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The Impact of Industrial Wastewater Pollutants on Benghazi's Groundwater and Environment City, Libya

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Abstract

This study was carried out in industrial settings, namely at the asphalt plant, Al-Aseel Company, Al-Jouf Company, and the cement factory. Samples were taken from the cement factory's groundwater wells as well as at the entrance and departure points. There are no sewage tanks nearby, and the groundwater sources are at least three km away from the companies. The secondary containment system used by Al-Aseel Company uses epoxy-coated carbon steel to withstand corrosion from chemicals and extreme salinity, preventing fluid leakage into the soil. To avoid contaminating groundwater, the asphalt plant has a concrete basin with secondary containment. Due to the lack of access to industrial water, AL-Jouf Company depends on a well. Electrical conductivity (EC), total dissolved solids (TDS), pH, turbidity (NUT), chemical oxygen demand (COD), biological oxygen demand (BOD), and coliform bacteria counts were among the chemical, physical, and bacteriological studies that were carried out. Groundwater and river water had pH values between 7.51 and 7.90, which is within an acceptable range of 6.5 to 8.5. whereas the pH of industrial discharge varied between 4.64 and 8.72, suggesting possible environmental effects. Because of the excessive salinity, the asphalt plant's EC was 47,800 µS/cm, which was over permissible limits. Due to industrial waste, the turbidity for Al-

Jouf was 1000 NUT, significantly higher than the allowable limit of 20 NUT. While BOD results showed that some chemicals could only oxidize physiologically, COD levels were below 1000 ppm. Furthermore, the amount of fats, oils, and greases (FOG) was higher than allowed. Both the cement and asphalt plants contained bacteria such as Shigella species, Streptococcus species, and Staphylococcus aureus. According to the study's findings, industrial zones have a big influence on the ecosystem and the quality of groundwater.
Keywords: Hydrocarbon contamination, Diagnosis Of bacteria Bioremediation, Soil pollution, PAHs, Benghazi, Libya.

*** INTRODUCTION**

One of the biggest problems the nation is currently facing, particularly in the recent past, is industrial pollution. Considering industrial management as an active and crucial partner in creating and carrying out pollution control programs, all executive institutions and industrial management have been working to find the best solutions to this problem through productive collaboration between these institutions and executive bodies. Without a doubt, the most effective way to address Libya's industrial pollution problem is for administrative institutions and industrial management to work together constructively to identify pollution problems. Due to its detrimental effects on groundwater, drainage systems, and aquatic bodies, industrial facility discharge is one of the largest problems facing drinking water and wastewater companies. Because industrial waste frequently contains suspended materials that might block the network, it also has an impact on pumping and treatment stations as well as sewage networks. Chemical-containing wastewater discharge can destroy metal components and concrete structures, releasing toxic fumes that have an adverse effect on maintenance and operation staff. (The Holding Company for Drinking Water and Wastewater in Dahlia and the German GIZ worked together to prepare this project.)The ongoing daily release of industrial waste is a problem that has detrimental effects on the economy as well as the environment. In addition to wasting vast tracts of land that get poisonous and contaminate the air and natural water sources, environmental management also comes with hefty prices for garbage removal. Aquatic life may also be impacted by the soil itself becoming saturated with pollutants. As a raw material or auxiliary agent, water is essential to modern enterprises, [1] particularly for cooling machinery through dissolving, mixing, and cleaning processes. For instance, about 300 cubic meters of water are needed to produce one tons of iron, and about 400 cubic meters are needed to extract one tone of nickel. About 600 cubic meters of water are needed to produce one tone of nitrogen fertilizers and 10 cubic meters are needed to refine one tone of oil. As a result, businesses use a lot of water, mostly from the seas and oceans, which have a total area of over 6.5 million square kilometers and a water content of about 1.43 billion cubic kilometers. Regrettably, human waste is discharged into these seas and oceans through a variety of activities, which causes pollution from the accumulation of contaminants—also referred to as the cumulative impact of pollutants. It is important to remember that pollution affects all industrialized nations worldwide, and it is not just a result of exposure to pollutants from industrial waste. [2] Since industry may boost national income, diversify revenue streams, and generate new job possibilities, it is regarded as one of the essential foundations for attaining comprehensive economic and social growth in every society. The degree of industrialization in a nation and its economic development stage are directly correlated, according to applied economic studies. The waste water that results from operations related to raw material manufacture is known as industrial wastewater. Cleaning, cooking, cooling, heating, extraction, material reactions, separation, transportation, and disposing of liquid waste are some of the operations that produce it. Approximately 85 to 95 percent of the water utilized in different processes is likely to end up as effluent. Rainwater from industrial yards or home sewage from manufacturing workers are usually absent from industrial wastewater. The term "polluted water" typically refers to activities and industrial wastes. Untreated discharge of contaminated water into natural water bodies will contaminate them and act as a disease vector, endangering human health. Since its invention in the early 20th century, biological treatment has emerged as the most widely used wastewater treatment technique globally. Microorganisms (bacteria, protozoa, algae, etc.) participate in this biological process by eating and breaking down carbon-based organic compounds. These microbes multiply as a result, and organic contaminants are eliminated from the water. In some circumstances, treated water can be recycled. The concept of biological treatment is straightforward, but because so many variables influence how it works, managing this approach is quite difficult. The water's pH level is one of these variables. Microorganisms can be inhibited by a small number of harmful compounds, which would stop biological treatment. Reducing the organic content (BOD and COD) and the concentration of nutrients like nitrogen and phosphorus in the treated water are the main objectives of biological treatment. [3] Numerous industrial wastewater streams originate from the production of plastics, metal finishing, oils, paints, drinks, and pharmaceuticals and pesticides. Depending on the circumstances, the number of dangerous pollutants must be identified by analyses and predicted based on experience to make sure they satisfy requirements for release into public sewers or water bodies. [4] The U.S. Environmental Protection Agency (EPA) regulates a class of chemical contaminants known as priority pollutants, for which analytical testing techniques have been created. The most recent list of 126 priority contaminants is another resource you might consult. The list is a crucial starting point for the EPA when creating national discharge standards (like liquid waste guidelines) or national permitting systems (like the NPDES), but it is not the only toxins covered by the Clean Water Act programs. [5] Every development initiative must priorities environmental preservation and sustainability in order to ensure a healthy environment for current and future generations. The development of any country is largely dependent on its industries [6] However, industrial wastewater effluents are a major contributor to a number of water pollution issues [7], [8]. Numerous physical, chemical, and biological processes change the properties of the polluted site when petroleum products are released into the environment. Individual contaminating chemicals at the site may separate from the original mixture based on their chemical properties. According to [9] some of these chemicals release themselves into the atmosphere. Petroleum hydrocarbons (PHCs) are frequently found on sites; however, they are not usually regarded as hazardous wastes and are thus managed as such. In sedimentary, aquatic, and soil settings, PHCs exhibit degradable and biodegradable properties. [10];

[11]; [12]; [13]. Oil and grease (O&G), an organic hazardous waste, has mutagenic and carcinogenic effects on humans, plants, animals, and aquatic life [14] [15]. They are released from a variety of sources to form a layer on the water's surface that reduces the dissolved oxygen content. The O&G layer reduces the biological activity of the treatment process, where an oil film forms around bacteria in water and suspended particles. The amount of dissolved oxygen in the water decreased as a result. Microbes then have a hard time oxidizing hydrocarbon molecule due to oxygen molecules, which causes ecological damage to water bodies [16], [17]. Skimming tanks and oil and grease traps are two conventional techniques used in treatment facilities to remove oil and grease. The main disadvantage of these methods, though, is how ineffective they are at eradication. In treatment facilities, the residual oil clogs pipes, requiring pipe cleaning and sometimes pipe replacement. This will result in increased maintenance and inspection costs [18]. Environmental research described ways to avoid fat obstruction or filming in waste systems prior to releasing wastewater into a sewage system. These studies looked at a new technique that uses a commercial combination of lipase enzymes to break down organic contaminants in order to clean holding tanks, septic tanks, grease traps, and other systems [19]. Lipases are a large class of water-soluble, widely dispersed enzymes. They hydrolyze water ester bonds in soluble substrates at the interface between an aqueous phase and a substrate phase [20]. They can depict the flow of organic matter in wastewater treatment, are cheap to create, and have ecological benefit in oxidation reduction [20]. Wastewater can be released from both point and nonpoint sources. WWTPs are among the easily identifiable outlets from which wastewater from point sources is discharged. of industrial establishments and municipal WWTPs. Runoff from farms and cities are examples of nonpoint sources that are hard to pinpoint and consist of multiple sources. As a result, point sources are usually easier to monitor and control and are more concentrated than nonpoint sources [21]. Water consumption variations resulted in effluent containing a variety of pollutants, containing poisons or diseases that are harmful to both human health and the environment. Examples of common contaminants include organic and inorganic materials, nitrogen,

phosphorus, and heavy metals [22]. Alongside its rapid progress, Rwanda is also becoming more industrialized. However, industrialization causes environmental problems, mostly due to poor industrial waste management, as has been observed in many developed countries. Getting older [23]. Auther [1] The investigation discovered that all industries involved in the wastewater treatment plants' (WWTP) effluent discharge did not meet either the (i) national and international acceptable parameter limits for oil and grease (O&G) or the (ii) faecal coliforms national norm. Furthermore, 66.7% of the major water quality monitoring measures (pH, dissolved oxygen (DO), chemical oxygen demand (COD), and biochemical oxygen demand (BOD)) were found to be in compliance. heavy metals, such as lead (Pb), cadmium (Cd), and chromium (Cr), and total suspended solids (TSS). In light of the study's conclusions, the REMA closed one industry for wilfully releasing untreated wastewater into a nearby river. This research suggests the relocation of enterprises to industrial zones next to delicate environments, installation or refurbishment of existing WWTPs, and use of the best available technology for effluent treatment in 2022.Auther [2] Said the Water is an essential resource for both the environment and human activity. Large amounts of wastewater are produced by industrial processes, and this wastewater may be highly contaminated or include harmful substances, which can have an adverse effect on the environment and public health.Wastewater produced by various sectors has drastically differing properties, including amount, concentration, and kind of pollutant. In order to choose the best treatment methods for wastewater treatment facilities and encourage sustainable water use, it is crucial to comprehend these features. An overview of wastewater produced by different industries and widely used treatment methods is given in this review article. The features, benefits, and drawbacks of chemical, biological, and physical therapeutic techniques are discussed in 2024. Author [3] In this study, three distinct process water (PWWs) from Qatar's oil and gas production. Numerous hazardous substances, such as polyaromatic hydrocarbons, phenol, heavy metals, ammonia, and other hydrocarbons and nonhydrocarbons, are present in the wastewater produced during different processing steps. had the highest pH (8.5), Finally, recorded the highest levels of extractable petroleum hydrocarbons and petrol range organics (GRO). Wastes with a high organic content made up the PWWs. The findings also showed that all three PWWs had higher levels of iron and zinc, and sixteen distinct hydrocarbon compounds were found, including pyrene, benzo(a)anthracene, fluorene, anthracene, phenanthrene, and acenaphthene in 2022. Author [4] The goal of the current study is to learn more about how oil and grease pollution might affect the aquatic ecosystem and contaminate fresh water. Then, oil and grease removal from production wastewater becomes necessary, but standard methods are insufficient. To evaluate the water quality and potential for oil and grease embarrassment from wastewater, enzyme and adsorption units—which represent a significant new laboratory development—were chosen. To evaluate the effectiveness of oil and grease removal, a number of environmental factors and components were examined, including dissolved oxygen, bacteriology measurements, flow rate, and amount of adsorption material. The findings showed that there were notable differences between the various tests that affected the microbially required role of oxidation declining produce biological treatment process, reaching 72%. The study focused on zeolite, a natural substance that, in the right circumstances, improved organic reduction. These factors, which included a longer adsorbing unit and closer spacing, increased the amount of time that oil and grease came into contact with the adsorbent and improved performance by reaching 99% elimination in 2014. Author [5] A case study of petroleum-contaminated soil/sediment samples is presented in this paper. The samples were subjected to gas chromatography-flame ionization detector (GC-FID) analysis for total petroleum hydrocarbons (TPH), volatile aromatic compounds (BTEX, BTEX, BTEX, and naphthalene) by GC-MS, and oil and grease (O/G) content by sonication in hexane. The hydrocarbon percentage ranges from 7% to 87%, according to the ratio of TPH to O/G. Only a small amount of total TPH is made up of the volatile organic fraction BTEX, and the ratio of (BTEX) / (TPH) falls between 0.1% and 0.6%. Because the possible harm provided by BTEX chemicals may not be sufficiently addressed, it should be emphasized that the employment of TPH techniques in contrast to gas chromatography must be done carefully in 2009. Author [6]

