T.C.
ISTANBUL GEDİK UNIVERSITY
INSTITUTE OF GRADUATE STUDIES

EVALUATION OF THE PERFORMANCE OF THE WASTEWATER TREATMENT PLANT IN AL FALLUJAH DISTRICT BASED ON NEURAL NETWORKS

MASTER'S THESIS

Ibrahim Kareem MADAB MADAB

Engineering Management Department

Engineering Management Master in English Program

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LİSANSÜSTÜ EĞİTİM ENSTİTÜSÜ MÜDÜRLÜĞÜ

Yüksek Lisans Tez Onay Belgesi

Enstitümüz, Engineering Management Department İngilizce Tezli Yüksek Lisans Programı 191281040 numaralı öğrencisi Ibrahim Kareem Madab MADAB MADAB'in "Evaluation of the Performance of the Wastewater Treatment Plant in Al Fallujah District Based on Neural Networks" adlı tez çalışması Enstitümüz Yönetim Kurulunun 12.08.2022 tarihinde oluşturulan jüri tarafından *Oy Birliği* ile Yüksek Lisans tezi olarak *Kabul* edilmiştir.

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DECLARATION

I, Ibrahim Kareem MADAB, do hereby declare that this thesis titled as “Evaluation Of The Performance Of The Wastewater Treatment Plant In Al Fallujah District Based On Neural Networks “, The Engineering Management faculty. I also declare that this thesis or any part of it has was an original academic work done by me for the award of the master’s degree in not been submitted or presented for any other degree or research paper in any other university or institution.

Ibrahim Kareem MADAB MADAB

DEDICATION

I would like to present this dissertation and my humble efforts for accomplishing this work to my kindly family, classmate and all my sincere friends for the great support, advising and encouragement along the period of my trip for education, search, and life. Special dedication goes to my supervisor Prof. Dr. Gözde ULUTAGAY my father, my mother and my family for their support and prayers during my research work, and thanks so much to my university "Istanbul Gedik University".

PREFACE

I would really be presenting my appreciation to every one supported me all through study and searching period of this voyage. I might to present my thank to my advisor, Prof. Dr. Gözde ULUTAGAY, for being my guide whenever I thought I was lost myself during research work and being in extraordinary role to haulage the culmination in this significant result. Addition to that, l would like to thank my supervisor for all the supportive and perfect advices that greatly enhanced my steps in the optimization of this work. Finally, I might to thank my university and especially the institution for hosting me during these wonderful years. I am very thankful to my mother, my father, my brothers and all my friends, whose instructions motivated me to keep on my aim. To my family, to everyone and to my country great the appreciation and love.

August 2022 Ibrahim Kareem MADAB MADAB

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ABBREVATIONS

WWTP	: Wastewater Treatment Plants
A2/O	: Anaerobic-Anoxic-Oxic
O&M	: Operation And Maintenance
TDS	: Total Dissolved Solids
BOD	: Biological Oxygen Demand
WFD	: Water Framework Directive
CECs	: Contaminants Of Emerging Concern
ANN	: Artificial Neural Network
DWWT	: Decentralized Wastewater Treatment
TSS	: Total Suspended Solids
WHO	: World Health Organization
BTEXs	: Benzene, Toluene, Ethylbenzene, And Xylenes
WWTTs	: Wastewater Treatment Technologies

LIST OF SIMPLES

m	: Meter
PH	: Acid function
CL	: Chlorine
NO3	: Nitrate
NH3	: Ammonia
PO4	: Phosphate

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EVALUATION OF THE PERFORMANCE OF THE WASTEWATER TREATMENT PLANT IN AL FALLUJAH DISTRICT BASED ON NEURAL NETWORKS

ABSTRACT

Industrial and economical process result so much amount of dirty and unusable water, and sometimes contains harmful chemicals to humans, animals, and plants, which will lead a big dangerous of the life and human future, so a wastewater reclamation and the process of reuse are considered so benefit for being the significant strategy to achieve present and future water demands. water scarcity of drinking and irrigation water is very big because of the result of lack of rain and other natural water resources in some countries and the result of pollution, especially in developing countries during in recent years as a result of the developments in both economical and industrial fields. WWT mainly involve a primary, secondary, and perhaps advanced/developed treatment steps, by using chemical, physical and biological various techniques. Now, much treatment processes are widely utilized in wastewater treatment plants (WWTP)s, involving traditional activated sludge treatment, anaerobic-anoxic-oxic (A2/O) which is most greatly employed WWT processes, anaerobic-oxic (A/O), sequencing batch reactor (SBR), and oxidation ditch. The efficiency of a WWTP depending on the different processes as well as on the scale of this plants.

This study focuses on analyzing the execution of a wastewater treatment plant in Fallujah, Iraq. This study included the design of the station and the nature of the water that can be treated. The results of laboratory analyze of the outputs of the station were studied and appropriate recommendations were written to address the pollution situation in general.

Keywords: *Wastewater Treatment, Sludge, Fallujah, Treatment Efficiency*

FELLUJAH İLÇESİ ATIKSU ARITMA TESİSİ PERFORMANSININ NÖRAL AĞLARA GÖRE DEĞERLENDİRİLMESİ

ÖZET

Endüstriyel ve ekonomik süreç, çok miktarda kirli ve kullanılamaz su ile sonuçlanır ve bazen insan, hayvan ve bitkiler için zararlı kimyasallar içerir, bu da yaşam ve insan geleceği için büyük bir tehlikeye yol açar, bu nedenle atıksu ıslahı ve yeniden kullanımı, atıksuyun ıslahı ve yeniden kullanımı olarak kabul edilir. Mevcut ve gelecekteki su ihtiyaçlarını karşılamak için en iyi strateji. Bazı ülkelerde yağmur ve diğer doğal su kaynaklarının azlığı ve özellikle gelişmekte olan ülkelerde son yıllarda gerek ekonomik gerekse endüstriyel alanlar. Atıksu arıtımı, kimyasal, fiziksel ve biyolojik çeşitli teknolojileri kullanarak temel olarak birincil, ikincil ve belki de ileri arıtma işlemlerinden oluşur. Günümüzde atıksu arıtma tesislerinde (AAT) geleneksel aktif çamur arıtma, en yaygın kullanılan atıksu arıtma proseslerinden anaerobik-anoksik-oksik (A2/O), anaerobik-oksik (A/O) olmak üzere birçok arıtma prosesi kullanılmaktadır., ardışık kesikli reaktör (SBR) ve oksidasyon hendeği. Bir AAT'nin arıtma verimliliği süreçle ilgilidir ve ayrıca AAT'nin ölçeğine de bağlıdır.

Bu çalışma, Irak'ın Felluce kentindeki bir atık su arıtma tesisinin performansının analizine odaklanmaktadır. Çalışma, istasyonun tasarımını ve arıtılabilecek suyun niteliğini içeriyordu. İstasyonun çıktılarının laboratuvar analizlerinin sonuçları incelenmiş ve genel olarak kirlilik durumunu ele almak için uygun öneriler yazılmıştır.

Anahtar Kelimeler: *Atıksu Arıtma, Çamur, Felluce, Arıtma Verimliliği*

1. INTRODUCTION

1.1 Background

Industrial and economical process result so much amount of dirty and unusable water, and sometimes contains harmful chemicals to humans, animals, and plants, which will lead a big dangerous of the life and human future, so a wastewater reclamation and the process of reuse are considered so benefit for being the significant strategy to achieve present and future water demands. water scarcity of drinking and irrigation water is very big because of the result of lack of rain and other natural water resources in some countries and the result of pollution, especially in developing countries during in recent years as a result of two the developments, the economical and the industrial (Zhang *et al.*, 2016). During the last third of the last century, environmental problems associated with the biological or chemical contaminations to a water have become a main and significant anxiety for public authorities in various countries of our world, that happened because of the undesired and harmful contaminants available in the wastewaters that is produce from daily domestic works and different industrial activities. Therefore, various efforts have been made in order to protect the life throughout keeping the resources of water, The present various practical ways of wastewater treatment include a biological, chemical large processes for removing soluble contaminants or insoluble particles or both from the effluents (Crini and Lichtfouse, 2019).

Wastewater various treatments practically include primary, secondary, and sometimes advanced treatment steps, throughout employing chemical, physical and biological different technical. Today, large number of treatment processes are utilizing in used Wastewater Treatment Plants (WWTP)s, including oxidation ditch, sequencing batch reactor (SBR), anaerobic-anoxic-oxic (A2/O) which is most widely used wastewater treatment steps, traditional activated sludge treatment and anaerobic-oxic (A/O).

The treatment efficiency of a wastewater treatment plant is depending on the scale of the plant. The anaerobic-anoxic-oxic (AAO) and oxidation ditch technologies are usually be utilized for treating the undesired wastewater because of their capability, relatively stable and comfortability during the management in daily processes. The classifications discharge and treatment qualification of the harmful sewage and wastewater treatment utilities change from area to other, based on urbanization, industrialization, amount of the population, quick economic growth and other considered factors (Zhang *et al.*, 2016).

One of the significant methods in the sector of wastewater process is the persulfate decontamination technologies, which depending on either direct electron transfer or employing radical driven processes. These methods are considered as perfect ways for treatment of a huge set of harmful or undesired impurities, involving halogenated olefins, BTEXs (benzene, toluene, ethylbenzene, and xylenes), per fluorinated chemicals, phenols, pharmaceuticals, inorganics, and pesticides. Moreover, a persulfates reactivity is significantly based on different techniques of the related activations and depending on the construction an appropriate matrix of the water which wanted to be treated. It is very great to develop effective and optimal treatment methods of wastewater and water (Wacławek *et al.*, 2017).

1.2 The Problems and Challenges of WWTP Construction

Wastewater treatment plants (WWTPs) are significantly performed in municipalities or companies widely for neglecting or reducing the undesired mischievous of wastewater results in various water bodies which may be use. One of the important problems that challenges the WWTPs construction is the energy sufficiency, because of the sustainable supplies of energy and water and analogical carbon resurrection are so important for plans of urban development. All main structures related to WWTs and sludge disposal techniques need energy, generally as electricity or any various types of other required fuels for pumping, mixing, separation, and process of wastewater, sludge and so on, as shown in figure 1.1, ('The feasibility and challenges of energy self-sufficient wastewater treatment plants.pdf', no date).

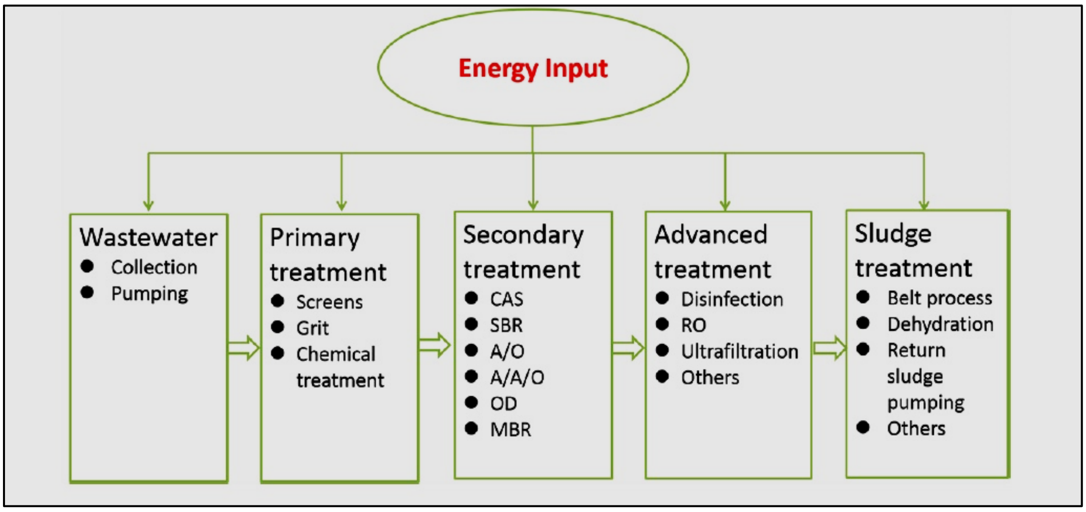

Figure 0.1: Input of energy in various wastewater treatment processes

The increasing costs of energy with the concerns about global climate change highlight the needing of achieve energy self-sufficiency in new establishments, so one of the important things of WWTPs is optimization of energy efficiency ('Energy Self sufficient Wastewater Treatment Plants Feasibilities and Challenges.pdf', no date).

The WWTPs average electricity consumption reached very high levels, which was 33.4 kWh/PE. In WWTPs the energy-water nexus has become one of the major subjects of current policy researches. Because the implementation of wastewater treatment system became depending on the cost-effective and high-performance, so the considering the WWTP as an significant nexus in the cities of the futures, must leads to expand in the WWTPs priorities (Neczaj and Grosser, 2018).

The accelerating development in different water networks has been greatly associated with the saving the targeting and design procedure depending on known graphical representation of water utilize and processes of treatment. A range of upgrading frameworks had been suggested to solve the undesired large-size industrial issues in which a great numbers of operations are involved and with (Klemes, 2012).

The plant place, plant scale, kind of treatment process and airing frameworks, effluent quality requirement, old of plant, and ability of the specific operators stand as other gauntlets of WWTPs ('The feasibility and challenges of energy self sufficient wastewater treatment plants.pdf', no date).

1.3 The WWTPs and Large Cities

In the large or densely populated cities, inauguration of much WWTPs is inescapable cause much of the produced wastewater must be treated dispose of Immediately. The used treatment technologies in WWTPs must be efficient as well as reliable, with unexpensive costs for building, administration and servicing that support self-sufficiency as well as acceptance according to the approved standards. Wastewater is nowadays and perhaps in future too, considered as a renewable and unavoidable source for getting the potable/non-potable water and energy as well as fertilizers (Piao *et al.*, 2016).

The geographical distribution, construction period, energy consumption and financial cost (operation and maintenance "O&M" cost) for WWTPs needs to be carefully and strategically considered (Zhang *et al.*, 2016).

1.4 The Troubles of the Safe Use of the Treated Wastewater

Water pollution causes the growing water lack and decreasing in the aquatic biodiversity. In past decades, the availability of desired freshwater for life has been so much declined, while water demand has been increased especially in areas which have arid or semi-arid climate (Ejeian *et al.*, 2018).

Generally, the major issue that can construct a great challenge in the perfect reutilize of the treated wastewater in processes of an agriculture is the small of datasets of each concerned actors, such as:

- Governmental authorities: shortage of enactments or guidelines on the reutilize of processed wastewater.
- Local authorities work together with other concerned authorities in wastewater treatment:

  (i) Shortage in data about the innovative cost-effective techniques for treatment processes of wastewater.

  (ii) challenges in the upgrading of technical properties for the building as well as operation of suitable wastewater treatment plants (in terms of technical, volume, ability of the outflow).

(iii) challenges in the upgrading of properties for the suitable utilize of the final stage of outflow.

(iv) challenges in finding the suitable costs for the refinement of the wastewater treatment plants.

- Operators: shortage of information and ability for the effective operation. Control and monitoring of system of the wastewater treatment.
- Farmers: shortage of necessary information on the undesired health dangers associated to the utilize of treated wastewater and the necessary administration procedures The effective and suitable management of the process of the upgraded WWTPs is related to the issues explained above. Hence their operation requires to be under supervision and control by their specific operators continuously and the concerned authorities. As far as the running of treatment plants is consumed, the absence of normal ways for samplings, measurements as well as analyses does not let a clear and scientific record of quantum and goodness of waste that end up in local recipients, specific water bodies as well as underground water, at same time unbeknown goodness treated wastewater re-utilize ambushes much risks for the around climate and general health. The concerned Authorities in much of the countries, in present, have not ability to be knowing of all information or data related to the treatment plants at any time. A prerequisite and which is now missing, for the control or/and monitoring of each mission related to treatment and reutilize, is the trained personnel of the authorities and the operators.

At end, the major issues that should be deals with are:

- The non-regulated employing of processed water in operations of agriculture the non-existing re-utilize criteria associated with hygiene, general health and goodness monitoring the non-existing reutilize criteria associated with irrigation technical, quality of wastewater treatment, and choice of locations and kinds of products that should be irrigated.
- The shortage of effective control as well as monitoring of developed wastewater treatment plants and the shortage of specialized operator in both

the concerned authorities and the treatment plants both together, the low level of acknowledge of the famers and the nation generally (Fatta *et al.*, 2005).

1.4.1 Using Wastewater Opportunities In Agriculture

Employing of wastewater producing from various daily activities for irrigating the different agricultural areas becomes a famous and a prevalent habit around our world, especially in the arid and semiarid areas where freshwater resources are insufficient to meet water needing of human, plants, and animals.

According to studies and guesses, 20 million hectares various lands on universal level are being irrigated with treated, partially treated, and untreated wastewater, contribute to secure the food. Growing of water scarcity with increasing of urbanization, industrialization, increasing urban wastewater flows because of expanded water supply, reliability in supply, nutrient value, sewerage services and consistency are the main factors of widespread utilize of irrigation depending on the wastewater. These effective factors are expected to be much efficiency during the few coming years, making wastewater use in agriculture sector an upgraded advantage.

Mainly, wastewater includes storm water runoff, local wastewater, and harmful industrial various effluents. Much of studies consider the wastewater is an important and possible resource for crossing the issue of water shortage and has difficult defiance and good chances. Wastewater depending on these studies, can have multi uses involving industrial and urban different uses, landscape and crop land irrigation artificial groundwater recharge, aquaculture and environmental and recreational multi uses.

Nevertheless, the utility of wastewater can cause expected risks and impacts such as negative effectives on growth of the plants, around environment and wanted soil health. It is also can be considered as possible carrier of toxic materials including poisonous gases, pesticide residues, heavy metals, salts, and a huge set of enteric pathogens that have sure unhealthy impacts on groundwater, air, crops, plant, soil, animals, and human. Social anxiety that is generate because of employing the produce of various crops grown with wastewaters and subsequent effect on marketing amount of such as these crops are also one of the major fields of general studies and investigation (Ashraf *et al.*, 2017).

1.5 Objectives and Aims of the Work

In accordance with some reviewed studies, in this study the current state of wastewater treatment in Al Fallujah district in Iraq will be review. Furthermore, the treatment technologies through wastewater reclamation and reuse, pollutants removals, operating load, and effluent discharge standards will be discussed, during studying of wastewater treatment plant that had been suggested in this proposal work. Therefore, the purpose of the study will be as explain bellow:

- The potential of wastewater treatment plant construction in Al Fallujah district (challenges and solutions).
- Study and analyze the economic feasibility of proposed plant construction, operating costs, the by-products of the proposed plant.

1.6 Thesis Outlines

General introduction is included in chapter one, while chapter two contains the literature review about wastewater treatment. The methodology of the work is discussed in third chapter. Results and discussion are in chapter four while fifth chapter covers the conclusions and future works.

2. LITERATURE REVEW

The salinity of the Euphrates River water in the regions of its availability in Iraq, because of the Total Dissolved Solids (TDS) and wastewater has more than doubled, with comparing to the statistics that are constructed at 1973. In the agricultural areas lies in the east and south of Iraqi capital "Baghdad", the water salinity average has grown up gradually through the last 30 years.

At "Al Nasiriyah" city the annual average TDS in the Euphrates River lower reaches has raised from 1,080 ppm and overtaken the 4,500 ppm through 22 years only (from 1979 to 2001). Purity and sweetness of the Euphrates water within Iraq has crumbled because of the reduction flow which interring in the Iraq, conversion the undesired flows to the Euphrates from Al "Tharthar Lake" and harmful flows return from the irrigation to the river, where the cause of flow minimization from accredited upstream sources was the projects of the reservoir construction.

Almost half of Iraq depends, for agriculture and water supplies, on the Euphrates River. As salinity raises in the Euphrates, the essential uses should become more limiting in order to support the economy of country.

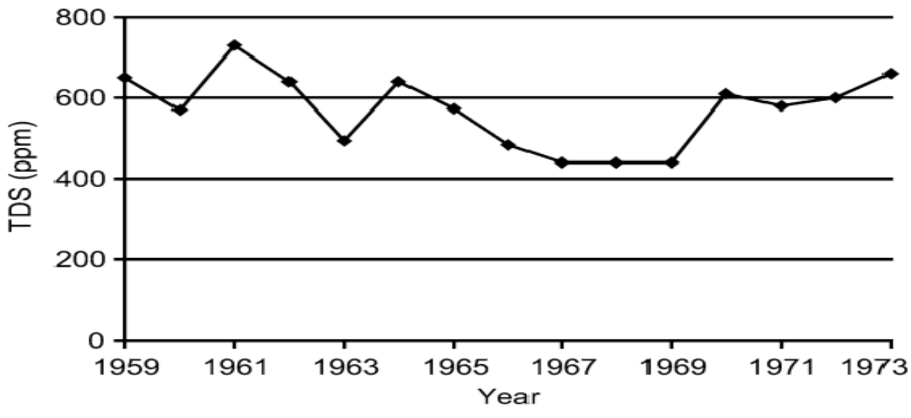

Figure 0.1: The mean annual "TDS" at Falluja Gauging Station, from 1959 year to 1973 year at Falluja Gauging Station

Figure 2.1 illustrate the mean annual "TDS" at Falluja Gauging Station, from 1959 year to 1973 year at Falluja Gauging Station for the Euphrates River.

