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THE CHEMICAL IMPACT ON RIVERS AND ITS ROLE IN INCREASING FINANCIAL COSTS ON IRAQI SOCIETY

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Abstract

Water pollution is a global problem that holds even greater importance in countries with limited water resources.** This research was conducted using a quantitative-inductive method with the aim of studying the chemical effects on rivers and their role in increasing financial costs on Iraqi society. Chemical test results of water samples were obtained from two stations located in the north and south of the city of Diwaniya, across two time periods: 2020 and 2024. Referring to the Diwaniya Water Organization, the data was collected and analyzed. Using a paired t-test, it was proven that changes in the chemical substances in the water during this period were significant. Thus, it can be definitively stated that the Diwaniya River water in 2024 was more polluted compared to 2020.A ten-question questionnaire, validated for reliability, was distributed among a sample of the population. Sampling was conducted using Cochran's formula, targeting 384 participants, with 300 fully completed questionnaires returned. The significant difference in results for all ten questions over the two periods revealed a meaningful increase in the costs associated with water purification devices and the treatment of diseases caused by water pollution. It can be definitively concluded that the pollution of the Diwaniya River, as the city's main water source, has caused financial pressure on households.

Keywords: Water Pollution, Chemical Effects, Gastrointestinal Diseases, Water Purification, Diwaniya Iraq.

Introduction

Today, various factors such as the drilling of illegal wells, the discharge of urban sewage, and the unauthorized disposal of industrial and municipal waste have led to the pollution of rivers. The direct impact of this pollution on agricultural products and consequently on human health is evident. Government officials have repeatedly destroyed illegal crops irrigated with polluted water to protect citizens' health. From a scientific perspective, water quality encompasses specific parameters that measure the condition of the water.

In recent years, the water sector in Iraq has not received adequate attention, leading to water pollution that poses significant risks. This study aims to assess the concentration and levels of environmental pollutants affecting the Diwaniya River (Shatt al- Diwaniya) by measuring certain physical and chemical properties.

According to the residents of Diwaniya , the city's water previously met health standards and was consumed with confidence. However, in the past two years, the volume of water pollutants has increased, causing numerous problems for the population. It appears that the establishment of a tire manufacturing factory in the city has contributed to the river's pollution.This research examines the impact of the river's water pollution on the financial costs borne by the city's residents.

1-1 Questions

How has the cost of living in Iraq changed in comparison to the time when the Diwaniya River's water was clean and its current condition?

1-2-Hypotheses

It is hypothesized that in the past two years, due to the pollution of the Diwaniya River, the city's residents have faced financial pressure related to healthcare and water purification costs. Thus, the following two hypotheses are proposed:

- Hypothesis 1:The pollution of the Diwaniya River has led to an increase in household water purification costs.
- Hypothesis 2:The pollution of the Diwaniya River has resulted in higher healthcare costs for households.

1-3-Importance and Necessity

The importance of having clean water for humanity is so obvious that it hardly needs mentioning. Naturally, the presence of clean water resources can lead to the flourishing of life. For Iraq, a country that has long suffered from unemployment, this issue could be a key to rural job creation, which would significantly contribute to the nation's economy. The results of this research could serve as a warning to Iraqi authorities, especially given that most political parties today are advocating for improvements in the living conditions of Iraqis. Efforts to keep the country's water resources clean could be one of the strategies for providing financial support to its citizens.

1-4Novelty

The relationship between water quality and the financial issues faced by citizens has not been previously studied. This research is the first to examine this connection within Iraq.

1-5 Structure of the Discussion

In this research, an introduction to the topic is provided first, followed by a review of the relevant literature to fully familiarize the reader with the subject. Then, the research methodology and operations are described. Finally, the research findings are presented, with appropriate conclusions drawn, and suggestions based on these findings are provided.

2- Water Quality Review

To gather information on water quality, over 50 parameters were selected. The most important ones include dissolved oxygen, biological oxygen demand (BOD), chemical oxygen demand (COD), levels of chloroforms, nitrates, and heavy metals.

