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Quality Appraisal of Drinking Water from Bharatpur, Chitwan, Nepal

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Abstract

In Nepal, underground water is the foundation of drinking water for the mainstream of populations. In this research, a random selection of samples was carried out through selection of 23 underground water samples in Bharatpur from April to May 2024, and the physicochemical parameters were analysed. The physical parameters included total dissolved solids (TDS) and turbidity, while the chemical parameters included alkalinity, hardness, calcium hardness, chloride, iron and sulphate. The results demonstrated that out of 23 water samples, 56.5% exceeded the calcium hardness value set by the WHO drinking water guidelines, and 8.7% exceeded the value set by National Drinking Water Quality Standards (NDWQS). Further, 21.7% samples showed turbidity, higher than the WHO guideline and NDWQS respectively. The highest percentage 60.8%, of the samples exceeded the turbidity and calcium hardness value compared to the guidelines for drinking water quality.

Keywords Underground Water, Physicochemical, Contaminant, Public health

Introduction

Underground water is defined as the water found below the earth's surface within the tiny space of sand, rock and soil (Emel, 1987). It is necessary part of every living thing and necessary to finish the life cycle. All living things require water to survive. The main reason it is essential that we live on this planet and water exists on it. Moreover, it also essential for human use for a range of tasks, such as drinking, cleaning, irrigation, and farming (Alam, Rais, & Aslam, 2012). If undesirable contaminants cause drinking water unsafe for human consumption and have a harmful impact on all living things. To be consumed, it has to be devoid of any kind of contamination (Adamsen & Pokhrel, 2002). According to the World Health Organisation, poor air quality or a lack of proper water supply can be the cause of up to 80% of illnesses and diseases worldwide. Many morbidities and deaths are main reasons of water-borne illnesses and contaminated drinking water (Havelaar, 1983). The growing rate of industrial revolution and rapid growth of population have both led to a significant demand for fresh water (Ramakrishnaiah, Sadashivaiah, & Ranganna, 2009). As a result, humanity

faces numerous difficulties in the twenty-first century related to problems with water quality (Nair et al., 2015).

In case of Nepal, groundwater is the chief source of drinking water for the majority of the inhabitants. A large percentage of citizen use water from wells, rivers and streams for their personal use because they do not have any portable water (Shittu, Olaitan, & Amusa, 2008). Contaminants such as chemicals, pathogens, and heavy metals may pollute water and damaging aquatic life as well as human health (Sojobi, 2016). Nepal has outstanding groundwater resources with an estimated total renewable water resource of 237 km^3/year, with groundwater contributing about 12 km^3 per year. According to estimates, the highest unrestricted groundwater in the Terai region recharges at a rate of 8800 MCM (million cubic meters) yearly. Arsenic contamination has been identified as a major issue in the Terai area, prompting further studies and assessments. Water properties in the region have been significantly studied through well testing and data collection (Shrestha, Tripathi, & Laudari, 2018).

Different parameter indicates the quality of water. Water quality as pH, can be influenced by chemical changes in the water, it serves as a crucial indicator of chemical alterations (Faysal et al., 2017). Turbidity, suspended or dissolved matter, may encourage the growth of microorganisms; however, no documented health effects have been linked to it. Turbidity in water can be indicated by a number of disease-causing organisms, including bacteria, parasites, and viruses. Additionally, turbidity may contribute to headaches, cramps, nausea, diarrhoea, and other related health issues (WHO/UNICEF, 2017). The World Health Organization conducted a study focus on several health risks linked to consuming mineral-free water. These risks include kidney issues, gastrointestinal problems, reduced bone density, and cardiovascular diseases, among others (Uddin et al., 2021). The alkalinity of water is capacity to nullify with strong acid. Alkalinity of the water consist of carbonate, bicarbonate and hydroxide compound with the sodium, magnesium and calcium. The consumption of alkaline water may contribute to the prevention of osteoporosis and offer protective effects on pancreatic beta cells through its antioxidant properties. Furthermore, literature indicate that decreasing the bacterial load in the digestive tract can significantly enhance blood alkalinity towards the normal upper range (Mousa, 2016). Groundwater containing above 500 mg/L of SO_4^{2-} may result in problems for the gastrointestinal tract (Koch, 1984). Nearly 55% of respondents experienced diarrheal symptoms and subsequent dehydration (Bashir, Ali, & Bashir, 2012). Iron (Fe) are essential micronutrient to some extent for human health and involved in many biological processes in O_2 transport and storage, electron transport, hydrogenases, and many redox active enzymes (Holm, Kennepohl, & Solomon, 1996). According to JECFA its maximum tolerable limit of daily intake (PMTDI) is 0.8 mg/kg body weight per day, for all sources except for iron oxide colouring agents (World Health, 2019). The total iron content in adult males and female, it frequently ranges between 50 mg and 34 to 42 mg per kg of body weight. (Cook, 1962).

