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Research Article

Integrated Hydrogeochemical Analysis and Assessment of Groundwater Quality Surrounding Darul Aman: A Case Study of Elm-e-Farhang, Alawdin Masjid Fatima Zahra, Animals Clinic, and Abas Qoli Masjid Salman Fars

Abdul Mohammad Aziz[1], Mohammad Dawod Shirzad[2] and Hiteshkumar Arvind Solanki[3]*

[1]Faculty of Chemistry, Kabul University, Kabul, Afghanistan

[2]Faculty of Environment, Kabul University, Kabul, Afghanistan

[3]Professor and Head, Department of Botany, Bioinformatics and Climate Change Impact Management and Environmental Science, Gujarat University, Ahmedabad, India

***Corresponding Author:** Hiteshkumar Arvind Solanki, Professor and Head, Department of Botany, Bioinformatics and Climate Change Impact Management and Environmental Science, Gujarat University, Ahmedabad, India.

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Abstract

This study was undertaken to assess the groundwater quality and its suitability for drinking purposes in Darul Aman, Kabul, Afghanistan. Four water samples were collected from bore wells in the study area and subjected to comprehensive analysis of various physical and chemical parameters, including temperature, ammonia, iron, copper, bicarbonate (HCO_3), and others. The recorded ammonia levels ranged from 0.02 mg/L to 0.27 mg/L, with an average of 0.04 mg/L, and iron concentrations ranged from 0 mg/L to 0.07 mg/L, averaging at 0.03 mg/L.

The analysis indicated that parameters exceeded the permissible limits set by WHO standards for drinking water in present study is bicarbonate levels ranged from 325 mg/L to 400 mg/L. the concentrations of these elements rendered the groundwater sources unsuitable for drinking purposes.

This study underscores the urgent need for remedial measures to address the compromised quality of drinking water in Darul Aman. The findings suggest that immediate environmental management interventions are necessary to safeguard the population from potential adverse health effects. Considering the contamination levels, it is concluded that the drinking water in Darul Aman is not potable. As a precautionary measure, it is recommended that individuals utilize water only after boiling, filtering, or treating with Reverse Osmosis to mitigate potential health risks.

Keywords: Groundwater; Industrialization; Urbanization

Introduction

Access to clean and safe drinking water is a pressing concern, particularly in developed nations, where its significance is often overshadowed by other issues. However, the quality of water profoundly impacts human welfare, influencing biological, chemical, and physical aspects. Termed as water quality, the assessment of these properties is crucial due to water's indispensable role in biological processes essential for sustaining life and fostering healthy human development. Aziz., *et al.* (2021) [1] studied Darul Aman groundwater quality assessment of Afghanistan and found that in samples almost all water quality parameters (PH, Calcium, Magnesium, Sodium, Chloride, Fluoride, Phosphate, Potassium Cyanide) are beyond the permissible limits as per WHO standards and Afghanistan National Standards.

Despite covering more than three-quarters of the Earth's surface, only a meager 2.8% of water is suitable for human consumption, with the majority residing in oceans (FAO, 2018).

The escalation of industrialization, urbanization, and population growth, alongside evolving lifestyles, has led to a concerning deterioration in water quality. Primary contributors to this decline include the discharge of domestic and industrial wastes into water bodies, introducing pollutants such as pesticides, fertilizers, herbicides, polychlorinated biphenyls, and synthetic organic compounds.

Contaminated groundwater emerges as a significant catalyst for epidemic and chronic diseases in humans, as highlighted by Fuchinoue., *et al.* (2002) [8], underscoring the critical need for comprehensive water quality assessments.

Beyond its immediate impact on human health, water's global significance is underscored by its role as a vital element for various economic activities. Approximately 71% of the Earth's surface is water-covered, with a mere 2.5% available in the form of rivers and lakes. This limited freshwater surface is crucial for sustaining economic endeavors such as agriculture, fisheries, mining, transportation, and tourism [10].

Human reliance on water extends beyond basic needs like drinking, washing, and bathing; it also encompasses the intricate relationship between water resources and aquatic life. Aquatic habitats serve as a fundamental resource for various species, eventually becoming a significant protein source for human consumption, emphasizing the intricate interdependence between water quality, human activities, and ecological systems.