2-1 Introduction to Heavy Metals and Their Effects

The rapid industrial progress and urban development in the past decade have raised serious concerns about environmental health. Heavy metal pollution in rivers is a major challenge in many countries. Metals are recognized by various environmental organizations as highly significant and toxic pollutants. Metals are divided into essential and non-essential categories, referred to as A and B, with an intermediate category as well. Category 4 includes elements such as calcium, magnesium, manganese, potassium, sodium, and strontium. Category B includes elements such as cadmium, copper, mercury, and silver. The intermediate category includes elements like zinc, lead, iron, chromium, cobalt, nickel, arsenic, vanadium, and tin. Scientists use the term “heavy metals” for metals that cause environmental problems. Metals enter the environmental cycle in two ways (Tikwa & Berg, 2004):

- Natural processes (including weathering of rocks, dust transfer by wind, volcanic activity, forest fires).

-Human activities typically through direct discharges into the environment.

Humans consume metallic elements through water and food. Biological tissues, in addition to organic materials, contain a series of heavier elements in low concentrations, which are referred to as trace elements. The usual definition of trace elements is that they have a concentration of less than 10 milligrams per liter in the sample and are generally divided into two categories: essential and toxic. Essential trace elements are those that play a vital role in biological functions, as many biochemical reactions occur through them, and their decrease or increase can cause metabolic and physiological disruptions. Some other trace elements do not participate in any of the processes in living matter and exist at very low concentrations, so they are considered pollutants in the body, referred to as toxic trace elements. Any increase or decrease in these chemical elements can cause certain diseases. The term "heavy metals" in a biological context refers to elements that have toxic properties. For instance, some metals such as sodium, potassium, magnesium, calcium, and iron are found in living tissues and are essential for human life, while some heavy metals like cadmium, lead, and mercury are highly toxic even at relatively low concentrations. These toxic metals can accumulate in body tissues for long periods and are unnecessary for human health (Vicente et al., 2013).

Heavy metals are presented as environmental pollutants in various physical and chemical forms and at different concentrations. Since heavy metals are non-biodegradable, they accumulate in the tissues of living organisms, thereby entering the food chain of plants, animals, and humans. Heavy metals not only severely contaminate the water consumable by humans and other living beings but also cause significant soil pollution. In some cases, due to heavy metal pollution, farmlands lose their value for agricultural use. Moreover, heavy metals discharged into the environment can penetrate the soil and pollute groundwater as well. Therefore, considering the severe harms of heavy metals, measuring their concentrations and removing them from industrial wastewater or surface water is a highly significant environmental issue.

One of the fundamental issues and problems related to heavy metals is their inability to be metabolized in the body. In fact, after heavy metals enter the body, they are not excreted but instead accumulate and deposit in tissues such as fat, muscles, bones, and joints. This accumulation can lead to numerous diseases and complications. Heavy metals also replace other necessary salts and minerals in the body. For example, in the absence of zinc in the diet, cadmium takes its place. Overall, neurological disorders (Parkinson's, Alzheimer's, depression, schizophrenia), various cancers, nutrient deficiencies, hormonal imbalances, obesity, miscarriage, respiratory, vascular, and heart disorders, liver, kidney, and brain damage, loss of appetite, joint inflammation, hair loss, osteoporosis, and, in severe cases, death, are among the consequences of heavy metal entry into the human body. Additionally, the bioaccumulative nature of heavy metals in plants and their entry into the food chain further amplifies the dangers associated with them.

2-2 Water Quality

Water quality is directly related to water consumption and the state of economic development. In industrialized countries, the issue of bacterial contamination in surface waters, due to its severe health risks in major industrial cities, has been under scrutiny since the mid-1800s. The expansion of sewage and wastewater networks in urban areas was prompted by widespread public fear. However, the pace of pollution in cities is exceptionally high due to their dense populations, and the pollutants carried by water are widespread. The prevalence of diseases like cholera and other similar illnesses is particularly pronounced in developing countries. Since World War II and the onset of the chemical era, water quality has deteriorated due to the widespread pollution from industrial and agricultural sources (Nazari, 2003).