The World Health Organization (WHO) and Nepal National Drinking Water Quality Standard (NDWQS), together suggest the matching parameters for several vital water quality matrices. The tolerable pH range is 6.5 to 8.5, and the turbidity cannot exceed 5 NTU. The maximum permitted concentration for total dissolve solids (TDS) and sulphate are 1000 mg/L and 250 mg/L, for Iron, 0.3 mg/L, respectively. This alignment implies that Nepal's national regulatory system for these metrices is in the line with international health-related recommendations (NDWQS, 2005; WHO, 2018).

The use of water for different purposes and sources of different localities has been studied. The dependence of survival on multiple water sources and health-risk-informed, evaluation of drinking water quality in Bharatpur, Chitwan, is lacking. This investigation directly addresses this absence.

Literature review

The research conducted near the industrial area of Bharatpur, Chitwan by Yadav et al., (2025) provided information about physicochemical parameters of underground water. The value of pH, total dissolved solid (TDS), hardness, alkalinity and chloride were within the Nepal Drinking Water Quality Standard (NDWQS) and World Health Organization (WHO) guideline. The research conducted by Maharjan et al., (2020) illustrated that the average pH value of well and boring water are within the guideline of WHO and NDWQS, while the mean value of turbidity (34.29 NTU) was significantly higher as compared with WHO and NDWQS guideline. Similarly, chemical parameter such as total hardness, chloride and ammonia are below the guideline, whereas iron exceeding the guideline by 1.52mg/L.

The research conducted by Mahato et al., (2018) in western Terai territory of Nepal; Morang, Jhapa and Sunsari give the information on the physicochemical parameter of underground water. In all 40 samples of tube well water were taken for the study and half of the tested samples cross the iron content as compared with NDWQS and WHO standard. Likewise, 37.5% of turbidity and 22.5% of pH are above the NDWQS and WHO standard guideline respectively. The investigation conducted by Pant, (2011) examined the physicochemical parameter of tube well water in Kathmandu valley, Nepal. Which showed that the concentration of iron (1.90 mg/L) and turbidity (55 NTU) was significantly higher than WHO and NDWQS guideline, while hardness, chloride, arsenic and fluoride were within the guideline.

Study carried out at Hasanpur, J.P. Nagar before and after the monsoon show that nearly every site underground drinking water is extremely contaminated. Each of the tested samples showed physico-chemical parameter was extremely polluted. It is for this reason using standard hand pumps need to be minimised. It was discovered that as soon as the monsoon arrived, the quality of the drinking water started declining (Sinha & Saxena, 2006). The study from different site of Oases show that the pH values of water ranged from 6.5 to 7.88. The concentration of both ions sulphate and calcium surpass the maximum permissible limit for drinking (Abdelhafez et al., 2021). Ogunbode et

al., (2016) experiment on water quality results that underground water sources are susceptible to contamination.

