J Nepal Health Res Counc 2012 Sep;10(22):192-6

Drinking Water Quality Assessment

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ABSTRACT

Background: Drinking water quality is the great public health concern because it is a major risk factor for high incidence of diarrheal diseases in Nepal. In the recent years, the prevalence rate of diarrhoea has been found the highest in Myagdi district. This study was carried out to assess the quality of drinking water from different natural sources, reservoirs and collection taps at Arthunge VDC of Myagdi district.

Methods: A cross-sectional study was carried out using random sampling method in Arthunge VDC of Myagdi district from January to June, 2010. 84 water samples representing natural sources, reservoirs and collection taps from the study area were collected. The physico-chemical and microbiological analysis was performed following standards technique set by APHA 1998 and statistical analysis was carried out using SPSS 11.5. The result was also compared with national and WHO guidelines.

Results: Out of 84 water samples (from natural source, reservoirs and tap water) analyzed, drinking water quality parameters (except arsenic and total coliform) of all water samples was found to be within the WHO standards and national standards. 15.48% of water samples showed pH (13) higher than the WHO permissible guideline values. Similarly, 85.71% of water samples showed higher Arsenic value (72) than WHO value. Further, the statistical analysis showed no significant difference ($P<0.05$) of physico-chemical parameters and total coliform count of drinking water for collection taps water samples of winter (January, 2010) and summer (June, 2010). The microbiological examination of water samples revealed the presence of total coliform in 86.90% of water samples.

Conclusions: The results obtained from physico-chemical analysis of water samples were within national standard and WHO standards except arsenic. The study also found the coliform contamination to be the key problem with drinking water.

Keywords: drinking water quality assessment; physico-chemical parameters; total coliform.

INTRODUCTION

Clean and safe water is an absolute need for health and productive life. The quality of the water supplied is important in determining the health of individuals and whole communities.[1] The problem is profound in developing countries like Nepal where water treatment does not exist in most of the places or is inadequate, if available though.

Sewage pollutes surface and ground water, domestic waste, industrial and agricultural effluents containing simple nutrients to highly toxic substances. The pollution of drinking water is responsible for large number of mortalities and morbidities due to water borne diseases like typhoid, cholera, diarrhoea, dysentery, hepatitis, as well as many protozoan and helminthes infections.[2]

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The present study intends to assess the physico-chemical and microbiological quality of drinking water from different natural sources, reservoirs and taps in Arthunge VDC of Myagdi district, Western Nepal. The primary goal of this research is to analyze the drinking water quality parameters to ensure that the water is safe for drinking.

METHODS

A cross-sectional study was carried out for drinking water quality assessment using simple random sampling for sample collection in Arthunge VDC of Myagdi district from the month of January to June, 2010. Total 84 water samples representing 11 natural sources, 5 reservoirs and 68 taps from study area were collected. The physico-chemical and microbiological analysis was performed following standard techniques set by American Public Health Association 1998.[3] Temperature, pH, conductivity, chloride, total hardness, alkalinity and free CO_2 were analyzed at the site during sampling period. Ammonia, Arsenic, Iron, Nitrate and Phosphate were analyzed at laboratory of Central Department of Environmental Science, Kirtipur. For microbiological analysis samples were transported to Microbiological Research Laboratory of Mount Annapurna College, Pokhara within 6 hours and analyzed. Total coliforms were enumerated by the membrane filtration (MF) technique as described by Aneja, (2008).[4] The physico-chemical and microbiological parameter of water quality was carried out by different methods (Table 1).

The values of physico-chemical and microbiological parameters were compared with national standard[5] and WHO guideline value[6] and statistical analysis of the data was carried out using SPSS 11.5.

Table 1. Parameter tested and analytical method

Parameters	Methods
pH	pH meter
Conductivity	Conductivity meter
Hardness	EDTA titrimetric
Chloride	Argentometric
Alkalinity, Free CO_2	Titrimetric
Phosphate	Ammonium molybdate
Iron	Phenanthroline
Ammonia	Colorimetric
Nitrate	Phenol disulphonic
Arsenic	Arsine generator
Total coliform	Membrane filtration

RESULTS

Out of eighty-four water samples (from natural source, reservoirs and tap water) analyzed, drinking water quality parameters of all water samples were found to be within WHO guidelines and national standard, except Arsenic and total coliform. Where arsenic values were found to lie within national standard only but it exceeds WHO guidelines value.The statistical result showed that there was no significant difference ($P<0.05$) of physico-chemical parameters and total coliform count of drinking water for Tap water sample in winter (January, 2010) and summer (June, 2010).

