ASSESSMENT OF DRINKING WATER OF BHAKTAPUR MUNICIPALITY AREA IN PRE-MONSOON SEASON

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Abstract: *The physico-chemical and microbiological analyses of the 116 water samples from four different sources namely, public tap, well, tube well and stone spout of Bhaktapur Municipality area were done following standard techniques for water sample collection and analyses set by the American Public Health Association (1998). The pH values of all water samples were found to lie within Nepal standard. Similarly 57(49.14%), 9 (7.76%), 56 (48.28%) and 1(0.87%) of water samples were found to exceed Nepal standard value for conductivity, turbidity, iron and chloride content respectively. Hardness content of all water samples were within the standard whereas 6 (5.17%) samples crossed ammonia permissible level. The nitrate and arsenic content of all samples were found within permissible level. The bacteriological analysis of water samples revealed the presence of total coliform in 96 (82.76%) of samples. So, the study has pointed out that the drinking water quality of city water supply has not been improved and traditional sources like stone spouts and tube well water are also not free from contamination. Such circumstances are responsible for spreading water borne outbreaks. The waterborne diseases are closely related with the conditions of living and environmental sanitation in the community. So, it can be effectively controlled by appropriate water management and safe disposal of excreta.*

Key words: Arsenic; *Coliform* bacteria; Diseases; Iron and water quality.

INTRODUCTION

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). Water quality has direct influence on public health. When water gets contaminated with various pathogenic as well as opportunistic microflora and toxic chemical compounds, it serves as the commonest vehicle of transmission of a number of infectious diseases. Unfortunately, over a billion people in the developing world do not have access to satisfactory water supply. The WHO has estimated that up to 80% of all sickness and disease in the world is caused by inadequate sanitation, polluted or unavailability of water. The pollution of drinking water is responsible for a large number of mortalities and morbidities due to water-borne diseases like typhoid, cholera, dysentery, hepatitis as well a many protozoan and helminthic infestations (WHO, 1997). Diarrhoeal diseases are still recognized as a major problem for Nepalese children, being recorded as the second most prevalent diagnosis in out-patience services. Today 72% of the nationwide disease burden is related to poor quality of drinking water, and around 75 children die each day from diarrhoea alone (Sherpa, 2003). A report from HMG ministry of health 0.37% of people had typhoid, diarrhea 0.53%, and jaundice and infective hepatitis 0.08% in Bhaktapur city. The chemical parameters of drinking water owe significant relation with the public health. Some chemicals, notably iron, ammonia, nitrates and recently arsenic are often included in routine monitoring of water supplies.

Bhaktapur Municipality is located at 27° 36' to 27° 44' North latitude and 85° 21' to 85°31' East longitude. It contains seventeen wards. Bhaktapur, at 1,401 meter above sea level, spreads over and area of 6.88 square kilometers. This conch shaped historic city, Bhaktapur, lying at 12 km east of Kathmandu was founded in the 12th century by King Ananda Dev Malla. People in Bhaktapur depend upon the well, stone spout, tube well and tap water to fulfill their needs and was target area for water sample collection and analysis. The study conducted area was one of the historical places of the Kathmandu valley. According the recent census, the population of Bhaktapur Municipality is 72,586. It consists of 87 stone spouts, 220 wells and 7207 piped lines (185 public tap).

Today, the need for clean water for drinking and sanitation has never been more pressing. The challenge is to create incentives in people to share human values of common responsibility not to pollute or overuse the water source (Johannessen, 2001). Clean water and sanitation are human rights, essential to life (Water aid, 2005). Studies on drinking water quality in Nepal was carried out by Bovier (1978), Sharma (1978), Leuenberger (1983), Adhikari *et al* (1986), Sharma (1986), ENPHO/DISVI (1990), WSSC (1990), ENPHO/DISVI (1991), Bottino *et al* (1991), Karmacharya *et al* (1991/92), ENPHO/DISVI (1992), Dhaubadel (1992), K.C (1992), Lohani (1992), Pradhananga *et al* (1993), Ghimire (1996), Maharjan (1998), GRI/IBS (1999), Karmacharya and Pariyar (1999), NESS (1999), ENPHO (2000), Khadka (2001), Regmi (2001), Prasai (2002), Sharma *et al* (2002), Sundas (2002), Schaffner (2003), Upadhaya *et al* (2004), ENPHO (2005), JICA/ENPHO/MPW (2005), NGO FORUM (2006), Bajracharya (2007), DWSS (2007) and Jayana (2007). The present study intends to assess the physico-chemical and microbiological quality of drinking water from different sources in Bhaktapur Municipality area.

