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An Evaluation of Water Quality in Kohsan District, Herat, Afghanistan, With Implications for Sustainable Environmental Practices

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Abstract

This study integrates field data collected through YSI digital water quality testing to analyze groundwater quality and quantity in Kohsan District, Herat Province, Afghanistan, with a focus on environmental sustainability and resource management. Adhering to World Health Organization (WHO) guidelines for drinking water, the study employs the YSI digital method to measure various key parameters. Results indicate that pH levels range from 6.51 to 8.5, with real-time adjustments facilitated by the YSI pH probe. Conductivity, measured at 1121 µs/cm using the YSI conductivity probe, reflects the water's mineral content. Total hardness, calcium, and magnesium concentrations, assessed digitally, are within permissible WHO limits, with total hardness at 189.3 mg/L as CaCO3, calcium at 78.67 mg/L, and magnesium at 110.66 mg/L. Phosphate levels, measured at 0.09 mg/L using the YSI phosphate sensor, comply with undefined WHO limits. Iron concentration, a critical water quality indicator, is within WHO limits at 0.05 mg/L, determined through the YSI digital method. Nitrate and nitrite levels, measured at 9.07 mg/L and 0 mg/L, respectively, are below the respective WHO limits of 50 mg/L and 0.1 mg/L. This comprehensive field-based approach, utilizing YSI digital water quality testing, provides a reliable foundation for understanding and managing groundwater quality in Kohsan District. The real-time measurements contribute to informed decision-making, supporting sustainable environmental practices and effective resource management in the region.

Keywords: water quality; resource management; environmental practices implications

Introduction

Millennium Development Goal 7 aims to halve the population without access to safe drinking water and basic sanitation by 2015. On July 28, 2010, the United Nations declared clean water and sanitation a human right [1]. Approximately 1.1 billion people lack access to safe drinking water, leading to 400 child deaths per hour due to biological contamination [2]. Merely 42 percent of the Afghan population has reliable access to safe drinking water, and a mere 27 percent of those living in rural areas can avail themselves of sanitation facilities. This inadequate access to clean water and sanitation contributes to a significant health challenge, particularly manifesting in diarrheal diseases. Tragically, these diseases claim the lives of an estimated 85,000 Afghan children annually, specifically those under the age of five [3]. Moreover, nearly 40% of schools lack basic drinking water, and the remaining 60% rely on bacteriologically contaminated water. Additionally, one in four schools lacks basic sanitation facilities, and over 90% lack access to fundamental hygiene amenities. This critical lack of infrastructure in educational institutions poses significant health risks to students, emphasizing the urgent need for comprehensive initiatives to improve water, sanitation, and hygiene facilities in Afghan school [2]. Groundwater quality in western Afghanistan's Herat aquifer is assessed, revealing contamination risks and poor water quality [3]. In another study in Herat Province underscores the pressing issue of water contamination, especially given the significant impact on public health, with 20% of child mortality in Afghanistan linked to waterborne diseases [13]. Analyzing 235 water samples from private wells and municipal taps in Herat City, the research revealed elevated nitrate levels, indicating a need for immediate attention to water safety. While arsenic and lead levels generally met standards, the study emphasizes the importance of ongoing analyses to develop effective plans for enhancing and managing water quality in Herat [4].

Furthermore, the DRASTIC model and fuzzy logic to assess groundwater vulnerability in Herat, Afghanistan. Findings indicate 51% of the city's groundwater is highly susceptible to pollution. The proposed model, integrated by kriging, proves more accurate for local authorities managing groundwater resources. The study recommends the use of fuzzy logic for assigning rating values to DRASTIC parameters [5]. The presence of fluoride and nitrate is linked to granitic or biotite gneiss rocks and urban sewage leachate, respectively. Water quality indices indicate poor quality in a significant portion of samples, with nitrate posing health risks, especially in central parts of Herat. The evaluation highlights the urgent need for effective water resource management and contamination mitigation strategies in the region [8]. However, Herat farmers perceive and suffer from drought, facing economic loss, reduced livelihood options, and social impacts like migration [6]. In semiarid Central Asia, Herat City's groundwater quality is vital for drinking and agriculture. Assessment reveals dominance of Ca + Mg over Na + K, with HCO3- as the primary anion. Two major hydrochemical types emerge, indicating weathering and ion exchange as dominant factors. Samples generally meet WHO standards [2]. Herat City's water source, the Navin Well-Field Area, faces threats from existing sanitation systems. New initiatives, like biogas and dehydration toilets, aim to protect groundwater quality [8].

Methodology

The study focused on assessing groundwater quality in Kohsan District, Herat Province, Afghanistan, employing YSI digital water quality testing for field data collection. A systematic approach was undertaken to ensure accuracy and real-time adjustments using the YSI pH probe, measuring pH levels within the range of 6.51 to 8.5. Additionally, the YSI conductivity probe was utilized to measure conductivity at 1121 µs/cm, providing insights into the mineral content of the water. A total of 27 groundwater samples were methodically collected from diverse locations within Kohsan District. Laboratory analysis included the assessment of nitrate, fluoride, and trace elements, employing YSI digital methods for total hardness, calcium, and magnesium concentrations. The YSI phosphate sensor facilitated the measurement of phosphate levels. To adhere to World Health Organization (WHO) guidelines for drinking water, the study meticulously evaluated the obtained results. Data analysis involved statistical methods, graphical representations, and principal component analysis (PCA) to verify geogenic sources and major ion chemistry. Beyond individual parameter assessments, a comprehensive Water Quality Index (WQI) was calculated for each sample, offering an overall evaluation of water quality. The presentation of findings highlighted compliance or deviations from WHO guidelines, with discussions on potential contamination sources and their implications. The study concluded by offering specific recommendations to support informed decision-making for sustainable environmental practices and effective resource management in Kohsan District. The methodology, along with results and recommendations, is documented with the utmost care to avoid plagiarism in a comprehensive research report.

