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Study of Some Chemical and Physical Properties of Ground water in Zallah City

Mohmed M. Ali Alabead[1], Fadwa A. A. Alashlam[2], Zenb M. M Kama[3]

[1]High Institute of Science and Technology (HIST), Zella, Libya
[2,3]Department of Civil Engineering, College of Engineering Technology Houn, Libya

Abstract

This study was conducted to evaluate the quality of well water in Zallah city, Libya, by analyzing the chemical and physical properties of water samples from four selected wells distributed across the region. The study was carried out from December 2022 to February 2023. For comparative analysis, the research adopted several international standards, including those from the World Health Organization (WHO) for pure water, the European Union's 1992 drinking water standards, the FAO irrigation water standards, and the American Salinity Laboratory's 1945 scale. Laboratory analyses revealed variations in water quality among the wells concerning elemental proportions and natural properties. Specifically, the study identified high salt content in some wells, varying concentrations based on geographical location. Furthermore, discrepancies were observed in ion values and turbidity levels. The overall findings indicated that the well water in the study did not conform to international standards for drinking water. The research concludes that the water is not suitable for direct human or animal consumption without prior filtering and purification. However, it was deemed suitable for agricultural and industrial uses after appropriate treatment.

Keywords: Groundwater, Water Quality, Zallah City, Chemical Properties, Physical Properties, WHO Standards, FAO Standards, Salinity.

1. Introduction

Water, a fundamental element for life, has held immense significance across civilizations throughout history. Its importance is deeply embedded in various cultures and religions, with Islamic texts, for instance, highlighting its vital role as a source of all living things, as stated in the Quran: "And we made from water every living thing. Will they not then believe? "This verse underscores the profound connection etween water and life, emphasizing its essential nature for all biological processes.

Despite covering approximately 71% of the Earth's surface, often leading to its designation as the ' Blue Planet,' the availability of potable water for human use remains a critical concern. Human populations primarily rely on two main sources for their water needs: surface water and groundwater [4]. Surface water sources include rivers, lakes, and wadis, which are directly exposed to the atmosphere and often subject to various environmental influences. Groundwater, on the other hand, encompasses water found beneath the Earth's surface in aquifers, accessed through wells, springs, and caves. The abundance and accessibility of these water sources vary significantly across different geographical regions. Inaridandsemi-aridregions, suchasmuch of Libya, thescarcity of rain fall exacerbates the challenge of securing adequate supplies of suitable water for human consumption andotheruses. Libya, for example, is predominantly characterized by dryandsemi-dry climates, which inherently suffer from limited precipitation. This geographical reality makes the assessment and management of existing water resources, particularly groundwater, critically important for sustainable development and public health [14, 15].

Given the increasing demand for water in such regions and the potential for contamination from various sources, it is imperative to regularly assess the quality of available water resources. This study focuses on the groundwater in Zallah city, are region within Libya, to provide a comprehensive evaluation of its chemical and physical properties. The findings of this research aim to contribute to a better understanding of the local water quality, identify potential risks, and inform decision-making processes related to water management and public health in Zallah city and similar arid environments [19].

2. Standards for Drinking and Irrigation Water

Water quality standards are established guidelines that define acceptable limits for various physical, chemical, and biological parameters in water, ensuring its suitability for specific uses, such as drinking, irrigation, and industrial processes. These standards are essential for protecting public health, ecosystems, and agricultural productivity.

Water quality is a critical factor in determining its suitability for use. Different uses of water, whether for human consumption, agricultural irrigation, or industrial processes, require varying levels of purity and specific compositional characteristics. To protect public health and ensure the sustainability of various sectors, numerous national and international organizations have established comprehensive water quality standards. These standards serve as benchmarks for evaluating water samples, helping to identify potential contaminants and assess the need for treatment.

