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Assessment on the Quality of Groundwater Sources : A Case of Godawari Municipality, Lalitpur

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Abstract

Groundwater has played a critical role in meeting the water demands of the valley, but safe drinking water has been a great public health concern. The study was undertaken to assess the existing status of drinking water quality of Godawari Municipality ward no. 12 in the month of January and February. Most of the people in the municipality are dependent on the groundwater and on the tap water supplied by the Kathmandu Upatyaka Khanepani Limited (KUKL). Regular and independent monitoring of the existing source of water is lacking in the municipality. A total of 20 samples comprising 10 from wells and 10 from stone spouts were collected. Different physico-chemical and microbiological parameters were analyzed by following the American Public Health Association (APHA) method. From the study, it was found that the physico-chemical parameter such as temperature, pH, conductivity, total dissolved solids, total alkalinity, hardness, magnesium and chloride were within the permissible limit of Nepal's Drinking Water Quality Standards (NDWQS) whereas iron and ammonia exceed the standard value by 5% each and 10% of water samples were found to be yellowish. Arsenic was not detected in any sample. Most problematic were total coliform and *E.coli* bacteria, which were presented in 80% and 40% of samples, respectively. The results of the study outline the unsuitability of groundwater for direct consumption, especially without any improved water treatment for bacteria. As, the sample were analyzed in winter season, the presence of total coliform and *E.coli* bacteria outline that it may outbreak different waterborne diseases especially in rainy and summer season.

Keywords: Drinking water, total coliform, water borne disease, stone spout, well

Introduction

Access to safe drinking water is crucial to health, a basic human right. Availability of safe water is one of the needs of mankind's development, not solely human beings, but all the living creatures in this world are also directly or indirectly dependent on the water (Gaikwad *et al.,* 2017). Despite two-thirds of our planet is covered with water, freshwater comprises 3% of the total water on earth where its access for human consumption is only 0.01% (Hinrichsen *et al.,* 2002).

As, water plays a vital role in human life, safe and readily available water has been a major challenge in today's world. Nepal being one of the richest countries in water resources, the Kathmandu valley is characterized by acute water shortage and degraded water quality (Udmale *et al.,* 2016). With unprecedented population growth, rapid urbanization, millions of people are frustrated by the shortage and lack of reliable sources of freshwater with appropriate quality and quantity. So, due to the paucity of adequate surface waters, invariably the people are thriving upon the groundwater sources to meet their water requirements (Abbulu *et al.,* 2013). People are facing different waterborne diseases using groundwater as an alternative source of water.

Globally, over 2 billion people still lack safely managed services as 8,29,000 people are estimated to die each year due to diarrhoea as a result of unsafe drinking water (WHO, 2021). Similarly, in Nepal Diarrhoeal disease is recognized as a major problem for children. According to the Department of Health Services (DoHS) the total diarrhoeal cases in children under five years were 10,13,002 with the fatality rate of 0.15 per 1000 children under 5 children. The survey performed for a month in 742 households in Godawari municipality, for a child under 5 years old, a total of 371 households were affected by diarrhoeal disease (Vaidya Shrestha *et al.,* 2019). Hence quality is next important issue after the availability of water. Changes in water quality are reflected in its physical, biological and chemical conditions; and these in turn are influenced by physical and anthropogenic activities (ADB/ICIMOD, 2006).

This study assesses the physico-chemical and microbiological quality of drinking water of existing water sources (stone spouts and wells) in the Godawari municipality – 12. Municipality has an entire population of 78,301 with a household of17,762 (Karki, 2019). Despite the major efforts to deliver safe piped water to community people in the municipality, people get affected with waterborne disease (mainly diarrhoeal disease). According to the survey performed for a month in 742 households, for a child under 5 years old, a total of 371 households were affected by the diarrhoeal disease (Vaidya Shrestha *et al.,* 2019). The primary goal of this research is to ascertain the level of suitability of water with NDWQS standards for drinking purpose and to identify the best source.

Materials and Methods

Study Area

The analysis of water was done in different places of Ward 12, Godawari municipality a southern part of a Lalitpur district, one of the three districts of the Kathmandu Valley, with the GPS coordinate of 27° 42' 14" N and 85° 18' 32" E. Godawari municipality covers an area of 96.11 square kilometers (Nepal Archives, 2021). In Godawari municipality, a total of 16,065 houses were equipped with piped tap water sources and 660 houses were reported to have well. And a municipality consists of 741stone spouts and 50 river streams (Nepal Archives, 2019).