The focus of the investigation is the quality of the underground water supply in Gharo, Sindh, Pakistan. Samples were taken at 28 different locations. Total dissolved solids (TDS), pH, hardness, phosphate, sulphate, nitrate, and chloride were all measured in the water samples. It was found that the average values for pH, TDS, chloride, hardness, and sulphate were 7.34, 1267.8 mg/L, 291.04 mg/L, 754.57 mg/L, and 290.39 mg/L (Alamgir et al., 2022). Mahfooz et al., (2019) investigated into the quality of drinking surface water and the impact on health. In this study, samples of 48 drinking water and 37 surface water were collected. In this study, the physiochemical and biological parameters are analysed. According to the water quality index, 56% of the samples had poor water quality, 8% had very poor water quality, and less than 6% had water that was unfit for human consumption.

Materials and methods

Study Area: The random selection of the hand-pump drinking water samples was incorporated in Bharatpur Metropolitan City. It is located 27˚32’58” to 27˚45’40” latitude and 84˚9’41” to, 84˚29’5” longitude. It is the district headquarters of the Chitwan district and positioned in the central-southern region of Nepal. Bharatpur is one fifth largest city having population 199,867. In Chitwan, the number of households used as main source of drinking water is 179,167 (total), among them Tap/piped water (within premises) is 90,866, Tap/piped water (outside premises) is 30,826, Tube well / hand pump is 48,326 (Goverment of Nepal, 2023).

Methods: Altogether 23 tube well water samples were taken as the laboratory. The physicochemical parameters were set using methods mentioned below. The table below describes the instrument and test parameter method used in this research.

Table 1. Company name and instrument used.

S.N	Parameter	Unit	Methods of analyses	Instrument/Kit
1	pH		pH meter	Mettler Toledo
2	TDS	mg/L	TDS meter	Mettler Toledo
3	Turbidity	NTU	Turbidimeter	Hach
4	M-Alkanility	mg/L	0.02N Sulphuric acid	volumetric method
5	Ca- Hardness	mg/L	EDTA titration method	volumetric method
6	Hardness	mg/L	EDTA titration method	volumetric method
7	Sulphate	mg/L	Kit method	SulfaVer Sulphate Reagent
8	Chloride	mg/L	Iodometric titration	volumetric method
9	Iron	mg/L	Kit method	FerroVer Iron Reagent

(Koju et al., 2015).

Results and Discussion

The physico chemical parameter of collected underground water sample from diverse location of Bharatpur are describe in table below.

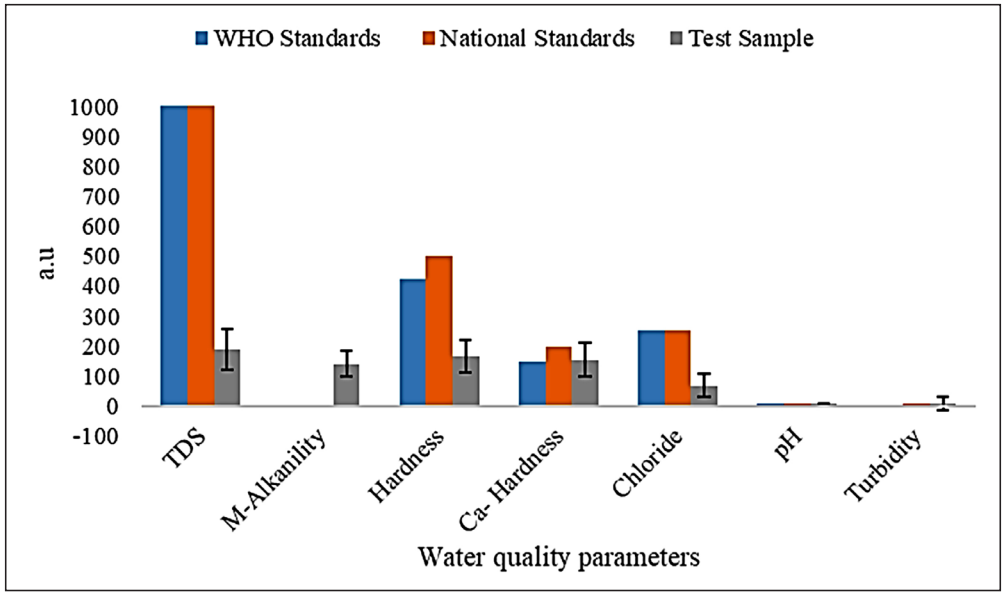

Figure 1. All tested water quality parameters are presented, along with their mean and range, and a comparison with WHO and NDWQS drinking water guidelines.

