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Evaluation of the quality of two types of RO water in Al-Muthanna Governorate

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Abstract: The current study aimed to evaluate two groups of drinking water they are (Commercial Reverse Osmosis ROc, Home Reverse Osmosis ROh) in Al-Muthanna Governorate , Samples were collected (100) water samples from Home Reverse Osmosis ROh and,(100) water samples from Commercial Reverse Osmosis ROc from December 2022 to June 2023.

The study includes the measurement of some physical Parameters such as (Turbidity, Electrical conductivity, Total dissolved solids, Total suspended solid) and some chemical Parameters (pH, Total hardness, Calcium hardness, Sodium, Potassium, Calcium ,Chloride , Phosphates, Nitrites, Nitrates), Indicators of bacterial contamination are also studied, which includes (Total bacterial count), The results showed that the pH values were recorded between(6.2 – 9.2).

The Turbidity values were ranged between (0 – 3.4 NTU), The Electrical conductivity values were recorded between (20-760 µS/cm), the values of Total Dissolved Solids were studied, their values ranged between (14-725 mg/l), while the values of Total hardness were recorded between (75 - 580 mg.CaCo3/l), Sodium values (2.4-327.2 mg/l) ,Potassium values (0 – 9.7 mg/l), Calcium values (19.9-431.4 mg/l) ,

The chloride concentration ranged between (9.9-356.9 mg/l), As for nutrients, the current study recorded of nutrients, as Phosphate values ranged between (0.02-0.62 mg/l), while Nitrite levels ranged between (0.005-0.066 mg/l) and Nitrate values ranged between (1.5-19.2 mg/l) As for the bacterial examination, the total number of Total bacterial count ranged between (0-4000 CFU/ml). .

From the results conclude, that the physical and chemical parameters for ROc , ROh drinking water showed that is no exceeded permissible limits for parameters (electrical conductivity, turbidity, TDS, TH, , Na+, K+, Ca++, Cl¯) , and low concentrations of chemical parameters (No2¯,No3¯, Po4-3) for ROc , ROh drinking water.

Key words: Drinking Water, Reverse Osmosis , Commercial Reverse Osmosis ROc, Home Reverse Osmosis ROh ,Al-Muthanna.

INTRODUCTION

The drinking water cycle involves the continuous movement of water through various stages: collection, treatment, distribution, and consumption [1]. Understanding this cycle is essential for recognizing the significance of clean and safe drinking water for the human body [2] (Ormerod,2019).

When water is collected from natural sources such as rivers, lakes, or groundwater, it undergoes treatment processes to remove impurities and ensure its safety for consumption. Once treated, the water is distributed through pipes and infrastructure to reach households and communities [3] (Dibner *et al.*,2020).

Reverse osmosis (RO) systems have gained significant popularity as a water treatment technology in both domestic and commercial settings[1] (WHO,2021), These systems are designed to remove impurities, contaminants, and unwanted substances from water, producing high-quality drinking water [4] .

Reverse osmosis is widely recognized as an effective method for purifying water due to its ability to remove a wide range of contaminants, including bacteria, viruses, chemicals, and heavy metals [5],The treatment process involves applying pressure to force water through a semipermeable membrane, selectively allowing only water molecules to pass while blocking impurities.

Although the membranes used in RO systems are designed to be highly effective in removing impurities, there is a possibility of some residual chemicals or by-products remaining in the treated water [6] .

Many researchers made a native studies to measured water quality of water treatment plants (WTPs) , Almuktar et al., (2020) evaluate the performance of the main water treatment plants (WTPs) within Basra province and to subsequently make recommendations for decision-makers to come up with new management strategies and policies, The effluents from eight WTPs were selected to study the quality of water supply for Basra city during the period between January 2018 and December 2018. The results showed that all WTPs were inadequate to treat raw water for drinking or irrigation purposes mainly due to the very bad raw water quality, this study concluded that the studied parameters (pH,Turbidity, TH, TDS, EC, Cl^-, HCO_3^-, K^+, Mg^{++},and Ca^{++}) of product water by the RO plant in ALMaaqel port were within the Iraqi standard limits. Therefore, the product water was suitable for drinking and other domestic uses. In addition, the study concluded the effectiveness of pretreatment processes in removing turbidity from water before entering the membranes to protect them from fouling.