Figure 1 : Study Area

Sample collection and analysis

20 different samples were collected from different places of ward 12; the sterile sampling bottles of 1 liter were used for collecting the sample. The sample were coded S_1 to S_{10} for stone spout and W_1 to W_{10} for well. Temperature (°C), pH, were measured at the sampling site with the help of digital thermometer and digital pH meter. The samples were transported and stored at 4°C for further analysis. The Physico-chemical and microbiological parameters were analyzed at Lalitpur Valley College (LVC) Laboratory and Nepal Academy of Science and Technology (NAST), according to "Standard Methods for the Examination of Water and Waste Water" (Baird *et al.,* 2017).

Table 1: Sampling site for analysis of water (stone spout)

Sample Code	Sampling Sites	Location	Type
S_1	Tahhiti	27°36'48.3"N 85°19'41.1"E	Public
S_2	Pakohiti	27°36'48.3"N 85°19'42.0"E	Public
S_3	Pakohiti	27°36'52.5"N 85°19'43.1"E	Public
S_4	Kwagalehiti	27°36'53.9"N 85°19'06.9"E	Public
S_5	Dochahiti	27°36'54.4"N 85°19'01.7"E	Public
S_6	Simashgalehiti	27°36'47.9"N 85°18'55.3"E	Public
S_7	Parahiti	27°37'21.9"N 85°19'03.8"E	Public
S_8	Kasihiti	27°36'41.9"N 85°19'04.1"E	Public
S_9	Dhasigalehiti	27°36'31.9"N 85°19'06.6"E	Public
S_{10}	Mahiti	27°37'02.4"N 85°19'39.8"E	Public

*S refers to Stone spout.

Table 2 : Sampling site for analysis of water (well)

Sample Code	Sampling Sites	Location	Type
W_1	Dhangasi	27°36'39.8"N 85°19'14.6"E	Private
W_2	Pacho	27°36'38.5"N 85°19'10.8"E	Private
W_3	Pingal	27°36'38.1"N 85°19'09.3"E	Public
W_4	Maligau	27°36'38.1"N 85°19'13.1"E	Private
W_5	Durikhel	27°36'49.3"N 85°19'16.1"E	Public
W_6	Buddha Pokhari	27°36'44.6"N 85°19'12.3"E	Public
W_7	Maligau	27°36'40.8"N 85°19'14.8"E	Private
W_8	Khudole	27°37'24.8"N 85°18'40.4"E	Public
W_9	Sirne	27°37'28.8"N 85°18'39.5"E	Public
W_{10}	Hochal	27°36'46.8"N 85°19'18.4"E	Private

*w refers to well

Results and discussion

The quality of water can be indicated by its physical, chemical and biological parameters. Monitoring these characteristics helps to determine if the water meets government regulations and is safe for human consumption and the environment (Element, 2021). A total of 20 samples from two different sources (well and stone spout) were analyzed for various physico-chemical and microbiological parameters which are discussed below.

Table 3 : Physico-chemical parameters of stone spout water and comparison with Nepal's Drinking Water Quality Standards

