T. R.
VAN YUZUNCU YIL UNIVERSITY
INSTITUTE OF NATURAL AND APPLIED SCIENCES
DEPARTMENT OF ENVIRONMENTAL ENGINEERING

EVALUATION OF THE ENVIRONMENTAL PERFORMANCE OF SMALL SIZE WASTEWATER TREATMENT PLANT

M.Sc. THESIS

PREPARED BY: Nawzad Hussein MUSTAFA
SUPERVISOR: Assoc. Prof. Dr. Zehra ŞAPCI AYAS
Co-SUPERVISOR: Assist. Prof. Dr. Nashwan Shawkat MAHMOOD

VAN-2021

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ACCEPTANCE and APPROVAL PAGE

This thesis entitled "**Evaluation of the Environmental Performance of Small Size Wastewater Treatment Plant** " presented by Nawzad Hussein MUSTAFA under supervision of Assoc. Prof. Dr. Zehra ŞAPCI AYAS in the department of Envirionmental Engineering and second supervison Assist. Prof. Dr. Nashwan Shawkat MAHMOOD has been accepted as an M.Sc./~~Ph.D.~~ thesis according to Legislations of Graduate Higher Education on 25/08/2021 with unanimity/ majority of votes members of jury.

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This thesis has been approved by the committee of The Institute of Natural and Applied Science on ..../........../........... with decision number ....

Signature

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Director of Institute

THESIS STATEMENT

All information presented in the thesis was obtained in the frame of ethical behavior and academic rules. In addition, all kinds of information that does not belong to me have been cited appropriately in the thesis prepared by the thesis writing rules.

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ABSTRACT

EVALUATION OF THE ENVIRONMENTAL PERFORMANCE OF SMALL SIZE WASTEWATER TREATMENT PLANT

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MSc. Thesis Environmental Engineering
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The demand for water used in various areas such as homes, factories, industries and agricultural activities is increasing. In order to meet this demand, both clean water resources and wastewater management need to be carefully planned. On the other hand, an unprepared for population increases may occur in unplanned situations, such as in Duhok governorate, whose population has increased due to the increase of inland or out-of-country immigrants. Unpredictable population growth causes both an increase in water demand and an increase in the amount of wastewater. Proper operation of wastewater treatment plants is important for reasons such as protecting the ecosystem and supporting the development of the socio-economic structure with the use of treated water.

The performance of a wastewater treatment plant (WWTP) is evaluated by examining the change in the physico-chemical and bio-chemical properties of wastewater. The presence, working principle and operating mode of each unit in the WWTP affect the effluent quality. For this reason, while evaluating the efficiency of the WWTP, it is necessary to evaluate the units of the WWTP. In the quality evaluation of the treated water from the WWTP, the suitability of the treated water for the sector in which it is intended to be used should be evaluated. This thesis contains suggestions that will help to determine the current situation in small-sized wastewater treatment plants and increase treatment efficiency for reuse.

Keywords: Wastewater treatment plant, IDP camps, Refugee camps, Duhok governorate

ÖZET

KÜÇÜK BOYUTLU ATIKSU ARITMA TESİSİ ÇEVRESEL PERFORMANSININ DEĞERLENDİRİLMESİ

MUSTAFA, Nawzad Hussein
Yüksek Lisans Tezi, Cevre Mühendisliği Anabilim Dalı
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Evler, fabrikalar, sanayi ve tarımsal faaliyetler gibi çeşitli alanlarda kullanılan suyun talebi artmaktadır. Bu talebin karşılanması için hem temiz su kaynaklarının hem de atıksu yönetiminin dikkatlice planlanması gerekmektedir. Öte yandan, hazırlıksız nufüs artışınının olması örneğin ülke içi veya ülke dışından göç edenlerin çoğalmasıyla nüfusu artan Duhok valiliğinde olduğu gibi planlanmayan durumlarda olabilmektedir. Öngörülemeyen nufüs artışı hem su ihtiyacının artmasına hem de atıksu miktarınında artmasına neden olmaktadır. Ekosistemin korunması, arıtılmış suyun kullanılmasıyla sosyoekonomik yapının gelişimine destek olması gibi nedenlerden dolayı atıksu arıtma tesislerinin uygun şekilde işletilmesi önemlidir.

Bir atıksu arıtma tesisinin (AAT) performansı, atıksuyun fiziko-kimyasal ve biyo-kimyasal özelliklerindeki değişimi incelenerek değerlendirilir. AAT deki her ünitenin varlığı, çalışma prensibi ve işletme biçimi çıkış suyu kalitesini etkilemektedir. Bu nedenle AAT verimliliği değerlendirilirken, AAT'nin sahip olduğu üniteleri de değerlendirmek gerekir. AAT'den çıkan arıtılmış suyun kalite değerlendirilmesinde ise arıtılmış suyun kullanılması düşünülen sektöre uygunluğunun değerlendirilmesi gerekir. Bu tez, küçük boyutlu atıksu arıtma tesislerindeki mevcut durumun tespiti, tekrar kullanım için arıtma verimliliğinin artırılmasına yardımcı olacak önerileri içermektedir.

Anahtar Kelimeler: Atıksu arıtma tesisi, Ülke içinde yerinden edilenlerin kampları, Mülteci kampları, Duhok valiliği.

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I must end this by thanking my mother, wife, and entire family and friends for their strong and encouraging support during the last few years. It would have been too hard for me to finish my education without them all.

My best respect and regards for all

2021
Nawzad Hussein MUSTAFA

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SYMBOLS AND ABBREVIATIONS

Some symbols and abbreviations used in this study are presented below, along with their descriptions.

Symbols	**Description**
µS/cm	Electrical Conductivity Unit
°C	Temperature Measurement Unit
Ca	Calcium
Cl	Chloride
Cr	Chromium
Cu	Copper
EC	Electrical conductivity
Fe	Iron
Mg	Magnesium
mg/L	Waste Water Parameters Unit
Mn	Manganese
N	Nitrogen
NH	Nitrate
Ni	Nickel
NTU	Nephelometric Turbidity Unit
P	Phosphorus
pH	logarithmic Hydrogen ion
Pb	Lead
S	Samples Label
TU	Turbidity
Zn	Zinc

Abbreviations	**Description**
APHA	American Public Health Association
APHA	American Water Works Association
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
FSS	Fixed suspended solids
FDS	Fixed dissolved solids

Abbreviations	Description
MOE	Ministry of Environment Iraq
SS	Suspended solids
TR	Turkish Republic
TDS	Total dissolved solids
TFS	Total fixed solids
TSS	Total suspended solids
TS	Total solids
TVS	Total volatile solids
VSS	Volatile suspended solids
UN	United Nations
WHO	World Health Organization

1. INTRODUCTION

1.1 General

Water demand in the daily life cycle in houses, factories, industrial areas, irrigations, and other places leads us to think more carefully about wastewater and its management. But, on the other hand, many refugees and IDPs immigrating to the Duhok governorate increase and make another source for wastewater pollution, leading to more discharge without adequate treatment.

Many new tools and methods have emerged for researching wastewater properties, which have resulted in a significant expansion of scientific knowledge. However, treatment methods are created to decline and break down over time, mainly due to environmental and health issues linked to recent research discoveries. However, there is still a significant gap between better constituent identification capability and treatment advancement concerning advancements in treatment technology effectiveness. Available treatment technologies cannot identify pollutants in lower quantities than may be achieved. It means that bypassing the time, and it becomes more critical to carefully examine the health and environmental implications of wastewater treatment; for that reason, public anxiety around these consequences increases in an equal measure. To ensure that community health and ecological issues are addressed, it is imperative to initiate a dialogue with them (Metcalf & Eddy, 2004).

Wastewater treatment can be defined as a process used to remove contaminants from wastewater or sewage and convert it to effluent that will be returned to the water cycle to minimize the impact on the environment and reused for various purposes. Kordrostami (2015) clarified that wastewater treatment takes place in different infrastructural structures known as wastewater treatment plants. Each project begins with the local authority, the general public, legal counsel, or the owner identifying an issue. The design expert becomes involved in the problem-solving activity throughout the concept development and evaluation phase. Following that, the design expert or firm is usually actively engaged in all aspects of the project, typically through the conclusion of the first year of operation (Federation & Water Environment Federation, 2009).

As stated in Grigg (2012), the wastewater systems gather, transport, treat, and dispose of water sources used by household, industrial, commercial, and public users. They are exact replicas of water supply facilities. He also mentions three categories of wastewater treatment: physical, chemical, and biological. The following are some examples:

1) Operations of the physical unit (screening, mixing, flocculation, sedimentation, flotation, filtration, and gas transfer)
2) Processing of the chemical unit (precipitation, adsorption, and disinfection)
3) Processes for biological units (various biological processes, such as activated sludge, trickling filter, and stabilization pond).

Zaher (1998) listed the following to represent the content of domestic wastewater:

1. Organic materials, as determined by the oxygen demand (BOD/COD),
2. Suspended solids (SS),
3. Heavy metals,
4. Pathogenic organism,
5. Nitrogen (N),
6. Phosphorus (P).

1.2. Small Wastewater Treatment Plant

Population expansion, industrialization, and urbanization all put extra stress on the environment, and the state of our world has worsened since 1900 as a result. In this setting, wastewater treatment has become one of the most critical environmental challenges since it minimizes natural water resources such as inland surface waters, groundwater, and transitional water. However, wastewater treatment has numerous processes with new environmental implications, which include energy consumption, usage of chemical reagents, sludge generation, and environmental emissions. So, environmental analysis is important to measure the overall pollution linked with these operations. The same report has also mentioned that the Life Cycle Assessment (LCA) of wastewater treatment plants has proven to be a helpful method in evaluating the environmental performance of these facilities (Flores-Alsina et al., 2010).

The European Union (EU) has published new and stricter rules for nitrogen removal in wastewater treatment in the past decade. So far, the summer nitrogen supply standard of 20 mg/L has only been introducing. The new European Directive (ED) requires an annual consumption of 10 mg N/L for large WWTP with more than 20000 population equivalent (P.E.) and 15 mg N/L for smaller WWTP (Fikar, 2001). In smaller systems, one basin is used, oxygen is supplied from the surface turbine during aeration (Fikar, 2001).

Grigg (2012) stated that most of the nation's wastewater treatment plants are small, with capacities of less than 1 million gallons per day (mg/d). Smaller wastewater systems may use packaged treatment plants or on-site solutions, most commonly septic tanks. Packaged plants are available in capacities up to 1.0 mg/d. However, the majority are in the 0.01–0.25 mg/d range. Extended aeration, contact stabilization, sequencing batch reactors, rotating biological contactors, and physical/chemical contractors are the most popular types. While they are not trouble-free, they can provide satisfactory performance for small flows.

To protect the aquatic environment, wastewater treatment is primarily concerned with removing pollutants from the wastewater. To be considered, the selected alternative must meet current regulatory criteria and reduce the environmental impact on the receiving water body (Gernaey et al., 2004).

Akin et al. (1989) conducted the crucial aspects in wastewater treatment and advantages as shown below:

1- *Wastewater as a potentially valuable resource:* Wastewater can be used as a substitute for fresh water in irrigation and aquaculture, and it has an essential function in water resource management. By releasing freshwater sources for potable water supply and other high-priority applications, wastewater reuse helps conserve water while also having a specific economic advantage.

2- *Control the surrounding environment:* On surface and groundwater, pollution concerns might occur because untreated or partially treated effluent is discharged into the environment. Using treated wastewater in irrigation or aquaculture, instead of depleting freshwater supplies, minimizes pollution in the environment, hence treated wastewater usage partly offsets the cost of the irrigation or aquaculture project.

3- *Chemical pollutants:* Where untreated industrial wastewater is allowed to enter the sewage system, it is probable that chemical contaminants will be found in municipal wastewater. The most important to pay attention to are harmful to humans, plants, and aquatic biota. Fears exist that toxins or salinity could get lodged in the soil as a result of wastewater irrigation. Finally, the biggest issue with discharging wastewater into the environment is ensuring that no toxic chemical contaminants are present in the wastewater treated before the discharge.

4- *Economic considerations:* One of several requirements for wastewater reuse is making sure wastewater is collected. Whether wastewater is reused or not, wastewater collection is always required, and this expense should not be factored into any reuse projects or wastewater charges for those who use it. All wastewater treatment costs that would not have been needed for pollution control purposes may be billed to the reuse project. Planning from the outset to consider reuse factors will allow for both economically and environmentally sustainable solutions.

5- *Institutional considerations:* Whenever it is not possible to secure the services of a single agency to act as the scheme for wastewater reuse, local procedures must be developed for cooperation and coordination between the agencies. It is vital for the seamless operation of the various agencies involved. Still, it is especially critical to implement efficient health-protection measures to have complete cooperation among them.

6- *Aspects of a sociocultural nature:* Important socio-cultural and religious issues may influence the viability and acceptance of a wastewater reuse program. For example, in some parts of Asia, such as China, raw excrement in agriculture is firmly ingrained and widely accepted as a cultural norm. Pretreatment may not be considered required in some areas of Asia. On the other hand, religious and cultural beliefs and national laws may restrict contact with human feces in some nations. The scientific group highlights the importance of considering social and cultural elements while developing wastewater reuse and recycling plans. This will frequently necessitate the involvement of experienced social scientists who know about the specific culture in question.

1.3. Problem Statement

Wastewater effluent has many materials and metals polluting that come from the daily use of water that directly or indirectly affects the environment, and through the daily supervision of the WWTP and required tests for the effluent, we can judge and then control the performance of the stations, and from the required tests for effluent, like the number of COD, BOD and the heavy metal concentrations, we can image what we need to reduce the effects on the environment. Thus, this study aims at reducing the effect of effluent on the environment by upgrading the performance of WWTP and enhancing the stakeholder the risk of untreated wastewater.

1.4. Study Area

This study will be conducted in the Duhok governorate as the scope of work. This location is in the north of Iraq under Latitude 36.8, Longitude 43, and it is rounded by three countries (Turkey, Syria, and Iran). Moreover, this city is essential due to its economic and commercial value to the region, e.g., agricultural and tourism activities (Abdullah et al., 2019), as shown in Figure 1.1 and Figure 1.2, respectively.

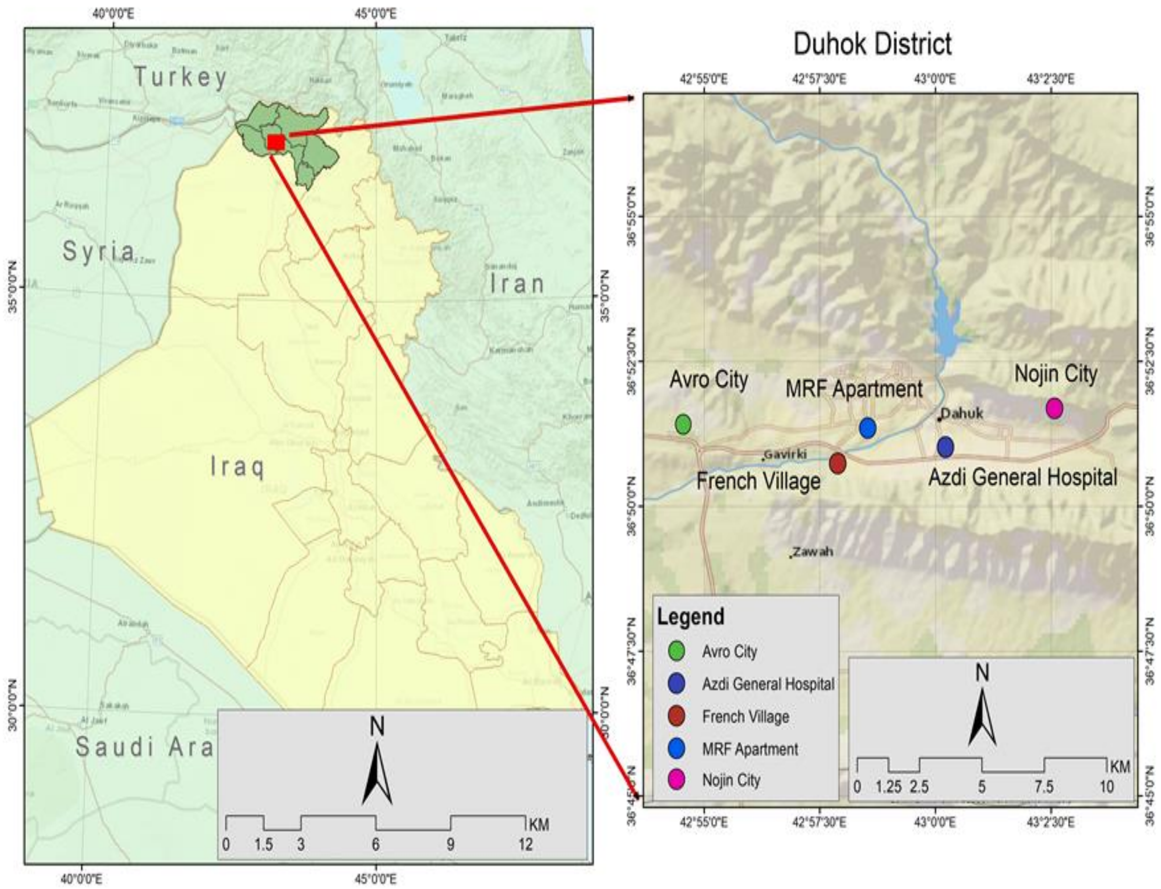

Figure 1.1 Map of Iraq, locations of Duhok district stations.

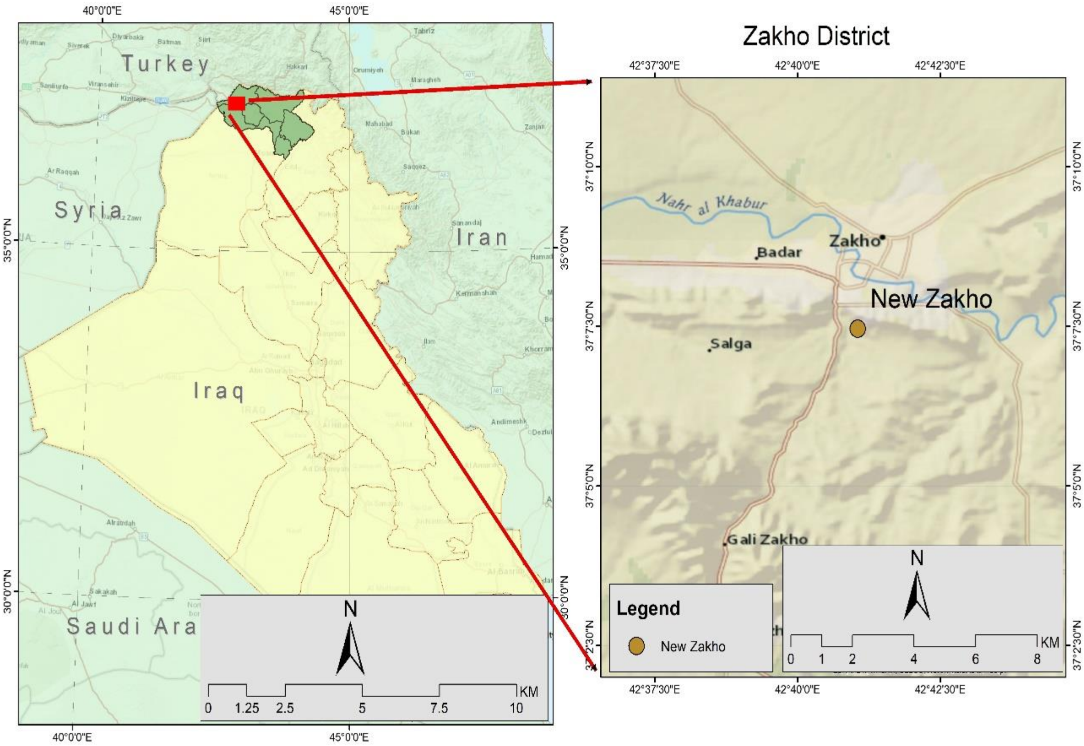

Figure 1.2 Map of Iraq, location of Zakho district stations.

1.5. Objectives of The Study

The objectives of the proposed work are the following:

1. To collect the existing wastewater treatment plant data from the Directorate of Environment in Duhok, showing the BOD, COD, TSS, pH, color, and other wastewater characterization parameters.
2. To evaluate the operation of the wastewater treatment plant and suggest ways to improve its management.
3. To observe the existing wastewater treatment plants, clarify each type, and determine their efficiency regarding the catchment area.
4. To investigate how it affected small-sized wastewater treatment plant management during the pandemic period.
5. The impact of management on the development of the wastewater treatment plant performance.

1.6 .Novelty of The Work

Evaluation of environmental management of Small-Sized Wastewater Treatment (WWTP) plants in Duhok governorate has not been documented yet. In addition, there are no more data regarding the existing wastewater treatment plants, and assessing to improve the stages of the plants and document all working details. In the Duhok governorate, this research has been carried out with six stations.