An overview of the main pollutants found in residential and commercial wastewater, together with their types and concentrations, is given in this study. The goal of the current study was to examine and gather information on harmful materials found in petrochemical effluent. factories, paper and pulp mills, power plants, electroplating companies, and municipal sources (small businesses and families) in 2015

*** The Effects of Impurities on Industrial Uses and Water Quality**

We performed a thorough examination of statistical data regarding the amount of wastewater released from various municipal and industrial sources throughout the Russian Federation. According to recent assessments, Russia's main cause of water contamination is power stations, where Approximately half of all outflows are wastewater from power plants [24]. Additionally, Power plant wastewater comprises a variety of waste contaminants, including petroleum products with an average concentration of 20–30 mg/l and organic compounds and surfactants found in household wastewater. The primary categories of pollutants found in wastewater from thermal power plants are displayed in the (Table 1) below. [24]

Table (1): Primary pollutants found in thermal power plant wastewater

Waste types	The levels of contaminants and their levels
Water contaminated with petroleum	Fuel oil, petroleum, and other substances with concentrations ranging from 5 to 100 mg/l
Water derived from chemical plants	Sand, organic substances, calcium and magnesium carbonates, iron and aluminum hydroxides, and hydrochloric acid salts as well as sulphonic acid
After cleaning the external heating surfaces, use water.	Ash, soot; sulphonic acid (0.5–1%); vanadium salt (0.2–0.4 g/l); nickel (0.05–0.08 g/l); iron Copper: 0.01 g/l, 5–7 g/l
Water for equipment cleaning and preservation	Ammonia, fluorides, nitrites, methenamine, hydrochloric acid, hydrazine, citric acid, 2-mercaptobenzothiazole, and others.
Coal-fired thermal power facilities using hydraulic ash removal to remove water	calcium oxide, arsenic, vanadium, sodium sulphate, magnesium sulphate, calcium sulphate, and others in concentrations up to 2000 mg/l.

In terms of the quantity of contaminated water discharges, the manufacturing sector ranks second [25]. Because there are many different types of production in this sector, the pollutants from each of these types of production are distinguished by their distinctiveness. Nonetheless, among all the many industrial units, the chemical and petrochemical industries [25], pulp and paper mills [26], and electroplating industries [6] may be identified in terms of water contamination. Wastewater from petrochemical industry, for instance, may contain over 20 different kinds of dangerous chemicals. Among these substances, phenol, acetone, benzene, petroleum products, and nitrogen compounds can be highlighted [25]. The heavy metal ions Zn, Ca, Mg, Na, and K are the primary waste pollutants in the electroplating industry [25]. Pulp and paper mill wastewater contains phenolic chemicals and several resin acids, including abietic acid [25]. Wastewater discharges from the oil and gas industry should be specifically highlighted [25]. It is It is well known that water is pumped into reservoirs in the petroleum sector in order to maintain the required pressure. Furthermore, during the manufacture of watered oil and subsequent settling, plants release water that has been contaminated by petroleum compounds. In addition, over 10% of all wastewater emissions come from extractive sectors. Naturally, petroleum compounds are the primary contaminants found in such wastewater. However, household wastewater typically has the most varied contaminant makeup. All of the aforementioned pollutants, including petroleum products, heavy metals, and caustic inorganic acids, are present in such effluent in trace amounts. The main pollutants found in homes Sulphid chemicals and organic materials are found in wastewater [25].

It should be mentioned that several wastewater treatment procedures (such as chemical oxidation, distillation, and others) include heating and evaporating liquids. Numerous theoretical and practical investigations [9–14] show that the shift in the levels of pollutants (both chemical and mechanical) in water may have a substantial impact on the properties and strength of heat and mass transport, and as a result, wastewater treatment efficiency.

1- Industrial Water Quality Impact of Contaminants: A Summary of Pollutants and Their Impacts

Water quality is influenced by its characteristics as well as the amounts and concentrations of contaminants it contains. The importance of pollutants, contaminants, and the primary metals and non-metals, as well as their effects on the characteristics and caliber of industrial water, are shown in (Tables 2 and 3).

Table (2): Indications of the Presence of Pollutants and Impurities and Their Impact on the Properties and Quality of Industrial Water [25]

Property	NO	its impression
Turbidity	1	Unstable, fine, suspended particles that don't settle. They give the water a murky, muddy look.
color	1	The organic plant residues and minerals that give natural waters their color is thought to be responsible for the color shift from colorless to dark brown.
Electrical Conductivity		1. Electric current cannot be conducted via pure water. 2. Water's electrical conductivity is a result of salts' solubility in it. 3. The quantity of dissolved salts in water is thought to be gauged by the electrical conductivity property.
Suspended Solids		1. Generally speaking, substances that are not dissolved in water are called suspended solids. 2. Silt, clay, organic materials, algae, bacteria, fungi, and minerals are examples of suspended solids. 3. It has a high proportion of organic components, which can decompose and lower the dissolved oxygen content. 4. It causes foaming in boilers and the formation of scales on equipment. 5. It clogs internal equipment parts and water transport tubes, causing turbidity. 6. They can accumulate in boilers and heat exchangers. 7. If such materials are filtered out and treated, they don't present any significant issues.
Dissolved solids.		1. One of the most crucial factors in assessing whether water is suitable for industrial applications is the concentration of dissolved solids. 2. Bicarbonates, carbonates, sulphates, chlorides, and nitrates of calcium, magnesium, sodium, and potassium make up the majority of dissolved solids, with trace amounts of iron and manganese also present. 3. A significant part of dissolved solids is silica. 4. Fluoride is found in extremely small amounts. 5. In boilers, phosphate is a part of the dissolved solids. 6. Because they are a major contributor to the development of scales and deposits, dissolved solids in water are undesirable for industrial applications. 7. In boilers, high dissolved solids concentrations hasten the production of foam and corrosion.
Total solids		It is the sum of the dissolved and suspended solids.
pH (hydrogen ion concentration)		1. The ability of water to function as an acid or a base in chemical reactions is one of its characteristics. 2. A liquid's acidity or alkalinity is determined by its pH value. 3. Water must fall within a certain pH range for some applications.
Acidity		1. There are other important components than acidity. 2. It gauges the impact of various chemicals and environmental factors in water. 3. The ability of water to neutralize hydroxyl ions is known as acidity, and it is measured in terms of calcium carbonate. 4. The breakdown of iron and aluminum salts, the presence of free carbon dioxide, mild dissociating acids, and mineral acids like sulphonic acid are the main causes of acidity. 5. The majority of natural waters are largely acidic due to dissolved carbon dioxide, with little or no mineral acidity. 6. Although acidity has no set limit, it is indirectly managed by figuring out the pH value's bounds. 7. Metallic structures are harmed by excessive acidity.

Table (3): The most important metals and non-metals and their effects on the quality of industrial water [25]

Type	The impact on water quality and industrial problems
Organic materials	• The existence of organic elements is ascribed to contamination from sanitary and industrial discharges. • Soil washing, plant and animal decomposition, and agricultural practices are the primary sources of organic compounds in water. • Organic elements are thought to be responsible for changes in the color, taste, and odor of natural water. • Water must be treated and organic pollutants removed before it can be used in industrial operations. • Organic materials can be oxidized to produce innocuous compounds by utilizing ozone, chlorine, or chlorine dioxide.
Dissolved oxygen	• Most waterways contain dissolved oxygen in variable amounts. • Surface waters have dissolved oxygen concentrations ranging from 3 to 12 mg/L; temperature, pressure, and water salinity all affect how soluble oxygen is. • One of the primary reasons why industrial metals like iron, steel, copper, and galvanized iron corrode is the presence of dissolved oxygen in industrial water. • While high pH values aid in delaying corrosion processes, low pH values accelerate them. • There should be no dissolved oxygen in industrial water, particularly boiler water. • As the temperature rises, the rate of corrosion increases roughly 500 times at 90 °C as opposed to 0 °C. • Boiler feed water should have a low dissolved oxygen level of no more than 0.005 mg/L. • To eliminate any residual oxygen from boiler feed water, compounds such as salt, sulfite, and hydrazine can be added.

* Industrial effluents from chemical fertilizers

Because of the extensive use of fertilizers in agriculture, nitrate poisoning of groundwater is becoming a bigger issue globally [27]. causes a number of medical conditions specifically, goiters, birth defects, hypertension, hemoglobinemia, and stomach cancer [28]. Sundaramoorthy and his colleagues [29] claim that the fertilizer business is one of the sectors that uses the most water and is in charge of pollution of soil and water enough. The primary component of fertilizer, ammonia, is found in water in two interchangeable forms: unionized ammonia, which is more dangerous, and ammonia ions, which are less harmful. The pH and temperature of the water can regulate the ratio of these two forms. [30] because temperature and pH can regulate their ratio [30]. According to EPA 2000 [31], heavy metals and other dissolved pollutants are main toxicant, meaning they are poisonous, bioaccumulate, and persistent. Similar findings to those from other locations were found in an assessment of the fertilizer industry's effluent in Sultanpur, Uttar Pradesh. The light-brown effluents were found to have low levels of dissolved oxygen and heavy metals, as well as greater pH, EC, COD, TDS, nitrogen, phosphate, and sulphate content [32]. These findings suggest that garbage that contains benzene's hydroxyl and chlorosubstituted derivatives may present a higher toxicity issue to microbiota compared to wastes that contain derivatives that have been methylated. The presence of these chemical groups in a river will also significantly impede the nitrogen cycle's nitrification stage [33]. Numerous contaminants and poisons found in wastewater are thought to pose the biggest threat to both public health and the ecosystem. Wastewater is defined globally. as follows: (i) Physical: temperature, turbidity, pH, color, odor, and total suspended solids (TSS); (ii) Chemical: chemical oxygen demand, or COD; and total organic carbon, or TOC. heavy metals that have dissolved (iii) biological: BOD (Biological Oxygen Demand), microorganisms such as bacteria, viruses, parasites, oxygen required for nitrification, and the microbial population; (iii) oxygen (DO), poisonous chemicals, phosphorus, chlorides, Sulphur, and other trace elements [49].When water containing these contaminants is released into surface, ground, and ocean, nutrient deficiency, water quality problem, and lowering the dissolve oxygen (DO) level, which has an impact on the aquatic environment. water quality that is created and fed, its production method primarily defines the effluent's aspect, quality, composition, and amount, all of which have an impact on the expense of treating and disposing of it. techniques. Wastewater contaminants may be inorganic (such as nitrogen, Sulphur, phosphorus, chlorides, and heavy metals like Hg, Pb, Cd, Zn, Ag, and Ni) or organic (such as aromatic hydrocarbons, phenols, pesticides, etc.). radioactive (nuclear material); pre-treatment and post-treatment techniques are applied in accordance with this. Additionally, additional by contributing to the primary industrial wastewater, industrial effluents like cement, cannery, metal containers, synthetic resins and polymers, soft drinks, soap and detergent, viscous rayon, gelatin, explosives, bleach liquid, dye, asbestos, chlor-alkali, metal-pickling, coffee pulping, slaughterhouses, meat-pickling, etc., pollute the environment. Therefore, the effluent treatment process must comply with the requirements and the features of the environment in order to safeguard the health of the general population. wastewater that is released into streams of water.

*** Important figures who are concerned about industrial effluents and how they affect the environment and public health**

Heavy metals, hydrocarbons, phosphorus, nitrogen, and microorganisms are the primary pollutants found in industrial effluent. Hazardous effluent production industries as shown in (Fig.1)

(Figure 1): Hazardous effluent-producing industries [34].

1- Nitrogen and phosphorus: The most common type of nitrogen in wastewater is ammonia, which is known to be hazardous. Consuming water containing nitrate may result in methemoglobinemia in infants and other vulnerable people, sometimes referred to as "blue baby's syndrome" [35]. One of the primary eutrophic nutrients, phosphorus accelerates the chlorine content needed for water body disinfection, which raises the risk of cancer and encourages the growth of harmful bacteria like P. fisteria, which irritates the eyes and respiratory system.

2- Hydrocarbons: When hydrocarbon contaminants are present in wastewater effluents, the ecosystem is negatively impacted and Fisheries, marine wildlife habitats, human health, and the ecological balance are all at risk, among other effects on human health [36].

