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Full Length Research Paper

Physico-Chemical and Microbiological Analysis of Drinking Water Quality of Bhim Datta Muncipality of Kanchanpur District, Nepal

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Background: Drinking water quality is the great public health concern because it is a major risk factor for high incidence of diarrhea diseases in Nepal. In the recent years, the prevalence rate of diarrhea has been also found high in Kanchanpur district.

Methods: A cross-sectional study was carried out using a random sampling method inward no. 4, 7 and 18 of Bhim Datta Municipality of Kanchanpur district from July to October 2014. Fifty water samples representing 43 hand pumps and 7 piped/ tap water from the study area were collected. The physico-chemical and microbiological analysis was performed following standard technique set by APHA 1998.

Result: Out of 50 water samples, four percent of water samples showed the total hardness higher than the WHO permissible guideline values. Similarly, 6% of water samples showed higher arsenic value than WHO value, but it was within Nepal Standard. Further, 30% sample showed nitrate, 6% of samples showed iron, ammonia and chloride higher than the WHO guideline value and Nepal Standards. The highest 35 (70%) samples showed exceed the value than WHO Guideline values in drinking water. The microbiological examination of water samples revealed the presence of total coliform in 58% and E. coli in 16% of water samples.

Conclusion: The drinking water quality was poor in both chemical and biological parameter. Hand pump/tube well water were more contaminated than piped/tap water supply. It will be necessary, to find affordable treatment methods for water from hand pump or could provide an adequate supply of safe drinking water.

Keywords: *Drinking water, CFU/ml, microbiological, physic-chemical, public health*

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BACKGROUND

The ensuring of good quality drinking water is a basic factor in guaranteeing public health, the protection of the environment and sustainable development, the protection of the environment and sustainable development (Ranjini et al., 2010). Clean and safe water is an absolute need for healthy and productive life. The quality of the water supplied is important in determining the health of individuals and whole communities (Sharma et al., 2005). The provision of portable water to rural and urban population is necessary to prevent health hazards associated with poor drinking water (Nikoladze and Akastal 1989; Lemo, 2002). The increased human population, industrialization, the use of fertilizers in the agriculture and man-made activity, it is highly polluted with different harmful contaminants. Therefore, it is necessary that the quality of drinking water should be checked at regular time interval, because due to use of contaminated drinking water, human population suffers from a variety of water borne diseases (Basavaraja et al., 2011). Like many developing countries, Nepal faces a plethora of problems regarding both its drinking water quality and availability. Owing to the impact of sewage, typhoid, dysentery, and cholera is endemic every summer (Khadka, 1993).

Ground water resources include hand dug wells, tube wells and bore holes. These are common in the Terai regions of the country. The principal contaminants of ground water sources include arsenic, iron and manganese, and pathogenic micro-organisms, In addition, nitrates and nitrites along with other trace elements also contribute to the ground water contamination. It is commonly recognized fact that the use of contaminated water for drinking purposes poses significant health risks mainly from microorganisms and chemical contaminants. Chemical pollutants can cause different types of intoxication (WaterAID, 2011).

Many of the documented problems are related to pollution of both surface water and shallow ground waters from domestic agricultural and industrial wastes. But, in far Western of Nepal including Kanchanpur still there are lacks of such work. The people of this region are drinking ground water. Ground water represents an important source of drinking water and its quality is currently threatened by a combination of over-abstraction and microbiological and chemical contamination. The existing water supply system in Bhim Datta Municipality has poor reliability and the quality of services availed by the consumers is very low and services are made available to only some part of the town. The municipality area does not get regular piped water supply and thus many households have to resort to hand pumps, which are often contaminated or have high iron content (IEE, 2009).Therefore, it can be said that there is a notable lack of water quality data for Kanchanpur and hence the assessment of the main quality problems is difficult. Hence this study was designed to determine both physiochemical and microbial pollution of drinking water.

METHODOLOGY

Study Site

This study was carried out at the Bhim Datta Municipality of Kanchanpur District. Bhim Datta, formerly Mahendranagar, is a city and municipality in far western Nepal, six kilometers from the border of India and the Mahakali river. It is the headquarters of the district of Kanchanpur in Mahakali Zone. Bhim Datta is the 9^{th} largest city in Nepal. It is 5 km east of the Indian border and 700 km west of Kathmandu.