1.7. Structure of The Thesis

This thesis comprises five chapters. The first chapter serves as a background of the study, problem statement, objectives of the study, scope, the novelty of the work, and the thesis structure.

Chapter two provides an introduction, detailed literature review, and theoretical background on characteristics of wastewater treatment plant units, including preliminary, primary treatment, secondary treatment, tertiary (disinfection) treatment, storage, produced sludge, management, and wastewater treatment plant efficiency. The last section of the chapter discusses the summary of the whole chapter.

Chapter three consists of an introduction and methodology of the work, wastewater sampling, site description, sampling process for wastewater, and analytical methods.

Chapter four consists of an introduction in the first part, characteristics of wastewater, the performance of wastewater package unit, statistical analysis, and evaluation of wastewater treatment plant.

In chapter five, the conclusions and recommendations for future work are put forward.

2. LITERATURE REVIEW

2.1. Introduction

Many sections of the world, both industrialized and developing countries, are becoming increasingly interested in wastewater reuse (Eriksson et al., 2002). A water shortage, whether by little rainfall associated with increased evaporation in Australia or by an excessive demand for freshwater from the population, is one of the factors contributing to global warming (e.g., Japan). However, environmental and economic reasons are the primary motivators for reusing wastewater in several world areas. The total cost of wastewater handling is decreased by reducing the amount of water that needs to be treated at the treatment plants.

In a wastewater treatment facility, the number and complexity of unit processes and, in turn, unit operations are determined by the legal and operational requirements of the treated water, the nature and degree of contamination of the incoming raw water, and the amount of water to be processed. This means that while wastewater treatment facilities differ in design and operation, they are all based on overlapping and even identical unit processes (Nicholas, 2002).

Urbanization and industrial expansion steadily increase water consumption and discharge wastewater and toxins into the environment (Zhou et al., 2019). High volumes of wastewater-carrying pollutants enter the environment with the potential to contaminate and destroy wildlife habitats. WWTPs are constructed to handle this possible problem with wastewater treatment with the development of urbanization worldwide. New wastewater treatment plants are rapidly being built in China, expanding from 1018 plants in 2008 to 2209 plants in 2017. The annual treatment capacity of WWTPs in China has grown from 2.56 × 1010 m^3 (70.2%) to 4.65 × 1010 m^3 (94.5 %).

Mizzouri et al. (2020) stated that the Duhok municipal sewer system currently serves just a limited area of Duhok city. The wastewater disposed of in the Hishkarow river finally drains into Mosul Lake. Only 15% of the sewage pipe network was installed, and the sewerage network system is no longer in other areas. Thus, wastewater will continue to flow throughout the city. The old and traditional buildings in Duhok city are equipped with a septic tank, and human excreta is emptied by a special vacuum truck into the tank before being discharged to the surrounding land. Duhok does not have a human waste collection system now, except for Azadi General Hospital. They have a small WWTP and two in IDP camps, Sharia IDP camp and Kaperto 2 IDP camp, and only some residential complexes projects have their wastewater treatment plants as a package. According to the Directorate of Environment in Duhok Governorate, more than 50 residential projects have been completed or are in ongoing stages. See Figures 1.1, 1.2, and 2.1, respectively.

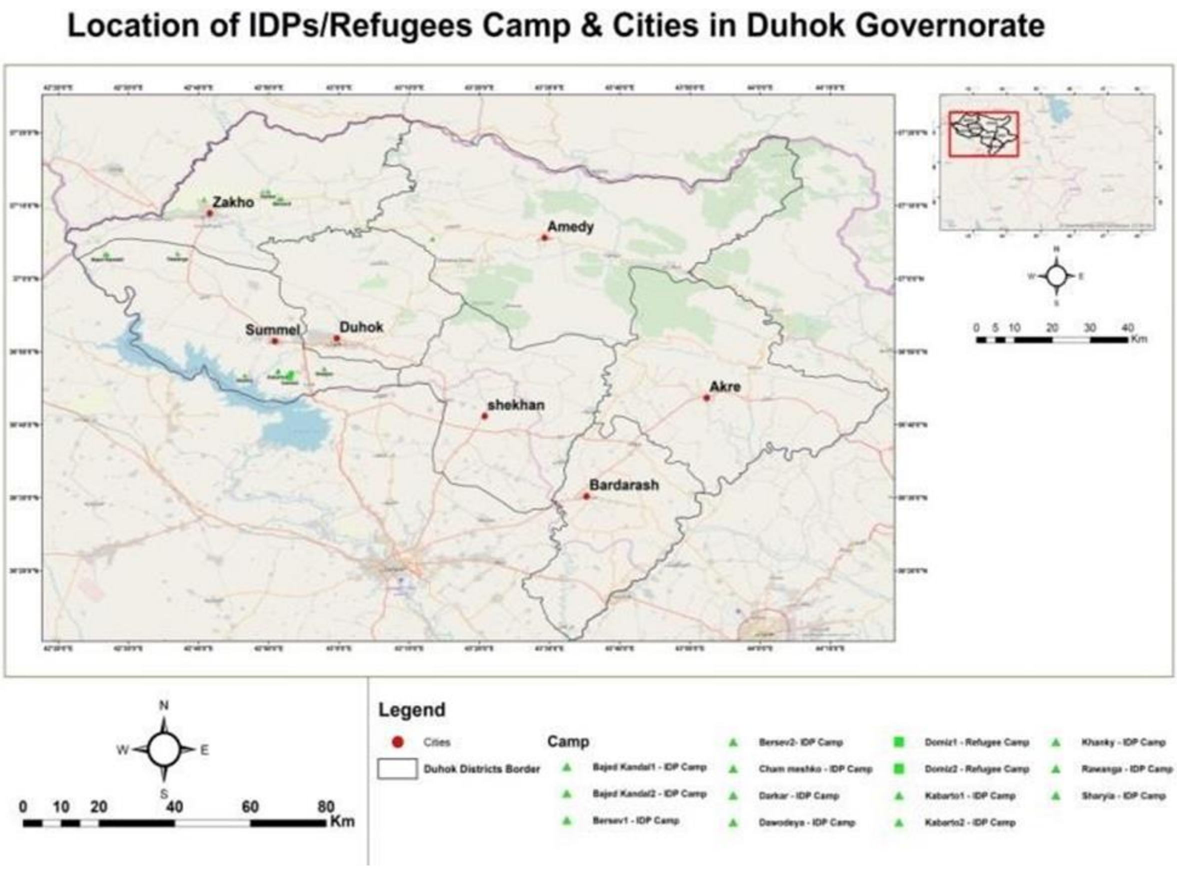

Figure 2.1 Camps Locations (Mizzouri et al., 2020)

2.2 .Wastewater Characteristics

The wastewater treatment plant is the most significant requirement for environmental and social society and can be classified according to the number of people in the wastewater catchment area. An actual mechanism must be applied to solve and reduce the impact of this waste on the environment, reuse, and reuse in irrigation, industrial fields, and returning to natural water sources (above ground and underground) (Jafarinejad, 2017). Therefore, the wastewater treatment plants are classified into preliminary, primary, secondary, and disinfection (tertiary) treatment (advanced), as shown in Figure 2.2. The flow diagram of the wastewater treatment plants also includes sludge treatment, sludge thickening, sludge digestion, and sludge dewatering (Metcalf & Eddy, 2004).

Wastewater disposal without sufficient treatment has resulted in many health problems and deterioration of the freshwater environment depending on the nature and duration of the plant failure, particularly during periods of population growth and increased water consumption (Khudair, 2017).

Domestic wastewater's chemical properties are generally restricted to several overall substances because of the number of chemical compounds in the wastewater. Therefore, these classes are typically more known by their names than by what is contained by the analysis process utilized. As stated by Davis (2010), the COD test is another nearly comparable test.

The seven-day and 30-day average concentrations are essential in selecting and designing treatment plants' efficiency and reliability in meeting treatment requirements in most discharge permits consisting of effluent constituent requirements. Since the quality of wastewater treatment effluent varies due to varying organic loads, changing environmental factors and new industrial discharges, the treatment system must be designed to generate concentrations of effluent equal to or less than the limit preceded by the discharge permits (Metcalf & Eddy, 2004).

The research indicated that the initial movement on the ground for design and implementation indicated that the wastewater treatment plants must be taken into consideration. (Eddy, 1991; Maggy, 2013):

1-Addressing and discussing issues that can arise during the planning and design of wastewater management systems.

2-Improve the current situation and future extension of the WWTP.

Wastewater should be thought of as a sustainable water supply, energy, nutrients, and other by-products. The wastewater from one portion of a river basin may provide the source for other settlements and purposes downstream. It is crucial to have a collaborative and realistic policy environment that incorporates industry, utilities, health, agriculture, and the environment (World Health Organization, 2018).

2.2.1. Characteristics

In general, wastewater characteristics can be described by their physical, chemical, and biological characteristics, as shown in Table 2.1. Table 2.2 shows different parameters of water quality. There are various activities connected with water use, and the characterization of wastewater includes physical, chemical, and biological contaminants. The different qualities of wastewater are dependent on the source from which it originated (Metcalf & Eddy, 2004).

Table 2.1 Wastewater characteristics (Rabah,2014).

Description of Characteristics			Sources of wastes
Physical characteristics	Color		Domestic and industrial wastes and natural decay of organic materials.
	Odor		Decomposing wastewater and industrial wastes.
	Solids		Domestic water supply, domestic and industrial wastes, soil erosion, and inflow infiltration
	Temperature		Domestic and industrial wastes
Chemical Characteristic	Organics	Carbohydrates	Domestic, commercial, and industrial wastes
		Fats, oils, and grease	Domestic, commercial, and industrial wastes
		Pesticides	Agricultural wastes
		Phenols	Industrial wastes
		Proteins	Domestic, commercial, and industrial wastes
		Priority pollutants	Domestic, commercial, and industrial wastes
		Surfactants	Domestic, commercial, and industrial wastes
		Volatile organic compounds	Domestic, commercial, and industrial wastes
		Other	The natural decay of organic materials Domestic
	Inorganic	Alkalinity	Domestic wastes, domestic water supply, and groundwater infiltration Domestic
		Chlorides	Domestic wastes, domestic water supply, and groundwater infiltration Domestic
		Heavy metals	Industrial wastes
		Nitrogen	Domestic and agricultural wastes Domestic
		pH	Domestic, commercial, and industrial wastes Domestic,
		Phosphorus	Domestic, commercial, and industrial wastes natural runoff
		Priority polluter sulfur	Domestic water supply; domestic, commercial. And industrial wastes
	Gases:	Hydrogen sulfide	Decomposition of domestic wastes

Table 2.1 Wastewater characteristics (Rabah,2014). continue

Biological Components	Methane	Decomposition of domestic wastes
	Oxygen	Domestic water supply, surface- water infiltration
	Animals	Open watercourses and treatment plants Open
	Plants	Open watercourses and treatment plants Domestic
	Eubacteria	Domestic wastes, surface water infiltration, treatment plants.
	Archaebacterial	Domestic wastes, surface-water infiltration, treatment plants
	Viruses	Domestic wastes

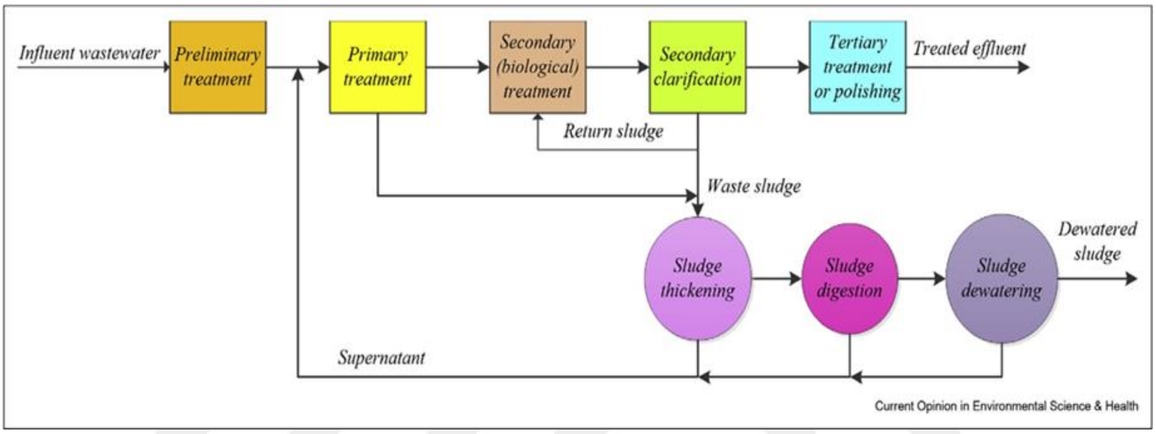

Figure 2.2 The simplified process flow diagram of a typical municipal WWTP (Jafarinejad, 2020).

Table 2.2 Parameters of water quality (Omer,2019).

Physical parameters	Chemical parameters	Biological parameters
Turbidity	PH	Bacteria
Temperature	Acidity	Algae
Color	Alkalinity	Viruses
Taste and odor	Chloride	Protozoa
Solids	Chlorine residual	
Electrical conductivity (EC)	Sulfate	
	Nitrogen	
	Fluoride	
	Iron and manganese	
	Copper and zinc	
	Hardness	
	Dissolved oxygen	
	Biochemical oxygen demand (BOD)	
	Chemical oxygen demand (COD)	
	Toxic inorganic substances	
	Toxic organic substances	
	Radioactive substances	

The types of wastewater are varied, starting from domestic wastewater from homes, municipal wastewater from communities, or industrial wastewater resulting from industrial activities, as shown in Figure 2.3 (Janevska and Bahtovska, 2018). Figure 2.4. shows the influent flows directly to the river.

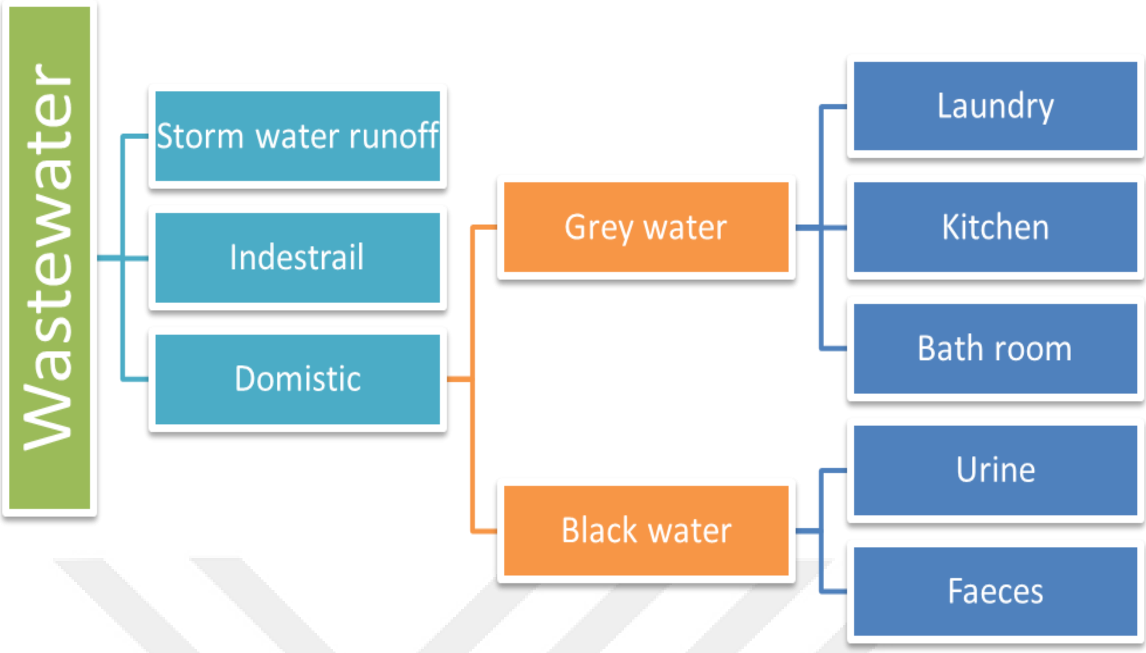

Figure 2.3 The wastewater source (Janevska & Bahtovska, 2018).

Figure 2.4 Influent wastewater flows directly to the river.

A municipality or community's wastewater must be finally discharged back into a receiving water body or the land. Alternatively, wastewater can be reused. As challenging as it is, the public health and environmental regulators must understand the problem that engineers and firms face when applying for discharge permits: the answer is that further treatment is required to ensure human health and the environment. To get at the correct solution, all aspects of the local conditions and personal preferences, along with an understanding of scientific principles and a built-in understanding of the engineer's previous experience, must be considered (Metcalf & Eddy, 2004).

2.3. Wastewater Treatment Plant (WWTP) Units

Shunova (2016) conducted that the main goal of wastewater treatment is to remove as much of the contaminated objects as possible before Table 2.3 shows the wastewater unit's treatment process. returning the remaining wastewater, known as effluent as shown in Figure 2.3, to be safer to the environment.

Table 2.1 Wastewater units and description (Rabah, 2014).

Unit Description	Operation	Pollutant
Physical	Screening	Turbidity, suspended solids
	Mixing and gas transfer	Tastes and odors, dissolved gases
	Sedimentation	Turbidity suspended matter
	Filtration	Turbidity suspended matter, iron and manganese
Chemical	Chemical precipitation	Turbidity, suspended matter, color, organic matter, hardness, heavy metals, iron and manganese, phosphorous,
	Disinfection	Pathogenic organisms, organic matter, dissolved gases
	Advanced oxidation processes	Tastes and odors, iron and manganese
Biological	Activated sludge	Biodegradable organics, nitrogen
	Anaerobic digestion	Nitrogen

2.3.1.Preliminary treatment

It is the first stage in wastewater treatment, and the purpose of this stage is to make the screening process remove and prevent the entry of large floating solids and organics, as shown in Figure 2.5. Heavy inorganic materials are removed like gravel, sand, and ash scraping, knowing these materials do not decompose. Still, they are a source of problems for pumps and make the digestion of sludge difficult (Department of Public Works, 2012).

The inlet gate shall be made from the coarse nets and range in size from coarse to fine, usually made from iron or steel, parallel bars with holes of about 1.5 cm (USEPA, 2004).

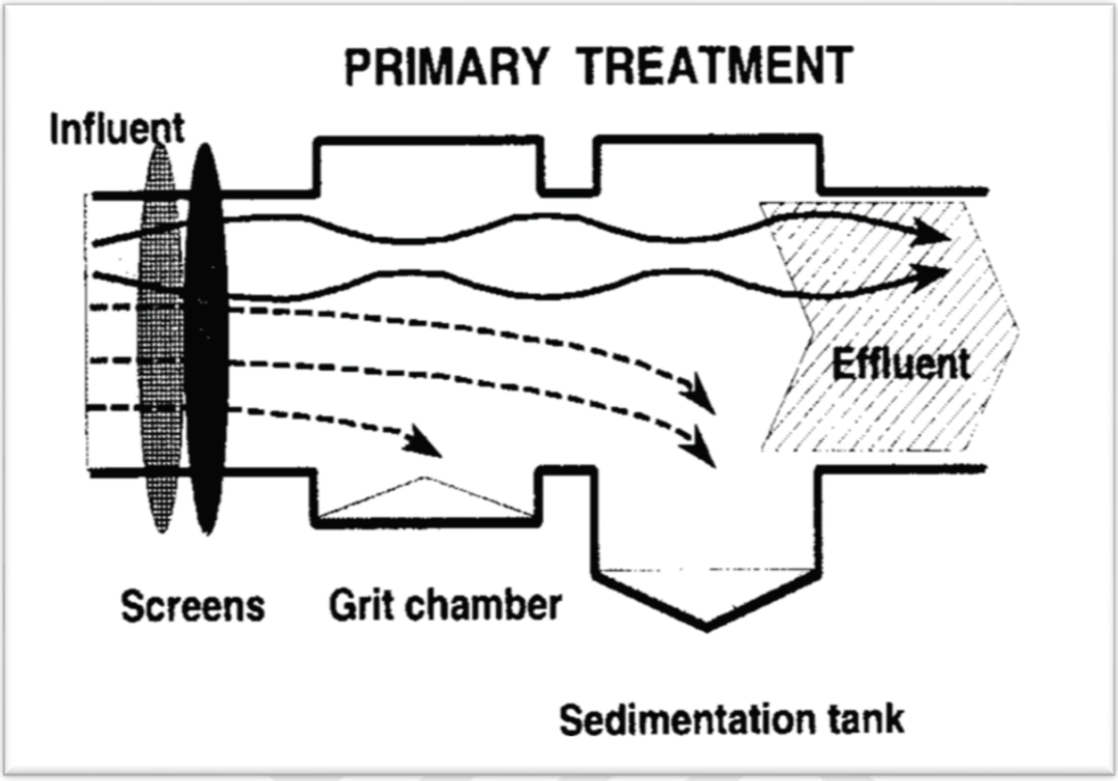

Figure 2.5 Primary treatment (USEPA, 1998).

