Nepal Journal of Science and Technology Vol. 15, No.1 (2014) 115-120

Drinking Water Quality of Kathmandu Valley

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Abstract
This research was conducted to analyze drinking water quality of Kathmandu valley. Total 969 water samples (392 from dug wells, 287 from deep boring, 218 from treated water, 46 from tap and 26 from other water sources) received from different places of Kathmandu, Lalitpur and Bhaktapur districts during March 2012 to March 2013. These samples were analyzed for the determination of physical (pH, temperature, conductivity, turbidity), chemical (hardness, chloride, iron, arsenic, ammonia, nitrate) and microbiological (total Coliform) parameters. It was found that the temperature and nitrate were within the WHO standards while pH, conductivity, turbidity, chloride, iron, arsenic, ammonia, and Coliform bacteria exceeded the WHO standard guideline. In ground water (well and Boring), pH, conductivity, hardness, turbidity, iron, arsenic, chloride, ammonia and total Coliform count crossed WHO standards as 5%, 2%, 0.8%, 36%, 51%, 0.1%, 2%, 11% and 86 % respectively. Hardness was within the standard in both treated and tap water samples. Compared to treated water, pH, arsenic and chloride were within the standard in tap water. The common problematic parameters of different sources of drinking were turbidity, iron, ammonia and conductivity. Coliform bacteria were found in 36% samples of treated water whereas 80% tap water samples were contaminated from Coliform bacteria.

Key words: coliform, ground water, physico-chemical parameter, tap water

Introduction
Water is the life giving as well as life maintaining element. It is essential for all sorts of living as well as non-living elements and is an indispensable factor. It is a fundamental natural resource and vital to the society (Pandey 2012). The presence of safe and reliable source of water is thus an essential prerequisite for the establishment of stable community. One third of the earth's space is occupied by water. But only 0.3% is safe for drinking purpose. Safe drinking water is defined as water with microbial, chemical and physical characteristics that meet WHO guidelines or national standards on drinking water quality (WHO 2007). The quality of water is determined by natural and anthropogenic activities. If such activities alter, the natural water quality is no longer fit for use and is said to be contaminated or polluted water.

WHO has estimated that up to 80% of all sickness and diseases in the world is caused by inadequate sanitation, pollution or unavailability of water. Polluted drinking water and water borne diseases are responsible for a large number of mortalities and morbidities (Prasai 2007). So, the safe water quality is a major concern with reference to public health importance as health and well being of the human race is closely tied up with the quality of water used (Sharma 2005). Globally, over 884 million people have no access to safe water and nearly two million children die every year from diarrhea. Nepal is not exception to this where five and half million have no access to safe drinking water. Due to this 10,500 children die every year in Nepal (Shrestha 2012).The Kathmandu valley constitutes the country's single largest urban economy and has a population of 1.5 million. The current piped water supply of groundwater and surface water in the dry season varies between 65 and 85 MLD. Even in the wet season, the supply only reaches 140MLD (Khatiwada 2002). Due to this, approximately 50% of the urban water supply of Kathmandu valley is obtained from groundwater sources and is also widely exploited for private, domestic and industrial uses (Pant 2010). This in turn pressurizes the groundwater sources. The water quality of Kathmandu valley is in degraded state and not in agreement with the WHO guideline (Prasai 2007). This is due to the contamination from sewage, septic failure, and open pit, leaching from landfill site, latrines and disposal of domestic and industrial wastes in open area (Karn 2001). The principal contaminants of drinking water sources include arsenic, iron, nitrate, ammonia and pathogens. So, such water is not suitable for drinking purpose and appropriate treatment methods need to be employed before using such water.

Methodology

Altogether 969 drinking water samples were received at the laboratory of Nepal Academy of Science and Technology, Khumaltar, Lalitpur (NAST) from different places of Kathmandu valley. Physicochemical and microbiological (total Coliform count) quality of the samples were assessed as per the methods described in APHA (2005). Test parameters, methods of analyses and instruments used for analyses are shown in Table 1 below.

Table 1. Test parameters, methods of analyses and instruments used

S.N.	Parameters	Unit	Methods of analyses	Instruments & Kit
	Physiochemical			
1	pH	-	pH meter	Sension1, Hach
2	Conductivity	µs/cm	Conductivity meter	Conductivity meter, Toa, Electronics, Japan
3	Temperature	Celsius	Thermometer	
4	Turbidity	NTU	Turbidimeter	Nephelometer, Elico, India
5	Hardness	mg/l	EDTA titrimetric method	-
6	Chloride	mg/l	Argentometric method	-
7	Iron	mg/l	Phenanthroline method	Spectrophotometer
8	Ammonia	mg/l	Kit method	Machegery Nagal test kit
9	Nitrate	mg/l	Kit method	Machegery Nagal test kit
10	Arsenic	mg/l	Kit method	Machegery Nagal test kit
	Bacteriologocal			
11	Total Coliform	cfu/100	Membrane filtration (MF)	Millipore membrane filter

