https://doi.org/10.3126/dristikon.v13i1.56044

Physiochemical and Microbiological Investigation of Surface and Ground Water Contaminants of Bhojpur Municipality

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Abstract

Water is an essential resource for life evolution. 75% of the whole earth is covered by water. The water sources that flow through the social periphery represent the development and awareness of that society. This paper focuses on investigating contaminants of different water sources within Bhojpur Municipality. The six different water samples, based on their different latitudes, were collected following all the guidelines. The physiochemical parameters and microbiological organisms like E. Coli were tested and analyzed. The results revealed that the physiochemical parameters were mostly found to be within the guideline and standardization of the World Health Organization (WHO), but in the Silichung water sample, the number of bacteria was found to be out of the WHO limit. Physiochemical parameters like total dissolved solids (TDS), total solids (TS), and chloride content were not found under the guideline of WHO. The dissolved oxygen (DO) content was found more in the water sample of Bahundhara, whereas Bhandari well sample had a low amount of DO among the other samples. The biological oxygen demand (BOD) level in Sera Khola sample was found more, while Silichung sample had a low amount of BOD, indicating Sera Khola water sample is a bit more polluted than others. On microbiological testing, the Silichung water sample was tested with *Providencia spp*, indicating not useful for drinking purposes. Thus, it reveals that the Silichung water should not take directly, which is rich in *Providencia spp.* Other physiochemical parameters of other samples were found to be within the range of WHO.

Keywords: BOD, coliforms, DO, wastewater, pollution

Introduction

Water is an inevitable and indispensable resource for all life on earth. It is the most valuable natural resource to a state or a nation and humanity as a whole. The wise exploitation of this resource is crucial to a country's success. Since human health and well-being are amazingly allied to drinking water quality, accessibility of clean and safe drinking water is a severe public health concern and challenge (Rojita *et al.*, 2019; Sharma *et al.*, 2005). The two most common natural sources are surface water (lakes, ponds, rivers, etc.) and groundwater (boring and well). Water is used extensively for irrigation, home, and industries worldwide. However, industrialization, urbanization, and an increase in population are causes of groundwater contamination (Tadiboyina and Rao, 2016). Water scarcity is a significant challenge in this 21st century. The intervention of government and state institutions in water management has increased since the 20th century with enormous investments. New technology has been introduced in water management for sustainable development. The most important to prevent water contamination is one of the challenges associated with awareness, proper drainage, and land field for garbage disposal and industrial byproducts. Therefore, society, social relations of power, culture, and natural or scientific-technical factors significantly influence drinking water management.

Fresh drinking water is rare, and its availability decreases day by day. Water is getting polluted due to industrialization, fertilizers in agriculture, pesticides, insecticides, and human activities. Garbage drains and industrial wastage are disposed into the river, which causes water pollution. Hazardous substances, both organic and inorganic, particularly heavy metals, are now contaminating water and posing a serious threat to human health and the ecosystem(Koju *et al.*, 2015; Prasai *et al.*, 2007). Drinking water contamination, particularly with heavy metals, is now a serious health concern. The investigation of the physical and chemical characteristics of water, particularly the presence of trace elements, is crucial for public health. These investigations are most important for studying environmental pollution (Bakraji *et al.*, 1999, Zareen *et al.*, 2000, Hassan *et al.*, 1989, and Solyak *et al.*, 2002).

The contamination of groundwater is unlikely to be a crackdown. Therefore, it is essential to preserve groundwater quality. World Health Organization (WHO) reports that 80%

of diseases are due to the contamination of groundwater (Timilshina *et al.*, 2013). The groundwater quality will decrease due to chemical reactions as the groundwater flows from the recharge area to the discharge area. Heavy metal is an essential environmental pollutant that increases with human behaviors like mining and releasing industrial wastes, batteries, and thermal power plants (Ullah *et al.*, 2009). The primary cause of groundwater contamination is the excessive use of heavy metals containing fertilizers (Ullah *et al.*, 2009). The world's industrial, agricultural, and municipal activities contaminate groundwater. Thousands of people die or suffer from numerous diseases related to water and sanitation. When water is used for drinking, it immediately affects human health and poses a severe risk of infection. Due to the lack of drinking water supplies, individuals now choose sealed bottled water or jar water (Sharma, 2000).