The accumulation of pollutants in surface waters, which results from human and agricultural wastewater and nitrogen leaching from groundwater, has had a significant global impact. The acidification of surface waters by air pollution from various sources has posed a substantial threat to aquatic life worldwide. In developed countries, different types of pollution have escalated with technological advancements and economic progress, affecting surface water quality. Newly industrialized countries like China, India, Thailand, Brazil, and Mexico also face similar levels of surface water pollution as developed countries. When assessing water quality, physical and aesthetic quality, chemical quality, and bacteriological quality are all considered (ibid).

2-2-1-Physical Water Quality

Physical water quality pertains to characteristics such as color, turbidity, taste, odor, and temperature, which are detectable through the senses of sight, taste, touch, and smell. Under any circumstances, a consumer's preference for water decreases as the levels of color, odor, turbidity, taste, and flavor increase, since these attributes are easily discernible by the senses (Abbaslou, 2001).

2-2-2 Chemical Water Quality

Chemical water quality relates to ions contributing to water hardness, especially the combination of cations and anions dissolved in water, toxins, and compounds of toxic and trace elements. For each of these, specific and acceptable standards have been set for drinking water. One consequence of population growth is the irregular expansion of human activities, leading to the introduction of vast quantities of polluted water containing heavy metals, and the discharge of urban and industrial wastewater into agricultural fields (ibid).

The use of such water in agricultural fields can potentially cause severe health issues for humans. The introduction of heavy metals into the environment, even at low concentrations, can have irreversible effects on human health. These metals may enter the food chain through agricultural ecosystems and aquatic environments, indirectly threatening human health. Due to their toxicity and carcinogenic properties, heavy metals have adverse effects on human health. Consequently, in recent years, there has been significant attention on these metals as pollutants. Studies have shown that the daily accumulation of heavy metals like cadmium, chromium, and arsenic in the body leads to serious health problems.

2-2-3 Biological Water Quality

In the context of water hygiene, the bacteriological quality of water holds particular importance. When water hygiene is discussed, diseases that are transmitted and spread through various microorganisms in water come to mind. Water that appears clean and clear may still be contaminated with live pathogenic microorganisms, making it essential to ensure water safety and the absence of microorganisms before consumption in any circumstance. Biological pollutants, especially pathogenic microorganisms in drinking water, can cause epidemics and the spread of various diseases, leading to irreparable damage. The signs of a waterborne epidemic include uniform spread throughout the entire community, affecting all age, gender, and social groups, along with symptoms like dysentery, acute gastroenteritis, and stomach cramps. During an investigation of a disease outbreak caused by contaminated water or food, collecting information such as the cause, laboratory findings, mode of transmission, extent of the outbreak, dates, average treatment duration, length of the illness, age and gender distribution, mortality rate, recurrence of attacks, doctors' final diagnosis, and measures for preventing and controlling the disease is essential (Shafiian, 1999).

Numerous diseases have been reported globally due to sudden microbial contamination in water distribution networks. However, with continuous monitoring and strict control of bacteriological water quality, such incidents can be easily prevented. Drinking water quality can be divided into two sections: "biological quality and chemical quality," and maximum allowable limits are set for both. Water is considered potable only if its chemical and biological qualities do not exceed these limits. Water used for hygienic purposes and washing must also be free of pathogens to prevent the spread of waterborne diseases. Research in this field has shown that many people have become infected with various bacteria and fecal parasites simply by washing their hands and faces in contaminated water (ibid).

4-2-2 Graphical Representation of Chemical Measurements

One of the most important tasks in water resource research is to present chemical data in a visually interpretable manner. To graphically represent the quality data of the river water samples under study and to determine hydrochemical facies, chemical graphs such as Piper, Durov, Stiff, time series, and Schuler diagrams, created using AqQa software, as well as Wilcox, composite, and element histograms, are used (Zehtabian et al., 2003).

5-2-2Statistical Analysis

Understanding the chemistry of natural waters requires statistical analysis of environmental factors such as lithology, climate, topography, and the dissolved components in water. Statistical analysis does not provide absolute proof of a relationship but can suggest a type of correlation. For example, a strong correlation between calcium (Ca) and other elements in water samples taken from a river could indicate a common source, such as gypsum, for both ions. However, this assumption could be incorrect, as pyrite oxidation may also produce the same type of relationship, so geological and geographical studies are necessary to determine the true cause.