The microbiological analysis of water samples revealed the presence of total coliform in 86.90% of samples (natural sources 54.55%, reservoir 100% and taps 91.18%).Table 3 shows the percentage of total coliform contamination for all 84 samples, the contaminated samples are also categorized according to the risk grade for natural source, reservoir and tap samples. The data describes that there is very high risk in taps.

Table 2. Physio-chemical parameters for drinking water

S.N	Test Parameters	Units	Range	Mean +s.d	Coefficient Of Var. %	WHO guideline
1	Temperature	°C	17-21	18.92±1.66	8.77	-
2	pH	-	7.65-7.73	7.68±0.22	0.03	6.5-8.5
3	Conductivity	µS/cm	74-489	200.23±11.53	7.75	1500
4	Chloride	mg/l	4.26-35.5	10.37±2.23	2.15	250
5	Total hardness	mg/l	12-190	69.80±7.68	11.00	500
6	Total Alkalinity	mg/l	15-225	106.39±9.14	8.5	-
7	Free CO2	mg/l	8.3-68.2	31.64±4.71	14.88	-
8	Ammonia	mg/l	0.018-0.089	0.028±0.004	14.28	1.5
9	Arsenic	mg/l	0.003-0.048	0.021±0.03	14.28	0.01
10	Iron	mg/l	0.009-0.10	0.018±0.03	16.67	0.3
11	Phosphate	mg/l	0.011-0.20	0.098±0.04	4.08	-
12	Nitrate	mg/l	0.001-0.10	0.040±0.018	4.5	50

Table 3. Total coliform risk for source, reservoir and tap water samples

Total coliform	Risk Grade	Source (n=11)	Reservoir (n=5)	Tap (n=68)
cfu/100ml		(%)		
0	A (No risk)	45.46	0	8.82
1-10	B (Low risk)	27.28	60	2.94
11-100	C (High risk)	27.28	20	17.64
101->1000	D (Very-high risk)	0	20	70.60

DISCUSSION

Changes in water quality are reflected in its physical, biological and chemical conditions; and these in turn are influenced by physical and anthropogenic activities.[7] Some chemicals, notably iron, ammonia, nitrates and arsenic have adverse public health impacts. The transmission of waterborne diseases is still a matter of major concern, despite worldwide efforts and modern technology being utilized for the production of safe drinking water.[8]

The Government of Nepal gazette the National Drinking Water Quality Standard (NDWQS) in 2062 B.S as an effort to take first step towards assuring drinking water quality.[5] So, it is essential to assess and compare the water quality parameters of drinking water supplied from different natural sources in the rural area of Nepal with National Drinking Water Quality Standards 2062.

This study assessed the physico-chemical and microbiological quality of various natural sources, reservoirs and taps supplied in the Myagdi district to identify the physical status, impurities, other dissolved substances and microorganisms that affects water used for domestic purposes. The pH is an important water quality parameter and a large variety of pollutants such as point and a non-point natural source of water pollutants from industry, agricultural and domestic practices affects the pH of receiving water. The water having pH less than 6.5 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 pH values were found within range of WHO standards and NDWQS guidelines value.

The result showed that the conductivity of all water samples was found to lie within WHO guideline value and national standard. The conductivity of water does not have direct health consequences; however, high conductivity indicates the addition of some pollutants to it.

Hardness of all water samples were found to lie within the acceptable limit as per mentioned in WHO and National Standard guidelines for drinking water quality parameters. Hardness in water is predominantly due to dissolved calcium and to lesser extent, magnesium. Sewage and industrial wastes are important natural sources of calcium and magnesium. The main impact of hardness is scum formation as well as consumption of more soap to produce lather.

Chloride can be an indicator of pollution. Chloride in drinking water originates from natural sources, sewages, industrial effluents, and urban runoff containing saline intrusion. Usually high concentrations of chloride in combination with nitrate or ammonium show that the water is contaminated by domestic natural sources. High chloride concentrations are corrosive to metals in the distribution system; particularly in waters of low alkalinity.[10] The study did not show high concentration of chloride in the water samples collected from different natural sources, reservoir and taps.