The development of urban areas further intensifies the reliance on groundwater as a primary water source for residences, companies, and industries. However, urban areas face unique challenges, with groundwater often contaminated at higher concentrations compared to rural counterparts.

This scientific introduction sets the stage for a comprehensive exploration of global water quality, addressing its multifaceted impacts on human health, ecosystems, and economic activities. Through an interdisciplinary lens, this study aims to elucidate the intricate dynamics of water quality and its implications on both developed and developing regions, thereby contributing to the broader discourse on sustainable water management and environmental health.

Problem statement

Water pollution, resulting from inadequate treatment of pollutants entering water bodies, adversely affects ecosystems and human life. Freshwater systems worldwide face contamination from industrial and natural compounds, posing a significant environmental challenge. Understanding and managing groundwater resources are essential, particularly in small island environments, to address potential water shortages.

Importance of research

Water, critical to human and environmental well-being, demands a comprehensive study to assess and manage its quality. Water quality affects domestic, agricultural, and industrial water supply, fisheries, aquaculture, and overall ecosystem health. Recognizing the sensitivity of surface water quality, this study aims to evaluate and classify groundwater quality in Darul Aman using the Water Quality Index (WQI).

Objective of study

To analyze temperature, ammonia, iron, copper, and aluminum value in Darul Aman groundwater.

Questions

Is the amount of ammonia, iron, copper, ammonium and temperature in the groundwater of Kabul city, Darul-Aman area according to national and international standards?

Literature Review

The study reveals that the water quality of river Narmada was found to be suitable for human consumption in the season summer and winter as the values of parameters found to be (pH 7.7–8.48, TDS 108–234mg L^{-1}, Turbidity 0.01–178.25NTU, Nitrate-Nitrogen 0.03–3.14mg L^{-1}, Phosphate0.01–0.52 mg L^{-1}, BOD 0.35–2.18mg $L^{-1}$and DO 2.4–7.8mg L^{-1}) as per the standard values prescribed by different regulatory bodies. For assessment of water quality of River Narmada, various Water Quality Index (WQI) such as Weighted Arithmetic Water Quality Index (WAWQI), National Sanitation Foundation Water Quality Index (NSFWQI) and Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI) has been used in this study. On comparison of these methods for evaluation of water quality of Narmada River at different sites, WAWQI method provides better idea about the water quality [11,12].

The results from environmental-isotope studies [14] indicate that interflow may be primarily displacement process in which the storm rainfall induces the displacement of subsurface-stored water (pre-event water). He described the ground water ridging is the large and rapid increase in hydraulic head in ground water during storm periods. He further explained that an assumption is made that water do not enter a large non capillary pore unless it is at or above atmospheric pressure. Such conditions only occur either below the water table or after ponding during rain fall at the soil surface. Borja., *et al.* (2000) proposed a marine Biotic Index (BI) for soft bottom benthos of European Estuarine and coastal environments. Using data from systems affected by recent human disturbances, the proposed index is validated, demonstrating that various anthropogenic changes in the environment can be detected using BI.

Lenat, (1988) discussed a standardized qualitative sampling technique which was developed and tested for shallow stream in North Carolina [6].

As it was cited in above and all the focus was on physio-chemical parameters so it's to be necessary to describe the water quality physio-chemical parameters as it prescribes by WHO and our national authorities [3].

Importance of groundwater

About 30 percent of the fresh water on Earth comes from groundwater. Just 1 percent of the remaining 70 percent is found in rivers and lakes, and nearly 69 percent is trapped in ice caps and mountain snow/glaciers. Although it can reach 100 percent in some regions of the world, groundwater supplies about one-third of the fresh water used by humans on average [11,16].

Groundwater has significant role in economy and is a very important natural resource. Also, groundwater is the key source of water for agriculture and industry. Generally speaking, groundwater is a flexible and dependable source of water for agriculture. More groundwater can be extracted during dry spells and periods of high demand, while less groundwater extraction is required during periods of abundant rainfall. Over 70 percent of all water withdrawals worldwide are used for irrigation (both surface and groundwater). It is estimated that approximately 43 percent of the water used for irrigation comes from groundwater [9].