2-3 Literature Review

In Anzali Wetland, a freshwater ecosystem, a comprehensive study on heavy metals in water, bed sediments, macrophytes, benthos, and fish was conducted. In this study, Pourang (1993) determined the concentrations of heavy metals, including lead, copper, zinc, and manganese, in the mentioned phases, showing that the highest concentration of lead was found in bed sediments and the lowest concentration in fish and benthic organisms.

Riahi Bakhtiari, Alireza (1994), measured the levels of heavy metals (lead, cadmium, zinc, nickel, and copper) in water, bed sediments, and fish from the Karun River during the winter, summer, and spring seasons. The study found that the concentration of lead and cadmium in the sediments was higher than in the water, exceeding acceptable standards. The highest concentrations of lead and cadmium in bed sediments and river water were observed in the summer and the lowest in the winter.

Lahijanzadeh (1997) measured mercury, lead, and cadmium levels in various layers (water, bed sediments, and fish) of the Karun River and found significant differences in the concentrations of these metals upstream and downstream of the river throughout the four seasons. The study also showed that the lead and cadmium levels introduced into the Karun and Dez rivers through urban, agricultural, and industrial wastewater were significant.

Hosseini (1998) examined the levels of four heavy metals, namely lead, cadmium, zinc, and copper, in *Pohnogrammars Mooiews* amphipods from the estuaries of several rivers along the southern Caspian Sea coast (from Fereydunkenar to Noor). The Haraz River estuary was one of the ten estuaries where the heavy metal content in the amphipods was determined, with lead and cadmium levels being higher in the amphipods of the Haraz estuary than in those from other estuaries. The study concluded that there was no correlation between the heavy metal accumulation in amphipods and their gender.

In another study, Riahi Bakhtiari (1999) investigated lead and cadmium concentrations in the muscle, liver, and gills of three species of fish from the Karun River: *Leuciscus cephalus*, *Punctatus*, and *Capota agena*. The study revealed significant differences between the concentrations of lead and cadmium in the gills and those in the muscle and liver tissues of all three fish species. However, no significant difference was found between the lead and cadmium levels in the liver and muscle tissues. The highest accumulation of these two metals was observed in the tissues of *Punctatus* fish.

Zehtabian and colleagues (2003) examined the water quality of the Jajroud River in Varamin. Their results indicated that the further south towards the plains, the poorer the water quality, primarily due to urban, agricultural, and industrial wastewater as well as the influence of evaporative formations.

Qasemi Zadeh and Dehrazma (2011) studied the water quality of the Kashkan River at the junction with the Madian River and the impact of geological factors. The study found that the concentrations of elements such as calcium, bicarbonate, chloride, sodium, magnesium, and sulfate were strongly influenced by the region's geological formations, particularly the Gachsaran and Aghajari evaporative formations.

Ahmadi Moghani and colleagues (2010), in their study titled "Investigating Pollutant Sources and Water Quality of the Tajan River," emphasized that rivers are among the most valuable aquatic ecosystems, whose health and survival are vital for the sustainability of all living beings that depend on them. The water quality of the Tajan River was assessed, focusing on its environmental functions between the Shahid Rajaee Dam and the city of Sari, over a length of approximately 35 kilometers. Five sampling stations were selected to analyze the ecosystem's sensitivity to pollutants from the riverbanks. The study examined the region's cropping conditions and farming activities as primary contributors to river pollution. To establish baseline water quality conditions, samples were collected in May before the start of the planting season, and the concentrations of nitrate, nitrite, ammonia, phosphate, dissolved oxygen, hardness, alkalinity, pH, and BOD5 were measured using standard methods. A three-week sampling interval was set from June to October, with additional sampling in early winter to compare seasonal water quality. The results showed that phosphate and ammonia concentrations exceeded acceptable standards, causing problems for the river and its aquatic life. Moreover, the hardness and alkalinity were significantly high, beneficial to the ecosystem's health and aquatic organisms.