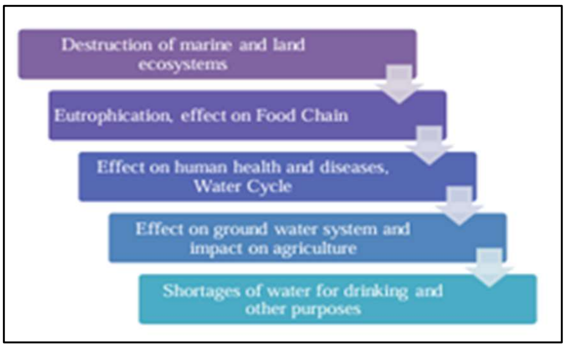
3- Microbes: Giardia and Cryptosporidium are the primary pathogenic protozoans present in industrial effluent, and they can cause both acute and chronic illnesses with short-term and long-term consequences, such as severe stomach ulcers and degenerative heart disorders. Consequently, the society is facing issues with wastewater treatment as a result of extensive industrialization and increased population density. One of the main sources of pollution that has a significant impact on managing water quality is the wastewater produced by industrial operations. Additionally, the potential for long-term survival in natural ecosystems and the capacity to build up at successive levels of the natural food chain are the risks associated with non-biodegradable and intractable contaminants in water. The wastewater effluent must undergo treatment before being released, taking into account the aforementioned significant effects. into the surroundings. Children may develop goiter as a result of nitrate exposure in their drinking water [37]. High levels of chromium contamination were also linked to an incidence of stomach cancer, according to a case from Changhua County, Taiwan [38]. Height decrease in adulthood is linked to pollution exposure throughout critical developmental stages in children [39].

* IMPACT OF INDUSTRIAL EFFLUENTS ON WATER BODIES RECEIVED

Long-term monitoring and research of faucal coliform in city stream water quality has revealed the impact of urbanization on water quality [40]. Organic contaminants and the primary cause of the contaminants in the river is heavy metals [41]. Water and chemical oxygen demand (COD) are closely related, and dissolved oxygen (DO) serves as a marker of water pollution [42]. Runoff from agricultural waste and organic contaminants are the main causes of contamination in river water [43]. Waste Water The primary danger to the quality of river water is improper operation of treatment plants [45] Public health is hampered and the food web is impacted by river pollution [44]. The properties of industrial effluents reveal details about the aquatic environment in the rivers and streams into which they are released. The majority of these effluents inflict extensive harm, with the microbiological organism being the most negatively impacted. Aquaculture, fisheries, agricultural production, and human health could all be significantly impacted by changes in the properties of the water. The plain areas of the rivers are clearly used, making them more susceptible to change [46]

*** AQUATIC LIFE IMPACT**

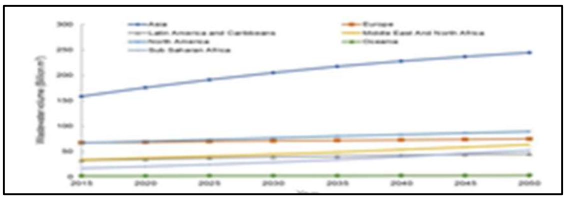
The water bodies' natural disasters are essential to the aquatic environment. agricultural practices, urban waste management problems, industrial effluents, and growing urbanization [47]. Anthropogenic contamination, industrial waste, and leaks containing chemicals or solid pollutants are all present in aquatic environments. [48]. Surface waterways are contaminated by phosphorus and nitrates from fertilizers and detergents, which serve as nutrients and promote the growth of Fish and other aquatic life are killed by oxygen-consuming algae that lower the water's DO levels [49]. Poisonous compounds including arsenic, mercury, cadmium, lead, and others are accumulated in industrial effluents and harm aquatic life. These chemicals can also enter the human body through contaminated food (fish, for example) [49]. Commercial, industrial, and residential wastewater (petroleum refineries, paper Organic contaminants from mills, breweries, tanneries, and slaughterhouses poison the water. These supply food for microbes that break down organic materials, take in oxygen, and lower the DO level of aquatic species, ultimately leading to their death. [47]. Water that has been thermally polluted loses its DO level, which prevents aquatic life forms from surviving. It has been established that fish and birds are caused by oil pollution [50]. By taking part in the material cycle and energy flow, phytoplankton perform an important and unique role as indicators and pollution cleaners in streams [51]. A large quantity can result in the water's oxygen levels being depleted, which will kill a lot of fish [52]. One important component of aquatic biodiversity is temperature. By taking part in the material cycle and energy movement in lakes, they play an essential and indispensable role as indicators and pollution cleansers [53]. occurrence and diminishes surface water's recreational value, which may detract from water-contact sports. Their large number may result in the Fish mortality will increase due to oxygen loss in the water [54]. The presence of dense algal flora typically occurs in areas with high nitrogen levels and a favorable environmental backdrop [55]. Figure 9 illustrates the effects of industrial effluents on the water cycle, food chain, land, and marine environments.



(Figure 2). Industrial effluents' effects

*** An increasing worldwide challenge is urban industrial effluents.**

A worldwide challenge Recently, a number of international studies have been carried out to estimate wastewater volumes and provide predictions. for the future. According to Qadir et al. [56], 380 billion m3 of wastewater are produced annually worldwide. Based on the rate of urbanization and population growth, it is projected that the volume of wastewater produced daily will increase by 51% (574 billion m3) by 2050 and by 24% (470 billion m^3) by the end of the period in 2030 (Fig.3). It is important to note that Asia produced the most wastewater in the world, making up 42% (159 billion m^3) of the total. It is estimated that by 2030, wastewater generation will rise to 44%, requiring attention.



(Figure 3). Global wastewater output by region from 2015 to 2050 [56]

*** The goal of this research**

This research conducted a comprehensive analysis of how industrial effluents affect receiving water bodies, aquatic life, and human health and the prognosis of various illnesses, with an emphasis on a thorough analysis of the interactions, systems, and determinants of water bodies. From a limitation's perspective, the primary topic of this work is environmental science research.

*** Investigative Items**

1- Evaluating the physical and chemical characteristics of samples from industrial drainage tanks belonging to businesses and manufacturers in Benghazi, as well as groundwater and river water before they enter treatment plants (input).

2- Assessing how industrial wastewater treatment processes affect the density and variety of the bacterial community environment in different well and tank waters as well as for industrial drainage.

3- Researching how untreated industrial effluent affects local inhabitants and industry products.

*** The significance of the study**

1- Environmental threats to groundwater and the areas surrounding industrial areas are identified, along with the impact of industrial drainage pollutants on the ecosystem.

2- The spread of infectious diseases like diarrhea and cholera is primarily caused by residential areas and their drainage in the oceans.

3- You can use treated industrial drainage water for a variety of purposes, including cleaning industrial sites and irrigating agricultural land.

*** The study of problems**

1- A comparison between the chromatic gas device and the TPH method for the overall analysis of organic hydrocarbons

2- Eliminating the oils and grease present in crude oil that contaminate the seas and nerve water, harm living things, and are caused by industrial drainage in the oceans.

3- Cleaning up industrial drainage produced by toughed-out or pollutant-containing industrial operations

4- The presence of coli bacteria, which indicates the presence of bacteria in stool and the leaking of industrial wastewater to wells and river water, leads to the microbiological treatment of industrial wastewater.

*** Material and Methods**

1- The Limits of Research

*** Time Limitations**

Search period: June 29–July 22

*** Particular Limitations**

Select every sample examined from wells and tanks tainted by industrial drainage (entry and exit) from an industrial inclusion (Al-Jawf Company, Al-Aseel Company, Cement factory, and Asphalt factory) in the Benghazi region.

2- Searching Up Mythology

Table 4: Summary of Industrial Wastewater Management and Characteristics".

Category	Procedure
➢ **Collecting Field Information**	**1.Samples of industrial drainage**: Next, use one-liter plastic bottles or jugs to collect drainage water from the closest open dumping site or a drainage tube. Before packing for the next step, raise the bottles three times with the sample water. **2.Cylindrical water samples:** To lessen the impact of daily temperature fluctuations. In order to remove standing water from the tubes (which can range from 100 to 200 meters, depending on the location), water must be present and the person polled straight from the well using a clean bowl or pump after pumping water for a brief amount of time (three to five minutes).
➢ **Biological and chemical analysis**	1.**Chemical analysis** includes the measurement of pH (PH), turbidity (TUB), electrical conductivity (EC), chemical oxygen demand (COD), biological (BOD), organic matter (OM), and organic carbon (TOC). **2.Instruments Used: acidity**: (PH) measurements; electrical conductivity (EC) meters; total dissolved solids (TDS) meters; turbidity meters; gas chromatographs; chemical oxygen demand (COD) tests; biological oxygen demand (BOD) tests; and the most probable number (MPN) method **3.Biological analysis**: Verifying the existence of E. Coli and other bacterial species

* Choosing a location

(Table 6). Summary for choosing a location for Industrial Wastewater Management

Category	Details
Choosing a Location	**1.Asphalt Company:** The concrete basin that serves as the industrial drainage tank measures two meters in depth, eight meters in width, and fifteen meters in length. The quality of the soil and groundwater may be impacted by pollution that results from the tank's leaking of gases or liquid waste
	2.Al-Jouf Company: Since the company does not have access to industrial water, they drilled a well with saline water. The concrete industrial wastewater tank is two meters wide, three meters long, and three meters high. It is utilized to gather materials that are released by reactors, and workers use the industrial wastewater to clean the factory. To be used in the incinerator, the wastewater—a mixture of various materials—is extracted from the tank. Naturally, the Al-Jouf Company's industrial wastewater tank is a concrete tank that is 2 meters wide, 3 meters long, and 4 meters deep due to the burning of production materials (oil burns).
Supposed Substances in Wastewater	**Supposed substances in Al-Jouf Company's industrial wastewater**: Because the business produces and uses chemicals for oil extraction and drilling, the industrial effluent frequently contains: ▪ **Suspended Solids**: synthetic or plant fibers (LCM), drilling mud, and bentonite. ▪ **Salts** include calcium carbonate ($CaCO_3$), sodium chloride (NaCl), and calcium sulphate ($CaSO_4$). ▪ **Organic Compounds**: Emulsifiers, demulsifies, and synthetic polymers (such PAC, or polyanionic cellulose). ▪ **Oil and Grease**: Traces of hydrocarbons from the materials used in production and drilling. ▪ **Special Treatment Chemicals**: Biocides (such glutaraldehyde), corrosion inhibitors (which frequently contain amines or phosphorus compounds),
Changes in Water Characteristics	increased salinity (TDS, EC), potentially alkaline pH, and organic material-induced increases in COD and BOD.
Estimated Pollutant Density	1.Chemical Pollution: High because of the amount of added and manufactured chemicals. 2. Because the activity is industrial rather than agricultural or municipal, the level of organic pollution is medium. 3. Oil and Grease Pollution: Moderate to high, particularly when drilling fluids are disposed of or equipment is cleaned. 4. Salt and Mineral Pollution: Elevated → is the main hazard to groundwater (hardening of the soil, increased salinity).
3.Al-Aseel Company	Industrial Tank Specifications: The industrial tank of the Al-Aseel facility has dimensions of 4 meters in height, 6 meters in width, 1 meter in cone bottom depth, and 15 cm in thickness. A supplementary containment layer is used to insulate the tank's floor and stop liquid from leaking into the ground. It is composed of carbon steel that has been epoxy-coated to prevent corrosion from chemicals and excessive salinity. Sodium chloride, magnesium sulphate, calcium sulphate, potassium salts, chlorine, phosphonates, anticipants like phosphates, chemical membrane cleaners (like diluted acids and alkalis), pre-treatment sand particles, and leftover organic materials like bacteria and algae are all found in the industrial drainage tank.
4.Cement Company	There are no sewage tanks nearby, and the factories are at least three kilometers from the groundwater wells. There are two 10 x 15 x 4 m drinking and cooling water storage tanks in the factories, and they were constructed with concrete some time ago. There are no sewage tanks in the factories; drainage lines are used instead. At a depth of three meters, there are distribution chambers called manholes along the drainage lines that connect to drainage lines outside the factories using lift pumps. This indicates that there are no drainage pipes close to any of the water gathering tanks.

* Study location.

We collected samples from the study site at the well and industrial discharge inlets and outlets of four businesses that represented Benghazi's industrial areas.

The site of the industrial discharge sample collection from Al-Jouf Company is depicted in image (11).