Turbidity: Water samples in this study showed the highest turbidity in terms of range (0.12 - 97.8 NTU) and mean value 8.6±21.3 NTU. For turbidity, it was found that 5 (21.73%) samples did not meet the WHO and NDWQS standard respectively. The similar study conducted by Koju et al. (2015); Shrestha et al. (2023) about the drinking water quality of this studies in Kathmandu Valley had been found high turbidity.

PH: The average pH level of sample was 7.6±0.4 found to be within the NDWQS and WHO recommendation values (6.5-8.5). Gaihre et al., (2022) also reported comparable results from research studies have been studied to determine the assurance of the purity of water from multiple locations in Nepal. Yadav et al., (2014) test the average concentrations of every groundwater quality parameter of pH that was tested were significantly within the WHO acceptable drinking water limits.

Total dissolved solids (TDS): TDS denoted the salinity behaviour of groundwater. The water holding less than 1000 mg/L of total dissolved solids is permissible for drinking purpose however, in unavoidable cases 1500mg/L is also allowed. TDS values of current study was found to be 63.63 to 381mg/L and average value 189.3±67.3 mg/L. The result indicates that's the TDS level of all water samples within the range of

acceptable limit. Similar finding conducted by Mahato et al., (2018) on the groundwater quality of three different districts of Nepal in Terai region

M-Alkalinity: The total alkalinity value of present study was found to be both terms of its mean value 139.6±43.1mg/L and range (66-218) mg/L. The study conducted by Ghimire.,(2012) in Kathmandu valley and find out the total alkalinity of water less than 80mg/L.

Total hardness: In this investigation, the total hardness of all water samples had a highest mean concentration of 166.5±55.9 mg/L, ranging from 70 to 314 mg/L. However, all samples were inside the confines set by the WHO and NDWQS guidelines. Similar study conducted by Maharjan et al. (2020). Total hardness was found to be greater than the WHO guideline value in the cross-sectional investigation performed from July to October 2014 in wards no. 4, 7, and 18 of the Bhim Datta Municipality of Kanchanpur district applying random sampling (Bohara, 2015).

Calcium hardness (Ca^{2+}): The existence of calcium in the sample essentially produces the calcium hardness of the water. The present research shows, calcium concentration varied between 50 mg/L to 310 mg/L, and average concentration was found 153.9±57mg/L. The present study shows that average calcium hardness concentration is greater than the WHO recommended level. 13 (56.5%) of the sample cross the WHO guideline (150mg/L) and 2 (8.7%) sample out of 23 sample cross the NDWQS guidelines (200mg/L) for drinking water. The research conducted by Bhusal & Gyawali found that calcium hardness 75mg/L in Basigad catchment area (Bhusal & Gyawali, 2017).

Sulphate (SO_4^{2-}): The levels of sulphate found in all of the tested samples were below the NDWQS and WHO guidelines which is 250mg/L. Sulphate content in present research found less than 50.0 mg/L as related study carried out by Shrestha et al., (2017).

Chloride: The outcomes of the present investigation showed that the concentrations fluctuated between 11.61 to 142.57 mg/L, with an average 68.1±38.1 mg/L. All tested samples showed chloride concentrations that were found to be within WHO and NDWQS standard. The similar result found by Shakya et al. (2019) in the pre-season water quality status measurement of the Kathmandu Municipality area. Chloride toxicity in humans has generally not been observed, except in specific conditions, for example in congestive heart failure. According to Campbell et al. (1958); WHO (2018) healthy individuals can tolerate 250mg/L high chloride intake.