Parameter	**Sources**										**NDWQS GV**
	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	
Temperature (°C)	15±0.1	14±0.1	16±0.1	16±0.1	15±0.1	18±0.15	12±0.1	16±0.1	12±0.1	12±0.1	-
pH	6.8±0.1	7.83±0.05	7.3±0.1	6.8±0.1	6.9±0.1	6.8±0.1	6.4±0.1	6.4±0.1	7.03±0.05	6.6±0.1	6.5-8.5
Conductivity (µs/cm)	528±0.02	312±1.73	241±1.0	1166.52±0.00	543±1.73	403±1.73	367.14±0.15	1216.26±0.0	522.66±1.15	470±1.0	1500
TDS (mg/L)	180±1.00	160±2.0	140±0.0	210±0.10	300±0.00	200±0.26	180±10.0	280±0.00	320±0.20	200±0.20	1000
Alkalinity (mg/L)	26.66±5.77	13.33±5.77	16.66±5.77	46.66±11.54	36.66±5.77	50.00±0.00	20±0.00	13.33±5.77	30±0.0	43.33±5.77	-
Hardness (mg/L)	109.33±6.11	58.67±2.30	53.33±4.61	197.33±2.30	110.66±2.30	237.20±0.0-	100±0.0	140±4.00	169.33±0.1	64±4.00	500
Calcium (mg/L)	34.68±0.92	9.6±1.60	6.93±0.92	41.09±0.92	10.66±0.92	17.07±1.84	11.20±1.60	45.36±0.92	49.63±1.60	11.20±1.60	200
Magnesium (mg/L)	5.5±0.10	8.41±0.11	8.75±0.06	23.03±0.00	20.46±0.11	47.80±0.20	17.56±0.15	6.51±0.00	10.98±0.00	8.76±0.25	-
Chloride (mg/L)	26.50±1.63	14.20±2.84	13.25±3.27	126.85±1.63	66.26±1.63	16.10±3.27	46.38±1.63	69.10±1.63	57.7±1.63	35.02±1.63	250
Ammonia (mg/L)	0	0	0	0.20±0.20	0.20±0.20	0.40±0.40	0.20±0.20	0.40±0.40	0.20±0.20	0	1.5
Nitrate (mg/L)	2±0.00	2±0.00	2±0.00	8±0.00	2±0.00	2±0.00	8±0.00	8±0.00	2±0.00	8±0.00	50
Arsenic (mg/L)	0	0	0	0	0	0	0	0	0	0	0.05
Iron (mg/L)	0.03±0.04	0.03±0.04	0.03±0.03	0.07±0.08	0.12±0.14	0.91±0.93	0.07±0.07*	0.07±0.07	0.15±0.16	0.10±0.15	0.3

*Indicate the parameter above the NDWQS guideline.

GV refers to guideline value

Parameter	Sources										NDWQS GV
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	
Temperature (°C)	14±0.17	13±0.10	16±0.1	16±0.17	17±0.17	15±0.10	16±0.17	16±0.10	16±0.11	17±0.1	-
pH	6.9±0.10	7.2±0.05	7.2±0.20	6.8±0.05	6.9±0.10	6.03±0.05	6.9±0.17	7.0±0.17	7.1±0.10	7.03±0.05	6.5-8.5
Conductivity (µs/cm)	1216.26±0.00	511.46±0.10	339±1.00	505±2.00	697±1.73	994±1.00	793.44±0.00	474.54±0.58	609.29±0.47	1123.39±0.00	1500
TDS (mg/L)	430±0.00	500±10.0	450±0.10	750±0.00	450±0.20	570±0.00	580±10.0	200±0.00	210±0.17	320±0.00	1000
Alkalinity (mg/L)	76.66±5.77	46.66±5.77	40±0.00	76.66±5.77	30±0.00	53.33±11.54	90±0.17.32	63.33±5.77	73.33±5.77	53.33±5.77	-
Hardness (mg/L)	234.67±14.04	117.33±2.30	94.66±2.30	138.67±4.61	108±4.00	133.33±6.11	141.33±2.30	133.33±2.30	113.33±2.30	122.26±2.30	500
Calcium (mg/L)	108.88±1.60	32.55±0.92	24.54±2.44	68.31±0.92	19.74±0.92	56.57±0.92	69.91±1.84	45.36±0.92	62.97±0.92	45.36±0.92	200
Magnesium (mg/L)	9.16±0.15	8.74±0.21	8.06±0.15	7.77±0.0	14.20±0.17	3.87±0.04	8.07±0.06	4.85±0.00	10.86±0.11	2.24±0.25	-
Chloride (mg/L)	83.30±1.63	8.51±0.01	9.46±1.63	109.81±1.63	36.92±0.00	114.45±1.63	108.87±1.63	25.56±2.84	21.77±3.27	84.25±1.63	250
Ammonia (mg/L)	0.2±0.00	0.2±0.00	0	0.20±0.00	0	0	0	0	1.8±0.00*	0.2±0.00	1.5
Nitrate (mg/L)	2±0.00	8±0.00	2±0.00	8±0.00	8±0.00	15±0.00	8±0.00	2±0.00	2±0.00	15±0.00	50
Arsenic (mg/L)	0	0	0	0	0	0	0	0	0	0	0.05
Iron (mg/L)	0.19±0.23	0.01±0.01	0.02±0.05	0.02±0.00	0.04±0.15	0.03±0.05	0.02±0.15	0.08±0.01	0.14±0.05	0.03±0.00	0.3

Table 4: Physico-chemical parameters of well water and comparison with Nepal's Drinking Water Quality Standards (NDWQS).