While the figure 2.2, shows the significant increasing of TDS contents in Al Nasiriyah city during 20 years only the Euphrates River (Rahi and Halihan, 2010).

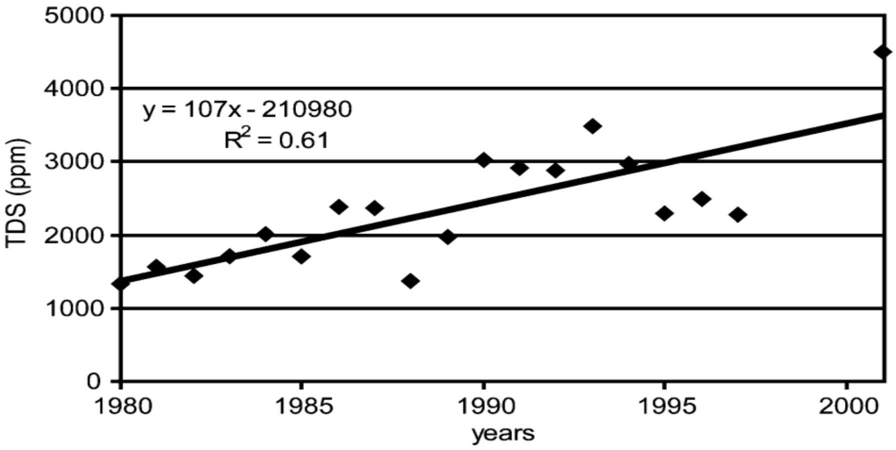

Figure 0.2: TDS contents increasement in the Euphrates at Al Nassiriah city during 20 years.

The projects of sustainable development in Iraq are continuously face so much difficulties and obstacles. Among those projects are those related to with water, due to relation between it and the food security. Water is a significant major wary that could cause many socio-economic dilemmas. So, if appropriate practical steps are not started immediately, the negative results are expected to destroy the development plans and become a real and dangerous threat for all life sectors in Iraq through the few future years. Therefore, the necessity to propose comprehensive and effective national plans for conservation and management of rivers water in country, and suggest practical solutions for reversing the environmental various and complicated challenges into opportunities contribute to construct the sustainable development projects.

About 90% of the annual rainfall in Iraq occurs during the winter, between November and April, while the hot months be so long comparing with the rainfall months, therefore, there is much desert in Iraq due to the very high evaporation rates and the soil that have the ability for lose the moisture earned from the little and not enough rain. So, the projects of sustainability and management of water play an important role for keeping the food security which becoming a main and significant challenge to grow the green regions water and secure the agricultural future in Iraq.

Water availability for important life activities such as industry, agriculture and various domestic supplies is a main goal in Iraq and much other countries. The quality, purity, sweetness, and quantity of the Iraq's water has been impacted by some causes such as inefficient and unregulated usage of water, pollution, and climate change because of global warming, etc. These lead to reduce the availability of water per one person per year, where water level reduced from 5,900 cubic meters, through 22 years only, to 2,400 cubic meters (During 1977 and 2009 years).

The required water that was expected for agriculture, marshland maintenance and other sectors in 2015 in Iraq can be shown in table 2.1, (Al-Obaidy, A. H. M. J., & Al-Khateeb, 2013).

Table 0.1: The forecast of essential and necessary requirement to water in Iraq in 2015

Water sector	Quantity (billion m^3)
Agriculture	40.5
Marshland maintenance	11
Evaporation and other losses	8.4
Civil use	3.78
Industry	2.77
Power generation	0.4

2.1 The Challenges of Water in Iraq

Large number of local and global studies insured that Iraq face great water issue and most dangerous crisis drought in decades. Under the present dangerous decline rate, local water limited supplies, generally, will not be enough for overcoming a population and humanitarian crisis may lead the country into the unknown future. The continuous water crisis has directly contributed, especially in the south areas, to rise levels of poverty, lack of food and local migration in Iraq (UNESCO, 2010).

The major challenges of the water sustainability in Iraq can be summarized as following aspects:

- Environmental Education:

  The plans of formal education in Iraq don't include the developed procedures to upgrade the population's mentality to face the present environmental issues. In addition to that, these curriculum and practices, practically, directly ignore the desires of Secondary Schools' students those have the eager for participating and activating the different and important environmental activities (Al-Obaidy, A. H. M. J., & Al-Khateeb, 2013).

- The various patterns of consumption:

Iraq, in the region's water availability, in the second place after, his neighbor, Turkey which have 2890 m3/capital, with 2400 m3/capital (IAU, 2010).Generally, the population in Iraqi are consumers greatly and this phenomenon, unfortunately, has become as a habit which can be defined as one of a inherited habits; but at sometimes this habit can be explained, traditionally, as generosity, others are a negative consequence of the government economic policy which the population depended on it (Significantly reduce the government tariff on usage water) over the final part of the last century.

The tariff of water in Iraq, approximately, is US$ 0.0034/m3 , while the public revenue of water covers 2-5 %,only, from the general costs of maintenance and daily operation (Al-Obaidy, A. H. M. J., & Al-Khateeb, 2013).

- Various Studies of The Pillars Issues:

As a consequence of various known factors, the scientific works is usually irrelevant to the water important issues, because of the weak relation and coordination between the government institutions while other insure that the base of problem due to bad explanation of the water issue's background in Iraq (Al-Obaidy, A. H. M. J., & Al-Khateeb, 2013).

- Shortage Necessary Water to Comply with the Daily Social and Economic Demands:

The climatic fast changes, patterns of the consumption, water irresponsible management and shared water resources with neighbor countries will result a scary real shortage in water supplies which is expected for increasing over the close future. In Iraq, the significant and dramatically increasing of water usage throughout the past century, in corresponding to that, the dropping in the number of rivers and lakes and cleaning and dredging operations of rivers to a critical level. all that and others lead to reduce the water level in both, Tigris and Euphrates rivers, that represent the major resources of Iraq's water, to less than a third of nature capacity of them (Al-Obaidy, A. H. M. J., & Al-Khateeb, 2013).

- Internal Immigration:

The continuous and significant local immigration, especially after 2014, from the dangerous to safe areas or from poor rural areas to the urban cities presents a great threat and leads, according to studies, to a random population growth and suddenly demographic change. Such a this demographic change results directly to reduce the rural farmers numbers, large degradation of the soil and agricultural lands damage with worrying expansion in the urbanized cities because of the increasing in the abandoned farmlands (June and Schnepf, 2004).

- Increasing in The Levels of Salinity:

The annual average of water salinity (TDS) at Al Nasiriyah city, that located on Euphrates River on the south of Baghdad, has increased from 1080 ppm at1979 and overtaken the level 4500 ppm at 200m, that’s means the increasing in TDS in Euphrates River only to more than doubled throughout this short period which not overtaken thirty years. Thus, quality of Euphrates water deteriorated because of the reduction in quantity to less than river's capacity and the salinity increment of the Euphrates's flows that enter to Iraq from the neighbor countries, Turkey, and Surya, with used flow diversions from the Tharthar Lake and flows that return from irrigation operation within Iraq.

The significant and dangerous decreasing in the river's flow from Turkey and Syria presents the main cause of the water goodness reduction. Therefore, water of Al Tharthar Lake and irrigation are used by divert them to compensate the reduction (Rahi, K. A., & Halihan, 2007).

- Chemicals Run-Off

The multitudes of different and harmful chemicals, especially Pesticide and fertilizer, led to great degradation of around environment, including water and soil where those toxic chemicals have been sprayed or dumped to support the agricultural side and raise the quality of various agricultural products.

Industrial effluents that are pumped, practically, into rivers and lakes, in addition to the industrial accidents that include lose much quantities of these chemical materials into the seas, rivers or lakes (Ozdogan, Woodcock and Salvucci, 2005).

Euphrates River's purity and sweetness deterioration leads to set of negative impacts that cause big harmful on the human health and around environment, in addition to increasement in the rate of soil salinity which, practically, reduce the productivity and convert agricultural lands to barren lands (Ashraf, Maah and Yusoff, 2010). The water quality deterioration, especially the river's water, surly results the reduction of the safe utilizing of water. This leads to create a great shortage of the water various supply and change the quality issue to quantity problem have much difficulties for solving it (Shinde, no date).

2.2 The Reality of the Water Environment in Iraq

The environmental survey statistical results in Iraq shows that the percentage of citizens whose are gotten water from the drinking water distribution networks was 78.7% at 2010, while in the environmental surveys that was implemented at 2008 in Turkey, the percentage of population whose are gotten water from drinking water distribution networks was 82% and their percentage in the Jordon was 98% in 2006, generally, in Urban and rural areas, as shown in figure 2.3.

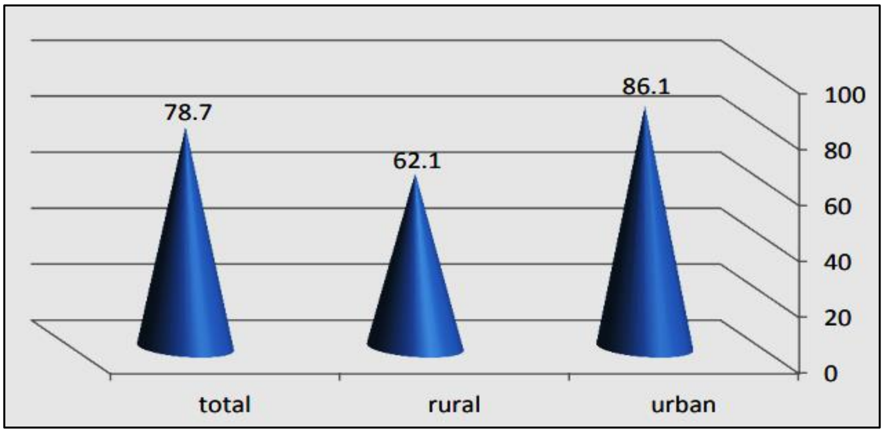

Figure 0.3 : population percentage connected to drinking water distribution network in 2010

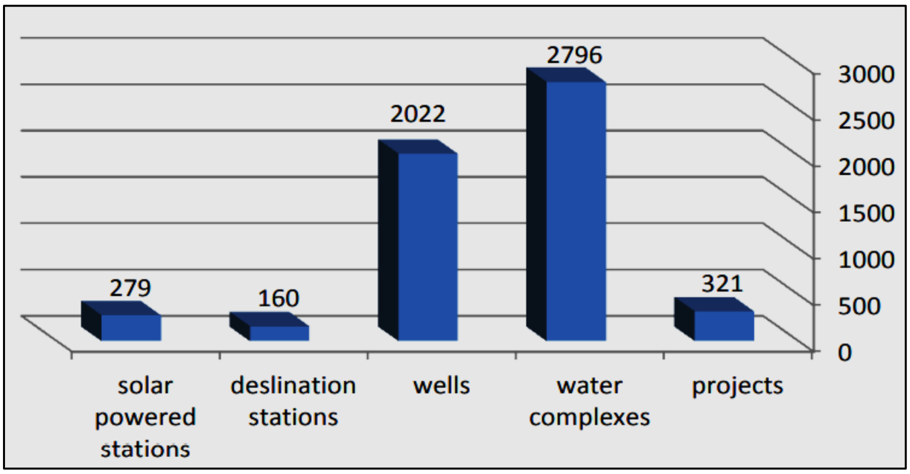

Figure 0.4: water production stations number in iraq by type for 2010

While the survey results as in figure 2.4, showed that the number of general water production stations equal to (5578), approximately, involving the water projects, RO water desalination stations and so on, in 2010.

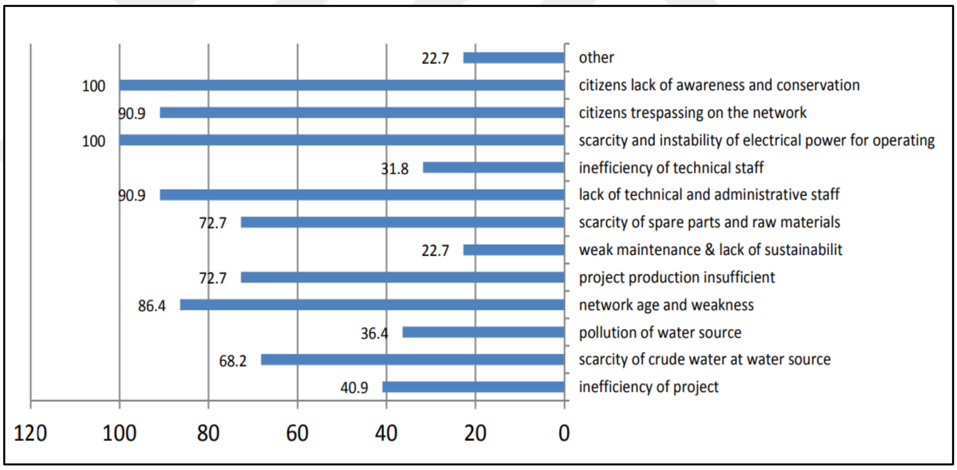

Figure 0.5 : Percentage of major troubels that faced sector of water in Iraq

And because of the increasing in the water salinity rates of Tigris and Euphrates rivers, there is significant need for construct and manage the wastewater treatment and water desalination stations with their general types to practical and life usages. Figure 2.5, explain the major issues face the water sector in all cities or governorates in Iraq, where the problem of electrical power which involving the instability and weakness in addition to awareness lack of citizens in order to keep it, while the trespasses of citizens on the various water networks at a percentage reached to 90.9%.

The amount of produced wastewater from small treatment units in the urban and rural unconnected areas equal to 32 thousand m3/day, approximately, while the treated water's amount reached 25 thousand m3/day and the percentage of the treated wastewater in the specific units equal to 78.1% at 2010. The size of produced wastewater that include the harmful liquid waste for various polluting activities, generally, reached 3300 m3/day and that 2970 m3/day of produced wastewater was treated in these treatment stations equaling 0.1%.

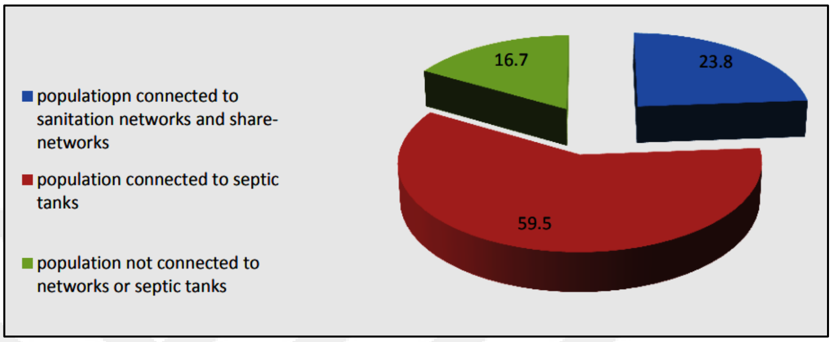

Figure 0.6 : Percentages of population according to thier ways of disposing from sanitation water

The Environmental Survey results in 2010, that are explained in figure 2.6, have sure that 23.8% of the Iraqi population using the sanitation networks or other shared-networks that available in cities, and 59.5% population using specific septic tanks, while the percentage of other, those don't use the sanitation networks or septic tanks, from the general population reached to 16.7%.

percentage of the governorates using the rivers to dispose from the wastewater equal to 36.8% while 5.3% utilizing the neighboring lands to discharge wastewater, as explain in figure 2.7.

52.6% of the citizens in governorates employing the neighboring lands in order to discharge wastewater while 36.8% utilize sewage lagoons for the same purpose (Planning, 2011).

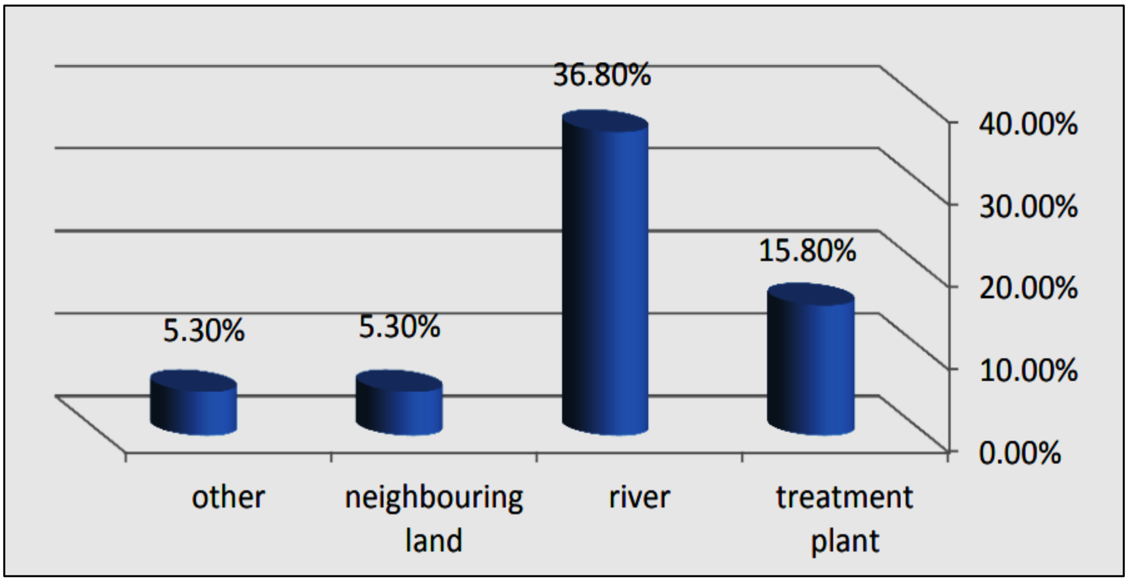

Figure 0.7: Percentage of discharge destinations of treated wastewater in 2010

2.3 Sustainability in the Water Resources Management

The necessity of the sustainability in the administration of various water resources increasing with a time in order to reach the purified water without any health problems and increasing the population percentage those can get clean and safe water supply with proper sanitation (Libralato, Volpi Ghirardini and Avezzù, 2012).

One of the utilized methods for achieving this goal depending on the wastewater treatment and increasing the efficiency of used station for this purpose by processed wastewater recovery and using it. Aim of environmental sustainability must be implemented for employing treated wastewater depending on treatment technologies have high efficient and great reliable, under comfortable conditions involving low costs for planning , construction and general management so that guarantee the acceptance and self-sufficiency by all governments and populations (Chung *et al.*, 2008),(Afferden *et al.*, 2010).

Wastewater, in present, is beholded as one of the renewable resource from which clean water which involving potable or non-potable water and renewable resource of the energy (Libralato, Volpi Ghirardini and Avezzù, 2012).

The modern and effective methods for protect the environment from the various types of contamination take a wide size in the scientific works and different searches in present. The important need and general demand for disposing from wastewater impacts and take advantage of it by retreat the harmful industrial wastewaters, although a difficult task, became a top priority of scientists, industrialists, decision makers and so on (Sonune and Ghate, 2004)

2.4 The Wastewater Treatment Stations

Much of the domestic and industry various activities product undesired contaminants involving chemical materials cause environmental problems for plant, human and animals, therefore, over last thirty years, many searches and works have been implemented to overcome the toxic impacts can be result various activities that cause significant concern in all fields. It's known that wastewater contains various materials lead to warried contaminations in the water sector, so, great efforts have to be made for protect the various water resources.

One of the practical methods depending on the wastewater treatment technical (Crini and Lichtfouse, 2019). The environmental rules dealing with various produced liquid from the industries imposes the process of all wastewater before released into surrounding environments (Ghillebaert, 2017).

2.4.1 Wastewater treatment

Wastewater treatment is an operation aims to remove partially the solids and changes it, based on the decomposition ,partially, to mineral or relatively stable organic solids after it was very complicated, putrescible, organic solids which was very harmful (Sonune and Ghate, 2004).

The different methods of Wastewater Treatment based on set of biological, chemical and physical specific processes, in addition to combination of operations and activities for removing insoluble particles and harmful soluble contaminants from the chemical materials (Crini and Lichtfouse, 2019).

Throughout the truth which says that using of water will leads to make it polluted by domestic and industrial activities (Augustine, Babu and Kalarikkal, 2015). According to the Water Framework Directive, chemicals can be classified into two major sets:

- The first set “Black List”: involves the chemicals have high dangerous that is considered as a great priority substance and highly toxic.

- The second set “Grey List”: includes the priority substances as a dangerous and have a significant presenting a significant negative impact of the around environment.

Recycling wastewater operations receive great attention from the various industries under the term of sustainable development which includes the environmental protection activities, attending the term of “green chemistry,” utilizing and employing of different renewable resources, in addition to improve the water management for keeping the general health (Kentish and Stevens, 2001), (Cox, M., Négré, P., & Yurramendi, 2007).

Water have ability to be treated can be classified into four categories:

- Industrial wastewaters produced from various industrial activities.
- Rainwater can be collected by lakes, tanks, and the house surfaces.
- Daily domestic wastewater.
- Agricultural water returned to the stations after using in the irrigation operations in agricultural fields (Crini, G., Montiel, A. J., & Badot, 2007).