Materials and Method

2.1: Description of the study area

Al-Muthanna province is located about 270 km south of Baghdad, the capital of Iraq. one of the governorates of Iraq Southern Province and the second largest province after Anbar in terms of area,with an area of (51,740) square kilometers of total Iraq is (434,128) square kilometers, which is equal to (11.9%), which is equal to (20,696,000) dunam of the area of Iraq, It is adjacent to it from the north side, the governorate of Al-Dawaniyyah, from Al-Najaf Al-Ashraf, and from the east, the two governorates of DhiQar and from the south of the Kingdom of Saudi Arabia, the Kingdom of Saudi Arabia, the governorates of the pacific and the state of Kuwait, The total rural and urban population (1,043,175) [7].

It includes nine administrative districts (Al-Samawah, Al-Rumaitha, Al-Khader, Al-Salman, Al-Warka, Al-Hilal, Al-Sawir, Al-Najmi, Al-Majd), three sub-districts are linked to these districts: (Al-Karamah belongs to the Warka district, Al-Daraji belongs to Al-Khader district, Busayya belongs to Al-Salman district) [8] .

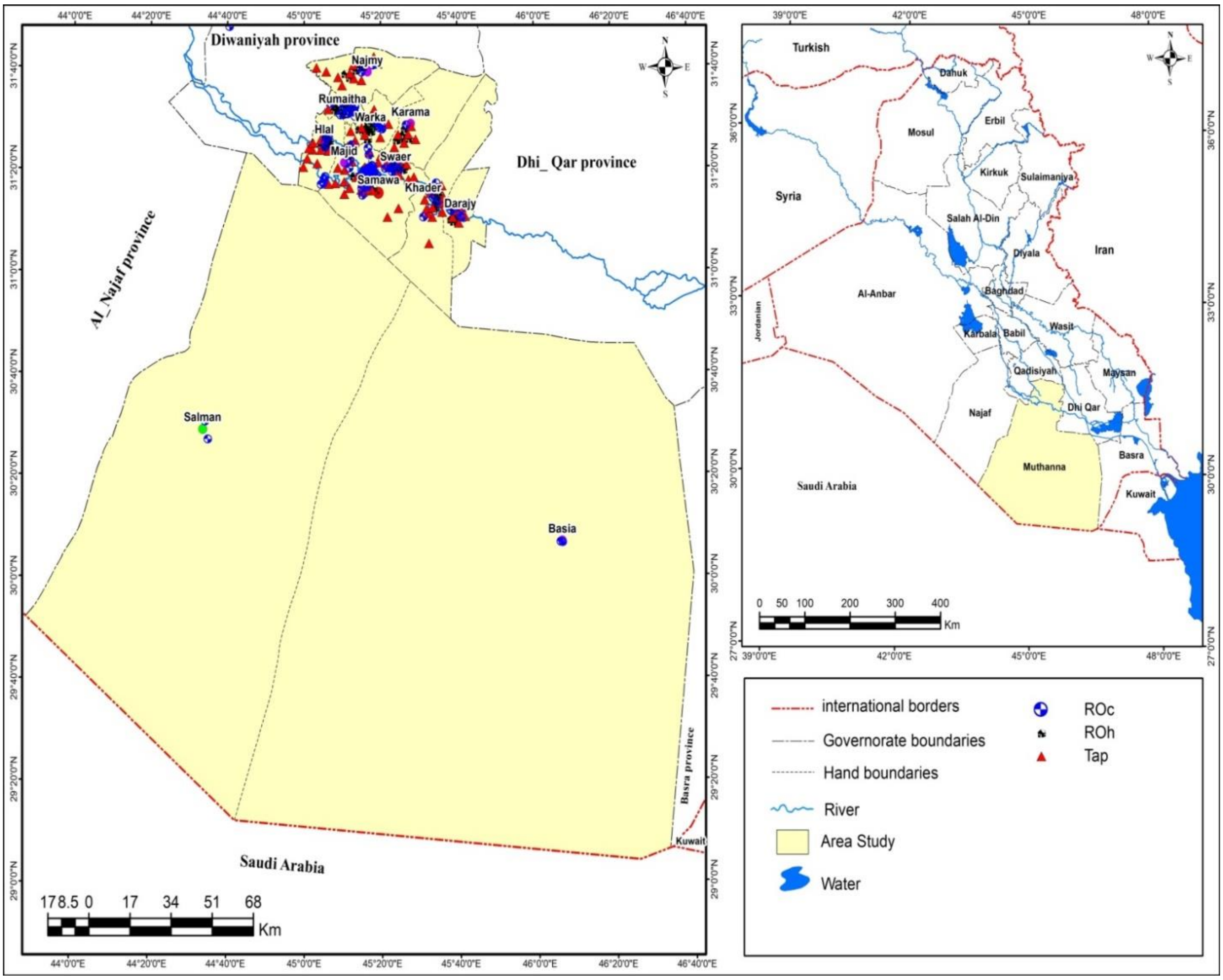

Fig (3-1): Map sampling sites in Muthanna governorate during the study periods

2.2: Sampling methods

Samples of water were collected by divided into : RO plants water, RO household, two types of analysis bottles are used which were a Plastic Bottles (500 ml) for physical and chemical analysis, and glass bottles (100 ml) for the bacteriological test[9]. After sampling completion, bottles were clearly labeled and transported to the laboratories of the AL-Muthanna University College of Science Department of Biology for physicochemical and microbiological tests, Samples handed to the lab are accompanied by a form containing all the necessary information(Numbers, Plants name, and Location) and rapidly analyzed [10].

3. Results and Discussion

Drinking water is not a good conductor of electric current but rather a good insulator. An increase in ion concentration enhances the EC of water [11]. Generally, the amount of dissolved solids in water determines the electrical conductivity. EC measures the ionic process of a solution that enables it to transmit current. According to WHO standards, EC value should not exceed 2500µS/cm and 2000µS/cm in IQS.

The results of the current study showed that the effect of the water source on EC there was a significant increase in ROh, with a mean (257.53 µS/cm), compared to ROc, with a mean (144.20 µS/cm) as showed in (Fig: 1). the results were less than the permissible limit of EC. for ROh, and

ROc (P value ≥ 0.05) because the reverse osmosis process that depends on it, where salts and ions are removed, so the EC. value decreases [12].

Turbidity is the cloudiness of water caused by a variety of particles and is consider another key parameter in drinking water analysis. It is also related to the content of diseases caused by organisms in water[13] ,The standard recommended maximum turbidity limit, set by WHO and IQS, for drinking water is (5 NTU).

