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Physico-Chemical Quality Assessment of Ground Water in Kathmandu Valley and Siraha District

Basanti Belbase1, Niru Bhandari 1, Nishan Paudyal 2, Bhola Nath Paudyal 2, Pradeep K. Shah 1

Corresponding author: Pradeep K Shah,pkshah210@gmail.com

1. **Department of Microbiology, Trichandra M campus.**
2. **Water Engineering & Training Centre, Ratopul, Kathmandu.**

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Abstract

A key element in maintaining human health is the quality of drinking water which is a vital component of natural resources. This study was conducted to assess the ground water quality in the Kathmandu Valley and Siraha district from October 2022 to March 2023 in the Water Engineering and Training Centre, Ratopul, Kathmandu. A total of 123 water samples were collected from various wells and borings around the Kathmandu Valley and Siraha district and were subjected to physicochemical investigation following the standard techniques for water sample collection and analyzed by methods as described in the American Public Health Association (1998). The pH, conductivity, turbidity, ammonia concentration, and iron content were found to exceed National Drinking Water Quality Standard guidelines value in 21.95%, 3.25 %, 53.65 %, 47.15 %, and 18.7 % of total water samples respectively. All water samples had total hardness and chloride levels within the acceptable range. The arsenic content of all samples except one well water sample from Siraha was found within a permissible level. The findings suggest that water quality is not satisfactory, which could lead to various water-borne illnesses. Therefore, proper water purification techniques should be usedbefore consumption.

Keywords: Groundwater, Qualityassessment,Physico-chemical,Kathmandu valley, Siraha district.

Introduction

Water is one of the vital elements of life and is extensively used for drinking, irrigation, agriculture, and animal feeds. It is estimated that 0.3% of the water resources in the world are usable (Kılıç, 2020). The quality of drinking water is of utmost importance as it directly impacts the well-being of communities and the environment. In Nepal, the availability and quality of groundwater are significant concerns, especially in urban centres like the Kathmandu Valley and rural regions like Siraha District. The increasing population, rapid urbanization, and industrial activities have put immense pressure on groundwater resources, leading to potential contamination and subsequent implications for public health. Therefore, a comprehensive assessment of water quality and bacterial contamination in these regions is imperative to understand the extent of the problem and to develop appropriate mitigation strategies (Rahman et al 2023). Safe drinking water is characterized as having microbiological, chemical, and physical properties that adhere to national or WHO guidelines for the quality of drinking water (WHO 2017).

Kathmandu Valley, which is situated in the centre of the country, has a bowl-like shape (UNESCO 2021.) The Kathmandu Valley consists of Kathmandu, Bhaktapur, and Lalitpur, three districts of the Bagmati Province with a combined population of 2,996,341 and an area of 933.73 square kilometres (360.52 sq. mi). Siraha District, located in the southeastern Terai region of Nepal, is a diverse and culturally rich district with a history deeply rooted in ancient traditions and customs. It had a population of 635,703 people. The total area of the district is 1,188 square kilometers. (CBS 2022).

According to the World Health Organization (WHO), water-related illnesses are the number one cause of mortality and morbidity and kill 1.8 million people annually, primarily in developing countries(WHO 2004). An illness brought on by contaminated water is one of the ten most prevalent waterborne diseases in Nepal(DoHS 2005; WHO-SEARO2010; Shakya et al 2012). According to the World Health Organization/United Nations Children's Fund Joint Monitoring Program (JMP) for water supply and sanitation, 663 million people in 2015 were expected to need improved drinking water sources, and 2.4 billion people were estimated to lack improved sanitation facilities (WHO2015). Unsafe and insufficient drinking water, inadequate sanitation, and subpar hygiene contribute to 7% of the global burden of disease and 19% of child mortality worldwide (Cairncross et al 2010; Shrestha et al 2017).

In summary, this research paper endeavours to contribute to the existing body of knowledge on water quality assessment in the groundwater of the Kathmandu Valley and Siraha District, Nepal. By highlighting the implications for public health, it seeks to underscore the urgency of sustainable water management and adequate water treatment practices to ensure safe drinking water sources for the communities in these regions.