In general, wastewaters wanted to treat it for irrigation and other usages differ from the drinking water significantly, where the resources of wastewaters is the industrial various activities while the resources of drinking water are, usually rivers, lakes or reservoirs, This lead to fact that level of various contaminants in wastewater are more than it's levels in the drinking water (Cooney, 1999).

Modern wastewater treatment can be classified into three main divisions according to the kind used scheme for the treatment flow:

- Tertiary treating
- Physicochemical processing
- Combined biological-physical treating (Sonune and Ghate, 2004).

2.4.2 General stages of the wastewater treatment plants

It's known that small Wastewater Treatment Plants (WWTP)s act in a specific decentralized way throughout the local field, as well as, the size of decentralized WWTPs, generally, cannot usually be considered as very small station (Gikas and Tchobanoglous, 2018). In the design of wastewater plants, big and long pipes usage is avoided, in addition excavation works for constructing one network or more that aim to collect the wastewater (McCann, 2010).

In Europe and the USA have been employed the sewage network for collecting wastewater, which will be, always, treated depending on specific central units. But this technique is now being challenged significantly, because of the sustainability concepts and the issues of exporting it to the countries living under scarcity of water or others that experiencing rapid development (Larsen and Gujer, 1997)Generally, traditional wastewater treatment involves set of processes (physical, chemical and/or biological) as well as different operations for removing harmful and toxic solids consist of colloids, organic matter, nutrients, soluble contaminants from materials.

Many techniques, classified as a traditional ways, can be utilized as a recovery processes, in addition to known emerging removal ways can be employed too, as shown in figure 2.8, while a process of wastewater purification, practically, includes five consecutive stages, as illustrate in figure 2.9, (Crini and Lichtfouse, 2019).

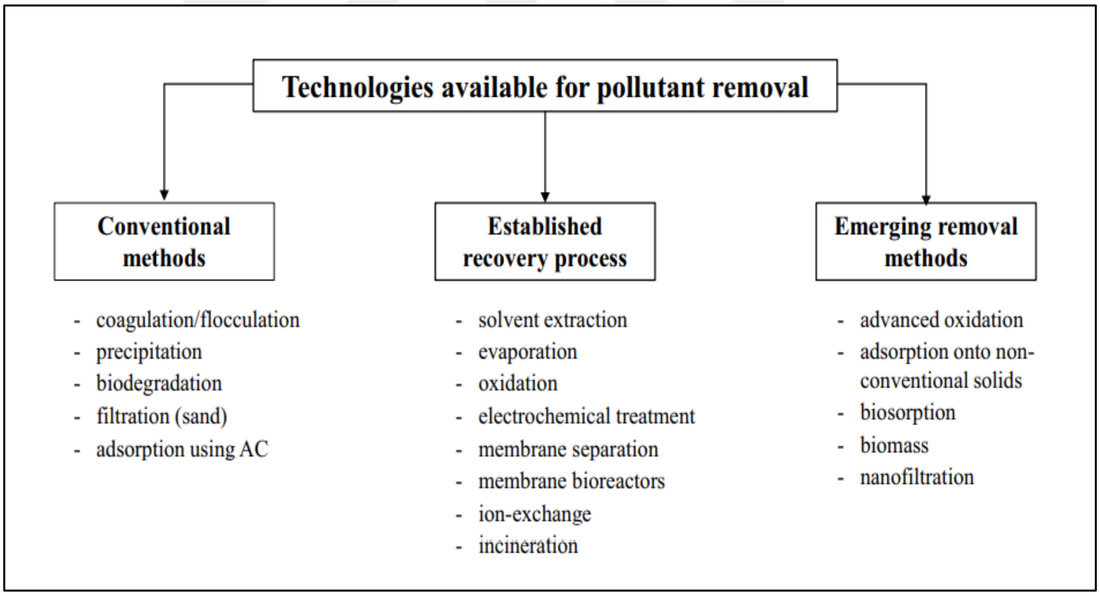

Figure 0.8 : Technologies utilized to remove the pollutants and some employed techniques examples

Wastewater treatment (WWT) is highly correlated with the term of the sustainable development, therefore it's important for keeping the health of various and surrounding eco-systems and organisms (Ullah *et al.*, 2020).

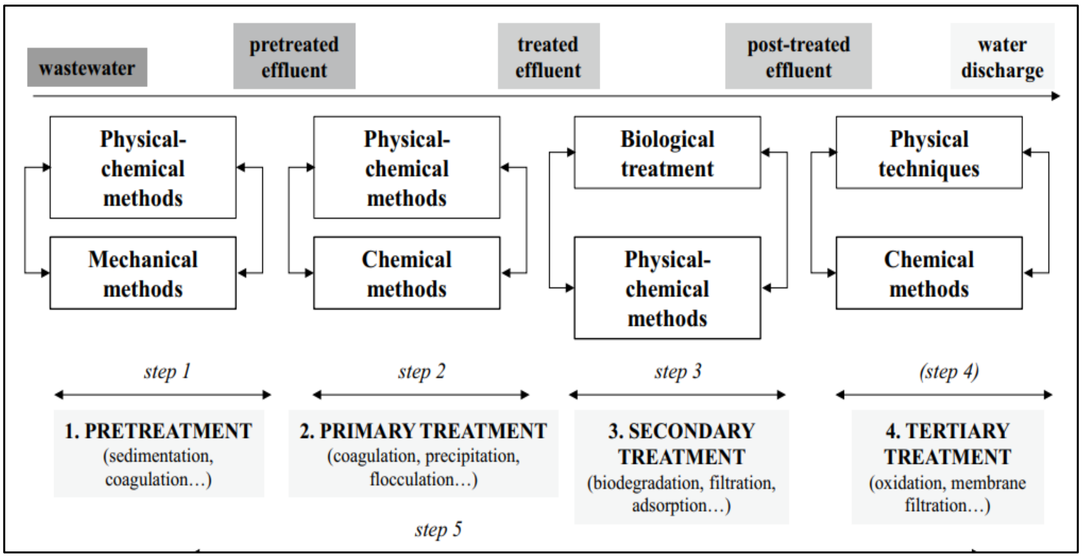

Figure 0.9: The five stages of wastewaters treatment

Primary and secondary stages in the wastewater treatment operations remove large rate of Biological Oxygen Demand (BOD) and suspended solids available. In a significant number of treatment cases, this applied level not enough for protecting the arrived waters to plants or for providing the reusable water for industrial and/or domestic recycling. So, extra strides have been added for successful operation of wastewater treatment plants for providing more suitable opportunities to dispose from both solids and organic or for providing more large area to remove of nutrients and toxic materials.

There has been much desired upgrading in the water treatment sector during last years. Alternatives have offered themselves for conventional systems of the water treatment. developed methods of wastewater treatments have become a field of global attention as industries and countries pursue for technical for keeping basic resources available and appropriate for employing.

Developed wastewater treatment technical, coupled with reduction of the wastewater and water recycling methods, represent hope in a method of slowing, and may be stopping, the unavoidable loss of utilizable water. Diaphragm technologies are so much appropriated for the recycling process or/and reutilizing of wastewater. Diaphragms can selectively divide ingredients through a huge range of unsuitable particle volumes and undesired molecular weights. Diaphragm technologies have become a practical division method through the past 10 years. The major power of membrane method is that it operates without any addition of specific or undesired chemicals, with comparatively low employing of power and simple and well-arranged operation conduction (Sonune and Ghate, 2004).

For achieving the high reliability of WWTPs, they not only apply the removal operations of the pollutants that are required and available on the regulations, but it follows an optimal approach aims for minimizing unnecessary inputs in order to block any overrun in the process path during the wastewater treatment operation (Hernández-chover, Bellver-domingo and Hernández-sancho, 2018).

Because of the increasing in the number of WWTPs, became very necessary complying with the economic and environmental criterions that available in the Water Framework Directive (WFD). The difficulties facing the authorities around the world on wastewater treatment are lie on two levels: provide the optimum quality for the treated water, in other hand achieve the low operational costs (Molinos-Senante, M., Hernandez-Sancho, F., & Sala-Garrido, 2014).

The modern environmental innovations in the wastewater plants fields (implementation and management fields) have two important advantages, clear system and simple infrastructure (Spiller, P. T., & Savedoff, 1999).

2.5 The Wastewater Treatment Stations and Modern Technologies

The employment of the environmental innovations in the wastewater treatment systems became a serious element in this systems development, but there is should be two practical goals, the triggering cause of implementation and management and an ultimate outcome (financial or/and service) of the whole evolutionary dynamics. Although, the optimal development in the wastewater treatment field, but the obstacles facing the innovation very large and so serious (Wehn and Montalvo, 2014).

The challenges facing the utilization of modern technologies in the wastewater treatment various plants can be summarized as following:

- The decision of employment relating to suitable environmental technologies based on a huge number of practical and financial determinants that have a significant role and serious interact in this context (Montalvo, Cort and Rennings, 2007).

- The implementation costs and various rewards of these sustainable environmental innovation, by the activated actors and operating communities in this sector, are unequally distributed (Boons *et al.*, 2013).
- The modern environmental technologies may be deployed by multiple or different stakeholders whose represent various goals (Water, 2014),(Spiller, P. T., & Savedoff, 1999).

The adoption of modern environmentally friendly methods became a major problem in both public discussion and policy fields.

Some studies focus on the innovation for applying the modern technologies to cover wastewater utilities. The advance technologies is relied upon in the new wastewater treatment systems became very complex because of the political or/and institutional impacts (Groppi *et al.*, 2016).

Some studies, in the sector of treated wastewater, depended on the duckweed for building the treatment systems through the scientific experiment in order to provide small treatment system with more simple, reliable, and cost-effective. This studies resulted that a reasonable employment of duckweed which seems have the ability to produce suitable quality secondary effluents by removing the both the suspended solids (SS) and biochemical oxygen demand (BOD) from the treated various communities (Bonomo, Pastorelli and Zambon, 1997).

Some new studies focused on avoiding the health effects related to Contaminants of Emerging Concern (CECs) through evaluate these environmental and health impacts based on advanced treatment processes covering three levels for removing the nutrient and carbon without and with additional tertiary Contaminants of Emerging Concern (CEC), in another word, this method of treatment depending on energy- and chemical-intensive.

CECs available in the aquatic environment widely including wastewaters. Although Contaminants of Emerging Concerns (CEC)s are found with unharmful levels (Pico, micro or less that levels), therefore haven't negative effects on human, animals, and plants. According this fact, the treatment processes both costly and technically difficult (Rahman, S. M., Eckelman, M. J., Onnis-Hayden, A., & Gu, 2018).

Wastewater treatment technologies that are used in the practical fields in the present, can be determined to four stages. The first stage (Preliminary Stage) implements simple missions, such as removing big things such as the gravel from the undesired gross solid pollution. The Primary Stage aims to settle the big, suspended matter, based on the employment the chemical and physical specific processes, which will reduce organic material, depending on a biological treatment usually. Finally, the treatment in the (Tertiary Stage) deals with various pollutants (for instance, nitrogen, harmful industrial pollutants and so on), after that will takes on a different shapes, such as ultra-violet light irradiation, chemical dosing or others (Groppi *et al.*, 2016).

In the developing countries, the installation, maintenance, and operation of the wastewater treatment technologies (WWTTs) is a significant challenge because of the limitation of experience and large cost of implementation, while in the developed countries, such as Europa and U.S.A, in order to update the WWTTs, there is need to meet difficult environmental regulations which may be impossible at sometimes.

The selection of an appropriate WWTT is a complicated mission due to requirement of huge practical experience, and objective feasibility studies. Traditionally, this selection depending on the economic and technical factors. However, other important and effective factors should be considered such as environmental and social factors for suitable and logical decision-making. Also, a different related aims and specific criteria must be considered in a way that leads to coordination in implementation. Choosing of determined WWTT based on user qualifications, prevailing situations and desired goals (Ullah *et al.*, 2020).

The exact prediction of (WWTP) major advantages can understand and prophecy behavior of the plant for supporting the process layout and controls, ameliorate plant desired reliability, minimize operational costs, and confess performance of the system. Deep learning (DL) technologies as proven data-driven soft-sensors have to be promoted for WWTP required applications for treating the operation of the dynamic nature and non-linearity of the available data for around environments.

Some studies based on the deep learning models as the soft sensors for forecasting WWTP main properties, such as impact flow and temperature as well as the impact of biochemical oxygen demand (BOD), effluent chloride, effluent BOD, and exhaustion of the energy.

Many techniques have been depended on for achieve the optimum prediction with perfect accuracy without any outlier effect.

2.6 The Investment In Wastewater Treatments Sector

Modern and developed industries of water from a mere conventional engineering specializations to play a perfect role in advanced economies and include more market-oriented and environmentally-friendly practices (Fuenfschilling, Lea, 2014).

In the modern wastewater treatment systems, the implementation of projects are affected by need to share with different actors such as suppliers and investors, in addition to the influence because of the communities, citizens' associations and so on, that actually, have no aligned goals or specific calculations (Groppi *et al.*, 2016).

Generally, new wastewater treatment plants should provide supplemental services under suitable tax allows the citizens to pay (Maurer, Rothenberger and Larsen, 2018).

Actually the implementation and management costs perhaps not a enough criterion for inducing to desired changes in the wastewater treatment plants, but practically its play a effected role in one of the serious stages, it's decision-making stage (Maurer, Rothenberger and Larsen, 2018).

According to different causes, determining of the annual costs for starting the projects is very hard. These reasons can be as following:

- It is hard to reach to all the various sources of investment capital in the wastewater treatment field because of the government and special moneys play main role in making of this decision.
- because of some reasons such as the problematic distinction between both maintenance and investment, the different methods to evaluate and estimate the required interest rates and so on, it is very hard to calculate, correctly, the total amount of the annual costs.
- The issues of the industrial wastewater plants (WWTP)s and private sewers (haven't any map to explain it) stay without suitable solutions, where the investments and the installations costs (special installations) are not calculated in the required practical statistics.

So in order to achieve the successful of this type of projects, and any other project, three cost elements have to be discuss: the costs of the maintenance and operation, depreciation and the costs of the capital-financing (Maurer, Rothenberger and Larsen, 2018).

2.7 The Management of Wastewater Treatments Stations

All governments around the world focusing on the importance of ability of new wastewater treatment projects to produce the treated wastewater that can be reuse under the appropriate aspects such as feasibility and design (Afferden *et al.*, 2010). In remote places such as rural areas that contain a low number of citizens, the construct and management of centralized wastewater treatment plants is very difficult and involving many difficulties such as high costs of the special or governmental investment, as well as the weak management will, surely, will hinder the perfect and practical implementation and the plans of infrastructure. These basic troubles can be beat them depending on decentralized wastewater treatment plants that have shorter consumption periods and the investment costs, usually, be cheaper (Maurer, Rothenberger and Larsen, 2018).

For successful operation of the decentralized wastewater treatment plants with it's a various sizes, much number of studies suggesting to use a centralized administration to overcome the troubles of regularly inspection and maintenance and implement them easily, as well as, any management, in the first stages of planning, must consider the important aspects that involving various social, cultural, environmental and economic situations in all work areas (Bakir, 2001), (Al-quraan, 2009).

This modern strategy (central management strategy for the construction and administration of DWWT) provides appropriate wastewater stations to collect and treat it for each main city and small town.

The strategy aims to build decentralized treatment stations for serving the various communities (semi-urban and rural) with explore decentralized treatment plants to serve the modern settlements in all country.

These implementation goals have to be specified depending on Wastewater Master Plan (WMP) which provide the aims for establishing the practical systems of the both collection and treatment operations into the country.

Such as this plan of the Wastewater Master must contains suitable investigations about the financing and operation systems that should be most practicable and suitable, modern treatment technologies, optimum systems for collecting and reusing the wastewater. But before the stage of definition of the parameters, a first step of the perfect and desired plan is the determining of the required potential for success the project and choosing lands or towns in which the accomplishment is more benefit.

This provide the ability for taking an clear idea and thoughtful review of the quantity of wastewater that is want to be treated and recharged as well as provide the information in order to deduce the first guess about the required future investments in infrastructure of the decentralized wastewater systems (Afferden *et al.*, 2010).

In the developed countries the choosing of place of wastewater treatment plant implementation depending on objective directives based on the assuming that all urban lands should involving this modern infrastructure for reducing the environmental harmful effects on the treated water. Various municipalities sizes affect the planning and implementation of wastewater treatment plant (WWTP) and lead to differences in the path of the treatment operation. The existence of scale economies in this field has a great and direct effect on the wastewater treatment process reliability as well as on the different operational costs and economic feasibility.

There is no compatibility between the parties about the appropriate size of new WWTPs construction. So, the working to apply an optimal utilities size present significant challenge faces all investigations in this field. This issue affects, directly, economic efficiency, especially when the treatment efficiency be lower, then both operational costs and environmental efficiency will grow sequentially due to the sewage process station has to be planed and implemented according to the number of Population Equivalent (p.e.) those have to be connected with the available network of the sanitation; therefore, the high load by users and differential pollution loads impact the harmful effluent quality. This mean that the impact of size economies in WWTPs will be high (Hernández-chover, Bellver-domingo and Hernández-sancho, 2018).

3. ARTIFICIAL NEURAL NETWORK

An Artificial Neural Network (ANN) is a great and perfect artificial cleverness method imitating biological neurons in the body of human, that perhaps oncome multivariate non-linear tasks. Depending on the way mending and linking of the known multiple layers of neurons to imitative functions of the specific input-compute-output, artificial neural network has the ability to catch data various patterns and employ them the three important and practical aims: emulation (simulation), forecast (prediction) and optimization for reach the high operational levels. The figure 2.10 illustrate the proposed system for using in the wastewater treatment plant (Cheng *et al.*, 2020).

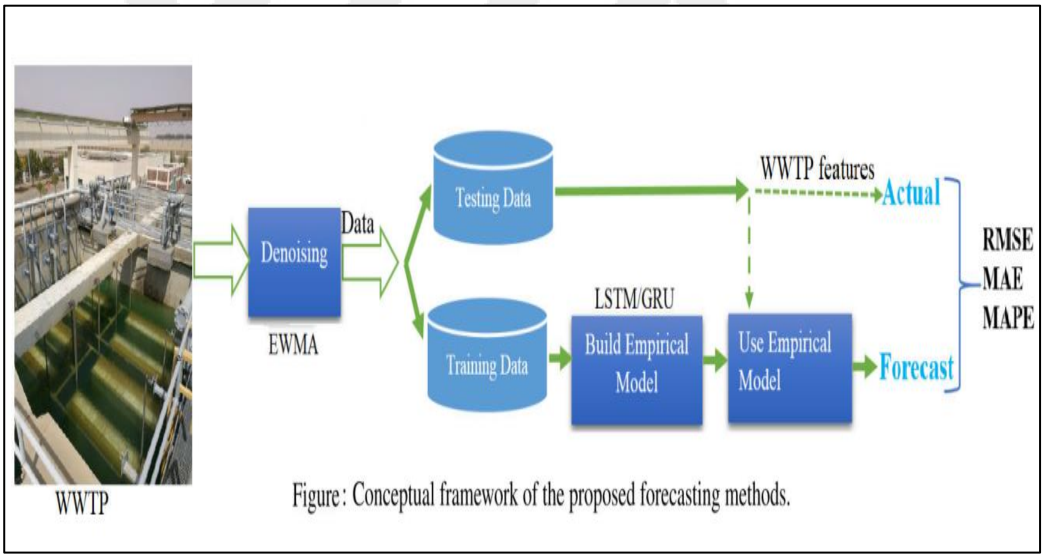

Figure 3.1: The path of operation for the proposed deep learning based on the specific procedures of prediction

3.1 Neural Network (NN) Training

The neural network performance is characterized by the it's learning algorithm, transfer function and structure. So, if neural network classifier uses a not suitable structure, then it appears weaker. The structure of neural network counts on the complication of the relationship which transfer from the input to the output, where there are not accurate rules can be depending on it in order to determine the structure of neural network. Therefore, studies must work to improve performance classification of neural network through changing the neural network's structure to make the issue easier. The results of some studies show that the linear model that depending on the Kalman filter can perfect the original neural network performance. The transfer functions which using in neural network are the linear function, the step function, and the sigmoid function, as shown in equations (3.1) and (3.2), while figure 2 explains the interconnected neurons and weights.

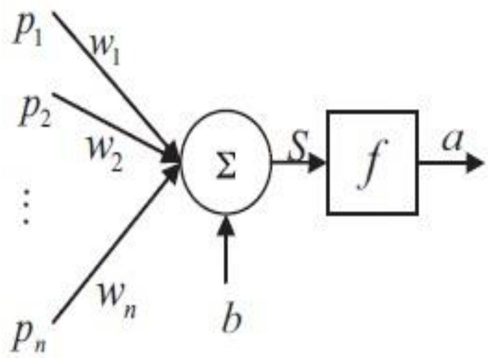

Figure 3.2: The interconnected neurons and weights

$$S = \sum_{i=1}^{n} w_i \, p_i + b \qquad \textbf{(3.1)}$$

$$a = f(S) \qquad \textbf{(3.2)}$$

Where:

w_i = the weights of inputs.

p_i = the inputs.

b = the bias.