The results of the current study showed that there is mean value of turbidity in ROh and Roc (0.33 NTU) and (0.11 NTU) respectively with significant differences (*P* value ≤ 0.001),There is no significant differences between ROh, and ROc and the results were less than the permissible limit of turbidity for ROh, and ROc (*P* value ≥ 0.05) as showed in(Fig: 2),because the RO dispenser machine is expected to have a low turbidity value due to the filtration system, which is possessed to ensure the efficient removal of undesired solids[14].

Water can dissolve a wide range of inorganic and organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates, etc. These minerals produced an unwanted taste and diluted color in the appearance of water. the TDS is considered a sign to determine the general quality of the water [15] .

The results of the current study showed that the mean value of TDS in ROh and Roc was (167.42 mg/l) and (121.68 mg/l) respectively with significant differences (P value ≤ 0.001) (Fig: 3), There is no significant differences between ROh, and ROc and the results were less than the permissible limit of TDS for ROh, and ROc (P value ≥ 0.05) because the reverse osmosis (RO) dispenser machine is designed to achieve a low turbidity value through its filtration system, which efficiently eliminates unwanted solids [16] . As Similar results were reported by (Al-Fanharawi *et al.*, 2022).

The pH of drinking water refers to the measure of hydrogen ions concentration in water. It ranges from (0 to 14), According to WHO standards pH of water should be (6.5 to 8.5) the results of the current study showed that there is pH in ROh with mean (7.81) in compare with Roc with mean (7.54), with significant differences (P value ≤ 0.001) as showed in (Fig: 4) The main reason for The pH value of ROh, and ROc was within the permissible limit Reverse osmosis is a water purification process that the RO membrane in the system may degrade or become fouled with deposits, which can affect its performance. If the membrane is damaged or not functioning optimally, it may allow certain ions or contaminants to pass through, potentially increasing the pH of the water[17] .

Hard water is characterized by high mineral contents that are usually not harmful to humans. It is often measured as calcium carbonate ($CaCO3$) because it consists mainly of calcium and carbonates the most dissolved ions in hard water [18].

According to World Health Organization (WHO), the hardness of water should be (500 mg.CaCo3/l). The results showed that the TH. Of ROh, which amounted to (284.35 mg.CaCo3/l), The reason for this is because the primary source of hardness in water is the presence of minerals, particularly calcium and magnesium, These minerals can naturally occur in the groundwater sources that supply tap water [19].And ROc which amounted to (206.01 mg.CaCo3/l) as showed in(Fig: 5) ,this is because The semipermeable membrane used in reverse osmosis has small pores that allow water molecules to pass through, but ions and larger molecules are rejected. Since the minerals contributing to hardness are in ionic form, they are effectively rejected by the membrane, resulting in a decrease in the total hardness of the water [20] .