Population and Settlement Pattern

The total population of the municipality is 80.839 which is increasing at the rate of 3.91%. Out of which 41,228 (51%) are male's and 39,611 (49%) females. The settlement pattern of the project area was divided into three categories. First is the core area (ward no. 4), which is the market and is situated in the main bazaar area where the main economic activities of the people are carried out. The other one is (ward no. 18), which is the adjoining area of the bazaar and is mainly developing residential area situated south east of the bazar and there is flat to moderate dense settlement which might be turned into dense settlement very soon as migration rate is high and there is land available sufficiently for new settlements. Third is the rural settlement (ward no. 7), which is far from bazaar and located at the northwest of the bazaar.

Research Design

A cross-sectional study was conducted for drinking water quality assessment using simple random sampling for sample collection in Bhim Datta Municipality of Kanchanpur district during the month of July 2014 to October 2014.

Sample Collection

Water samples were collected in autoclaved bottled (1 litre capacity) with necessary precaution from different sites. The sampled bottled were capped and labelled with detailed of source of water, address of locations, date and time of collection. A of Total 50 water samples representing 7 tap/ piped, and 43 tube well/hand pump were collected from ward no. 4, 18 and 7of different localities of Bhim Datta Municipality**.**

Data Collection and laboratory Test Procedure

The physiochemical and microbiological analysis was performed following standard techniques set by American Public Health Association in 1998. Temperature and pH were analyzed by the site during the sampling period. Conductivity, Chloride, Total hardness, Ammonia, Arsenic, Iron, Nitrate and Phosphate were analyzed at the laboratory of the Department of Microbiology Siddhnath Science Campus Mahendranagar, Kanchanpur. For microbiological analysis samples were transported to Microbiology Laboratory Siddhanath Science Campus Mahendranagar within 6 hours and analyzed. When immediate analyses were not possible, the samples were preserved at 40^{o}C.

Total coliforms and *E. coli* was enumerated by the membrane filtration (MF) technique as described by Aneja, (2008). The physicochemical and microbiological parameter of water quality was carried out by WHO Guide line. Values of physiochemical and microbiological parameters were compared with national standard and WHO guideline value and statistically analyzed (WHO, 2007 b). The samples were analyzed on the same day immediately after its delivery. All isolated colonies will streak on nutrient agar to get pure colonies. Bacterial isolates will be identified on the basis of their cultural, morphological and biochemical tests.

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

S.N.	Parameter	Methods of analyses	Instrument/Kit
1	pH	pH meter	Toa Electronics, Japan
2	Conductivity	Conductivity meter	Conductivity meter LF 91
3	Temperature	Thermometer	Thermometer
4	Free chlorine	Kit method	ENPHO Water test kit
5	Chloride	Iodometric titration	Burette methods
6	Ammonia	Kit method	ENPHO Water test kit
7	Nitrate	Kit method	ENPHO Water test kit
8	Phosphate	Kit method	ENPHO Water test kit
9	Iron	Kit method	ENPHO Water test kit
10	Arsenic	Arsenic generator	HACH Water test kit
11	Total hardness	EDTA titration method	Burette
13	Carbon dioxide	Titration Method	Burette
12	Total alkalinity	Titration Method	Burette
11	Total Coliform	Membrane filter technique	Millipore membrane filter and M-endo agar
S,	*E. coli*	Membrane filter technique	Millipore membrane filter and M-endo agar

Data Analysis

The information was collected by laboratory finding of physiochemical and microbiological test. Data were tabulated and manipulated. The values of physiochemical and microbiological parameters were compared with national standard and WHO guideline value and statistical analysis of the data was carried out using SPSS 11.5.

RESULTS

This study assessed the physiochemical and microbiological quality of various sources, ground water, i.e. hand pumps and taps supplied in the Bhim Datta Municipality of Kanchanpr district to identify the physical status, impurities, other dissolved substances and microorganisms that affects water used for domestic purposes.

The result of the physiochemical analysis, drinking water quality parameters of water samples only physical parameter pH, conductivity, and temperature was found to be within WHO guidelines and national standard. The chemical parameter Arsenic, Iron, Ammonia, Nitrate, Phosphate, Total hardness, Total alkalinity, Chloride, and bacteriological parameter total coliform and *E. coli* exceeded WHO guideline value. Where arsenic values were found to lie within national standard only, but it exceeds the WHO guidelines value.

