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Assessment of Groundwater Quality for Human Uses

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Abstract:- Evaluating the quality of groundwater holds utmost importance in determining its suitability for safe consumption. This study delved into the groundwater conditions in selected regions of southern Iraq (Thiqar government), specifically Al-shatra and Al-naser districts. Physical and chemical water parameters were examined including, pH, electrical conductivity, turbidity, total dissolved solids, alkalinity, nitrates, nitrites, fluoride, sulfate, hexavalent chromium, copper, manganese, and iron. The results demonstrated the quality of ground water was not suitable for human uses according to WHO and Iraqi guidelines. Heavy metals and anions contaminates have not influenced on the human health and the environment due to their higher concentrations less than the acceptable value. However, other parameters have concentrations higher than the allowable value. The maximum concentration of TDS was 1955 mg/l at Al-zamil (Al-naser) (W8) and the turbidity was slightly more than the WHO standard. The concentration of alkalinity was higher than the healthy value.

Keywords:- *Groundwater, Physical and Chemical Properties, Global Warning, Assessment, Iraq.*

I. INTRODUCTION

Water, being essential for human survival, is commonly known as "water is life."(Dirican, 2014), (Bouslah et al., 2017). The hydrological cycle guarantees the presence of water in diverse forms, including the atmosphere, oceans, seas, lakes, and groundwater, constituting a substantial portion of Earth's makeup. Nonetheless, not all water found in these reservoirs may be suitable for human consumption or for utilization in activities like crop irrigation, fish farming, or other agricultural endeavors, primarily because of water pollution (Duan et al., 2016), (Krishnan and Saravanan, 2022). Undesirable water quality is a widespread issue across the globe, and water pollution is a major contributing factor. This pollution can arise from various sources, such as the release of acidic gases into the atmosphere or the discharge of waste products from industries into water bodies(Mohajan and Mohajan, 2018). Additionally, the use of pesticides and fertilizers to enhance plant growth, which falls under anthropogenic factors, can lead to groundwater pollution and contamination, as it is a primary source of freshwater(Bexfield et al., 2021), (Michel et al., 2021). The mentioned anthropogenic activities are linked to population growth over the years, and unpredictable changes in climate.

Approximately 71% of our planet is covered in water, with 97.5% found in the ocean and the remaining 2.5% in the form of freshwater. The ice and snow covering the Arctic and Antarctic, along with mountain glaciers, store the largest portion (68.7%) of freshwater. Fresh groundwater accounts for approximately 30% of the total (Khilchevskyi and Karamushka, 2021), (Marshall, 2013). The majority of freshwater accessible to terrestrial organisms, particularly humans, is found underground. Roughly one-third of the world's human water consumption is sourced from groundwater, with approximately 85% of the rural drinking water supply obtained from underground reservoirs(Jakeman et al., 2016). However, anthropogenic activities are negatively impacting the quality of this limited freshwater resource. Groundwater pollution has emerged as a significant environmental issue over the last two decades, posing a threat to both the environment and human well-being. Water quality deterioration due to contamination is one of the most pressing environmental concerns. Despite the fact that drinkable water is primarily derived from groundwater, which is present almost everywhere in the world, contamination is rapidly becoming a critical problem.

Iraq is a country that is particularly vulnerable to the impacts of climate change due to its arid and semi-arid climate, which is characterized by high temperatures, low rainfall, and high rates of evaporation. These factors, combined with a legacy of strife and inadequate water management approaches, have resulted in substantial difficulties concerning both surface and groundwater resources within the nation. Groundwater resources in Iraq are also under threat from climate change. In certain regions where surface water resources are scarce, groundwater has emerged as a vital source of water for both agricultural needs and drinking water supplies. However, over-extraction of groundwater combined with decreased recharge rates due to decreased rainfall and increased evaporation rates could lead to depletion of these resources, resulting in lower water availability and decreased agricultural productivity. Moreover, the effects of climate change are exacerbated by factors such as population growth, urbanization, and unsustainable land use practices, which all contribute to increased pressure on water resources(Al-Maliki et al., 2022),(Al-Dabbas et al., 2015),(Abbas et al., 2016). The Iraqi government has recognized the importance of addressing these challenges and has developed a national

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water resources management plan to address water scarcity and increase water use efficiency.

The significance of this work becomes apparent in the midst of the global warming crisis. Addressing the issue of drought necessitates comprehensive preparation and utilization of all available water sources. Groundwater is recognized as a crucial resource in various countries. The objective of this study is to evaluate the quality of groundwater. This involves an investigation into the physical and chemical parameters of groundwater, comparing the findings with the established standards of both Iraq and the World Health Organization (WHO).

II. METHODS AND MATERIALS

➢ *Study Area*

The study is conducted in the Thi-qar governorate. The source of groundwater is taken from wells in the Al-naser district and the Al-shatra district. Two cities are located to the north of the Thi-qar governorate. Groundwater is used for domestic activities and irrigation purposes, as the area is also an agricultural zone with various agricultural activities and farming methods being practiced. In the study area, numerous wells existed, but the majority of them were dry. This was primarily due to the low rate of rainfall and the reduced water level of the Al-Graff River. Consequently, global warming emerged as the main cause of this crisis.