Table 2. Samples of exceeding WHO standard guideline values

S.N	Parameters	Units	Tap samples that crossed the WHO guideline values		Treated samples that crossed the WHO guideline values		Well samples that crossed the WHO guideline values		Boring samples that crossed the WHO guideline values		WHO standard guideline values
			No.	%	No.	%	No.	%	No.	%	
1.	Temperature	^{0}C	-		-		-		-		
2.	pH		-		**11**	5	**11**	3	**22**	9	6.5-8.5
3.	Conductivity	µS/cm	**1**	2	**3**	1	**12**	3	**1**	0.4	
4.	Turbidity	NTU	**3**	7	**12**	6	**132**	36	**85**	36	10
5.	Total hardness	mg/l	-		-		**5**	1	**-**		500
6.	Chloride	mg/l	-		**3**	1	**9**	2	**2**	0.8	250
7.	Iron	mg/l	**7**	15	**33**	15	**168**	46	**136**	58	0.3
8.	Arsenic	mg/l	-		-		**-**		**1**	0.4	0.05
9.	Ammonia	mg/l	**1**	2	**20**	9	**40**	11	**27**	11	1.5
10	Nitrate	mg/l	-		-		**-**		**-**		50
11.	Total Coliform count		**37**	80	**79**	36	**329**	91	**187**	79	0 (0/100 ml)

Results and Discussion

A total of 969 water samples (392 from dug well, 287 from deep boring, 218 from treated water, 46 from tap and 26 from other water sources) were received from different places of Kathmandu, Lalitpur and Bhaktapur districts and were analyzed for the determination of physical (pH, temperature, conductivity, turbidity), chemical (hardness, chloride, iron, arsenic, ammonia, nitrate) and microbiological (total Coliform) parameters. The physical parameters i.e. temperature, pH, turbidity and conductivity have been considered as a non- health related factors (Prasai 2012). From this study except temperature all the physical parameters and except nitrate all the chemical parameters exceeded the WHO guideline values in different water sources which have been shown in Table 2.

Out of the total the temperature and nitrate content of all the samples was within the permissible limits of WHO standards. In compare to boring water except pH and arsenic, well water is more contaminated both chemically and bacteriological. The major problematic parameter of drinking water sources of Kathmandu valley are pH**,** conductivity, turbidity, total hardness, iron, arsenic, ammonia and total Coliform. The graphical representations of physico- chemical parameters of different sources that exceed the Nepal Standard were represented in Fig. 1.

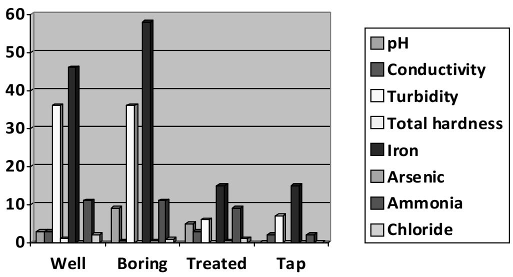

Fig. 1. Different parameters of different water sources exceeding WHO guidelines values

Bacteriological analysis

Eighty-six percent groundwater samples, 80% tap water and 36% treated water samples contained Coliforms (Max. 300 CFU/100 ml) by MF technique indicating possible contamination of bacteria from faecal origin. The maximum numbers of total Coliform were found in well water sources which was shown in Fig. 2.

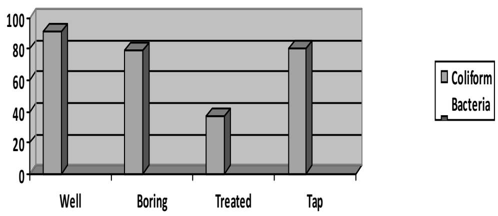

Fig. 2. Presence of Coliform in different sources of water

Total Coliform test theoretically indicates the presence of all Coliform group bacteria, both in vegetative and fecal in origin. The fairly high values of total Coliform are indicative of increasing pollution of the drinking water by organic means particularly through the discharge of sewage and domestic effluents into sources. Similarly, the other reasons for microbial contamination could be unhygienic handling of water and poor sanitation around different water sources.

The study revealed that 9 % of the boring samples, 3% well water and 5% treated water samples showed the pH values below the permissible guideline value as prescribed by WHO. In drinking water, acidic pH may cause corrosion of metal pipes in the distribution system and alkaline pH adversely affects the disinfection process. pH is not a static, it changes over time, and in fact are changes over the course of a single day. The leaching of soils, organic matter and rocks is influenced by pH. According to the WHO, the range of desirable pH values of water prescribed for drinking purposes is 6.5 – 8.5 (WHO 2004).