S = the output.

$f(S)$= the transfer functions (Benjebbour *et al.*, 2015).

The weights and bias must be adjusted until the training depending on training data and learning algorithm until the error between the desired output and portend output (mean square error “MSR”) reaches the minimum value. The value of mean square error MSR can be calculated by the equation (3.3):

MSR = $\frac{1}{K*M} \sum_{i=1}^{k} \parallel \hat{z}_i - z_i \parallel^2$ **(3.3)**

Where:

K= the sample number.

M= neural network output numbers.

z= portend output.

ẑ= desired output (Benjebbour *et al.*, 2015).

Examples of known "inputs" and "results" are processed, producing probability-weighted connections between the two that are stored in the data structure of the neural network. The difference between the network's processed output (often a prediction) and a target output is often used to train a neural network from a given example. In this case, the discrepancy is to blame. The network then uses this error number to update its weighted associations. The neural network's output will get more and more similar to the goal output with each change. After a specific number of these modifications, the training might be discontinued. As the name suggests, this method is called guided learning.

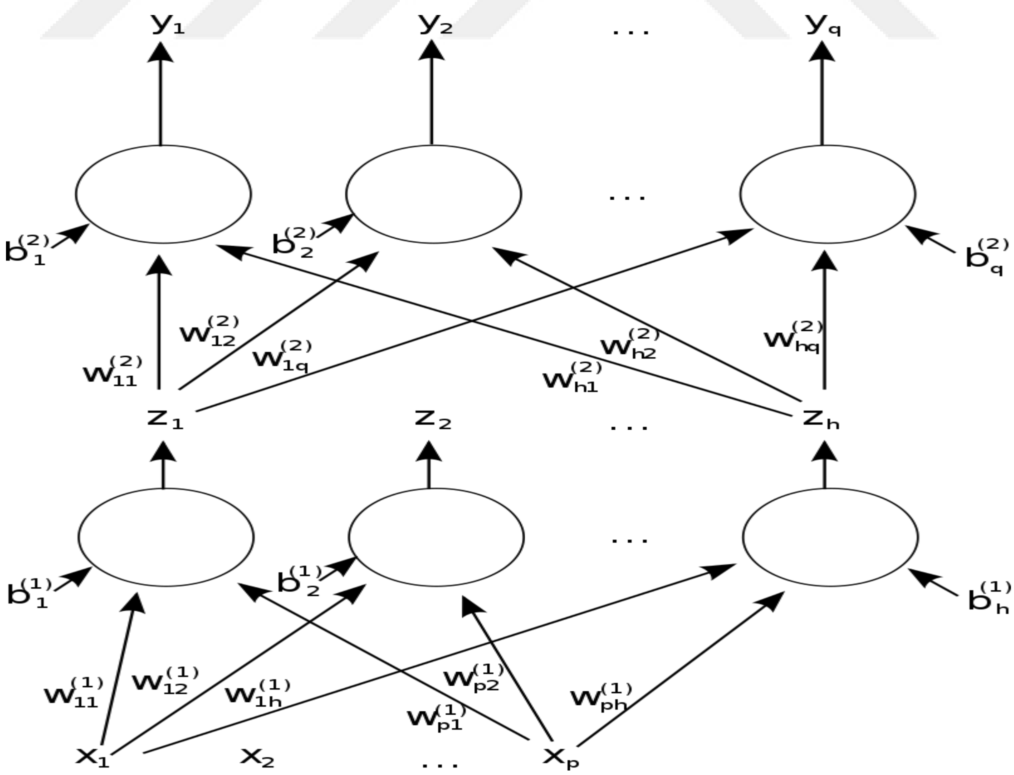

Figure 3.3: Deep neural network

Rather of being pre-programmed with rules particular to a certain activity, these systems "learn" by doing. Using examples of photographs that have been manually

classified as "cat" or "no cat," they may, for example, learn how to detect images that include cats using image recognition by examining examples of images. They don't realize that cats have hair, tails, whiskers, and cat-like faces, for example. Instead, they use the data they analyze to automatically produce unique identifiers. Figure 3.3 shows deep neural network.

3.1.1 ANN modeling challenges

ANNs are the most currently of model for machine learning (ML) which are using now, that become compete to statistical models and conventional regression, because the ANNs full applications has the ability of respect to the factors of data analysis, such as fault tolerance, accuracy, processing speed, latency, volume, scalability, performance, or convergence. But there are some challenges with ANN modeling which can be abbreviated as bellow:

- Model transparency is very big, where the data of inputs has high effect to desired outputs, therefore, working on Improving model transparency must receive great care.
- The ANN has not the predictive ability to deals with different range of data, for example, using of ANN for to improve modeling prediction of the financial market depending on the information of texts and the data. So, much searches must be spending in order to improve designing of these models under any range of conditions and reach the model’s correlation and desired robustness.
- It is very difficult to measure ANN predictions quality, which can limit their efficacy so much, when uncertainty in the predictions is not accounted, which may not be taken to account at much times, therefore, it's very important to work to improve new approaches to uncertainty (Abiodun *et al.*, 2018).

3.1.2 Classification of ANN

- **A feedforward neural network (FFNN):**

  is one of the machine learning classification algorithms that be manufacture from collective layers, where all the other units in the layers relate together, and every connection can have a different power or weight. The NN units are known, in the topology shape of neural network, as nodes.

  The two applications of FFNN are dynamical systems control and spaces control.

- **The feed-backward neural network (FBNN):**

  In feedback NNs or backpropagation, the connections between nodes are very sequence.

  the building of this type of neural networks can help it to use the internal state (stored information) in order to process sequence of data inputs. Feed-backward NN can applied to tasks like un-segmentation, and pattern recognition (Abiodun *et al.*, 2018).

  The two models of ANN and inter classifications in figure (2.4).

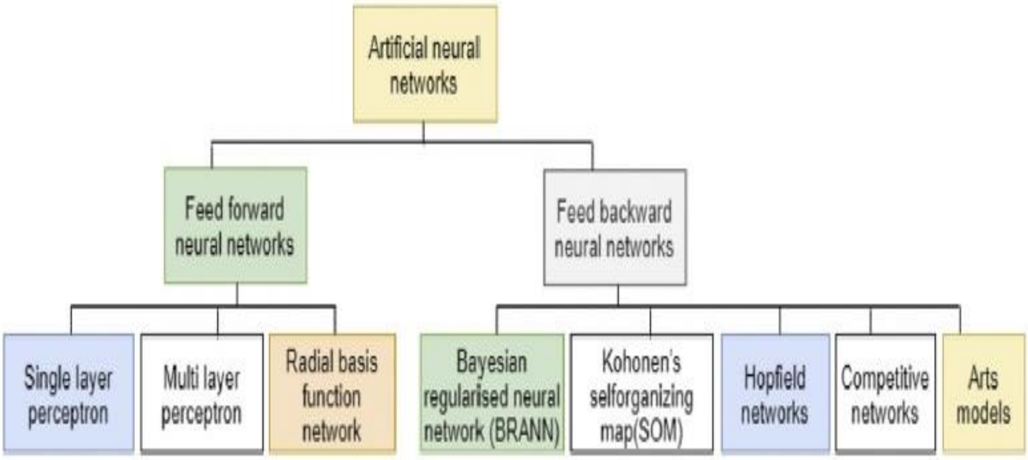

Figure 0.1: The two models of ANN and their classifications

3.1.3 Applications of ANN

ANN techniques have been adopted in many academia and industries fields in order to simplify computer vision applications, speech and so on. These include:

- **In the Speech recognition field:**

  The properties of ANNs had been adopted to understand speech and communication, where machine learning algorithms have applied in fields of acoustic modeling and automatic speech recognition (ASR).

- **In the Pattern recognition fields:**

  The large development in this field has given new and suitable ways to neglect the recognition issue of a pattern or pattern recognition (PR), which focus in determination of sequence in each input.

- **In the Computer vision fields:**

  the function of computer vision (where Deep Neural Network DNN is considered one of his most prominent methods. (Tan *et al.*, 2018)) is making the computers more understand and process of visual data efficiently accurately, that's mean, provide computers with the kind of ability of brain functions, through the logical control which studies how to separate different types of data, such as separate a data from images in artificial frameworks.

- **In the Face alignment fields:**

  In the last years ANNs succeeded in face alignment and face recognition and other models.

- **In the detection fields:**

  ANNs plays an essential role in the detection in medical, traffic signs, security, fault in different systems and so on, depending on its properties such as specificity, accuracy, sensitivity and performance (Abiodun *et al.*, 2018).

3.2 Deep Neural Network (DNN)

In this study, the performance of WWT is validated using artificial neural network (ANN) models due to their excellent capacity to handle complicated information and produce precise predictions.

A typical feedforward ANN has three different types of layers: input, hidden, and output layers, each of which contains numerous neurons (nodes). Typically, a feedforward ANN can be referred to as a deep neural network (DNN) when there is more than one hidden layer (Sugiyama, 2019). Artificial neurons, which are a set of interconnected units or nodes that loosely resemble the neurons in a biological brain, are the foundation of an ANN. Like the synapses in a human brain, each link has the ability to send a signal to neighboring neurons. An artificial neuron can signal neurons that are connected to it after processing signals that are sent to it. The output of each neuron is calculated by some non-linear function of the sum of its inputs, and the "signal" at a connection is a real number. Edges refer to the connections. The weight of neurons and edges often changes as learning progresses. The weight alters a connection's signal intensity by increasing or decreasing it. Neurons may have a threshold, and only send a signal if the combined signal crosses it. Neurons frequently group together into layers. Different layers may modify their inputs in different ways. Signals move through the layers, perhaps more than once, from the first layer (the input layer) to the last layer (the output layer).

Deep learning can be defined as a representation learning algorithm depending on large-scale data in the machine learning, and it need to big data amount in order to understand the latent patterns of data, where the scale of the model with the desired data amount size has a linear relationship, approximately (Tan *et al.*, no date).

The deep learning concept generated from the artificial neural networks (ANNs) study. Generally, the deep learning (DL) algorithm is constituting from a hierarchical architecture for much layers each of which consist of unit of non-linear information processing, where the Deep neural networks (DNNs) (which depending on deep architectures in (NNs)) can represent functions with so much complexity when the layers number and units are increased in one layer.

There are four main deep learning architectures:

- **Restricted Boltzmann machine (RBM).**
- **Deep belief network (DBN).**
- **Auto encoder (AE).**
- **Deep convolutional neural networks (CNNs).**

In CNNs, the convolution has use in standard NNs, instead of the general matrix multiplication, where the number of weights was decreased, thereby the network will be simpler, and the importing of the images to the network became be available.

These properties of CNNs made it the first successful deep learning architecture, and can be applying in different fields such as face detection, speech recognition, recommender systems, image classification, and so on.

The CNN topology leverages placement relations for reducing the parameters number in the network, and by using the standard backpropagation algorithms, the performance is improved for different data, moreover the (CNN) model requires minimal pre-processing (Liu *et al.*, 2017).

4. METHODOLOGY

This chapter includes three sections: The first section relates to a study of the reality of the sewage desalination plant in Fallujah district in Iraq, and official reports and documents prepared by competent authorities in this regard will be relied upon, in addition to the field visit to the aforementioned station and an assessment of its current reality.

The second section reviews the economic feasibility of operating the station and the expected costs of operating and completing the deficiencies in the station.

While the third section studies the area of agricultural land that can be irrigated based on the water that was desalinated by the desalination plant.

Wastewater treatment includes a group of chemicals, natural and biological processes to remove pollutants or reduce their percentage to an acceptable degree, and these treatments are divided into primary, primary, secondary, and tertiary complex processes.

- Pre-treatment: In this stage of treatment, the large parts present in the water are separated and cut for the purpose of protecting the plant’s equipment and preventing clogging of pipelines, such as oil, grease, solid materials, and sand. The stage: 5-10% of the degradable organic matter and 2-20% of the suspended matter can be ejected, as this water cannot be reutilized in all other activity(RICHARDS and SCHÄFER, no date).

- Primary treatment: It is prepared before transportation and treatment operations to limit the accumulation of solid materials, as high-density organic materials are removed, through the use of flotation and sedimentation basins, where grease and oils can be disposed of, in addition to some light materials, using very high air pressure in Flotation basins, because their stay in sewage impedes the subsequent treatment processes, while sedimentation basins are used to separate and remove soft solid materials, to reduce the occurrence of blockages in the later stages, and to prevent the corrosion of mechanical parts as a result of friction, and at this stage it can be removed (71 27% of the Biodegradable organic matter, as well as 51-71% suspended matter.

4.1 Reality Study of the Desalination Plant

If the Falluja Wastewater Treatment System is judged merely on the basis of its high expenses and limited results, the nature of its secondary goals and objectives may be overlooked. Secondary goals are common in wartime initiatives, and they impact management decisions made along the route. The secondary goals of this initiative were to increase local individuals' trust in their government's ability to offer important services, strengthen local government service capacity, win the hearts and minds of a key part of the Iraqi population, and stimulate the economy by increasing jobs. This project took place in a war-torn city in 2004. Little had been prepared for the project; there was little knowledge of the site's circumstances, no competent workforce, and no clear estimate of the new system's cost.

In order to know the extent of water pollution, wastewater projects were studied and analyzed, Table 3.1 contains the results of laboratory examination of wastewater in Fallujah plant.

Table 0.1 : Laboratory examination of wastewater in Fallujah plant

Test type	Limits	Input	Output
PH	6-9	8.090	8.44
T.S. S	60	284.0	204.0
B.O. D5	40	46.6	25.0
C.O. D	100	163.6	111.5
CL^-	600	496.7	503.9
NO^{-3}	50	8.2	9.16
NH3	10	31.96	30.1
TDS	1500	2649.0	2978.0
$PO4^{-3}$	3	3.36	1.0

The permissible limit according to the water resources conservation system (2) for the year 2002 and amending Law /1/ published in the Iraqi Gazette in the number

(3890). Environmental determinants of the system of maintaining rivers and public waters from pollution No. (25) for the year (1967).

To find out the goodness of the processed water and the efficiency of the treatment plants (%) through the concentration of Environmental determinants of incoming water (in) and the percentage of treated water (out), mathematically using the equation:

$$\frac{\textit{Annual average specific concentration of incoming water} - \textit{Annual average specific concentration of treated water}}{\textit{Annual average concentration of the determinant incoming water (in)}} \times 100\% \quad \textbf{(4.1)}$$

The efficiency of the station is inversely proportional to the volume of expenses contained therein, as well as the efficiency of the treatment units, and table (5) explains the efficiency of a treatment plant “Fallujah”.

Table 0.2: Efficiency of the treatment units

Test	Result
PH	-4.32
T.S. S	28.16
B.O. D5	45.65
C.O. D	31.59
CL^-	-1.41
NO^{-3}	-10.97
NH3	5.81
TDS	-12.41
PO_4^{-3}	70.23

4.1.1 Oxygen demand (Biochemical) B.O.D.5

This indicator is one of the significant employed indicators of organic pollution in a field of water Wastewater, which is used as an indicator to measure the effectiveness of wastewater treatment plants Healthy, as it represents a gauge of the quantity of oxygen exhausted by known microorganisms and bacteria for analysis Dissolved organic matter and foam, which constitutes a load on biological units in plants processing. It is noted through the results of the qualitative analyzes of wastewater that the proportions of (BOD5) vary by comparison, as the water received into the station records values higher than the permissible limits, due to the increase in the daily discharge of waste water and thus the increase of organic waste and the increase in bacterial and oxygen activity, which constitutes a burden On the biological units in the treatment plants, as for the treated water, the Fallujah plant recorded a value within the permissible environmental limits. The Fallujah plant has approached half of the average operational design capacity to perform The plant in the treatment, where it recorded the efficiency of the treatment plants (reduction efficiency) (97 %), as the efficiency of the plant is inversely proportional to the volume of expenses contained therein, as well as the efficiency of the treatment units, due to the loading of the central and sub-treatment plants more than their design capacity at the expense of the quality of treatment, in addition to stopping at the plant to conduct maintenance operations. Periodic and repeated during the year, and the ideal reduction percentage of (BOD5) value ranges between (81-87%) at the aeration basin, and in the event that this percentage is not reached by the good removal of organic matter within the aeration basins, the final treated water will lead to the emergence of harmful algal growth Significantly if it is directly discharged to the river, which affects human health and aquatic ecosystems, and thus increases the environmental pollution of the governorate.

4.1.2 Chemical oxygen consumed COD

It is the quantity of biologically exhausted oxygen by these known microorganisms during their vital activity at a specific temperature degree and through a specific interval time called the (Incubation period). value of COD was large, and the water was more polluted. The biologically consumed amount of oxygen depends on the value of the pH value of the water and the temperature of the water, as well as the quality and quantity of microorganisms and organic matter present in the water and subject to decomposition.

Through the results of the qualitative analyzes of wastewater, it is noted that the percentages of COD vary by measurement, as the incoming and treated water recorded values greater than the permissible limits of the environmental determinants, as the larger the quantity of biologically consumed oxygen, the more polluted the water, which constitutes a burden on the environment. Biological units in treatment plants.

4.1.3 Total salts

It is the sum of positive and negative ions present in a dissolved form in water, and expresses the amount of organic and inorganic substances contained in water, as organic compounds include activities resulting from human, agricultural and industrial activities and activities, while inorganic substances result from the dissolution of carbonates, sodium and chlorides, and this depends on the concentration of Each of them(Wilby *et al.*, 2017).

Through the results of the total salts of sewage water, we note that the incoming and treated water in the Fallujah plant recorded values higher than the environmentally permissible limits, due to the influence of the region, in which there are many agricultural lands that use fertilizers to increase agricultural production, and therefore this water enters the wastewater as a result of soil fertilization operations. In addition to the increase in organic waste resulting from human, industrial and agricultural activities, and it is considered a pollutant that is not thrown into the river directly, as it increases the environmental pollution in the governorate.

4.1.4 Total suspended solids TSS

They are the small solid particles that remain suspended in the water or due to the movement of water, and carry pollutants and pathogenic microorganisms on the surfaces of these particles, and the TSS ratio is considered as one of the significant indicators of the extent of water pollution, Through the results of T.S.S wastewater, we note that the incoming and treated water in the Fallujah plant recorded values higher than the permissible limits due to the increase in the daily discharge of wastewater and thus the increase of organic waste resulting from human, industrial and agricultural activities.

4.1.5 Acid function PH

It is the logarithm of the hydrogen ion preceded by a negative sign, and this means that the higher the concentration of the hydrogen ion, the lower the pH for the presence of the negative sign. The PH measurement is used to indicate the degree of basal or acidity of a particular solution and expresses the activity and effectiveness of the hydrogen ion and affects the soil on living organisms and bacterial activity. Toxic elements, as the pH of the acidic solution is less than 5 and the pH of the basic mobile is more than 5 and the optimum pH of fresh water is at the number 5 and that wastewater whose value is higher than the environmental limits is difficult to treat biologically, and the PH value is affected by gases dissolved substances such as carbon dioxide, hydrogen sulfide and ammonia, as well as the amount of phytoplankton and algae present in the water(Syed, 2006).

Because of the raising in organic waste and the raising in bacterial and oxygen activity, which constitutes a burden on the biological units in the process plants, in addition to the low percentage of dissolved oxygen in the plant's aeration basins, which is needed to digest and remove organic materials.

4.1.6 Nitrates NO^{-3}

The presence of the nitrate ion in water is an indication of its contamination with sewage water, as well as the second source of nitrate, which is nitrogen fertilizers. groundwater as it descends. Through the results of nitrates, we note that the incoming and treated water recorded values within the permissible limits, and that the value of nitrates for the incoming and treated water of the Fallujah plant is due to the influence of the region, in which there are many agricultural lands that use nitrogen fertilizers to increase agricultural production, in addition to the water collected from sewage networks for some industrial activities and hospitals.

4.1.7 Phosphate PO_4^{-3}

Phosphate is a natural substance, and it consists mainly of tri-calcium phosphate, which is poorly soluble in water. Phosphate is important in the manufacture of fertilizers to increase agricultural crops. Phosphate stimulates the growth of plankton and aquatic plants such as algae. Therefore, it grows rapidly in water and thus affects the percentage of dissolved oxygen in water due to the presence of a green cover These plants prevent enough light and air from reaching the water. Phosphate is used in many industries such as mining, medical, food, military, ceramics, textiles, and matches. Phosphate is important in the manufacture of fertilizers to increase agricultural yields.

Through the results of phosphates for wastewater, we note that the incoming and treated water in the Fallujah plant recorded values higher than the permissible limits and the result of the increase in agricultural and industrial activities in it, where there are many agricultural lands that use fertilizers to increase agricultural production, and thus this water enters the wastewater due to Soil fertilization operations, as well as water collected from the sewage network, some industrial activities. And that the Fallujah plant recorded the highest positive value for the efficiency of the treatment plants, the reduction efficiency by 51.32% due to the efficiency of the plant in performance.