Tayebi and Ardakani (2012) conducted a study titled "Assessment of Water Quality Parameters in the Gamasiab River and Influencing Factors." They highlighted that due to the increasing use of Gamasiab River, the largest and most voluminous river in Hamadan Province, for various purposes, especially the establishment and expansion of trout hatcheries, it is essential to assess the water quality parameters of this river. In this study, to evaluate the water quality and assess the factors affecting it, particularly for fish hatcheries, five sampling stations along the river were chosen. Sampling was carried out during August, September, and December 2007 to obtain a suitable temporal distribution regarding the effects of fish feeding on water quality characteristics. Water samples were collected in sealed polyethylene containers, and parameters such as dissolved oxygen, pH, and electrical conductivity were measured on-site. The samples were then refrigerated and transported to the laboratory as quickly as possible for the measurement of biochemical oxygen demand (BOD), ammonium, nitrite, nitrate, and orthophosphate concentrations. The results indicated that, except for the average electrical conductivity where no significant differences were found between stations, differences in other evaluated parameters were observed. Specifically, the average concentrations of dissolved oxygen, pH, and BOD showed no significant difference between the inflow channel of the Danesh trout hatchery and the control station. Additionally, the average concentrations of ammonium and nitrite ions in the control station differed significantly from other sampling stations due to substantial nutrient input from aquaculture activities and wastewater from surrounding villages.

Comparing the hatcheries in terms of average concentrations of nutrients such as ammonium and nitrate showed significant statistical differences. The Danesh hatchery, with a production of 100 tons of fish, introduced more pollution into the river compared to the Zagros hatchery, which produced 190 tons of fish. Comparing the average concentrations of evaluated parameters with water quality classification tables revealed that the water quality of the Gamasiab River ranged from slightly polluted to moderately polluted. Therefore, the river currently has some self-purification capacity for pollutants; however, with the country's policies, particularly in Hamadan Province, regarding the expansion of aquaculture and the lack of monitoring of pollutant sources, the river may face serious problems, including eutrophication, in the near future.

Habat al-Ghaib and colleagues (2013) examined the water quality of the Kakarreza River in Lorestan Province. Their analysis of 15 samples along the river indicated that the water quality was classified as good for drinking and agricultural purposes.

Yaghoubzadeh and Safary (2013) conducted a study titled "Assessment of Microbial Pollution in Surface Waters of the Haraz River." They noted that the Haraz River, one of the three major rivers in northern Iran (Mazandaran Province), originates from the northern slopes of the Central Alborz and collects various pollutants as it passes through agricultural areas, cities, and villages before emptying into the Caspian Sea. This study aimed to evaluate the microbial quality of surface waters in the Haraz River, focusing on total coliforms and fecal coliforms as indicators of environmental impacts from various projects, including the Manghel Reservoir Dam construction. The study collected 84 surface water samples from seven stations (Sorkhrood, Keresang, Pol-e-Jelav, Noorood, Tehran 115 km, Lasem, Lar) over a year (a total of 12 sampling periods) and assessed total coliforms and fecal coliforms. Results showed that the highest and lowest average logarithmic numbers of total coliforms were found at the Sorkhrood (CFU/100ml 4.9) and Lasem (CFU/100ml 2.4) stations, respectively. Similarly, the highest and lowest average logarithmic numbers of fecal coliforms were at the Sorkhrood (CFU/100ml 3.2) and Lasem (CFU/100ml 1.1) stations, respectively. The study revealed that coliform populations varied with seasonal, temporal, and spatial changes, and the water quality of the Haraz River was found to be poor and unsuitable for human consumption.

Sadeghi Far and colleagues (2014) conducted a year-long sampling from the Khorramabad River, focusing on toxic and heavy metal elements. The results indicated chemical pollution (cadmium, nickel, and lead) in the Khorramabad River, with the main sources of this pollution being urban and rural wastewater and industrial effluents in the region.

