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Evaluation of Physico-chemical Characteristics of Drinking Water Supply in Kathmandu, Nepal

Tamrakar Chirika Shova
Department of Chemistry, Faculty of Science, Padma Kanya Multiple Campus, Tribhuvan University, Kathmandu, NEPAL

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Abstract

In order to understand the quality of drinking water supply in Kathmandu metropolitan city, physico-chemical characteristics were studied and analyzed. Various physico-chemical parameters, such as turbidity, water temperature, pH, conductivity, total alkalinity, total hardness, calcium, magnesium, chloride, iron and total ammonia were studied and compared with National Drinking Water Quality Standard (NDWQS) of Nepal and WHO water quality guidelines. The results revealed that most of the parameters were in normal range and indicated suitability for drinking purposes.

Keywords: Drinking water, physico-chemical parameters, NDWQS and WHO guideline values, Kathmandu metropolitan city.

Introduction

Supply of safe water is univocally a basic requirement for human consumption. It is one of the most important compounds that profoundly influence life. Unsafe drinking water contributes to numerous health problems associated mainly with water borne diseases[1]. Obviously, the quality of water is described by its physical, chemical and biological characteristics. Rapid industrialization, urbanization and indiscriminate use of chemical fertilizers and pesticides in agriculture are deteriorating water quality. Due to use of contaminated water, human population suffers from water born diseases. According to WHO, about 80% of all the diseases in human beings are caused by contaminated water[2]. It is therefore important to check the water quality at regular interval of time.

The present investigation involves the analysis of physico-chemical parameters of drinking water supply to the residents of Kathmandu metropolitan city. During wet season nearly 50% percent of the total water is being supplied for drinking purpose in the Kathmandu valley by the government's authentic operator, Kathmandu Upatyaka Khanepani Limited (KUKL). However, 60-70% of the total water demand is fulfilled from groundwater sources during dry season[3]. In a situation when supply of safe drinking water is a major concern for global population today, monitoring of water quality status is required at regular interval of time. The present study therefore assesses the current status of drinking water supply in Kathmandu and evaluates its suitability for drinking with respect to National Drinking Water Quality Standard (NDWQS) of Nepal and WHO guidelines[4].

Material and Methods

Study sites and water sampling: Kathmandu valley covers an area of about 650 km^2 in the central part of Nepal which is situated in 27º 42' N, 85º 20' E. The valley is located at an altitude of about 1350 m above the sea level. The average rainfall is 2,000 mm/year. About 80% of the total rainfall occurs during the monsoon period. The municipal water is being supplied by Kathmandu Upatyaka Khanepani Limited (KUKL).

The study was carried out in samples of municipal water (tap water) collected from eight major sites of Kathmandu metropolitan city (figure 1). Details of study locations and sources of water are given in table 1. The water samples were taken during monsoon period (month of July-September 2013). Samples were collected at different intervals directly from tap in sterilized PET bottles of a litre capacity. The water samples were acidified immediately with 2 ml/L concentrated nitric acid (HNO_3) as described in APHA-AWWA-WPCF[5]. The sampling bottles were labeled and delivered on the same day to laboratory. The samples were preserved at 4°C until further processing and analysis.

Table-1
Description of study sites of drinking water supply in Kathmandu metropolitan city

Sample code	Location	Sources
S_1	Bagbazar	Municipal water (Tap water)
S_2	Kalimati	Municipal water (Tap water)
S_3	Pashupati	Municipal water (Tap water)
S_4	Putalisadak	Municipal water (Tap water)
S_5	Khusibu Town Planning	Municipal water (Tap water)
S_6	Balkhu	Municipal water (Tap water)
S_7	Tripureshwor	Municipal water (Tap water)
S_8	Lazimpat	Municipal water (Tap water)

Analysis of physico-chemical parameters: Various physico-chemical parameters of the collected water samples were analyzed as per the standard methods[5,]. Accordingly, water temperature, pH and electrical conductivity (EC) were measured at the sampling stations. Total alkalinity was measured following titrimetric method while total hardness was measured by complexometric titration method. Ca and Mg were analyzed using flame photometry and flame atomic absorption spectrometer (FAAS) respectively. Iron was determined by colorimetric method using 1,10-phenanthroline as a chelating agent. Chloride was determined by argentometric method and total ammonia by colorimetric nesslerization method after distillation of samples.

Results and Discussion

The physico-chemical parameters of the drinking water supply in Kathmandu metropolitan city is given in table 2. The results are then compared with National Drinking Water Quality Standard (NDWQS) of Nepal and WHO guideline value for drinking water.

Results revealed that the turbidity in the drinking water of the sampling sites was found between <5 to 80 NTU. The water samples of the study sites *viz.,* S_1, S_5, S_6, S_7 and S_8 showed the values within the guideline of National Drinking Water Quality Standard (NDWQS) of Nepal while the rest exceeded the guideline value. The maximum turbidity was found at S_4. The presence of organic matter, slit, clay and other microscopic organisms causes turbidity in natural water system. Any substance having particle size more than 10^{-9}m will produce a turbidity[6].

In the present study, the water temperature was recorded in the range of 21 to 27^0C with the higher temperature at S_5 site during the study period. The temperature is one of the important factors in aquatic environment since it regulates physicochemical as well as biological activities[7]. The taste of water may alter with season since the increase in temperature decreases the potability of water due to the unpleasant taste produced by CO_2 and other gases[8].