➢ *Chemical and Physical Analysis*

During the winter season, water samples were taken from hand-dug wells, and sterile containers were used to collect the samples. Prior to collecting the samples, field parameters, including pH and turbidity, were measured using a digital meter. A HANNA pH meter (Model HI98103) was used for pH measurements, and a turbidity meter (Turb550, WTW) was used for measuring turbidity. Subsequently, groundwater samples were transported to the Environmental Lab at the University of Thiqar. Electrical conductivity (EC) and total dissolved solids (TDS) were measured using the WTW instrument (inlob720). Heavy metals, some anions, and alkalinity were determined in the laboratory using a multi-photometer (HANNA, Model HI83200). All reagents were purchased from a local company in Baghdad. The chemical analysis of the samples was conducted within 48 hours from the time of collection. All instruments were provided by the Department of Environmental and Pollution at the Marshes Research Centre. Table 1 displays the sample sites.

Table 1 The Site of Collected Samples

	Location of well	**Abbreviation**	**Coordinate**
1	Aleamaar (Al-shatra)	W1	31.414276N 46.135378E
2	Aleamaar (Al-shatra)	W2	31.411613N 46.132280E
3	Al-jahl (Al-shatra)	W3	31.360736N 46.164116E
4	Al-jahl (Al-shatra)	W4	31.358867N 46.159319E
5	Al-kazim (Al-naser)	W5	31.566369N 46.127674E
6	Al-kazim (Al-naser)	W6	31.566488N 46.127706E
7	Al-zamil (Al-naser)	W7	31.517887N 46.035374E
8	Al-zamil (Al-naser)	W8	31.518679N 46.033958E

III. RESULTS AND DISCUSSION

A. *Chemical and Physical Properties*

➢ *pH*

The pH level is a critical factor in assessing water quality for various operational purposes. It serves as a measure of both the acidity and alkalinity of groundwater, significantly influencing the concentration and chemical composition of numerous organic and inorganic substances present in the groundwater. Within the dataset, this parameter exhibits a range between 6.45 and 7.49. Figure 1 displays the pH values, revealing that the majority of samples fall within the desirable range set by the WHO (Bouslah et al., 2017). The acidity values in Al-shatra and Al-naser are close to neutral. The highest value was recorded at W6, while the lowest value was recorded at W5. A lower pH value may indicate the presence of pollution, which can impact the concentration of hydrogen ions.

Fig 1 Average of pH values of Collected Groundwater Samples

➢ *Turbidity*

Turbidity refers to the cloudiness or haziness of water caused by suspended particles that obstruct the passage of light. This phenomenon is assessed using a measurement technique called turbidimetry. Figure 2 represents the turbidity values for the collected samples. According to the World Health Organization (WHO) guidelines (Wekesa and Otieno, 2022), the maximum acceptable level of turbidity is 5 NTU. The results confirmed that the turbidity was higher than the healthy level, with the maximum value reaching 8 NTU at W4 and W5. The main reason for the high turbidity is the winter season.