4.2 Reuse of Wastewater in Agriculture

It turns out that the re-utilize of wastewater in agriculture is an economically practical employing and a good environmental utilizing of local wastewater for irrigation and aquaculture purposes. Re-utilize will generally lead to:

- Supplying of extra sources of water, nutrients, and organic material for improving soil.
- Improving the circumference by preventing or decreasing discharge for surface water.
- Conservation of fresh water sources.
- Improving the economic competence of desired investments in wastewater that is produced from disposal processes and irrigation operations, majorly beside cities or small towns where sewage networks are located.

Wastewater is generally not utilized as a resource and is not considered, practically, for five main reasons: lack of available information on its benefits, fear of potential risks to health and cultural impact, shortage of a way to comprehensively analyze the economics of reutilize plants, and negative practices around reuse Wastewater in locations without planning or developing weak design plans.

The impact of wastewater irrigation on general health is the significant concern of the legislatures in 1985, cooperation began between multiple bodies to review the epidemiological sectors of wastewater reutilize. Organizations contributing to this cooperation included: the World Health Organization, the United Nations

Development Program, the United Nations Environment Program, the International Reference Center for Waste Disposal, and the World Bank.

Depending on their evaluation of the health situation prevailing in upgrading countries, specifications (WHO Report, 1985) were proposed, which take into account four points for improvement, and were later adopted by the World Health Organization (1989)(Organization, 1985). Health guidelines for using of liquid waste in agriculture operations and aquaculture processes. The importance of these water goodness guidelines is that they can be achieved by simple and low-cost treatment methods. As a result, the guidelines can be applied and implemented effectively. These guidelines supply an initial point for those nations interested in regulating the reutilize of wastewater and may result a great raising in the adoption of reutilize. A viable option for wastewater disposal.

The meeting of the Scientific Group of the World Health Organization in Geneva adopted recommendations and new guidelines were drafted considering the supposed increase and the abolition of the guidelines issued in 1973. New evidence was published in 1989 on the use of wastewater for process of irrigation. Another documents have been published that adopt the 1989 WHO guidelines and are related to the study of cases in detail(Mara, 2013). The issue of wastewater reuse has led to the availability of numerous excellent documents that are practically impossible to include here (all of them, and the documents indicated above as well as the current report offer a various view of reutilize, all of which depend on a concerted effort that culminated in the World Health Organization's 1989 guidelines. This document differs from other documents.

It does not attempt to justify the basis for the new quality indices, but rather includes the bacteriological evidence and expands the horizons of its application to include practical problems encountered in general at the project level. The purpose of this report is to arrive at the preparation of wastewater use projects and broaden the scope of the discussion to include agricultural and environmental evidence for reuse.

4.3 Key Important Aspects of Wastewater Reuse Planning

The reutilize of wastewater in agriculture needs consideration of health effect, agricultural productivity, economic feasibility, and socio-cultural sides. As a result, four or five professionals or at least two of them must collaborate to design a project that is socially acceptable, with reasonable benefits, low costs, and protects general health. These specialists may perform the disciplines of general health, sewage engineering, agricultural engineering, irrigation engineering, and financial, economic, and social (behavioral) sciences. In spite of the topics debated in this chapter can be employed in all municipals or domestic wastewater reutilize project, it is significant to observe that a multidisciplinary solution to the (wastewater reuse) problems should be related to the project site and compatible with local economic and social conditions., and to have continuity.

4.3.1 Water resources

Seasonal differences in precipitation may be significant in any region although annual precipitation (annual average) stays rationally constant through the long term. The management of available water resources (involving rain and water from other sources) should consist allocation programs to suit different seasonal water needs, given that agriculture is the main user of water (about 75% of total utilize in upgrading nations), followed by industry, commerce and domestic use(Mays, 2010).

There is a difficulty in allocating water in dry and semi-arid areas, and it is necessary to use water efficiently in agriculture, through more effective irrigation. In the industrial and domestic fields, it is possible to use water rationalization devices that reduce water demand, as can the real pricing of the consumed quantities. To encourage water conservation in agriculture, industry, and domestic consumption. Recycling wastewater for less important purposes, industrial or domestic, or within the community can conserve fresh water. In order to activate these procedures, specific strategies and policies must be developed to control the utilize of freshwater resources and make allocations. The employing of reclaimed waste water for the purposes of irrigating agricultural lands near cities can have an economic return that provides markets for high-yielding crops(Mays, 2010).

4.3.2 Quality

The allocation of water resources should be based on quality considerations, in addition to quantity. Usually, good quality is reserved for human consumption and some industrial processes. Thus, national policies entail the development of large water resource plans, river basin plans, and legislation; Priority must be given to a use of fresh water for human purposes (humanitarian), and to prepare qualitative specifications for wastewater, which encourage it reutilize for agricultural, domestic, and industrial objectives. As this is particularly significant in arid and semi-arid areas, the specific specifications for the quality of wastewater can be obtained by treating or blending with fresh water (dilution), or by conducting both processes (treatment and mixing). The motive for such successive use of water, may not be caused by the need for water, it may be related to the demand to maintain the goodness of water resources. Consuming wastewater before it reaches good water resources prevents the degradation of this source, and because agriculture is the main consumer of water compared to industrial and domestic uses, agricultural utilize can be placed at the end of any combination of repeated water use (Rahimi *et al.*, 2018).

4.3.3 Water allocation and pricing

The allocation of water resources is affected by the multiple, and sometimes conflicting, concerns of different sectors. Farmers may not understand the benefits of wastewater irrigation, and the industrial sector may refuse the investment in the sectors of wastewater treatment and reutilize. Resisting this trend is, generally, due to a shortage of data on the importance of this resource or a mistake in the policy of water resource allocation or pricing.

Appropriate and factual water pricing is significant to cover costs and conservation of the encourage. In much instances, fresh water is supplied to local farmers without any cost. This not only reduces the incentives required for conserving water but also jeopardizes any endeavor to partially irrigate with treated wastewater against costs. Another obstacle to farmers asking for the costs of treated wastewater is that the farmers often used the (raw) wastewater for irrigating, and realized the agricultural interests of it, (but were not aware of the risks to health), and in these cases the farmers may resist by paying part of the value of the water which Covers part of the cost of the treatment system. The third chapter presents a more comprehensive discussion of different scenarios for project implementation. The formulation of an appropriate water pricing policy in each case can determine the feasibility of a wastewater reuse project(Tsur, 2009).

It can be said that all users have to pay the real costs of extracting, processing, and transferring the water to specific site for the purposes of post-treatment and disposal after utilizing. Through this wide principle, rules must be provided for the similar sharing of appropriate costs and desired benefits that are resulting from the multiple employing of water. If the wastewater reutilize process saves money for the producer and user, the benefits must be divided equitably, and if the result is additional costs for one or the other, the cost must be shared as well. One of the ways of settling variance and inconsistent water requirements is to establish the River Basin Authority, to be responsible for managing and allocating water resources. This agency can plan for the most frequent and effective employing of water resources for all goals while supplying farmers and other users with water of the required goodness with quantity without neglecting reasonable cost and environmental protection.

4.3.4 Costs and benefits

Attention in working the feasibility of irrigation operations with wastewater should be limited to the costs and benefits directly related to its use. Thus, it is possible that irrigation with wastewater will not be economically or financially attractive when the amount of rainfall is sufficient, to make irrigation in itself an undesirable process. Because the marginal augmentation in production is equivalent to the cost of the irrigation system to be equipped. On other side, where there is an existing irrigation system or where the need for irrigation water overrides the available resources, the marginal cost of using treated wastewater is justified by the increase in production(Molinos-Senante, Hernández-Sancho and Sala-Garrido, 2010).

Alternatively, wastewater irrigation may be an attractive option for wastewater disposal (land use) if a high degree of pre-discharge treatment is demand for environmental regarding or for high disposal costs (e.g., near a marine estuary). The interests of reducing process and disposal costs and increasing agricultural production justify the investment in the irrigation system.

Each case must be analyzed for the purpose of deciding whether wastewater irrigation is viable from the point of view of both cultivation and disposal. In some cases, the disposal option is more attractive than the reuse option for irrigation. In other cases, the irrigation option is very attractive, even if the beneficiary of the irrigation project contributes to the cost of treating waste water. In other cases, where there are no other sources of water and large areas of arable land are available near treatment plants, farmers are willing to invest in water treatment and water storage. In many cases, although the benefits do not justify the investment for disposal alone or irrigation alone, the two together may be a justification for investment, especially when taking into account the environmental benefits such as reducing pollution of receiving waters and indirect injection of groundwater. Therefore, the sanitation engineer must evaluate the feasibility of irrigation with waste water as a disposal method and the irrigation engineer must consider the possibility of using waste water as a source of irrigation water and nutrients in agricultural areas and around urban settlements(Molinos-Senante, Hernández-Sancho and Sala-Garrido, 2010).

4.3.5 Bacterial risks to health

The most important determinant of wastewater reuse is public health, as the wastewater carries pathogens. In general, modern treatment methods (such as activated sludge) are not designed to get rid of pathogenic organisms, knowing that disinfection processes can get rid of these pathogenic agents, but at a relatively high cost and exceed the financial and technological abilities of some fields in developing countries. Different organisms that can stay a life and tolerate the various treatments (without disinfection) involve bacteria, protozoa, intestinal worms, and appropriate viruses, and much of these pathogens infect the body only during ingestion of water and food contaminated with excreta (Hussain and Qureshi, 2020).

Main factors that manage bacterial risks to health involve:

- The capability of pathogens to live or reproduce in the environment.
- The dose is important for against the infection.
- The demand for the existence or nonexistence of an intermediate supplier.
- Personal susceptibility to danger (continuous exposure may create immunity).

Pathogens infect different groups of the population in different ways. Consumers of uncooked vegetables are more susceptible to infection than consumers of cooked vegetables, and workers irrigating fields irrigated with RAW are more vulnerable than workers in other fields. There are groups that are not exposed to infection, so it is important to establish a foundation to protect the health of those who are exposed.

There are four groups of people at risk as a result of agricultural irrigation with wastewater or human excreta, and they are:

- Agricultural workers working in the field and their families.
- Crop traders.
- Consumers of crops, milk, and meat.
- People who live near fields irrigated with wastewater.

Preventive measures for protecting orchard workers and harvest handlers involve preventative clothing, raised hygiene, and possible vaccinations. For instance, the exposure of agricultural workers in the crop to hookworm contagion can be decreased if the workers utilize suitable shoes. This may be more hard than it sounds because in much areas conventional irrigation is usually practiced by farmers wearing ill-fitting shoes. Disease immunization is another feasible preventive measure against certain diseases (such as hepatitis A, typhoid fever) but is not a preventive measure against other diseases (such as worm infections, diarrheal diseases). Preventive health measures need adequate medical facilities for treating diarrhea, amoebiasis and acute infections caused by drafts (Hussain and Qureshi, 2020).

4.3.6 Controlling legislative aspects

Most of the countries in which irrigation with wastewater is practiced have instructions related to protecting the public health of agricultural workers and consumers of crops irrigated with this water. The instructions require stopping irrigation before a specific time of harvest, as well as requiring the wearing of certain clothes, special shoes (boots) and providing the necessary health care for workers. The imposed standards for water quality or the Irrigation Organization's guidelines are often strict, reflecting California's guidelines. In most industrialized countries, achieving these standards can be achieved without difficulties. Due to water pollution control requirements during treatment. The industrialized countries are characterized by the availability of technology

The operational ability to achieve the required specifications with the presence of agencies and bodies for monitoring the quality of water leaving the stations, which have the ability to impose appropriate instructions. The instructions in industrialized countries reflect the state of sanitation and the pathological map in them, for example, intestinal worms, which have not been taken into account for a long time, so they are not among the factors that enter the development of specifications for reuse.

Most of the developing countries do not have the technological equipment needed to achieve the quality of treated water (conforming to standard specifications), and if available, it does not enjoy continuity, as legislative agencies, if available, can rarely impose the required specifications. Therefore, irrigation with uncontrolled wastewater puts agricultural workers and consumers at risk. In order to solve legal problems related to the imposition and support of standards, the first step is to prepare real standards that reflect the prevailing health risks. This will lead to limited health risks and imposed and acceptable specifications that encourage the safe use of wastewater for irrigation purposes.

4.4 Proposed Model Based On Neural Network

The proposed model based on a deep neural which assist the plant to compare the water test results with the data store in the neural network. The proposed system simulated using MATLAB program. The training data is taken from a standard WWTP, training data listed in appendix A. The proposed system based on training a deep neural network to estimate the WWTP required measurements and compared it with actual measurements. The input and output flowrates are taken to be the index for data matching. The neural network training processes is shown in figure 4.1, while the training performance is shown in figure 4.2. linear regression for training test is shown in figure 4.3 and testing error histogram is shown in figure 4.4.

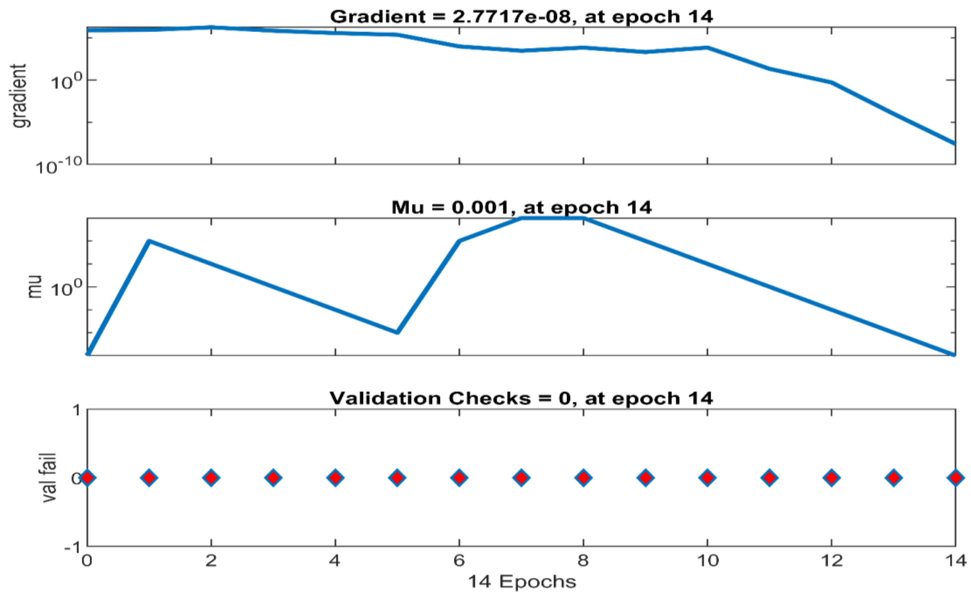

Figure 0.1: Neural network training status

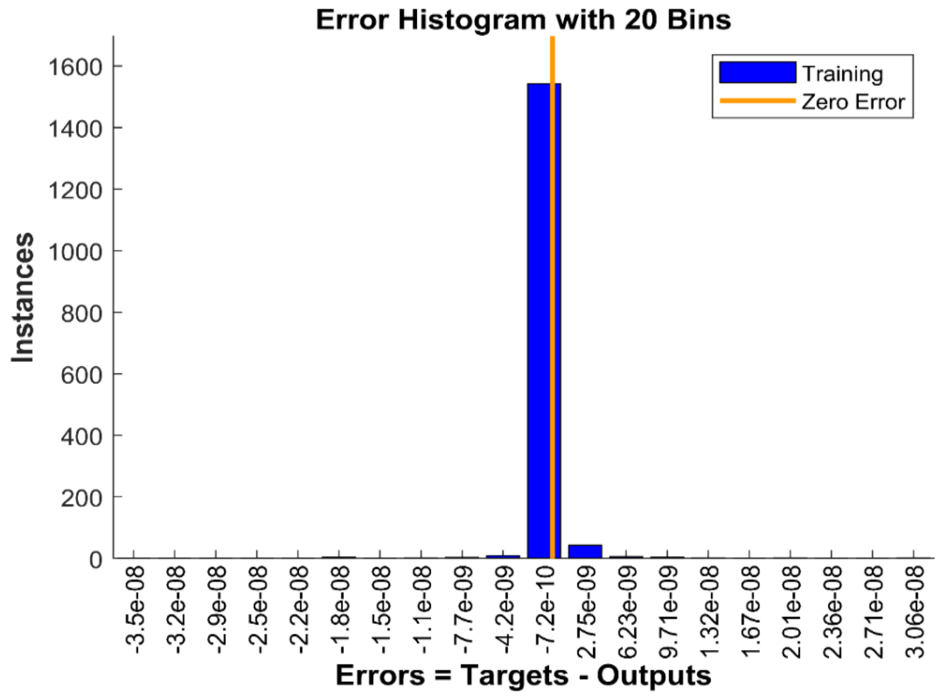

Figure 0.2: Error histogram

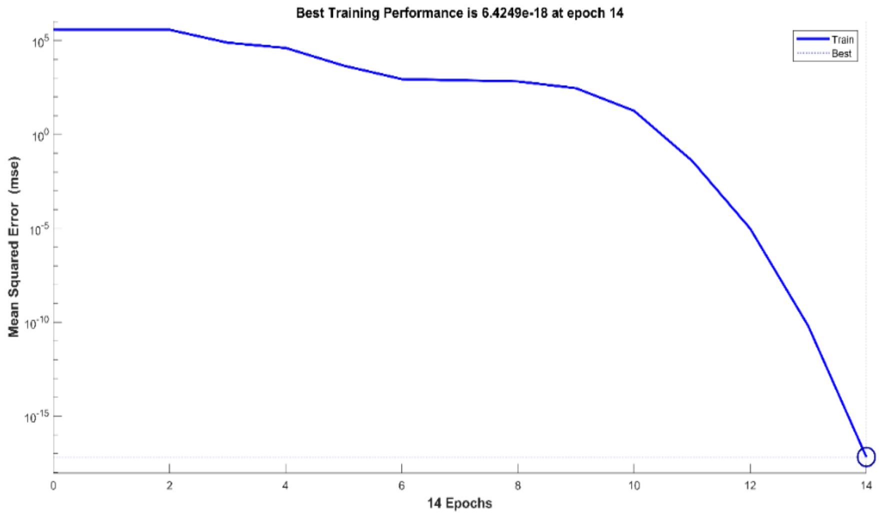

Figure 0.3: Neural network training performance

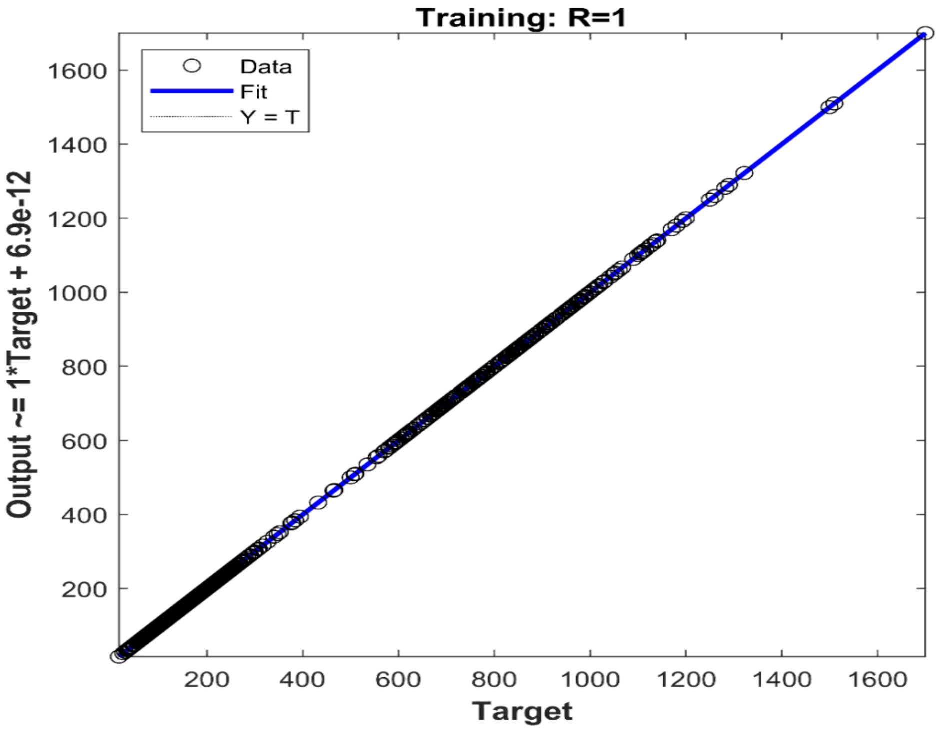

Figure 0.4: Linear regression test

The number of hidden layers in the neural network is selected depending on the number of inputs, number of outputs (it must be less than the number of outputs), also it must be in the range that gives high performance with minimum training requirements. In our application the selected number of hidden layers is 10 layers.

5. RESULTS DISCUSSION

In order to find out whether the plant was used for irrigation purposes, the specifications of the treated water produced by the plant were compared with the specifications stipulated by Iraqi legislation in the field of using treated sewage water.