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Table 1: Percentage of water samples above Nepal Standard (%)

Parameters	Tap water (n_2=31)	Well (n_3=56)	Tube well (n_3=4)	Stone spouts (n_1=25)	Total (N=116)
pH	0	0	0	0	0
Conductivity	0	98.21	0	8	49.14
Turbidity	0	10.71	0	12	7.76
Hardness	0	0	0	0	0
Chloride	0	1.79	0	0	0.87
Iron	3.23	73.21	0	56	48.28
Nitrate	0	0	0	0	0
Ammonia	0	7.14	25	8	5.17
Arsenic	0	0	0	0	0

* Below Nepal Standard

METHODOLOGY

This study was conducted in Bhaktapur Municipality area from April 2007 to June 2007. One hundred and sixteen water samples were randomly collected from four different sources viz. public taps, wells, tube wells and stone spouts. Physico-chemical and microbiological status was analyzed for assessment of drinking water quality. Analyses of the physico-chemical parameters were done by following APHA (1998). pH, Conductivity, ammonical-nitrogen, nitrate-nitrogen and arsenic of water samples were recorded at the site during sampling period. Other parameters were analyzed in the Environment Laboratory of NAST. The samples were analyzed on the same day immediately after its delivery and always within 6 hours of collection. When immediate analyses was not possible, the samples were preserved at 4^0C. Total coliforms were enumerated by the membrane filtration (MF) technique as described by APHA (1998).

Table 2: Sampling sites for public tap water showing total coliform count

SN	Sample Water code	Location	Total coliform count
1	PTW_{01}	Sakotha, Ward no.-11	0
2	PTW_{02}	Tibukchhe, Ward no.-8	0
3	PTW_{03}	Kolachhen, Ward no.-13	16
4	PTW_{04}	Tasimala, Ward no.-13	0
5	PTW_{05}	Bangsagopal, Ward no.-16	0
6	PTW_{06}	Bangsagopal, Ward no.-16	0
7	PTW_{07}	Yalachhen, Sano Byasi, Ward no.-10	54
8	PTW_{08}	Yalachhen, Sano Byasi, Ward no.-10	0
9	PTW_{09}	Yalachhen, Sano Byasi, Ward no.-10	0
10	PTW_{10}	Thulo Byasi, Ward no.-10	0
11	PTW_{11}	Thulo Byasi, Ward no.-10	0
12	PTW_{12}	Chochhen, Mulachhen, Ward no.-9	0
13	PTW_{13}	Mahankali, Ward no.-5	101
14	PTW_{14}	Mahankali, Ward no.-5	1
15	PTW_{15}	Mahankali, Ward no.-5	1
16	PTW_{16}	Chochhen, Ward no.-9	0
17	PTW_{17}	Bolachhen, Ward no.-10	0
18	PTW_{18}	Sukuldhoka, Ward no.-8	0
19	PTW_{19}	Lalachhen, Ward no.-5	4
20	PTW_{20}	Yachhen, Ward no.-5	0
21	PTW_{21}	Yachhen, Ward no.-5	0
22	PTW_{22}	Dattatrya, Ward no.-3	0
23	PTW_{23}	Taulachhen, Suryamadhi, Ward no.-1	13
24	PTW_{24}	Twacha Gali, Suryamadhi, Ward no.-1	0
25	PTW_{25}	Innacho, Ward no.-6	0
26	PTW_{26}	Innacho, Ward no.-6	112
27	PTW_{27}	Golmadi, Ward no.-7	4
28	PTW_{28}	Chanchel, Golmadi, Ward no.-8	0
29	PTW_{29}	Hanumanghat, Ward no.-6	18
30	PTW_{30}	Degamana, Ward no.-16	0
31	PTW_{31}	Sallaghari, Ward no.-17	>300

Risk category as per microbial contamination ranges:
0: in compliance with WHO guidelines
1-10: Low risk
10-100: Intermediate Risk
100-1000: high risk
More than 1000: very high risk

RESULTS

Out of one hundred and sixteen water samples (from public taps, wells, tube wells and stone spouts), The pH values of all water samples were found to lie within WHO guideline values. Similarly, 57 (49.14%), 9 (7.76%), 56 (48.28%) and 1(0.87%) of water samples were found to exceed Nepal standardfor conductivity, turbidity, iron and chloride content respectively. Hardness content of all water samples were within the guideline values whereas 6 (5.17%) samples crossed ammonia permissible level. The nitrate and arsenic content of all samples were found within permissible level. These results compared with Nepal standard values for drinking water is as shown in Table 1.