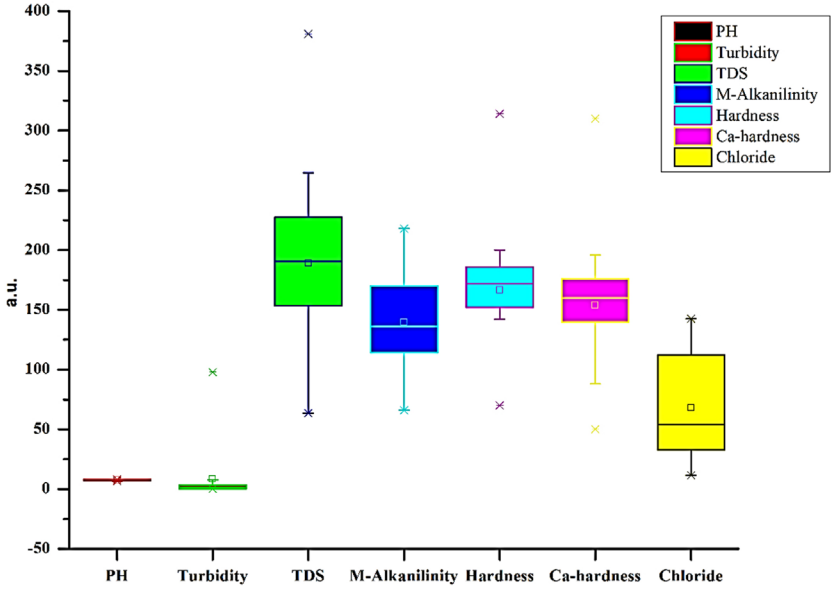

Figure 2. Water quality assessment result

Iron: The iron concentration of all of the test sample was found to under the guideline of WHO and NDWQS standard. Similar finding was observed by Bharat (2012), research conducted in Kathmandu Nepal.

The physiochemical properties of the underground water in the Bharatpur-11 were examined in this study. The result of all tested parameters are mention as average levels and variable ranges. Additionally, the outcomes were compared with National drinking water quality standard and the World Health Organization's guidelines. The tested parameter like pH, TDS, turbidity, chloride, M-alkalinity, hardness, calcium hardness, sulphate and iron levels in water samples. The lower value of mineral and TDS are also significant effect in human health (Rafiqul Islam, 2016). The total tested sample of the present study shows that, 21.7% of the water sample cross the NDWQS and WHO limits for turbidity. Whereas 56.5%, 8.7% samples crossed WHO standard and NDWQS for calcium hardness respectively. Only 39.13% of the tested underground water sample are risk free. Similar, study conducted by Das and Choudhary (2021). The main factors influencing groundwater quality in Biratnagar were identified as elevated values of turbidity, free carbon-dioxide (FCO_2), and arsenic in the groundwater (Das & Choudhary, 2021). Additionally, Annapoorna & Janardhana found that the groundwater is alkaline with a pH range of 6.84 to 7.71 (Annapoorna & Janardhana, 2015). Furthermore, the research underscores the potential health and environmental risks associated with poor water quality, emphasizing the need for comprehensive strategies to address water access challenges and prevent waterborne diseases (Sojobi, 2016).

Conclusion

The underground water analysis showed that the water quality in Bharatpur is currently unsatisfactory for safe and effective consumption by the general public. As a result, unwanted contaminants surpass the levels specified by the WHO and the National Drinking Water Standards. Therefore, there should be continuous monitoring from the local authority as well as water quality testing laboratory of the government to ensure for the safety of drinking water. This study also reveals the importance of monitoring the quality of drinking water. Beside this, public awareness campaign as well appropriate method should be advised in the local level to maintain the quality as per the WHO and National standard. When utilising water for human consumption, it is suggested that it first undergo proper treatment.

Declaration of Competing Interest: The author has no any financial and personal relationship with any organization that would affect the result of this study.

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