For the purposes of this regulation, the following terms shall have the meanings indicated thereto('قاعدة التشريعات العراقية', no date):

- **Treated Water:** The water leaving a sewage process plant after it has been processed in regard to the standards stipulated in this system.
- **Standards:** Standard values for determining the physical, chemical, and biological components on the basis of which the goodness of treated water is determined.
- **Dual treatment:** The quality of treatment that can be reached through biological process that ends with sedimentation and sterilization, so that the producing water conforms to the wastewater standards stipulated in table 4.1 and that water can be utilized for limited irrigation.
- **Tertiary treatment:** The level of treatment that can be reached through biological treatment that ends with filtration and sterilization or any other processes so that the resulting water conforms to the wastewater standards stipulated in table 4.2, and that water can be used for unrestricted irrigation.
- **Unrestricted watering:** watering plants.
- **Restricted Irrigation:** Irrigation of plants with the exception of vegetables, tuberous different productions and sits whose fruits or vegetative parts come into contact with treated water, whether they are eaten fresh or cooked.

5.1 Station Data Statics

To study the station working performance the data for the main parameters for 18 month is collected and analyzed. The collected data for: TSS, BOD, COD, NH3, Nitrate, TNK, input flow rate, and output flow rate.

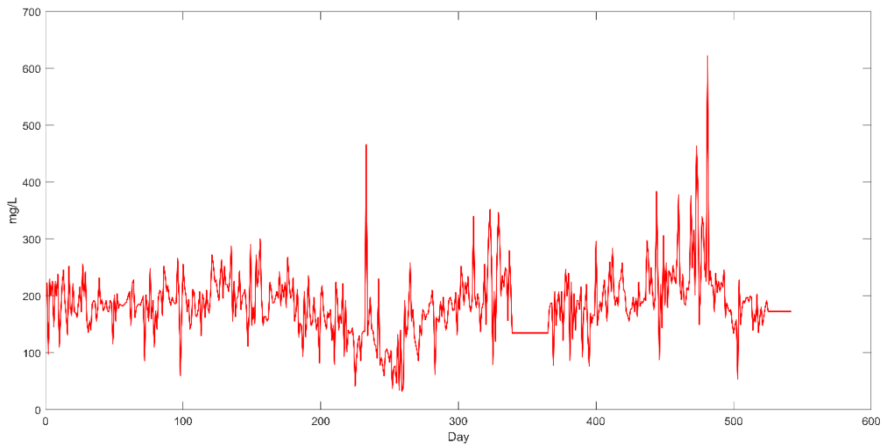

Figure 0.1: TSS level (mg/L)

Figure 5.1 shows the TSS level for the studied duration. The mean value of TSS during the same duration is: 199 mg/L.

The BOD test results shown in figure 5.2. BOD average value for studied duration is: 125 mg/L

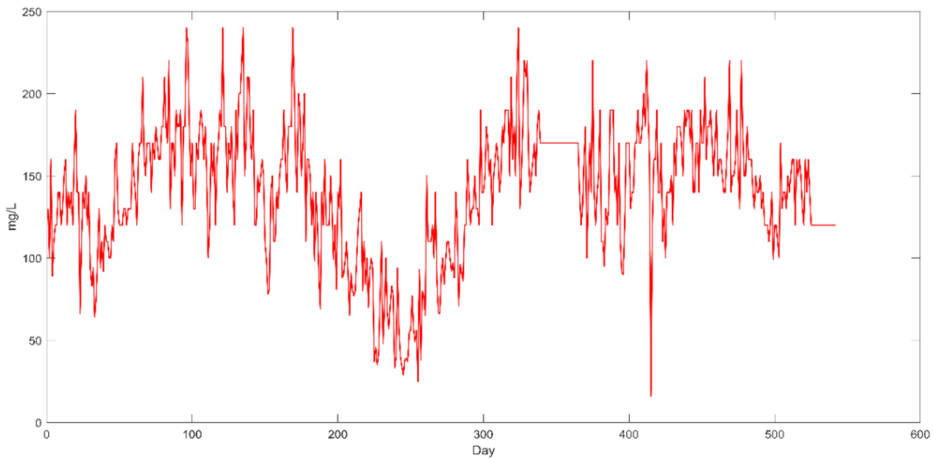

Figure 0.2: BOD level (mg/L)

COD test results are shown in figure 5.3,

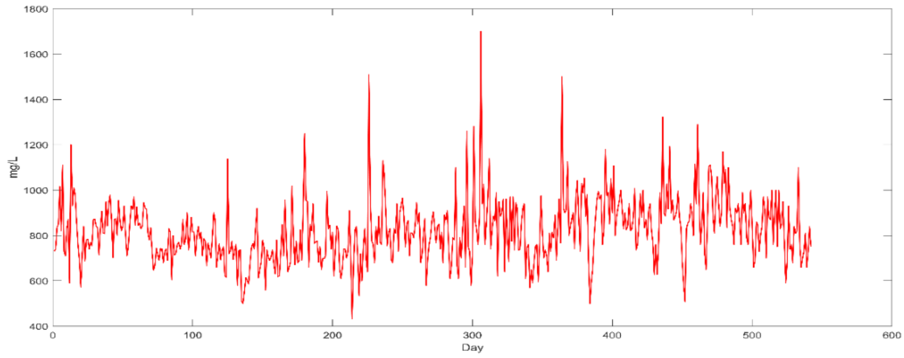

Figure 0.3: COD level (mg/L)

While NH3 test results *are shown in figure 5.4.*

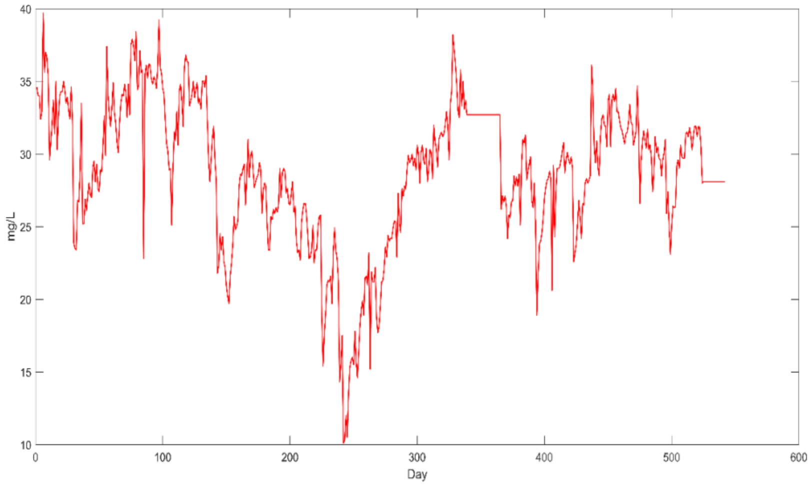

Figure 0.4: NH3 level (mg/L)

Figure 5.5 shows Nitrate quantity test for 18-month duration.

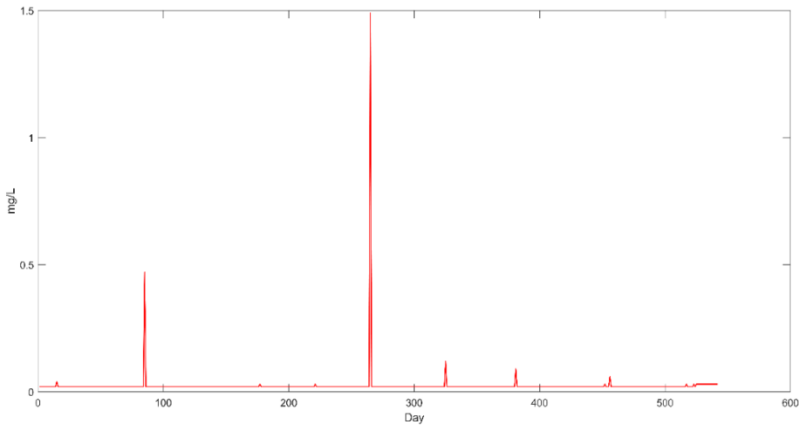

Figure 0.5: Nitrate level (mg/L)

NTK quantity is shown in figure 5.6

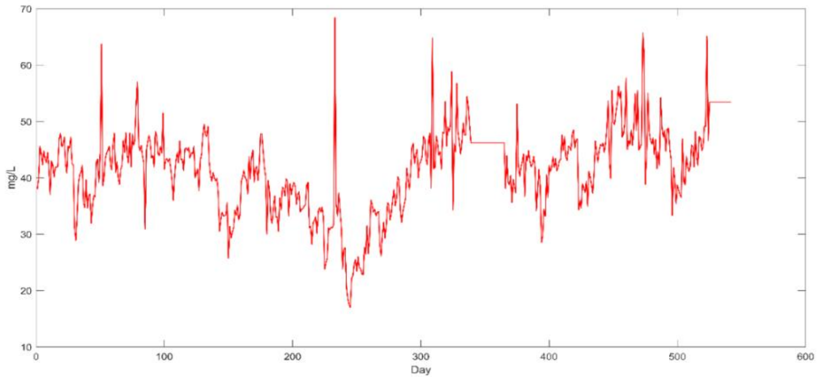

Figure 0.6: NTK level (mg/L)

5.2 Station Treatment Efficiency

To calculate the station treatment efficiency the outcomes of the station compared with the Iraqi standards for treated water.

5.2.1 Biochemical oxygen demand (B.O.D.5)

This indicator is one of the most widely used indicators of organic pollution in the wastewater field, and it is used as an indicator to measure the effectiveness of wastewater treatment plants, as it represents a measure of the amount of oxygen consumed by microorganisms and bacteria to analyze dissolved organic matter and foam, which constitutes a burden on biological units in treatment plants, figure 5.7 shows the B.O.D.5 of the station and the standards.

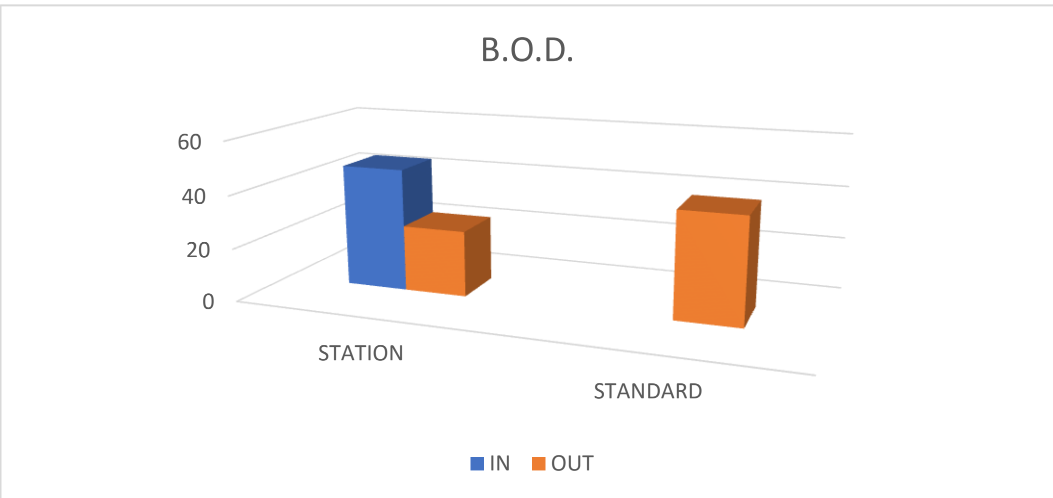

Figure 0.7: B.O.D level (mg/L)

The B.O.D. level is less than the standard limit. While the station efficiency for B.O.D reduction is -39.6%.

5.2.2 PH Test

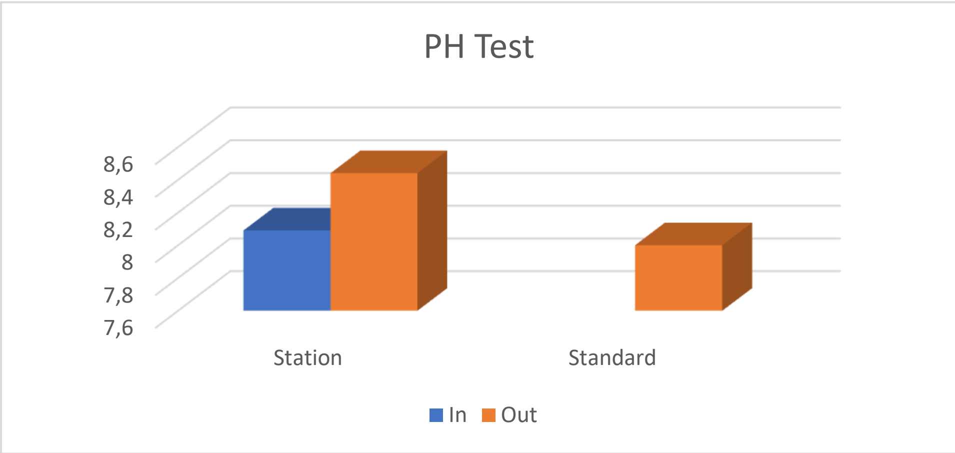

Figure 0.8: PH test

Figure 5.8 shows the PH range for the station compared with the Iraqi standard. It is clear that the PH range in the output of the station is in the accepted level. Station efficiency for PH parameter is: -4.32%.

5.2.3 Total salt quantity

It is the sum of positive and negative ions present in a dissolved form in water, and expresses the amount of organic and inorganic materials contained in water, as organic

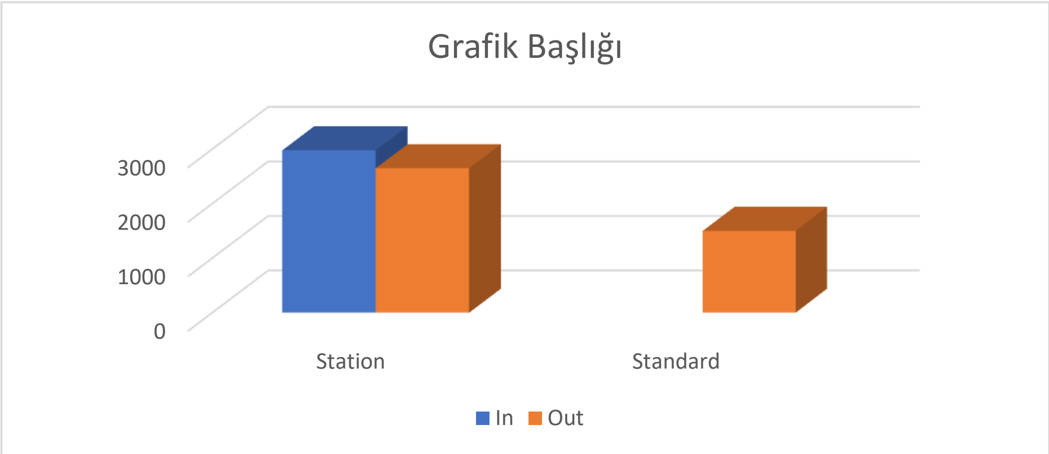

Figure 0.9: T.D.S level (mg/L)

Compounds include activities resulting from human, agricultural and industrial activities, and activities, while inorganic materials result from the dissolution of carbonates, sodium, and chlorides, and this depends on the concentration of each. Figure 5.9 shows the level of T.D.S in the input and output of the station compared with the standards. T.D.S reduction efficiency is: -12.41%.

5.2.4 Total suspended solids (T.S.S)

Fallujah station recorded the lowest percentage in the reduction efficiency by (39.06%) due to stopping at the station to perform periodic and recurring maintenance operations during the year, in addition to the lack of efficiency in the collection basins and the accumulation of organic matter in them, as the incoming water mixes with the previously existing water concentrated in the collection basins Which increases the level of pollution in it. Figure 4.10 shows the reduction levels compared with standards.

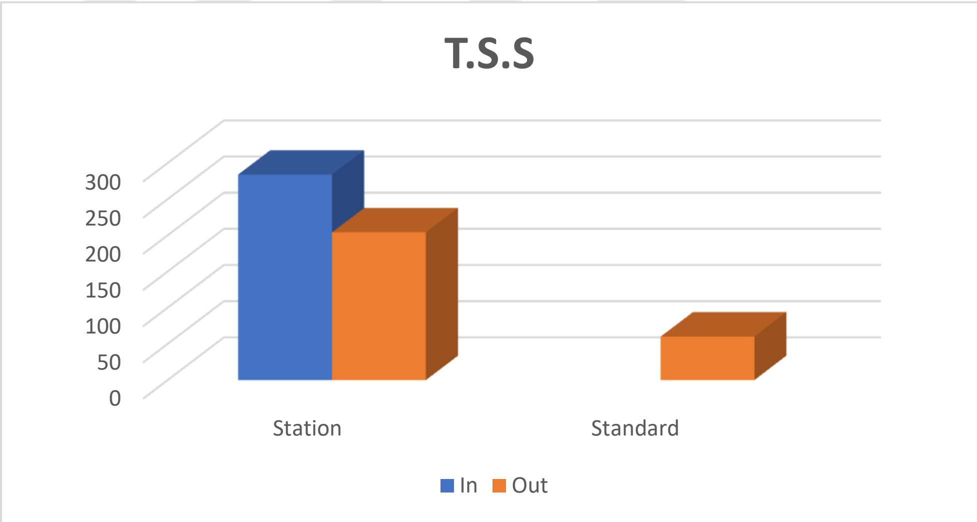

Figure 0.10: T.S.S

5.2.5 Nitrates

The efficiency ratio of the treatment plant (reduction efficiency) recorded a negative value, where the highest negative value of the reduction was recorded in the Fallujah plant by (-10.97%), due to the nitrification process, in which the ammonia is oxidized, which converts nitrates into nitrites as a result of consuming a quantity of oxygen that lives It contains organic materials during the breathing process in the aeration basins, in addition to the lack of efficiency in the collection basins and the leaving of organic materials in them, as the incoming water mixes with the previously existing water concentrated in the collection basins, which increases or decreases the pollution rate. Figure 5.11 shows the reduction percentage compared with the standard value.

5.2.6 Ammonia (NH_3)

Through the results of (NH3), we note that the incoming and treated water of the Fallujah plant recorded values higher than the environmentally permissible limits of the environment. Figure 5.12 explain the comparison pf that parameter with the standard.

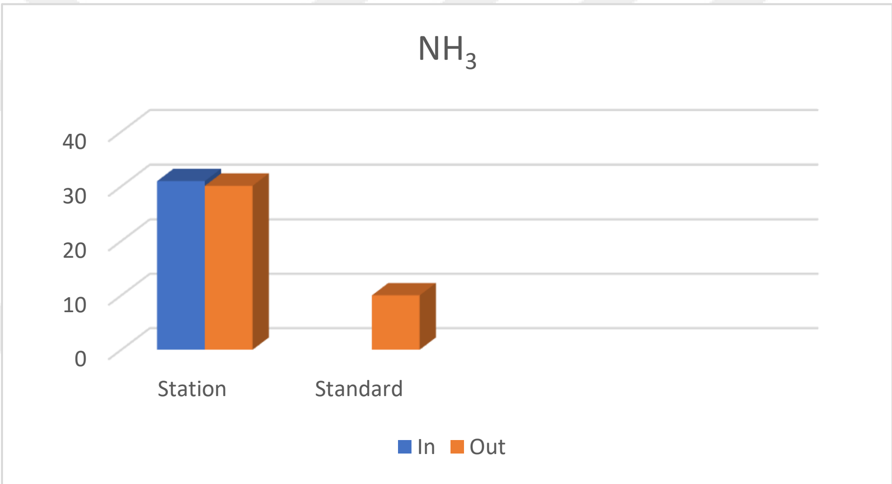

Figure 0.11: NH3

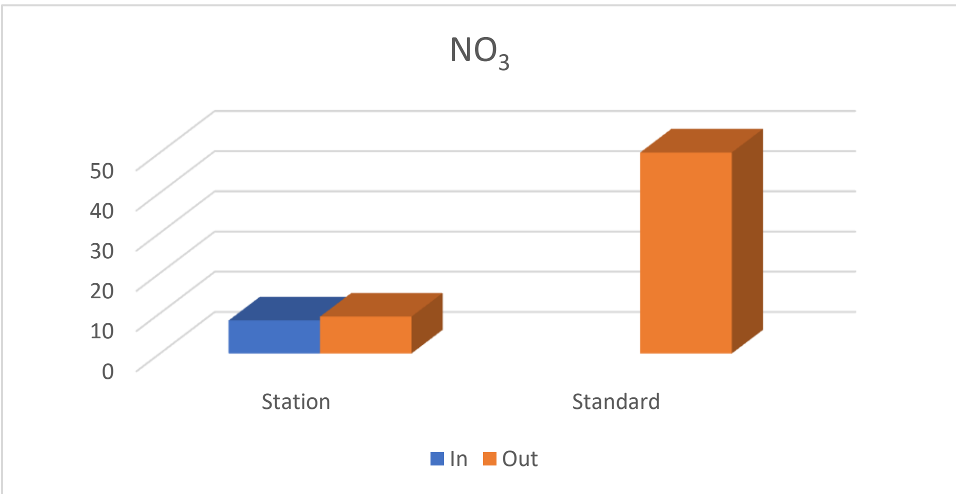

Figure 0.12: NO3

5.2.7 Phosphate (PO_4^{-3})

The Fallujah plant recorded the highest positive value for the efficiency of the treatment plants (reduction efficiency) by 51.32% due to the plant's efficiency in performance. The phosphate level in both input and output of the station compared with the standard are shown in figure 5.7.