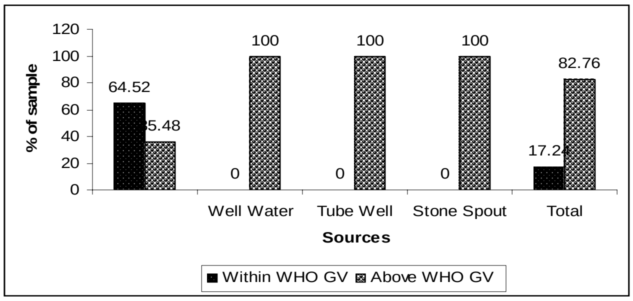

Fig 1: Total coliform count with respect to water sources

The bacteriological analysis of water samples revealed the presence of total coliform in 82.76% of samples (public tap 35.48%, well 100%, tube well 100 % and stone spout 100 %). Of the total 31 public tap water samples, 20 were deprived of total coliform and rest were contaminated with total coliforms. The places including Kolachhen, Yalachhen, Mahankali, Lalachhen, Taulachhen, Innacho, Golmadi, Hanumanghat and Sallaghari were in the risk category (Table 2). Regarding wells, tube wells and stone spouts, water samples were found positive for total coliforms i.e.greater than 300 cfu.

DISCUSSION

This study assessed the physicochemical and bacteriological quality of various water sources. All water samples showed their pH values within the permissible level. pH is an operational water quality parameters and a large variety of pollutants such as discharges from industries containing detergents, heavy metals, bleaching materials, acids, alkalis etc affect the pH of receiving water. pH less than 7.0 may cause corrosion of metal pipes thereby releasing toxic metals like Zn, Pb, Cd and Cu, etc. and higher than 8.0 adversely affect the disinfection process.

The conductivity of 57 (49.14%) samples crossed the limit. Higher conductivity value was also seen in the studies of

Karmacharya and Pariyar (1999), Prasai (2002) and Bajracharya (2007).It does not have a direct health effect. However, high conductivity most of the time is due to pollution. The Nepal standard for turbidity has been violated by 9 (7.76%) of the samples. Previous studies by Karmacharya and Pariyar (1999), Khadka (2001), Prasai (2002), Schaffner (2003), Bajracharya (2007) and Jayana (2007) also revealed higher turbidity value in their water samples. Turbidity in water is caused by the presence of suspended and colloidal matter. Usually, water with high turbidity has offensive appearance, color, taste and odor. The main problem associated with turbidity is the microbiological quality since its presence can interfere with the detection of bacteria and viruses. Disinfection of water becomes less effective because the microorganisms are protected by the particles that cause turbidity.

The test result of hardness showed all water samples within the Nepal standard. Hardness of water is predominantly due to dissolved calcium and magnesium. Studies carried out so far do not reveal direct and conclusive health effect due to hardness in water 1 (0.87%) of water samples contained high chloride content above permissible value. Chloride can be an indicator of pollution. Chloride in drinking water originates from natural sources, sewage and industrial effluents, urban runoff containing de-ionizing salts and saline intrusion. Usually the high concentrations of chloride in combination with nitrate or ammonium show that the water is contaminated by domestic sources. Concentrations of chloride were observed higher in wells, tube well and stone spouts than in public tap water. Studies of Ghimire (1996) and Jayana (2007) also found higher chloride content in their water sample.

Iron is one of the most abundant elements of the rocks and soil, ranking fourth by weight. All kinds of water have appreciable quantities of iron. Some of water samples 56 (48.28%) exceeded the Nepal standard. High iron content was observed in the studies of ENPHO/DISVI (1990), ENPHO (1991), Bottino *et al* (1991), K.C (1992), Lohani (1992), Pradhananga *et al* (1993), Ghimire (1996), NESS (1999), Khadka (2001), Prasai (2002), Upadhaya *et al* (2004), JICA/ENPHO/MPW (2005), Bajracharya (2007) and Jayana (2007). Staining of laundry and plumbing may occur at concentrations above 0.3 mg/liter. Iron also promotes undesirable bacterial growth ("Iron bacteria") in water works and distribution system, resulting in the development of a slimy coating on the pipe. In addition to the natural sources of iron, corrosion of pipes, pumps, etc. can also increase its concentration in distribution systems. Although iron has got little concern as a health hazard but it is still considered as a nuisance in excessive quantities. When high concentrations of iron are absorbed, for example by haemochromatose patients, iron is stored in the pancreas, the liver, the spleen and the heart. This may damage these vital organs. Healthy people are generally not affected by iron overdose, which is also generally rare. It may occur when one drinks water with iron concentrations over 200 ppm.