The site of the well sample collection from Al-Jouf Company is seen in Image (12).

(Site 1) is Al-Jouf Company: which is situated at the company's well (19059'55" E, 31058'45" N) at a height of 56.29 meters. At an elevation of 49.84 meters, the industrial discharge is also situated at (19059'55" E, 31058'45" N).

The site of the cement factory well sample collection is depicted in image (14) as well.

The location of the cement factory where the industrial discharge sample was collected is depicted in image (15).

The Cement Factory is Site (2): At an elevation of 56.29 meters, the Cement Factory well is situated at (20009'28" E, 32000'44" N). The industrial discharge has an elevation of 49.84 meters and is situated at (20008'05" E, 32000'17" N).

Site (3) is the Asphalt Factory: The Ras Al-Minqar warehouse in Benghazi is 8 km to the east and occupies an area of about 58.75 hectares. The well is situated at (20007'46" E, 32011'47" N) with an elevation of 56.29 m, and the industrial discharge is at the same coordinates.

The Asphalt Factory's industrial discharge sample collection site is seen in Image (18).

The location of the well sample collection from the Asphalt Factory is depicted in Image (17).

Site (4) is Al-Aseel Company. The industrial discharge is at (20014'52" E, 32008'04" N), and the well is at (20014'52" E, 32008'02" N).

The site of the industrial discharge sample collection from Al-Aseel Company is seen in Image (20).

The site of the well sample collection from Al-Aseel Company is depicted in Image (21).

*** An overview of the Benghazi industrial sites where samples were collected.**

Table 7: Sample Collection Procedures and Details.

Section	Details
➢ Sample Collection	To guarantee reliability and correct portrayal, samples were collected in accordance with recognized scientific procedures. There were two main types of water at each industrial site: " (1) Industrial Wastewater Samples (2). Groundwater Samples in the Area
➢ Number of Samples	Four industrial locations were chosen to symbolize different industrial operations: 1. The Cement Factory 2. The Al-Jouf Company 3. Mineral Water Factory Al-Aseel 4. The Al-Asphalt Plant Eight samples in total 4 groundwater and 4 wastewater)
➢ Techniques of Sampling	**A. Bottle Preparation** (1) Sterilized and cleaned one-liter glass or plastic bottles. (2) Before the last filling, it was rinsed three times with sample water (3) Nitric acid-filled sterile polypropylene bottles for samples of heavy metals. **B. The moment of collection**: (1) To reduce temperature swings, samples were taken between 9 AM and 3 PM. (2) Temperature, time of collection, and, if available, GPS position are recorded. **C. The Collection Method**: Industrial Wastewater: (1) Gathered at the closest discharge point (open channel or drainage pipe). (2) After pumping for three to five minutes to remove any standing water, groundwater is extracted straight from the well. **Transportation and Storage**: Samples are delivered to the laboratory in less than an hour and kept in ice-filled crates to keep the temperature below 4°C.
➢ Extra Information	Color, fragrance, and the presence of oils or foam on the surface were among the visual observations made while wearing gloves and a mask to prevent contamination.

* Materials

* Sampling Equipment

1- The pH scale: determines whether a solution is basic or acidic by measuring its alkalinity or acidity. To be more precise, it is the negative logarithm of the hydrogen ion (H^+) concentration in water.

Figure (22) pH Meter

The pH scale goes from 0 to 14, to put it simply: -

1- A solution is considered acidic if its pH is less than 7.

2- A neutral solution has a pH of 7.

3- A basic (alkaline) solution has a pH higher than 7. PH= -log[H],[H]=10^{-pH}

Figure (23) Electrical Conductivity Meter

2- Electrical Conductivity: The capacity of a solution to transport an electric current—the opposite of resistance—is known as electrical conductivity. This characteristic is dependent on the temperature, ion types and concentrations in the solution, and both. Pure water is recognized to be a poor electrical conductor; nevertheless, electrical conductivity increases with the number of contaminants and dissolved salts.

3- **Relationship with Total Dissolved Solids (TDS):** Assessing the electrical conductivity in water samples is done to determine the total dissolved solids (TDS), and the electrical conductivity is proportional to the solid's concentration, as stated by the following equation:

A×EC=TDSA \times EC = TDS A×EC=TDS

Where:

- A = constant (0.64)
- EC = electrical conductivity (mmhous/cm)
- TDS = total dissolved solids (mg/L)

Therefore, the sum of equivalent positive and negative ions can be used to describe electrical conductivity for an ionic substance (salt):

Figure (24) Total Dissolved Solids (TDS) Meter

A0=A0+A0

*** Units of Measurement**

In the metric system, electrical conductivity is expressed in microsiemens/cm (S/cm) or micro mhos/cm (mmhous/cm)

4- Turbidity: The amount of light scattered and dispersed by suspended particles, such as soil, clay, silt, bacteria, algae, and other organic and inorganic elements in water, is known as turbidity. These particles are frequently the result of erosion processes at riverbeds and riverbanks brought on by water currents.in addition to what is transported by sewage and industrial effluent, as well as by soil erosion and runoff from nearby regions. Aquatic life is impacted by turbidity because it limits the quantity of light available to producers during photosynthesis, which lowers the amount of oxygen produced. Because it can block fish gills and perhaps introduce microorganisms and trace metals among the suspended particles, it also affects fish respiration. Using a nephelometer, turbidity is measured. In freshwater, turbidity levels of 5 NTU are acceptable.

Figure (26) Turbidity Meter and Calibration Process

Figure (25) Illustrates a Turbidity Meter.

5- **Chemical Oxygen Demand (COD)**

* **Reagents for Chemical Oxygen Demand (COD) Analysis**

1- $K_2Cr_2O_7$ (Potassium dichromate)

2- H_2SO_4 (Sulfuric acid) reagent

3- Ferroin reagent solution

4- 0.1 M FAS (Ferrous Ammonium Sulfate) titrant solution

5- Concentrated H_2SO_4 (Sulfuric acid)

6- Potassium hydrogen phthalate standard

* **FAS Titration Procedure (Use Safety Goggles)**

1- **Dilution**: In a conical flask, dilute 10.0 mL of the standard $K_2Cr_2O_7$ solution to about 100 mL.

2- **Add Acid**: Using a graduated cylinder, carefully add 30 mL of concentrated H_2SO_4. Mix thoroughly and allow the solution to cool to about 20°C.

3- **Add Indicator**: Add 4 drops of ferroin indicator.

4- **Fill Burette**: Fill the burette with the FAS solution.

5-**Titrate**: Add FAS to the solution until the color shifts from greenish-blue to reddish-brown.

* **Calculation: FAS mL / FAS Molarity = 2.5000**

The amount of oxygen needed to oxidize the organic molecules in the sample is estimated using this formula for ferrous ammonium sulphate (FAS) in chemical oxygen demand analysis.

$$\text{COD as mg } O_2/L = \frac{(A - B) \times M \times 8000}{\text{ml sample}}$$, where

A = ml FAS used for blank
B = ml FAS used for sample
M = molarity of FAS

*** Calculations for Chemical Oxygen Demand (COD)**

A diluted sample should be used for a repeat assessment if the COD is greater than 900 mg O_2/L. COD less than 50 mg O_2/L

6- **Biochemical Oxygen Demand (BOD)**

The quantity of oxygen that microorganisms will need to break down organic materials in water under aerobic circumstances is known as the biochemical oxygen demand, or BOD. It is a crucial determinant of pollution levels and water quality.

1- The assessment of water quality is crucial, and BOD aids in determining the level of organic contamination in water bodies.

2- The efficacy of treatment procedures and the possible effects of effluents on receiving waters are evaluated through wastewater treatment.

3- Measurement: To determine BOD, a sample of water is normally incubated in the dark to prevent photosynthesis for a predetermined amount of time (commonly 5 days at 20°C; this is known as BOD_5). The dissolved oxygen (DO) level is then measured both before and after the incubation period.

4- Units: The results are given in mg O_2/L, or milligrams of oxygen per liter.

5- Applications include evaluating the degree of organic pollution in rivers and lakes and tracking the efficiency of wastewater treatment facilities. And assessing the effects of discharges into natural water bodies on the environment

Image (27) Method for Titrating Chemical and Biochemical Oxygen

7- **Technique for Assessing Oils and Grease in Environmental and Water Samples**

1- PH Adjustment: Use a sodium hydroxide solution to raise the sample's ph.

2- Extraction: Use 100 milliliters of hexane as a solvent for every 500 milliliters of the sample to remove oils and greases.

3- Separation: Shake the sample briskly for three to five minutes with a 1-liter separatory funnel, then let it settle until two layers form.

4- Drying: Gather the sample in a flask that has been previously weighed after passing it through sodium sulphate to eliminate water.

5- Evaporation: To fully eliminate the hexane, evaporate the solvent in a water bath set at 70°C.

6- Cooling and Weighing: Use the following formula to determine the number of oils and greases in the flask after it has been cooled, dried, and weighed.

$$\text{Oil\& Grease (mg/L)} = \frac{\text{Remining Weight of grease and oil(mg)}}{\text{Sample volume (L)}}$$

8- **Technique for Assessing Petroleum Derivatives and Compounds in Environmental and Water Samples**

EPA Method 8015B (non-halogenated organics using (GC-FID)

1- Preparing the Sample: [57] Sodium hydroxide solution is used to bring the sample's pH down to 7.

2- To separate petroleum materials and derivatives, shake the sample well before taking out 10 milliliters. To extract the petroleum components, shake the sample thoroughly after adding 2 mL of an acetone and hexane combination. To get rid of any remaining water, separate the sample and run it through sodium sulphate.

*** Sample Analysis**

Chemicals: -

1- Lab Box produces GC-Grade high-purity hexane solvent.

2- Lab Box produces High-Purity Acetone Solvent.

3- Standard Solution: Grey Hound-made, 250 mg/L C8-C40.

Work Steps: -

4- **Get the chromatography apparatus ready**: The gas chromatograph with a flame ionization detector (GC-FID) should be set up in accordance with the parameters required for this kind of sample.

5- **Inject Standard Sample**: Make use of a standard sample that has petroleum derivatives (C8–C40) in recognized amounts.

6- **Obtain an Appropriate Curve**: Note each compound's retention duration and area under the curve.

7- **Inject the Sample**: Determine the amount of each constituent by contrasting its area under the curve with that of the previously acquired standard solution. **[58]**

*** The Equipment Used**

Figure (28) Gas Chromatography GC-FID A6890 Agilant-USA

9- **Identification of Microbes**

The optimum criteria for water safety and acceptability are established through microbiological testing of the water. Changes in water characteristics and marine pollution can result from the growth of microorganisms, some of which can cause illnesses. To get rid of bacteria in water, it is crucial to determine their kind and number. The coliform bacteria are a type of bacteria that are used to measure the amount of pollution in water and determine its acceptability for different purposes.

Table (8): sample delivery to the lab, the following analysis are carried out

Collection	**Details**
1. Sample Collection	Clear Water samples are collected in 250 mL bottles.
2. **Labelling**	Labels with information about each sample should be written and affixed to each bottle. Before being taken to the lab for analysis, samples are stored in a cooler with crushed ice.
3. Temperature Measurement	The temperature of the samples is directly measured using an Oceanographic Surface Thermometer.
Microbiological Analysis	Details
1. **Estimation of Total Coliform Bacteria**	➢ The Most Probable amount (MPN) approach (1999, ROPME) is used to estimate the number of coliform bacteria. ➢ For the presumptive test, use Lactose Broth (produced by IDG), and for the confirmatory test, use MacConkey Broth (produced by OXOID). ➢ Use MPN tables (2003, USDA) to estimate counts after 48 hours of incubation at 35 ± 0.5°C.
2. **Estimation of Fecal Coliform Bacteria**	➢ The Most Probable Number approach is used to estimate the number of faucal coliform bacteria. ➢ For the presumptive test, use OXOID's Brilliant Green Bile Broth and incubate for 24 hours at 44.5 ± 0.2°C. For ➢ confirmatory testing, use Tryptone Water (produced by IDG) and incubate at the same temperature. ➢ Use MPN tables to estimate numbers and add Kovac's Indole Reagent for the confirmatory test.
3. **Detection of Salmonella**	➢ As directed by the manufacturer, use Buffer Peptone Water. After preparation, take 225 mL, sterilize it, and then put it in a 250 mL flask, sterilizing both at the same time. ➢ Let it cool, then add 25 mL or 25 g of the sample, or make selenite broth, and incubate for 24 hours at 40–44°C. ➢ Before consuming 100 mL, sterilize the flask and then sterilize it once more. Using a base, sterilization can be carried out at 80°C for 15 minutes after gas develops. ➢ Make 19 g of selenium broth and 4 g of salmonella biselenite in 1 liter of water. ➢ Take 10 mL from the prepared mixture (25 + 225 mL) and add it to selenite broth.
Additional Media	XLD, DSA, Bezmot, S.S.A, MacConkey, SAO.