Groundwater is crucial to the environment because it maintains the water level and flow in rivers, lakes, and wetlands. It gives the environment groundwater flow through the bottom of these bodies of water, which is crucial for the plants and wildlife that live there, especially in the dry months when there is little direct recharge from rainfall (Gupta., *et al*. 2017). During the dry seasons, groundwater is also crucial for maintaining navigation through inland waters. By going out of groundwater into the rivers, it contributes to maintaining higher water levels [10].

Because groundwater is held in subsurface layers, sometimes at extremely high depths, it is better shielded from pollution and its quality is maintained. Furthermore, unlike surface water, which frequently requires significant infrastructure and treatment investments, groundwater is a naturally occurring resource that is frequently found close to the final consumers. The most crucial aspect of using groundwater is striking the correct balance between drawing from and allowing the aquifer's level to recover in order to prevent overuse and pollution of this vital resource [17].

Materials and Methods

A total number of four representative groundwater samples collected in well points from different parts of the study area to determine water quality parameters. The physical and chemical parameters in the water are measured by different devices in the laboratory of Faculty of Environment of Kabul University and direct ship of Hydrology. It should also be noted that this research has used other sources such as books, journals, scientific articles, research papers. The investigational values are matched with standard values recommended by World Health Organization (WHO) and Afghanistan national standards [12,19].

Date of sampling and analyzing

Table 1: Sampling and analyzing date.

No	Sampling	Analyzing
1	9-Apr-2019	10-Apr-2019
2	9-Apr-2019	10-Apr-2019
3	9-Apr-2019	10-Apr-2019
4	9-Apr-2019	10-Apr-2019

Result and Discussions

Table 2 displays the average monitoring period value for each groundwater quality parameter used in this study at each sampling location.

No	Parameters	Sample NO	Location	Value	Units
1	Temperature	S 1	Elm-e-Farhang	16	^0C
		S 2	Alawdin Fatima Zahra Masque	15.5	^0C
		S 3	Animal Clinic	15.6	^0C
		S 4	Abas Qoli Salman Fars masque	15	^0C
2	HCO_3^-	S 1	Elm O Farhang	400	mg/L
		S 2	Alawdin Fatima Zahra Masque	375	mg/L
		S 3	Animal Clinic	375	mg/L
		S 4	Abas Qoli Salman Fars masque	325	mg/L
3	Ammonia	S 1	Elm O Farhang	0.27	mg/L
		S 2	Alawdin Fatima Zahra Masque	0.03	mg/L
		S 3	Animal Clinic	0.02	mg/L
		S 4	Abas Qoli Salman Fars masque	0.06	mg/L
4	Iron	S 1	Elm O Farhang	0.03	mg/L
		S 2	Alawdin Fatima Zahra Masque	0.01	mg/L
		S 3	Animal Clinic	0	mg/L
		S 4	Abas Qoli Salman Fars masque	0.07	mg/L
5	Copper	S 1	Elm O Farhang	0.05	mg/L
		S 2	Alawdin Fatima Zahra Masque	0	mg/L
		S 3	Animal Clinic	0.03	mg/L
		S 4	Abas Qoli Salman Fars masque	0.06	mg/L
6	Aluminum	S 1	Elm O Farhang	0.008	mg/L
		S 2	Alawdin Fatima Zahra Masque	0	mg/L
		S 3	Animal Clinic	0.015	mg/L
		S 4	Abas Qoli Salman Fars masque	0.038	mg/L

Table 2: Checked parameters of the research area.

Temperature

The amount of temperature which recorded from groundwater of Darul Aman ranged from 15°C to 16°C with average of 15.52°C. The maximum temperature rate which noted is 16°C at Sample 1 from Elm o Farhang and minimum temperature value which recorded is 15°C at Sample 4 from Abas Qoli Salman Fars masque. Other temperature rate which noted from groundwater of Darul Aman is 15.6°C at Sample 3 from Animal Clinic another is 15.50C at sample 2 from Alawdin Fatima Zahra Masque. The average tem-

Table 3: Comparison of samples value with standards.