Mortazavi and colleagues (2017) in a study titled "Analysis of Naproxen, Sebex, and Diclofenac Concentrations in the Karaj River and Its Incoming Effluents, Alborz Province, Iran" noted that due to the toxicity and long-term persistence of pharmaceutical pollutants in aquatic environments, this research aimed to assess the residual concentrations of anti-inflammatory drugs naproxen, sebex, and diclofenac in the Karaj River. Sampling was conducted from 14 stations along the river, six stations at treatment plants, and their corresponding effluents. After sample preparation and filtration, the concentrations of pharmaceutical pollutants were measured using an HPLC device. The results showed that the average concentrations in the Karaj River were 0.409 µg/L for naproxen, 0.091 µg/L for sebex, and 0.034 µg/L for diclofenac. In treatment plants and their effluents, the concentrations were 0.774 µg/L and 0.566 µg/L for naproxen, 0.260 µg/L and 0.171 µg/L for sebex, and 0.082 µg/L and 0.064 µg/L for diclofenac, respectively. The concentration of these pollutants decreased in the following order: effluent, wastewater, and river water, with naproxen having the highest and diclofenac the lowest concentrations. The correlation between these pollutants in different samples suggests the inefficiency of treatment plants and the persistence of these substances, which eventually enter the river via effluents. Effective treatment methods are necessary to protect the region’s environment.

Suyik and colleagues (2009) investigated metal pollution in surface sediments of Lake Seyhan in Turkey and reported severe enrichment in cadmium and very low enrichment in chromium.

Aydin and Tanili (2013) studied the presence of 14 pharmaceuticals (antibiotics, anti-inflammatory drugs, etc.) in the Buyukkome River in Turkey. Using a rapid, strong, and sensitive solid-phase extraction method combined with liquid chromatography, they measured minimum concentrations of pharmaceutical pollutants between 1.1 and 1.15 ng/L.

Guti and colleagues (2014) assessed heavy metal pollution in groundwater at various locations in the city of MLBI. The study revealed high concentrations of heavy metals in groundwater in certain areas, indicating a need for special attention to reduce metal concentrations.

Wu and colleagues (2014) measured the concentrations of 50 pharmaceutical pollutants in the Yangtze River in China. Pollutants such as caffeine, sulfamethazine, and paraxanthine had 100% detection frequencies. The highest concentrations observed were for erythromycin at 296 ng/L and caffeine at 142 ng/L. The total concentration of these pollutants exceeded 1547 ng/L. They performed a risk assessment for all studied pollutants, with the highest risk ratio (greater than 1) reported for erythromycin.

Dia and colleagues (2015) were the first to examine the concentrations of 15 pharmaceuticals and personal care products in surface waters of the Beijing River across different seasonal conditions. The average concentration of selected compounds was about 4200 ng/L, with the highest levels found in early spring. Additionally, the results indicated a significant presence of untreated wastewater in the river.

Korja and colleagues (2016) investigated the concentrations of 24 pharmaceuticals, including antibiotics, antiviral drugs, analgesics, anti-inflammatory drugs, and psychiatric medications, in wastewater, surface water, and groundwater in Nairobi, Kenya. Their study assessed the efficiency of wastewater treatment, identified major sources of pharmaceutical pollution, and examined the dilution effects of pollutants in natural river flows. The results revealed that the total concentration of pollutants in river water reached up to 320 µg/L, with higher concentrations of antiretrovirals and antibiotics, which are crucial for treating common African diseases like HIV and malaria, compared to Western countries. Additionally, in drinking water reservoirs, the removal efficiency of pharmaceutical compounds ranged from 11% to 99%.

Aligrekis and colleagues (2016) studied the presence of 158 pharmaceuticals and drugs in the bays of Greece. The area was affected by various pressures from human activities, including the discharge of treated wastewater in major areas of Athens and coastal entry points. This study provided the first evidence of the presence of pharmaceutical compounds such as amoxicillin, lidocaine, citalopram, and tramadol in the marine environment. The results indicated that the wastewater treatment plants in Athens were the primary source of pollution in the Saronic Gulf, along with other anthropogenic pressures such as pollution from transportation activities, industrial effluents, and dredging.

3. Research Methodology

The research method is a quantitative-descriptive correlational approach. Variables were measured quantitatively using a questionnaire, and the quantitative data, once extracted, are analyzable. Using the t-test, the quantitative data were analyzed, and in the descriptive section, the relationship between variables was examined to test hypotheses. This study is applied in nature, with a descriptive survey approach. The researcher aims primarily to achieve practical goals and develop applied knowledge in the relevant field. The study is field-based in terms of data collection and non-experimental regarding variable control. Therefore, the research method can be described as a quantitative descriptive correlational approach.The statistical population consists of all citizens of Diwaniya aged between 20and 60 years who have resided continuously in the city for more than five years. According to statistics from Qadisiyyah Province, the total population of this city is 650,000. The age range is chosen to ensure participants have adequate education and information on the subject, as age can influence this aspect. The length of residence is also significant, as respondents should recall the state of the river water.