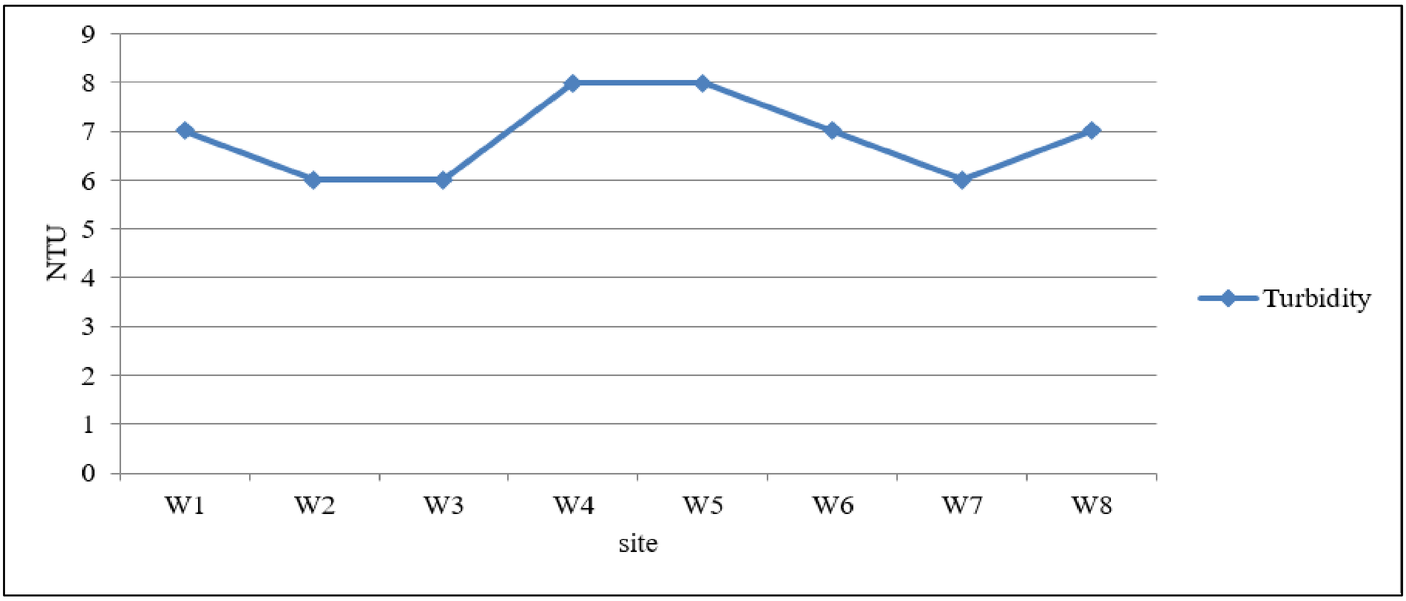

Fig 2 Average values of Turbidity of Collected Ground Water Samples

➢ *Electrical Conductivity (EC)*

Electrical Conductivity (EC) is a quantitative measure representing the capacity of an aqueous solution to conduct electric current. It serves as a valuable metric for assessing the purity of water, as demonstrated by Sajitha and his team in their study (Vijayamma and Asok Vijayamma, 2016). The measurement of EC is performed using a specialized device known as an electrical conductivity meter, which is calibrated using a standard potassium chloride (KCl) solution. This meter enables us to gauge the electrical conductivity of water, providing essential insights into its quality. In the study area, electrical conductivity values ranged from 1804 to 3910 µs/cm. These results may be considered normal due to global warming, hot weather conditions in Iraq, and low rainfall. Consequently, the low value of EC can be attributed to the proximity of these wells to the river. Figure 3 represents the electrical conductivity values.

Fig 3 Average value of Electrical Conductivity of Ground Water Samples

- *Total Dissolved Solids*

Total Dissolved Solids, abbreviated as TDS, represent the diverse array of minerals found within water. The recommended acceptable TDS level stands at 500 milligrams per liter, as established by the World Health Organization (Sadat-Noori et al., 2014). The TDS measurements in the study spanned from 902 to 1955 mg/l. The examination of groundwater samples in the current research revealed high TDS levels, implying a higher mineral content and greater contamination in the water. Figure 4 shows the amount of TDS in samples of groundwater. The maximum concentration was recorded at W8, as this well is not near the surface water source (rivers, lakes, etc.), and the lower amount of rainfall is considered a main reason for higher TDS.

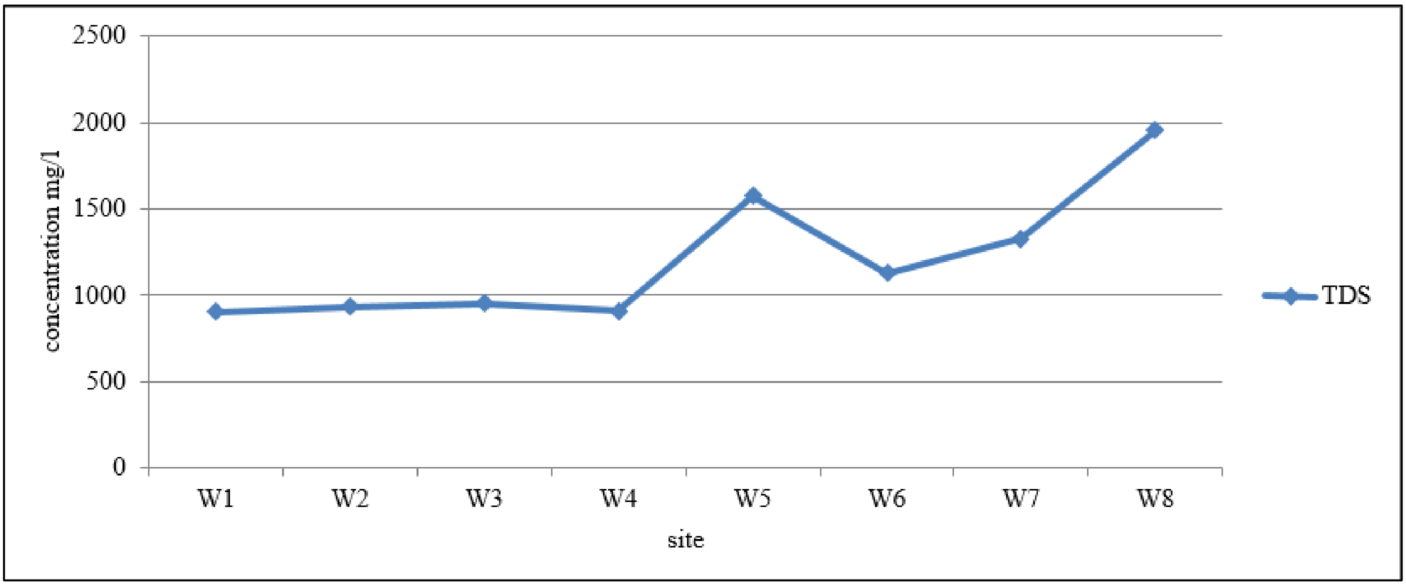

Fig 4 Average value of TDS of Ground Water Samples

- *Alkalinity*

The recommended allowable alkalinity (as $CaCO_3$) level, according to Iraqi standards, stands at 125-200 mg/l as $CaCO_3$ (Alanbari et al., 2015). Within the study area, the observed range of alkalinity concentrations in the collected water samples spans from 253 to 395 mg/l, exceeding the Iraqi standards. At W8, the average alkalinity was recorded. The source of alkalinity is natural soil, and these samples were collected from farming areas. Figure 5 represents the concentration of alkalinity as $CaCO_3$.