Figure-1
A map of sampling sites of Kathmandu metropolitan city

Table-2
Water quality of municipal supply (tap water) of various sites of Kathmandu metropolitan city

Parameters/Sites	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	NDWQS	WHO
Turbidity/ NTU	<5.0	20.0	48.0	80.0	<5.0	<5.0	15.0	15.0	5 (10)	-
Temp/ °C	23.0	21.0	21.0	23.0	27.0	26.0	25.0	24.0	-	-
pH	6.8	6.7	7.1	6.8	6.5	6.8	6.5	6.5	6.5-8.5	6.5-8.5
EC/ μScm^{-1}	632.0	218.0	432.0	736.0	483.0	750.0	918.0	334.0	1500	800-1000
T. Alkalinity/ mgL^{-1}	14.0	106.0	16.0	16.0	116.0	260.0	350.0	122.0	-	200
T. Hardness/ mgL^{-1}	12.0	140.0	12.0	14.0	180.0	290.0	430.0	106.0	500	80-120
Calcium/ mgL^{-1}	3.2	40.0	3.2	3.2	60.0	84.0	116.0	31.2	200	-
Magnesium/ mgL^{-1}	0.97	9.2	0.97	1.4	7.2	19.5	34.0	6.7	-	-
Total Fe/ mgL^{-1}	0.1	0.3	0.1	0.1	0.3	0.2	0.3	0.3	0.3	0.3
Chloride/ mgL^{-1}	5.26	7.68	5.76	5.26	40.00	26.00	92.00	47.68	250	250
T. Ammonia/ mgL^{-1}	0.02	0.02	0.02	0.02	0.02	11.2	3.6	12.0	-	1.5

Results showed that the pH of the water samples was found to vary from 6.5 to 7.1. However, the values fall within the guideline of NDWQS and WHO for pH (6.5-8.5). pH values are usually altered by the presence of organic and inorganic solutes together with the reaction of carbon dioxide[9]. Similarly, the EC values (218-918 μScm^{-1}) at all the sampling sites were found within the permissible limit as guided by both the NDWQS and WHO standards. Higher electrical conductance in water is usually attributed to high salinity and mineral contents. The presence of ions such as Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, NO_3^- , PO_4^{3-}, CO_3^{2-} and HCO_3^- contribute to salinity of water in most fresh water[10].

Total alkalinity of the water samples was varied from 16 to 350 mgL^{-1}. All the sampling sites except S_6 and S_7 recorded normal values and within the guideline as recommended by WHO for total alkalinity (200 mgL^{-1}). Total alkalinity in natural water is attributed to bicarbonate[11]. Phenolphthalein alkalinity was not detected in any of the samples analyzed.

Total hardness in water is the sum of concentration of alkaline earth metal cations such as Ca^{++} and Mg^{++} [12]. The total hardness is the total soluble magnesium and calcium salts present in water expressed as its $CaCO_3$ equivalent. Total hardness also includes the sulphates, chlorides of calcium and magnesium. In most natural water the predominant ions are those of bicarbonates associated mainly with calcium to lesser degree with magnesium and still less with sodium and potassium. Consumption of salty water in excess is reported to have caused hypertension and increases the risk for stroke, left ventricular hypertrophy, osteoporosis, renal stones and asthma[13]. The present study showed that the total hardness analyzed in the water samples were found in the range of 12 to 430 mgL^{-1}. The values are found within the guideline as recommended by NDWQS. However, the WHO guideline value (total hardness range: 80-120 mgL^{-1}) indicates that S_2, S_5, S_6 and S_7 exceeded the maximum limit for drinking water.

Calcium content of water in the present study was found in the range of 3.2 to 116 mgL^{-1}. The value is well below the maximum permissible limit of NDWQS guideline. Similarly, Mg content varied from 0.97 to 34.0 mgL^{-1}. Ca and Mg are both essential minerals for living organisms. Both the minerals occur in all kinds of natural water with Mg concentration generally lower than the calcium[14].

Iron content in the present study was found within the guideline value as recommended by NDWQS and WHO. The study revealed that all sampling sites contained the metal content in the normal range of 0.1 to 0.3 mgL^{-1}. Iron is one of the most abundant elements in nature ranking fourth by weight. All kinds of water including groundwater have appreciable quantities of iron. Although the metal has got little concern as a health hazard but is still considered as a nuisance in exceeding quantities for domestic as well as industrial uses[15].

The chloride content in the present study was found in the range of 5.26 to 92 mgL^{-1}. The values are well below the NDWQS and WHO guideline for drinking water (maximum permissible level: 250 mgL^{-1}). Chloride concentration higher than 200 mg/L is considered to risky for human consumption and causes unpleasant taste of water[16].

In the present study, the total ammonia content in the drinking water samples was found to vary from 0.02 to 12.0 mgL^{-1}. Most of the sampling sites recorded the total ammonia content within the normal guideline value. However, the values of S_6 (11.2 mgL^{-1}), S_7 (3.6 mgL^{-1}) and S_8 (12.0 mgL^{-1}) sites were exceptionally higher than the maximum permissible limit as recommended by the NDWQS and WHO for drinking water (1.5 mgL^{-1}). The high content of ammonia may be due to sewage contamination in water and other natural degradation processes most inevitably ammonification of organic matter[17]. Ammonia in higher concentration is harmful to aquatic animals, biota as well as human health[15].

Conclusion

The present work is an attempt to assess the drinking water quality. Water quality analyses reveal that most of the physico-chemical parameters of the drinking water fall within the standard limits as per the NDWQS and WHO guidelines. Hence, it can be concluded that the present status of drinking water quality in Kathmandu metropolitan city is suitable for drinking purposes.

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