Numerous variables, like the quantity of salt (or salinity), bacteria levels, dissolved oxygen concentrations, and the amount of debris suspended in the water, are used to determine water quality (turbidity). To assess the water quality in some bodies of water, measurements of contaminants, heavy metals, and the number of pesticides and herbicides can also be made. Some the diseases, like diarrhea, typhoid, and fever, are spread due to contaminated water and poor sanitation (Diwakar *et al.*, 2008; Magar *et al.*, 2019). These health hazards are the result of contaminated water and inadequate sanitation facilities. Globally, 15% of patients get infected during a hospital stay, and the percentage is much more significant in developing and undeveloped countries. The management of urban, industrial, and agricultural wastewater is not enough. As a result, the drinking water is severely contaminated or polluted. The natural occurrence of arsenic, ammonia, iron, and fluoride in groundwater can also be of health threat. In contrast, other chemicals, such as lead, may beelevated in drinking water due to leaching from water supply components in contact with drinking water (WHO, 2011).

Despite being the second largest country in the world in water resources, the Nepal governmentcannot manage the potable water in the highly dense area. Because of Nepal's geographical structures, it is challenging to facilitate by using pipelines in rural, hilly, and mountainous regions. Also, many families don’t know how to purify water without education, sanitation, and proper guidance. Due to the intake of polluted water, many waterborne diseases get transmitted.

In highly dense areas like Kathmandu, Pokhara, Dhangadhi, Butwal, Biratnagar, etc., the surface water is being polluted by factories, industries, hospitals, etc. Because of the heavy usage of water by the large population, the sources of groundwater, like wells and springs, were coming to extinction. Also, the concrete land of the city eventually helps not to recharge the underground water bodies. Limited water resources, consumption of water by the huge population, no proper management by the government, no recharge of the underground water resources, unscientific water fetching system, etc., are the major reasons for the water problem and scarcity in the town.

Bhojpur municipality belongs to the Bhojpur district of Province No. 1, Nepal, and is considered an urban municipality. Since the Kirat Rai tribe first settled there, Bhojpur has been their traditional home. The municipality has 12 wards scattered across 160 square kilometers of geographical area, has almost 27,204 population according to census 2078, and is 354 kilometers from Kathmandu. Being a hilly municipality, it has not had as much water pollution as Kathmandu, and other major cities of Nepal have got. However, the distribution of pure drinking water is still infeasible in Bhojpur municipality. Rivers, wells tap water, waterfalls, etc., are the major sources of ground and surface water resources. The drinking water supply in different areas of Bhojpur municipality is difficult as water sources are far behind their access. Geographical distribution is one of the reasons. The Bhojpur municipality is slowly running towards unmanaged urbanization and suffering severe drinking water supplies, particularly in the dry season of every year. Drinking water quality assessment in Bhojpur municipality has slowly been crucial as water sources distributed to different areas of the municipality are being polluted due to overgrazing, decaying of fallen leaves, and disposing of litter on water sources, treatment of sewage and dumping to water sources mainly in town areas of the municipality.

Research Problem

Surface water in densely populated places, such as Kathmandu, Pokhara, Dhangadhi, Butwal, Biratnagar, etc., is being contaminated by factories, industries, hospitals, etc. The groundwater sources, such as wells and springs, were going extinct due to the large population's intensive use of water. Additionally, the city's concrete-covered soil prevents subterranean water reserves from recharging. The leading causes of the water pollutants problem and scarcity in the town include limited water resources, excessive water consumption by the large population, improper government administration, no replenishment of the underground water resources, unscientific water fetching system, etc.

Research Objectives

The study intends to assess the quality of surface and groundwater from different locations of Bhojpur Municipality, determine the physiochemical parameters of the water sample, and identify coliform and selected pathogenic bacteria by pour plating technique and membrane filtration techniques.

Rationale

Limited research has been carried out in the past about the water quality of Bhojpur municipality. All the water samples are being used as direct drinking water. Over time, the quality of the running water is changeable and depends on many environmental and anthropogenic factors.

Therefore, the chief job is to examine the quality of the water samples, study the relationship between the cause and effect of waterborne diseaseinside Bhojpur Municipality, and spread awareness about the causes and consequences of polluted water.

Literature Review

Drinking water or potable water must have acceptable quality in terms of its physical, chemical, and bacteriological so thatit can be safely used for drinking and cooking (WHO, 2004). Nepal is rich in water resources, with more than 6000 rivulets and rivers, many lakes, ponds, and reservoirs. The annual mean flow of major rivers is estimated to be 4930-meter cubes per second. These account for 70% of total surface runoff, where 60-85% of the surface runoff occurs during monsoon. Lakes, ponds, and reservoirs account for the other 30% of total surface runoff. The total available surface water potential is estimated to be 224 billion meter cubes, and the estimated ground potential is 2 billion meters. Despite being rich in water resources, Nepal still suffers from water-related problems. National water supply coverage is said to have increased substantially in the past decade. Yet, people still spend hours getting a bucket of water in rural and urban communities, including the capital city. Increasing water demand, shortage of clean drinking water, and pollution of water resources are common phenomena of urban development (ENPHO, 2001).