The preliminary treatment stage involves getting rid of the wastewater constituents such as floatable, grit, and grease that could cause operational or maintenance problems in the treatment operations, then the treatment processes and effects on the systems (Zaher, 1998).

Figure 2.6 Screening of influent, solid materials are retained on the screen while the liquid passes through (Kebbede, 2018).

All the materials of small grit of sand, stone, and even small metals and glass lead to an increase in the rate of mechanical equipment corrosion and consequently the clogging of pipes as shown in Figure 2.6, so this must be removed daily manually or mechanically and dumped landfill sites (Kebbede, 2018).

2.3.2. Primary treatment

Primary is a stage of the wastewater treatment plant cycle. It aims to remove all materials easily collected from the wastewater before damaging or clogs the pumps and sewage pipes (Parr et al., 2000). The primary treatment removes a considerable portion of organic particle matter as suspended solids in wastewater treatment plants (Grigg, 2012). The suspended particles in wastewater can raise the BOD value. Eliminating suspended particles from the wastewater causes a reduction of the BOD. A low oxygen demand, lower energy consumption rate, and fewer operational difficulties downstream are all attributable to reducing suspended particles and BOD. Grit removal is another key function of primary treatment, eliminating scum and inert particle matter missed during the grit chamber process. There is some thick layer of scum made up of grease, oil, plastic, leaves, rags, and hair; see Figure 2.7.

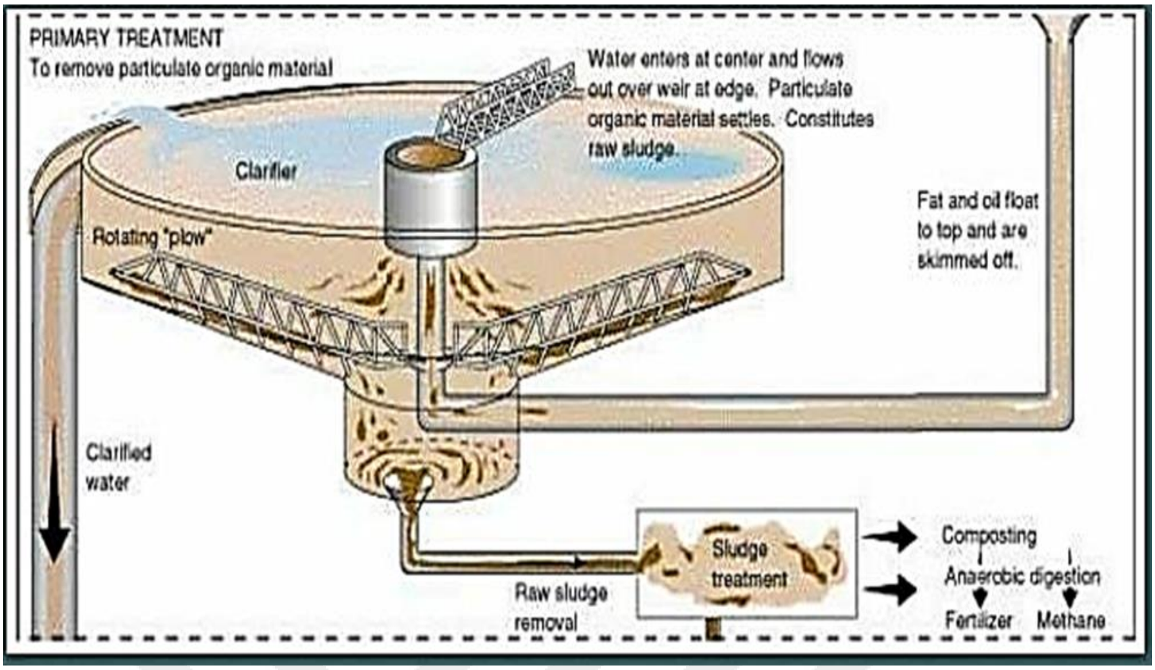

Figure 2.7 A diagram for the primary treatment (www.slideserve.com/len/wastewater-treatment).

Although the quantities of materials in wastewater do not exceed 1.0%, they are very dangerous because they contain harmful solids, dissolved, suspended, and microorganisms (Amer, 2017). In the primary treatment, a part of the suspended particles and organic debris is removed from the wastewater (Zaher, 1998). Preliminary and pretreatment are common in most wastewater treatment plants and are effective in removing and reducing a lot of pollution (Amer, 2017).

In this treatment, the natural and physical properties of impurities, such as weight and volume, in the wastewater are the main dependency and are generally applied as the first stage in all kinds of treatment where additional treatment forms are used.

The purpose of the primary treatment is shown below:

1- Removal of giant and extensive floating materials,

2- Removal of oil and grease,

3- Removal of sand, gravel, silt, etc.

4- Removal of suspended solids and BOD, 50% and 30% respectively, as shown in Figure 2.8 (Amer, 2017).

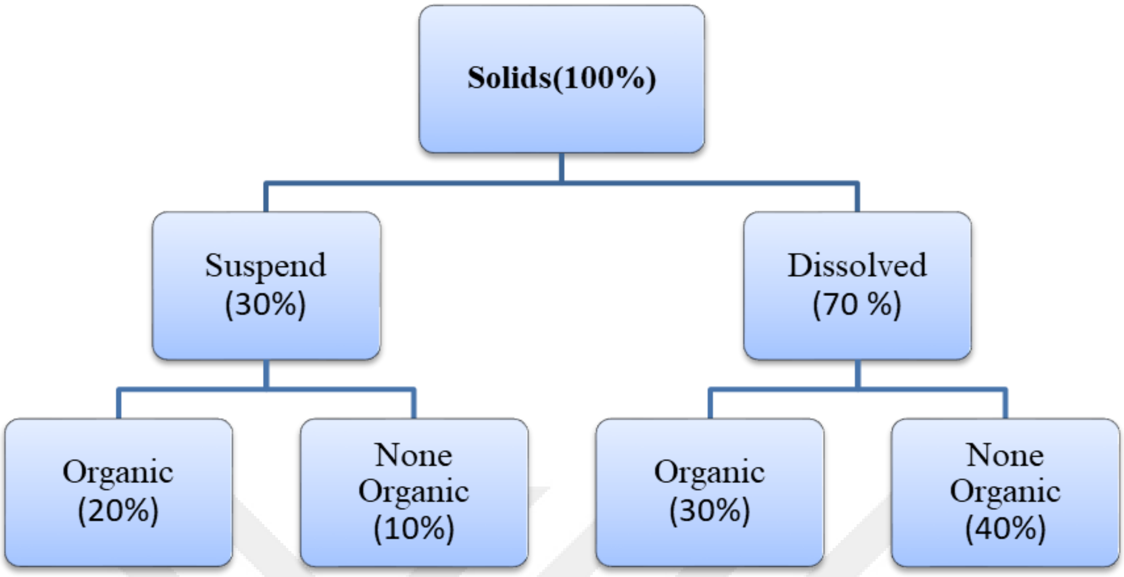

Figure 2.8 Solids and their classification (Amer, 2017).

2.3.3. Secondary treatment

Secondary treatment is a wastewater treatment process that aims at reaching a certain degree of separation of settable solids and a biological process to remove dissolved and suspended organic compounds (Wikipedia, 2021). This treatment is a process that can remove the biodegradable organic matter and the suspended solids (Zaher, 1998). As mentioned in his project, disinfection is necessary for this stage. One of the fundamental goals of conventional secondary treatment is to oxidize the rapidly biodegradable BOD that escapes primary treatment and offers additional removal of suspended particles (Grigg, 2012). Secondary treatment frequently includes treating nitrogen and phosphorus to combat the harmful effects of nutrients.

Up to 90% of the organic matter can be removed from the wastewater (USEPA, 2004). Through the bacteria produced from this stage and their interaction with organic matter, we make materials that can be disposed of and consequently facilitate their sedimentation for the next step (Abdelrahman, 2017).

The USA apply the standards for the secondary treatment effluent discharge in the wastewater treatment plant, and the main parameter is BOD, TSS, pH, and CBOD, as shown in Table 2.4 (Rabah, 2014).

Table 2.4 Discharge characteristics standards in the USA (Jafarinejad, 2017) .

Discharge Characteristics	Unit	Average 30-day concentration	Average 7-day concentration
BOD	mg/L	30	45
CBOD	mg/L	25	40
PH	pH units	Within the range 6-9 always	
TSS	mg/L	30	45

This treatment is called biological treatment, and it stabilizes the dissolved solids. Different types of secondary processes can be used and employed; one of the most widely used is the activated sludge by this method; the wastewater is mixed with the living organisms that returned from the secondary clarifiers (Janevska & Bahtovska, 2018).

A report has concluded that secondary treatment aims to treat the residual organic materials and suspended solids by treating effluents that have gone through primary treatment (Pescod and Wear,1992). This procedure is also accompanied by aerobic biological processes for the dissolved and colloidally biodegradable.

The EPA in the United States reveals that secondary includes two strategies, one trickling filter and one activated sludge (USEPA, 1998).

Galbraith et al. (2015) defined organisms like bacterial, viral, and protozoan pathogens that pass from the primary treatment would perish in secondary treatment. They also mentioned that the conversion of the remaining nitrogen (N) into the nitrate form is carried out in secondary treatment, and phosphorus (P) will also be removed in the secondary treatment stage.

2.3.4. Tertiary treatment

To be more specific, Muralikrishna and Manickam (2017) stated that the tertiary treatment would be supplementary after primary and secondary treatments to eliminate the remaining organic and inorganic substances. On the other hand, Zaher (1998) stated that the tertiary treatment is usually granular medium filtration or micro screens to remove remaining suspended particles. In addition, disinfection is generally required for this tertiary treatment process. Hence, one of the essential components of nutrient removal is usually included in this definition.

The treatment in the wastewater treatment plant is a stage that comes after the secondary treatment and involves a chain of extra steps to decrease organics, turbidity, nitrogen, phosphorus, metals, and pathogens (Gerba and Pepper, 2015). The process is also one additional method that may improve water properties to a level that can be reused in some cases, such as irrigation. This may be done chemically or biologically (Amer, 2017).

Ameta (2018) conducted the tertiary treatment, also called the polishing technique, and it is used after classical treatments. It is utilized in some industrialized countries through synthetic membranes or micro-filtration. The process treatment can take different forms depending on the final effluent quality required (Mudge and Ball, 2008). The effluent from this treatment process is discharged to the land or the surface stream when the specifications are within the local authority's standards. Also, as mentioned before, this kind of effluent discharged to the surface should be passed through disinfection systems that often rely on chlorination, ozonation, or ultraviolet light (Galbraith et al., 2015).

2.3.5. Storage

Storage tanks are mainly used for the water treatment plant process and are applied before distributing the treated water (Abdelrahman, 2017).

According to Pescod and Wear (1992), a storage tank, in most cases, is an important vital connection and especially for the irrigation system during the wastewater treatment process, because of the following reasons:

1. It balances the daily changes in treatment plant flux and stores excess when irrigation demand is above average treated water flux and includes winter storage.
2. To satisfy the highest irrigation requirements.
3. To minimize disturbances' impact on treatment plant and irrigation system operations.

We also use the storage to ensure that unsuitable reclaimed wastes join the irrigation system and provide sufficient time to address issues of temporary water quality.

2.3.6. Sludge process

According to Metcalf & Eddy (2004), authors of wastewater treatment engineering and reuse, the sludge process is one of the most complex and costly problems facing wastewater treatment. To fulfill water quality standards, a wastewater treatment process should be improved (Grigg, 2012). Disposal of the wastewater and sludge handling systems are constructed to safeguard the land and water resources downstream.

For several years, the term sludge was used to refer to residual wastewater products (Abdelrahman, 2017). The primary sedimentation and secondary biological flocculation also concentrate waste organics into a volume of sludge that is less than the volume of treated wastewater. Although waste sludge disposal is an important economic component in wastewater treatment, there are other important factors, too. Aerobic digestion and mechanical dewatering using a belt filter press or centrifuge are two techniques for treating raw sludge. Conventional disposal techniques include using it as a fertilizer or soil conditioner on agricultural land, landfilling it in an approved disposal location, or mixing it into municipal solid garbage (Viessman et al., 2008).

Their physicochemical and microbiological properties determine the final use of biosolids generated by the treatment of residual municipal waters. Biosolids can be managed carefully to reduce threats and hazards (Garrido et al., 2005). Hope (1986) concluded that sludge disposal and utilization must be scientifically handled and treated to avoid polluting the environment and harming it. More treatment processing in each step is required for wastewater sludge before it may be released (Grigg, 2012). The operation includes several things, including pumping, grinding, regrinding, thickening, stabilization, conditioning, disinfection, wastewater treatment, drying, thermal reduction, and final disposal.

Solid and liquid wastes generated in water treatment procedures are separated into their constituent liquid and solid components until it is essential to dispose of the mixture as directed by the specified disposal technique. Because disposal methods directly influence treatment requirements, the treatment requirements directly impact selecting the proper disposal technique. In turn, the disposal technique is controlled by regulations, limiting the disposal technique's capabilities, and the economics of the disposal method influences that decision (Davis, 2010).

2.4. Management

There are two alternatives for wastewater management in smaller and rural communities: they can either utilize individual on-site treatment systems, which include a septic tank and a land-based system for effluent dispersal, or they can use a centralized wastewater treatment facility, which is connected to each residence via a wastewater conveyance system (Gikas et al., 2017). The progress made in developing countries affects rapidly and negatively on all aspects, the environment. Wastewater management in these countries is still in the first steps, so quick urban expansion and mismanagement are causing an issue for the wastewater treatment plants and suffering from un-improving (Libralato et al., 2012). Jafarinejad (2020) stated that the three crucial elements of sustainable development are economy, society, and the environment.

2.4.1. Introduction

From the early nineteenth century to the present, the evolution of urban wastewater management techniques and technologies followed a cyclical pattern as Burian et al. (2000) conduct that benefits from managing the wastewater treatment plant are (1) to examine the evolution of wastewater management techniques and technology choices, and (2) to explore how recent developments indicate future guidelines for urban wastewater management. Then according to the influence of the Life Cycle Assessment (LCA), that can be defined as the method for environmental management that can be used to measure the environmental effect of a product, system, or operation, (Yang et al., 2019). The managers and engineers require defined life-cycle management principles for water, wastewater, and stormwater infrastructure systems to control expenses and enhance performance using enterprise asset management solutions. There are more capital demands and increasing failure rates when water, sewage, and stormwater systems are renewed simultaneously. Utility administrators face a grim scenario: decaying networks with soaring rates. Thus, although robust management systems now will prolong service life, reassure decision-makers, and boost public confidence (Grigg, 2012).

And by the mid-19th century, Burian et al. (2000) stated that engineers, health workers, and the general public sought alternative wastewater management solutions that could efficiently enact the ideals that increasing sanitary reformation promoted.

Therefore, based on all mentioned above, we can say that management becomes an important factor affecting the wastewater treatment plant process. Also, the operation and maintenance goals are to maintain and keep the wastewater levels at or above specified requirements as to be investigating (District, 2006).

Department of Public Works (2012) reached that the life cycle cost section performs an analysis of the wastewater system's life cycle costs based on the rehabilitation and operation and maintenance (O & M) plans chosen by each region.

The purpose and objectives of evaluation of environmental management of small size wastewater treatment plant strengthen training to enable engineering, inspection, worker, and construction staff to be involved with the latest methods and techniques update regarding the wastewater treatment plant (Isq et al., 2006).

Jafarinejad (2020) stated that adequate wastewater management is a global challenge due to the need to meet effluent quality standards, prevent harm to the surrounding environment and human health, reuse potential, and energy and resource recovery issues.

Flores-Alsina et al. (2010), Kärrman & Jönsson (2001), Lundin et al. (2000) and Tillman et al. (1998) mentioned that Life Cycle Assessment (LCA) had proven valuable tools for evaluating the environmental results of w0astewater treatment plants.

2.4.2. Operation and maintenance

Manuals for operation and maintenance do not provide much operational guidance. In their perspective, the basics of starting, shutting down, and maintaining equipment are critical. They do not always include the operation and maintenance manuals for the equipment providers. Generally, operators must ensure that standard operating procedures (SOPs) for process control are completed. To ensure that the operators have time to prepare the SOPs, they should be employed before completing the project. The necessity for operators to be involved before construction is complete should be brought to the engineer's attention, as this is the owner's obligation (Davis, 2010)

In the past, facility management has often consisted of operations and maintenance. While other aspects, such as safety, the workplace environment, building air quality, and security, are also considered (Grigg, 2012), operating agencies find it particularly vital to cover operational and maintenance costs with local because these costs are financed with total costs from the local authority (Eddy, 1991).

Amer (2017) pointed out that operation and maintenance are some of the factors that influence design costs for the wastewater treatment plant. Moreover, Grigg (2012) stated that maintenance management's objective is to look after assets to maximize their performance and life while also maximizing the return on investment. Typically, maintenance management relies on inventory and condition assessment operations, which are essential asset management operations. In an ideal world, inventory and condition assessments would be updated by maintenance personnel, who would then transmit the information to IT, which would then send it to other areas.

Handbook of operation and maintenance; this manual must have a description of the treatment, control, and pumping equipment, as well as the necessary maintenance and scheduling, as well as a troubleshooting guide for common problems (Environment and Conservation, 2005), and maybe sometimes in terms of workshop or making site visits to the country and meeting people with more experience.

3. MATERIALS AND METHODS

3.1. Introduction

In this chapter, the methodologies that have been used for this study are described in detail. Three sections are covered in this chapter. Section one gives an introduction to this chapter, and section two explains the methodology of the work. Finally, section three is devoted to the collection of tests of samples, including site description and sampling process.

3.2. Collection of the Wastewater Sample

3.2.1. Site description

The study area belongs to the Duhok governorate, which is located in northern Iraq under (N 36˚ 52′ 03″, E 42˚ 59′ 34″). It has bounders three countries: Turkey, Iran, and Syria (Abdullah et al., 2019), as shown in Figure 3.2. According to the Duhok Governorate-Wikipedia website (https://en.wikipedia.org/wiki/Duhok_Governorate), the estimated population in 2018 was 1 292 535 the area was about 10 955,91 km^2. Table 3.1 shows the station's coordination; see Figure 3.1, 3.2 and 3.3, respectively. Table 3.2 gives information about the wastewater treatment capacity of the plants in the Duhok Governorate.

Figure 3.1 Duhok Governorate Districts map.

Table 3.1 Coordination of the investigated wastewater treatment plants

#	Station Name	Location	Coordination			No. individuals	Remark
			N	E	Alti.		
1	New Zakho Unit	Zakho District	37°07'20.5"	42°41'22.8"	538m	5000-6000	Sample 1
2	Avro City	Summel District	36°51'08.5"	42°53'49.8"	524m	>10,000	Sample 2
3	Azdi Gene Hospital	Duhok District	36°51'02.8"	43°00'16.3"	565m	1750-2000	Sample 3
4	Nojin City	Duhok District	36°51'23.3"	43°02'33.4"	675m	1500-1750	Sample 4
5	French Villag	Duhok District	36°50'33.0"	42°57'49.6"	546m	>3,900	Sample 5
6	MRF Apartment	Duhok District	36°51'25.1"	42°58'31.6"	517m	1,100-1,35	Sample 6

Table 3.2 Properties of each wastewater treatment plant in Duhok Governorate

#	Station name	Establishment year	Project place	Service place	Design capacity m^3/day	Produce capacity m^3/day
1	New Zakho City	2011	Zakho city	New Zakho city project	6,000	4,500
2	Avro City	2007	Duhok city	Avro city project	6,000	4,000
3	Azadi General Hospital	1984	Duhok city	Azadi hospt.	5,000	3,000
4	Nojin City	2015	Duhok city	Nojin city project	3,000	3,500
5	French Village	2019	Duhok city	French village project	10,000	2,000
6	MRF Apartment	2010	Duhok city	MRF Apartment project	3,000	1,000

3.2.1.1. New Zakho city unit

The first station is the New Zakho city unit located at the gate of Zakho district; it was built in 2011. The station capacity is about 6,000 m^3/d. It is a compact unit consisting of screening channels, aeration, equalization, last colorization, storage according to their needs, and the rest treated wastewater released to the downstream channel, as shown in Figure 3.2.