The results of chloride concentrations in this current study showed that the effect of the water source on the Cl^{-} there is ROc with mean (166.46 mg/l) the main reason of this is a Plant Efficiency, The presence of higher chloride concentrations can affect the efficiency of various water treatment processes [21]. and It is noticed that The Cl^{-} value of ROh water was low concentrations (9.9 mg/l) because of the Chloride can react with disinfectants, particularly chlorine-based disinfectants like chlorine gas or sodium hypochlorite, used in water treatment processes[22] . As showed in(Fig: 6).

Sodium is a silver-white metallic element and is found in less quantity in water. The results of the current study showed that there is ROh and Roc with mean (75.83 mg/l) and (27.62 mg/l) respectively with significant differences (P value < 0.001) as showed in (Fig: 7). There is no significant differences between ROh, and ROc and the results were less than the permissible limit of turbidity for ROh, and ROc (P value ≥ 0.05) because the Sodium ions are relatively small in size, and the RO membrane has a high rejection rate for these ions.

Potassium is a silver-white alkali which is highly reactive with water, The results of the current study showed that there is ROh and Roc with mean (1.99 mg/1) and (0.95 mg/1) respectively with significant differences (P value ≤ 0.001) as showed in (Fig:8).

The concentrations of these ions in drinking water can be influenced by various factors such as water treatment processes, and potential contamination[23] .

Calcium is the fifth most abundant element on the earth's crust and is very important for human cell physiology and bones [24] .The results showed that the effect of the water source on the Ca^{++}in ROh and Roc with mean (202.79 mg/l) and (104.17 mg/l) respectively with significant differences (P value ≤ 0.001) as showed in (Fig:9), There is no a significant differences between ROh, and ROc and the results were less than the permissible limit of turbidity for ROh, and ROc (P value ≥ 0.05) because the semi-permeable membrane used in reverse osmosis is designed to be highly selective, It has a nominal pore size that typically ranges from(0.0001 to 0.001 micrometers), which is much smaller than the size of calcium ions. As a result, the membrane acts as a barrier to calcium ions, preventing their passage and leading to a low concentration of calcium in the treated water [25].

The results of the current study showed that there is a low concentrations of NO_2^{-} in ROh and Roc with mean (0.026 mg/l), (0.029 mg/l) respectively as showed in (Fig:10) in compare with permissible limit IQS standards concentration of Nitrite should be (3 mg/l), The reason for the decrease in Nitrite values in the ROh, and ROc are due to the Water Treatment Processes: Municipal water treatment plants employ various treatment processes that effectively reduce or eliminate nitrite levels. These processes can include disinfection e.g., chlorination, filtration, sedimentation, and oxidation, These steps help remove or convert nitrite into other forms, such as nitrate (NO_3^{-}), which is typically less harmful [26] .

The results of the current study showed that there is a low concentrations of NO_3^{-} in ROc and Roh with mean (7.77 mg/l), (6.75 mg/l) respectively as showed in (Fig:11) in compare with permissible limit IQS standards concentration of Nitrite should be (50 mg/l) , The reason for the decrease in Nitrate values in the ROh, and ROc are due to the Dilution: Nitrate levels can decrease naturally through dilution, If a water source with high nitrate concentrations is mixed with other water sources with lower nitrate levels, the overall nitrate concentration in the drinking water can decreased [27] .

Phosphate (Po_4^{-3}) concentrations in drinking water can vary depending on the water source and treatment processes[9] (WHO,2011), Phosphates can naturally occur in water sources through the weathering of rocks and minerals [10] .The results of the current study showed that there is a low concentrations of Po_4^{-3} in ROh and Roc with mean (0.22 mg/l), (0.21 mg/l)respectively as showed in (Fig:12) in compare with permissible limit IQS standards concentration of Po_4^{-3} should be (0.4 mg/l), this lead to the Distribution System, After treatment, There is no significant differences between ROh, and ROc and the results were less than the permissible limit of PO_4^{-3} for ROh, and ROc (P value > 0.05) because the Pre-Treatment Processes, RO systems often include pre-treatment stages, such as sediment filters and activated carbon filters, which are designed to remove larger particles, sediment, and organic matter. These pre-treatment processes can also contribute to the reduction of phosphorus in the water before it reaches the RO membrane[28] .