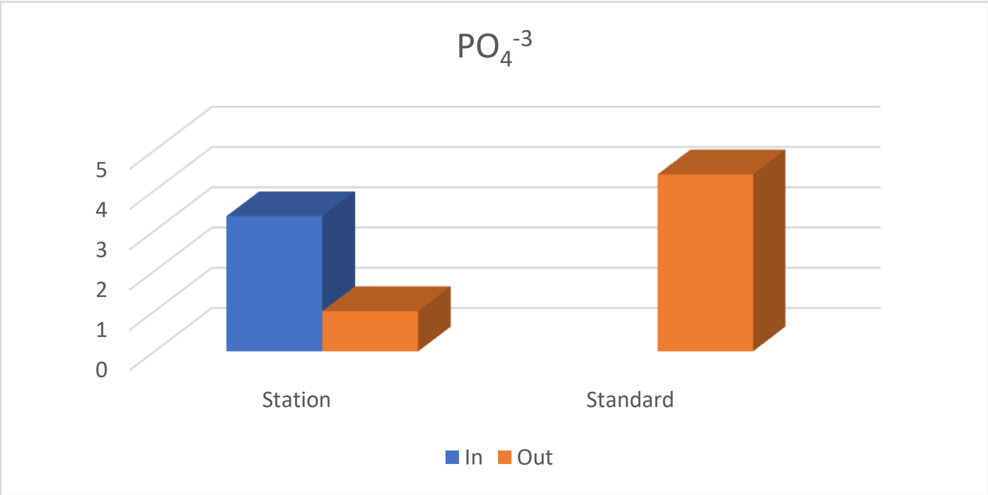

Figure 0.13: PO_3^{-4}

Table 0.1: Station outcomes compared with standards of treated wastewater used for agricultural irrigation

Item	Standard (mg/L)	Station outcomes (mg/L)
Supernatants	Free	-
Total suspended solids TSS	40	204
Total dissolved salts TDS	2500	2978
PH	4 - 6	8.44
Bio oxygen demand BOD	40	25
Chemical oxygen demand	100	-
Oil & Grease	-	-
Phenol	0.002	-
Nitrates (NO_3-N)	50	9.16
Ammonium (NH4)	5	-
Aluminum (Al)	5	-

Table 0.2: Station outcomes compared with standards of treated wastewater used for agricultural irrigation (Cont.)

Arsenic (AS)	0.1	-
Beryllium (Be)	0.1	-
Boron (B)	0.75	-
Cadmium (cd)	0.01	-
Free chlorine (Cl_2)	0.5	-
Chrome (Cr)	0.1	-
Cobalt (Co)	0.05	-
Copper (Cu)	0.2	-
Fluoride (F)	1	-
Iron (Fe)	5	-
Lead (Pb)	0.1	-
Lithium (Li)	2.5	-
Manganese (Mn)	0.2	-
Mercury (Hg)	0.001	-
Molybdenum (Mo)	0.01	-
Nickel (Ni)	0.2	-
Selenium (Se)	0.02	-
Vanadium (V)	0.1	-
Zinc (Zn)	2	-
Phosphate (PO_4)	25	1.0
Sodium (Na)	250	-
Calcium (Ca)	450	-
Magnesium (Mg)	80	-
Potassium (K)	100	-
SAR	6 – 9	-
The number of fecal colic bacilli	1000 cell/100 mL	-

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The reliance on artificial intelligence, especially neural networks, and deep learning in predicting the required standards for the quality of treated water showed good performance, as the differences and error rates were very few between the expected values and the real values. A deep neural network was trained on the data of the sewage treatment plant for a period of one year, and the results were verified on other values.

The training process results show that the error range was in 10^{-10} level as shown figures 4.2, 4.3, and 4.4 for error histogram, training performance and linear regression respectively.

1- The treated water recorded values more than the permissible environmental parameters for the indicators (TSS, TDS, PH), while the other indicators are less than the standard levels.
2- The station treatment efficiency recorded positive values for the indicators (BOD, COD, TSS, NH_3, and PO_4^{-3}).
3- The station treatment efficiency recorded negative values for the indicators (TDS, PH, NO^{-3}.
4- The absence of agricultural fertilizer production plants from the wastes of water treatment plants increases the risks of pollution due to the accumulation of solid waste resulting from the treatment processes.

6.2 Recommendations

1- It is necessary to establish a plant for the production of agricultural fertilizers near the central sewage station through the treatment of wastewater plant residues resulting from the treatment processes (sludge).

2- Initiating the implementation of a national program to study and identify the causes of pollution in all its forms and to develop an urgent plan to treat them.
3- Attention to spreading environmental awareness among all members of society, and for it to be a lesson dedicated to the environment and its preservation within the study curricula.
4- Implementation of workshops and development courses for farmers in order to inform them about the irrigation techniques with treated water and what crops can be irrigated with this water and the impact of sewage waste on the quality and safety of the crop.

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APPENDICES

Appendix A

Table A.1: Dataset of the reference WWTP for first month

Date	Day	TSS	CBOD5	TKN	NH3	Nitrates	Flow ST (GPM)	Flow NT (GPM)
01/01/2018 00:35	1	224	130	38.0	34.6	0.02		
01/02/2018 00:25	2	98	100	39.8	34.0	0.02	7137.811636	8000.039799
01/03/2018 00:30	3	230	160	45.6	34.0	0.02	7204.256769	8528.504314
01/04/2018 00:30	4	202	89	44.3	32.4	0.02	7104.867779	9144.884336
01/05/2018 00:30	5	226	110	42.3	32.9	0.02	7061.551421	8841.95644
01/06/2018 00:30	6	146	120	44.8	39.7	0.02	7154.467293	9086.373926
01/07/2018 00:30	7	226	120	43.4	35.6	0.02	7014.17828	8776.471368
01/08/2018 00:30	8	200	140	42.7	37.0	0.02	7087.182517	8619.527009
01/09/2018 00:35	9	238	140	44.5	36.6	0.02	7166.582477	10512.45657
01/10/2018 00:35	10	110	120	41.8	35.2	0.02	7150.854563	10299.61161
01/11/2018 00:30	11	164	130	37.0	29.6	0.02	7157.235953	9808.461151
01/12/2018 00:30	12	218	150	43.0	30.8	0.02	7166.01492	10014.38257
01/13/2018 00:30	13	246	160	42.3	32.1	0.02	7112.256952	10063.28497
01/14/2018 00:30	14	194	120	40.1	33.7	0.02	7123.771826	9570.084615
01/15/2018 00:35	15	166	140	41.9	31.4	0.04	7078.836492	9799.961065
01/16/2018 00:30	16	132	130	41.8	35.0	0.02	7139.365127	9194.029297
01/17/2018 00:35	17	252	140	42.0	30.3	0.02	7060.645519	9188.274794
01/18/2018 00:30	18	180	120	46.9	32.6	0.02	7157.297806	8437.732479
01/19/2018 00:30	19	166	160	47.9	34.0	0.02	7124.026508	9063.933126
01/20/2018 00:35	20	222	190	45.5	34.3	0.02	7141.729961	8848.078969
01/21/2018 00:30	21	172	140	45.8	34.3	0.02	7180.232976	9545.822618
01/22/2018 00:30	22	170	140	47.2	35.0	0.02	7127.413669	9311.599149
01/23/2018 00:35	23	162	66	42.5	34.4	0.02	7168.470707	8953.651407
01/24/2018 00:30	24	190	110	40.8	33.5	0.02	7242.711715	9026.921214
01/25/2018 00:35	25	216	140	45.6	33.9	0.02	7120.362854	8985.6627
01/26/2018 00:30	26	172	130	45.3	33.0	0.02	7174.109901	8810.464353
01/27/2018 00:35	27	256	150	47.2	32.4	0.02	7133.605885	8892.906641
01/28/2018 00:30	28	200	120	42.5	34.6	0.02	7557.240969	11220.68388
01/29/2018 00:35	29	242	140	42.3	32.3	0.02	7959.381608	13782.94858
01/30/2018 00:30	30	158	94	31.2	23.9	0.02	7754.707648	12483.24642
01/31/2018 00:30	31	136	83	28.9	23.5	0.02	7364.10009	11680.87627

Table A.2: Dataset of the reference WWTP for 2nd month

02/09/2018 00:30	40	186	120	34.6	26.1	0.02	7318.080575	11794.39096
02/10/2018 00:30	41	194	110	36.7	27.1	0.02	7155.074872	11930.33373
02/11/2018 00:30	42	174	110	37.1	28.0	0.02	7158.058187	11522.13136
02/12/2018 00:30	43	180	100	31.9	27.2	0.02	9341.208192	8780.38152
02/13/2018 00:35	44	192	100	34.9	27.0	0.02	9250.937261	8867.598203
02/14/2018 00:45	45	174	120	36.9	29.1	0.02	9222.206456	8829.155043
02/15/2018 00:30	46	172	110	36.6	29.5	0.02	9242.762247	8674.996544
02/16/2018 00:30	47	192	160	42.8	28.1	0.02	9155.925816	8334.279483
02/17/2018 00:30	48	188	170	43.3	29.3	0.02	9064.876349	8511.358359
02/18/2018 00:30	49	116	130	39.2	27.6	0.02	9147.47063	8379.589603
02/19/2018 00:35	50	202	120	44.7	27.4	0.02	9164.359139	8374.053902
02/20/2018 00:30	51	156	120	63.7	28.9	0.02	8780.202119	8564.041766
02/21/2018 00:35	52	204	120	38.6	28.8	0.02	6453.627191	11063.97982
02/22/2018 00:30	53	178	130	40.0	30.5	0.02	9237.465035	7590.128126
02/23/2018 00:30	54	186	130	43.3	32.6	0.02	8467.790287	8631.306954
02/24/2018 00:30	55	184	120	44.4	29.9	0.02	7496.130214	9519.048438
02/25/2018 00:30	56	182	130	44.9	37.4	0.02	8104.461913	8984.908138
02/26/2018 00:20	57	184	130	45.6	34.0	0.02	7998.906959	9074.645571
02/27/2018 00:35	58	188	130	42.3	32.7	0.02	7825.503302	8924.013368
02/28/2018 00:30	59	190	170	41.4	31.9	0.02	7754.005784	9018.408918

Table A.3: Dataset of the reference WWTP for 3rd month

Date	Day	TSS	CBOD5	TKN	NH3	Nitrates	Flow ST (GPM)	Flow NT (GPM)
03/01/2018 00:35	60	200	150	45.7	33.2	0.02	7867.6227	8665.753889
03/02/2018 00:30	61	208	140	47.9	34.9	0.02	8010.0755	7925.774566
03/03/2018 00:30	62	148	120	40.9	32.9	0.02	8009.6578	7661.620845
03/04/2018 00:30	63	222	160	42.8	32.1	0.02	8081.7487	7746.844769
03/05/2018 00:35	64	228	170	40.1	30.8	0.02	8043.5694	7732.266856
03/06/2018 00:30	65	162	170	38.8	30.1	0.02	8019.3063	7933.739288
03/07/2018 00:30	66	180	210	41.5	32.1	0.02	8000.6933	7685.419685
03/08/2018 00:35	67	184	160	42.2	33.5	0.02	8976.7665	6575.727216
03/09/2018 00:30	68	186	150	46.6	34.1	0.02	9488.5223	5931.809135
03/10/2018 00:35	69	184	170	44.5	34.0	0.02	9568.1552	6266.589345
03/11/2018 00:30	70	192	170	48.0	34.8	0.02	9906.933	6491.841088
03/12/2018 00:30	71	200	170	44.1	34.2	0.02	9593.8881	6348.375672
03/13/2018 00:30	72	86	140	42.6	32.5	0.02	9581.591	6111.529668
03/14/2018 00:35	73	202	170	47.9	34.8	0.02	9605.9524	6365.918802
03/15/2018 00:35	74	180	160	41.9	32.7	0.02	9461.1049	5927.196951
03/16/2018 00:30	75	156	180	47.8	37.5	0.02	9479.7689	6269.530432
03/17/2018 00:35	76	248	170	45.7	37.9	0.02	9490.3996	6051.966451
03/18/2018 00:30	77	160	160	46.6	37.4	0.02	9608.5428	6255.029546
03/19/2018 00:35	78	192	160	53.2	36.4	0.02	9610.7366	6102.96497
03/20/2018 00:30	79	110	180	57.0	38.4	0.02	9562.4941	6275.182765
03/21/2018 00:35	80	174	180	45.7	34.4	0.02	9548.92	6116.852128
03/22/2018 00:35	81	142	210	44.8	34.7	0.02	9264.344	5977.395536
03/23/2018 00:30	82	198	180	45.7	37.1	0.02	9162.0452	5755.010192
03/24/2018 00:30	83	210	170	43.9	35.6	0.02	9404.6328	6076.811183
03/25/2018 00:30	84	206	220	42.6	35.8	0.02	9481.8499	5899.103096
03/26/2018 00:30	85	166	130	30.9	22.8	0.47	9323.0318	5912.725934
03/27/2018 00:35	86	252	170	44.9	35.5	0.02	9200.6374	5606.214267
03/28/2018 00:35	87	234	170	46.3	36.1	0.02	9158.6363	5656.73925
03/29/2018 00:40	88	208	150	47.5	35.2	0.02	9416.0895	5793.624827
03/30/2018 00:40	89	218	190	46.4	36.2	0.02	7265.6469	7866.00795
03/31/2018 00:30	90	194	180	43.5	36.1	0.02	6374.0005	8987.07437

Table A.4: Dataset of the reference WWTP for 4th month

Date	Day	TSS	CBOD5	TKN	NH3	Nitrates	Flow ST (GPM)	Flow NT (GPM)
04/01/2018 00:30	91	184	180	43.9	35.2	0.02	6409.3613	9162.643214
04/02/2018 00:30	92	198	190	41.9	34.8	0.02	6364.7679	9078.54792
04/03/2018 00:35	93	190	120	48.2	35.3	0.02	6223.515	8855.301732
04/04/2018 00:35	94	186	180	47.5	35.1	0.02	6296.7809	9198.030585
04/05/2018 00:30	95	188	180	44.3	34.5	0.02	6170.5574	9133.640267
04/06/2018 00:35	96	266	240	43.9	36.0	0.02	6067.0726	9012.926685
04/07/2018 00:30	97	192	230	45.6	39.2	0.02	6149.3867	9161.0629
04/08/2018 00:35	98	60	180	44.4	36.0	0.02	5929.8326	8939.077514
04/09/2018 00:30	99	166	150	51.5	35.5	0.02	5922.4288	8941.992181
04/10/2018 00:35	100	256	170	41.5	34.5	0.02	6065.7701	9119.783027
04/11/2018 00:35	101	218	130	43.2	34.1	0.02	6362.8797	9572.011599
04/12/2018 00:30	102	200	130	43.4	32.2	0.02	6146.6072	9174.959267
04/13/2018 00:35	103	172	170	42.8	30.7	0.02	5690.7995	9055.150192
04/14/2018 00:30	104	194	160	43.4	30.2	0.02	5999.5258	8932.28278
04/15/2018 00:30	105	142	180	41.6	28.9	0.02	6320.3873	9616.114214
04/16/2018 00:35	106	152	190	39.4	29.0	0.02	6570.8498	9551.535421
04/17/2018 00:30	107	212	180	36.0	25.1	0.02	6174.3375	9581.334819
04/18/2018 00:35	108	206	160	40.3	29.0	0.02	6304.9778	9300.296553
04/19/2018 00:30	109	166	180	42.9	31.5	0.02	6103.8256	9538.039028
04/20/2018 00:35	110	164	150	44.4	30.9	0.02	5987.3779	9006.474436
04/21/2018 00:30	111	176	100	42.6	32.9	0.02	5721.2912	9099.778044
04/22/2018 00:30	112	208	120	46.5	30.6	0.02	5999.3185	8998.077548
04/23/2018 00:35	113	130	170	43.2	34.4	0.02	5806.4359	9194.752752
04/24/2018 00:30	114	204	150	43.3	34.8	0.02	5885.8068	8917.661201
04/25/2018 00:35	115	194	170	41.3	33.6	0.02	5683.5813	9028.21372
04/26/2018 00:35	116	162	120	45.1	31.9	0.02	5741.7415	8769.772085
04/27/2018 00:30	117	210	160	45.3	35.9	0.02	5565.6638	8884.575917
04/28/2018 00:30	118	178	170	44.8	36.8	0.02	5682.1333	8735.673097
04/29/2018 00:30	119	170	190	45.4	36.4	0.02	5611.8179	8933.983755
04/30/2018 00:30	120	206	180	43.5	36.3	0.02	5597.1817	8599.479073

Table A.5: Dataset of the reference WWTP for 5th month

Date	Day	TSS	CBOD5	TKN	NH3	Nitrates	Flow ST (GPM)	Flow NT (GPM)
05/01/2018 00:35	121	272	240	44.4	33.3	0.02	5473.1408	8831.856884
05/02/2018 00:35	122	252	180	44.2	33.7	0.02	5491.3427	8533.24213
05/03/2018 00:35	123	224	180	45.6	34.1	0.02	5342.458	8679.156108
05/04/2018 00:35	124	228	140	40.0	35.0	0.02	5491.3173	8517.648229
05/05/2018 00:30	125	208	170	40.8	33.9	0.02	5222.7057	8550.953053
05/06/2018 00:30	126	192	160	41.6	34.5	0.02	5406.2162	8377.007842
05/07/2018 00:35	127	238	180	37.7	34.9	0.02	5316.6111	8633.984099
05/08/2018 00:30	128	264	140	43.1	33.5	0.02	5368.8121	8401.234011
05/09/2018 00:30	129	196	120	44.1	33.8	0.02	5158.3205	8352.137846
05/10/2018 00:35	130	252	190	47.5	33.1	0.02	5171.4544	8143.509785
05/11/2018 00:35	131	220	160	49.5	35	0.02	5090.1735	8252.406125
05/12/2018 00:30	132	220	200	47.7	35	0.02	5154.1366	8150.794138
05/13/2018 00:30	133	208	200	47.3	34.6	0.02	5195.23	8472.933032
05/14/2018 00:30	134	232	220	49.1	35.4	0.02	6007.2861	9164.791299
05/15/2018 00:35	135	288	240	42.8	32.4	0.02	5800.4693	9234.239728
05/16/2018 00:30	136	156	150	40.4	29.6	0.02	5893.2687	9004.572331
05/17/2018 00:30	137	226	170	39.4	28.1	0.02	5720.2689	9139.947717
05/18/2018 00:35	138	164	210	40.9	29.6	0.02	5700.4444	8785.10624
05/19/2018 00:30	139	196	210	40	31.1	0.02	5693.5573	9105.856757
05/20/2018 00:20	140	200	170	39.4	31.9	0.02	6126.0041	9301.574586
05/21/2018 00:35	141	244	160	39.9	29.6	0.02	6744.4609	10330.55533
05/22/2018 00:30	142	176	190	37.3	28.2	0.02	7671.7204	11263.2466
05/23/2018 00:30	143	200	120	30.5	21.8	0.02	7137.6843	10999.43421
05/24/2018 00:30	144	204	120	32.5	22.4	0.02	7160.7832	10481.34074
05/25/2018 00:35	145	212	150	33.9	24.5	0.02	6685.0528	10815.4325
05/26/2018 00:30	146	178	140	33.2	23.4	0.02	7119.9335	10444.32019
05/27/2018 00:30	147	112	150	33.3	24.3	0.02	7372.457	11602.01951
05/28/2018 00:30	148	180	160	33.4	22.6	0.02	7795.8556	11030.13238
05/29/2018 00:35	149	290	150	35.6	22.2	0.02	7532.6904	11877.51922
05/30/2018 00:30	150	148	110	25.7	20.9	0.02	8908.7286	11866.7628
05/31/2018 00:35	151	180	99	31.4	20.2	0.02	7809.9357	12181.61088