* Indicate the parameter above the NDWQS guideline.

GV refers to guideline value

Physico-Chemical Parameters

As, colour and odour is an indicators of the quality factor affecting the acceptability of drinking water (Baird *et al.,* 2017), out of 20 samples analyzed for the colour and odour in situ, it was found that the colour and odour of entire samples from well and stone spout was found to be colourless and odourless except two samples from stone spout which is yellowish in colour and three samples from well was found to be metallic odour.

Generally, there is no guideline value recommended for the temperature of drinking water but it is an important factor to consider when assessing water quality. As, high water temperature enhances the growth of microorganisms and may increase problems related to taste, odour, colour and corrosion (WHO, 2011). All of the water samples were within the range of 12-18°C with mean value of 14.6±2.06 and 15.3±1.49 in stone spout and well, respectively.

pH is the measure of the intensity of acidity or alkalinity and the measure of the hydrogen ion concentration in water. It is the master variable in water quality as the slight change in hydrogen ion influence many chemical reactions (Boyd, 2015). pH of all samples ranged from 6-7.8 with an average pH of 6.89 which lied within the standard limit of NDWQS. The results showed that the average pH values of well and stone spout are 6.89±0.40 and 6.9±0.34, respectively.

The purity of water was evaluated by conductivity and therefore it is a useful tool to check the purity of water and a sudden rise in conductivity in the water indicated the addition of some pollutants to it (Trivedy *et al.* 1986). The conductivity of all the samples was within the permissible guideline value of 1500 μs/cm as prescribed by (NDWQS). However, high amount of conductivity was found in the both well and stone spout samples i.e. 1216.26±0.02 μs/cm. A study by Ganesh *et al.* (2018) also reported maximum value of conductivity in the ground water i.e 1980 μs/cm.

The concentrations of TDS in water depend considerably in different geological regions results in differences in the solubilities of minerals. The principal constituents of the TDS are Calcium, Magnesium, Sodium, Bicarbonates and Chlorides (Boyd, 2015). The maximum permissible limit for TDS for drinking water is 1000 mg/l. All samples are within the NDWQS and range from 140-750 mg/L in which stone spout has lowest TDS i.e 140 mg/L while that of well water has the highest value 750 mg/L.

Alkalinity measurements are used in the interpretation and control of water and wastewater treatment (Baird *et al.,* 2017). All water samples ranged from 13 to 90 mg/L. The mean value for well water was 60.33 ± 18 and stone spout is 29.66 ± 13.91. Alkalinity in itself is not harmful to human beings; water supplies of alkalinity of <100 mg/L are desirable for domestic purposes (Rai, 2006).

Most of well samples were found to be hard as the hardness of the entire water samples are in the range of 53.3 mg/L to 237.2 mg/L as $CaCO_3$ which was within the NDWQS guideline. Hardness in water is due to the natural accumulation of salts from contact with soil and geological formation or it may enter from direct pollution by human activities. It prevents the lather formation with soap and increases the boiling point of waters (Baird *et al.,* 2017; Awoyemi *et al.,* 2014). The maximum and minimum hardness value was observed in stone spout with the mean value of 123.98 ± 61.76 while that of well had 133.73 ± 38.39.

Average calcium concentration was 23.74 ± 16.90 and 53.42 ± 26.25 in the samples collected from stone spout and well, respectively. Generally, calcium concentration has no hazardous effects on human health. In fact, it is one of the important nutrients required by organisms but high amount of calcium content in water is disadvantageous in household and industrial use (Lehr *et al.,* 1980).

Magnesium also occurs in all kinds of natural waters with calcium but its concentration remains generally lower than the calcium (Trivedy, *et al.,* 1986). The mean value of stone spout is 15.77 ± 12.78 and that of well 7.78 ± 3.46.

The high amount of chloride can give rise to detectable taste in water if the cation is sodium (Baird *et al.,* 2017). The average chloride content of the entire sample was 53.72mg/L having low amount of chloride content in well sample i.e 8.51 mg/L and high amount in stone spout i.e 126.8mg/L which was within the NDWQS standard. Chloride can be an indicator of pollution. A high concentration of chloride gives a salty taste to water and beverages (WHO, 1996).