Materials and Methods

Kathmandu Valley and Siraha district was taken as the sample site. A total of 123 water samples were collected randomly from different places in Kathmandu Valley and Siraha district of Nepal. A total of 123 samplesconsisting of 91 boring water and 32 well water were taken from different sites of Kathmandu Valley and Sirahadistrict in separate sterile bottles of 1-litre capacity. The 82 samples from Kathmandu, 16 from Bhaktapur, 17 from Lalitpur, and 8 from Siraha District were collected and examined. The collected samples were transported to the Water Engineering and Training Centre Laboratory, Ratopul, Kathmandu, Nepal,and keptinan ice box at 4°C.Water samples were collected following the guidelines described by the American Public Health Association (APHA 1998).The Physicochemical parameters of water that arepH (by digital pH meter), turbidity (by digital turbidity meter), Conductivity (by digital conductivity meter), Iron and

Ammonia(by UV spectrophotometer), Chloride and total hardness (by titration),Arsenic were analysed(APHA 1998). Statistical analysis was conducted using Statistical Package for Social Science (SPSS) ver. 26.

Results

Out of 123 water samples (from well and boring), The pH, conductivity, turbidity, ammonia concentration, and iron content were found to exceed National Drinking Water Quality Standard guidelines value in 27(21.95%), 4(3.25 %), 66(53.65 %, 47.15 %, and 18.7 % of total water samples respectively. All water samples had total hardness and chloride levels within the acceptable range. The arsenic content of all samples except one well sample from Siraha was found within a permissible level. These results compared with Nepal standard values for drinking water are shown in Table 1-5.

Table 2: *Conductivity of water samples*

S. N	Types of water samples	Ph value in total no. of water samples								Total	
		Kathmandu		Bhaktapur		Lalitpur		Siraha			
		Below Limit (%)	within Limit (%)	Below Limit (%)	within Limit (%)	Below Limit (%)	within Limit (%)	Below Limit (%)	within Limit (%)	Below Limit (%)	within Limit (%)
1	Boring	18 (27.69)	47 (72.30)	3 (27.27)	8 (72.72)	3 (27.27)	8 (72.72)	1 (25)	3 (75)	25 (27.47)	66 (72.53)
2	Well	1 (6.25)	16 (93.75)	0 (0)	5 (100)	1 (16.66)	5 (83.33)	0 (0)	4 (100)	2 (6.25)	30 (93.75)
	Total	19 (23.17)	63 (76.82)	3 (18.75)	13 (81.25)	4 (23.53)	13 (76.47)	1 (14.28)	7 (85.71)	27 (21.95)	96 (78.04)

Table 2: *Conductivity of water samples*

S.N.	Types of water samples	Conductivity value (µS/cm) in total no. of water sample								Total	
		Kathmandu		Bhaktapur		Lalitpur		Siraha			
		Above Limit (%)	within Limit (%)	Above Limit (%)	within Limit (%)	Above Limit (%)	within Limit (%)	Above Limit (%)	within Limit (%)	Above Limit (%)	within Limit (%)
1	Boring	0 (0)	65 (100)	0 (0)	11 (100)	1 (9.09)	10 (90.90)	0 (0)	4 (100)	1 (1.09)	90 (98.91)
2	Well	0 (0)	17 (100)	0 (0)	5 (100)	3 (50)	3 (50)	0 (0)	4 (100)	3 (9.38)	29 (90.62)
	Total	0 (0)	82 (100)	0 (0)	16 (100)	4 (23.53)	13 (76.47)	0 (0)	8 (100)	4 (3.25)	119 (96.74)

Table 3: *Turbidity values of various water sample*

S. N	Types of water samples	Turbidity value (NTU) in total no. of water samples								Total	
		Kathmandu		Bhaktapur		Lalitpur		Siraha			
		Above Limit (%)	within Limit (%)	Above Limit (%)	within Limit (%)	Above Limit (%)	within Limit (%)	Above Limit (%)	within Limit (%)	Above Limit (%)	within Limit (%)
1	**Boring**	38 (58.46)	27 (41.53)	5 (45.45)	6 (54.54)	7 (63.63)	4 (36.36)	2 (50)	2 (50)	52 (57.14)	39 (42.85)
2	**Well**	7 (41.17)	10 (58.82)	3 (60)	2 (40)	2 (33.34)	4 (66.66)	2 (50)	2 (50)	14 (43.75)	18 (56.25)
	Total	45 (54.87)	37 (45.12)	8 (50)	8 (50)	9 (52.94)	8 (47.06)	4 (50)	4 (50)	66 (53.65)	57 (46.34)