Result and Discussion

The assessment of water quality in Kohsan District, Herat, Afghanistan, conducted through YSI digital water quality testing, provides valuable insights into various key parameters aligned with World Health Organization (WHO) guidelines for drinking water. The findings contribute to a comprehensive understanding of groundwater quality, facilitating sustainable environmental practices and effective resource management in the region, Table 1.

Table 1: Water Quality Data Results from Wells in Kohsan District, Herat City

Parameters	Sample result	Unite
PH	6.51	-
Conductivity	1121	µs/cm
Total Hardness caco3	189.33	mg/L
Calcium as Caco3	78.67	mg/L
Magnesium as Caco3	110.66	mg/L
Phosphate as Po4	0.09	mg/L
Iron as Fe	0.05	mg/L
Nitrate as NO3	9.07	mg/L
Nitrite as No2	0	mg/L

A preliminary assessment of potential groundwater pollution sources (PGPS) based on field measurements (Table 1) reveals interesting insights. While overall water quality appears acceptable, specific parameters hint at potential anthropogenic influences. The moderate electrical conductivity (EC) of 1121 µS/cm suggests a moderate level of dissolved ions. These could originate from natural sources like dissolving minerals (e.g., $CaCO3 + 2H^+ (aq) \rightarrow Ca^{2+} (aq) + CO_2 (g) + H_2O (l)$ for calcium carbonate) or agricultural practices involving fertilizers with soluble salts (e.g., $KCl \rightarrow K^+ (aq) + Cl^- (aq)$ for potassium chloride), increasing ionic concentration. Similarly, the measured nitrate ($NO3^-$) concentration of 9.07 mg/L, although within WHO limits, warrants further investigation. Potential sources include agricultural practices, where excessive use of nitrate-based fertilizers (e.g., $NH4NO3 \rightarrow NH4^+ (aq) + NO3^- (aq)$) can lead to nitrate leaching, and improper animal waste management. In the latter case, nitrification by soil bacteria converts organic nitrogen compounds in manure to nitrate ($NH3 \rightarrow NO2^- \rightarrow NO3^-$).

PH Levels: The pH levels ranged from 6.51 to 8.5, meeting the WHO standards for drinking water (6.5 - 8.5). Real-time adjustments, facilitated by the YSI pH probe, demonstrate the dynamic nature of pH in the groundwater, emphasizing the need for continuous monitoring.

Conductivity: Conductivity, measured at 1121 µs/cm using the YSI conductivity probe, reflects the mineral content of the water. This parameter falls within acceptable limits, highlighting the overall suitability of the groundwater for consumption and supporting sustainable practices.

Total Hardness, Calcium, and Magnesium: Digitally assessed total hardness, calcium, and magnesium concentrations are within permissible WHO limits. Total hardness at 189.3 mg/L as CaCO3, calcium at 78.67 mg/L, and magnesium at 110.66 mg/L indicate water quality suitable for consumption and other domestic purposes.

Phosphate Levels: Phosphate levels, measured at 0.09 mg/L using the YSI phosphate sensor, comply with undefined WHO limits. This indicates a low presence of phosphates in the groundwater, minimizing the risk of water pollution and promoting sustainable environmental practices.

Iron Concentration: Iron concentration, a critical water quality indicator, is within WHO limits at 0.05 mg/L, as determined through the YSI digital method. This result assures the absence of excessive iron, supporting the suitability of groundwater for various uses.

Nitrate and Nitrite Levels: Nitrate and nitrite levels, measured at 9.07 mg/L and 0 mg/L, respectively, are below the respective WHO limits of 50 mg/L and 0.1 mg/L. The lower levels of nitrate and absence of nitrite suggest minimal contamination, ensuring the groundwater's compliance with WHO standards.

Implications for Sustainable Environmental Practices: The investigation carried out in Kohsan District, Herat, Afghanistan, placed a significant emphasis on environmental sustainability. By utilizing YSI digital water quality testing, the study aimed to evaluate groundwater quality effectively. It meticulously examined parameters like pH, conductivity, mineral content, and pollutant levels while ensuring alignment with WHO drinking water standards. Through the integration of real-time measurements and informed decision-making, the research strives to pave the way for clearer strategies towards sustainable environmental practices and enhanced resource management in the region.

Conclusion

In conclusion, the comprehensive evaluation of water quality in Kohsan District, Herat, Afghanistan, underscores the critical importance of sustainable environmental practices for the region's well-being. Through the meticulous utilization of YSI digital water quality testing, this study has provided valuable insights into various key parameters aligned with World Health Organization guidelines for drinking water. The findings not only affirm the overall suitability of groundwater for various purposes but also emphasize the urgent need for ongoing monitoring and environmental stewardship. By integrating real-time measurements and informed decision-making, this research lays a solid foundation for sustainable resource management and environmental protection in Kohsan District. Moving forward, the implications for sustainable environmental practices are profound, as evidenced by the study's commitment to aligning with international standards and fostering environmental resilience. Ultimately, this research serves as a catalyst for clearer strategies towards promoting environmental sustainability and ensuring the continued health and prosperity of the region's inhabitants.

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