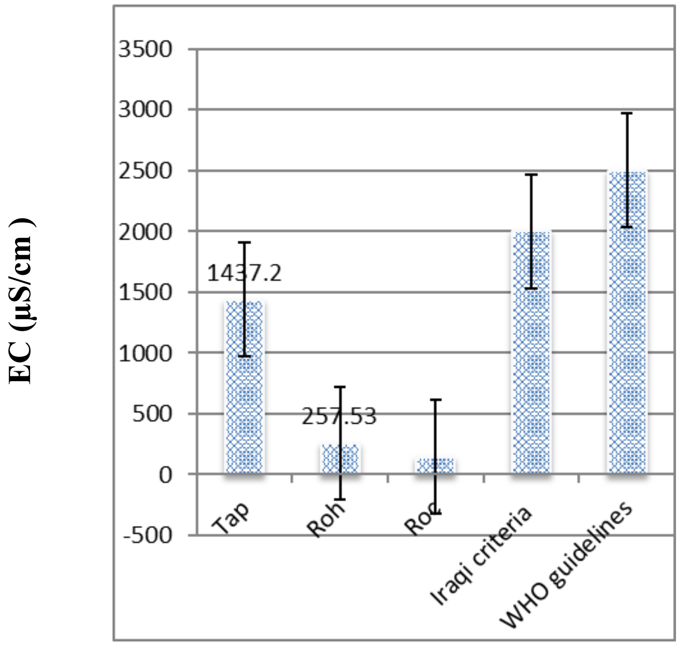

Fig. (1) Effect of Water sources on EC. in the water compare with Iraqi criteria 2009-2022 and WHO guidelines 2011-2022.

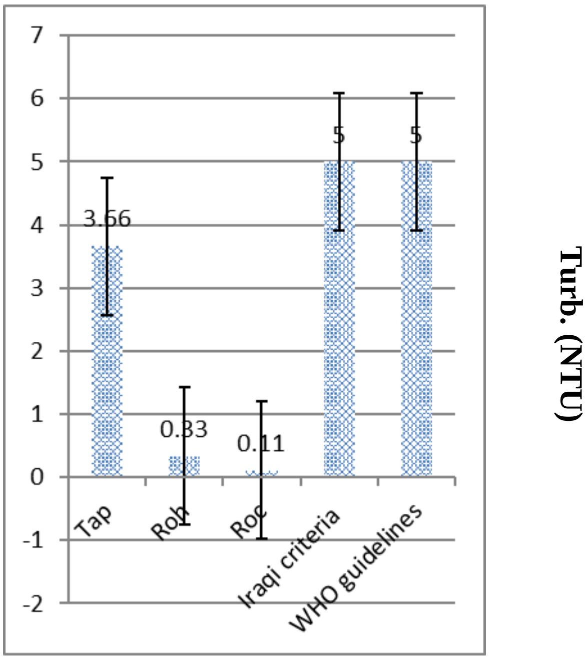

Fig. (2) Effect of Water sources on Turb. in the water compare with Iraqi criteria 2009-2022 and WHO guidelines 2011-2022.

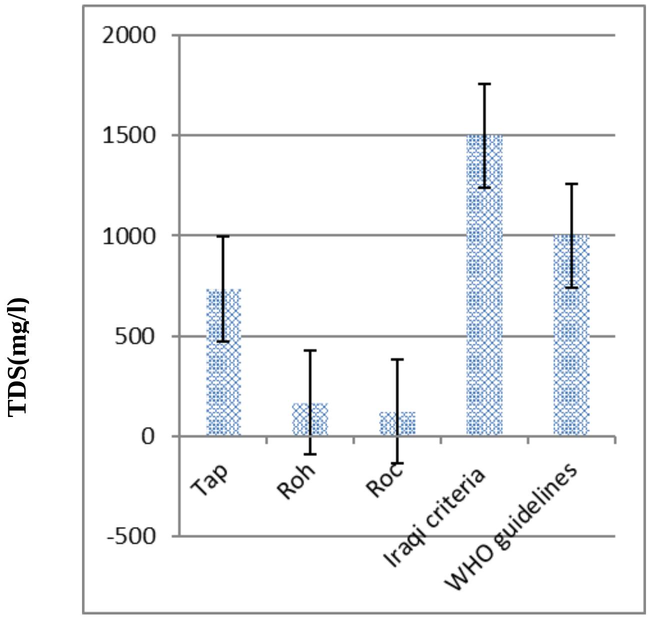

Fig. (3) Effect of Water sources on TDS in the water compare with Iraqi criteria 2009-2022 and WHO guidelines 2011-2022.