45% of the water samples were found to be nil for ammonia and all were within the standard at the time of analysis except one well water sample which exceed the ammonia limit of 1.5 mg/L. Ammonia in water is an good indicator of possible bacterial, sewage and animal waste pollution. Ammonia in higher concentration is toxic to man (Subedi *et al.,* 2017).

Nitrate generally occurs in trace quantities in surface water but may attain high levels in some groundwater (Trivedy *et al.,* 1986). All of the water samples were within the guideline with the mean value of 4.4 ± 3.09 and 7 ± 5.07% in stone spout and well, respectively. The maximum amount of nitrate was found in 10% of well sample i.e 15 mg/L in comparison to stone spout. Maximum amount of nitrate levels in drinking water pose a health risk to infants because they may cause methemoglobinemia, a condition known as "blue baby syndrome." A limit of 10mg/L of nitrate as nitrogen has been imposed in drinking water to prevent this disorder (IDPH, 2010).

Arsenic is considered to be the most toxic form as its effects on health even at small doses can be quite harmful (Shrestha *et al.,* 2013). Arsenic was not detected in any of samples. Previous study in Drinking water quality in Nepal's Kathmandu Valley conducted on different sources including municipal taps, dug wells, shallow-aquifer tube wells, deep-aquifer tube wells, and dhunge dharas showed that only 11% of water samples contained concentrations at or slightly above this guideline and the highest frequency of violations was found in dug wells (5 of 17) (Warner, 2008).

High amount of iron stains the laundry, sanitary wares, gives undesirable taste and develops turbidity as well(WHO, 1997). From the study, only one sample from stone spout had exceed the NDWQS guideline value having iron concentration of 0.92mg/L. Iron is an essential element in human nutrition but excessive ingestion of it will result in the condition known as haemochromatosis which can damage parts of the body such as the liver, joints, pancreas and heart (WHO, 1997). Similarly, the study conducted in ground waters in the valley revealed the high amount of iron was estimated in tube well and deep-tube wells (Pant, 2011).

Microbiological Parameter

In present study, the microbiological analysis of water sample revealed the presence of total coliform and E.coli in 80% and 40% of total samples respectively which exceed the NDWQS guideline value (0 cfu/100ml). 90% of the well samples had total coliform >100 cfu/ml. The study was similar to previous study on Groundwater Quality of Kathmandu Valley showed that 94.5% of all ground water samples tested were contaminated by coliform bacteria (Prasai *et al.,* 2021). While in another study conducted in Bungamati revealed the indicators of fecal contamination viz. coliform bacteria and E. coli did not fall within the guidelines (Pradhan *et al.,* 2005). The Total Plate Count (TPC) for total bacteria count performed for all water samples showed that 65% of the samples had <500 cfu/ml. Similarly study on different water samples of Kathmandu valley showed 71.1% of tube well, 89.5% of well, 82.4% of tap and 100% of stone spout samples were exceeded the guideline value for TPC. (Prasai *et al.,* 2007).

Conclusion

The main objective of this study was an evaluation of the quality of water from different places of Godawari municipality which has been used by people for drinking and domestic purposes. The present study disclosed the physico-chemical and bacteriological contamination of groundwater sources. The results clearly showed that most of the wells and stone spouts i.e., 35%, 80%, 40% had microbial contamination indicating loads of TPC, coliform bacteria and fecal coliform, respectively in natural water sources were higher than the NDWQS guideline value. Besides that, ammonia (5%) and iron content (5%) of samples exceed the NDWQS guideline. From the study it was concluded that the microbiological qualities on water sample revealed that water available in those sampling sites were unsafe because of presence of total coliform and *E. coli.* Most of the tested water was found to have higher number of coliform bacteria indicating not suitable for direct consumption. As, the sample were analyzed in winter season, the presence of total coliform and E.coli bacteria outline that it may outbreak different waterborne diseases such as diarrhea, typhoid fever, includes cholera, dysentery, gastroenteritis, giardiasis, cryptosporidiosis and Hepatitis-A. especially in rainy and summer season. The reason for maximum bacterial contamination may be due to increased water pollution and haphazard disposal of domestic wastes near groundwater sources. If quality of water is not improved, it may exert serious health hazard for consumers. Furthermore, the nitrate was not in satisfactory level. From the study it was concluded that two sources from stone spout (S_1 and S_2) and one source from well (W_6) are the best source for drinking purpose as all the physico-chemical and microbiological parameter had meet the NDWQS guideline.

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