1051	331	74	36	187	600	81	3	
4	7	25.6	1.5	1043	360	92	32	250	632	60	2.8	
5	6.7	26.9	2.7	1149	352	86	33	255	686	104	2.8	
6	7	31.4	1.8	114	346	91	29	283	680	82	2	
7	7	32.8	10.5	1257	365	93	32	325	772	98	3.6	
8	7.66	33.6	4.2	1234	374	84	40	286	744	95	4	
9	7.3	28.4	10	1204	372	83	40	288	702	103	4.3	
10	7.2	32.1	10.8	1233	379	89	38	288	730	101	4.2	
11	6.7	22.3	9.5	1252	389	85	43	254	796	101	4.9	
12	7	19	10.2	1261	391	88	42	275	778	147	5.5	
slandered	6.5-8.5	30	5	1000	500	50	50	400	1500	200	12	

Table (C.30):Treated Water for the Hashimyah Station (2018)												
Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO4 ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.4	16.8	2.5	1149	324	81	30	232	744	79	2.8	88.5532
2	6.5	17.8	1.8	1038	316	71	34	203	586	84	2.8	
3	6.3	23	2.7	1020	328	74	35	187	572	76	3	
4	6.7	26	2	1036	360	95	30	248	638	63	2.8	
5	6.6	28.9	1.6	1096	332	85	29	252	654	100	2.8	
6	7	31.4	1.1	113	355	91	31	279	680	83	2.1	
7	7	32.8	1.4	1230	365	93	32	326	772	98	3.7	
8	7.22	33.6	2.5	1182	374	84	40	296	778	94	3.7	
9	7.1	28.4	10.8	1200	368	84	39	284	698	101	4.3	
10	7.3	32.1	5.2	1233	379	85	41	284	730	103	4.1	
11	6.6	22.3	4.5	1274	393	84	45	256	806	106	4.9	
12	7	19	6.6	1168	381	87	40	265	714	123	4.7	
Standard	6.5-8.5	25	5	2000	500	150	100	400	1000	300	10	

Table (C.31): Raw water for the New Hilla Station (2019)

Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.56	15.966	12.9	1303	434.333	111.666	37.666	350	826	93	4.166	68.1160
2	7.166	16.333	12.666	1367.333	447.333	117.666	37.333	346.333	835.333	112.666	5.166	
3	6.566	20.066	15.166	1331.666	459.333	128	34.333	395	875.333	99	3.833	
4	7.4	22.333	5.766	1146	407.666	87.666	29	339.666	746.666	81.333	3.633	
5	7.475	30.45	30.8	973	363.75	99	28.5	241.25	596.5	55.75	2.825	
6	7.45	29.4	33.65	859.75	344.5	96.75	24.5	229	521	36.75	2.425	
7	7.7	30.5	57.7	824	328	87	27	215	506	54	2.1	
8	7.433	30.7	52.6	864.666	357	95.333	26.333	247.333	554	48.333	2.166	
9	7.5	30.15	42.35	866	349.5	97	26	251	561	48	2.3	
10	6.5	29.6	21	813	297.5	70	30	173.5	498	54.5	2.65	
11	7.3	26	13.7	995.5	475.5	94.5	33.5	249	613	69.5	3.45	
12	Protests											
standard	6.5-8.5	30	5	1000	500	50	50	400	1500	200	12	

Table (C.32): Treated water for the New Hilla Station (2019)												
Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.516	15.833	0.9	1292	425.666	111	36	349.666	801.333	91.666	4.2	93.4919
2	7.166	16.266	0.8	1355.666	443.333	116.666	37	349	834.666	111.666	5.2	
3	6.5	19.2	0.683	1322	459.666	123.666	36.666	388.666	843.333	79.333	3.766	
4	7.166	25.133	0.3	1143.666	407.666	87.666	29	336	743.333	79.333	3.6	
5	7.3	28.625	0.425	987.25	364.75	98.75	28.5	225.75	592.5	55	2.8	
6	7.4	29.175	1.94	856.25	340	95.25	25	221.25	522.5	35.75	2.425	
7	7.6	29.8	2.6	834	328	89	26	211	521	55	2.1	
8	7.5	30.6	2.4	696.333	342.333	94	26	245.666	550.666	48.333	2.2	
9	7.45	29.25	2.3	867	349.5	96	27	244	569	48.5	2.35	
10	6.6	27.55	4	812.5	295.5	73	30.5	171	502	55	2.7	
11	7.145	25.4	1.05	992	371	91	35	248.5	610	70.5	3.45	
12	Protests											
Standard	6.5-8.5	25	5	2000	500	150	100	400	1000	300	10	