Table 4: *Iron value of water samples*

S. N	Types of water samples	Iron value (mg/l) in total no. of water samples								Total	
		Kathmandu		Bhaktapur		Lalitpur		Siraha			
		Above Limit (%)	within Limit (%)	Above Limit (%)	Within Limit (%)	Above Limit (%)	within Limit (%)	Above Limit (%)	within Limit (%)	Above Limit (%)	within Limit (%)
1	**Boring**	21 (32.30)	44 (67.69)	5 (45.45)	6 (54.54)	8 (72.72)	3 (27.27)	1 (25)	3 (75)	16 (17.58)	75 (82.41)
2	**Well**	3 (17.64)	14 (82.35)	2 (40)	3 (60)	2 (33.34)	4 (66.66)	0 (0)	4 (100)	7 (21.87)	25 (78.12)
	Total	24 (29.26)	58 (70.73)	7 (43.75)	9 (56.25)	10 (58.82)	7 (41.17)	1 (12.5)	7 (87.50)	23 (18.7)	100 (81.30)

Table 5: *Ammonia value of different water samples*

S. N	Types of water samples	Ammonia value (mg/l) in total no. of water								Total	
		Kathmandu		Bhaktapur		Lalitpur		Siraha			
		Above Limit (%)	within Limit (%)	Above Limit (%)	Within Limit (%)	Above Limit (%)	within Limit (%)	Above Limit (%)	within Limit (%)	Above Limit (%)	within Limit (%)
1	Boring	33 (50.76)	32 (49.23)	5 (45.45)	6 (54.54)	10 (90.90)	1 (9.09)	0 (0)	4 (100)	48 (52.75)	43 (47.25)
2	Well	7 (41.17)	10 (58.82)	1 (20)	4 (80)	2 (33.34)	4 (66.66)	0 (0)	4 (100)	10 (31.25)	22 (68.75)
	Total	40 (48.78)	42 (51.21)	6 (37.50)	10 (100)	12 (70.58)	5 (29.41)	0 (0)	8 (100)	58 (47.15)	65 (52.84)

Discussion

The main objective of this study was an evaluation of the quality of ground water from different sources of Kathmandu Valley and Siraha district. During the study period, 123 water samples were collected and examined for physicochemical parameters like pH, turbidity, temperature, electrical conductivity, total alkalinity, hardness, iron,chloride, ammonia, and arsenic.

The pH of 27(21.95%) water samples was found to be out of range i.e. below 6.5. Similar results were found in studies done by Maharjan et al (2020) which showed 9% of boring and 3% of well water samples below the permissible level . A change in pH value may affect the physico-chemical factors that influence the quality of the water (Wetzal and Limnology1975). The variations in pH levels also could be a result of photosynthesis and respiration occurring in the water body. Most often, CO_2 is the cause of water's acidity. This raises carbonic acid and lowers the pH of the water (Trivedi and Goel 1984). Disinfection is less effective above apH of 8 (WHO 2017), whereas low pH causes corrosion and a bitter metallic taste (AWA1971).

The electrical conductivity of 4(3.25%) water samples were found to be above the NDWQS limit. In the studies of Karmacharya and Pariyar (1999); Bajracharya (2007); Shrestha (2002); Prasai (2002); Jayana et al (2009); Joshi and Baral (2004); Maharjan (1998); Shakya et al (2019); Koju et al (2014) and Ullah et al (2014), a greater conductivity value was also observed. The ability of water to conduct electric current is conductivity and is directly related to the amount of salt dissolved in it. It has no immediate impact on health. High conductivity is typically brought on by pollutants (Diwakaretal (2010).

Turbidity of water is the expression of the optical property and is caused by clay, silt, organic matter, phytoplankton, etc (Koju et al 2014). According to NDWQS, the permissible value of turbidity is 5NTU. Turbidity of 66(53.65%) water samples was found to be above the permissible limit.The study reported by Gharti magar et al (2020) showed 20% of well water and 32% of boring water samples have turbidity values above the given level .Higher turbidity values in their water sample were also reported by earlier research by Karmacharya and Pariyar (1999); Bajracharya (2007); Shrestha (2002); Prasai (2002); Jayana et al(2009); Joshi and Baral (2004); Maharjan (1998); Shrestha et al (2017); Koju et al(2014); Diwakar et al (2010); Shittu et al (2008) and Kurup et al (2010). Also, thestudy done by Maharjan et al (2020) showed turbidity of well water and boringwater was greater than the NDWQS. Colloidal and suspended materials are the main causes of turbidity in water. High turbidity water typically has an undesirable look,colour,taste,and odour . The biggest issue with turbidity is its microbiological quality since it makes it more difficult to detect bacteria and viruses. The turbidity-causing particles protect the germs, so, water disinfection becomes less effective (Diwakaret al 2010). The iron content of water samples and turbidity are correlated (Koju et al2014).