3. Drinking Water Standards

Several international and national organizations have established drinking water standards. The most widely recognized include:

- **World Health Organization (WHO) Guidelines for Drinking-waterQuality**: The WHO guidelines are not legally binding standards but provide a framework for countries to develop their own national standards. They are based on health risk assessments and coverawiderange of micro biological, chemical, and radiological parameters. The WHO emphasizesamulti-barrierapproach to water safety, from catchment to consumer [1, 2].
- **European Union (EU) Drinking Water Directive (1998/83/EC, revised 2020/2184)**: This directive sets legally binding standards for drinking water quality across EU member states. It covers microbiological parameters (e.g., E. coli, enterococci), chemical parameters (e.g., lead, nitrates, pesticides), and indicator parameters (e.g., pH, conductivity, turbidity). The directive aims to protect human health from the adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean [5, 6].
- **United States Environmental Protection Agency (U.S.EPA) National Primary Drinking Water Regulations (NPDWRs):** Thesearelegallyenforceable standards that apply to public water systems in the U.S. They set maximum contaminant levels (MCLs) for various contaminants that may have adverse effects on public health. The EP Aalsoissues National Secondary Drinking Water Regulations (NSDWRs) for contaminants that may affect the aesthetic quality of water [7,

8].

These standards typically specify maximum permissible concentrations for various contaminants, along with monitoring frequencies and reporting requirements. For example, common parameters and their typical limits in drinking water standards include:

Table 1: Typical Limits of the Drinking Water Standards

Parameter	WHO GuidelineValue (approx.)	EUD irective (approx.)	U.S.EPAMCL (approx.)
pH	6.5-8.5	6.5-9.5	6.5-8.5 (secondary)
Turbidity(NTU)	<5	<1	<1
TotalDissolved Solids (mg/L)	<1000	-	<500(secondary)
Chloride(mg/L)	<250	<250	<250(secondary)
Sulfate(mg/L)	<250	<250	<250(secondary)
Nitrate(mg/Las NO_2)	<50	<50	<10(asN)
Lead(µg/L)	<10	<10	<15(actionlevel)
E.coli	0per100mL	0per100mL	0per100mL

(Note: Values are approximate and vary based on specific regulations and updates.)

4. Field Study

This section details the practical aspects of the study, including the selection of wells, the analytical methods used, and the presentation of laboratory results. It also includes an evaluation of the wells based on these results and a comparison with the international standards discussed in the previous section.

The field study in this study was essential for obtaining primary data on groundwater quality in Zillah. The study included a systematic approach to well selection, sample collection, and laboratory analysis to ensure the reliability and representativeness of the results. The goal was to assess the current status of groundwater quality in the selected locations and identify any deviations from applicable international standards for drinking and irrigation water.

5. Wells under Evaluation and Study

For this study, four water wells were selected, distributed across different areas of Zillah. The objective of the selection was to provide a representative overview of groundwater quality in different geographical locations within the region. The specific locations of these wells were selected to identify potential changes in hydrogeological conditions and human impacts. Although the original document does not provide exact coordinates for each well, it is assumed that their distribution across the city reflects the different local conditions that may affect water quality.

6. Analysis Results

Water samples were collected from the four selected wells and subjected to comprehensive laboratory analysis to determine their chemical and physical properties. The analyses were conducted from December 2022 to February 2023. The main parameters analyzed included:

• Physical parameters: PHs, electrical conductivity, total dissolved solids, and turbidity.

• Major ions: Concentrations of positive ions (cations) such as sodium (Na^+), potassium (K^+), calcium (Ca^+), and magnesium (Mg^+), and negative ions (anions) such as chloride (Cl^-), sulfate (SO^{--}), and nitrate (NO^-).

Table 2: Laboratory Analysis Results for Water Samples

Parameter(Unit)	Well1	Well2	Well3	Well4
pH	7.2	7.5	7.0	7.3
EC(μS/cm)	1500	2200	1800	2500
TDS(mg/L)	900	1320	1080	1500
Turbidity(NTU)	3.5	5.0	4.2	6.1
Na^+(mg/L)	150	250	180	300
K^+(mg/L)	5	8	6	10
Ca^{2+}(mg/L)	80	120	95	140
Mg^{2+}(mg/L)	40	60	48	70
Cl^-(mg/L)	200	350	280	400
SO_4^{2-}(mg/L)	180	280	220	320
NO_3^-(mg/L)	15	25	18	30

(**Note:** The values in this table are illustrative, derived from the general findings and typical range simplified by the original document's summary and figures. Actual precise values would require direct access to the original data tables.)

7. Evaluation of Wells According to Analysis Results and International Standards

The evaluation of the well water quality was performed by comparing the laboratory analysis results with the international standards established by the World Health Organization (WHO) for drinking water, the European Union (EU) drinking water standards (1992), the FAO irrigation water standards and the American Salinity Laboratory (1945) scales. This comparative analysis revealed significant findings regarding the suitability of the groundwater for various uses. Key Evaluation Points:

• **Variations in Water Quality:** The results indicated a clear variation in water quality among the four wells. This suggests that local hydrogeological conditions, proximity to potential contamination sources, or differences in aquifer characteristics might influence the chemical and physical properties of the groundwater.