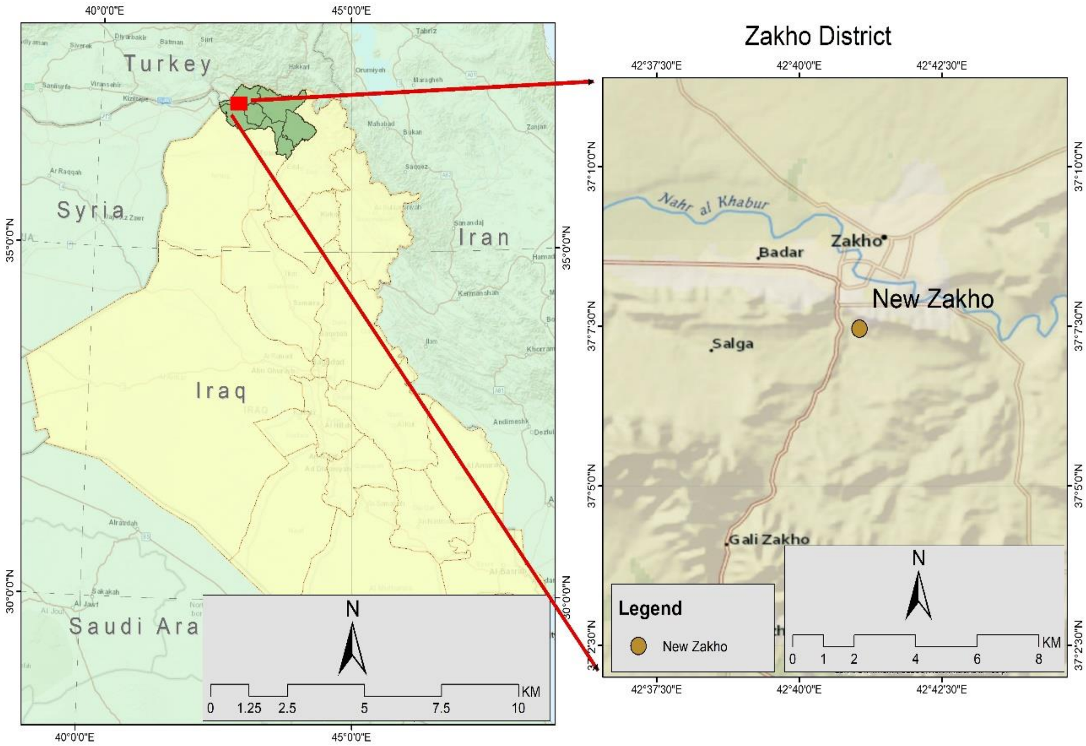

Figure 3.2 The study area of Zakho district (the New Zakho project).

3.2.1.2. Avro city

Avro city station is located on the main road connecting Duhok and Turkey; it was built in 2007. The plant's capacity is about 6,000 m^3/d. This compact unit consists of screening channels, aeration, equalization, colorization, storage, and the rest of treated wastewater overflow released to the Hishkarow river, as shown in Figure 3.3.

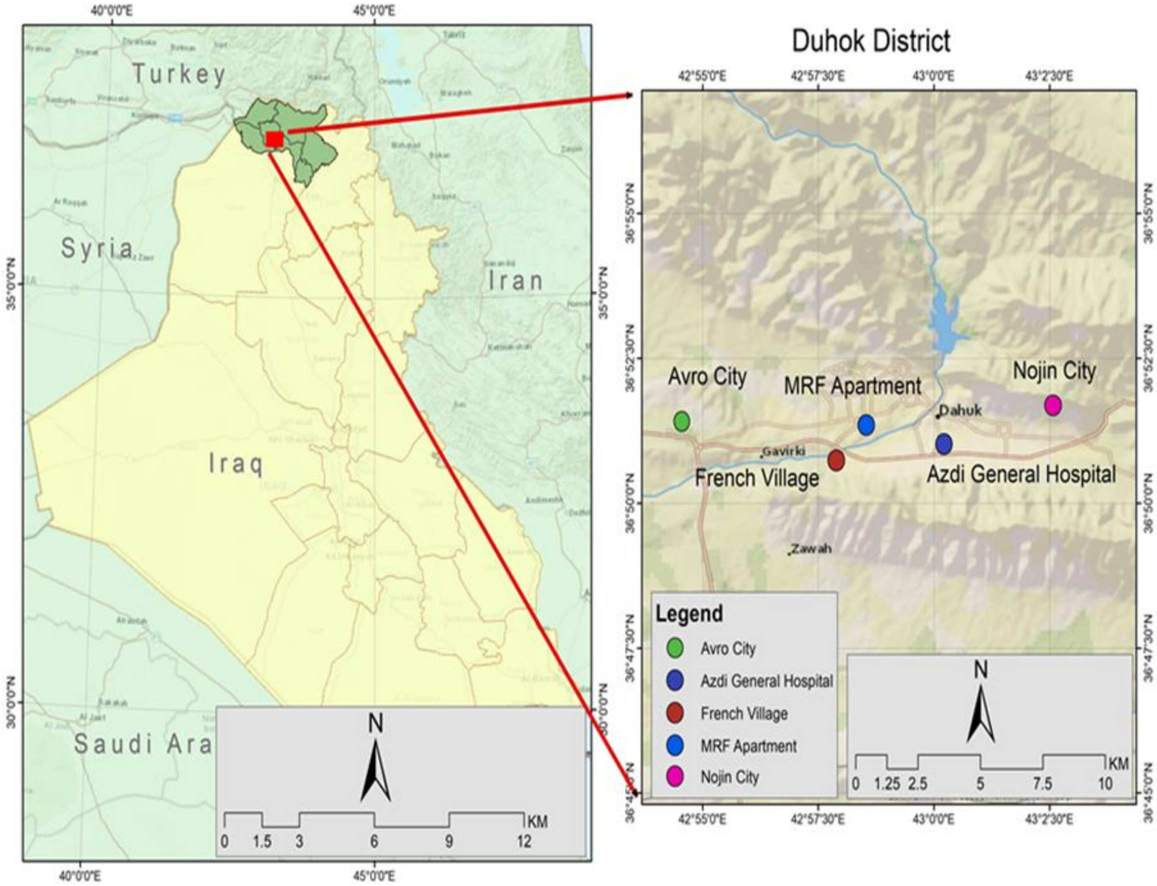

Figure 3.3 The study area of the Duhok district.

3.2.1.3. Azadi general hospital

Azadi general hospital wastewater treatment plant located in the city center of Duhok gov., as clarified in Table 2, was built for the general hospital. This plant inside the hospital and the facility was constructed in 1984. The plant capacity is 5,000 m^3/d, consists of screening channels. It carries out 3 phases functions, aeration and sedimentation equalization, at last colorization then storage or release to the downstream channel, as shown in Figure 3.3.

3.2.1.4. Nojin city

This station was built in a very public area, like an apartment, and it is a new infrastructure in the Baroshki quarter in the Duhok district; it was built in 2015. The plant's capacity is about 3,000 m^3/d, and this compact unit consists of screening, equalization, and colorization, then released to the main channel for the area, as shown in Figure 3.3.

3.2.1.5. The French village

It is the most modern and newest village, and it is not finished yet. It is located in the Duhok district; it started in 2019. The plant's capacity is about 10,000 m^3/d, and this compact unit consists of screening channels, equalization, aeration, colorization, storage, and the overflow released to the Hishkarow river, as shown in Figure 3.3.

3.2.1.6. The MRF apartment

This apartment is located in the Duhok city center, and it was built in 2010. The plant's capacity is about 3,000 m^3/d, and this compact unit consists of screening, equalization, and colorization, and then the treated wastewater is released to the Hishkarow river, as shown in Figure 3.3.

3.3. Wastewater Treatment Parameters' Definition and Measurement

3.3.1. Physical parameters

3.3.1.1. Solids

In every wastewater sample, solids are an important ingredient to measure. Solid pollutants present in wastewater discharge add to the sediment load placed on a receiving stream. Solids may be classified into two broad categories: suspended and dissolved. Let us look at a couple more examples. If a 0.45-1.2μm filter removes anything filtered out of a sample, it will register suspended solids. An ingredient that passes through the filter is a dissolved solid. Volatile solids are separated from fixed solids under the dissolved and suspended solids classification. At a temperature of 550°C, volatile materials will combust, but fixed solids will not (Ellis, 2004). Below is the relationship between the solids:

$$TS= TSS+TDS \quad (3.1)$$

$$TVS=VSS+TDS \quad (3.2)$$

$$TFS=FSS+FDS \quad (3.3)$$

We can see volatile, fixed, dissolved, and suspended solids correlated to each other through the solid's matrix. They use a connector on the bottom of the rows to add rows and get the constituents in the top, as seen above equations (equation 3.1, 3.2 and 3.3).

All water contaminants add to the solid's content, except for gases. Solids include typically inorganic stuff like silt, sand, gravel, clay, and organic stuff such as plant fibers, microorganisms, and human-made microbes. Dispersible in water, in both suspended and dissolved forms, can be classified by size and status, chemical properties, and size distribution solid. Solids may be suspended, settled, colloidal, or dissolved in wastewater in terms of size. They are also known to be volatile or non-volatile (Akcin et al., 2005). Because of the differences in particle sizes, numerous analytical processes are available for analyzing solids in wastewater, including settling, filtration, and evaporation.

- TS in wastewater is the amount of all solids calculated by drying a known volume of the sample in a pre-weighed crucible dish at 105 °C. After cooling, the crucible dish is again weighed. And it is determined as in the following formula:

$$TS = (M1–M2)/V \quad (3.4)$$

With M1 is a mass of crucible dish after drying at 105 °C (mg), M2 is the mass of the initial crucible dish (mg), V is the volume of the sample (L) (Akcin et al., 2005).

- VS is the quantity of solid that volatilizes when heated at 550°C. To obtain the total organic matter present in wastewater, combust the complete solid sample at 550°C for 2 hours. After cooling in an evacuated tube, it is weighed.

$$VS = (M1–M3)/V \quad (3.5)$$

With M1is, the mass of crucible dish after drying at 105 °C (mg), M3 is mass of crucible dish after ignition at 550 °C (mg), and V is the volume of the sample (L) (Akcin et al., 2005).

- FS is described as the quantity of solid that does not volatilize when heated to 550 Degrees Fahrenheit. This is a test that is used to determine the amount of mineral matter present in wastewater.
- Infiltration, SS is defined as the solids retained in a filter and are often determined by filtering with glass fiber filters (GFF).

$$SS= (M4–M5)/V \quad (3.6)$$

With M4 is the mass of filter after drying at 105 °C (mg), M5 is the mass of the initial filter (mg), V is the volume of a sample (L)

- VSS is a type of suspended solids that can be eliminated by heating the solids at 550°C in a muffle furnace for 2 hours and then weighing the solids after cooling. And they can be found through the formula below:

$$VSS=(M4–M6)/V \quad (3.7)$$

With M4 is the mass of filter after drying at 105 °C (mg), M6 is the mass of filter after ignition at 550 °C (mg), and V is the volume of a sample (L).

- FSS is inflammable solids at 550 °C and is calculated by subtracting VSS from SS.
- It is possible to calculate DS or filterable solids by deducting SS from TS. Colloidal and dissolved particles are among the substances that pass through the filter.

3.3.1.2. Turbidity

Water clarity is typically assessed by its turbidity. In turbidity, suspended materials act as a medium for light absorption or scattering. These properties affect absorption and scattering, and turbidity measurement is vital to the quality of drinking water. The wastewater effluent that is reused should be measured. For UV to be successful in disinfecting wastewater effluent, UV light must enter the streamflow. Turbidity is assessed by evaluating the ratio of light scattered by the sample to a standard solution. NTU is the measurement unit (Akcin et al., 2005).

3.3.1.3. Color

Pure water has no color. In wastewater, treatment color is only used as an indicator of the wastewater stated. And the wastewater's age is evaluated by the presence of color and odor. Light brownish-grey wastewater is fresh, and the wastewater turns from grey to dark grey and then to black in order (Steinmetz, 2013).

3.3.1.4. Temperature

Temperature is critical because it influences chemical processes, aquatic life, and the solubility of crucial gases like oxygen in the water. To measure the temperature of wastewater, a conventional mercury thermometer or digital thermometer may be used.

3.3.1.5. Odors

When it comes to wastewater, odors are a big source of concern, especially for people who live near a wastewater treatment plant. Decomposition of organic debris or compounds added in wastewater is the source of these scents. The fresh wastewater smell is less off-putting than wastewater that has experienced anaerobic decomposition. Septic wastewater is famous for its unique sulfide odor caused by anaerobic microbes that convert sulfate to sulfide. Diluting a sample with odor-free water until the least detectable odor level is attained allows identifying the malodorous chemicals responsible for producing offensive aromas in water. This is registered with the letter TON (Threshold Odor Number). It is possible to quantify the concentration of malodorous gases discharged into the air from wastewater using any available gas monitor, including hydrogen sulfide, ammonia, mercaptans, etc. (Akcin et al., 2005). Table 3.3 shows some famous odors in a wastewater plant.

Table 3.3 Odoriferous chemicals in wastewater (Fahid, 2011)

#	Item	Formula	Odor
1	Amines	CH_3NH_2, (CH_3) 3H	Fishy
2	Ammonia	NH_3	Ammoniacal
3	Diamines	$NH_2(CH2)_4NH_2$, (CH_2) $5NH_2$ H_{25}	Rotten eggs
4	Mercaptans (E. methy1and ethy1)	CH_2SH, CH_3 (CH_2) SH	Decayed cabbage
5	Organic sulfides		Rotten cabbage
6	Skatole		Fecal matter

3.3.2. Chemical parameters

3.3.2.1. Alkalinity

An ability to neutralize acid or absorb hydrogen ions is called alkalinity. The total number of acid-neutralizing bases in the water. Alkalinity in wastewater is heavily affected by a variety of contributing elements, which include municipal and industrial wastewater. This list includes dissolved inorganic and organic compounds, suspended organic matter, pH level, and the presence or absence of free hydroxyl alkalinity (Marietta, 2014).

3.3.2.2. pH

pH is defined as the negative log of the hydrogen ion concentration (pH= - log10 [H+]). The concentration of hydrogen ions in both natural water and wastewater is an important attribute criterion. To protect organisms, the pH of wastewater must remain between 6 and 9. Acids and other chemicals that affect the pH of a solution can render treatment techniques ineffective (Akcin et al., 2005). Because there must be enough alkalinity present in the wastewater to counteract the acids created by the active biomass during wastewater treatment, the wastewater PH must be maintained appropriately. Ensuring correct effluent pH is critical for wastewater treatment due to alkalinity (Marietta, 2014).

3.3.2.3. Dissolved oxygen (DO)

The amount of molecular oxygen dissolved in water is referred to as dissolved oxygen. It is essential for the respiration of aerobic bacteria. Water, on the other hand, only has a minor solubility in oxygen. The actual amount of oxygen (and other gases) that can be present in a solution and can be depended on are as below:

- The partial pressure of the gas in the atmosphere,
- The solubility of the gas,
- The concentration of the impurities in the water (e.g., salinity, suspended solids, etc.),
- The temperature.

3.3.2.4. Biochemical oxygen demand (BOD)

To determine oxygen demand, there are three extensively used techniques. A few measurements directly quantify oxygen demand: biochemical oxygen demand (BOD) and cellular oxygen demand (COD), and the total organic carbon (TOC) approach is a third method for measuring indirect oxygen demand (Wayne, 2006). The amount of dissolved oxygen consumed in five days by biological activities breaks down organic materials (Nicholas, 2002). It is evaluated by measuring the amount of dissolved oxygen consumed by microorganisms during the biochemical oxidation of organic materials during a 5-day period at 20 C° (Rabah, 2014).

Metcalf & Eddy (2004) stated that the 5-days BOD_5 is one of the most extensively used organic pollution measures, and it is applied to both wastewater and surface water. This determination requires the measurement of dissolved oxygen required by microorganisms in the biochemical oxidation of organic matter. And the rationale for the BOD test might be used for a variety of purposes, as follows:

1- Calculate the approximate amount of oxygen that will be necessary to biologically stabilize the organic matter that is present in the environment,
2- Calculate the capacity of wastewater treatment plants,
3- To evaluate the effectiveness of wastewater treatment processes,
4- Determine whether or not wastewater discharge permits are being followed.

Also, Akcin et al. (2005) stated that when measuring BOD, a unique liquid called "dilution water" is added to wastewater bottles. This wastewater effluent, which may still contain microorganisms, could be the final discharge from a wastewater treatment plant, and before being used, it needs to be supplemented with nitrogen, e.g., urea and phosphate and given time to be aerated. The use of a nitrification inhibitor (such as allylthiourea) is also implemented, as this inhibits the oxygen consumption of organic wastewater contents but not of ammonia. The bottles are filled to the brim with BOD, and the caps are sealed with a glass stopper to ensure no air bubbles remain. During the preparation of each combination, an equal number of identical bottles are made. Using an oxygen probe, the dissolved oxygen concentration in one bottle of each pair is measured as soon as the mixture is completed, for n days at 20°C in the dark, the other bottle is in storage (to prevent photochemical reactions). After this measurement period, the amount of dissolved oxygen in this bottle is recorded as well. This formula measures oxygen consumption (OC) (mg O_2/liter). The BOD n is derived by using the following equations:

$$BOD\ n = DF*OC- (DF -1)*OC\ DW \qquad (3.8)$$

When DF is the dilution factor (V(diluted sample)/V(sample before dilution)), OC is oxygen consumption, and OC DW is the blanks' oxygen consumption.

And Wayne (2006) stated that the BOD test, out of the three methods used to measure oxygen demand (biochemical oxygen demand, chemical oxygen demand, and total organic carbon), is the one that most accurately models aerobic waste treatment in the aquatic ecosystem. When exposed to organic molecules for food in this test, bacteria eat oxygen while ingesting organic compounds.

3.3.2.5. Chemical oxygen demand (COD)

The amount of oxygen necessary for organic and oxidizable inorganic substances is oxidized in mg/l (Cheremisinoff, 2002). Overall, Davis (2010) pointed out that the COD of waste would be greater than the BOD_5 because more compounds can be oxidized chemically than can be oxidized biologically and the fact that the BOD 5 does not equal ultimate BOD. The COD test can be completed in three hours or less. If it can be linked to BOD 5, it can assist in operating and controlling the wastewater treatment facility.

Numerous regulatory authorities recognize the COD test as a helpful instrument in the wastewater treatment process. The total organic carbon test is also used to determine the organic content of wastewater. The COD measures the oxygen content equivalent of the organic matter susceptible to oxidation by a strong oxidant, such as potassium dichromate. COD is empirically correlated with BOD, organic carbon, or organic matter. The COD test controls and monitors wastewater treatment processes after establishing the link between BOD5 and COD. The COD test for BOD data takes three to four hours rather than five days. The results of the COD are usually more significant than the values of BOD. The relationship between COD and BOD varies amongst plants. BOD: The COD ratio changes from influence unit to effluent across the facility. The ratio for crude wastewater is usually 0.5:1 and may decrease to 0.1:1 for well-stabilized secondary wastewater—testing of COD. A boiling mix of sulfuric and chromic acids with over potassium dichromate oxidize several organic matter types in water or wastewater ($K_2Cr_20_7$). The remaining unreduced $K_2Cr_20_7$ is titrated with iron ammonium sulfate after two hours of refluxation to assess the consumption of the $K_2Cr_20_7$ and determine the oxidizable organic matter oxygen equivalent. Either the open reflux or the closed reflux approach may perform the COD test. The open reflux procedure applies to a variety of wastes. Still, the closed reflux approach is cheaper, but it requires samples that contain suspended solids to homogenize to get reproductive results (Dar, 2007).

3.3.2.6.Total organic carbon (TOC)

Wayne (2006) stated that to quantify the Total Organic Carbon, it must be oxidized to CO_2 and water using heat, ultraviolet light, and a strong chemical oxidant (or a combination of these three). CO_2 is produced via infrared spectroscopy, conductivity, or coulometry, and this gives an indirect reading of the amount of oxygen needed (an electrochemical technique). The time required to finish the test can vary greatly, and in most cases, TOC and BOD/COD information yield vastly different results. While it is true that the TOC test does not differentiate between compounds with the same number of carbon atoms and will thus generate varied oxygen demand readings, another benefit of the test is that it incorporates oxidization steps as it evaluates oxygen demand. Thus, results indicate the original oxidation stated of the chemical contaminants because they are directly assessed using BOD and COD assays. The total organic carbon analysis is one of the most critical drinking water and wastewater facility measures, which helps determine the implementation treatment. TOC measurement may be essential to optimize water treatment procedures for a water treatment plant. This is a criterion for organic monitoring not specific but encompassing. TOC levels can also be employed to measure treatment efficacy and as an indicator of contamination, as knowing and comprehending throughout the process. TOC comprises all organic substances in contrast to biological oxygen demand (BOD) or chemical oxygen demand (COD) and can be achieved in minutes using instruments instead of hours or days in a laboratory using reagents. Table 3.4 shows the Comparing the COD, BOD and TOC tests.

3.3.2.7. Relationship between BOD, COD, and TOC

Typical BOD, COD ratio (BOD/COD) levels for untreated municipal wastewater fall in the range from 0.3 to 0.8, as shown in Table 3.4. Untreated wastewater with a (BOD/COD) ratio of 0.5 or above is considered biologically treatable. Accustomed microorganisms may be necessary for waste stabilization if the ratio is below about 0.3. An untreated wastewater BOD/TOC ratio of 1.2 to 2.0 is present. When calculating these ratios, remember that they are significantly affected by the treatment the trash has received. (Akcin et al., 2005).