All water samples tested for this study showed total hardness following NDWQS guidelines. Calcium and magnesium ions are thecause of water hardness. Important sources of calcium and magnesium include sewage and industrial waste. Human diets require the same nutrients, which can be partially satisfied by drinking hard water, but so far there have been no reports of any health effects linked to water hardness. Moreover, some data support its connection to heart disease (Schroeder 1960). All the tested water samples showed the chloride value within the given range ascompared to NDWQS. Khalil et al (2013); Shittu et al (2008); Ullah et al (2014); Maharjan et al (2020); Ghartimagar et al (2020); Pradhananga et al (1993) and Thapa (1997) also found chloride content for all water samples within guideline value. Chloride can be a marker of pollution and is crucial in identifying sewage contamination of ground water (Purandara2003).Natural sources ,sewage ,industrial effluents ,urban run off including deionizing salts, and saline intrusion are the main sources of chloride in drinking water. Water and other drinks have a salty taste when chloride concentrations are high. Metal corrosion in the distribution system is accelerated by high chloride concentrations (Koju et al 2014).

Arsenic of 1 (0.81%) water samples were found to be above the NDWQS limit. A common substance that naturally occurs in the crust of the planet is arsenic (Mandal and Suzuki 2002). Some of the main sources of arsenicare natural geology, mining, the use of pesticides, and the burning of fossil fuels. Because of its toxicity and persistent nature ,arsenic pollution in water is of special concern to people. Skin cancer, gangrene, haematological poisoning,and cardiovascular and mental diseases are among the health risks associated with arsenic (Pontius et al 1994).

In this study , the Ammonia content of 58(47.15%) water samples was found to be above the NDWQS limit. The ammonia content was reported to be in 11% groundwater (Koju et al 2014), 7.5% in well water (Jayana et al 2009),34% in groundwater (Ghartimagar et al 2020), 33.3% in groundwater (Shakya etal 2019), 5.17% in a water sample (Diwakar et al 2010), 40% in groundwater(Maharjan et al 2020), 22% in a water sample (Bajracharya et al 2007) and 38.6% in a water sample (Maharjan 1998). Higher ammonia content was also found in the ground water samples of the Kathmandu valley in studies by K.C (1992);Pradhananga et al(1993);Karmacharya and Pariyar (1999); NESS (1999); ENPHO(2000); Upadhaya et al (2004); JICA/ENPHO/MPW

(2005) and NGO FORUM (2006), The presence of ammonia in water is a sign that it may be contaminated with bacteria, sewage, and animal waste. Since ammonia can be transformed into nitrate ,its presence in water may be hazardous to human health(Upadhya2004).

Iron of 23(18.7%) water samples were found to be above the NDWQS limit .The findings are found to be consistent with those of other studies that ground water samples from the Kathmandu Valley were contaminated with iron in 48 % of the Bhaktapur Municipality, 26 % of cases in Madhyapur Thimi, and 51%, 59% and48.5% of cases in the valley overall (Diwakar et al 2010; Jayana et al 2009; Kojuet al 2014; Maharjan et al 2020; Shakya et al 2019). Similarly, high iron content was observed in the studies of Kurup et al (2010); Shamsur et al (2017); Maharjan et al (2018); ENPHO/DISVI(1990); NESS(1999); JICA/ENPHO/MPW(2005); Ghartimagar et al (2020); Shrestha (2002); Jayana et al (2009); Maharjan (1998);Bajrachary et al (2007);Prasai(2002) and Joshi and Baral (2004).Iron contamination can happen as a result of excessive iron pipe corrosion, which is primarily caused by the oxidation of dissolved oxygen to generate an iron (III)precipitate. High iron levels typically do not pose a direct threat to health, but they may negatively affect flavour and odor (Smedleyetal1995).Iron may stain clothes ,hair, and nails at larger concentrations, which can be unattractive.

Conclusion

The present study disclosed the physicochemical contamination of different water sources in Kathmandu Valley and Siraha district. Besides arsenic in one sample of the Siraha district, the concentration of iron and ammonia was high in some of the water samples.

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