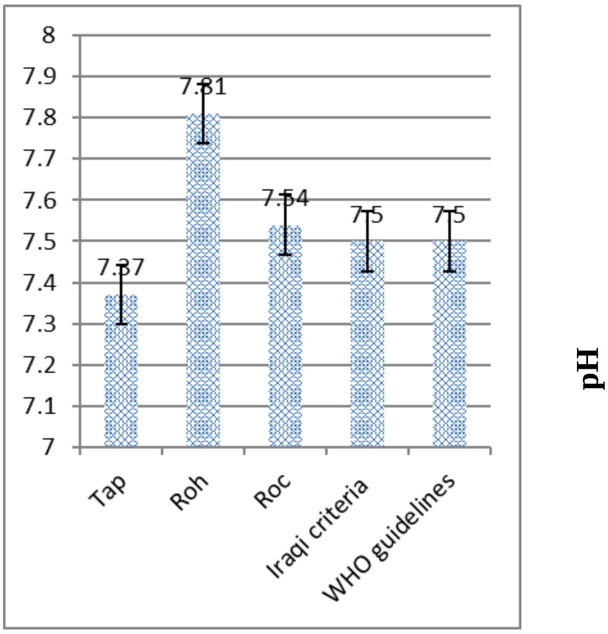

Fig. (4) Effect of Water sources on pH in the water compare with Iraqi criteria 2009-2022 and WHO guidelines 2011-2022.

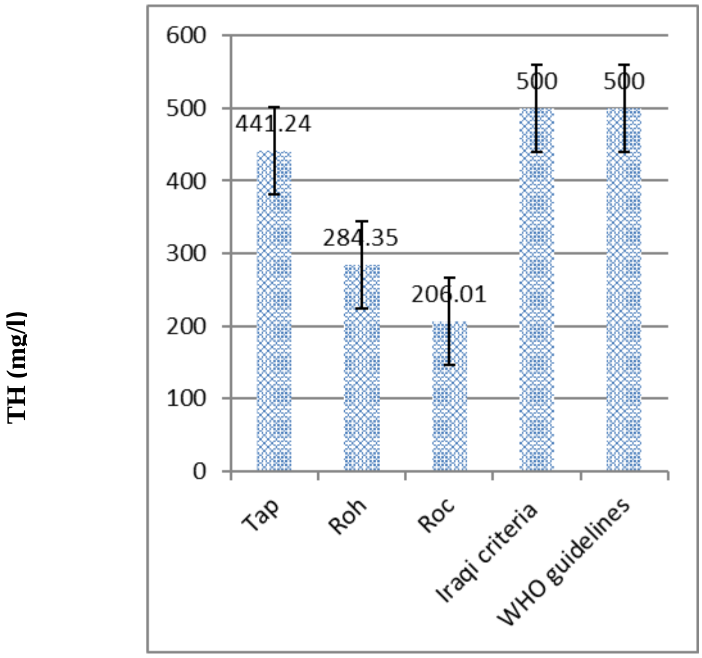

Fig.(5) Effect of Water sources on TH in the water compare with Iraqi criteria 2009-2022 and WHO guidelines2011-2022.

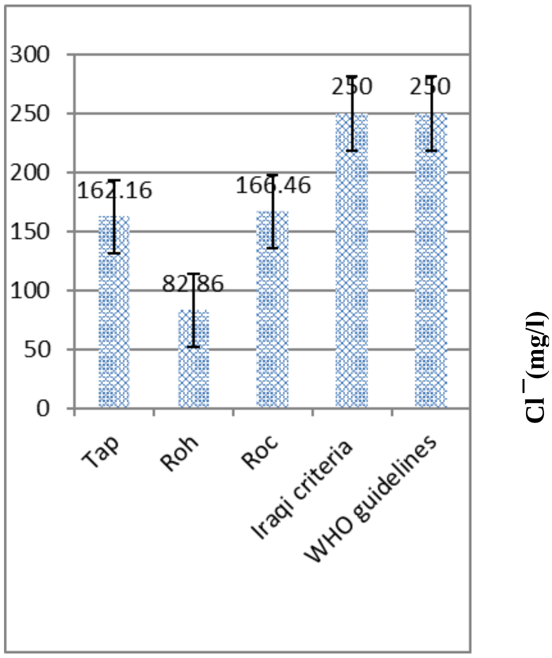

Fig.(6) Effect of Water sources on Cl¯ in the water compare with Iraqi criteria 2009-2022 and WHO