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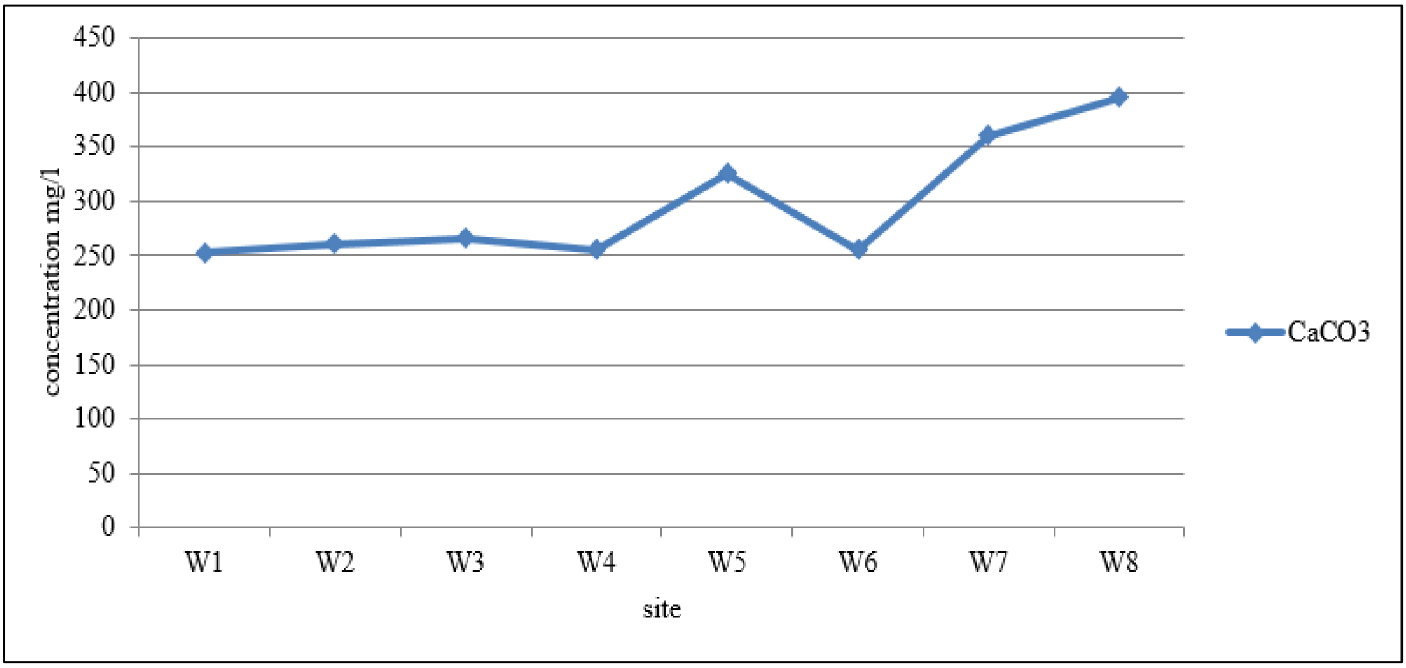

Fig 5 Average value of Alkalinity as $CaCO_3$ of Ground Water Samples

➢ *Anion pollutants*

The concentration of anions in water has influenced the health. In the current study, several pollutants have been measured such as nitrates, nitrites, sulfate and fluoride. These parameters are considered an essential due to a high concentration more than allowable value has a dangerous effect on the health and the environment.

- *Nitrates*

Nitrate, an important ion, poses a potential risk to human health, particularly when present in water. The presence of this ion is often attributed to human activities(Al-Kaabi et al., 2021). The World Health Organization (WHO) has established a maximum concentration of 50 mg/l for nitrate in water(Ghalib, 2017). In Figure 6, the average nitrate values are illustrated, with the highest concentration recorded at W3, reaching 9 mg/l. These results indicate that agriculture is the primary contributing factor. Conversely, the lowest concentration was observed at W8, measuring 1 mg/l.