In the present study the Nepal standard of ammonia (1.5mg/l) was violated by 6 (5.17%) of the samples. Studies of K.C (1992), Pradhananga *et al* (1993), Karmacharya and Pariyar (1999), NESS (1999), ENPHO (2000), Khadka (2001), Sharma *et al* (2002), Upadhaya *et al* (2004), JICA/ENPHO/MPW (2005), NGO FORUM (2006), Bajracharya (2007) and Jayana (2007) also found higher ammonia content in the ground water samples of Kathmandu valley. Presence of ammonia does not always mean that it is due to domestic pollution. High ammonia content in deep well can be due to the underlying intercalated layers of peat and lignite. Ammonia content in water may be harmful to health since it can be converted to nitrate. If only ammonia is present, pollution by sewage must be very recent. The occurrence of NO_2 with ammonia indicates that some time has been lapsed since the pollution has occurred. If all the nitrogen is present in nitrate form, a long time has been passed after pollution, because water has purified itself and all nitrogenous matter has been oxidized. The presence of ammonia in ground waters is quite generally a result of natural degradation processes. Ammonia in higher concentration is toxic to man. The toxicity of ammonia increases with pH because at higher pH most of the ammonia remains in the gaseous form. The decrease in pH decreases the toxicity due to conversion of ammonia into ammonium ion which is much less toxic than the gaseous form.

Nitrate concentration was within the standard for all the water samples.

The ground water samples from all areas of Bhaktapur were found to be within the Nepal standard. In water, arsenic is found in the form of arsenite, arsenate and organic arsenicals which may result from mineral dissolution, industrial discharges or the application of pesticides. Continued consumption of arsenic contaminated water generally leads to numerous diseases, including skin cancer, gangrene, hematological poisoning, cardiovascular and nervous disorders.

In the present study, the microbiological analyses of water revealed the presence of total coliforms in 96 (82.76 %) of total samples i.e. the majority of water samples taken were found positive for total coliforms. Only 20 (64.52%) tap water was total coliform count negative. Sourcewise distribution of coliform count clearly showed that wells 56 (100%), tube wells 4 (100 %) and stone spouts 31 (100 %) crossed the Nepal standard and Nepal standard i.e. 0 cfu/100ml.

The principal reason of the bacteriological pollution of drinking water are due to the use of unrepaired old pipeline systems for distribution, parallel arrangement of the drinking water pipeline with that of the drainage system and irregular supply of the drinking water in the pipeline. Beside that the contamination may be either due to the failure of the disinfections of the raw water at the treatment plant or because of the infiltration of contaminated water (sewage) through cross-connection and leakage points. All the natural water sources, such as wells, stone spouts and tube wells are neither treated nor protected properly. Thus, deteriorating water quality is the major problem and it has created serious threat to human health and environment. The quality of water has deteriorated due to poor management and no monitoring of water quality.

The greatest problem continues to be the microbial contamination of drinking water supplies. It is a tragedy that infants and young children are the innocent victims of the failure to make safe drinking water and basic sanitation services. In Nepal, morbidity and mortality rates from water borne disease are considered high particularly among children below the age of five. A report from HMG ministry of health 2004, in Bhaktapur, people suffered from typhoid 0.37%, diarrhea 0.53%, and jaundice and infective hepatitis 0.08%. Improvements (safe water supply and of adequate means of sanitation) bring immediate and lasting benefits in health, dignity, education, productivity and income generation. The conservation of water sources is very important to provide safe water. As far as possible, water sources must be protected from contamination by human and animal waste, which can contain a variety of bacterial, viral, protozoan and helminthes parasites. The control of drinking water quality in distribution networks remains a major challenge in urban areas. Protection of sources, treatment and distribution management are all-critical strategies in maintaining and improving piped water supplies. Prevention of the disease is therefore a matter of providing safe drinking water.

CONCLUSION

The present study disclosed the physicochemical and bacteriological contamination of different water sources in Bhaktapur municipality area in pre-monsoon season. Besides coliform contamination, the concentration of chloride, iron and ammonia were high in some of the water samples.

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