Table 3.4 Comparison of several wastewater parameter ratios (Akcin et al., 2005)

Wastewter Type	BOD/COD	BOD/TOC
Untreated	0.3-0.8	1.2-2.0
After primary settling	0.4-0.6	0.8-1.2
Final effluent	0.1-0.3	0.2-0.5

3.3.2.8. Chlorides

The main sources of chlorides in water are industrial processes such as battery manufacturing and pulp mills, bullion refining and electroplating, pesticide manufacturing, a large number of small-scale processing units, and so on. However, the industrial, domestic, and agricultural wastewaters generated by human society may have a high concentration of chlorides, which can cause considerable disruption in the ecological balance of the surrounding environment. Various approaches have been implemented to lower the number of chlorides in wastewater, including demineralization, reverse osmosis, coagulation, precipitation, electro dialysis, and other treatment methods. On the other hand, these approaches are physicochemical in nature and, therefore, expensive, both in terms of capital expenditure and maintenance expenditure. In the chemical world, chloride is a salt compound formed by the reaction of chlorine gas with an elemental metal. Two chloride salts are commonly found in water: sodium chloride (NaCl) and magnesium chloride ($MgCl_2$). As mentioned above, the usage of lime ($Ca(OH)_2$) or Sodium

Hydroxide (NaOH) for the neutralization of acidic effluents is the most common source of chlorides in the effluent. Hydrochloric acid (HCl) and Sodium Hydroxide (NaOH) can play an essential role in several industrial processes. They are employed for the first de-coating of an oil layer on raw material, among other things. Naturally, they significantly contribute to wastewater's chlorides; nevertheless, they are present in tiny proportions (Apte et al., 2011).

3.3.2.9. Nitrogen

Nitrogen and phosphorus are known as nutrients biostimulants, which are required to grow micro-organisms plants and animals. For biological growth, trace volumes of other elements such as iron are also necessary. However, in most situations, the main nutrient is nitrogen and phosphorus because of a major building block in nitrogen. In order to assess the treatability of wastewater by biological process, nitrogen data will be required for protein synthesis (Metcalf & Eddy, 2004). The biological processes of nitrification and denitrification are employed to remove nitrogen from wastewater, resulting in a higher-quality effluent, reducing nitrification, and subsequent oxygen depletion in the receiving medium (Tallec et al., 2006). Ammonia, nitrite, nitrate, and Kjeldahl nitrogen are common wastewater analytes because they have an environmental impact. In the presence of nitrifying bacteria, ammonia discharged to surface water can be nitrified. Oxygen is used up as part of the nitrification process, leading to the loss of the water's oxygen level and the widespread death of fish. Also, NH3 is produced if the surface water pH is above an alkaline level. This is harmful to fish. Nitrate is a nutrient that causes water pollution because of the excessive growth of algae. At the same time, nitrite is dangerous because it can combine with amines to generate N-nitrosamines, known carcinogens. The total of all compounds with the nitrogen atom with an oxidation value of -3 is Kjeldahl nitrogen (ammonia, amines, and many other organic nitrogen compounds) (Akcin et al., 2005). Generally, the processes of nitrification and denitrogenation in wastewater treatment are carried out in two separate steps because the ambient conditions of these processes are different. According to the composition of the wastewater to be treated (such as the C/N ratio and the various nitrogen forms present), as well as the desired removal efficiency, the sequence in which these processes are applied determines the sequence in which these processes are applied (Tallec et al., 2006).

The test used for measuring this metal is called a photometry test, and it is used in many wastewater investigations (not only for nitrogen compounds). Photometry is an analytical tool that makes use of light. Because different substances (analytes) absorb photons of different wavelengths to varying degrees, the wavelength (or color) of the light used for photometric analysis affects the specificity of the analytical technique for a given analyte. The specificity of an analyte can be increased by turning it into colored products through reaction with specific reagents because (together with the color) the reaction with a specific reagent is specific for the analyte (other wastewater constituents would not react at all with the reagents used for conversion of a particular analyte). The photometer measures the intensity of the light entering the cuvette (Io), as shown in Figure 3.4 as well as the intensity of the light leaving the cuvette (I) (using a photodiode or a photomultiplier). According to the Beer-Lambert law, the absorbance, i.e., log (Io/I), is linearly linked to the indophenol concentration as shown below:

$$A = \log(Io/I) = \varepsilon \cdot c \cdot l \qquad (3.9)$$

Where A is absorbance, ε is molar absorption coefficient $m^{-1}1cm^{-1}$, c is molar concentration m, l is optical path length cm. According to cuvette as shown in Figure 3.4, we can determine (Io/I)

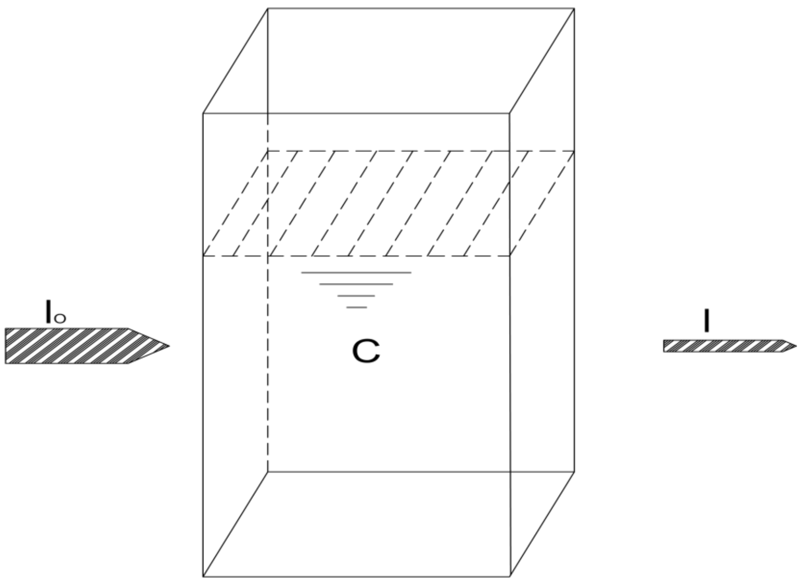

Figure 3.4 Cuvette (glass or quartz glass) contains a solution of colored material generated from the analyte and special reagents (Akcin et al., 2005).

3.3.2.10. Phosphorus

The main element of life is phosphorus. In animal feed and fertilizer, there is no substitute for its use. With waste and losses everywhere across the phosphorus life cycle, today's situation raises the specter of future supplies and environmental contamination. If phosphorus production and usage are highly efficient, alongside recycling and proper waste management, resources can be conserved and lasting phosphorus reserves are still available for future generations; the lack of phosphorus and other nutrients from wastewater pollution leads to an increase in plant and algae development (Sholtz, 2013). Metcalf & Eddy (2004) stated that in addition to supporting plant growth, phosphorus is required for algae and other biological life to flourish. There is currently a great interest in phosphorus compounds (such as phosphorus from sewage treatment plants and fertilizer runoff) entering surface waters because of noxious blooms that occur in surface waterways. The orthophosphate, polyphosphate, and organic phosphate are among the common forms of phosphorus present in aqueous solutions. There has been concern raised about nitrogen and phosphorus removal because of its effect on water clarity.

Nitrate is a danger to human health since it may cause neonatal methemoglobinemia. Activated sludge is frequently employed in wastewater treatment, although the effluent from wastewater treatment plants frequently contains residual phosphorus and nitrogen as ammonium and nitrate. Since effluent has a post-treatment process, this must be done after treatment. It is necessary to supply a carbon source to eliminate the nitrogen (Yamashita & Ikemoto, 2014). As Ragsdale (2007) stated, wastewater discharges can be the most significant source of phosphorus burden. Environmental agencies and the EPA are mandating dischargers to minimize the quantity of phosphorus in their effluent. Reducing phosphorus levels in treated wastewater will need installing further treatment. Akcin et al. (2005) stated that without phosphorus, algae and other biological organisms could not flourish. To keep surface water free of hazardous algal blooms, phosphorus compounds must be under control in wastewater discharge.

3.3.2.11. Oil and grease

A valuable consideration for waste disposal in surface waters is the number of floating particles in the waste; two types of floating matter are identified: “grease balls” particles and film-forming liquid components covering enormous areas. Wastewater floatables have many unique properties, such as being easily visible, readily transported by wind, and occasionally harboring pathogenic bacteria and viruses linked to specific particles. Colloidally dispersed oil and grease behave like other dispersed organic materials and are included in the COD, BOD, and TOC tests. A floatable oil test shows the readily separable portion. The data are beneficial in the design and operation of oil and grease separators and the efficiency of running separators. There are floatable oil and grease restrictions for wastewater discharges in several districts and cities (Clesceri et al., 1999). When the contact duration is increased, the oil and grease removal rate also increases. The longer the contract duration, the more oil molecules were added to the adsorbent's active sites. While the exposure period increases, the adsorption sites diminish as oil molecules crowd in. The number of options for removing oil and grease in wastewater depends on wastewater properties and conditions. Gravitational techniques, floating, chemical and biological treatment, and dissolved air flotation are examples of typical wastewater treatment processes. They required significant investment and ongoing upkeep. De-emulsification could be another option, despite low removal efficiency and high expense (Abdul Hamid et al., 2016).

3.3.2.12. Gases

Metcalf & Eddy (2004) pointed out that the gases nitrogen (N_2), oxygen (O_2), carbon dioxide (CO_2), hydrogen sulfide (H_2S), ammonia (NH_3), and methane (CH_4) are some of the gases often detected in untreated wastewater. Each of the first three is a standard atmospheric gas that can be found in any body of water that has been exposed to the atmosphere. The latter three are produced as a result of the decomposition of organic substances found in wastewater. They also mentioned that even though chlorine (Cl_2) and ozone (O_3) are not found in untreated wastewater gases, the environmental engineer should be familiar with them because they are used for disinfection and odor control, as well as the oxides of sulfur and nitrogen produced during the combustion process. The following are the most significant gases to be concerned about in the wastewater treatment process: N_2, O_2, CO_2, H_2S, NH_3 and CH_4 (Rabah, 2014).

3.3.2.13. Sulphur

It is a natural component of most water supplies, and the sulfate ion can also be found in wastewater. Anaerobic circumstances enable the biological reduction of sulfate to sulfide, which can then react with hydrogen to generate hydrogen sulfide (H_2S). Generic reactions such as the ones listed below are common (Akcin et al., 2005).

$$\text{Organic matter} + SO4^{-2} \xrightarrow{\text{Bacteria}} S^{-2} + H2O + CO2$$

$$S^{-2} + 2H \longrightarrow H2S$$

It is possible for the H_2S that accumulates in sewers to oxidize and form sulfuric acid, which is damaging to sewer lines (Akcin et al., 2005).

3.4. Sampling Process

3.4.1. Raw wastewater (Influent) and treated wastewater (Effluent) samples

The samples were collected as shown in Table 3.2 from the units between April 2021 and May 2021 for all wastewater treatment units. Raw wastewater and the treated wastewater samples were collected in bottles and cool plastic containers and immediately transferred to the specialized laboratory. Then, to avoid contamination and biological activities, they were held in the refrigerator at 4°C before being used in the experiment. The samples collected were analyzed for 17 wastewater parameters (BOD, COD, TSS, pH, P, N, Cr, Cu, Pb, Ni, Total N, Zn, K, Fe, and Ca) are measured in mg/l. EC, turbidity, and temperature are µs/cm, NTU, and C°, respectively. The experiments were accomplished in the laboratory of the Duhok Environmental Directorate, Duhok Governorate - Iraq.

3.4.2. Raw Wastewater (Influent) Samples Places

The three samples for the raw wastewater were collected per plant from April 2021 to May 2021 from the stations. And the samples were taken from raw wastewater before they entered the plant and were symbolled as $S_{\text{Infl.}}$ as shown in Figure 3.4

3.4.3. Treated Wastewater (Effluent) Samples Places

The three samples for the treated wastewater were collected per plant from April 2021 to May 2021 from the stations. And the samples were taken from treated wastewater after they left the plant and were symbolled as $S_{\text{Eff.}}$ as shown in Figure 3.4.

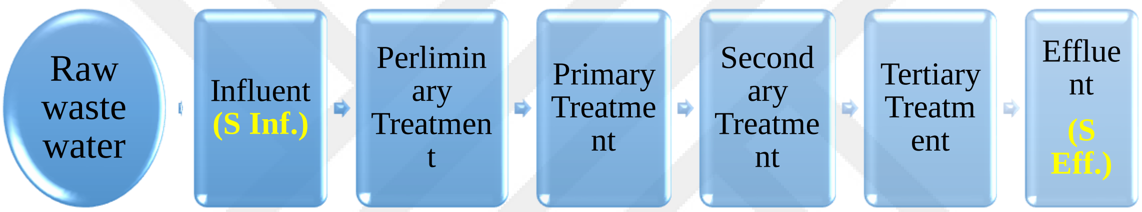

Figure 3.5 Location for the sampling, S= Sample.

3.5. Test of Samples

The samples collected from the stations, as shown in Table 3.1, are transferred in a clean bottle on a cool box at 4 C° to the laboratory of the Directorate of Environmental in Duhok Governorate for the required testing.

Fadini et al. (2004) detailed that the BOD and the COD are the two critical criteria that are routinely employed as surrogate tests for determining the amount of organic carbon released into the environment. Besides that, the research had mentioned that having the ability to measure organic and inorganic carbon in surface and groundwater was of tremendous relevance to assessing the quality of life in numerous ecosystems. Moreover, organic carbon assessment has been a rapid and straightforward approach for measuring pollution levels and the accumulation of non-biodegradable or refractory organic compounds in pollution abatement projects. Khambete et al. (2017) found the efficiency of WWTP with different effluent standards as listed in Table 3.5.

Table 3.5 Efficiency of WWTP with different effluent standards (Khambete et al., 2017)

#	Parameters	Effluent standards for different reuse					
		Gujarat pollution control board	Irrigation	Fishery	Mineral water	Reverse osmosis	Distilled water
1	Temp.	40	25	25	25	25	25
2	TDS (mg/L)	21000	1000	500	250	125	3
3	SS	100	50	25	10	5	0
4	BOD	30	15	7	3	0	0
5	COD	100	50	25	12	0	0
6	Oil & Grease	10	5	2	0	0	0
7	Chloride	600	300	150	70	35	0
8	pH	7.6	7	7	7	7	7
9	Effluent wastewater index	0.82	0.35	0.18	0.08	0.03	0.016
	Reduction with GPCB standard	0.64	0.73	0.79	0.81		
	The efficiency of WWTP in% for reuse in %	78.26	90.00	95.89	98.00		

3.5.1. The analytical method

The COD parameter was analyzed according to the Standard Methods for examining water and wastewater (APHA and AWWA) (Rodger et al., 1967). The COD concentration was estimated using the 5220 C closed reflux titrimetric method.

3.5.2 Types of equipment

1. For the BOD test, conducted by the Mantech (Auto max73),
2. For the COD test, the Hach COD Reactor is used.
3. For the heavy metals' parameters, the measurement was conducted in the laboratory by the instrument of ICP_OES.

4. RESULTS AND DISCUSSION

4.1. Introduction

In this chapter, a discussion is made through the results and outcomes in four sections. Section one gives an introduction to this chapter along with the raw wastewater sample. Then the results of characteristics of the raw wastewater samples from the selected plant are outlined in section two. The performance of the wastewater treatment plant is explained in the third section. In the fourth section, an evaluation of the wastewater treatment plant is carried out.

4.1.1. The Raw Wastewater Sample

This study took 36 raw wastewater samples between April 2021 to May 2021 for the six stations. All these samples were transferred to the Duhok Environmental directorate laboratory to do the required tests for all samples. Each sampling result is represented and evaluated separately below.

4.2. Characteristics of The Raw Wastewater and Treated Wastewater for The Stations

All investigated treatment plants were carried out in the six tested samples. Half of them had their influents, and the other half had effluents from each wastewater treatment station. In addition, 17 parameters in each sample were analyzed in the laboratory. Each parameter's results are indicated in its tables and compared according to not only effluent value but also to the standards, which are Iraqi specification standards.

4.2.1. New Zakho city unit

Table 4.1 shows the test results for New Zakho city for the six tested samples

Table 4.1 New Zakho Station test results

#	Parameters	Average Influent results	Average Effluent results	Iraqi Specification Effluent
1-	BOD (mg/l)	206.11	159.17	40
2-	COD (mg/l)	371	286.5	100
3-	Cr (mg/l)	0.105	0.095	0.1
4-	Cu (mg/l)	0.017	0.012	0.2
5-	Ca (mg/l)	12.8	11.9	450
6-	Color (Hazen)	Brown	-	Normal
7-	EC (µS/cm)	925	865	1200
8-	Fe (mg/l)	1.037	1.471	5
9-	K(mg/l)	11.7	13.4	100
10-	Ni (mg/l)	0.67	0.094	0.2
11-	Pb (mg/l)	0.098	0.105	0.1
12-	P (%)	4.7	5.1	--
13-	pH	7.85	7.9	6.4-8.0
14-	Temp. C°	22	22	-
15-	Turbidity NTU	81	78	5
16-	Total-N(mg/l)	18	21	--
17-	TSS (mg/l)	89	44	40
18-	Zn (mg/l)	0.294	0.104	2

4.2.2. Avro City

Table 4.2 shows the test results for six collected samples for Avro city.

Table 4.2 Avro city Station test results

#	Parameters	Average Influent results	Average Effluent results	“Iraqi Specification Effluent
1-	BOD (mg/l)	297.78	39.69	40
2-	COD (mg/l)	536	71.45	100
3-	Cr (mg/l)	0.084	0.081	0.1
4-	Cu (mg/l)	0.012	0.013	0.2
5-	Ca (mg/l)	11.9	10.7	450
6-	Color (Hazen)	Dark Brown	-	Normal
7-	EC (µS/cm)	925	753	1200
8-	Fe (mg/l)	0.678	0.914	5
9-	K(mg/l)	11.9	11.3	100
10-	Ni (mg/l)	0.088	0.094	0.2
11-	Pb (mg/l)	0.106	0.091	0.1
12-	P (%)	5.2	0.14	--
13-	pH	7.5	8.05	6.4-8.0
14-	Temp. C°	21	21	-
15-	Turbidity NTU	88	67	5
16-	Total-N(mg/l)	14	29	--
17-	TSS (mg/l)	142.5	59.5	40
18-	Zn (mg/l)	0.127	0.14	2

4.2.3. Azadi general hospital wastewater treatment plant

Table 4.3 shows the test results for Azadi general hospital wastewater treatment plant regarding the six collected samples.

Table 4.3 Azadi Hospital Station test results

#	Parameters	Average Influent results	Average Effluent results	Iraqi Specification Effluent
1-	BOD (mg/l)	38.16	9.4	40
2-	COD (mg/l)	72.5	4.95	100
3-	Cr (mg/l)	0.164	0.091	0.1
4-	Cu (mg/l)	0.017	0.012	0.2
5-	Ca (mg/l)	10.5	12.1	450
6-	Color (Hazen)	-	-	Normal
7-	EC (μS/cm)	1093	793	1200
8-	Fe (mg/l)	1.041	0.947	5
9-	K(mg/l)	12.7	10.2	100
10-	Ni (mg/l)	0.079	0.109	0.2
11-	Pb (mg/l)	0.093	0.047	0.1
12-	P (%)	5.7	6.7	--
13-	pH	7.85	8	6.4-8.0
14-	Temp. C°	22	22	-
15-	Turbidity NTU	109	72	5
16-	Total-N(mg/l)	23	24	--
17-	TSS (mg/l)	69.5	53.5	40
18-	Zn (mg/l)	0.176	0.207	2

4.2.4. Nojin City

For the Nojin City, Table 4.4 shows the test results for the collected samples, which are six.

Table 4.4 Nojin city Station test results.

#	Parameters	Average Influent results	Average Effluent results	Iraqi Specification Effluent
1-	BOD (mg/l)	154.17	169.17	40
2-	COD (mg/l)	277.5	304.5	100
3-	Cr (mg/l)	0.231	0.185	0.1
4-	Cu (mg/l)	0.018	0.014	0.2
5-	Ca (mg/l)	13.8	12.6	450
6-	Color (Hazen)	Dark Brown	-	Normal
7-	EC (µS/cm)	1262	1083	1200
8-	Fe (mg/l)	1.031	2.041	5
9-	K(mg/l)	12.9	11.1	100
10-	Ni (mg/l)	1.95	1.126	0.2
11-	Pb (mg/l)	0.201	0.164	0.1
12-	P (%)	4.9	5.6	--
13-	pH	7.6	7.1	6.4-8.0
14-	Temp. C°	22	22	-
15-	Turbidity NTU	135	110	5
16-	Total-N(mg/l)	29	26	--
17-	TSS (mg/l)	182.5	97.5	40
18-	Zn (mg/l)	0.14	0.129	2

4.2.5. The French Village

Table 4.5 shows the six test results for the French village.

Table 4.5 The French Village Station test results.