Ammonia concentration was also found to lie within the permissible value of WHO and National Standard (NDWQS-2062) guidelines for drinking water quality parameters. Ammonia can occur naturally in water supplies, while some water treatment plants add ammonia to react with chlorine to form combined chlorine residual to control formation of trihaloethanes. Ammonia will increase the chlorine demand of raw water in the chlorination process. Sewage contains large amount of ammonia formed by bacterial decay of nitrogenous organic wastes. It is an indicator of possible bacterial, sewage and animal waste pollution.[11]

Iron is objectionable because of the bad taste associated with the water. High concentration of iron in water stains laundry, sanitary ware, gives an undesirable taste and develops turbidity as well. Iron also promotes the growth of “iron bacteria” which derives their energy from the oxidation of ferrous iron to ferric iron and in the process deposits a slimy coating on the piping.[11] Iron content was found to be less in tested water samples.

The study revealed that 72 (85.71%) of water samples crossed the WHO guideline value of arsenic but the value lies within the national standard. Arsenic may be introduced into drinking water natural sources primarily by dissolution of naturally occurring minerals, ores, and industrial effluents. Arsenic is one of the most dangerous

and predominantly found in rocks, soil, natural water and organisms that is invisible and do not affect the taste and odor of the water. Studies reported that arsenic affects many organs and system in the body such as skin, heart vessels, respiratory organs and kidneys consequently may lead to the development of lung, kidney and bladder cancer.[12] High Arsenic value in the tested water samples might be due to of naturally occurring minerals, ores, etc. Usually, in Nepal high Arsenic content is found in the ground water available in Terai region.The people of Terai region who used ground water with high arsenic content have encountered many major health problems but no such problem has been observed in hilly areas like Myagdi.

The statistical analysis through paired t-test revealed that physico-chemical parameters total coliform count of drinking water for Tap water samples in winter (January, 2010) and summer (June, 2010) did not differ significantly at 5% level of significance. This shows that there is no significant change of physico-chemical parameters and coliform count of water samples in distribution system in winter and summer season.

In the present study, the microbiological analyses of water sample revealed the presence of total coliform in 73 (86.90%) of total samples. The majority of water samples taken were found positive for total coliform, which exceeds the national standard standards (0 cfu / 100 ml). The result showed high proportions of water samples (source, reservoir and taps) were contaminated. Out of 11 source water samples, 6 (54.55%) were found to be contaminated with total coliform, while rest are free from coliform. Most of the natural sources were springs in nature having no direct human impact. Similarly, 100% of reservoirs sample were showed contamination with coliform. This might be due to infiltration of contaminated water and sewage through cross connection and leakage points.[13] Out of 68 tap water samples, 62 (91.18%) were contaminated with total coliform rest were free from coliform. The presence of coliform bacteria in the tap water may be due to contamination in old pipelining system, back siphoning, drainage system and discontinuity in water supply pattern. Also carelessness may be the reasons for contamination with coliform.

From Microbial analysis performed on water sample it revealed that water available in those sampling sites were unsafe because of presence of total coliform. Most of the tested water was found to have higher number of coliform bacteria especially in tap water, which is not to say safe to drink. If quality of water is not improved it may exert serious health hazard for consumers. It is a tragedy that infants and young children are the innocent victims of failure to make safe drinking water and basic sanitation services. In Nepal, morbidity and mortality rates from water borne diseases are considered high particularly among children below the age of five. Water pollution is the most serious public health issues in Nepal. The disease caused by contaminated water is between top ten most prevalent diseases in Nepal.[14] Water-borne diseases are concerning the most recent emerging and re-emerging infectious diseases, which have recently proven to be the biggest health threat worldwide.

The conservation of water natural sources is essential to provide safe drinking water preventing contamination from solid, organic and hazardous wastes. The monitoring of drinking water quality remains a major challenge in urban as well as rural areas. Strategies like protection of natural sources, treatment and distribution management should be applied in order to maintain and improve drinking water supply system.

CONCLUSIONS

The data obtained from physico-chemical analysis of water samples were within national standard and WHO guideline. However, arsenic was not in satisfactory level.The study showed coliform contamination to be the major problem with drinking water. Microbiological analysis showed the water was not safe for drinking without purification.

ACKNOWLEDGEMENTS

The Nepal Health Research Council as regional grant program funded this study. We would like to acknowledge Central Department of Environmental Science, Kirtipur and Mount Annarpurna Campus, Pokhara for delivering laboratory facilities and apparatuses for this work. We are also grateful to Mr. Meghnath Dhimal, Research Officer at NHRC for his cooperation during research work.

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