NO	Parameters	Unit	Min	Max	Mean	WHO	AFG Standard
1	Temperature	^0C	15	16	15.50	12-25	<3
2	HCO_3^-	mg/L	325	400	368.75	125-350	-
3	Ammonia	mg/L	0.02	0.27	0.04	1.5	3.5
4	Iron	mg/L	0	0.07	0.03	0.3	0.3
5	Copper	mg/L	0	0.06	0.04	2	2
6	Aluminum	mg/L	0	0.038	0.02	0.2	-

perature of groundwater according to the recommendation of the WHO is 18.5 degrees Celsius and according to the national standard it is <3 degrees Celsius.

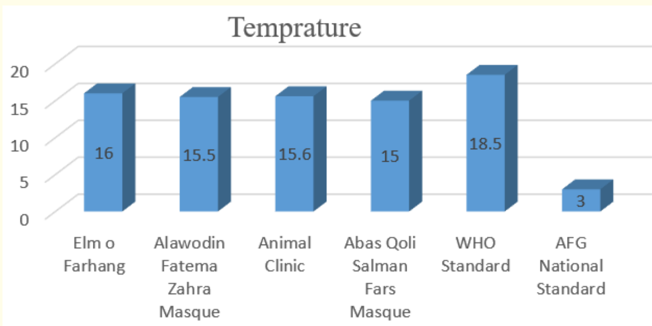

Figure 1: Compare the temperature of the samples with the standards of WHO and AFG.

Bicarbonate (HCO_{-3})

The amount of which recorded from groundwater of Darul Aman ranged from 325mg/L to 400mg/L with average of 368.75mg/L. The maximum value which recorded is 400mg/L at Sample 1 from Elm-e-Farhang and minimum value which recorded is 325 mg/L at Sample 4 from Salman Fars masque. Another value that was measured in Darul Aman's groundwater was 375 mg/L at Sample 3 from the Animal Clinic and 375 mg/L at Sample 2 from the Alawdin Fatima Zahra Masque. The average quantity that the WHO advises is 237.5mg/L and recommended value by AFG National standard for is not available.

Ammonia

Ammonia levels found in Darul Aman's groundwater ranged from 0.02 mg/L to 0.27 mg/L, with an average of 0.04 mg/L. The maximum ammonia value which recorded is 0.27 mg/L at Sample 1 from Elm-e-Farhang and minimum ammonia value which recorded is 0.02 mg/L at Sample 3 from Animal Clinic, Salman Fars masque. Other ammonia value which recorded from groundwater of Darul Aman is 0.06 mg/L at Sample 4 from Abas Qoli Salman Fars masque another is 0.03 mg/L at sample 2 from Alawdin Fatima Zahra Masque. The amount of ammonia recommended by WHO is 3.5 mg/L and recommended value by AFG National standard for ammonia is not available.

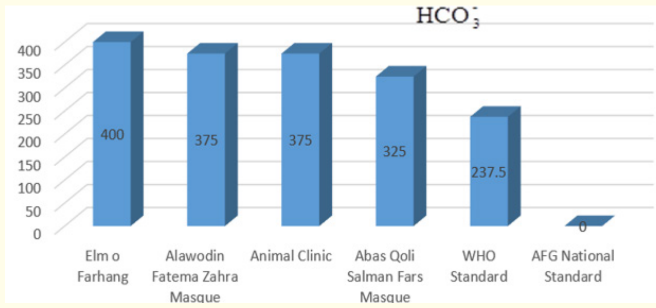

Figure 2: Compare of the sample with the standards of WHO and AFG.

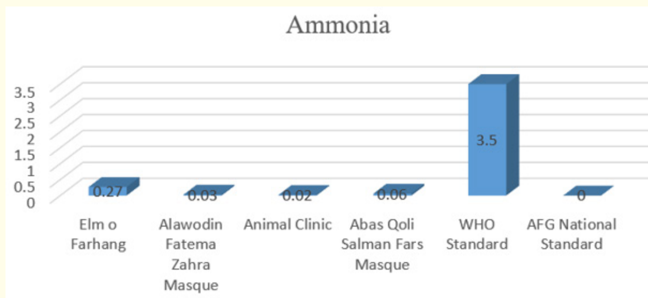

Figure 3: Compare the Ammonia of the sample with the standards of WHO and AFG.