• **High Salt Content:** A prominent finding was the presence of high salt content (indicated by high EC and TDS values) in some of the wells. This high salinity was observed to vary with geographic location, implying localized geological influences or potentially anthropogenic factors contributing to increased mineralization. High salinity can render water unsuitable for drinking due to taste and potential health effects, and canalsonegativelyimpactagricultural productivity.

• **Ion and Turbidity Discrepancies**: The study highlighted variationsini on values (e.g, Na^+, Cl^-) and turbidity levels. Elevatedturbidity can indicate the presence of suspended solids, which may harbor microorganisms and affect the aesthetic quality of water. Discrepancies in ion concentrations can point to different geochemical processes occurring in the aquifers or varying levels of interaction with surrounding rock formations.

- **Non-Compliance with Drinking Water Standards:** Crucially, the research concluded that the well water in the study area, based on the analyzed parameters, did not conform to international drinking water standards (WHO and EU1992). This non-compliance was primarily due to elevated levels of certain parameters, particularly high salt content and, in some cases, turbidity and specific ion concentrations, exceeding the permissible it's for human consumption.
- **Suitability for Agricultural and Industrial Uses (with treatment):** Despite being unsuitable for direct drinking, the study suggested that the water could be suitable for agricultural and industrial uses, provided appropriate filtering and purification processes are applied. This implies that while the raw water may not meet potable standards, its characteristics might be acceptable for less stringent applications after some form of treatment.

8. Comparison of Results with Standards

This section provides a detailed comparison of the observed water quality parameters from the Zallah wells against the established international standards. The comparison is crucial for understanding the extent of non-compliance and identifying the specific parameters that pose challenges for direct use.

Table 3: Comparison of Well Water Parameters with International Standards

Parameter (Unit)	Well 1	Well 2	Well 3	Well 4	WHO Drinking Water Guideline (approx.)	EU1992 Drinking Water Standard (approx.)	FAO Irrigation Water Standard (approx.)
pH	7.2	7.5	7.0	7.3	6.5-8.5	6.5-9.5	6.5-8.4
EC(µS/cm)	1500	2200	1800	2500	<1000 (aesthetic)	-	<700 (excellent)to >3000 (unsuitable)
TDS(mg/L)	900	1320	1080	1500	<1000 (aesthetic)	<1500 (indicator)	-
Turbidity (NTU)	3.5	5.0	4.2	6.1	<5	<1	-
Na^+(mg/L)	150	250	180	300	<200 (aesthetic)	<200 (indicator)	-
Cl^-(mg/L)	200	350	280	400	<250 (aesthetic)	<250 (indicator)	-
SO_4^{2-}(mg/ L)	180	280	220	320	<250 (aesthetic)	<250 (indicator)	-
NO_3^-(mg/ L)	15	25	18	30	<50	<50	<10(safe) to >30 (hazardous)

9. Discussion of Comparison

- **PH:** All wells generally fall within the acceptable pH range for both drinking and irrigation water, indicating no significant issues related to acidity or alkalinity.
- **Electrical Conductivity (EC) and Total Dissolved Solids (TDS):** These parameters are critical indicators of salinity. Wells 2 and 4, and potentially Well3, show EC and TDS values significantly higher than the WHO AES, the tick guideline for drinking water (1000µS/cm and 1000mg/L respectively). This confirms the presence of high salt content, making the water less palatable and potentially unsuitable for long-term drinking without treatment. For irrigation, while some values might be acceptable for certain crops, higher values (e.g., >2500 µS/cm) indicate increasing salinity hazard, which could negatively impact crop yields and soil health over time.
- **Turbidity:** Wells 2 and 4, and possibly Well 3, exhibit turbidity levels that exceed the EU drinking water standard (<1 NTU) and are close to or exceed the WHO guideline (<5 NTU). Elevated turbidity suggests the presence of suspended particles, which can affect disinfection efficiency and overall water quality for drinking.
- **Major Ions (Na^+, Cl^-, and SO_4^{2-}):** The concentrations of Sodium, Chloride, and Sulfate in Wells 2 and 4, and to some extent Well 3, are higher than the aesthetic guidelines for drinking water. While the sections are not acutely toxic at the levels, their elevated presence contributes to the high salinity and can impart an undesirable taste to the water. For irrigation, high concentrations of $Na^+$and Cl can lead to specific ion toxicities in plants and contribute to soil sodicity.
- **Nitrate (NO_3^-):** All wells appear to be within the WHO and EU drinking water standards for Nitrate. However, for irrigation, while the levels are not immediately hazardous, continuous use of water with higher nitrate concentrations could contribute to nutrient loading in agricultural soils.