#	Parameters	Average Influent results	Average Effluent results	Iraqi Specification Effluent
1-	BOD (mg/l)	62.14	57.28	40
2-	COD (mg/l)	117.5	108.5	100
3-	Cr (mg/l)	0.175	0.212	0.1
4-	Cu (mg/l)	0.011	0.015	0.2
5-	Ca (mg/l)	13.5	12.4	450
6-	Color (Hazen)			Normal
7-	EC (μS/cm)	1073	1090	1200
8-	Fe (mg/l)	1.147	2.354	5
9-	K(mg/l)	14.1	11.3	100
10-	Ni (mg/l)	0.954	1.981	0.2
11-	Pb (mg/l)	0.114	0.125	0.1
12-	P (%)	5.1	6.9	--
13-	pH	7.29	6.72	6.4-8.0
14-	Temp. C°	23	23	-
15-	Turbidity NTU	120	115	5
16-	Total-N(mg/l)	22	27	--
17-	TSS (mg/l)	135	122.5	40
18-	Zn (mg/l)	0.102	0.115	2

4.2.6. MRF Apartment

Table 4.6 shows the test results for the MRF apartment for six samples collected from the station.

Table 4.6 MRF Apartment Station test results.

#	Parameters	Average Influent results	Average Effluent results	Iraqi Specification Effluent
1-	BOD (mg/l)	51.67	16.19	40
2-	COD (mg/l)	93	29.15	100
3-	Cr (mg/l)	0.314	0.238	0.1
4-	Cu (mg/l)	0.034	0.024	0.2
5-	Ca (mg/l)	9.4	11.3	450
6-	Color (Hazen)			Normal
7-	EC (μS/cm)	1451	1165	1200
8-	Fe (mg/l)	1.152	1.034	5
9-	K(mg/l)	13.4	12.9	100
10-	Ni (mg/l)	1.025	0.874	0.2
11-	Pb (mg/l)	0.108	0.139	0.1
12-	P (%)	6.4	5.9	--
13-	pH	7.22	7.4	6.4-8.0
14-	Temp. C°	22	22	-
15-	Turbidity NTU	139	131	5
16-	Total-N(mg/l)	34	31	--
17-	TSS (mg/l)	153.5	145.5	40
18-	Zn (mg/l)	0.134	0.214	2

4.3. Performance of Wastewater Treatment Plant

We can see from the collected data from the Duhok Investment directorate that we have more than 50 residential complex projects; some of them are finished, and the rest are ongoing and under construction. These projects must have wastewater treatment plants in accordance with the guidance from the local authorities. Mizzouri et al. (2020) stated similar results as shown in Figure 4.3 the effluent wastewater for 22 projects overall Duhok governorate. The maximum rate was 4,500 m^3 per day for Avro city. More than 3,000 apartments have been finished and handed over to the owner. In contrast, War City has 2,100 m^3 per day for 1,400 apartments concluded and are handed over to the owners. Tables 4.7, 4.8, and 4.9 show the results of these study stations.

Table 4.7 Raw water (Influent) average samples analysis results.

#	Parameters	New Zakho Inf.	Avro City Inf.	AzadiGen. hospital Inf.	Nojin City Inf.	French Village Inf.	MRF Apartment Inf.
1-	BOD (mg/l)	206.11	297.78	38.16	154.17	62.14	51.67
2-	COD mg/l	371	536	72.5	277.5	117.5	93
3-	Cr mg/l	0.105	0.084	0.164	0.231	0.175	0.314
4-	Cu mg/l	0.017	0.012	0.017	0.018	0.011	0.034
5-	Ca (mg/l)	12.800	11.900	10.500	13.800	13.500	9.400
6-	Color (Hazen)	-	-	-	-	-	-
7-	EC-µS/cm	925.0	925.0	1,093.0	1,262.0	1,073.0	1,451.0
8-	Fe mg/l	1.037	0.678	1.041	1.036	1.147	1.142
9-	k mg/l	11.700	11.900	12.700	12.900	14.100	13.400
10-	Ni mg/l	0.067	0.088	0.079	1.950	0.954	1.025
11-	Pb mg/l	0.098	0.106	0.093	0.201	0.114	0.108
12-	P (%)	4.700	5.200	5.700	4.900	5.100	6.400
13-	pH	7.850	7.500	7.850	7.600	7.290	7.220
14-	Temp. C°	22	24.3	25	25.5	25.1	26.2
15-	Turbidity NTU	81.000	88.000	109.000	135.000	120.000	139.000
16-	Total-N	18.0	14.0	23.0	29.0	22.0	34.0
17-	TSS mg/l	89	142.5	69.5	182.5	135	153.5
18-	Zn mg/l	0.294	0.127	0.176	0.140	0.102	0.134

Table 4.8 Effluent average samples analysis results.

#	Parameters	New Zakho Eff.	Avro City Eff.	Azadi Gen. Hospital Eff.	Nojin City Eff.	French village Eff.	MRF Apartment Eff.
1-	BOD (mg/l)	159.167	39.69	4.95	169.17	57.28	16.19
2-	COD mg/l	286.5	71.45	9.4	304.5	108.5	29.15
3-	Cr mg/l	0.095	0.081	0.091	0.185	0.212	0.238
4-	Cu mg/l	0.012	0.013	0.012	0.014	0.015	0.024
5-	Ca (mg/l)	11.9	10.7	12.1	12.6	12.4	11.3
6-	Color(Hazen)	-	-	-	-	-	-
7-	EC-µS/cm	865	753	793	1083	1090	1165
8-	Fe mg/l	1.471	0.914	0.947	2.041	2.354	1.034
9-	k mg/l	13.4	11.3	10.2	11.1	11.3	12.9
10-	Ni mg/l	0.094	0.094	0.109	1.126	1.981	0.874
11-	Pb mg/l	0.105	0.091	0.047	0.164	0.125	0.139
12-	P (%)	5.1	5.9	6.7	5.6	6.9	5.9
13-	pH	7.9	8.05	8	7.1	6.72	7.4
14-	Temp. C°	26.1	27.3	27	25.2	25.5	25.4
15-	Turbidity NTU	78	67	72	110	115	131
16-	Total-N	21	29	24	26	27	31
17-	TSS mg/l	44	59.5	53.5	97.5	122.5	145.5
18-	Zn mg/l	0.104	0.14	0.207	0.129	0.115	0.214

Table 4.9 Comparing the Influent and Effluent results to the Iraqi standards

#	Parameters	Influent analysis results				Effluent analysis results				Iraqi standard
		Ave	M	M	S	Avera	Ma	Min	SD	
1-	BOD(mg/l)	135.	29	38	10	74.4	169	4.9	71.	40
2-	COD mg/l	244.	53	72	18	134.9	304	9.4	129	100
3-	Cr mg/l	0.2	0.	0.	0.	0.2	0.2	0.1	0.1	0.1
4-	Cu mg/l	0.01	0.	0.	0.	0.015	0.0	0.0	0.0	0.2
5-	Ca (mg/l)	12.0	13	9.	1.	11.8	12.	10.	0.7	450
6-	Color (Hazen)	-	-	-	-	-	-	-	-	Normal
7-	EC-µS/cm	1,12	1,	92	20	958.2	1,1	753	175	1200
8-	Fe mg/l	1.0	1.	0.	0.	1.5	2.4	0.9	0.6	5
9-	k mg/l	12.8	14	11	0.	11.7	13.	10.	1.2	100
10-	Ni mg/l	0.7	2.	0.	0.	0.7	2.0	0.1	0.8	0.2
11-	Pb mg/l	0.1	0.	0.	0.	0.1	0.2	0.0	0.0	0.1
12-	P (%)	5.3	6.	4.	0.	6.0	6.9	5.1	0.7	--
13-	pH	7.6	7.	7.	0.	7.5	8.1	6.7	0.5	6.4-8.0
14-	Temp. C°	26.1	27	27	25	25.5	25.	25.	0.9	-
15-	Turbidity NTU	112.	13	81	23	95.5	131	67.	26.	5
16-	Total-N	23.3	34	14	7.	26.3	31.	21.	3.6	--
17-	TSS mg/l	128.	18	69	42	87.1	145	44.	41.	40
18-	Zn mg/l	0.2	0.	0.	0.	0.2	0.2	0.1	0.0	2

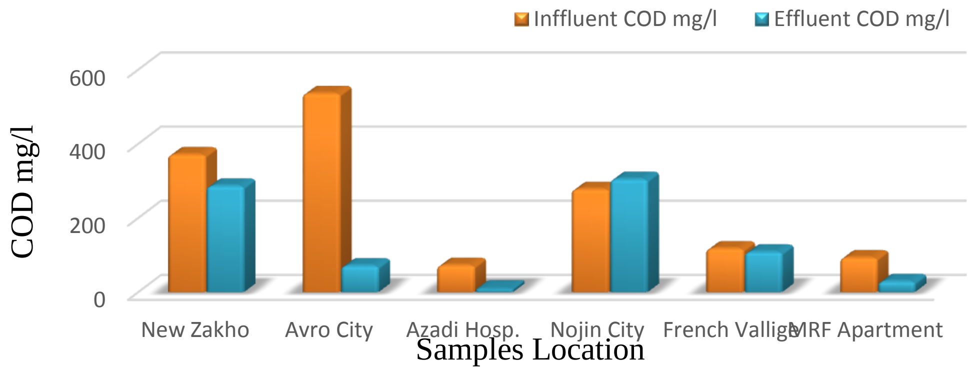

Figure 4.1 Average COD comparing for the influent and effluent for the stations.

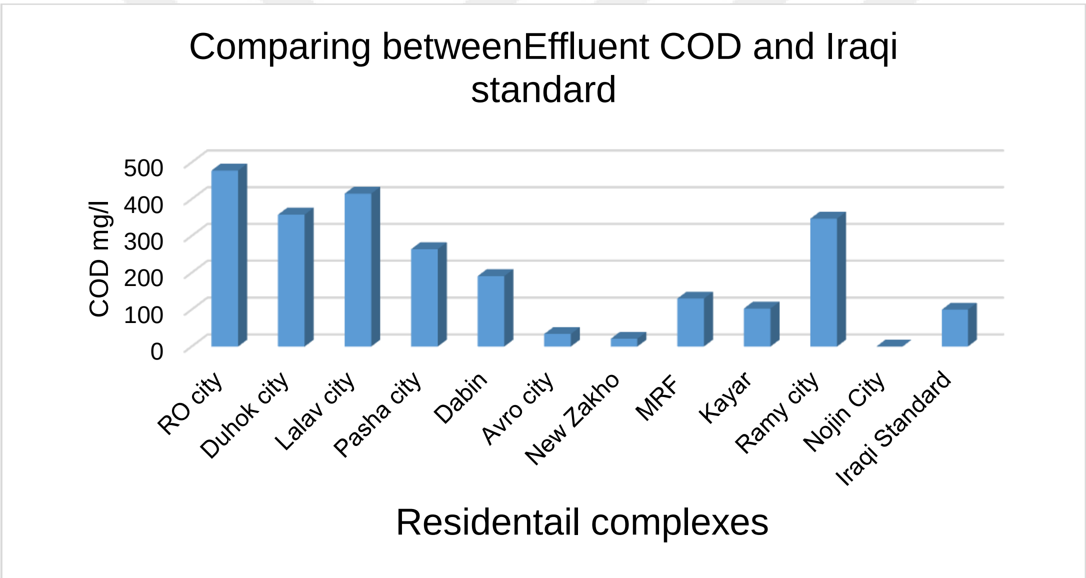

Figure 4.2 Comparing between effluent COD and Iraqi standards (Mizzouri et al., 2020)

Based on the results previewed in Figure 4.1, we can see the effluent COD parameter collected from six wastewater treatment stations and according to the acceptable Iraqi standard, most of the COD values for effluent over the acceptable Iraqi standard for COD 100 mg/L unless for the Avro city project, which is 71.45 mg/l. Compared to Mizzouri et al. (2020), Figure 4.2 effluent COD, we can see that the similarity of all of them exceed the limits and Nojin city neglected due to the highest result wich is 1720 mg/l , unless Avro city with 34 mg/l and New Zakho with 21.4 mg/l.

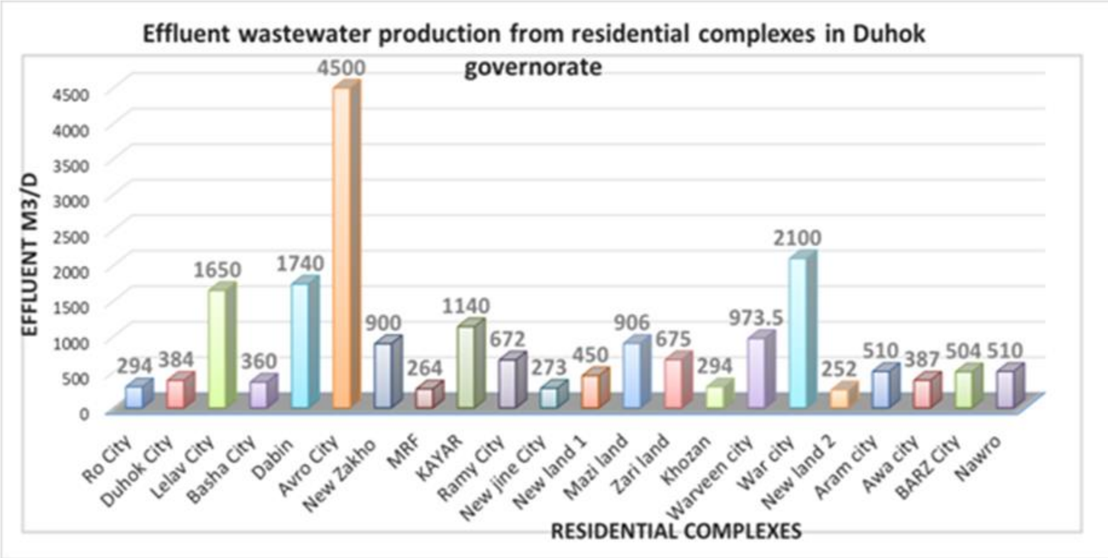

Figure 4.3. The wastewater effluent for a residential apartment in Duhok governorate (Mizzouri et al., 2020).

In this study, the maximum value for the COD effluent can be found in Nojin city, which is 304.5 mg/l, while in Avro city, the number of COD can only be observed from 536 mg/l to 71.45 mg/l, and this means that the station works. The rest does not work correctly, and the effluent in Figure 4.1 shows the COD for the stations. But for the BOD effluent, found that the max. value for Nojin city and Avro city decreased from 206.11 mg/l to 39.69 mg/l, which means that under the Iraqi standard, the rate is 40 mg/l as shown in Table 4.8.

As for the heavy metals, all are within the Iraqi standards, but in parameter, TSS exceed for all stations. Also, the turbidity shows the same result exceed for all stations, as shown in Table 4.9.

And comparing the COD levels of the samples from the stations of wastewater treatment plants and Iraq's water quality requirements criteria as shown in Figure 4.1, while Azadi hospital, Nojin city and MRF apartment stations do not work, and most of the effluent value of COD override Iraq's standards that is COD 100 mg/l except Avro city station that is under Iraq's standards. The rest are not working, as shown in Figure 4.1.

When compared to the standard, the results in influent and effluent samples for the WWTP do not match with the reasonable results or with the standards; this refers to the fact that the sewerage system (kitchen, bath, WC, and laundry) flow does not connect to the WWTP, the WWTP does not work efficiently and finally may be there is some other pipe connection to the stations.

As a result, further research on the principle of reducing pollution through wastewater treatment techniques is required. According to this, there are numerous reasons why these stations are unable to produce the quality of effluent required to meet guidelines and standards. As a result, the vast majority of these failures are as follows:

1. There is no much collaboration between the owners and the local authorities regarding the WWTPs' performance on environmental criteria.
2. Around 65% of the wastewater treatment plants selected were not in compliance with environmental standards. A certain amount of carelessness is apparent among the partners.
3. The design capacity of the wastewater treatment plants is insufficient for treating the influent raw wastewater.
4. There are not enough qualified operators to keep wastewater treatment stations running performance efficiently.
5. The needed maintenance for these plants is insufficient, and it may have been gone ignored.
6. The majority of the wastewater treatment plant's parameters are outside of allowed limits.
7. No more accurate data for redesigning or updating the stations adequate for working are available.
8. There is no follow-up from the local authorities to the plants to regulate the situation and prepare a report for the owner to rectify the concerns to ensure that everyone is safe.
9. To improve the quality of wastewater and determine the effects of untreated wastewater discharge.

4.4. Evaluation of Wastewater Treatment Plant

d updating the existing treatment plant's performance review is critical to determine whether the current effluent quality can withstand organic loadings while still meeting the treatment criteria. Furthermore, the grade of BOD, COD, and suspended particles, which indicate organic pollutants, is used to assess the efficiency of a wastewater treatment plant's performance to determine its efficiency.

To be more transparent, the work that has been completed to this point provides a positive sign and shows that a favorable working environment is on the horizon.

And as a result, we can achieve our objectives through this type of study and research while also reducing the gap between what we desire and need. Nevertheless, when evaluating wastewater treatment plants, it is necessary to consider different factors simultaneously.

5.CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The increasing population in the Duhok governorate and the influx of refugees and internally displaced persons (IDPs) would increase wastewater (of all types) and sludge, which will harm the environment. BOD, COD, TSS, pH, color, and other metrics related to wastewater characterization which were collected from the Directorate of Environment in Duhok and used to characterize the existing wastewater treatment plant. Based on the information we have gathered from our site visits to the stations, it is concluded that the stations' operation falls short of standard criteria. More site inspections, workshops, and seminars for all partners are needed to improve operations. And we must upgrade these stations and conduct a new assessment of the management standards, among other things.

The WWTP can illustrate how wastewater treatment plants contribute to the COVID-19 pandemic and to what extent we can use the data from the station to provide feedback to local authorities, researchers, and research centers to serve as a source for this type of pandemic.

Also, the influence of management on the development of wastewater treatment plants is not to be forgotten, which can be strengthened through regular meetings with plant partners, by attending regular visits, workshops, seminars, and keeping up to date with the latest technology, as well as feedback on the new updates between the local authorities and the plant owners.

5.2. Recommendations

Regarding this study and other researchers’ articles, we recommend the following points to help and to add a forwarded step for the future and to minimize the impact on the environment as:

1- Improving collaboration between the local government and the project owner is a priority.
2- Improving the overall performance of the existing WWTPs.

3- The wastewater treatment plants should be redesigned to perform more efficiently, with reliable data for the influent and a good specification for the effluent.
4- Increase the number of workshops for operators by providing them with the most recent technological updates.
5- Enhance the understanding of the terms "operations" and "maintenance" among all involved employees.
6- There is a need to conducting a new survey of the existing plants in order to detect and resolve any concerns that have arisen.
7- It is vital to enhance the acceptance of employing a new power source by using plant gas emissions.
8- Researchers and local authorities exchange acknowledgments in a collaborative effort.
9- Minimizing the wastewater consequences on the environment, elimination of pollutants, toxicants, and many such, and making it more usable for other purposes.
10- Enhancing the local authority and the stakeholders to the risks of untreated wastewater.
11- Raising environmental awareness in the community.

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(Genişletilmiş Türkçe Özet)

EXTENDED TURKISH SUMMARY

KÜÇÜK BOYUTLU ATIKSU ARITMA TESİSİ ÇEVRESEL PERFORMANSININ DEĞERLENDİRİLMESİ

MUSTAFA, Nawzad Hussein
Yüksek Lisans Tezi, Cevre Mühendisliği Anabilim Dalı
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ÖZET

Evler, fabrikalar, sanayi ve tarımsal faaliyetler gibi çeşitli alanlarda kullanılan suyun talebi artmaktadır. Bu talebin karşılanması için hem temiz su kaynaklarının hem de atıksu yönetiminin dikkatlice planlanması gerekmektedir. Öte yandan, hazırlıksız nufüs artışınının olması örneğin ülke içi veya ülke dışından göç edenlerin çoğalmasıyla nüfusu artan Duhok valiliğinde olduğu gibi planlanmayan durumlarda olabilmektedir. Öngörülemeyen nufüs artışı hem su ihtiyacının artmasına hem de atıksu miktarınında artmasına neden olmaktadır. Ekosistemin korunması, arıtılmış suyun kullanılmasıyla sosyoekonomik yapının gelişimine destek olması gibi nedenlerden dolayı atıksu arıtma tesislerinin uygun şekilde işletilmesi önemlidir.

Bir atıksu arıtma tesisinin (AAT) performansı, atıksuyun fiziko-kimyasal ve biyo-kimyasal özelliklerindeki değişimi incelenerek değerlendirilir. AAT deki her ünitenin varlığı, çalışma prensibi ve işletme biçimi çıkış suyu kalitesini etkilemektedir. Bu nedenle AAT verimliliği değerlendirilirken, AAT’nin sahip olduğu üniteleri de değerlendirmek gerekir. AAT'den çıkan arıtılmış suyun kalite değerlendirilmesinde ise arıtılmış suyun kullanılması düşünülen sektöre uygunluğunun değerlendirilmesi gerekir. Bu tez, küçük boyutlu atıksu arıtma tesislerindeki mevcut durumun tespiti, tekrar kullanım için arıtma verimliliğinin artırılmasına yardımcı olacak önerileri içermektedir.