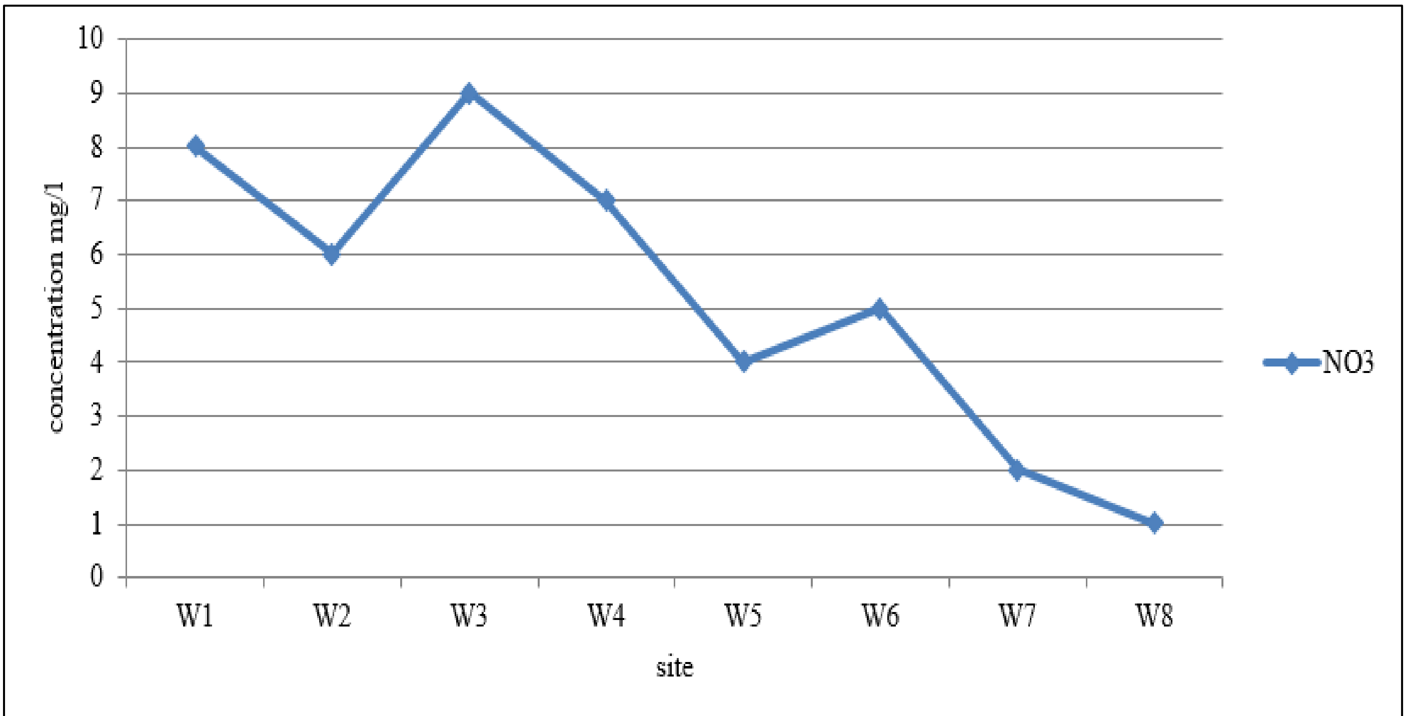

Fig 6 Average value of Nitrate of Ground Water Collected Samples

- *Nitrites*

Groundwater pollution is a pressing environmental concern, with nitrite being a significant contributor to this issue. Nitrite contamination in groundwater primarily results from agricultural runoff, industrial discharges, and improper waste disposal practices. As a byproduct of various human activities, nitrite poses a serious threat to both the environment and human health (Al-Kaabi et al., 2021). In Figure 7, the concentration of nitrite ions is depicted. All concentrations fall below the permissible limit(Feldman et al., 2007). However, it is noteworthy that the concentration of nitrite ions in Al-shatra samples surpasses that in Al-naser samples. This disparity is attributed to the impact of domestic and agricultural activities.

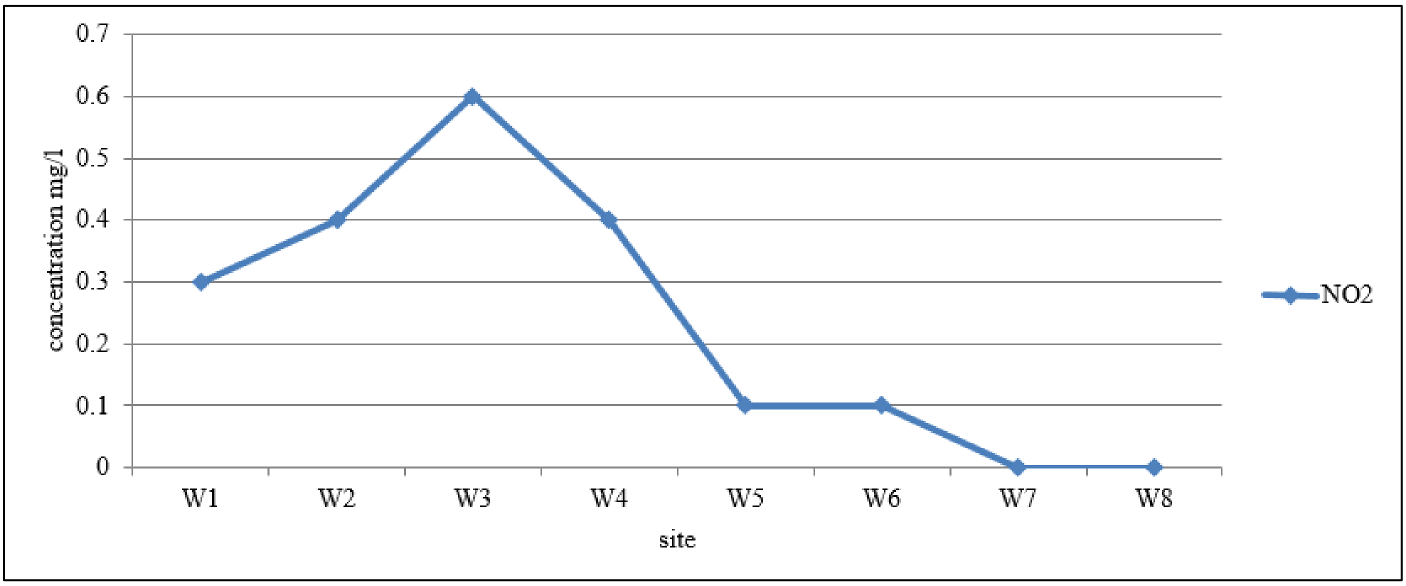

Fig 7 Average value of Nitrite of Ground Water Collected Samples

- *Sulphate*

Sulphate contamination in groundwater can have diverse sources, including mineral dissolution, atmospheric deposition, and human activities such as mining and fertilizer application. Notably, gypsum plays a significant role in increasing sulphate concentrations in numerous aquifers globally. According to Iraqi and WHO standards, the acceptable concentrations are 400 mg/l and 250 mg/l, respectively(Mahdi et al., 2021). The study results indicate a high sulphate concentration compared to WHO standards, with the maximum concentration observed at W8. The sulphate levels in Al-shatrah samples were lower than those in Al-naser samples. These sulphates are believed to originate primarily from sedimentary rocks rich in gypsum(Janardhana Raju et al., 2011), (Ghalib, 2017). Elevated sulphate content, especially when combined with excessive magnesium, can potentially induce a laxative effect. Additionally, in cases where water has low alkalinity, it may contribute to the corrosion of metals within the distribution system. Figure 8 illustrates the average sulphate concentration.