Drinking water quality in Nepal has been investigated by several researchers, such as (Diwakar *et al*., 2008; Koju *et al*., 2015; Magar *et al*., 2019; Prasai *et al*., 2007; Rojita *et al.*, 2019; Sharma *et al.*, 2005; Timilshina *et al*., 2013). Gopali (2008) studied the microbiological quality of chlorinated water in Kathmandu Valley. In this study, 111 water samples were collected from 7 distribution points of Sundharighat reservoir and 13 distribution points of Balaju reservoir in which 68.78% of the total samples of the former and 90.41% of the total samples of the latter were found to exceed the WHO guidelines of Total coliform. A fecal coliform bacterium is a major reason for poor quality water in Nepal. According to recent studies of NAST, more than 90% of Kathmandu Valley's groundwater is contaminated with coliform bacteria. There is an increase in cases, between 25 and 30%, who come tovisit hospitals suffering from diarrhea, typhoid, and fever, primarily due to poor qualitydrinking water inside Kathmandu. The situation is more problematic in rural areas with adequate water and sanitation facilities and depleted conditions. The rains during the monsoon are responsible for the outbreak of communicable waterborne diseases like cholera and diarrhea in many rural villages (WHO, 2008).

Diwakar *et al.* (2008) examined the physiochemical parameters and bacteriological analysis of drinking water of Bhaktapur municipality in the pre-monsoon season, and the results revealed water contained excessive ammonia and coliforms. Similarly, Magar *et al.*(2019) studied the microbiological contaminants of drinking water in different samples of Kathmandu Valley. The result revealed that coliforms were present in both groundwater and bottled water samples

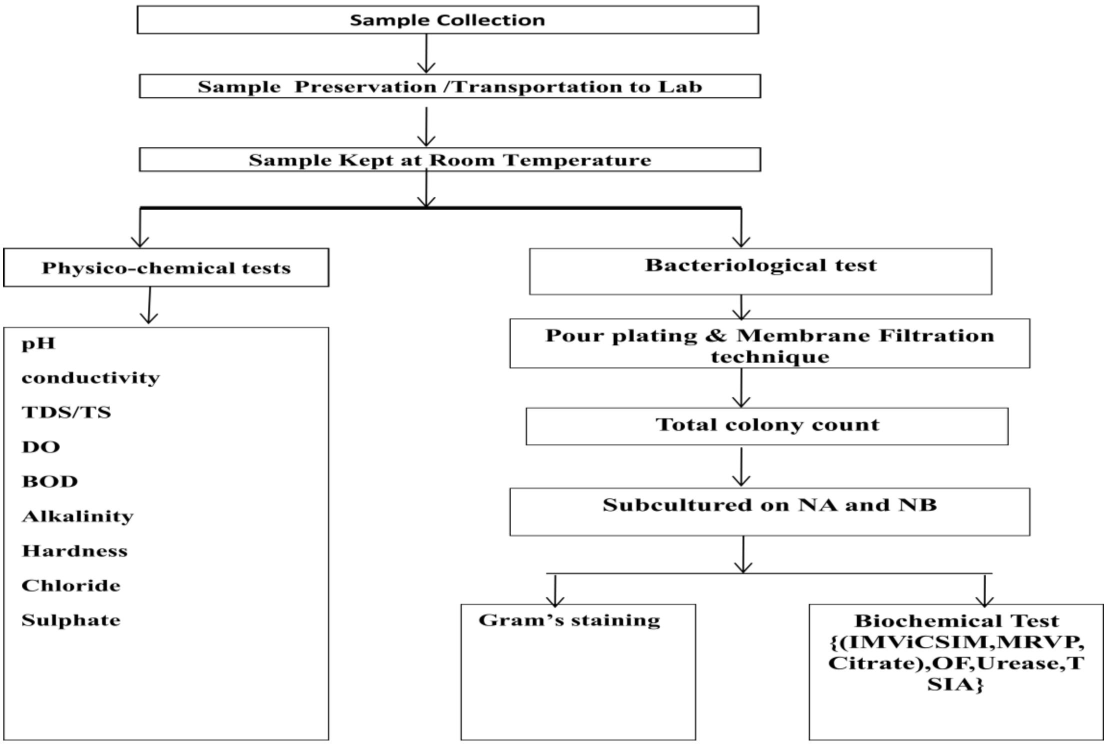
Karmacharya (2021) investigated processed water quality from the different treatment plants in Kathmandu Valley. Sarkar *et al.* (2022) also analyzed drinking water samples from Kathmandu Valley, and the result showed that water samples contained widespread bacterial contaminations and arsenic, iron, manganese, and aluminum. Chapagain *et al.*(2022) analyzed the climate change impact on water availability and the links between water pollution and the economy for sustainable water resource management in Kaski. The study concluded that the agriculture and livestock sectors were significant biological oxygen demand (BOD) polluters.