Iron

The amount of iron which recorded from groundwater of Darul Aman ranged from 0 mg/L to 0.07 mg/L with average of 0.03 mg/L. The maximum iron value which recorded is 0.07 mg/L at Sample 4 from Abas Qoli Salman Fars masque and minimum iron value which recorded is 0 mg/L at Sample 3 from Animal Clinic. Another iron value which recorded from groundwater of Darul Aman is 0.03 mg/L at Sample 1 from Elm-e-Farhang another is 0.01 mg/L at sample 2 from Alawdin Fatima Zahra Masque. The amount of iron recommended by WHO and AFG National standard is 0.3 mg/L.

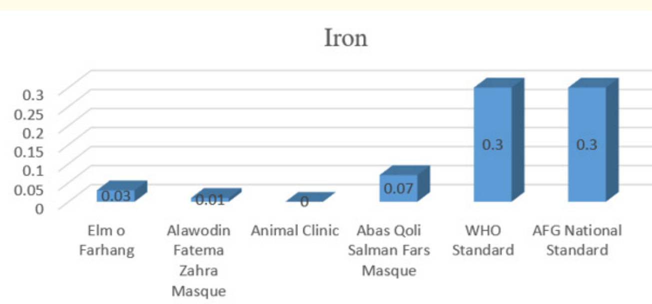

Figure 4: Compare the Iron of the sample with the standards of WHO and AFG.

Copper

The average amount of copper found in Darul Aman's groundwater was 0.04 mg/L, with a range of 0 mg/L to 0.06 mg/L. The maximum copper value which recorded is 0.06 mg/L at Sample 4 from Abas Qoli Salman Fars masque and minimum copper value which recorded is 0 mg/L at Sample 2 from Alawdin Fatima Zahra Masque. Another copper value which noted from groundwater of Darul Aman is 0.05 mg/L at Sample 1 from Elm-e-Farhang another is 0.03 mg/L at sample 3 from Animal Clinic. The amount of copper recommended by WHO is 2 mg/L and recommended value by Afghanistan National standard for copper is 0.5 mg/L.

Figure 5: Compare the Copper of the sample with the standards of WHO and AFG.

Aluminium

The quantity of aluminium which recorded from groundwater of Darul Aman ranged from 0 mg/L to 0.038 mg/L with average of 0.02 mg/L. The maximum aluminium value which recorded is 0.038 mg/L at Sample 4 from Abas Qoli Salman Fars masque and minimum aluminum value which recorded is 0 mg/L at Sample 2 from Alawdin Fatima Zahra Masque. Other aluminium value which recorded from groundwater of Darul Aman is 0.008 mg/L at Sample 1 from Elm-e-Farhang another is 0.015 mg/L at sample 3 from Animal Clinic. The WHO recommends 0.2 mg/L of aluminum, while the Afghanistan National Standard recommends 3 mg/L of aluminium.

Figure 6: Compare the Aluminium of the sample with the standards of WHO and AFG.

Conclusion and Recommendation

Conclusions

According to the analysis of the samples, nearly all water quality parameters (temperature, ammonia, iron, copper, aluminium, and so on) were present in the groundwater samples that were taken from different locations in Darul Aman. These parameters are above the allowable limit as per WHO standards and Afghanistan national standards. The conclusions of this research can be summarized as follows:

- The majority of physical and chemical parameters are nearly below the WHO and Afghanistan National Standard maximum allowable level.
- The groundwater contains moderate concentrations of, Ammonia, Iron, Copper, and Aluminium. An acute issue is the extremely high levels of Total hardness in relation to all another parameter.
- As regards physical parameters, the result was that groundwater source has a reasonably good physical quality.

Recommendations

- Determine the source of your drinking water. Inquire as to whether the public water treatment facility that supplies your water comes from groundwater or surface water (streams, rivers, reservoirs).
- Make a file containing test results, maintenance history, depth, construction method, and other details if you have a well.
- If you have a septic system, be sure to have regular tank pumping and inspections.
- Do not pour harmful chemicals down your home's drains and do not pour the pollutants on the ground, especially motors oil.
- Drill the wells in a suitable place and away from the septic tank, and also use the water after boiling or filtering.

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