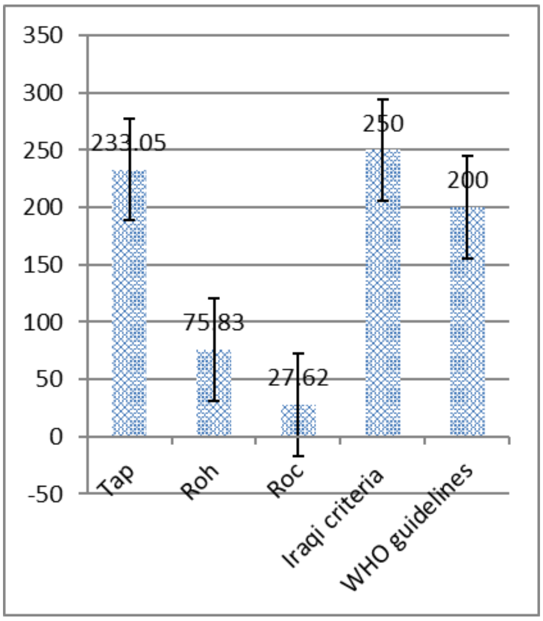

Fig.(7) Effect of Water sources on Na^{+} in the water compare with Iraqi criteria 2009-2022 and WHO guidelines2011-2022.

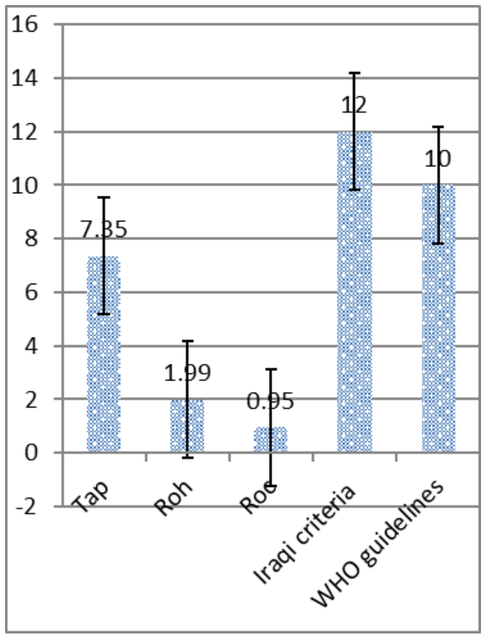

Fig.(8) Effect of Water sources on K^{+} in the water compare with Iraqi criteria 2009-2022 and WHO guidelines2011-2022.

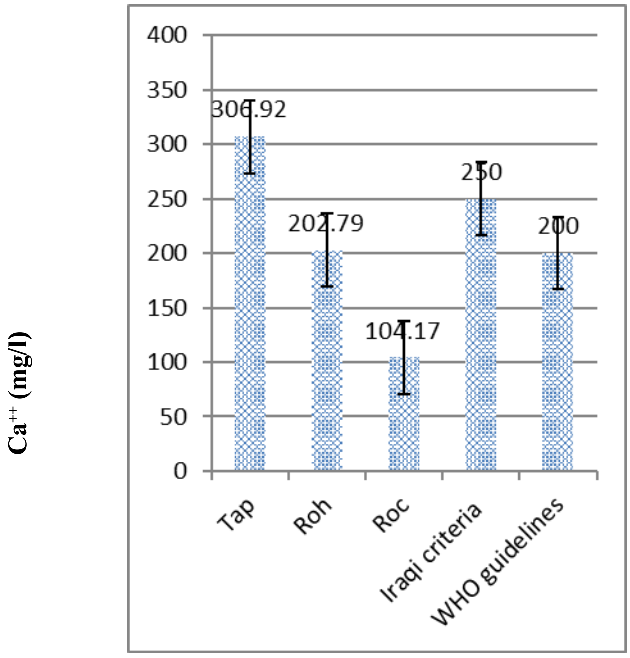

Fig.(9) Effect of Water sources on Ca^{++} in the water compare with Iraqi criteria 2009-2022 and WHO guidelines2011-2022.