According to officials in Qadisiyyah Province (Governorate of Qadisiyyah), with these limitations, the statistical population is reduced to 400,000. Simple random sampling was conducted using Cochran's formula, determining a sample size of 384 individuals. Questionnaires were distributed in person throughout the city, and ultimately 300 completed questionnaires were returned. The questionnaire consisted of ten questions: 5 questions concerning health costs and the remaining 5 related to water treatment costs. The questions were asked in two time periods: 2020 and 2024. The questionnaire has validity and reliability. The reliability of the questionnaire was calculated using Cronbach's alpha, which was 0.95.

The questionnaire is attached. The study focused on the Diwaniya River, the primary source of drinking water for the city's residents. The Diwaniya River is a branch of the Al-Hilla River, passing through the cities of Diwaniya, Al-Sudair, Al-Hamza, and Al-Rumaitha. It splits into three branches and ends in agricultural lands, with a total length of 124 kilometers. The river width ranges from 45 to 50 meters and expands to 70 meters in some areas. Its depth ranges from 3 to 4 meters, with an average water depth varying seasonally between 1.5 to 3 meters. The study area is geographically located south of the Diwaniya River and north of the city, 11 kilometers from the city's wastewater treatment plant. Additionally, there is a textile and plastic factory south of the Diwaniya River. The study was conducted in January 2020 and 2024, with three samples taken from each location to minimize and ideally eliminate research error. These data were obtained from the Diwaniya Water Authority. The location of the Diwaniya River sampling station is shown on the map in Figure 1.

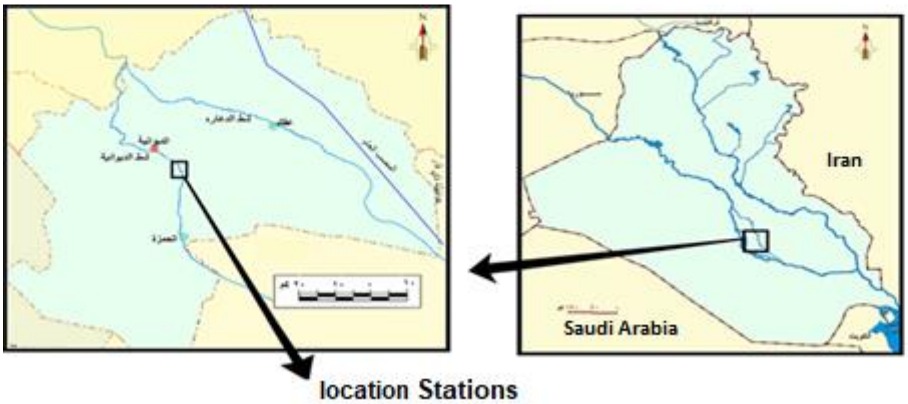

Figure 1 - Location of Sampling Stations on the Map

First Station (ST1)	32.015851,44.897107
Second Station (ST2)	31.963414,44.963910

4- Findings

The water hardness data at the two stations over the four-year period are as follows.

Table 2 - Initial Results of Parameters in Four Samples

parameter	**2020** south	the north	**2024** south	the north
PH	6.5	7	8.8	9.5
Turb.NTU	19.5	22.5	50.59	60.59
EC.	925	978	1305	1406
TDS	470	490	685	700
TSS	28.5	27.5	77.5	88.5
DO	8.5	10.2	20.12	25.2
BOD	1.5	1.2	2.9	2.5
CaCo3	95	97	170	186
PO4	0.11	0.2	0.55	0.65
NO3	1.59	1.35	4.5	4.9
NO2	10.5	10.26	20.5	21.5
Cd	0.08	0.05	0.15	0.18
pb	2.5	1.6	5.6	5.3
Zn	1.2	1.5	2.9	3.8
Total Coliform	290	460	1100	1100
Fecal Coliform	9.1	14	28	28

To investigate significant changes in water hardness, a paired t-test was used. The analysis results are shown in Table 3.