Table (C.33):Raw Water for Al-Hussein Station (2019)												
Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO4 ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.65	15	8.6	1316	446	113	36	371	316	91	4.1	70.4182
2	7	19	8.5	1311	449	117	38	349	814	113	4.5	
3	7.1	21	13	1362	467	129	35	410	906	92	4.3	
4	7.7	23	10	159	420	112	34	279	674	70	3.2	
5	7.1	27.3	12.5	986	367	97	30	245	606	53	3.1	
6	8.7	36.9	19.3	881	351	96	27	217	542	34	2.5	
7	7.3	31	60	859	338	92	26	231	544	54	2.3	
8	7.7	24.2	81.2	851	342	92	27	233	528	47	2.3	
9	7.86	28.9	57	937	370	99	30	266	578	50	2.5	
10	6.8	27.6	15	797	302	74	29	193	496	64	2.7	
11	Protests											
12												
standard	6.5-8.5	30	5	1000	500	50	50	400	1500	200	12	

Table (C.34):Treated Water for Al-Hussein Station (2019)												
Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO4 ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.65	15	4.2	1320	442	119	35	366	822	90	4.1	81.4071
2	6.8	19	4.8	1317	445	119	36	350	818	111	4.4	
3	6.5	20.9	15.4	1372	467	131	34	401	912	93	4.1	
4	7.2	22.9	3.8	1065	409	112	31	271	674	68	3.2	
5	7.3	27.3	4	989	364	97	30	239	616	53	3.2	
6	8.5	37.6	8.5	884	348	96	27	232	546	37	2.6	
7	7.4	30	35	861	342	92	27	239	550	55	2.4	
8	7.7	24.2	25.8	856	345	92	28	231	540	46	2.2	
9	7.77	28.5	14.3	947	366	99	29	269	594	50	2.5	
10	6.7	27.2	9.5	801	307	74	30	190	500	64	2.8	
11	Protests											
12												
Standard	6.5-8.5	25	5	2000	500	150	100	400	1000	300	10	

Table (C.35):Raw Water for the Hashimyah Station (2019)												
Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.4	15	7.6	1337	445	119	36	379	842	87	4.3	71.5436
2	7.5	19.6	10.1	1445	418	114	32	297	816	125	7.4	
3	6.8	22.5	5.2	1324	445	127	31	418	854	102	2.2	
4	7.3	27.5	5.2	1316	473	183	40	353	860	109	4.8	
5	7.2	25.5	2.9	1048	388	101	32	244	630	66	3.1	
6	7	28.1	11	873	349	97	26	236	554	41	2.8	
7	Protests											
8	Protests											
9	7.7	30	55	867	355	99	26	256	572	41	2.1	
10	7	26.8	15.1	767	302	70	31	151	464	62	2.6	
11	Protests											
12	Protests											
standard	6.5-8.5	30	5	1000	500	50	50	400	1500	200	12	

Table (C.36): Treated Water for the Hashimyah Station (2019)												
Time	pH	Temp	Turb	EC	TH	Ca ⁺²	Mg ⁺²	SO ₄ ⁻²	TDS	Na ⁺	K ⁺	CCMEWQI
1	7.24	15	5	1355	448	119	36	385	896	91	4.5	81.2488
2	6.6	20.5	4.7	1316	407	106	35	304	744	180	5.2	
3	6.8	22.5	5.6	1327	451	133	29	411	850	106	2.2	
4	6.9	26.5	3.7	1284	484	118	49	312	840	110	5.1	
5	7	26	2.1	1052	391	101	32	251	680	65	3.1	
6	7	27.9	13	878	349	97	26	228	560	41	2.7	
7	Protests											
8	Protests											
9	7.6	29	50	867	355	97	27	263	576	41	2	
10	7.9	26.8	17.6	767	302	70	32	160	462	63	2.7	
11	Protests											
12	Protests											
Standard	6.5-8.5	25	5	2000	500	150	100	400	1000	300	10	