* Discussion and Result

1- Analyses and Statistics

* Analysis of Groundwater and Industrial Effluents in Benghazi

The samples were analyzed to determine the pollution load in the Benghazi industrial groundwater and effluents for various physio-chemical parameters. The results were compared with the values for industrial wastewater specified by the National Environmental Quality Standards [59] and international standards set by the World Health Organization [60] and the U.S. Environmental Protection Agency [61] for drinking water.

* Key Findings

The characteristics of water and effluents from subterranean tube wells were examined, focusing on crucial parameters such as electrical conductivity, pH, and temperature (USEPA, 1998; Richards, 1954). The concentration of heavy metals [62], biological oxygen demand (BOD) (Hamer, 1986), conductivity (Richards, 1954), and total soluble solids (TDS) [62] were assessed.

Using a handheld thermometer, the water's temperature, pH, and electrical conductivity were measured on-site with a conductivity meter [63] Additional physio-chemical parameters examined included total hardness (TH), COD, and chloride. Water samples from several locations were collected, preserved, and analyzed according to established procedures [64]; [65].

*** Bacteriological Investigation**

Water samples underwent bacteriological investigation (APHA, 1985) for fecal coliforms (FC), total coliforms (TC), and total heterotrophic bacteria (THB). The nutrient agar medium was used to calculate the total number of heterotrophic bacteria, employing the pour plate technique for counting. Both total and fecal coliforms were measured using the most probable number (MPN) approach.

The presumptive test for coliform was conducted with MacConkey broth using the repeated 5-tube MPN dilution method. For fecal streptococci (FS), sodium-azide broth was used, and a heavy inoculum was streaked onto MacConkey agar plates.

The MPN of fecal streptococci and coliforms was calculated using accepted techniques for wastewater and water analysis [54]. Colonies with distinct morphologies were separated, and identification was performed using Bergy's Manual of Determinative Bacteriology [66].

Table (9) Standards for Wastewater Quality in Industrial Areas

NO	Parameter	Units	Maximum Levels
1	PH	mg/l	6.0-9.0
2	EC	(μs/m)	500
3	BOD	mg/l	50
4	COD	mg/l	100
5	Oil and fat	mg/l	15
6	Oil and grease	mg/l	10
7	Total Dissolved Solids	mg/l	0-1000
8	Total coliform bacteria	MPNb / 100 ml	The quantity of coliform bacteria must be non-detectable or less than 100.
9	Turbidity	mg/l	Less than 20

Table (10) Standards for River and Groundwater Quality in Industrial Areas

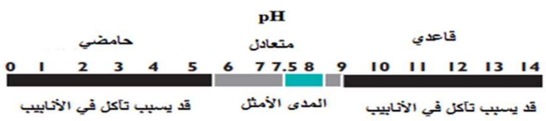
NO	Parameter	Units	Standard Specifications for Groundwater Wells	Standard Specifications for River Water
1	PH	mg / L	٨,٥-٦	٨,٥
2	Total Dissolved Solids	mg / L	100-1500	500
3	Electrical Conductivity	EC (μs/m)	١00-1٥00	400
4	Turbidity	mg / L	Less than 5.	Less than 5
5	BOD	mg / L	Not available	60
6	COD	mg / L	Not available	150
7	Oil and fat	mg / L	Not available	Not available
8	Oil and grease	mg / L	Not available	Not available
9	Total coliform bacteria	MPN b / 100 ml	400 a	Less than 500ml CFU/100.

2- Analysis the Result

1- pH value.

If wastewater's pH is less than 7, it is categorized as acidic; if it is greater than 7, it is categorized as alkaline. Significant environmental damage can result from both acidic and alkaline wastewater, particularly if the pH drops below 6 or rises over 9. For industrial effluent to be released into sewage systems, its pH must be neutralized to stay between the permissible range of 6 and 9.[67] Because pH has an impact on the biological treatment processes, it is a crucial indicator in wastewater management. The pH of receiving waters may be adversely affected, and wastewater with a pH outside the appropriate range makes microbiological treatment more difficult. Furthermore, pH affects the concentration of both weakly ionized and non-ionized compounds—the latter of which are frequently more toxic—by interacting with a variety of substances, especially acids and bases.[68]

Figure (29) illustrates the pH



Excessive quantities of chlorine in wastewater can damage aquatic species' gills and skin, raise soil acidity, and hinder plants' ability to absorb nutrients, all of which can result in death. In addition to giving water pipelines a harsh taste, too much chlorine can lessen the effectiveness of disinfection.[69]

While pH does not directly affect human health, high pH can lead to scale formation in heating devices and promote the production of toxic trihalomethanes. It also impacts dissolved oxygen levels, photosynthesis in aquatic plants, and the metabolic rates of aquatic organisms. Most rivers have a pH range of 6.5 to 8.5; values below 5.5 may be too acidic for fish, while values above 8.6 may be excessively alkaline. Changes in pH can also alter water chemistry, increasing the solubility of heavy metals, which can be harmful to aquatic life.[70]

2- Electrical Conductivity (µS/cm at 25°C)

A solution's electrical conductivity, which is impacted by the kind and quantity of ions present, is a measurement of its capacity to carry electricity. Since organic salts do not dissociate in water to transmit electricity, these ions are usually inorganic salts. The amount of dissolved salts in water and its suitability for different uses are thus indicated by electrical conductivity. Because it is quick and simple to use, electrical conductivity measurement has become a standard technique for determining the salinity of water, enabling direct readings with portable instruments. This test can also be used to assess the cleanliness of water; pure water has a low conductivity, whereas water that contains salts and pollutants has a high conductivity.**[71]**

3- Total Dissolved Solids (TDS) ppm

Total dissolved solids are defined as the materials that pass through a glass fiber filter and remain after evaporation at 180°C. TDS represents the total of all dissolved mineral components and is usually expressed in milligrams per liter. The concentration of dissolved solids can affect the taste of water. Water containing more than 1000 mg/L is unsuitable for many industrial uses. Some dissolved minerals are preferred; otherwise, water would lack flavor.[72] The concentration of dissolved solids is commonly referred to as water salinity and is classified as follows: -

1- Freshwater: 0-1000 mg/L

2- Slightly Saline Water: 1000-3000 mg/L

3- Moderately Saline Water: 3000-10000 mg/L

4- Highly Saline Water: 10000-35000 mg/L

5- Saline Water: More than 35000 mg/L

4-Turbidity (NTU)

Turbidity quantifies the clarity of water and shows how light is scattered by suspended solids including clay, algae, trash, and excrement. Turbidity is caused by a number of factors, such as sewage discharge, nutrient inputs that cause algae blooms, soil erosion, and benthic creature activity that disturbs sediments. Because less sunlight can reach aquatic plants when turbidity levels are higher, photosynthesis and oxygen generation are reduced. Furthermore, heat from sunlight is absorbed by suspended particulates, increasing the temperature of the water and further reducing the amount of dissolved oxygen. Organic particles from the breakdown of plant and animal matter, as well as fibrous elements like asbestos and clay, are the source of turbidity. In conclusion, increased turbidity has a detrimental effect on oxygen production, light penetration, photosynthesis, and water temperature, all of which have an effect on dissolved oxygen levels.**[72]**

5- Chemical Oxygen Demand (COD) ppm

The COD/BOD ratio in wastewater with biodegradable materials like food typically ranges from 1.2 to 2.0; a ratio above 3 indicates the presence of non-biodegradable materials. COD is a crucial indicator used to measure organic materials in wastewater, especially those containing toxic compounds. It estimates biodegradable organic components through chemical oxidation, providing a rapid assessment of the total organic load. On average, COD values are higher than BOD values because some compounds can be chemically oxidized while only a subset can be biologically oxidized. World Health Organization (WHO) guidelines state that treated sewage water used for agricultural irrigation can have an average of 20 mg/L and a maximum of 100 mg/L. COD is a more effective assessment method since it can be evaluated in an hour, while BOD needs five days to incubate. BOD quantifies the amount of oxygen needed by bacteria to oxidize organic molecules into carbon dioxide in aerobic circumstances, whereas COD refers to the oxidation of all oxidizable organic compounds by potent oxidizing agents.[73]

6- Biochemical Oxygen Demand (BOD) ppm

The amount of oxygen needed by microbes to chemically oxidize organic molecules in wastewater into stable compounds during a five-day period at room temperature is measured by the biochemical oxygen demand, or BOD. Because some oxidizable particles, which are frequently found in industrial effluent, cannot be biologically broken down without an oxidizing agent, BOD values are usually higher than COD. In order to quantify BOD, diluted wastewater samples are made in specific bottles with bacteria added and oxygen-saturated water. Additionally, a control bottle with just water and bacteria is incubated. After five days, BOD, which is measured in milligrams per liter, is computed using the difference in dissolved oxygen levels between the test and control bottles. The World Health Organization (WHO) standards for wastewater treatment plant design and water source pollution assessment depend on an understanding of BOD. Fats and oils, like kerosene and lubricating oils, can make wastewater treatment more difficult because they float on the surface or settle as sludge, and if they are not removed before discharge, they can damage aquatic life by forming layers of invisible floating materials.[73]

7- Fats, Oil & Grease Analysis

The hydrocarbon components of oils and greases, including free and emulsified oils, are identified by analysis of industrial wastes. The right treatment approaches are determined in part by these tests. While emulsified oils need a Dissolved Air Flotation (DAF) system after chemical breakdown, free oils and greases are usually extracted by flotation or skimming with a gravity oil separator. To avoid clogging water and air distribution pipes, oils and greases must be removed prior to biological treatment. The intricacy of the petroleum refining process and the quality of the crude oil are two factors that frequently influence the classification of industrial effluent. Numerous hydrocarbon molecules and hazardous organic substances, including phenols, which are important organic pollutants, are found in crude oil. Pollutants in wastewater can be classified into four main categories:[74]

1- Oils and Greases

2- Organic Pollutants (e.g., hydrocarbons, compounds contributing to biochemical oxygen demand (BOD)) **[75]**

3- Inorganic Pollutants (e.g., ammonia, nitrogen, phosphorus, chlorides, inorganic salts)

1. **Heavy Metals**

Understanding and controlling wastewater treatment operations requires an understanding of these classes.[77]. Wastewater treatment plants are made to eliminate both organic and inorganic contaminants. Because treated wastewater contains aliphatic and aromatic hydrocarbons, emulsified fats and oils, ammonia, cyanide, and other inorganic chemicals originating from crude oil, it frequently exhibits high levels of chemical and biochemical oxygen demand (COD) and BOD. Pollutants that affect the environment include metals, oil, phenols, suspended particles, and compounds that lower oxygen levels. High concentrations of hydrocarbons, which fall into three primary categories, are commonly found in treated wastewater: -

1- Paraffins: Low carbon chain hydrocarbons like methane (CH_4), ethane (C_2H_6), and propane (C_3H_8).

2- Naphthene: Compounds like dimethyl cyclopentane and cyclohexane.

3- Aromatic Compounds: Includes benzene and its derivatives (BTEX: benzene, toluene, ethylbenzene, xylenes), which are toxic to humans and aquatic life.

Understanding these components is crucial for effective wastewater treatment and environmental protection.[78]

Figure (30): The Main Classification of Industrial Wastewater Pollutants

To mitigate their significant environmental impact, petroleum refining industries set discharge limits for various pollutant concentrations to comply with regulations. Research and review articles have established maximum concentration levels (MCL) for industrial wastewater pollutants, with average quality values reported as follows: pH 6-9, biochemical oxygen demand (BOD) <20 mg/L, chemical oxygen demand (COD) <200 mg/L, oils/greases <10 mg/L, phenols <0.25 mg/L, and total organic carbon (TOC) <75 mg/L. The increased presence of oils, greases, and fats in asphalt compared to BOD and COD is attributed to the nature of these materials. Oils, greases, and fats are organic compounds with long hydrocarbon chains that decompose slowly and have low reactivity with oxygen. Their presence in asphalt raises viscosity and decreases biodegradability, making the material less susceptible to oxidation and microbial degradation. Understanding these factors is crucial for effective wastewater management and compliance with environmental regulations.