Table 3 - Results of Paired T-Test

Station Location	Statistic	Significance Level	Interpretation
South	2.069	0.056	Confirmed at a confidence level above %90
North	1.874	0.08	Confirmed at a confidence level above %90

The result shows that the changes in water hardness from 2024 compared to 2020 at both stations are significant. Considering the increase in hardness, we can confidently state that the water of the Diwaniya River, which is the main source of drinking water for the people of this city, was at a healthy level in 2020 but had shifted to a polluted level by 2024.As mentioned earlier, the questionnaire was designed such that the first five questions were related to health costs associated with water pollution, and the next five questions concerned household water purification costs. All questions were asked in two periods, 2020 and 2024. The independent t-test was used to examine the significant differences for each question between the two periods, and the results are shown in Table 4.

Table 4 - Examination of the Level of Significant Difference for Each Response Between Two Periods

Question	Statistic	Significance Level	Interpretation
First	67.04	0.000	Significant difference confirmed at a confidence level above %99
Second	69.235	0.000	Significant difference confirmed at a confidence level above 99%
Third	53.337	0.000	Significant difference confirmed at a confidence level above 99%
Fourth	52.542	0.000	Significant difference confirmed at a confidence level above 99%
Fifth	39.891	0.000	Significant difference confirmed at a confidence level above 99%
Sixth	49.069	0.000	Significant difference confirmed at a confidence level above 99%
Seventh	276.736	0.000	Significant difference confirmed at a confidence level above 99%
Eighth	278.486	0.000	Significant difference confirmed at a confidence level above 99%
Ninth	297.94	0.000	Significant difference confirmed at a confidence level above 99%
Tenth	71.18	0.000	Significant difference confirmed at a confidence level above 99%

The final result is that the citizens of Diwaniya city in 2024, compared to 2020, spent more on household water purification and treatment for diseases caused by contaminated water, which is considered a financial burden on families. The change in the condition of the Diwaniya River's water from "healthy" to "polluted" between the two periods was also confirmed.

5- Summary and Conclusion

The statistical analysis results have proven the research hypothesis. Earlier, Allegrikiss and colleagues (2016) stated that water pollution imposes hidden costs on middle-class families, ultimately leading to a reduction in their living standards. Korjeh et al. (2016) also deemed river water pollution to be destructive to the urban and national economy.

Sadeghi Far et al. (2014) stated that river water pollution at a significant level implies the necessity of incurring costs for water purification. Mortezavi et al. (2017) mentioned that the probability of river water pollution over a four-year period is high.The final conclusion is that in Diwaniya city, Iraq, due to the confirmed pollution of river water between 2020 and 2024, which is statistically proven, citizens were forced to incur costs for medical treatment and household water purification, which significantly differs from the healthy river water period. The government of Iraq must identify the sources of water pollution in the country and allocate funds to prevent the spread of this pollution. This would help alleviate the economic burden on families, who would not have to spend substantial amounts on their health and household water.

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Appendix: Questionnaire Questions

Dear Respondent,

Greetings and thank you for taking the time to participate in our survey.

The questionnaire you have been provided with is part of an academic thesis. We kindly ask you to complete this questionnaire carefully to assist us in conducting this research. Please be assured that your responses will be treated with complete confidentiality and will only be used in the aggregation and analysis of the research findings. There is no need to provide your personal details in this questionnaire; only general information is required. We sincerely thank you in advance for your cooperation and support.

General Questions

1- Gender: Male--- Female---

2- Age: ....

3- Marital Status: ....

4- Highest Educational Degree: ....

No	Questions Please specify the cost in Iraqi Dinars	2020	2024
1	Clinic costs due to problems caused by water pollution.		
2	Hospital costs due to problems caused by water pollution.		
3	Insurance costs due to problems caused by water pollution.		
4	Medication costs due to problems caused by water pollution.		
5	Laboratory costs due to problems caused by water pollution.		
6	Water purification device costs.		
7	Water purification device filter costs.		
8	Electricity costs for the water purification device.		
9	Servicing costs for the water purification device.		
10	Costs of accessories for the water purification device.		