Research Framework

The physicochemical parameters were assessed as per the standardguidelines given by (APHA, 2000).

Figure 1

Research Framework



Methods and Materials

Water samples were collected from different locations in Bhojpur Municipality. The locations are Silichung Khola, Juke Khola, Sera Khola, Bhandari Well, Bahun Dhara, Khokti Dhara. A total of 6 samples of water were collected following the guidelines provided by APHA (2005). Samples were collected directly into the bottle. The sample was collected away from the bank and near the draw-off point. The bottles were rinsed three times before collecting samples. Water samples were fetched 15-20 cmbelow the water surface, and bottle caps were used inside the water surface. For the testing of dissolved oxygen (DO), water samples were collected in BOD bottles and preserved in the laboratory by following the necessary procedure and precautions. Physiochemical properties like pH, conductivity, alkalinity, total solids (TS), total dissolved solids (TDS), hardness, and chloride tests were carried out and processed in the laboratory. The Hitech Lab India (HI-102) pH meter and Chemiline Digit Conductivity Meter Cl 220 were used to measure the pH and conductivity of the water samples.

Bacteriological analysis was performed by pour plating method using Violet Red Bile Agar (VRBA) as the medium for the growth of coliforms and membrane filtration technique (Timilshina *et al.*, 2013). Coliforms were counted by examining pink colonies with or without metallic sheen grown in VRBA. Identification of bacteria and biochemical tests were carried out at Medmicro Laboratory, Babarmahal, Kathmandu.

Results and Discussion

Physico-chemical Parameters of Drinking Water

The physicochemical properties were analyzed to investigate the physical status, impurities, and other dissolved substances that affect the aesthetic quality of water. The study compared pH, conductivity, TS, TDS, TA, Total Hardness, chloride, DO, and BOD withthe standard. The investigation showed that the value of the pH of the water sample is greater than 7 (slightly basic). pH is a significant variable because it is the controlling factor determining most metals' solubility. Out of 6 samples, the entire sample was within the WHO guideline (Koju *et al.*, 2015). The conductivity value of all water samples was determined, which was found to be within the WHO standard. Generally, conductivity refers to the process of transmitting heat and electricity. A higher conductance value refers to the high dissolved gases & chemicals in the water. Even though conductivity does not directly affect human health, high conductivity might indicate pollutant introduction in the water sample (Sharma *et al.*, 2005). According to the WHO guideline, the standard value of TDS is 1000, and the TDS in water samples was not in accordance with WHO. The high value of TS and TDS ultimately depicts polluted water.

The total hardness in water ranges from 500, and out of 6 samples, the entire samples were within the WHO guideline. Hardness basically addresses the carbonates, bicarbonates, sulphates, chlorides, nitrates, etc., present in the water. Chloride ion (Cl^-) is a common anion in most water and wastewater. The small quantity of chloride in potable water has no harmful effects. There is no salty taste if it is in the 200 mg/L range. But the taste becomes detectable as it exceeds 250 mg/L in the form of sodium chloride. Also, high chloride content in irrigation water gradually accumulates salt and adversely affects the soil's properties. In cities, the drinking water supply is chlorinated to make it safe from a health viewpoint as chloride kills or deactivates the waterborne disease-causing bacteria and other microorganisms. Chlorination also improves the water quality but may produce adverse taste effects (Rajbhandari, 2005). Out of 5 samples, entire sampleshave chloride values within the 20-170 mg/L range, which accepts the WHO guideline. The alkalinity measures the resistance to change in pH, the "buffering capacity of water." The total titrable bases are carbonate, bicarbonate, hydroxide, borates, phosphates, and silicates. Among six samples, the high alkalinity value was measured at Khokti Dhara, and the minimum value was measured at Sera Khola. Basically, DO means the amount of oxygen dissolved in the water, and BOD implies the quantity of oxygen needed to oxidize the organic content in water at 20^oC for5 days. The range of sulphate present is 208-438 mg/L. Also, the optimum value of total alkalinity was measured at Khokti Dhara, and minimum value of total alkalinity was measured at Sera Khola.