Table A.6: Dataset of the reference WWTP for 6th month

Date	Day	TSS	CBOD5	TKN	NH3	Nitrates	Flow ST (GPM)	Flow NT (GPM)
06/01/2018 00:35	152	152	78	29.3	19.7	0.02	7532.7304	10884.72234
06/02/2018 00:30	153	272	81	30.3	21.6	0.02	6803.5815	11030.69555
06/03/2018 00:30	154	216	140	31.2	22.5	0.02	6861.6035	10115.62214
06/04/2018 00:35	155	240	150	34.2	23.7	0.02	6152.5156	10355.30238
06/05/2018 00:35	156	300	110	33.3	25.7	0.02	6353.1803	9721.404019
06/06/2018 00:35	157	196	110	35.1	24.8	0.02	5925.4264	10085.2205
06/07/2018 00:30	158	148	140	32.5	25	0.02	6239.8032	9581.155536
06/08/2018 00:30	159	164	130	33.4	25.4	0.02	5698.2687	9777.391703
06/09/2018 00:30	160	164	150	39.4	27.8	0.02	6057.475	9320.810647
06/10/2018 00:30	161	156	160	40.1	28.6	0.02	5630.078	9614.776432
06/11/2018 00:30	162	160	160	41.3	28.5	0.02	5900.0721	9173.25024
06/12/2018 00:35	163	224	190	40	29	0.02	5521.5398	9513.083982
06/13/2018 00:35	164	212	160	39.7	29.3	0.02	5970.7223	9255.664084
06/14/2018 00:30	165	188	140	37.1	26.5	0.02	5550.9254	9526.969983
06/15/2018 00:30	166	188	180	43.7	28.2	0.02	5829.9059	9075.525222
06/16/2018 00:30	167	196	180	39.8	31	0.02	5408.6247	9312.528691
06/17/2018 00:30	168	208	180	43.7	28.4	0.02	5563.2626	8763.006079
06/18/2018 00:35	169	196	240	44.9	29.9	0.02	5379.6101	9266.42741
06/19/2018 00:30	170	242	210	39.2	30.2	0.02	5878.4794	9143.535875
06/20/2018 00:30	171	183	160	41.6	28.9	0.02	5611.3159	9632.95398
06/21/2018 00:30	172	220	140	42	27.7	0.02	6018.0479	9307.969361
06/22/2018 00:35	173	198	200	39.5	28.1	0.02	5481.7921	9473.425907
06/23/2018 00:30	174	224	190	42.1	28.4	0.02	5580.0274	8815.776841
06/24/2018 00:30	175	180	150	47.8	28.6	0.02	5326.5507	9193.494246
06/25/2018 00:30	176	268	170	47.8	29.4	0.02	6138.4249	9363.320313
06/26/2018 00:35	177	224	200	44.7	28.9	0.03	6050.4933	10123.40758
06/27/2018 00:30	178	196	110	41.9	25.9	0.02	6193.349	9511.678603
06/28/2018 00:30	179	202	160	40.2	27.5	0.02	5838.5757	9838.471978
06/29/2018 00:30	180	232	160	30	28	0.02	6414.8258	9733.424702
06/30/2018 00:30	181	156	150	39.5	27.8	0.02	7076.7497	11170.67359

Table A.7: Dataset of the reference WWTP for 7th month

Date	Day	TSS	CBOD5	TKN	NH3	Nitrates	Flow ST (GPM)	Flow NT (GPM)
07/01/2018 00:30	182	172	120	37.5	25.2	0.02	7341.3432	10581.03274
07/02/2018 00:35	183	212	140	32.8	23.4	0.02	6513.0134	10686.17375
07/03/2018 00:30	184	128	98	31.9	23.4	0.02	6558.2799	10069.48754
07/04/2018 00:30	185	152	140	34.6	25.7	0.02	6228.7394	10482.91644
07/05/2018 00:30	186	148	120	36.8	25.5	0.02	6561.3432	10079.62334
07/06/2018 00:30	187	94	87	33	26.2	0.02	5962.1943	10323.16985
07/07/2018 00:30	188	208	69	33.1	25.9	0.02	6169.9862	9704.016059
07/08/2018 00:30	189	128	140	30.5	26.3	0.02	5731.9038	9978.630828
07/09/2018 00:30	190	164	120	36.4	26	0.02	5855.3442	9439.188832
07/10/2018 00:35	191	236	160	34.3	26.5	0.02	5399.5438	9734.424592
07/11/2018 00:30	192	172	120	38.3	29	0.02	5660.8281	9509.222293
07/12/2018 00:35	193	148	120	38.1	27	0.02	5351.4723	9633.763088
07/13/2018 00:30	194	154	120	36.8	28.7	0.02	5496.5926	9317.976458
07/14/2018 00:30	195	198	150	39.8	29	0.02	5299.1332	9582.296814
07/15/2018 00:30	196	162	130	39.4	28.8	0.02	5895.1449	9763.473511
07/16/2018 00:35	197	140	99	33.2	27.3	0.02	5638.1548	9994.147699
07/17/2018 00:30	198	162	120	38.9	27.6	0.02	5632.2646	9428.143929
07/18/2018 00:30	199	82	81	37	26.6	0.02	5630.9281	10031.02576
07/19/2018 00:35	200	200	140	38.4	26.5	0.02	5821.6217	9728.219462
07/20/2018 00:30	201	218	130	39.2	27.3	0.02	5789.816	10208.3488
07/21/2018 00:30	202	174	160	38.5	28.1	0.02	6729.0931	10754.74645
07/22/2018 00:30	203	156	88	35.3	26	0.02	5993.2027	10489.06069
07/23/2018 00:30	204	142	90	37	26.4	0.02	7201.4	11829.54573
07/24/2018 00:35	205	172	99	37.5	24	0.02	6546.0555	11182.03722
07/25/2018 00:30	206	162	110	33.9	23.2	0.02	7232.7193	11332.59923
07/26/2018 00:35	207	176	91	34.4	23.4	0.02	6766.1955	11438.10893
07/27/2018 00:35	208	122	65	34.5	22.7	0.02	6556.1224	10584.21008
07/28/2018 00:30	209	148	91	35	25.2	0.02	6051.3228	10574.33631
07/29/2018 00:30	210	80	81	35.2	26.1	0.02	6215.4491	10142.8563
07/30/2018 00:35	211	224	77	38.7	26.6	0.02	6166.599	10662.26113
07/31/2018 00:30	212	196	80	39.2	26.6	0.02	6689.1636	10648.43862

Table A.8: Dataset of the reference WWTP for 8th month

Date	Day	TSS	CBOD5	TKN	NH3	Nitrates	Flow ST (GPM)	Flow NT (GPM)
08/01/2018 00:30	213	140	100	31.1	25.8	0.02	6922.4636	11814.96779
08/02/2018 00:35	214	168	120	31.4	24.4	0.02	6300.7792	10356.53452
08/03/2018 00:30	215	152	130	28.2	22.8	0.02	6481.7756	11753.64719
08/04/2018 00:30	216	222	140	32	22.9	0.02	7218.8778	11456.98859
08/05/2018 00:30	217	94	80	32.4	23.4	0.02	6925.0865	11305.3451
08/06/2018 00:30	218	192	110	33.1	25.1	0.02	6345.3727	10750.97455
08/07/2018 00:35	219	102	84	30.1	22.5	0.02	6274.5482	11096.52354
08/08/2018 00:35	220	140	100	34.1	23.4	0.02	6531.6154	10668.9377
08/09/2018 00:35	221	134	70	34.7	23.4	0.03	6114.5365	10366.47823
08/10/2018 00:35	222	136	92	33.9	25	0.02	4889.5306	8961.078856
08/11/2018 00:30	223	144	100	34.8	25.7	0.02	8564.548	13291.6318
08/12/2018 00:30	224	118	93	33	25.8	0.02	8963.2654	13439.13145
08/13/2018 00:30	225	42	37	23.8	18.9	0.02	10277.458	15468.50933
08/14/2018 00:35	226	88	46	24.9	15.4	0.02	10699.783	15079.87049
08/15/2018 00:35	227	120	35	25.7	17.6	0.02	8131.7302	13568.402
08/16/2018 00:35	228	130	42	31.1	19.1	0.02	7528.4084	11925.17943
08/17/2018 00:30	229	86	76	30.8	21	0.02	6864.754	11396.49683
08/18/2018 00:30	230	134	110	31.2	21.3	0.02	7625.4643	12493.63621
08/19/2018 00:30	231	138	48	31.1	21.2	0.02	7103.4597	11007.02849
08/20/2018 00:30	232	138	67	31.7	21.6	0.02	6096.1747	10542.98182
08/21/2018 00:30	233	466	100	68.4	19.7	0.02	6914.5938	11629.34899
08/22/2018 00:30	234	130	67	35.3	23.3	0.02	6096.1743	9906.574753
08/23/2018 00:30	235	162	57	33.2	24.9	0.02	6786.06	11227.45143
08/24/2018 00:30	236	198	72	37.3	23.4	0.02	7148.0532	11351.74963
08/25/2018 00:30	237	142	83	34	22.8	0.02	9881.3636	14821.33004
08/26/2018 00:30	238	138	77	31.2	21.3	0.02	8207.801	13493.82268
08/27/2018 00:35	239	116	33	23.8	14.3	0.02	7630.7108	12462.14774
08/28/2018 00:30	240	112	40	27.3	15.6	0.02	17210.414	21492.00506
08/29/2018 00:30	241	91	94	27.6	17.5	0.02	16751.364	21193.68911
08/30/2018 00:35	242	230	56	20.5	10.1	0.02	12979.291	17636.27198
08/31/2018 00:35	243	78	40	18.5	10.3	0.02	14196.428	20245.70704

Table A.9: Dataset of the reference WWTP for 9th month

Date	Day	TSS	CBOD5	TKN	NH3	Nitrates	Flow ST (GPM)	Flow NT (GPM)
09/01/2018 00:30	244	92	34	17.5	12	0.02	10350.905	15047.55285
09/02/2018 00:35	245	77	29	17	10.5	0.02	8252.3945	14086.31206
09/03/2018 00:30	246	60	38	22.2	13.5	0.02	9364.6056	13091.92578
09/04/2018 00:35	247	102	39	22.6	15.3	0.02	8509.4617	13979.4151
09/05/2018 00:30	248	107	37	24.7	15.8	0.02	11804.125	17357.01495
09/06/2018 00:35	249	98	55	25.5	16	0.02	9863.0018	15618.49581
09/07/2018 00:30	250	84	56	23.4	15.5	0.02	8525.201	12985.02949
09/08/2018 00:30	251	104	77	26	17.8	0.02	12103.162	18075.45887
09/09/2018 00:30	252	38	57	24	15.7	0.02	12027.091	15031.80861
09/10/2018 00:35	253	74	49	23.9	14.6	0.02	7132.314	12440.60265
09/11/2018 00:30	254	77	56	22.9	16.4	0.02	8236.6559	12279.84362
09/12/2018 00:30	255	47	25	22.8	18.2	0.02	7347.4116	12484.52134
09/13/2018 00:35	256	132	93	27.7	19.3	0.02	7562.5092	11650.06558
09/14/2018 00:30	257	35	38	26.4	19.9	0.02	6964.4335	11197.61964
09/15/2018 00:30	258	140	80	31.5	18.9	0.02	8011.0656	11306.17393
09/16/2018 00:30	259	33	77	26.5	21.5	0.02	5537.4458	9962.094492
09/17/2018 00:30	260	39	65	29.2	21.6	0.02	6943.4484	11176.90338
09/18/2018 00:35	261	192	150	36.1	21	0.02	7439.2219	12574.84489
09/19/2018 00:30	262	128	110	35.3	23.2	0.02	6038.4654	10291.89958
09/20/2018 00:35	263	142	110	33.9	15.2	0.02	7318.5566	12334.53419
09/21/2018 00:35	264	190	110	34.4	21.9	0.02	6890.9857	10483.31857
09/22/2018 00:30	265	258	120	33.2	21.2	1.49	5975.51	10875.27275
09/23/2018 00:35	266	156	100	33.9	21.2	0.02	9587.5727	13776.39439
09/24/2018 00:35	267	176	140	34	22.2	0.02	9351.4899	14646.48313
09/25/2018 00:30	268	128	87	28.1	18.8	0.02	10062.361	14141.83246
09/26/2018 00:30	269	114	67	26.1	17.7	0.02	8430.7677	13563.43097
09/27/2018 00:30	270	104	66	29.8	18.1	0.02	7976.9648	12362.70865
09/28/2018 00:35	271	86	90	32.1	19.5	0.02	5836.4838	10122.02501
09/29/2018 00:30	272	148	100	29.3	21.2	0.02	6885.7392	10468.40284
09/30/2018 00:30	273	130	84	31.5	21.3	0.02	7019.5191	10651.53546

Table A.10: Dataset of the reference WWTP for 10th month

Date	Day	TSS	CBOD5	TKN	NH3	Nitrates	Flow ST (GPM)	Flow NT (GPM)
10/01/2018 00:30	274	176	98	35.6	22.1	0.02	7468.0762	11587.08798
10/02/2018 00:35	275	172	110	35.2	23.6	0.02	7549.3935	12444.74583
10/03/2018 00:35	276	158	110	32.5	22.9	0.02	5403.6659	7999.009556
10/04/2018 00:35	277	168	100	33.8	24.4	0.02	6159.1301	11418.04192
10/05/2018 00:30	278	168	92	36.1	24	0.02	6308.6487	10113.73831
10/06/2018 00:30	279	188	97	37.9	24.2	0.02	4577.3771	8675.192793
10/07/2018 00:30	280	188	88	35	24.2	0.02	5555.808	8691.765865
10/08/2018 00:35	281	210	140	36.3	24.9	0.02	5681.7187	10629.16219
10/09/2018 00:35	282	176	120	40.2	25.4	0.02	6890.9857	10891.01732
10/10/2018 00:35	283	62	71	39.6	25.3	0.02	6332.2571	11730.44509
10/11/2018 00:35	284	162	96	34.1	22.9	0.02	6623.4254	10369.79291
10/12/2018 00:40	285	158	91	32.1	27.3	0.02	5157.0911	9726.75648
10/13/2018 00:30	286	154	86	34	25.2	0.02	5805.006	9788.905581
10/14/2018 00:30	287	190	120	35.2	24.6	0.02	3719.6106	7852.337758
10/15/2018 00:30	288	164	120	36.3	27.6	0.02	3719.6106	3719.610638
10/16/2018 00:35	289	198	160	41.7	27.1	0.02	3719.6106	3719.610638
10/17/2018 00:35	290	158	140	39.7	27.8	0.02	3719.6106	7852.337758
10/18/2018 00:35	291	140	120	37.9	27.6	0.02	3719.6106	7852.337758
10/19/2018 00:35	292	156	130	40.9	29	0.02	3719.6106	7852.337758
10/20/2018 00:30	293	192	130	45.3	29.9	0.02	3719.6106	7852.337758
10/21/2018 00:30	294	198	150	46.1	29.4	0.02	3719.6106	7852.337758
10/22/2018 00:35	295	190	130	42.5	29.6	0.02	3719.6106	7852.337758
10/23/2018 00:35	296	174	130	44	30	0.02	3719.6106	7852.337758
10/24/2018 00:30	297	176	120	45	29.2	0.02	3719.6106	7852.337758
10/25/2018 00:35	298	206	190	40	29.7	0.02	3719.6106	7852.337758
10/26/2018 00:35	299	132	140	42.4	28.9	0.02	3719.6106	7852.337758
10/27/2018 00:30	300	202	140	42.9	30.6	0.02	4981.3406	9602.457947
10/28/2018 00:30	301	176	150	43.8	30	0.02	6626.0484	11284.62818
10/29/2018 00:30	302	252	180	47.3	28	0.02	6626.0484	11284.62818
10/30/2018 00:35	303	226	170	46.9	30.1	0.02	6626.0484	11284.62818
10/31/2018 00:30	304	184	150	43.3	30.6	0.02	6626.0484	11284.62818

Table A.11: Dataset of the reference WWTP for 11th month

Date	Day	TSS	CBOD5	TKN	NH3	Nitrates	Flow ST (GPM)	Flow NT (GPM)
11/01/2018 00:30	305	224	160	42.3	29.5	0.02	6626.0484	11284.6282
11/02/2018 00:30	306	204	120	46.7	29.3	0.02	6626.0484	11284.6282
11/03/2018 00:30	307	234	150	47.9	30.4	0.02	6626.0484	11284.6282
11/04/2018 00:30	308	184	160	38.2	28.1	0.02	6626.0484	11284.6282
11/05/2018 00:35	309	172	170	64.8	28.9	0.02	6626.0484	11284.6282
11/06/2018 00:30	310	194	160	41.6	30.3	0.02	6626.0484	11284.6282
11/07/2018 00:30	311	340	140	41.8	30.1	0.02	6626.0484	11284.6282
11/08/2018 00:40	312	200	150	47.4	28.3	0.02	6626.0484	11284.6282
11/09/2018 00:35	313	180	180	46.3	32	0.02	6626.0484	11284.6282
11/10/2018 00:30	314	204	170	44	30.9	0.02	6626.0484	11284.6282
11/11/2018 00:30	315	187	190	44.6	30.3	0.02	6626.0484	11284.6282
11/12/2018 00:30	316	137	190	41.5	29.1	0.02	6626.0484	11284.6282
11/13/2018 00:35	317	177	190	48.1	31	0.02	6626.0484	11284.6282
11/14/2018 00:30	318	187	150	47.9	31.3	0.02	6626.0484	11284.6282
11/15/2018 00:35	319	256	210	53.5	31.5	0.02	6206.3462	10354.0483
11/16/2018 00:30	320	150	160	45.6	31.2	0.02	6177.4919	10144.3986
11/17/2018 00:30	321	220	180	49	31.4	0.02	4278.3393	7599.59817
11/18/2018 00:30	322	308	150	48.2	32	0.02	5967.6405	10607.6171
11/19/2018 00:30	323	352	210	49.2	32.9	0.02	5582.0392	9884.20082
11/20/2018 00:30	324	264	240	58.8	32	0.02	6198.4771	10358.1915
11/21/2018 00:30	325	80	130	34.3	29.6	0.12	5621.3862	9111.06533
11/22/2018 00:30	326	208	150	46	33.4	0.02	4860.6762	8389.30673
11/23/2018 00:30	327	120	180	44.6	34.3	0.02	5398.4195	8969.36556
11/24/2018 00:30	328	263	220	56.7	38.2	0.02	5241.0313	9644.71963
11/25/2018 00:30	329	347	210	48.1	37.2	0.02	3625.1777	6637.52953
11/26/2018 00:35	330	300	220	46.4	36.2	0.02	5246.2775	9875.91412
11/27/2018 00:30	331	200	160	44.2	34.8	0.02	4792.4745	8617.18688
11/28/2018 00:35	332	236	140	46.4	33	0.02	6324.3876	10687.9966
11/29/2018 00:30	333	216	150	49.7	32.5	0.02	5909.9317	9056.3741
11/30/2018 00:30	334	250	160	47.6	35.8	0.02	5823.3678	9000.85436

Table A.12: Dataset of the reference WWTP for 12th month

Date	Day	TSS	CBOD5	TKN	NH3	Nitrates	Flow ST (GPM)	Flow NT (GPM)
12/01/2018 00:30	366	176	140	38.1	26.2	0.02	8826.8614	8832.637469
12/02/2018 00:30	367	187	120	43.9	27.1	0.02	9398.7061	8531.006508
12/03/2018 00:30	368	188	130	39.2	26.7	0.02	8737.675	8989.252978
12/04/2018 00:35	369	78	160	38.7	27.1	0.02	7200.5159	9930.60569
12/05/2018 00:35	370	208	180	40.4	26.4	0.02	6825.4073	11359.2075
12/06/2018 00:31	371	148	100	35.6	24.2	0.02	6953.9411	9936.406215
12/07/2018 00:31	372	190	140	39.7	25.8	0.02	7384.136	11336.8339
12/08/2018 00:31	373	207	170	38.5	25.6	0.02	6552.6009	8006.467753
12/09/2018 00:36	374	157	140	37.3	26.7	0.02	8310.1037	12305.5319
12/10/2018 00:36	375	208	220	53.1	26.8	0.02	7082.4746	10178.37359
12/11/2018 00:32	376	122	140	42.3	28.5	0.02	5073.1502	8003.981908
12/12/2018 00:32	377	187	120	40.2	27.8	0.02	6208.9695	8887.328704
12/13/2018 00:32	378	247	140	41.9	28.4	0.02	5823.3678	9362.147914
12/14/2018 00:37	379	200	150	42.8	27.8	0.02	5823.3678	9362.147914
12/15/2018 00:37	380	240	190	44.2	28.6	0.02	5823.3678	9362.147914
12/16/2018 00:31	381	87	110	36.7	25.1	0.09	6014.857	9662.949708
12/17/2018 00:31	382	224	110	44	29.3	0.02	6555.2238	12214.37984
12/18/2018 00:31	383	124	95	43	31	0.02	5440.3899	8711.653617
12/19/2018 00:36	384	204	130	44.8	30.8	0.02	4949.8629	9255.251288
12/20/2018 00:36	385	140	120	42.9	31.3	0.02	6035.8422	9354.690048
12/21/2018 00:37	386	192	130	41.9	28.2	0.02	6114.5362	11365.00769
12/22/2018 00:38	387	192	190	42.5	28.8	0.02	6203.7233	9449.156788
12/23/2018 00:39	388	177	190	43.8	29.3	0.02	6998.5343	11381.58076
12/24/2018 00:40	389	216	190	41.9	29.8	0.02	8121.2378	12785.32346
12/25/2018 00:41	390	93	140	34.1	26.8	0.02	6397.8354	10926.64931
12/26/2018 00:42	391	180	150	37.6	26.3	0.02	6274.5478	9887.515505
12/27/2018 00:43	392	176	120	41.5	28	0.02	11591.65	15171.85105
12/28/2018 00:44	393	220	170	38.6	25.3	0.02	8769.1529	13022.31881
12/29/2018 00:45	394	133	110	28.5	18.9	0.02	7339.5424	11178.56039
12/30/2018 00:46	395	77	91	29.7	21.6	0.02	7052.3087	10723.21435
12/31/2018 00:47	396	224	190	49.4	33.7	0.02	5631.8788	10650.70728

RESUME

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EXPERIENCE:

I contracted in 2005 in Al-Ikhaa State Company for Mechanical Industries which affiliated with the Ministry of Industry.

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