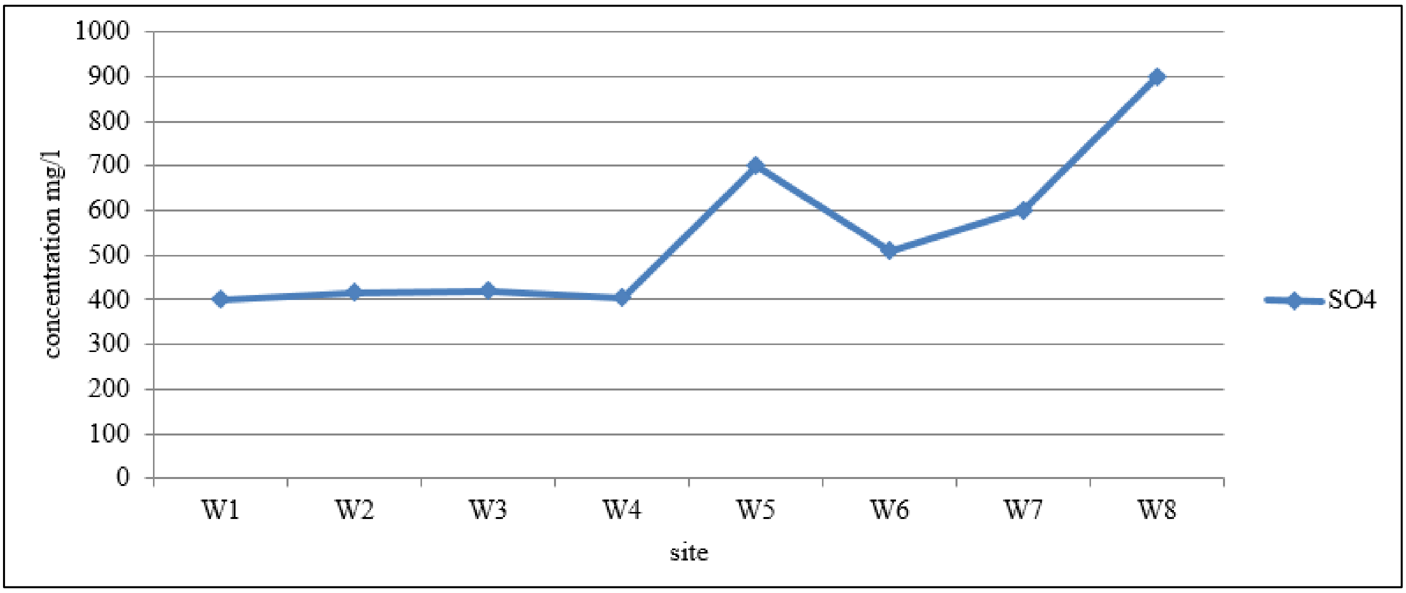

Fig 8 Average value of Sulphate of Ground Water Collected Samples

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- *Fluoride*

Fluoride, an ionic form derived from the chemical element fluorine, belongs to the halogen group and is frequently present in groundwater. Prolonged ingestion of fluoride can result in health issues, particularly dental and skeletal fluorosis, significantly impacting those affected. Fluorine, a naturally abundant element in the Earth's crust, gives rise to fluoride minerals found in soil and aquifer sediments, leading to the accumulation of fluoride in freshwater resources, especially groundwater. The findings confirm the low concentration of fluoride during the study period. As per the guidelines set by the World Health Organization (WHO), the acceptable level of fluoride in drinking water stands at 1.5 mg/l. (Podgorski and Berg, 2022). Figure 9 illustrates the concentration of fluoride ions in groundwater samples.