Conductivity of well water (3%) was comparatively higher than other sources of drinking water. It does not reveal direct in health however, high conductivity for the most of the time indicates addition of some pollutants to it. Thirty-six percent of ground water samples crossed the permissible limit for turbidity which was similar to previous studies (Prasai 2007, Bajracharya 2007, Manandhar 2010). Turbidity indicated clarity of water and is caused by the presence of suspended and colloidal matters. Usually, water with high turbidity has offensive appearance, colour, taste and odor. Turbidity also correlates with iron content of water samples. Turbidity in natural water is caused by clay, silt, organic matter, phytoplankton and other microscopic organisms.

Hardness of most of all water samples were found within the acceptable limit proposed by WHO guideline values. Only five water sample from well contained hardness above the WHO Guideline values. Water hardness has no known adverse effects; however, some evidence indicates its role in heart disease (Schroeder 1960). Hardness in water is due to dissolved calcium and to a lesser extent, magnesium. Sewage and industrial wastes are important sources of calcium and magnesium. The main impact of hardness is deposition of scale and scum formation as well as consumption of more soap to produce lather.

Overall, 11 (2%) groundwater samples in which 9 well sample and 2 boring water samples exceeded the WHO recommended values for chloride which was similar to previous studies (Maharjan 2000, Jayana 2009). Chloride in drinking water enters through natural sources, sewage and industrial effluents, urban runoff containing de-ionizing salts and saline intrusion. High concentration of chloride gives a salty taste to water and beverages. Excessive chloride concentrations increase rate of corrosion of metals in the distribution system.

Overall 301 (51%) groundwater samples crossed WHO guideline values for iron which was also similar to previous studies (Prasai 2007, Bajracharya 2007, Jayana 2009, Manandhar 2010, Pant 2010). Similarly, 15% of tap and 15% treated water samples were contaminated from iron. The maximum use of bleaching powder in tap water leads to corrode a pipe line and found iron in tap water sources.

Of the total water samples, 64 (11%) exceeded the allowable limit for ammonia content in groundwater. Previous researchers (Upadhaya 2004, Bajracharya 2007, Jayana 2009) also found similar results. Similarly, 9% treated water and 2% tap water also contained ammonia. Ammonia in water is an indicator of possible bacterial, sewage and animal waste pollution. Ammonia content in water may be harmful to health since it can be converted to nitrate (Upadhaya 2004).

All the tested water samples contained nitrate within the WHO permissible values. Nitrate can be added to water from industrial effluents, agricultural and domestic wastes. Nitrate itself is not toxic but the effects are hazardous. It is converted to nitrite by microbial action. It leads to a disease in infant known as Blue baby syndrome. This disease can even lead to death, as a result of prolonged consumption of nitrate rich water (Jayana 2009).

Presence of arsenic is one of the emerging problems in drinking water as it may cause cancer and skin lesions. In the present study, 0.4% boring water samples crossed WHO guideline values for arsenic. Arsenic is introduced into drinking water sources primarily by dissolution of naturally occurring minerals and ores. And also from industrial effluents, and atmospheric deposition, concentrations in ground water in some areas are sometimes elevated as a result of erosion from natural sources.

Eighty-six percent of groundwater samples were contaminated from Coliforms which is similar to previous results (Prasai 2007, 2012). Similarly, 80% tap water and 36% treated water samples also were contaminated from Coliform bacteria. The reason behind a microbial contamination in drinking water sources may be due to direct discharge of untreated sewage or municipal wastes into surface waters or in open places near to water sources.

A comparative study of different water sources was carried out by taking certain important parameters like temperature, pH, conductivity, turbidity, nitrate, chloride, total hardness, ammonia, iron, arsenic and total Coliform. The level of contaminants in different sources of drinking water were determined as pH, turbidity, conductivity, arsenic, iron, ammonia, chloride, hardness and total Coliforms which were detected above WHO guidelines. Turbidity, iron, ammonia and total Coliform count were the major problematic parameters. The maximum concentration estimated for arsenic, iron, turbidity, ammonia, and coliform were 0.08 mg/l, 9mg/l, 1100FNU and 3mg/l and more than 300 respectively. The results clearly showed the deteriorating conditions of water quality of Kathmandu valley. Thus, the quality of drinking water is degraded and we concluded that groundwater, tap and treated water are not directly suitable to drink due to the presence of microbiological and inorganic pollutants beyond the WHO guidelines. The appropriate treatment approaches should be undertaken depending on the defects, in order to make water potable and rules and regulations of environment protection should be strictly adopted to conserve groundwater resources and to protect these sources from contamination.

Acknowledgements

The authors are grateful to Nepal Academy of Science and Technology for providing the laboratory facilities. Thanks to all people who brought water samples at NAST research laboratory.

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