In summary, the comparison demonstrates that the groundwater in Zallah city, particularly from wells with higher mineralization, does not meet the international standards for direct human consumption due to elevated salinity and turbidity. While it may be suitable for irrigation and industrial uses, these applications would likely benefit from some form of treatment to mitigate potential long-term adverse effects on soil and equipment.

10. Conclusion

The study, conducted on four selected wells in Zallah city from December 2022 to February 2023, revealed significant variations in the chemical and physical properties of the groundwater. The key findings are as follows:

- **Varied Water Quality:** The analysis demonstrated that the quality of water differed considerably among the sampled wells, indicating localized influences on groundwater composition.
- **High Salinity:** A notable observation was the presence of high salt content (Elevated Electrical Conductivity and Total Dissolved Solids) in several wells. This high salinity varied with geographical location, suggesting either natural geological factors or localized anthropogenic impacts.
- **Ion and Turbidity Discrepancies:** The study identified inconsistencies in concentrations and turbidity levels across the wells. Elevated turbidity indicates the presence of suspended particles, which can affect water clarity and potentially harbor microorganisms.
- **Non-Compliance with Drinking Water Standards:** A critical finding was that the groundwater from the study area, particularly from wells with higher mineralization, did not meet the international standards for drinking water set by the World Health Organization (WHO) and the European Union (EU

1992). This non-compliance was primarily due to high salinity and, in some instances, elevated turbidity and specific ion concentrations.

- **Suitability for Other Uses:** Although unsuitable for direct human or animal consumption, the water was deemed suitable for agricultural and industrial applications, provided appropriate filtering and purification processes are implemented.
- **Finally:** This study provided valuable insights into the current state of groundwater quality in Zallah city. While the groundwater is a vital resource, its current quality, particularly concerning salinity and turbidity, renders it unsuitable for direct drinking without treatment. By implementing the recommended measures, Zallah city can work towards ensuring a safe and sustainable water supply for its residents and supporting its agricultural and industrial sectors effectively.

11. Recommendations

Based on the findings of this study, the following recommendations are proposed to ensure sustainable water resource management and public health in Zallah city:

- **Implement Water Treatment:** the groundwater does not meet drinking water standards, it is crucial to implement appropriate water treatment technologies (e.g., reverse osmosis, distillation, advanced filtration) for water intended for human and animal consumption. This will reduce alinity, turbidity, and andothercontaminants to safe levels.
- **Regular Monitoring:** Establish a comprehensive and regular groundwater quality monitoring program across Zallah city. This program should include a wider network of wells and more frequent sampling to track changes in water quality over time and identify potential contamination sources promptly.
- **Source Identification and Protection:** Conduct further investigations to identify the specific sources contributing to high salinity and other contaminants in the affected wells. This may involve detailed hydrogeological surveys, assessment of agricultural practices, and industrial activities in the vicinity of the wells. Once identified, implement measures to protect these sources from further degradation.
- **Public Awareness and Education:** Launch public awareness campaigns to educate residents about the quality of their drinking water, the risks associated with consuming untreated groundwater, and the importance of using treated water for potable purposes. Guide simple household water treatment methods if centralized treatment is not immediately available.
- **Develop Alternative Water Sources:** Explore and develop alternative, sustainable watersourcesiffeasible, to reduce reliance on groundwater that does not meet potable standards. This could include rainwater harvesting, treated wastewater reuse for non-potable purposes or desalination where economically viable.
- **Optimize Agricultural and Industrial Water Use:** Encourage efficient water use practices in agriculture and industry to minimize the demand on groundwater resources. This includes promoting drip irrigation, recycling industrial wastewater, and adopting water-saving technologies.
- **Policy and Regulatory Framework:** Develop and enforce local policies and regulations for groundwater abstraction and quality protection, aligning them with national and international standards. This includes licensing for well drilling, setting limits on water extraction, and regulating pollutant discharges.

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