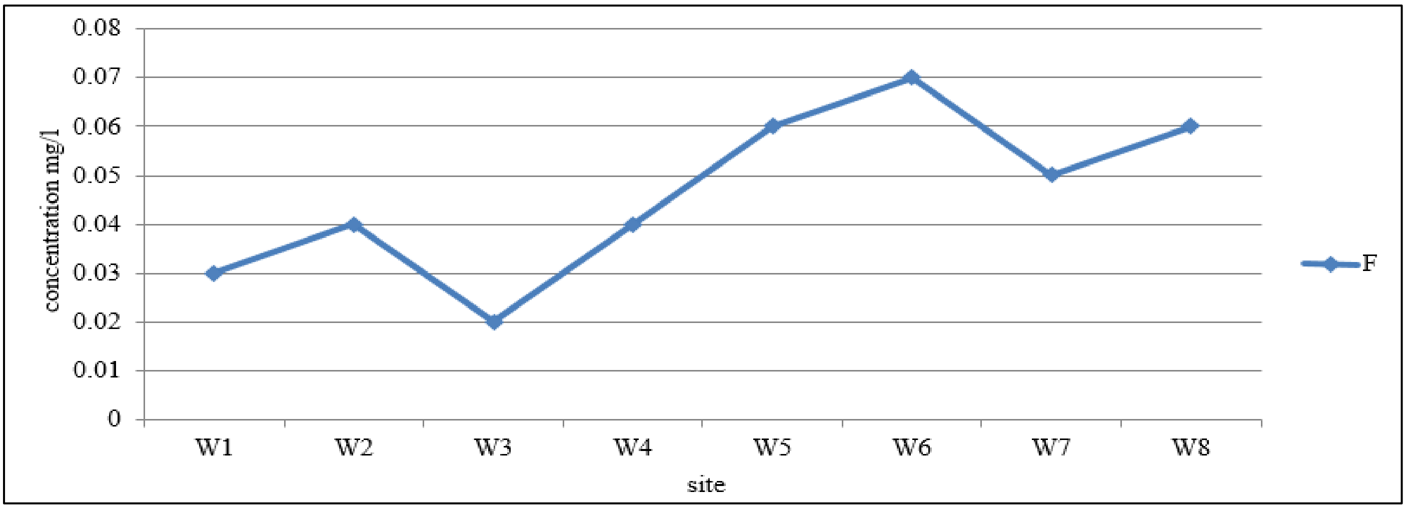

Fig 9 Average value of Fluoride of Ground Water Collected Samples

➢ *Heavy Metals*

Groundwater can become contaminated with heavy metals, giving rise to substantial environmental and health concerns. Heavy metals are naturally occurring elements characterized by their high density and toxicity, even in trace amounts. Examples of these metals include lead, arsenic, cadmium, and mercury. They enter groundwater through a combination of natural processes and human activities; including industrial discharges, mining operations, and agricultural runoff. In the present study, we specifically investigated chromium, copper, manganese, and iron.

- *Chromium*

The widespread occurrence of chromium in these water sources reflects its essential role as an industrial metal used in various processes(Saha et al., 2011). Chromium is a naturally occurring element found in various forms, including trivalent (Cr III) and hexavalent (Cr VI) states. Hexavalent chromium is highly toxic, and contaminated groundwater can pose a serious threat when used for drinking, irrigation, or other purposes. In this study, hexavalent chromium was examined, and its concentration was considered low, with a maximum of 0.1µg/l. Although all samples were collected from countryside areas, the pollutant's amount is very low. Figure 10 illustrates the concentration of hexavalent chromium in groundwater samples.

Fig 10 Average value of Hexavalent Chromium of Ground Water Collected Samples

- *Copper*

Copper is an essential element for human health, but an elevated copper level can have harmful effects on both health and the environment. The highest recorded copper concentration in our study was 0.06 mg/l. Interestingly, the copper levels in groundwater across the region consistently remained within the acceptable limits set by Iraqi authorities, as defined in the Iraqi Potable Water Standard. In fact, all laboratory-analyzed groundwater samples showed copper concentrations below 2 mg/l, in accordance with Iraqi standards. These findings also complied with the stringent guidelines outlined in the WHO Drinking Water Standards (2 mg/l)(Ongen et al., 2008). Figure 11 illustrates the concentration of copper in groundwater samples.

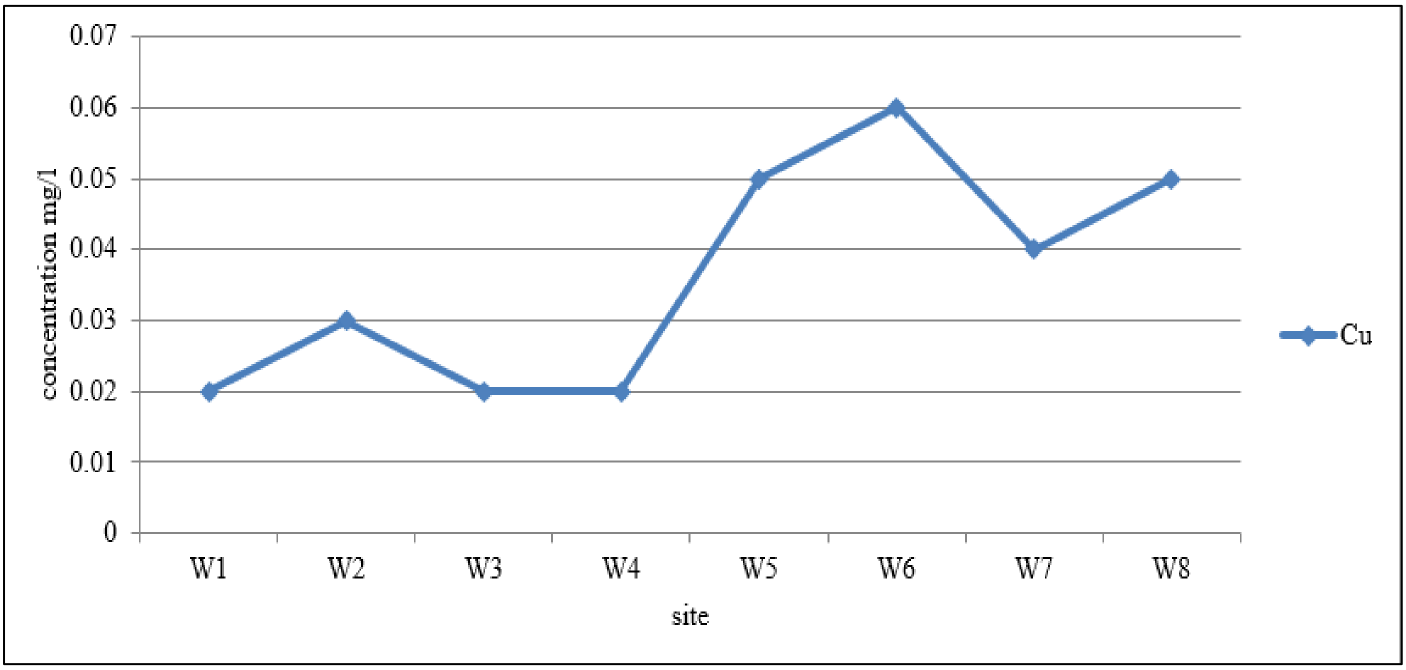

Fig 11 Average value of Copper of Ground Water Collected Samples

- *Iron*

The presence of iron in groundwater primarily arises from the leaching of iron compounds within soil and rock formations as rainwater gradually filters through and drains down these geological layers(Usman et al., 2021). Figure 12 shows the concentration of iron in collected groundwater samples. The results demonstrate that the higher concentration is not dangerous. According to the US EPA, the maximum concentration of iron in water is 0.3 mg/l. All concentrations were less than 0.3 mg/l.