الخلاصة

في هذه الدراسة تم جمع عينات مياه من نهر شط الحلة داخل مدينة الحلة للمياه (الخام والمعالجة) لثلاث محطات مختلفة (الحلة الجديدة ، الحصين ، الهاشمية) ودراسة العوامل الفيزيائية والكيميائية ومقارنتها مع المواصفات القياسية العراقية. تم تحديد مؤشر جودة المياه باستخدام نموذجين ، هما الحساب الموزون والمجلس الكندي للوزراء لمؤشر جودة المياه البيئية (CCME WQI). تم جمع عينات المياه شهرياً من (أكتوبر 2020 إلى يونيو 2021) ، حيث تم فحص اثني عشر معاملاً للمياه الخام والمعالجة ، بما في ذلك درجة الحرارة ، والعسرة الكلية (TH) ، والتوصيل الكهربائي (EC) ، والحموضة (pH) ، وإجمالي المواد الذائبة الصلبة (TDS) ، الكبريتات (SO_4^{2-}) ، الكالسيوم (Ca^{+2}) ، المغنيسيوم (Mg^{+2}) ، الصوديوم (Na^+) ، الطلب البيولوجي على الأكسجين (BOD_5) ، البوتاسيوم (K^+) والعاكسة. أظهرت نتائج قياسات وتحليل جودة المياه أن معظم معايير جودة المياه التي تم قياسها على طول النهر كانت ضمن الحدود المعيارية المقبولة باستثناء (الكالسيوم ، العكارة والتوصيل الكهربائي للمياه الخام ودرجة حرارة المياه المعالجة).

أظهر التوزيع المكاني لمؤشر جودة المياه على طول النهر أن متوسط قيم مؤشر جودة المياه في ثلاث محطات تراوحت بين (87.246 إلى 109.006) للمياه الخام ومن (46.098 إلى 64.302) للمياه المعالجة والتي تعتمد على الحساب الموزون. بينما تراوح مؤشر جودة المياه الذي يعتمد على الطرق الكندية من (79.307 إلى 81.232) للمياه الخام و (94.620 إلى 94.718) للمياه المعالجة. أظهر النموذج الحسابي الموزون أن جودة المياه الخام تم تصنيفها "شديدة التلوث" إلى "غير صالحة وغير صالحة للشرب" وللمعالجة تراوحت جودة المياه من "مياه جيدة" إلى "متوسطة التلوث". بينما صنفت طريقة CCME WQI مياه النهر على أنها "عادلة" وتعامل المياه على أنها "جيدة" للشرب. أظهرت نتائج المقارنة بين النموذجين أن CCME WQI أعطت قيمة جودة مياه أكبر من قيمة الطريقة الأخرى ، أو ربما تم اعتبار CCME WQI أكثر مرونة.

تم إجراء التحليل الإحصائي باستخدام البرنامج الإحصائي للعلوم الاجتماعية (SPSS) الإصدار (25) ، وهو أحد أفضل البرامج المتاحة للتحليلات الإحصائية للفترة (أكتوبر 2020 - يونيو 2021). وكانت نسبة (R^2) للمياه الخام جيدة (0.88, 0.90, 0.89) لمحطات (الحلة الجديدة ، الحصين ، الهاشمية).

(0.88, 0.78, 0.92) للمياه المعالجة ، على التوالي ، مما يشير إلى وجود علاقة جيدة بين مؤشرات المياه ومؤشر جودة المياه.



جمهورية العراق
وزارة التعليم العالي والبحث العلمي
جامعة بابل
كلية الهندسة
قسم الهندسة البيئية

التحليل الإحصائي لجوده الماء الخام والمعالج لنهر الحلة, العراق

رسالة مقدمة الى

قسم الهندسة البيئية كلية الهندسة

في جامعة بابل كجزء من متطلبات نيل

درجة الماجستير في الهندسة / الهندسة البيئية

من قبل

شهد عبد الكريم عبد علي عبد

اشراف

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