Table (11): Classification of Petroleum Hydrocarbons by Product Types and the Numerical Distribution of Carbon Atoms

Type of Petroleum Compound	**Numerical Distribution of Carbon Compounds in the Molecule**
Gas	C1-C4
Organic Solvents	C7-C5
Gasoline	C5-C10
Kerosene	C18-C12
Diesel	C12<
Oils	C20-C16
Greases	C22-C18
Wax	C30-C20
Tar	C40-C30

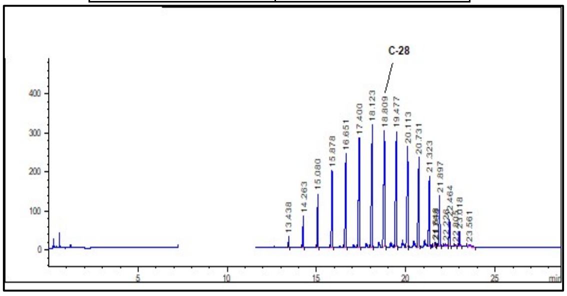


Figure (31) Gas Chromatography Analysis (GC). This type of analysis is used to separate and identify chemical compounds in a sample, such as hydrocarbons in this case.

Crude oil contains hydrogen and carbon molecules known as petroleum hydrocarbons (PHC). The quantifiable amount of petroleum hydrocarbons in an environmental matrix is indicated by total petroleum hydrocarbons (TPH). TPH shows the real findings of sampling and analysis, whereas PHC is an absolute number. However, because TPH analysis relies on reliable measurements of petroleum-derived hydrocarbons and the risk levels that go along with them, it is frequently limited for risk assessment. To quantify various petroleum chemical categories, including saturated, aromatic, and polar/resinous compounds, group-type assays are carried out. Particularly for heavy hydrocarbons like tar and asphalt, these measures aid in the identification of fuel types and the tracking of contaminated plumes. Thin-layer chromatography (TLC), high-performance liquid chromatography (HPLC), and multidimensional gas chromatography are common techniques for group-type testing. The total hydrocarbon content (THC), which is the sum of the several hydrocarbon components, may be recorded as 1780 mg/L in a particular assay. Peaks in matching graphs help identify the compounds in the sample by showing retention times for certain compounds, such as C9 at 14.23 minutes and C10 at 15.80 minutes.

8.Detection of Bacteria

Salmonella (pathogenic) or **Proteus** (non-pathogenic) can be identified using a urease test:

1. Prepare the urea solution according to the instructions.
2. Incubate for 24 hours.

The normal color of urea is very light orange, which does not change in the case of a Salmonella result. If it changes to a soft pink, this indicates Proteus (non-pathogenic), where the color changes from orange to pink.

MacConkey Agar: -

- 1.7 mL
- 1.2 mL

Proteus: Pink

The color does not change for Salmonella.

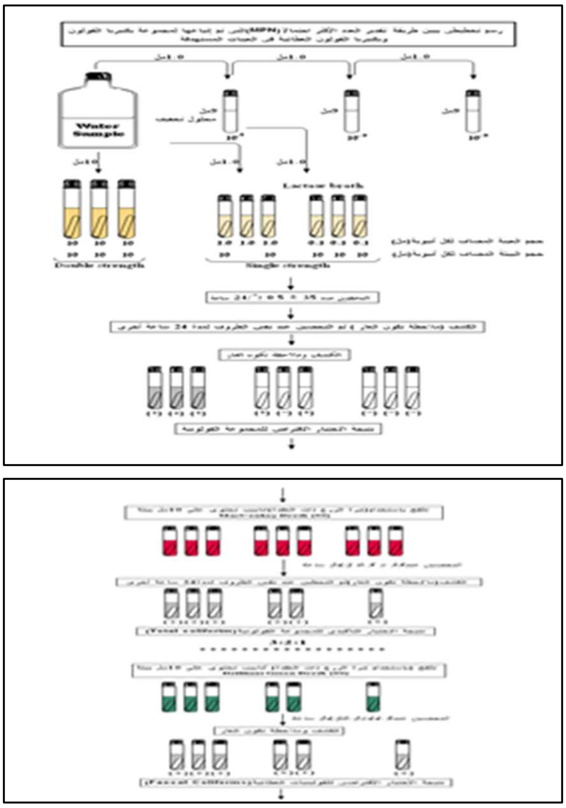


Figure (32) illustrates the layout showing the method used to estimate the Most Probable Number (MPN) for a group of coliform bacteria and enteropathogenic E. coli in the targeted samples.

* Result

1- PH Values

Table (12): pH Values of Water Samples for Various Companies

Company/Source	Sample Type	PH Range	Alkalinity/Acidity Description
Al-Jouf Company	River Water	7.90	Neutral, according to the pH values, which establish the medium's acidity and alkalinity
Al-Jouf Company	Industrial Effluent	4.64	which is below 7, making it acidic. This demonstrates the substantial effect of industrial waste, which lowers pH levels. This demonstrates how acids and their salts affect the water that is released into the river
The Asphalt Company	River Water / Effluent	7.51 - 8.72	Alkaline, which indicates that the water is alkaline because it is over 7. As a result, water often becomes more corrosive as its pH drops
Cement Plant	Groundwater / Effluent	7.63 - 8.40	Alkaline
Al-Aseel Company	Groundwater / Effluent	7.62 - 8.26	Alkaline

* Important Points

1- Al-Jouf Company's industrial effluent is acidic, although its river water is neutral.

2- The alkaline water from The Asphalt Company might turn caustic if the pH drops.

3- Alkalinity is also evident in the samples from the Al-Aseel Company and the Cement Plant

4- The stations' near-neutral pH, which is healthy for freshwater life and appropriate for direct discharge into marine settings, is generally shown by the pH data.

The current study's pH data indicate that the stations are maintaining a pH near neutrality by not releasing acidic or alkaline effluent [79]. If these discharges are released into water bodies, freshwater fish and benthic invertebrates are protected because the results fall between 6 and 9. As mentioned [79], they are likewise regarded as suitable for direct dumping into the sea.

Table (13) shows the pH values for groundwater, river water, and industrial effluent in industrial areas.

Situation	Type of Analysis / pH			
	Groundwater / River	Standard Specifications for Groundwater/River	Industrial Effluent	Standard Specifications for Industrial Effluent/River
Al-Jouf Company	7.90	٨,٥-٦	4.64	6-9
Asphalt Industry	7.51	٨,٥-٦	8.72	6-9
Cement Industry	7.63	٨,٥-٦	8.40	6-9
Al-Aseel Company	7.51	٨,٥-٦	8.72	6-9

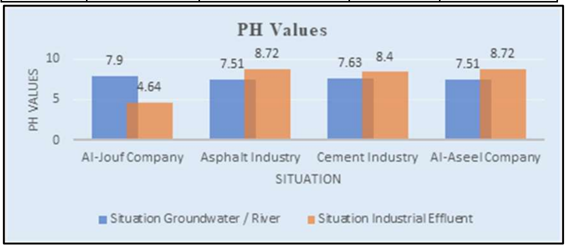


Figure (33) illustrates the difference between well water, river water, and industrial effluent in terms of pH values.

2- The electrical conductivity measured in microsiemens per centimeter (µS/cm) at 25°C

Table (14): Electrical Conductivity Values of Water Samples for Various Companie

Company/Source	Sample Type	Electrical Conductivity (µS/cm)	Contamination Description
Al-Jouf Company	River Water	49.0 - 32.5	Indicates that the river water is fresh and has only minor contaminants.
Al-Jouf Company	Industrial Effluent	32.5	Indicates that it is not highly contaminated
The Asphalt Company	River Water	47,800 - 659	. This is explained by the entry of seawater and the leaching of salts from the soil by irrigation water, which then percolates down into the groundwater. According to the results, salinity rises with depth and may contain dangerous materials or industrial contaminants, rendering it unfit for routine applications like drinking or irrigation and posing threats to the environment. Because it only contains trace amounts of contaminants, industrial effluent is regarded as light.
Cement Plant	Industrial Effluent	1,463 - 1,486	It is not suitable for routine use without previous treatment since the conductivity of industrial effluent may indicate the presence of hazardous compounds or industrial contaminants.
Cement Plant	Well Water	1,463 - 1,486	Moderate given the high concentration of salts and dissolved materials, the water may need to be treated before being used for irrigation or other purposes and may not be fit for everyday usage, such as drinking contamination; suitable for irrigation after treatment
Al-Aseel Company	Industrial Effluent	1,928 - 1,523	It is not suitable for routine use without previous treatment since the conductivity of industrial effluent may indicate the presence of hazardous compounds or industrial contaminants.
Al-Aseel Company	Well Water	1,928 - 1,523	Given the high concentration of salts and dissolved materials, the water may need to be treated before being used for irrigation or other purposes and may not be fit for everyday usage, such as drinking.

* Important Points

1- Al-Jouf Company's industrial effluent is mildly contaminated, although its river water is pure with only trace impurities.
2- The excessive salinity of the river water used by the Asphalt Company renders it unfit for regular use.
3- The modest conductivity of the well water and industrial effluent from the cement factory points to possible contamination.
4- Water tests from Al-Aseel Company show excessive salinity and may need to be treated before use, particularly for drinking.

Table (15) shows the electrical conductivity values for well water, river water, and industrial effluent in industrial areas.

Situation	The electrical conductivity(µS/cm) at 25°C			
	Groundwater / River	Standard Specifications for Groundwater/River	Industrial Effluent	Standard Specifications for Industrial Effluent/River
Al-Jouf Company	٤٩,٠	100-1500	٣٢,٥	500 - 1,500
Asphalt Industry	47800	100-1500	659	500 - 1,500
Cement Industry	1463	100-1500	1486	500 - 1,500
Al-Aseel Company	1928	100-1500	1523	500 - 1,500

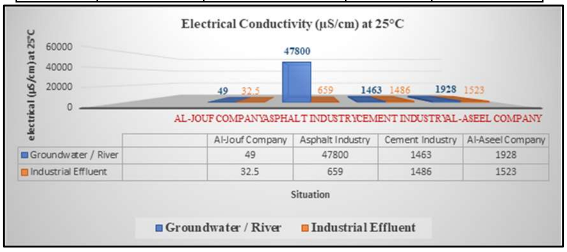


Figure (34) illustrates the differences in electrical conductivity values for well water, river water, and industrial effluent at industrial sites.

3- Analysis of Total Dissolved Solids (TDS ppm)

Table (16): Total Dissolved Solids (TDS) in Water Samples for Various Companies

Company/Source	Sample Type	Total Dissolved Solids (mg/L)	Contamination Description
Al-Jouf Company	River Water	33.8	This implies that the water has a very low concentration of dissolved salts, which makes it appropriate for a range of industrial uses
Al-Jouf Company	Industrial Effluent	20.0	Which is within the range of 0-1000 mg/L, the Al-Jouf Company's industrial effluent test findings indicate minimal salinity and possible safety for use.
Cement Industry	Well Water	1020	Within acceptable range; influenced by pollution
Cement Industry	Industrial Effluent	1055	Suggesting moderate salinity and the requirement for post-use treatment.
Al-Aseel Company	River Water	1081	Indicating moderate salinity that need treatment after consumption and falling between 1000 and 3000 mg/L.
Al-Aseel Company	Industrial Effluent	1365	Within permissible limits for industrial water
The Asphalt Company	River Water	34,000	Is regarded as extremely high. Significantly, conductivity values from the industrial water flow before and after treatment at the treatment plant have increased, suggesting that industrial waste contains higher quantities of salts, which results in higher values from post-treatment river samples.
The Asphalt Company	Industrial Effluent	468	Which is likewise within acceptable bounds.

* Important Points

1- The industrial effluent and river water from Al-Jouf Company have low levels of total dissolved solids, which qualifies them for industrial usage.

2- The modest salt levels of the cement industry's well water and wastewater suggest some pollution influence.

3- The mild salinity of the water samples from Al-Aseel Company necessitates treatment.

4- While the Asphalt Company's industrial effluent is within permitted bounds, the river water has exceptionally high TDS levels that pose major health hazards.

Table (17) shows the total dissolved solids (TDS) values for well water, river water, and industrial effluent in industrial areas.