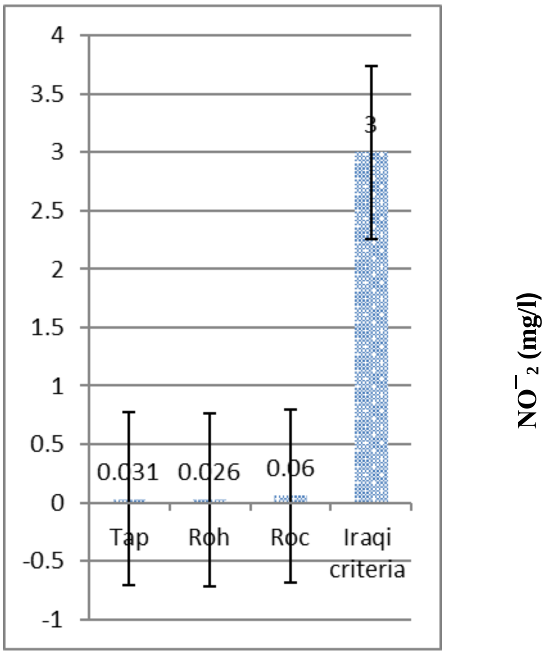

Fig.(10) Effect of Water sources on NO^{-}_{2} in the water compare with Iraqi criteria 2009-2022 and WHO guidelines2011-2022.

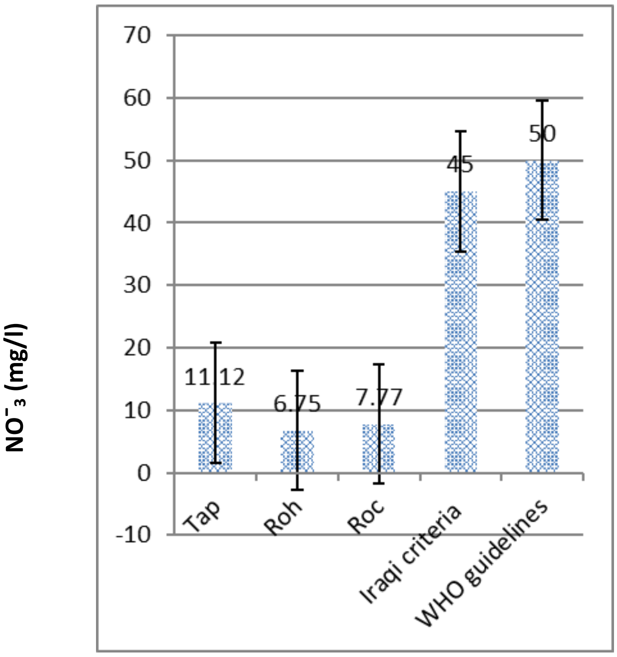

Fig.(11) Effect of Water sources on NO^{-}_{3} in the water compare with Iraqi criteria 2009-2022 and WHO guidelines2011-2022.

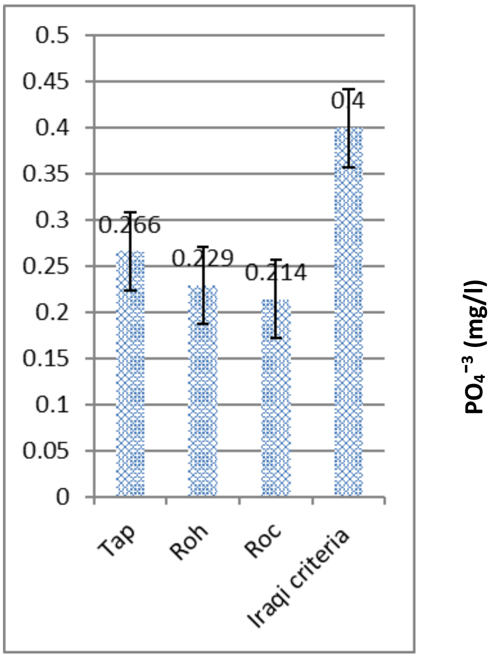

Fig.(12) Effect of Water sources on Po_4^{-3} in the water compare withIraqi criteria 2009-2022.

Conclusion

The results of ROc , ROh drinking water showed that is no exceeded permissible limits of (WHO 2011_2022, Iraqi criteria 2009-2022) for parameters (electrical conductivity, turbidity, TDS, TH), and low concentrations of chemical parameters (No_2^{-},No_3^{-}, Po_4^{-3} , K^{+}, Na^{+}, Ca^{++}) for ROc , ROh drinking water, the percentage of people who preferred to drink ROh water was 45%, those who preferred to drink ROc water was 38.33, and those who preferred to drink Tap water was 16.67 This is based on the results of the questionnaire conducted during the study period

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