Anahtar Kelimeler: Atıksu arıtma tesisi, ülke içinde yer değiştirenlerin kampları, Mülteci kampları, Duhok valiliği.

1.GİRİŞ

1.1. Genel

Evler, fabrikalar, sanayi ve tarımsal faaliyetler gibi çeşitli alanlarda kullanılan suyun talebi artmaktadır. Bu talebin karşılanması için hem temiz su kaynaklarının hem de atıksu yönetiminin dikkatlice planlanması gerekmektedir. Öte yandan, hazırlıksız nufüs artışınının olması örneğin ülke içi veya ülke dışından göç edenlerin çoğalmasıyla nüfusu artan Dohuk valiliğinde olduğu gibi planlanmayan durumlarda olabilmektedir. Öngörülemeyen nüfus artışı hem su ihtiyacının artmasına hem de atıksu miktarının da artmasına neden olmaktadır. Ekosistemin korunması, arıtılmış suyun kullanılmasıyla sosyoekonomik yapının gelişimine destek olması gibi nedenlerden dolayı atıksu arıtma tesislerinin uygun şekilde işletilmesi önemlidir.

Ekosistem ve sağlık üzerine olumsuz etkileri nedeniyle atıksuların arıtımıyla ilgili yapılan bilimsel çalışmalar zamanla yerini hızlı, ekonomik ve yeniden kullanabilir çıkış suyu kalitesi veren sistemlerin geliştirilmesine bırakmıştır. Mevcut atıksu arıtma teknolojilerinin tasarımı ve çalışma prensibi kirletici miktarına bağlıdır. Eğer sistemin ölçüm değerlerinin altında yani çok küçük oranlarda kirleticiler söz konusu ise uygulanan arıtma teknolojisi bu kirleticilerin giderimi için uygun olmayacaktır. Bu nedenle atık suyun kalitesi sağlık ve çevresel etkileri bakımından dikkatlice incelenmelidir. Aynı zamanda atıksuyun kalitesindeki kötüleşme toplumsal kaygıyı da paralelinde artırabilir. Toplum sağlığı ve ekolojik konuların ele alınmasını sağlamak için toplumla bir diyalog başlatmak zorunludur (Metcalf & Eddy, 2004).

Atıksu arıtımı, atıksudan kirleticilerin uzaklaştırılması ve çevre üzerindeki etkiyi en aza indirmek için suyun tekrardan su döngüsüne uygun kalitede geri dönmesi amacıyla veya çeşitli amaçlarla yeniden kullanılacak arıtılmış suya dönüştürmek için kullanılan bir süreç olarak tanımlanabilir. Kordrostami (2015), atıksu arıtma tesisleri olarak bilinen farklı proseslere sahip tesislerde atıksu arıtımının yapıldığını açıklamaktadır. Her proje, yerel yönetim, halk, hukuk müşaviri veya mal sahibinin bir sorunu tanımlamasıyla başlar; tasarım uzmanı, konsept geliştirme ve değerlendirme aşaması boyunca problem çözme faaliyetine dahil olur.

Evsel, endüstriyel, ticari ve kamu kullanıcıları tarafından kullanılan atıksular toplanır, taşır, arıtır ve bertaraf edilir (Grigg, 2012). Su sağlama tesislerinde olduğu gibi, atıksu arıtımıda üç kategori de gerçekleşir. Bunlar:

1) Fiziksel prosesler (eleme, karıştırma, flokülasyon, çökeltme, flotasyon, filtrasyon, gaz transferi),

2) Kimyasal prosesler (çökeltme, adsorpsiyon, dezenfeksiyon),

3) Biyolojik prosesler (aktif çamur, damlatma filtresi, stabilizasyon havuzu gibi çeşitli biyolojik prosesler).

Dr. Zaher (1998) evsel atık suların içeriğinin aşağıdaki parametreler olarak ifade etmiştir. Bunlar:

I. Oksijen ihtiyacı (BOD/COD) tarafından belirlenen organik malzemeler,

II. Askıda katılar (AKM)

III. Ağır metaller,

IV. Patojenik organizma,

V. Azot (N),

VI. Fosfor (P).

1.2. Küçük Atıksu Arıtma Tesisi

Son on yılda, Avrupa Birliği (AB) atık su arıtımında nitrojen giderimi için yeni ve daha katı kurallar yayınlamıştır. 20 mg/L'lik azot standardı yeni AB Direktifi ile 20.000 p.e. (nüfus eşdeğeri)'den fazla olan büyük AAT için yıllık 10 mg/L azot, 20.000 p.e. 'den küçük AAT için 15 mg/L olarak verilmiştir (Fikar, 2001). Büyük artıma tesislerine göre küçük tesislerde tek havuz kullanılır, havalandırma sırasında oksijen yüzey türbininden sağlanır (Fikar, 2001).

Bu tez çalışmasında; Duhok valiliğinde bulunan küçük yerleşim yerlerine ait olan ve veya merkezi kanalizasyon hattından uzak olması nedeniyle hatta bağlanmamış kendi arıtması olan apartmanlara ait küçük arıtma tesisleri incelmemiştir. İncelenen tesis sayısı altı adettir.

1.3. Sorun Bildirimi

Bu çalışma, atıksuyun çevreye olan etkisinin en aza indirilmesini, arıtma prosesi için model bir yaklaşım belirlenmesini, arıtılmamış atıksuların çevrede yarattığı sorunları değerlendirmeyi ve işletmeyi iyileştirmeyi, atıksu arıtma tesisi yönetimini, doğru tip ve seçimi yapmayı amaçlamıştır.

1.4. Kapsam

Bu çalışma, çalışma kapsamında Irak'ın kuzeyinde yer alan (Enlem.36.8, Boylam 43) ve üç ülkeye (Türkiye, Suriye ve İran) komşu olan Dohuk Valiliğine bağlı bölgede gerçekleştirilmiştir. Bu şehir, bölge için tarım ve turizm faaliyetleri gibi ekonomik ve ticari yönüyle son derece önemli bir konumdadır (Şekil 1.1) (Abdullah vd., 2019).

1.5. Amaç

Önerilen çalışmanın amaçları şunlardı:

1. Duhok valiliğinde bulunan küçük ölçekli arıtma tesislerindeki mevcut durumunun tespiti.

2. Atıksu arıtma tesisinin işletilmesi ve işletmenin iyileştirilmesi için gerekenlerin irdelenmesi,

3. Pandemi döneminde küçük ölçekli atıksu arıtma tesisi yönetiminin nasıl etkilendiğinin araştırılması,

5. Arıtılmış suyun kalitesini iyileştirme için yönetim açısından iyileştirme önerileri araştırılmıştır.

1.6. İşin Yeniliği

Duhok vilayetindeki küçük ölçekli atık su arıtma tesislerinin çevre yönetiminin değerlendirilmesi henüz belgelenmemiştir. Ek olarak, mevcut atıksu arıtma tesisleri ile ilgili daha fazla veri mevcut değildir ve tesislerin aşamalarını iyileştirmek ve tüm çalışma detaylarını belgelemek için değerlendirme yapılmıştır. Bu çalışma ile eksik olan bu bilgilerin literatüre kazandırılması, toplumdaki endişeyi giderecek ve çevreye en az zarar verecek şekilde işletilmesi için öneriler sunmaktır.

1.7 .Tezin Yapısı

Bu tez (Beş) bölümden oluşmaktadır. Birinci bölüm, çalışmanın arka planı, problem durumu, çalışmanın amaçları, kapsamı, çalışmanın yeniliği ve tezin yapısı olarak hizmet vermektedir.

İkinci Bölüm, ön arıtma, birincil arıtma, ikincil arıtma, üçüncül (dezenfeksiyon) arıtma, depolama, üretilen çamur, yönetim ve atıksu arıtma tesisi verimliliği dahil olmak üzere atık su arıtma tesisi ünitelerinin özellikleri hakkında bir giriş ve ayrıntılı literatür incelemesi ve teorik arka plan sağlar. Bölümün son kısmı, tüm bölümün özetini tartışır.

Üçüncü Bölüm, çalışmanın metodolojisinden, saha tanımından, atık su örneklemesinden, atıksu için örnekleme sürecinden, analitik yöntemlerden oluşmaktadır.

Dördüncü Bölüm, incelenen altı tesise ait atıksuların özellikleri ve atıksu arıtma tesisinin arıtmaya ilişkin kirletici giderimlerinin değerlendirilmesinden oluşmaktadır.

Beşinci bölümde, gelecekteki çalışmalar için sonuçlar ve öneriler özetlenmiştir.

2.MATERYAL VE YÖNTEM

2.1. Giriş

Bu bölümde, çalışmada kullanılan metodolojiler ayrıntılı olarak açıklanmıştır. Bu bölümde yedi alt bölüm ele alınmıştır. Girişi içeren birinci alt bölümden sonra, çalışmanın metodolojisini açıklandığı ikinci bölüm ele alınmıştır. Ayrıca, üçüncü bölümde saha tanımı ve numune alma süreci dahil olmak üzere atık su numunelerinin toplanmasından bahsedilmiştir. Son olarak, dördüncü bölüm, bu çalışmanın temel aldığı analitik yöntemleri gösterdi.

2.2. Atıksu Numunesinin Alınması

2.2.1. Site açıklaması

Çalışma alanı Kuzey Irak'ta (K 36˚ 52′ 03″, D 42˚ 59′ 34″) yer alan Duhok vilayetine aittir. Şekil 3.2'de gösterildiği gibi üç ülkeye sınırı vardır: Türkiye, İran ve Suriye (Abdullah ve diğerleri, 2019). Duhok Governorate-Wikipedia web sitesine (https://en.wikipedia.org/wiki/Duhok_Governorate) göre 2018 yılında tahmini nüfus 1 292.535 ve alan yaklaşık 10.955,91 km^2 idi.Istasyonun koordinasyonunu göstermektedir; sırasıyla Duhok Valiliği'ndeki tesislerin atıksu arıtma kapasitesi hakkında bilgi vermektedir.

2.2.1.1. Yeni Zakho şehir birimi

Yeni Zakho şehir birimi, Zakho bölgesinin kapısında yer almaktadır; 2011 yılında inşa edilmiştir. İstasyon kapasitesi yaklaşık 6.000 m^3/d'dir. Fiziksel arıtma, havalandırma, dengeleme, çökeltme, ihtiyaçlarına göre depolama ve geri kalan arıtılmış atıksuların mansap kanalına salınmasından oluşan kompakt bir ünitedir.

2.2.1.2. Avro şehri

Avro şehir istasyonu, Duhok ile Türkiye'yi birbirine bağlayan ana yol üzerinde yer almaktadır; 2007 yılında inşa edilmiştir. Tesisin kapasitesi yaklaşık 6.000 m^3/d'dir ve bu kompakt ünite gösterildiği gibi ızgaralar, havalandırma, dengeleme, çöktürme, depolama ve Hishkarow nehrine bırakılan arıtılmış atık suyun geri kalanından oluşmaktadır.

2.2.1.3. Azadi genel hastanesi

Tablo 2'de açıklandığı üzere Duhok il merkezinde bulunan Azadi genel hastanesi atıksu arıtma tesisi hastane için yapılmıştır. Hastane ve tesis içinde yer alan bu tesis, 1984 yılında inşa edilmiştir. Tesis kapasitesi 5.000 m^3/gün olup, ızgara kanallarından oluşmakta ve 3 faz fonksiyonu, havalandırma ve çökeltme, dengeleme, ardından depolama veya akış aşağı kanala salma işlemlerini gerçekleştirmektedir.

2.2.1.4. Nojin şehri

Bu yerleşim, halka açık bir alanda apartman olarak inşa edilmiştir. Duhok semtindeki Baroshki mahallesindeki bu yeni bir altyapı 2015 yılında inşa edilmiştir. Tesisin kapasitesi yaklaşık 3.000 m^3/d'dir ve kompakt bir ünite olarak inşaa edilmiştir. Arıtılmış su ana kanala bırakılmaktadır.

2.2.1.5. Fransız Köyü

Duhok semtinde bulunan en modern ve en yeni köydür. 2019 yılında inşaatı başlamış, henüz bitmemiştir. Tesisin kapasitesi yaklaşık 10.000 m^3/gün olup, gösterildiği gibi kompakt ünitelerden oluşmakta olup ve çıkış suyu Hishkarow nehrine bırakılmaktadır.

2.2.1.6. MRF daire

Bu daire Duhok şehir merkezinde yer almaktadır ve 2010 yılında inşa edilmiştir. Tesisin kapasitesi yaklaşık 3.000 m^3/d'dir. gösterildiği gibi kompakt ünitelerden oluşmakta olup ve çıkış suyu Hishkarow nehrine bırakılmaktadır.

2.3 Atıksu Arıtma Parametrelerinin Tanımı ve Ölçümü

2.3.1 Fiziksel parametreler

2.3.1.1. Katılar

Her atık su örneğinde, katılar ölçülmesi gereken önemli bir bileşendir. Atık su deşarjında bulunan katı kirleticiler, alıcı bir akışa yerleştirilen tortu yüküne eklenir. Katılar iki geniş kategoride sınıflandırılabilir: askıda ve çözünmüş. Birkaç örneğe daha bakalım. 0.45-1.2 µm'lik bir filtre, bir numuneden filtrelenen herhangi bir şeyi çıkarırsa, askıda katıları kaydeder. Filtreden geçen bir bileşen, çözünmüş bir katıdır. Uçucu katılar, çözünmüş ve askıda katılar sınıflandırması altında sabit katılardan ayrılır. 550°C'lik bir sıcaklıkta uçucu maddeler yanacak, ancak sabit katılar yanmayacaktır (Ellis, 2004).

Sınıflandırmaları aşağıdaki gibidir:

* Atık sudaki toplam katılar,
* Uçucu katılar,
* Sabit katılar,
* Askıda katı maddeler,
* Uçucu askıda katı maddeler
* Sabit askıda katılar,
* Çözünmüş katılar.

2.3.1.2. Bulanıklık

Su berraklığı tipik olarak bulanıklığı ile değerlendirilir. Bulanıklıkta, askıda kalan maddeler ışık absorpsiyonu veya saçılması için bir ortam görevi görür. Bu özellikler absorpsiyon ve saçılmayı etkiler ve bulanıklık ölçümü içme suyunun kalitesi için hayati önem taşır. Yeniden kullanılan atık su miktarı ölçülmelidir. UV'nin atık su çıkışını dezenfekte etmede başarılı olması için UV ışığının akış akışına girmesi gerekir. Bulanıklık, numune tarafından saçılan ışığın standart bir çözeltiye oranı değerlendirilerek değerlendirilir. NTU ölçüm birimidir (Akçın vd., 2005).

2.3.1.3 Renk

Saf suyun rengi yoktur. Atıksuda, arıtma rengi sadece belirtilen atıksuyun bir göstergesi olarak kullanılır. Açık kahve rengimsi gri atıksu tazedir ve atıksu sırayla griden koyu griye ve ardından siyaha döner (Steinmetz, 2013)

2.3.1.4. Sıcaklık

Sıcaklık kritiktir çünkü kimyasal süreçleri, sudaki yaşamı ve sudaki oksijen gibi önemli gazların çözünürlüğünü etkiler. Atık suyun sıcaklığını ölçmek için geleneksel bir cıva termometresi veya dijital termometre kullanılabilir.

2.3.1.5.Kokular

Atık su söz konusu olduğunda, kokular, özellikle atık su arıtma tesisinin yakınında yaşayan insanlar için büyük bir endişe kaynağıdır. Bu kokuların kaynağı, atık suya eklenen organik artıkların veya bileşiklerin ayrışmasıdır. Taze atık su kokusu, anaerobik ayrışma yaşayan atık sudan daha az rahatsız edicidir. Septik atık su, sülfatı sülfüre dönüştüren anaerobik mikropların neden olduğu eşsiz sülfit kokusuyla ünlüdür. Bir numuneyi kokusuz su ile en az saptanabilir koku düzeyine ulaşılana kadar seyreltmek, suda rahatsız edici aromalar üretmekten sorumlu kötü kokulu kimyasalların belirlenmesine olanak tanır. Bu, TON (Eşik Koku Numarası) harfi ile kaydedilir. Hidrojen sülfür, amonyak, merkaptanlar vb. dahil olmak üzere mevcut herhangi bir gaz monitörü kullanılarak atık sudan havaya boşaltılan kötü kokulu gazların konsantrasyonunu ölçmek mümkündür (Akçın ve diğerleri, 2005).

2.3.2. Kimyasal Parametreler

2.3.2.1. Alkalinite

Asidi nötralize etme veya hidrojen iyonlarını emme yeteneğine alkalinite denir. Sudaki asit nötrleştirici bazların toplam sayısı. Atık sudaki alkalilik, belediye ve endüstriyel atık suları içeren çeşitli katkı unsurlarından büyük ölçüde etkilenir. Bu liste, çözünmüş inorganik ve organik bileşikleri, askıda organik maddeyi, pH seviyesini ve serbest hidroksil alkalinitesinin varlığını veya yokluğunu içerir (Marietta, 2014).

2.3.2.2. pH

pH, hidrojen iyonu konsantrasyonunun negatif logaritması olarak tanımlanır (pH= -log10 [H+]). Hem doğal su hem de atık sudaki hidrojen iyonlarının konsantrasyonu önemli bir nitelik kriteridir. Organizmaları korumak için atık suyun pH'ı 6 ile 9 arasında kalmalıdır. Bir çözeltinin pH'ını etkileyen asitler ve diğer kimyasallar arıtma tekniklerini etkisiz hale getirebilir (Akçın ve diğerleri, 2005). Atık su arıtımı sırasında aktif biyokütle tarafından oluşturulan asitlere karşı koymak için atıksuda yeterli alkalinite bulunması gerekmektedir. Alkalinite nedeniyle atık su arıtımı için doğru çıkış pH'ının sağlanması kritik öneme sahiptir (Marietta, 2014).

2.3.2.3. Çözünmüş Oksijen (DO)

Suda çözünmüş moleküler oksijen miktarına çözünmüş oksijen denir. Aerobik bakterilerin solunumu için gereklidir. Öte yandan su, oksijende sadece küçük bir çözünürlüğe sahiptir. Bir çözeltide bulunabilecek ve güvenilebilecek gerçek oksijen (ve diğer gazlar) miktarı aşağıdaki gibidir:

- Gazın atmosferdeki kısmi basıncı.
- Gazın çözünürlüğü.
- Sudaki safsızlıkların konsantrasyonu (ör. tuzluluk, askıda katı maddeler vb.).
- Sıcaklık.

2.3.2.4. Biyokimyasal Oksijen İhtiyacı (BOİ)

Oksijen ihtiyacını belirlemek için yaygın olarak kullanılan üç teknik vardır. Birkaç ölçüm doğrudan oksijen talebini ölçer: biyokimyasal oksijen talebi (BOİ) ve kimyasal oksijen ihtiyacı (KOİ) ve toplam organik karbon (TOC) yaklaşımı, dolaylı oksijen talebini ölçmek için üçüncü bir yöntemdir (Wayne, 2006). Organik maddeleri parçalayan biyolojik aktiviteler tarafından beş gün içinde tüketilen çözünmüş oksijen miktarı (Nicholas, 2002)Organik maddelerin biyokimyasal oksidasyonu sırasında mikroorganizmaların tükettiği çözünmüş oksijen miktarının 20 C°'de 5 günlük bir süre boyunca ölçülmesiyle değerlendirilir (Rabah, 2014).

Metcalf ve Eddy (2004), 5 günlük $BOİ_5$'in en yaygın kullanılan organik kirlilik önlemlerinden biri olduğunu ve hem atık su hem de yüzey sularına uygulandığını belirtmiştir. Bu belirleme, organik maddenin biyokimyasal oksidasyonunda mikroorganizmaların ihtiyaç duyduğu çözünmüş oksijenin ölçülmesini gerektirir.

2.3.2.5. Kimyasal Oksijen İhtiyacı (KOİ)

Organik ve oksitlenebilen inorganik maddeler için gerekli oksijen miktarı mg/l olarak oksitlenir (Nicholas, 2002)Davis (2010), biyolojik olarak oksitlenebilenden daha fazla bileşiğin kimyasal olarak oksitlenebileceği ve BOİ5'in nihai BOİ'ye eşit olmadığı gerçeği nedeniyle, atığın KOİ'sinin BOİ5'ten daha büyük olacağına işaret etmiştir. KOİ testi üç saat veya daha kısa sürede tamamlanabilir. BOİ5'e bağlanabilirse, atık su arıtma tesisinin işletilmesine ve kontrol edilmesine yardımcı olabilir.