Table 3: Physicochemical parameter of drinking water

Parameter	Units	Range (minimu-maxmiu)	Average	No. of water sample exceeding WHO Standards	No. of water sample exceeding Nepal Standards
Ph	-	6.5 -7.2	6.8	0	0
Conductivity	µS/cm	80-600	260	0	0
Temperature	^{0}C	26-34	31.3	-	-
Chloride	mg/l	12.6-752.6	107.6	3	3
Ammonia	mg/l	0.03-3.0	0.7	2	2
Nitrate	mg/l	0-100	35.8	15	15
Phosphorus	mg/l	0.0-0.7	0.05	--	-
Iron	mg/l	0.0- 5.0	0.27	3	3
Arsenic	mg/l	0.0- 0.05	0.03	3	0
Total hardness	mg/l	180-600	358.8	2	2
Carbon dioxide	mg/l	10.5- 98.6	58.9	-	-
Total alkalinity	mg/l	60- 460	270	35	-

The microbiological analysis of water samples revealed the presence of total coliform in 58% of samples (Hand pumps 62.8% and 28.6% piped water).Table 3 shows the percentage of total *E. coli* contamination for all 8 samples, the contaminated samples were 16% hand pumps sources and 14% piped supplied water. The hand pumps sources of drinking water were more contaminated with bacteria than piped supplied water. The statistical result showed that there was a significant difference ($P>0.05$) of total coliform count of tap water and hand pump drinking sample.

Table 3: Bacterial contamination in drinking water

Sources	No. of samples	*E. coli* (CFU/100ml)		Total coliform (CFU/100ml)	
		No.	Percentage	No.	Percentage
Hand pumps	43	7	16	27	62.8
Piped supplied water	7	1	14	2	28.6
Total	50	8	16	29	58

DISCUSSION

Quality of water consumed is critical in controlling infectious diseases and other health problems. Water quality can be ensured through regular monitoring. A regular monitoring of water not only prevents diseases and hazards, but also checks the water resource from going further pollution.

Changes in water quality are reflected in its physical, biological and chemical conditions; and these in turn are influenced by physical and anthropogenic activities (Diwakar et al., 2008). 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 (ADB/ICIMOD, 2006).

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 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 the range of WHO standards and NDWQS guideline 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.

The temperature range of 26.5-31^{o}C of the water samples is believed to have been influenced by the intensity of sunlight. The present study revealed the range of 26- 34^{o}C temperature, which is high value. It may be due to exposure to sunlight or high environmental temperature in terrain region.

Overall, 96% percentage of water samples were found to lie within the acceptable limit of hardness 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 a 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 (Trivedi et al., 1996). The study showed 3 (6%) of samples high concentration of chloride in the water samples collected from different hand pumps. Similar result was recorded by (Maharjan, 1998) and (Jayana et al., 2009).

Ammonia concentration in most water samples (96%) 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 (Jayana et al., 2009).

Overall, 35(70%) samples were found higher alkalinity than WHO guideline value in drinking water. It indicates that there were higher concentration of carbonate (CO_3^{2-}), bicarbonate (HCO^{3-}), and hydroxyl (OH^-) ions in the drinking water.

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 (Jayana et al., 2009). Iron content was found to be higher than WHO standards and Nepal standards guideline for drinking water in 6% tested water samples.

The study revealed that 3 (6 %) 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 odour 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 (Aryal et al., 2012). 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.

The microbiological analyses of water sample revealed the presence of total coliform in 29 (58%) of total samples. The majority of water samples were found positive for total coliform, which exceeds the national standard standards (0 cfu / 100 ml). The result also showed the presence of *E. coli* in 8 (16%) of water samples taken were detected. Out of 43 hand pump water samples, 27 (62.8%) were positive for coliform and 7 (17%) were positive for *E. coli* while the rest were free from coliform. Similarly, out of 7 piped/ tap water 2 (28.5%) samples were found positive for coliform and 1 (14%) were contaminated with *E. coli*. In general, the hand pumps, water sampled are more contaminate with bacteria than piped water. This might be due to the shallow tube well in this region that may be contaminated with faeces or sewage. Even though, the tap water was chlorinated and then supplied, but they were also found to be contaminated from coliform and *E. coli*. The presence of coliform bacteria in the tap water may be due to contamination in the old pipeline system, back siphoning, drainage system and discontinuity in water supply pattern or may not be efficiently disinfected. Also, carelessness may be the reasons for contamination with coliform. From Microbial analysis performed on water sample it revealed that water available at those sampling sites were unsafe because of presence of total coliform. