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Evaluation of Fatha Formation Clays for Drilling Fluid Production Using Water from Four Iraqi Sites and Their Application in Oil Field Conditions

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ABSTRACT

This study focuses on evaluating the validity of surface water and well water for the purpose of using it in the preparation of drilling fluid with bentonite clays of fatha formation taken from four sites for three Iraqi governorates are (Salah al-Din, Kirkuk and Ninevah), the selected sites from which water was Collected from (Upper Zab water, Lower Zab water, Tigris River water and well water), to conduct chemical and physical tests of water samples and indicate their suitability in using them as drilling fluid, and this analysis included properties Physical and chemical, which is the (pH) Total dissolved solid (TDS) and electrical conductivity (EC) and the Concentrations of Cations (Ca^{+}, Na^{+}, K^{+} and Mg^{+}), and Anions (Cl^{-}, HCO^{3-}, SO^{4-} and CO^{3-}), and the results showed the suitability of water as a drilling fluid and rheological properties were tested (Rheological) for samples (density, viscosity, pH, Filtration and calcium ions). As well as adding some activated chemicals such as (XC-polymer, CMC L.V, Caustic Soda) to the drilling fluid and gave appropriate results according to the American Petroleum Institute (API).

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تقييم الاطيان المحلية المستخدمة لانتاج سوائل الحفر باستخدام مياه مختلفة النوعية وبيان مدى وملاءمتها لظروف الحفر في الحقول العراقية للبترول

سهاد فيصل محمد، ياسين صالح كريم، صبار عبد الله صالح

قسم علوم الارض، كلية العلوم، جامعة تكريت، تكريت، العراق

الملخص

يركز البحث في هذا الدراسة على تقييم صلاحية المياه السطحية ومياه الابار لغرض استخدامها في تحضير سائل الحفر مع اطيان البنتونايت تكوين الفتحة المأخوذ من اربع مواقع لثلاث محافظات عراقية هي (صلاح الدين وكركوك ونينوى)، المواقع المختارة التي تم سحب ونمذجة المياه منها هي (مياه الزاب الاعلى ومياه الزاب الاسفل ومياه نهر دجلة ومياه الابار)، لأجراء الفحوصات الكيميائية والفيزيائية لعينات المياه وبيان مدى صلاحيتها في استخدامها كسائل حفر، وشملت هذا التحاليل الخواص الفيزيائية والكيميائية وهي الدالة الحامضية (pH) المواد الصلبة (TDS) والايصالية الكهربائية (EC) وتراكيز الايونات الموجبة هي الكالسيوم والصوديوم والبوتاسيوم والمغنسيوم، والايونات السالبة هي الكلوريدات والبيكاربونات والكاربونات والكبريتات، وبينت النتائج ملائمة المياه كسائل حفر كما تم اختبار الخواص الريولوجية (Rheological) للعينات منها الكثافة واللزوجة والدالة الحامضية والراشح وايونات الكالسيوم. فضلاً عن اضافة بعض المواد الكيميائية المنشطة مثل (XC-polymer, CMC L.V, Caustic Soda) الى سائل الحفر واعطت نتائج ملائمة حسب معهد النفط الامريكي (API).

الكلمات المفتاحية / سوائل الحفر، نوعية المياه، الريولوجية، الايونات الرئيسية وتكوين الفتحة.

1. Introduction

Water is an essential resource for life, as well as various uses (industrial, agricultural, and human), and sustainable access to water, specifically safe drinking water, remains a global problem as many people in the world still consume water from unfit sources according to international standards. Water problems represented by surface water pollution, salt water interference, and excessive withdrawal of groundwater are exacerbated by the lack of water supply infrastructure, the preservation of water resources, and the reinforcement of water shortages through the search for alternative sources and advanced water treatment [1]. Assessing the quality of surface and groundwater for any purpose, especially for human, agricultural, industrial, or other uses, is necessary mainly related to the spatial and temporal variation in the quality of water sources, whether surface or groundwater, monitoring the quantity and quality of water resources, and determining the heterogeneity in the chemical and physical properties of water [2]. Water quality, in general, is a decisive factor

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in determining the type of use and the chemical content, as water quality is affected by the geology and rocks of the studied area and the physical and chemical specifications of water to determine the suitability of water for different uses. Human activities, agricultural and industrial activities contribute to raising the concentrations of ions and dissolved salts in surface and groundwater systems, as well as the nature of the geological and rock environment and the geochemical processes that occur in these systems, which poses great challenges to water management and sustainability [3]. It is essential to understand the hydrochemical properties and quality of the water source for proper planning and management of water resources and to ensure their safe and sustainable use for drinking, agricultural, and industrial purposes [4]. This study is the first to manufacture drilling fluids from selected water sites. Groundwater (wells) along with surface water (Upper Zab, Lower Zab, Tigris River) in the study area is an important source for many different uses (drinking, industry, agriculture, irrigation), including the preparation of drilling fluids locally. Many studies are related to the study area and focused on assessing the hydrochemical status of water sources for different uses.

1.1 Study Area Location

Three sites were chosen, the first in the lower Zab area in Kirkuk governorate, 45km away, the second site in the southeast of Mosul, represented by the upper Zab water, the third site was in Salah al-Din governorate, represented by the water of the Tigris River, the fourth site and the fourth station represented the groundwater in Salah al-Din, Table (1) Fig. (1).

Table 1: Name symbol and coordinates of the selected sites in the study area.

Sequence	Site Name	location code	Location coordinates
1	Lower Zab	ZL	(44°03'54.3"E) (35°41'15.0"N)
2	Upper Zab	ZU	(43°28'21.3"E) (36°02'33.6"N)
3	Tigris River	TI	(43° 42'40.9"E) (34° 35'22.9"N)
4	Groundwater	GW	(43° 35'11.1"E) (34° 52'31.1"N)

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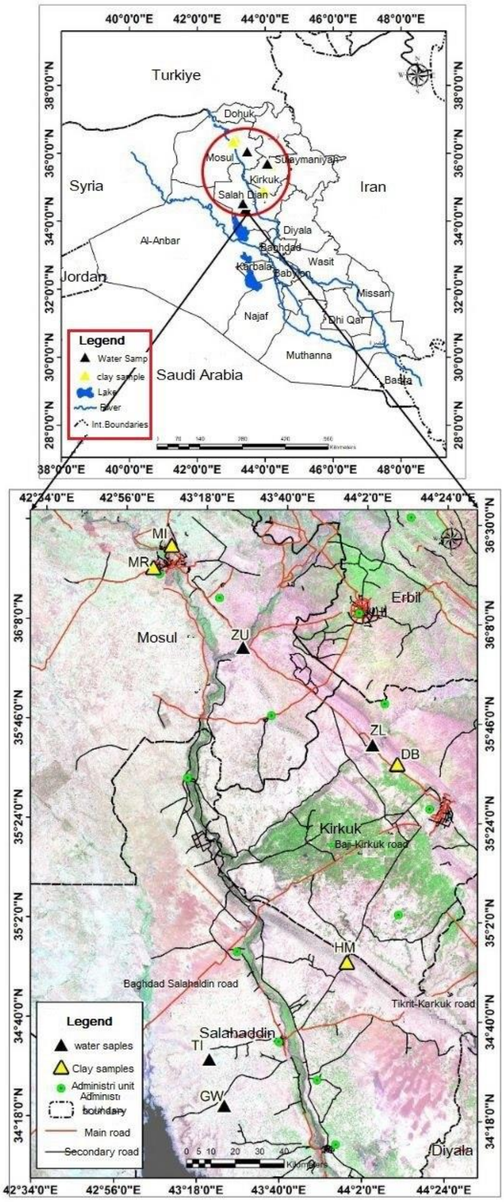

Fig.:1. Location of the study area.

The study aims to assess the groundwater quality in selected areas, including samples from the Upper Zab water, Lower Zab water, and Tigris River water. It seeks to evaluate their suitability in the production of drilling muds specifically for use in Iraq's drilling processes.

2. Materials and methods

2.1. Field work

In this study, four water samples were collected from various sources over several months. A groundwater sample was taken on 10/28/2023, while surface water samples included Lower Zab on 3/10/2023, Upper Zab from the Gwer area in Mosul on 10/27/2023, and Tigris River water from Tikrit on 10/28/2023. These samples were gathered in high-quality 450ml plastic bottles, pre-washed, and filled to minimize air [5]. They were stored in a cool place with labels indicating the model and collection date and sent to the lab within a day. The lab tests focused on positive ions (Ca+2, Mg2+, Na+, K+), negative ions (Cl-, SO4-2, HCO3-, CO3), and physicochemical properties like total dissolved solids (TDS), electrical conductivity (EC), pH, and total hardness (TH) to evaluate their suitability for drilling fluid preparation.

2.2 Laboratory work:

Laboratory work of water samples (physiological measurements and chemical analyzes).

Chemical analyses of water samples collected from selected wells and water sites from the study area were conducted at the Ministry of Science and Technology - Department of Environment, Water and Renewable Energies, according to [6].

3. Preparation of drilling fluid with water samples

After Sampling, the clay specimens are transported from the field, and crushing, grinding, and smoothing are performed on the dry samples. They are then sieved by a 75µm sieve For Bentonite) to eliminate deposits that may affect the results of the samples. After that, the drilling fluid is prepared by mixing an appropriate amount of each Water-type with a weight of (22.5gm) equivalent to the field

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(22.5Ib/BbL*2.85) = 64kg/m3 according to the specifications of [7] per (350ml) of water selected from the sites near the mud samples, the water is placed in the mixing bowl. Then, the container is installed in a mixer device, and during mixing, bentonite is added (22.5gm) gradually to avoid agglomeration of the material. This basic mixture is mixed in all samples for (20) minutes, the form is fermented for (16) hours, and then the following drilling fluid specifications are measured (density, viscosity, PH, filtration, Plastic Viscosity, Apparent Viscosity, Yield Point, Gel strength10min, Gel strength10sec, Ion's calcium Ca+).

4. Results and Discussion

4.1 Physical and chemical properties of water

4.1.1 Physicochemical properties of water

Table 2: Results of chemical and physicochemical properties of groundwater and surface water samples in mg/l and electrical conductivity in micro-Siemens/cm.

Samples / Elements	Tigris River Water	Groundwater	Upper Zab Water	Lower Zab Water
pH	7.7	7.5	7.8	7.8
EC(uS/cm)	490	1976	460	443
TDS(mg/L	264	1111	251	238
T.H%	150	620	115	120
Ca^{2+} (mg/L)	40	170	48	45
Mg^{2+} (mg/L)	12.16	47.4	8.1	7.9
Na^{+} (mg/L)	15	120	12	8
K^{+} (mg/L)	2.4	4.5	2	1.6
$CO3^{-}$ (mg/L)	1	2	1	1
$HCO3^{-}$ (mg/L)	97	100	98	96
CL^{-} (mg/L)	20	212	17	10
$SO4^{2-}$ (mg/L)	75	456	65	68

4.1.1.1. pH:

According to the Environmental Protection Agency (EPA) Water Quality Standards (1986), the pH levels for surface water should be between 6.5 and 9 to ensure the protection and safety of aquatic life [8], while groundwater pH values typically range from 6.5 to 8.5, with some hot spring water potentially falling below 6.5. In the samples studied, the pH values ranged from 7.5 to 7.8. The pH of the water-based drilling fluid containing bentonite significantly impacts the mud's rheology. The relationship between shear stress and shear rate varied with changes in pH [9], as illustrated in Table (4) and Figure (1). The water of the study area was classified as weak alkaline based on the classification of [10] Table (3).

Table 3: Water classification based on pH values according to [10]

Values pH	Water Type
3.5<	Highly acidic
3.5-5.5	Acidic
5.5-6.8	Weak acidity
6.8-7.2	Moderate
7.2-8.5	Weak alkalinity
>8.5	Alkaline

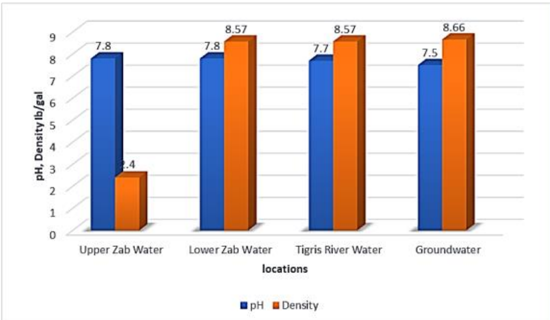

Fig. 1: Values of the pH with density of the samples studied

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4.1.1.2 Total Dissolved Solids

Dissolved solids in any water source represent the sum of the dissolved salts of cations (calcium, sodium, potassium, magnesium) and anions (chlorides, sulfates, bicarbonates). The high values of dissolved solids in natural waters are generally due to increased human activity, pollution, water concentration, and some geological factors like the dissolution of rocks …etc. These mainly affect water quality [11]. According to WHO standards [12], the highest desirable level of TDS for drinking water is up to 500mg/L, up to a maximum of 1500mg/L allowed for other uses [13]. Table 4 shows the water classification by the number of dissolved solids. According to [14], the water in this study was classified as fresh and brackish for surface and groundwater, respectively. The highest concentration was recorded in the Tigris River water, and the lowest recorded concentration of lower Zab water in surface water Freshwater may lead to changes in the viscosity and rheological properties of drilling mud, such as increased viscosity if the mud is not modified appropriately, Brackish water contains low levels of salts, which can be beneficial for clay if the salinity is low enough to keep the clay stable without significantly affecting its properties, as in Figure (2). at the same time, the values of the amount of dissolved salts were higher than those in surface water and recorded (1111 mg liter-1). The variation in TDS concentrations is attributed to the diverse lithology of the region, which in turn affects the salinity of the groundwater; increased TDS usually leads to an increase in viscosity. This can affect the clay's ability to flow smoothly and increase the pressure required to pump it, hindering the drilling process. High concentrations of TDS may alter the rheological properties of clay, such as an increase in gel strength and yield point, affecting how the mud handles the side walls of the well.

Table 4: Classification of water based on the number of dissolved solids by [16] in mg/ l^{-1}.

Water Class	Water intake
Fresh Water	<1000
Slightly Saline Water	1000-3000
Brakish Water	3000-10000
Saline Water	10000-35000
Brine	>35000

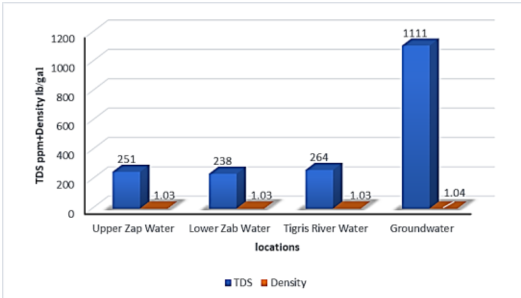

Fig. 2. Variation of the values of the amount of dissolved salts (TDS) in the water samples under study

4.1.1.3 Electrical Conductivity

Electrical conductivity measures water's ability to conduct an electric current through ion charges. The World Health Organization (2004) sets the recommended limit for drinking water at 1.50 µS/cm. Measuring electrical conductivity is crucial for various hydrogeological, hydrochemical, and agricultural applications [15]. It is often used as a proxy for salinity, providing a quick estimate through mathematical relationships [16]. Several factors influence water conductivity, including the geological and rocky characteristics of the basin, soil type, water drainage, runoff from unknown sources, atmospheric inputs, evaporation rates, and certain bacterial activities [17]. Increased EC and conductivity effect on drilling mud may lead to an increase in the viscosity of the clay,

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affecting its ease of flow and efficiency in drilling; the standard unit for measuring water conductivity is microsiemens per centimeter (µS/cm). Increasing water temperature by one Celsius degree increases conductivity by 2% [18]. Electrical conductivity is valuable for detecting dissolved salts, assessing water quality, and determining the degree of water mineralization. [19], There is a direct relationship between dissolved salts and electrical conductivity. The electrical conductivity values in the surface water types ranged between (490-443) microsiemens / cm, while the electrical conductivity values were recorded in the studied groundwater sample (1976 microsiemens/cm), as shown in Table (3) and Figure (3), and we note the increase in electrical conductivity values with increasing the number of dissolved salts. Based on the classification [20], In the study area, groundwater was categorized as weakly mineralized, whereas all surface water samples were classified as very weakly mineralized.

Table 5: Classification of water based on electrical conductivity [19]

Conductivity (µS/cm)	Mineralization degree
1000<	very weak mineral water
1000-2000	weak mineral water
2000-4000	Minimal mineral water
4000-6000	Medium mineral water
6000-10000	High mineral water
10000>	Very high mineral water

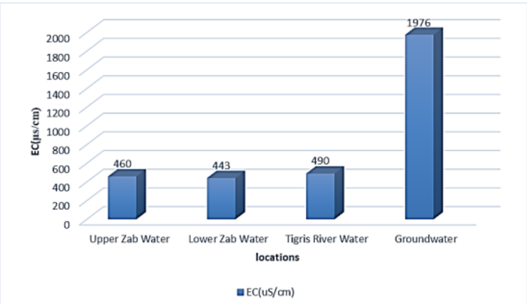

Fig. 3. Variation of EC in the water samples under study

4.1.2 Major Ions

4.1.2.1 Calcium Ion $(Ca)^{2+}$

The calcium ion is an alkaline earth metal under natural conditions. The source of calcium ion in water comes from the dissolution of some rocks that are subjected to chemical weathering and minerals that contain calcium ion such as a minerals like (calcite, dolomite, Aragonite, gypsum and anhydrite) and its concentration ranges between 8-3.3 m Eq [21], and in sedimentary rocks and minerals found in igneous rocks such Minerals like (pyroxene, amphibole and feldspar), as well as clay minerals are a source of calcium ion [16], that the effect of increasing calcium and chloride concentrations in the form of calcium chloride in drilling muds leads to a variation in the density and stability of the drilling fluid and thus its deviation from the standard drilling fluid specifications recommended in the API. The concentrations of calcium ion in the surface water of the study area ranged between (40-48 mg l-1) while the highest value was recorded in groundwater, amounting to (170 mg l-1) Table (3) Figure (4), the reason for the high concentrations of calcium is due to the chemical weathering of calcium minerals, which is the most important factor that controls its presence dissolved in aquatic environments (gypsum rocks, limestone, dolomite, and anhydrite) [22].

4.1.2.2 Magnesium Ion $(Mg)^{2+}$

The magnesium ion is one of the widespread earth metals in the earth's crust and has a state of oxidation (2+) and is not freely found in nature, but in a compound form, as well as a smaller amount of calcium and sodium and can fit into

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the space in the middle of the crystal structure of water molecules, as well as the dilution of magnesium is more than the dilution of calcium and sodium [23], and the origin of magnesium present in water is the result of the dissolution of igneous rocks and minerals that contain magnesium ion in their chemical composition such as (olivine, pyroxene and amphibole, as well as clay minerals containing magnesium ion in their composition [16], as most of the sources of magnesium ion in water come from carbonate rocks, which is similar to the element calcium in the behavior of chemical exchange and its concentration ranges between 0.5-5 m McAf [24, 16], and the presence of magnesium with chloride and increasing their concentration in the water used in the manufacture of drilling muds leads to heterogeneity in the properties of viscosity, productivity and gel of drilling mud[25], and the presence of magnesium in concentrations above the normal limit leads to a decrease in plastic viscosity and yield point and thus directly affects the efficiency and work of drilling muds [26]. Magnesium ion concentrations in surface water ranged between (7.9-12.16 mg/l). In comparison, the highest concentrations were recorded in groundwater and amounted to (47.4 mg/l) Table (3) Figure (4). The high values are because groundwater sources contain most of the quantities of magnesium sourced from clay minerals such as (Sepiolite and Smectite) in addition to Carbonate rocks and dolomite.

4.1.2.3 Total Hardness (T.H)

Calcium and magnesium cations are one of the most important causes of total hardness, and the cause of total hardness is due to ions and chemicals that are released to water [27], and hard water is the one in which soap does not foam [28], and as a result, it causes an increase in the use of a larger amount of soap to perform cleaning purposes and depends on many factors such as (pH) and Alkalinity [29,30] and measured total hardness in terms of ($CaCO_3$) alone (mg / L), and there are two types of total hardness The first type Temporary hardness is the carbonate hardness resulting from the union of calcium ions, bicarbonates and a few carbonates and where the temporary hardness disappears by heating and the precipitation of calcium carbonate, the second type of hardness is permanent hardness, which is the non-carbonate hardness resulting from the union of calcium and magnesium ions with sulfate ions, chlorides and nitrates and add To the hardness resulting from rare elements that cannot be removed by heating [16], the total hardness values ranged between (150-115 mg/l) in the surface water samples, while the highest value was recorded in the groundwater sample at a concentration of (620 mg/l) as in Table (3)., it was found that the surface water samples were of a medium hard type, while the groundwater sample was of a very hard type.

Table 6: Classification of water based on total hardness by [16]

Total Hardness as $CaCO_3$ (mg/l)	Water Class
0-75	Soft
75-150	Moderately Hard
150-300	Hard
>300	Very Hard

4.1.2.4 Sodium ion $(Na)^+$

Sodium ion is one of the alkali metals widespread in the rocks of the earth's crust, sodium is available in most natural waters because it is one of the main elements in the earth's crust and its important natural sources are halite mineral in sedimentary rocks as well as ion exchange The natural concentration of sodium in water is higher than 8.7 mMcAf [21] and feldspar minerals in igneous rocks [31], and is characterized by its high mobility in the aquatic environment and is fast soluble as well as clay minerals resulting from weathering are a major source of sodium in groundwater [32], as well as the presence of calcium and sodium in varying proportions leads to the occurrence of ion exchange between Na and Ca on the surfaces of muds, and this cycle contributes mainly to changing the specification of clays, which affects the uses of clays in drilling[33], and the presence of sodium in surface water is estimated at 6.3 mg L^{-1}, in groundwater at 30 mg L^{-1} [34] and up to 10000ppm in marine waters [35]. Sodium ion concentrations in surface water ranged from (15-8 mg/l^{-1}) while the highest concentration of sodium was recorded in the groundwater sample (120 mg l^{-1}), Table (3) Fig. (4).

4.1.2.5 Potassium ion (K+)

The potassium ion is one of the alkaline metals, and there is a smaller amount than sodium. One of the most important sources in the water is weathering feldspar minerals and biotite, and the dissolution of evaporative deposits in water is an important source. Its concentration in natural water is usually less than the concentration of sodium despite the wide abundance in the earth's crust because Potassium enters the composition of clay minerals during weathering processes. In addition, potassium resistance is greater than sodium and ion exchange processes, which are the most important sources of Potassium in water. The normal concentration of Potassium in water does not exceed 0.51 mCafé [21]; the presence of Potassium along with chloride and in the form of KCl in acceptable concentrations helps to prevent the adhesion of drilling pipes during the drilling process [26], the concentrations of potassium ion in surface water ranged between (2.4-1.6 mg/l-1). At the same time, the highest value was recorded in groundwater and reached (4.5 mg/ l-1), Table (3) Figure (4), and reached very low concentrations of Potassium compared to sodium ions. However, they are present in the ground crust in quantities due to the high transition of sodium and the relative stability of Potassium due to its entry into the composition of clay minerals during the weathering process [36].

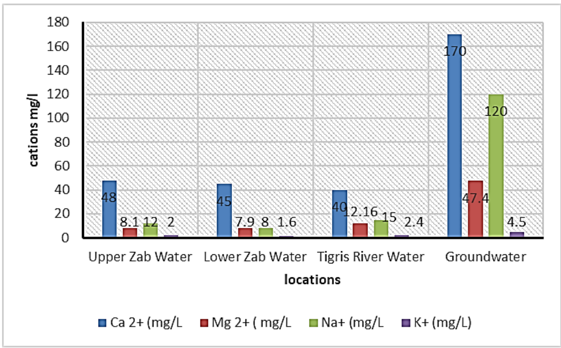

Fig. 4. Concentrations of cations for the studied samples.

4.1.3 Major Ions

4.1.3.1 Chloride Ion (Cl) $^{-}$

The most important source of chloride in the earth's crust is the mineral halite (NaCl) found in evaporated sediments in sedimentary rocks and in igneous rock minerals such as apatite, which were formed over geological time by seawater evaporation. Chloride is also found in other, less

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common salts (such as sylvite (KCl)) and calcium chloride ($CaCl_2$) associated with evaporation deposits. The chloride concentration in rainwater is usually less than 10ppm, with a normal concentration of 28.2 mCaffe[21], and in groundwater, it is more common. Its content ranges from a few parts per million in the snow it feeds to a high percentage in desert saline solutions]37[. In general, the source of chloride in groundwater is from ancient marine waters confined to sediment and dissolving halyite salt. Chloride concentrations ranged from (20-10 mg-l-1) in surface water samples, while groundwater recorded higher values (212 mg l-1) Table (3) Fig. (5).

4.1.3.2 Bicarbonate and Carbonate ions ($HCO_3)^-$

Basality is a constant measure of carbonate and bicarbonate ions for most natural waters. The main source of carbon dioxide that produces alkalinity in water is the fraction of carbon dioxide in the atmosphere, or atmospheric gases found in the soil or in the unsaturated region, which lies between the earth's surface and the groundwater level and is formed by the interaction of carbon dioxide with water and carbonate rocks such as limestone and dolomite [38], In general, the amount of pH plays an important role in the basality of water, where bicarbonate salts are commonly found in water at pH less than 8.3 while carbonate is found at pH above 8.3, as the pH value is the point at which all carbonic acid (H_2CO_3) and carbonate ion (CO_3) are converted to bicarbonate ion (HCO_3^-) [39], bicarbonate, imstone and rainwater are the main sources of ion and the normal concentration is 13.1 m Café [21], the effect of bicarbonate specifically sodium bicarbonate affects the heterogeneity of the acidity of the drilling fluid and the increase in concentration affects the diffraction of drilling muds and thus variation in acidity values and works as a Buffer for acidic water to raise the acidity of 8-9 [40]. The concentration of bicarbonates and carbonates ranged (from 96-98 mg L-1) and (1 mg L-1) in surface waters, respectively, while groundwater recorded higher values of 100 mg L-1 and (2 mg L-1) for bicarbonates and carbonates, respectively. Table (3) Fig. (5).

4.1.3.3 Sulfate ion (SO_4^{2-})

Sedimentary rocks such as gypsum and anhydrite are an important source of sulfates. Other sources of sulfate include agricultural and industrial activities. Sulfate concentrations (SO_4) in natural waters can be elevated due to the presence of naturally abundant sedimentary sulfur minerals or evaporated rocks as well as clay at a concentration of 20.8 mCaffe [41, 21], that most sulfate compounds have the ability to dissolve in rainwater and irrigation, and the increase of that water works to wash the soil and dissolved in soil water or water that is re-pumped increases, which increases the dissolved substances and over time the effect of the process increases and affects groundwater [42]. The increase in the concentration of sulfate in the water used in the manufacture of drilling muds directly causes corrosion of drilling pipes, as well as its effect with the rest of the ions on reducing the electrical resistance of the muds, which directly affects the Filtrate, and the high

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concentrations of sodium carbonate, contribute to reducing the plastic viscosity in the drilling mud and the deposition of sulfate later affects the drilling equipment [43] sulfate concentrations ranged (75-65 mg-l-1 (in surface water samples, while groundwater recorded higher values of 456 mg l-1) Table (3) Fig (5).

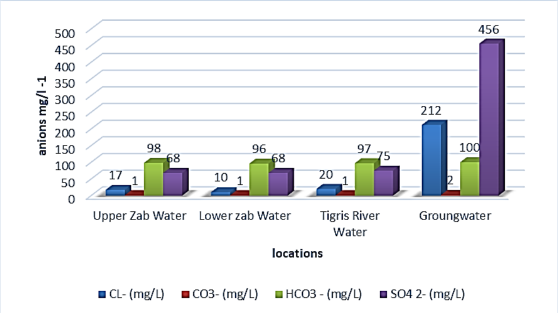

Fig. 5. Anion concentrations of the studied samples

4.2 Preparation of drilling fluid mixture

The quality of water was tested from different locations (Tigris River water, Upper Zab water, Lower Zab water, groundwater) and its suitability for preparing drilling fluid with international specifications and then compare the results obtained with imported bentonite, Iraqi bentonite, and imported paligurskite according to the international specifications of the American Petroleum Institute (API) for drilling fluids, and these specifications include (density, viscosity, pH, calcium ions, leachate) [44]. **4.2.1 Preparation of the form fold Hamreen using groundwater**

Table. 7. Effect of Additive Chemicals on Rheological (Current) Measurements of Hamreen Fold in Groundwater.

checkups / properties	Before adding Bentonite 2.5gm/350ml	After adding Caustic soda(0.5gm) XC-polymer (1.25gm CMC-L.V(2.5gm)	After 4 days From ermentation	API Standard	Unit of measurement
Density	8.57	8.66	8.66	8.65-9.60	Ib/gal or g/cc
PH	7	10	9	More than 9.5	-----
Filtration	104	9	9	Less than 15cc	Cm^3/30min
Ø600	2	25	25	More than 30	Ib/100ft^2
Ø300	1	17	16	More than 23	Ib/100ft^2
Plastic Viscosity	Ø300=1-Ø600	Ø300=8-Ø600	9	More than 7	CP
.ApparateViscosity	Ø600/2=1	Ø600/2=12.5	12.5	More than 15	CP
Yield Point	Ø300-P.V=0	Ø300-P.V=9	7	More than 16	Ib/100ft^2
Yield Point / Plastic Viscosity	0	1.12	1.12	More than 3	
Gel Strength10Sec	0.5	3	3	4-8(MDS)	Ib/100ft^2
GelStrength 10Min	1	4	4	8-12(MDs)	Ib/100ft^2
Ca^+	0.2*400=80ppm	0.4*400=160ppm	80	Less than 250ppm	Ppm

4.2.2. Preparation of the sample of the village of Hittin (Dibbs) using the water of the lower Zab. Where:

AV: Apparent Viscosity, unit CP

P.V.: Plastic Viscosity, unit CP.

Ca^+: Concentration of Calcium Ion, unit ppm.

Ø600: Viscometer Dial Reading at 600 RPM, unit Ib/100ft2.

Table. 8. Effect of chemical additives on rheological measurements of molasses model in lower zab water.

checkups / Properties	Before adding Bentonite 22.5gm/350ml	After adding Caustic soda(0.5gm) XC-polymer(1.25gm) CMC-L.V(2.5gm)	After 48 hours	After 6 days of fermentation	API Standard	Unit of measurement
Density	8.57	8.57	8.57	8.57	8.65-9.60	Ib/gal or g/cc
PH	6	10	9	8	More than 9.5	-----
Filtration	114	10	10	10	Less than 15cc	Cm^3/30min
Ø600	4	38	44	17	More than 30	Ib/100ft^2
Ø300	3	28	29	10	More than 23	Ib/100ft^2
Plastic Viscosity	Ø300=1−Ø600	Ø300=10−Ø600	15	7	More than 7	CP
Apparente Viscosity	Ø600/2=2	Ø600/2=19	22	8.5	More than 15	CP
Yield.Point	Ø300-P.V=2	Ø300-P.V=18	29	3	More than 16	Ib/100ft^2
Y.P/P.V=18/10	2	1.8	1.8	1.8	1.8	
Gel strength10Sec	0.5	4	4	2	4-8(MDS)	Ib/100ft^2
Gel Strength10Min	1	7.5	7.5	2.5	8-12(MDs)	Ib/100ft^2
Ca^+	0.2*400=80ppm	0.4*400=160ppm	160	160	Less than 250ppm	Ppm

4.2.3 Preparation of the right-side sample using the water of the Tigris River

Table. 9. Effect of chemical additives on rheological measurements of the right-side sample in the Tigris River water.

Checkups / Properties	Before adding Bentonite 22.5gm/350ml	After adding Causticsoda(0.5gm) XC-polymer (1.25gm) CMC-L.V(2.5gm)	After 4 days of fermentation	API Standard	Unit of measurement
Density	8.57	8.57	8.57	8.65-9.60	Ib/gal or g/cc
PH	6	11	10	More than 9.5	----
Filtration	120	10	10	Less than 15cc	Cm^3/30min
Ø600	3	38	48	More than 30	Ib/100ft^2
Ø300	1	25	27	More than 23	Ib/100ft^2
PlasticViscosity	Ø300=2−Ø600	Ø300=13−Ø600	21	More than 7	CP
Apparent Viscosity	Ø600/2=1.5	Ø600/2=19	24	More than 15	CP
Yield Point	Ø300-P.V=-1	Ø300-P.V=12	6	More than 16	Ib/100ft^2
Yield Point/Plastic Viscosity=12/13	0.5	0.9	0.9	More than 3	
Gel Strength10Sec	0.5	4	3	4-8(MDS)	Ib/100ft^2
Gel Strength10Min	1	6	5	8-12(MDs)	Ib/100ft^2
Ca^+	0.1*400=40ppm	0.2*400=80ppm	80	Less than 250ppm	Ppm

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4.2.4 Prepare the left side of the connector using the Upper Zab water

Table. 10. Effect of Additive Chemicals on Rheological (Current) Measurements of Left Side Sample in Upper Zab Water.

Checkups / Properties	Before adding Bentonite 22.5gm/350ml	After adding Causticsoda (0.5gm) XC-Polymer (1.25gm CMC-L.V(2.5gm)	After 4 days of fermentation	API Standard	Unit of measurement
Density	8.57	8.57	8.57	8.65-9.60	Ib/gal
PH	6.5	11	10	More than 9.5	-----
Filtration	82	6	6	Less than 15cc	Cm^3/30min
Ø600	3	36	40	More than 30	$Ib/100ft^2$
Ø300	2	24	29	More than 23	$Ib/100ft^2$
Plastic Viscosity	Ø300=1-Ø600	Ø300=12-Ø600	11	More than 7	CP
Apparent Viscosity	Ø600/2=1.5	Ø600/2=18	20	More than 15	CP
Yield Point	Ø300-P.V=1	Ø300-P.V=12	18	More than 16	$Ib/100ft^2$
Yield Point/Plastic Viscosity	0	1	1	More than 3	
Gel Strength10Sec	0.5	3.5	4	4-8(MDS)	$Ib/100ft^2$
Gel Strength10Min	1	6	8	8-12(MDs)	$Ib/100ft^2$
Ca^+	0.1*400=40ppm	0.3*400=120ppm	120	Less than 250ppm	Ppm

Discussion

The current study showed the evaluation of the validity of surface water (Upper and Lower Zab and Tigris River) and groundwater well water for use in the preparation of drilling fluids, with the use of bentonite Fatha formation taken from areas near this water. Four sites were selected in three Iraqi governorates (Salah al-Din, Kirkuk and Nineveh), where samples were collected from Upper Zab, Lower Zab and Tigris River, in addition to well water. The study included chemical and physicochemical analyses of water samples to assess their suitability as drilling fluids. Physicochemical properties such as (pH), dissolved solids (TDS), electrical conductivity (EC), Cations (calcium, sodium, potassium and magnesium), and Anions such as (chlorides, bicarbonates, carbonates, sulfates). The results of the study showed that this water is suitable as drilling fluids according to the program for drilling wells and depending on the lithology of wells and water use according to the depths of the well, and the rheology properties of the samples were examined, such as density (Density), viscosity (Viscosity) and pH function. Filtration and calcium ions. Activated chemicals were added to drilling fluids such as (CMC L.V, XC-polymer, Castic Soda) and some sample results showed compliance with the standards of the American Petroleum Institute. (API) The study proved that well water and surface water in the specified places in the Iraq are suitable for use in the manufacture of drilling fluids based on chemical, physicochemical and well lithologic analyzes, which showed that they meet the drilling requirements for this type of industrial application

5. Conclusions

1- Suitability of surface and well water and its suitability for use in drilling fluids Chemical and physicochemical analyzes showed that well water and surface water studied are suitable for use as drilling fluids. Properties such as pH, dissolved solids (TDS), electrical conductivity (EC), and positive and negative ion ratio were

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measured and found to meet the standards required for the manufacture of drilling fluids.

2- Rheological properties of mixed liquids the mixed liquids were tested by adding bentonite from neighboring areas, and the results of some tests showed their compatibility with the standards of the American Petroleum Institute (API), density, viscosity, pH and leachate were measured, and their suitability for use in drilling operations was ascertained.

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