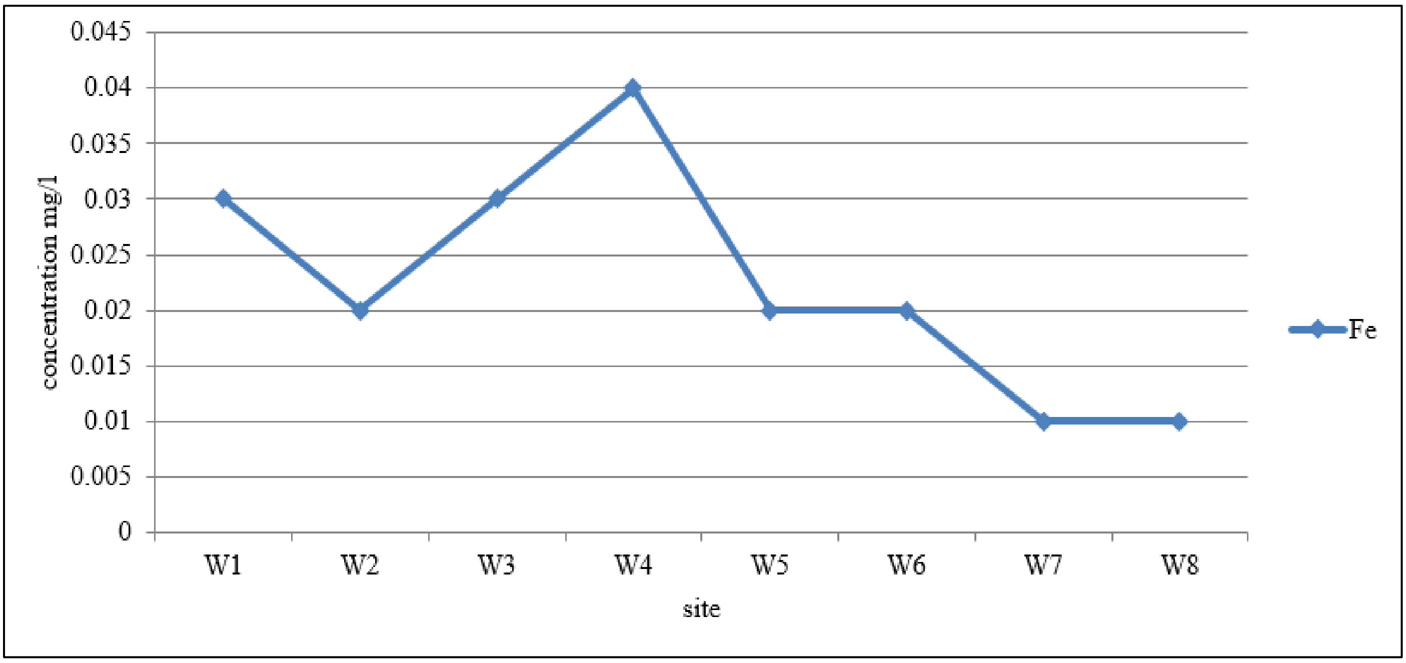

Fig 12 Average value of Iron of Ground Water Collected Samples

- *Manganese*

Manganese plays a pivotal role in the overall health of both humans and animals. Several epidemiological studies have documented neurological concerns associated with prolonged exposure to heightened levels of manganese in drinking water. An optimal health-based threshold for manganese, meticulously derived, stands at 0.5 mg/l(Usman et al., 2021). This threshold takes into meticulous account the upper echelons of daily manganese intake, firmly established at 11 mg/day through comprehensive dietary surveys. All readings were less than 0.5 mg/l. Figure 13 presents the concentration of manganese.

Fig 13 Average value of Manganese of Ground Water Collected Samples

IV. CONCLUSIONS

The study area faces significant challenges arising from urbanization, the impacts of global warming, and a growing demand for water resources. The main goal of this study is to evaluate the physical and chemical properties of groundwater to ascertain its fitness for drinking purpose. Various physical and chemical parameters were thoroughly investigated, including electrical conductivity, total dissolved solids, pH, alkalinity, turbidity, nitrates, nitrites, fluoride, sulfate, hexavalent chromium, copper, manganese, and iron. The study findings suggest that the water quality falls below both Iraqi and WHO standards for human consumption. However, heavy metals and anion contaminants have not had a significant impact on health or the environment due to their concentrations being below the allowable limits. The pH level was within an acceptable range. However, parameters like electrical conductivity, total dissolved solids, alkalinity, and turbidity surpassed the acceptable thresholds.

Given that groundwater primarily serves human needs, such as drinking and washing, as the surface water supply is insufficient, the findings are of considerable concern. In other words, the use of groundwater is restricted to domestic purposes. Furthermore, the high concentration of total dissolved solids can be attributed to the gypsum-rich nature of the study area. The results confirm the influence of climate change on water quality, primarily due to reduced rainfall during the winter season.

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- *Conflict of Interest*

No conflict of interest

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