Situation	Type of Analysis: Total Dissolved Solids (TDS ppm)			
	Groundwater / River	Standard Specifications for Groundwater/River	Industrial Effluent	Standard Specifications for Industrial Effluent/River
Al-Jouf Company	33.8	١٥٠٠-٥٠	20.0	0-1000
Asphalt Industry	1020	١٥٠٠-٥٠	1055	1000-3000
Cement Industry	1365	١٥٠٠-٥٠	1081	1000-3000
Al-Aseel Company	34000	١٥٠٠-٥٠	468	0-1000

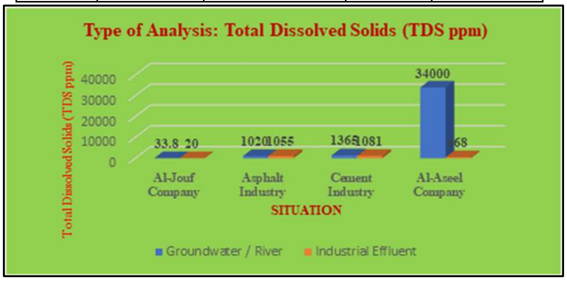


Figure (35) illustrates the differences in values for well water, river water, and industrial effluent in industrial sites for the analysis of total dissolved solids (TDS)

4- Turbidity (NUT)

Table (18): Turbidity Levels in Water Samples from Various Industries

Company/Industry	Turbidity Level (mg/L)	Status	Notes
Asphalt Industry	> 1.94	Above allowable limits	Exceeds WHO standards
Al-Jouf Company	> 1000	Above allowable limits	High turbidity due to industrial pollutants and recent drilling practices.
Cement Industry	0.72	Within acceptable bounds	Below WHO and international standards; requires treatment before use.
Al-Aseel Company	2.88	Within acceptable bounds	Below WHO and international standards; requires treatment before use.

* Important Results

1- One indicator of water quality that shows the presence of suspended particulates is turbidity.

2- High turbidity is associated with problems with drinking water's taste and odor and might

3- make it less appealing to consumers.

Particle size, sedimentation processes, and water movement all have an impact on turbidity.

High quantities of suspended particles in the water can have detrimental effects on the environment. Among the different kinds of suspended particles are: -

1- Industrial Waste: This includes organic compounds, oils, and greases.

2- Microbes and Algae: -

a- Algae: When they overproliferated (algal blooms), they can raise turbidity.

b- Bacteria: Excessive amounts may cause turbidity to rise.

3- Industrial Wastewater: such as petrochemical facilities, which might have elevated levels of contaminants.

Turbidity for the asphalt plant is below 100 and within allowable bounds, but it needs to be treated before being released.

Table (19) shows the turbidity values for the well, river water, and industrial wastewater from industrial areas.

Situation	Type of Analysis: the turbidity values NUT			
	Groundwater / River	Standard Specifications for Groundwater/River	Industrial Effluent	Standard Specifications for Industrial Effluent/River
Al-Jouf Company	1.94	Less than 5	1000<	Less than 20
Asphalt Industry	1.0	Less than 5	90.2	Less than 20
Cement Industry	3.8	Less than 5	0.72	Less than 20
Al-Aseel Company	2.03	Less than 5	2.88	Less than 20

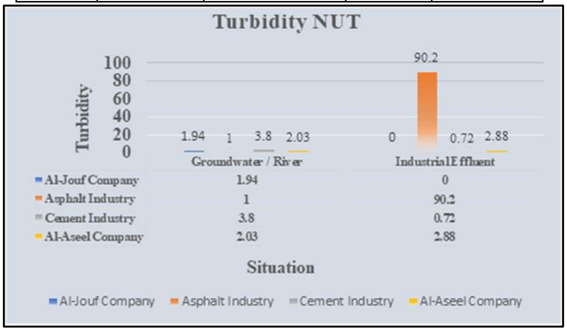


Figure (36) illustrates the difference in turbidity values for well water, river water, and industrial wastewater at industrial sites.

5- The chemical oxygen demand (COD) in ppm

Table (20): COD Levels in Water Samples from Various Industries

Company/Industry	COD Level (ppm)	Status	Notes
Cement Factory	206.4	Within weak range	Permissible by law; indicates presence of contaminants or organic compounds, which could have an impact on the quality of the water. As a result, industrial processes should be assessed and possible sources of contamination within the firm investigated.
Al-Aseel Company	34.4	Within poor range	Low concentration of contaminants, this implies that the water has a low concentration of contaminants and organic compounds, making it appropriate for a range of applications.
Asphalt Factory	172.0	Within poor range	Indicates a certain number of contaminants and organic compounds; still below the 250 mg/L maximum limit.
Al-Jouf Company	Not documented	N/A	frequently treats chemical materials rather than organic ones, which lowers the formation of chemical oxygen demand, as seen in the table, there is no documented COD for this company.

Table (21) presents the chemical oxygen demand (COD) values for the industrial wastewater samples.

Analysis	Cement Factory	Al-Aseel Company	Al-Jouf Company	Asphalt Factory
Chemical Oxygen Demand (COD) in ppm	٢٠٦,٤	٣٤,٠	-	١٧٢,٠

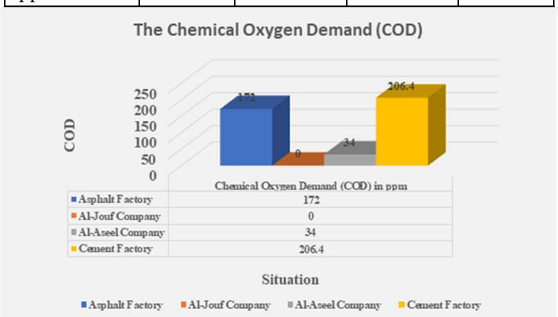


Figure (37) Chemical Oxygen Demand Values for Industrial Wastewater in Industrial Areas

All elevated levels of Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD5) in industrial wastewater indicate high levels of organic materials in the receiving waters. This leads to increased oxygen consumption by the decomposition of organic matter. The latter results in the depletion of oxygen content in the receiving water body, which translates to water pollution.

6- Biological Oxygen Demand (BOD) ppm

Table (22) Summary of Biological Oxygen Demand (BOD) in Water Samples

Company/Source	Sample Type	Biological Oxygen Demand (BOD) (ppm)	Contamination Description
Cement Factory	Industrial Effluent	150	Below permissible limit; indicates falling below the average calibration limit of 200 parts per million. It does, however, signal the existence of pollution that could have an impact on the regional ecology.
Al-Aseel Company	Industrial Effluent	24.0	Very good water quality; low contaminants, it shows very low levels of contaminants and organic compounds. This value is much below the permitted limit, demonstrating the company's continued commitment to environmental standards
The Asphalt Company	Industrial Effluent	125.0	Moderate organic compounds; good treatment
Al-Jouf Company	Industrial Effluent	Not Detectable	Use of organic solvents affects measurement, The microbes that cause biological degradation may be poisoned by these solvents, which makes it challenging to measure oxygen consumption precisely

* Key Observations

1- The Cement Factory's BOD is within acceptable limits but indicates potential pollution.

2- Al-Aseel Company's low BOD reflects excellent water quality and compliance with environmental standards.

3- The Asphalt Company's BOD suggests effective treatment but moderate organic contamination.

4- Al-Jouf Company's use of organic solvents complicates the measurement of BOD, indicating potential impacts on biological degradation.

Table (23) Biological Oxygen Demand (BOD) Values for Industrial Wastewater Samples

Analysis	Cement Factory	Al-Aseel Company	Al-Jouf Company	Asphalt Factory
Biological Oxygen Demand (BOD) in ppm	١٥٠,٠	٢٤,٠	-	١٢٥,٠

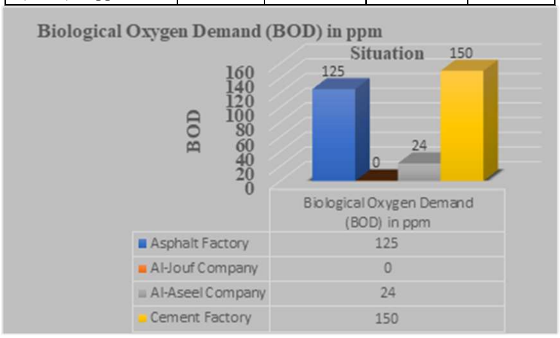


Figure (38) Biological Oxygen Demand (BOD) Values for Industrial Wastewater in Industrial Areas

Monitoring liquid discharge in industrial areas yielded BOD5 results ranging from 24.0 mg/L (Sopyrwa Ltd.) to 150 mg/L (Bralirwa Plc). The high BOD5 value in cement and asphalt factories may be due to the full production of fermentation lines and the oxidizing polymers used in the industrial wastewater treatment plant. This problem can be resolved by increasing filtration during fermentation to reduce the suspended solids entering the wastewater treatment plant and by mitigating water flow through more thorough cleaning procedures.

By reducing the number of suspended particulates that reach the wastewater treatment plant through increased filtration during fermentation and reducing water flow through more thorough cleaning procedures, this problem can be resolved.[80]

In order to mitigate water flow through more thorough cleaning procedures, this problem can be resolved by boosting filtration during fermentation to lower the number of suspended solids entering the wastewater treatment plant.[81]

Conversely, a high pH can produce a bitter taste and cause deposits to build up in water pipes and equipment. Additionally, it reduces the efficiency of chlorination, requiring more chlorine as pH levels rise.[81]

Aquatic life in rivers and lakes where wastewater is released, as well as soil and agriculture in wetland areas close to the affected industry, are likely to be impacted by this circumstance.

The quantity of oxygen needed for the biological breakdown of organic molecules in water bodies is known as the total Biochemical Oxygen Demand (BOD5). Because bacteria suck up the available oxygen in the water, dissolved oxygen levels fall when BOD5 levels are high.

Because of the low oxygen levels, fish and other aquatic life may find it difficult to survive [81]

7- Analysis of Fats, Oils, and Grease (FOG)

Table (24): Oils and Grease Levels in Wastewater from Al-Jouf and Asphalt Companies

Company/Industry	Oil and Grease Level (g/L)	Compliance Status	Notes
Al-Jouf Company	> 152.2	0%	Significantly exceeds national standards; indicates untreated wastewater discharge into wetlands.
Asphalt Company	0.224	N/A	Lower levels found; suggests possible compliance, but specific context needed.

Monitoring of oils and grease from Al-Jouf and Asphalt firms' industrial wastewater treatment plants yielded findings ranging from 152.2 g/L to 0.224 g/L. [82] Interestingly, the amount stated by Al-Jouf Company is significantly higher than the national standards' permissible limit.[81]

The fact that this value is greater than any of the samples collected at the wastewater treatment plant's entrance makes it abundantly evident that the Fanfold plant is releasing wastewater into wetlands untreated. This industry may retain grease because the wastewater treatment plant is inefficient or non-operational, which prevents the amounts of grease in the effluent from falling below allowable limits.

A compliance rate of 0% indicates that Al-Jouf Company has not complied with the allowed quantities of oil and grease for wastewater discharge criteria in any of the tested and analyzed samples.

Oil and gas components can have harmful physical impacts, such as suffocating animals and plants by coating them with oil and reducing their oxygen supply. In addition, they may cause poisoning and the production of harmful byproducts, damage to breeding animals and their habitats, and the devastation of present and future food supply. Oil spills can also clog wastewater treatment plants, contaminate beaches, and release unpleasant odors.

Table (25) shows the analysis of fats, oils, greases, and the hydrocarbon group.

Type of analysis	The results	
	Asphalt Company	**Al-Jouf Company**
Fats, Oils, and Grease (FOG) analysis	0.224 g/l	152.2 g/L
Total Hydrocarbons (THC) analysis	1780 mg/L C9 590 C10 185 C11 28 C12 219 C14 16 C16 282 C18 92 C20 278 C24 8.0 C28 14 C32 4 C36 64	**Nil**

The results obtained are comparable to the data obtained by other authors who conducted analyses on similar cases. For example, [83] identified the concentration of petroleum hydrocarbons in soil within a range of 2500 to 10000 parts per million, within an extended range of 100 to 10000 parts per million using gas chromatography/spectrometry techniques. The data from Park's paper [84] remained at the same level. In the literature, it is difficult to find relationships for data recording (TPH) / (O/G) and (BTEX) / (TPH) that were identified in our paper. Therefore, the aforementioned relationships in the case of industrial discharge heavily depend on the intensity of biological transformations [86]. However, the processes causing these phenomena can be used practically, for example, for the removal of volatile organic compounds. Despite the large number of hydrocarbons present in petroleum products, relatively few have had their toxicity described. Health effects of certain fractions can be accurately described concerning their components or representative compounds (for example, the light aromatic BTEX fraction: benzene, toluene, ethylbenzene, xylene, and naphthalene). The Agency for Toxic Substances and Disease Registry (ATSDR) does not assess the carcinogenic potential of TPH components, nor does it provide toxicity information for most components, except for some, such as the minimum risk level (MRL). It is noteworthy that the common health effects of BTEX compounds are neurological in nature. Benzene has a blood effect and is classified in Group A of the EPA classification (a human carcinogen). The minimum risk level for inhalation for each BTEX compound (acute minimum risk level) has been determined with results indicating the quantities of the components as follows: benzene 0.05 parts per million, toluene 0.02 parts per million, ethylbenzene 0.2 parts per million, o-, m-, and p-xylene 1.0 parts per million, and naphthalene 0.002 parts per million.