Table 1

Physico-chemical Parameters of Different Samples

	Locations						
Parameters	Bhandari Well	Silichung	Bahun Dhara	Sera Khola	Khokti Dhara	Juke Khola	WHO MPL of DW
pH	7.16	8.15	8.02	7.49	7.56	8.50	6.5- 8.5
Conductivity(µS/cm)	61.8	54.3	84.9	58.1	78.8	79.4	300
Chloride(mg/L)	177.5	88.75	106.5	53.25	74.55	71	200
T. Hardness(mg/L)	70	130	100	60	150	110	500
T. Alkalinity(mg/L)	150	190	220	100	350	300	600
T.S(mg/L)	1300	750	1000	7650	6500	2155	1500
T.D.S(mg/L)	1150	650	700	2350	350	850	1000
DO(mg/L)	4.048	6.47	4.858	7 .28	4.45	6.868	4-6

Parameters	Locations						
	Bhandari Well	Silichung	Bahun Dhara	Sera Khola	Khokti Dhara	Juke Khola	WHO MPL of DW
BOD(mg/L)	16.2	4.04	16.36	32	8.09	7.8	6
Sulfate(mg/L)	342	142	438	422	222	208	400

MPL is the Maximum Permissible Limits

Microbiological Profile of Bacterial Isolates

In the study, two different types of bacteria were isolated after putting the sample in the VRBA and M-endo media. *Providencia spp* was isolated. Total coliforms shouldn't be observed in 100 ml of drinking water, per WHO recommendations from 2017 and DFTQC from 2005(Koju *et al.*, 2015; Prasai *et al.*, 2007). Pathogens such as *Providencia spp* in drinking water threaten human health. Organisms cause serious health hazards, primarily gastrointestinal tract disorders such as hemorrhagic colitis, diarrhea, nausea, abdominal cramps, fever, and vomiting. By observing various data in the study, it was concluded that the water is not being polluted in Bhandari well and Juke Khola. But water is somehow contaminated in Silichung

Altogether only one type of bacteria was isolated from the Silichung water sample in the VRBA medium. The obtained colony was pink-colored, as shown in Figure 2 (Aryal, 2009). Later, the different biochemical tests proved that the bacteria was *Providencia spp*. Bacteriological examinations were done to detect E. coli present in the sample, but there was no *E. coli*. The microbiological test report of the three samples is shown in the table below.

Figure 2

Culture of Bacteria Showing Presence of Total Coliforms

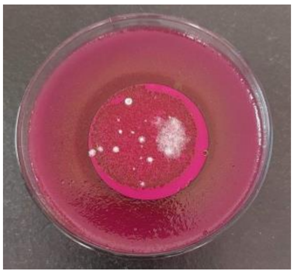


Table 2

Numbers of Bacteria after Growing them in VRBA Media

Sample Location	Neat (cfu/100 mL)	10^{-1}	10^{-2}
Juke	00	00	00
Bhandari Well	00	00	00
Siliuchung	36	00	00

Conclusion

All five samples were analyzed for physical, chemical, and microbiological parameters to assess the water quality. The result of this study lucidly indicates the pH of all the samples in the range of DFTQC guidelines. The range of pH of the water samples is 7.16-8.50.The number of chloride ions present in the analyzed samples is in the range of 53-178, which is within the guideline of WHO and DFTQC 2018. The observed hardness value is within the guideline of WHO and DFTQC. This may indicate that many anions like sulphate, carbonate, bicarbonate, chloride, nitrate, etc., in deficient amounts. The amount of DO in the well sample is lower than in running water. The DO level in the river is high, indicating that aquatic animals can survive without hesitance. Also BOD level in the running water of the river is high as compared to tap water which also depicts that some river water possesses a high amount of organic matter present in the water. The level of the running water of the river is high as compared to tap water which also depicts that some river water possesses a high amount of organic matter present in the water.

Providencia spp in the Silichung sample shows that it will undoubtedly pose several health risksto people consuming such water for drinking. *Providencia spp* was detected in the VRBA medium. Other pathogens like *Vibrio spp*, *Pseudomonas spp*, etc., may also be present in the water.

Limitation

The major limitations of this research were that the sample's chemical oxygen demand (COD) level could not be measured, and in the microbiological study, only *Providencia spp.* colony was cultured. Many microorganisms like *Vibrio spp, Klebsiella, Enterobacter spp, Shigella spp*.were not cultured.

Acknowledgments

The authors would like to thank Tri- Chandra Multiple Campus, Ghantaghar, Kathmandu, for providing laboratory facilities to carry out this work and Medmicro Laboratory for the bacteriological analysis.

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