2.3.2.6. Toplam Organik Karbon (TOC)

Wayne (2006), toplam organik karbonu ölçmek için ısı, ultraviyole ışık ve güçlü bir kimyasal oksitleyici (veya bu üçünün bir kombinasyonu) kullanılarak CO_2 ve suya oksitlenmesi gerektiğini belirtmiştir. CO_2, kızılötesi spektroskopi, iletkenlik veya kulometri yoluyla üretilir. Burda ihtiyaç duyulan oksijen miktarının dolaylı bir okumasını sağlanır (bir elektrokimyasal teknik). Testi bitirmek için gereken süre büyük ölçüde değişebilir ve çoğu durumda TOC ve BOİ/KOİ bilgileri çok farklı sonuçlar verir.

TOC testinin aynı sayıda karbon atomuna sahip bileşikler arasında ayrım yapmadığı ve bu nedenle çeşitli oksijen talebi okumaları üreteceği doğru olsa da, testin bir başka faydası da oksijen talebini değerlendirirken oksitleme adımlarını içermesidir. Bu nedenle sonuçlar, doğrudan BOİ ve KOİ tahlilleri kullanılarak değerlendirildiklerinden, kimyasal kirleticilerin belirtilen orijinal oksidasyonunu gösterir. Toplam organik karbon analizi, uygulama arıtmasının belirlenmesine yardımcı olan en kritik içme suyu ve atık su tesisi önlemlerinden biridir. TOC ölçümü, bir su arıtma tesisi için su arıtma prosedürlerini optimize etmek için gerekli olabilir. Bu, organik izleme için spesifik olmayan ancak kapsayıcı bir kriterdir.

2.3.2.7. Klorürler

Sudaki ana klorür kaynakları, pil üretimi ve kağıt hamuru değirmenleri, külçe rafine etme ve galvanik kaplama, pestisit üretimi, çok sayıda küçük ölçekli işleme birimi vb. gibi endüstriyel işlemlerdir. Bununla birlikte, insan toplumu tarafından üretilen endüstriyel, evsel ve tarımsal atık sular, çevredeki ortamın ekolojik dengesinde önemli bozulmalara neden olabilecek yüksek konsantrasyonda klorürlere sahip olabilir. Demineralizasyon, ters ozmoz, pıhtılaşma, çökeltme, elektro diyaliz ve diğer arıtma yöntemleri dahil olmak üzere atık sudaki klorür sayısını azaltmak için çeşitli yaklaşımlar uygulanmıştır. Öte yandan, bu yaklaşımlar doğası gereği fizikokimyasaldır ve bu nedenle hem sermaye harcaması hem de bakım harcaması açısından pahalıdır (Apte ve diğerleri, 2011).

2.3.2.8. Azot

Azot ve fosfor, mikro organizmaları bitki ve hayvanları büyütmek için gerekli olan besin biyo-uyarıcıları olarak bilinir. Biyolojik büyüme için demir gibi diğer elementlerin eser hacimleri de gereklidir. Bununla birlikte, çoğu durumda, azottaki ana yapı taşı nedeniyle ana besin azot ve fosfordur. Atık suyun biyolojik işlemle arıtılabilirliğini değerlendirmek için protein sentezi için nitrojen verileri gerekecektir (Metcalf & Eddy, 2004). Nitrifikasyon ve denitrifikasyonun biyolojik süreçleri, atık sudan nitrojeni uzaklaştırmak için kullanılır, bu da daha yüksek kaliteli bir atık su ile sonuçlanır, nitrifikasyonu azaltır ve ardından alıcı ortamda oksijen tükenmesini sağlar (Tallec ve diğerleri, 2006). Amonyak, nitrit, nitrat ve Kjeldahl azotu, çevresel etkileri olduğu için yaygın atıksu parametreleridir.

2.3.2.10. Fosfor

Yaşamın ana unsuru fosfordur. Hayvan yemi ve gübrede kullanımının yerini hiçbir şey tutmaz. Fosfor üretimi ve kullanımı, geri dönüşüm ve uygun atık yönetiminin yanı sıra yüksek verimli ise, kaynaklar korunabilir ve gelecek nesiller için kalıcı fosfor rezervleri hala kullanılabilir; atık su kirliliğinden kaynaklanan fosfor ve diğer besin maddelerinin eksikliği, bitki ve alg gelişiminde artışa neden olur (Roland W, 2013). Metcalf ve Eddy (2004), bitki büyümesini desteklemenin yanı sıra, alglerin ve diğer biyolojik yaşamın gelişmesi için fosforun da gerekli olduğunu belirtmiştir.

2.3.2.11. Yağ ve gres

Yüzey sularında atık bertarafı için değerli bir husus, atıktaki yüzen parçacıkların sayısıdır; iki tür yüzen madde tanımlanmıştır: "yağ topları" parçacıkları ve muazzam alanları kaplayan film oluşturan sıvı bileşenler. Yüzebilen atık sular, kolayca görülebilmeleri, rüzgarla kolayca taşınabilmeleri ve zaman belirli partiküllere bağlı patojenik bakteri ve virüsleri barındırabilmeleri gibi birçok benzersiz özelliğe sahiptir. Kolloidal olarak dağılmış yağ ve gres, diğer dağılmış organik malzemeler gibi davranır ve KOİ, BOİ ve TOC testlerine dahil edilir.

2.3.2.12 Gazlar

Metcalf ve Eddy (2004), azot (N_2), oksijen (O_2), karbondioksit (CO_2), hidrojen sülfür (H_2S), amonyak (NH_3) ve metan (CH_4) gazlarının sıklıkla tespit edilen gazlardan bazıları olduğuna dikkat çekmiştir. İlk üç gaz, atmosfere maruz kalmış herhangi bir su kütlesinde bulunabilen standart bir atmosferik gazdır. Son üçü ise atık suda bulunan organik maddelerin ayrışmasının bir sonucu olarak üretilir. Ayrıca klor (Cl_2) ve ozon (O_3) arıtılmamış atık su gazlarında bulunmasa da, dezenfeksiyon ve koku kontrolü ile kükürt ve nitrojen oksitleri için kullanıldıkları için çevre mühendisinin bunlara aşina olması gerektiğini belirtmişlerdir (Rabah, 2014).

2.3.2.13 Kükürt

Çoğu su kaynağının doğal bir bileşenidir ve sülfat iyonu atık sularda da bulunabilir. Anaerobik koşullar, sülfatın biyolojik olarak sülfüre indirgenmesini sağlar, Bu daha sonra hidrojen ile reaksiyona girerek hidrojen sülfür (H_2S) oluşturabilir. Aşağıda sıralananlar gibi jenerik reaksiyonlar yaygındır (Akçın ve diğerleri, 2005).

2.4. Örnekleme Süreci

2.4.1 Ham atıksu ve arıtılmış atıksu numuneleri

Tüm atıksu arıtma üniteleri için Nisan 2021 ile Mayıs 2021 tarihleri arasında ünitelerden gösterildiği gibi numuneler toplanmıştır. Ham atık su ve arıtılmış atık su numuneleri şişelerde ve soğuk plastik kaplarda toplandı ve hemen özel laboratuvara aktarıldı. Daha sonra kontaminasyon ve biyolojik aktivitelerden kaçınmak için deneyde kullanılmadan önce buzdolabında 4°C'de tutulmuştur. Toplanan numuneler 17 atıksu parametresi (BOİ, KOİ, TSS, pH, P, N, Cr, Cu, Pb, Ni, Toplam N, Zn, K, Fe ve Ca); tüm bunlar mg/l olarak ölçülür. EC, bulanıklık ve sıcaklık sırasıyla µs/cm, NTU ve C°'dir. Deneyler, Irak Duhok Valiliği, Duhok Çevre Müdürlüğü laboratuvarında gerçekleştirilmiştir.

2.4.2. Ham atık su (influent) numune yerleri

Nisan 2021'den Mayıs 2021'e kadar istasyonlardan tesis başına üç ham atıksu numunesi toplanmıştır. Ham atıksudan alınan numuneler ise tesise girmeden önce S_{Infl} olarak sembolize edildi.

2.4.3 .Arıtılmış atık su (atık) numune yerleri

Arıtılan atıksu için istasyonlardan Nisan 2021 ile Mayıs 2021 tarihleri arasında tesis başına üç numune toplanmıştır. Arıtılmış atıksudan alınan numuneler ise tesisten ayrıldıktan sonra S_{Eff} olarak sembolize edilmiştir.

2.5. Numunelerin Testi

Çizelge 3.1'de gösterildiği gibi istasyonlardan alınan numuneler, gerekli testler için Duhok Valiliği Çevre Müdürlüğü laboratuvarına 4 C°'de serin bir kutuda temiz bir şişede nakledilir.

2.5.1 Analitik yöntem

KOİ parametresi, su ve atıksuyu incelemek için Standart Yöntemlere (APHA and AWWA)(Rodger ve diğerleri, 1967) göre analiz edildi ve KOİ konsantrasyonu, 5220 C kapalı geri akış titrimetrik yöntemi kullanılarak analiz edilmiştir.

2.5.2 Ekipman türleri

Aşağıdaki ekipmanlar suyun analizinde kullanılmıştır.

1. BOİ testi için Mantech (Auto max73),
2. KOİ testi için Hach KOİ Reaktörü,
3. Ağır metal parametreleri için ICP_OES cihazı ile laboratuvarda ölçüm yapılmıştır.

3.SONUÇLAR VE TARTIŞMALAR

3.1. Giriş

Bu bölümde, sonuç ve sonuçlar üzerinden bir tartışma yapılmıştır.

3.1.1. Ham atıksu örneği

Bu çalışma, altı istasyon için Nisan 2021 ile Mayıs 2021 arasında 36 ham atık su numunesi alınmıştır. Tüm numuneler için gerekli testlerin yapılması için Duhok Çevre Müdürlüğü laboratuvarına götürülmüştür.

3.2. Ham atıksu ve arıtılmış atıksuyun özellikleri

İncelenen tüm arıtma tesisleri, test edilen altı numunede gerçekleştirildi. Yarısının kendi giriş suyu vardı ve diğer yarısının her atıksu arıtma istasyonundan çıkış suyu vardı. Ayrıca her numunedeki 17 parametre laboratuvarda analiz edilmiştir.

3.2.1. Yeni Zaho şehir birimi

Tablo 4.1, New Zakho şehri için test sonuçlarını göstermektedir.

3.2.2. Avro şehri

Tablo 4.2, Avro şehri için test sonuçlarını göstermektedir.

3.2.3. Azadi genel hastanesi atıksu arıtma tesisi

Tablo 4.3, Azadi genel hastanesi atıksu arıtma tesisi için test sonuçlarını göstermektedir.

3.2.4. Nojin Şehri

Tablo 4.4, Nojin Şehri için test sonuçlarını göstermektedir.

3.2.5. Fransız köyü

Tablo 4.5 Fransız köyü için test sonuçlarını göstermektedir.

3.2.6. MRF daire

Tablo 4.6, MRF dairesi için test sonuçlarını göstermektedir.

3.3. Atıksu arıtma tesisinin performansı

Önizlenen sonuçlara dayanarak, altı atıksu arıtma istasyonundan toplanan giriş KOİ sonuçları görülmektedir. Irak standardına göre atık su için KOİ değerlerinin çoğu kabul edilebilir Irak standardı 100 mg/L'nin üzerindedirMizzouri ve diğerleri, (2020), atık KOİ ile karşılaştırıldığında, 34 mg/l ile Avro şehri ve 21.4 mg/l ile New Zakho olmadığı sürece hepsinin benzer şekilde standartların üstünde olduğunu görülmektedir.

Bu çalışmada KOİ çıkış suyu için maksimum değer 304,5 mg/l olan Nojin şehrinde bulunurken, Avro şehrinde KOİnin 536 mg/l'den 71,45 mg/l'ye düştüğü gözlemlenmektedir. Buda küçük arıtma tesisinin çalıştığı anlamına gelir. Gerisi ise düzgün çalışmamamktadır. Nojin şehri ve Avro şehri için BOİ çıkış suyu değeri 206.11 mg/l'den 39.69 mg/l'ye düşmekte, bu da Irak standardına uyduğunu göstermektedir.

Ağır metallere gelince, hepsi Irak standartlarındadır, ancak parametre olarak TSS, tüm istasyonlar için aşmaktadır. Ayrıca bulanıklık, Tablo 4.12'de gösterildiği gibi tüm istasyonlar için aynı sonucun aşıldığını gösterir.

Azadi hastanesi, Nojin şehri ve MRF apartman AATler çalışmadığı anlaşılmaktadır.

Standartla karşılaştırıldığında, AAT için giriş ve çıkış suyu numunelerindeki sonuçların makul sonuçlarla veya standartlarla uyuşmaması; bu, kanalizasyon sistemi (mutfak, banyo, WC ve çamaşırhane) akışının bağlanmaması ve AAT'ye deşarj edilmesi veya AAT'nin verimli çalışmaması anlamına gelir.

Sonuç olarak, atık su arıtma teknikleriyle kirliliğin azaltılması ilkesine ilişkin daha fazla araştırma yapılması gerekmektedir. Buna göre, bu istasyonların kılavuzları ve standartları karşılamak için gereken atık su kalitesini sağlayamamasının birçok nedeni vardır. Bu başarısızlıkların büyük çoğunluğu nedeni;

1. AAT'lerin çevresel kriterler gücü konusundaki performansı konusunda mal sahipleri ve yerel yönetimler arasında fazla bir işbirliği olmayışından,

2. Seçilen atıksu arıtma tesislerinin yaklaşık %65'i çevre standartlarına uygun olmayışından,

3. Atıksu arıtma tesislerinin tasarım kapasitesi, gelen ham atık suyun arıtılması için yetersizliğinden,

4. Atıksu arıtma tesislerinin verimli bir şekilde çalışmasını sağlamak için yeterli kalifiye operatör bulunmamasından,

5. Bu tesisler için gerekli bakımın yetersiz olmasından ve bakımın ihmal edilmiş olmasından,

6. Yeniden tasarlanması veya güncellenmesi için verilerin güncel ve doğru olmayışından,

8. Herkesin güvende olduğundan emin olmak, mevcut durumun iyileştirilmesi ve mal sahibinin endişelerini giderilmesi gibi nedenlerle gelmesi beklenen yerel yetkililerin gelip, tesislere herhangi bir takip yapmamasından olabilir.

3.4. Atıksu Arıtma Tesisinin Değerlendirilmesi

Mevcut arıtma tesisinin performans incelemesini yürütmek ve güncellemek, mevcut atık su kalitesinin arıtma kriterlerini karşılarken organik yüklere dayanıp dayanamayacağını belirlemek için kritik öneme sahiptir. Ayrıca, organik kirleticilere işaret eden BOİ, KOİ ve askıda katı madde miktarı, bir atık su arıtma tesisinin verimliliğini belirlemek için kullanılır.

Daha şeffaf olmak gerekirse, bu noktaya kadar tamamlanan çalışmalar olumlu bir işaret vermekte ve uygun bir çalışma ortamının ufukta olduğunu göstermektedir. Sonuç olarak, bu tür bir çalışma ve araştırma yoluyla hedeflerimize ulaşabilirken, aynı zamanda arzu ettiğimiz ve ihtiyaç duyduğumuz arasındaki farkı da azaltabiliriz. Yine de atıksu arıtma tesislerini değerlendirirken farklı faktörleri aynı anda göz önünde bulundurmak gerekir.

4.SONUÇ VE ÖNERİLER

4.1. Sonuçlar

Duhok vilayetinde artan nüfus ile mültecilerin ve ülke içinde yerinden edilmiş kişilerin (IDP'ler) akını, çevreye zarar verecek olan atık suları ve çamuru artıracaktır. Atıksu karakterizasyonu ile ilgili BOİ, KOİ, TSS, pH, renk ve diğer parametreler Duhok Çevre Müdürlüğü'nden toplanmış ve mevcut atıksu arıtma tesisini karakterize etmek için kullanılmıştır. İstasyonlara yaptığımız saha ziyaretlerinden elde ettiğimiz bilgilere göre, istasyonların işleyişinin standart kriterlerin altında kaldığı sonucuna varılmıştır. Operasyonları iyileştirmek için tüm ortaklar için daha fazla saha incelemesi, çalıştay ve seminere ihtiyaç vardır. Diğer şeylerin yanı sıra bu istasyonları yükseltmeli ve yönetim standartlarının değerlendirmesini yapmalıyız.

AAT'lerin COVID-19 pandemisine nasıl çalıştığı ve bu tür bir pandemide hizmet eden yerel yetkililerin, araştırmacıların ve araştırma merkezlerine önemi ve elde edilen verileri ne ölçüde kullanılabildiği gözlenmiştir.

Ayrıca, tesis ortakları ile düzenli toplantılar, düzenli ziyaretler, çalıştaylar, seminerlere katılmak ve en son teknolojiyi takip etmek suretiyle güçlendirilebilecek atıksu arıtma tesislerinin yönetimin etkisi de unutulmamalıdır. Yerel yetkililer ve tesis sahipleri arasındaki yeni güncellemeler hakkında geri bildirim eksikliklerinin giderilmesi gerekmektedir.

4.2. Öneriler

Bu çalışma ve diğer araştırmacıların makaleleri ile ilgili olarak, yardımcı olmak ve geleceğe yönelik bir adım eklemek ve çevre üzerindeki etkiyi en aza indirmek için aşağıdaki noktaları tavsiye edilir:

1- Yerel yönetim ile proje sahibi arasındaki işbirliğinin geliştirilmesi bir önceliktir.

2- Atıksu arıtma tesisleri, giriş suyu için güvenilir veriler ve çıkış suyu için iyi bir spesifikasyon ile daha verimli çalışacak şekilde yeniden tasarlanmalıdır.

3- Operatörlere en son teknolojik güncellemeleri sağlayarak atölye sayısını artırılmalıdır.

4- İlgili tüm çalışanlar arasında "işletme" ve "bakım" terimlerinin anlaşılmasını geliştirilmelidir.

5- Ortaya çıkan herhangi bir endişeyi tespit etmek ve çözmek için mevcut tesislerde yeni bir anket yapılmasına ihtiyaç vardır.

6- Merkezi gaz emisyonlarını azaltmak için yenilenebilir güç kaynağı kullanımını artırmak hayati önem taşımaktadır.

7- Araştırmacılar ve yerel yetkililer ortak bir çaba içinde karşılıklı bilgi alışverişinde bulunmalıdırlar.

CURRICULUM VITAE

I was enrolled in Baroshki primary school in the city of Duhok, Duhok-Iraq, from 1978 to 1983. Then I joined Chira intermediate school from 1984 to 1986. Finally, I attended Al-Shoala secondary school from 1987 to 1992 (Duhok, Iraq). I was enrolled in the university of Salah Al-Deen in 1993, was accepted into the college of Engineering, and earned a B.Sc. in Civil Engineering in1997, Erbil (Iraq). After graduation, I entered a master's program in Environmental Engineering at the Department of Natural Applied Sciences at Van Yüzüncü Yil University in Turkey in September 2019.

T.C
VAN YÜZÜNCÜ YIL ÜNİVERSİTESİ
FEN BİLİMLERİ ENSTİTÜSÜ
LİSANSÜSTÜ TEZ ORİJİNALLİK RAPORU

Tarih: ……/……/20……

Tez Başlığı / Konusu:

EVALUATION OF THE ENVIRONMENTAL PERFORMANCE OF SMALL SIZE WASTEWATER TREATMENT PLANT

Yukarıda başlığı/konusu belirlenen tez çalışmamın Kapak sayfası, Giriş, Ana bölümler ve Sonuç bölümlerinden oluşan toplam 117 sayfalık kısmına ilişkin, ………/………/……… tarihinde şahsım/tez danışmanım tarafından TURNİTİN intihal tespit programından aşağıda belirtilen filtreleme uygulanarak alınmış olan orijinallik raporuna göre, tezimin benzerlik oranı % 14 (ONDÖRT) dır.

Uygulanan filtreler aşağıda verilmiştir:

- Kabul ve onay sayfası hariç,
- Teşekkür hariç,
- İçindekiler hariç,
- Simge ve kısaltmalar hariç,
- Gereç ve yöntemler hariç,
- Kaynakça hariç,
- Alıntılar hariç,
- Tezden çıkan yayınlar hariç,
- 7 kelimeden daha az örtüşme içeren metin kısımları hariç (Limit inatch size to 7 words)

Van Yüzüncü Yıl Üniversitesi Lisansüstü Tez Orijinallik Raporu Alınması ve Kullanılmasına İlişkin Yönergeyi inceledim ve bu yönergede belirtilen azami benzerlik oranlarına göre tez çalışmamın herhangi bir intihal içermediğini; aksinin tespit edileceği muhtemel durumda doğabilecek her türlü hukuki sorumluluğu kabul ettiğimi ve yukarıda vermiş olduğum bilgilerin doğru olduğunu beyan ederim.

Gereğini bilgilerinize arz ederim.

Tarih ve İmza

Adı Soyadı: Nawzad Hussein MUSTAFA

Öğrenci No:18910001121

Anabilim Dalı: Çevre Mühendisliği

Programı: ……………………………………………………………

Statüsü: Y. Lisans X Doktora □

DANIŞMAN ONAYI
UYGUNDUR

Dr. Öğr. Üyesi Zehra ŞAPCI AYAS

ENSTİTÜ ONAYI
UYGUNDUR