8- **Detection of Bacteria**

Bacteriological Analysis Results: The bacteriological analysis revealed the presence of four types of microbes in the river water sample from the asphalt company and the groundwater well of the cement factory. All samples contained Escherichia coli bacteria, indicating fecal contamination. Additionally, Staphylococcus aureus and Pseudomonas aeruginosa were found in the industrial wastewater samples from both the asphalt and cement processes.

Escherichia coli is the most common indicator of fecal contamination, and it can be easily isolated and identified. Its numbers are typically reported as fecal coliforms (FC) per 100 mL of industrial wastewater (De Boer 2000). Outbreaks of diseases can occur due to drinking contaminated well water containing various microorganisms from industrial wastewater, consuming contaminated fish, or engaging in recreational activities in contaminated water bodies that harbor waterborne pathogens.

Escherichia coli can cause urinary tract infections and diarrhea, while Bacillus anthracis is known to cause anthrax. Pseudomonas aeruginosa is a common bacterium that can cause diseases in both animals and humans [85].

Pseudomonas aeruginosa can, in rare cases, cause community-acquired pneumonia, as well as ventilator-associated pneumonia. It is one of the most commonly isolated pathogens in various studies.

Staphylococcus aureus is the most common cause of staphylococcal infections. This spherical bacterium is often found in the human nose and skin. It can cause a wide range of diseases, ranging from simple skin infections, such as boils, impetigo, abscesses, cellulitis, folliculitis, and scalded skin syndrome, to life-threatening conditions such as pneumonia, meningitis, osteomyelitis, endocarditis, and toxic shock syndrome. Staphylococcus aureus can also lead to sepsis. This disease can spread from the skin, soft tissues, respiratory system, bones, joints, and internal blood vessels, resulting in wound infections.

The results indicated that the well water at Al-Aseel factory showed no contamination, while the wastewater in Al-Aseel contained pathogenic E. coli when cultured on nutrient agar. Similarly, the well water at Al-Jouf company also showed the presence of pathogenic E. coli on nutrient agar. In the asphalt factory, the well water tested positive for E. coli and Staphylococcus aureus, which appeared yellow. However, the wastewater in the asphalt factory did not show any growth on nutrient agar, likely due to the presence of harmful chemicals in the effluent. This suggests that both groundwater and asphalt wastewater do not support bacterial growth due to the presence of bactericidal substances. Additionally, Shigella spp., Streptococcus spp., Staphylococcus aureus, and Klebsiella aerogenes were detected in both the cement and asphalt factories, indicating both positive and negative results as shown in the findings. Our study concludes that industrial areas significantly impact the environment and groundwater quality.

Table (26): Microbial Analysis Report of Well Water and Industrial Wastewater from the Asphalt Factory

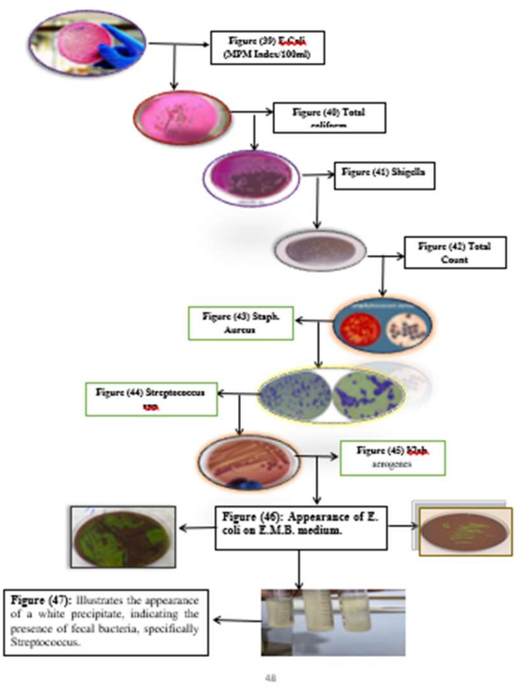
Parameter	Result		Quality Standard
	Asphalt Well	Asphalt weast	
Total coliform (MPM Index/100ml)	negative	negative	Nil
E.Coli (MPM Index/100ml)	negative	negative	Nil
Total count/1ml	500	negative	Nil
Shigella spp	positive	negative	Nil
Streptococcus spp	positive	negative	Nil
Staph.aureus	positive	negative	Nil
Kleb aerogenes	positive	negative	Nil

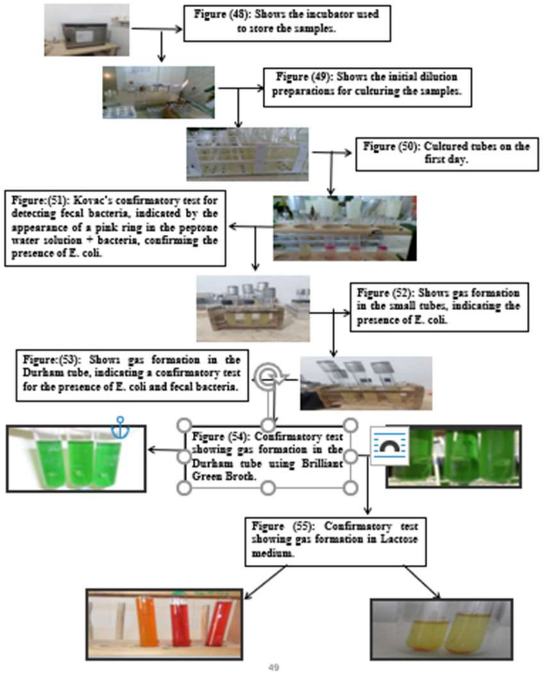
*** Bacterial Pathogens and Their Implications**

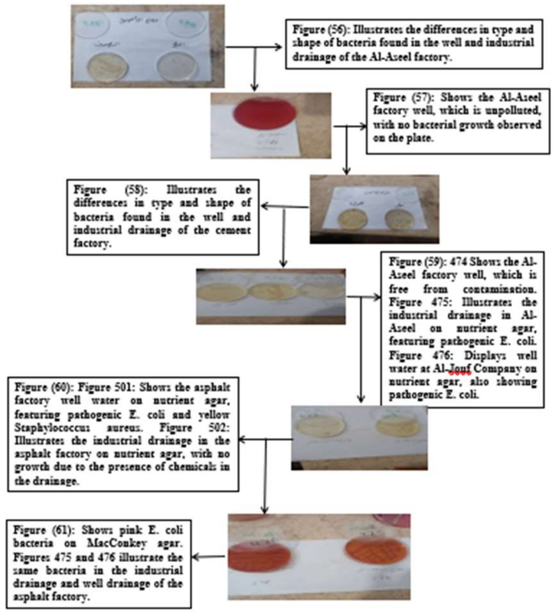
The pathogenic bacteria mentioned, particularly E. coli, are known to cause intestinal diseases. The presence of pathogenic E. coli indicates fecal contamination, which can lead to serious gastrointestinal issues.

Table (27): Microbial Analysis Report of Well Water and Industrial Wastewater from the Asphalt Factory

Parameter	Result		Quality Standard
	Cement Well	Cement west	
Total coliform (MPM Index/100ml)	7	1100	Nil
E.Coli (MPM Index/100ml)	negative	240	Nil
Total count/1ml	50	1000	Nil
Shigella spp	positive	negative	Nil
Streptococcus spp	positive	negative	Nil
Staph. Aureus	positive	negative	Nil
Kleb aerogenes	positive	negative	Nil







* Summary and Recommendations

1- Summary

The results of this study indicate that the trend of environmental pollution caused by industrial waste discharge in Rwanda is concerning. Placing industries outside designated industrial areas requires special attention; otherwise, it may hinder the country's goals of maintaining environmental resilience. This study revealed that the compliance level of industries outside industrial areas remains low, with industrial owners still discharging untreated or substandard wastewater into the environment, despite legal penalties. Fortunately, the findings of this study were considered during inspections, leading to additional measures, including the closure of some factories.

Regarding national and international standards for wastewater discharge, the compliance level with key industrial wastewater treatment standards is extremely low. First, none of the five industries complied with the permissible national and international limits for oil and grease treatment standards. The overall compliance level, considering all samples taken from all outlets of industrial wastewater treatment plants and receiving environments for the five industries, was only 16.7%. Second, only one out of the five concerned industries complied with the accepted standard limits for pH, dissolved oxygen (DO), biochemical oxygen demand (BOD5), chemical oxygen demand (COD), electrical conductivity (EC), and total dissolved solids (TDS).

Industries adjacent to fragile ecosystems or prohibited industrial areas (wetlands) require special attention. These industries cause significant environmental pollution, and upgrading wastewater treatment plants at their current locations is unfeasible, as establishing wastewater treatment plants in wetlands is not permitted under environmental laws and regulations. These industries should be relocated to designated industrial areas as soon as possible, prioritizing certain companies. At the same time, a strict monitoring system should be implemented to ensure these industries cease discharging untreated wastewater into the environment.

Additionally, the government should plan for the rehabilitation of contaminated areas. A feasibility study for rehabilitation should be conducted to clearly guide the rehabilitation plan, recommend the best rehabilitation techniques, and assess the potential for reusing and restoring the area for the benefit of local communities. The involved industries should contribute to the rehabilitation costs, adhering to the "polluter pays" principle. The concerned industries are generally advised to reduce or eliminate non-compliance in their wastewater treatment facilities by constructing or upgrading their treatment plants and adopting the best available technologies to meet national and international standards for wastewater discharge. Furthermore, it is recommended to adopt a self-assessment approach by regularly monitoring the water quality in their wastewater treatment plants to determine processing efficiency.

This research describes a case study that employed three analytical techniques, including gas chromatography/mass spectrometry (GC/MS), gas chromatography/flame ionization detection (GC/FID), and ultrasound, to identify and characterize oils/greases, total petroleum hydrocarbons (TPH), and volatile aromatic compounds (BTEX) in soil and sediment samples. Our results and data interpretation clearly indicate the following: -

1- The contamination of soil/sediment samples with diesel fuel is real and evident. The volatile aromatic hydrocarbons detected in the soil and sediment samples were found to originate from gasoline/diesel.

2- Sediment samples were contaminated with total petroleum hydrocarbons (TPH), but to a much lesser extent (five times lower) compared to soil samples.

3- The majority of total petroleum hydrocarbons (TPH) were heavy petroleum products. When released into the environment, primary hydrocarbons cause severe damage to water systems, and their toxic effects can persist for a long time. When treated appropriately by enhancing their biodegradability, hydrocarbons naturally degrade, allowing for the rapid elimination of the primary hydrocarbon pollution.

2- Recommendations

1- Find an Alternative to Septic Tanks: Develop alternatives to septic tanks due to their negative impact on human, plant, and animal health. Establish advanced wastewater treatment plants that comply with Libyan and international standards, recycle waste produced, and create networks with sensors to monitor changes in groundwater reservoirs.

2- Utilize Treated Wastewater: Prioritize treated wastewater as a resource in Libya to compensate for the shortage of freshwater sources. This water should be exploited in agriculture, industry, and other sectors as an unconventional water resource.

3- **Conduct Regular Testing:** Perform periodic measurements and analyses of treated wastewater used in agriculture in different regions of Libya, comparing the results with local and international specifications.

4- **Establish Green Spaces:** Create green zones and agricultural projects in various regions of Libya utilizing treated wastewater.

5- **Reduce Untreated Wastewater Discharge:** Limit the discharge of untreated wastewater into open spaces and into collection pits known as black wells. Instead, discharge it into the sea to maintain environmental cleanliness.

6- **Encourage Research and Awareness:** Support and encourage researchers in Libya to engage in analyses related to environmental and developmental projects. Increase public awareness by conducting intensive research and studies.

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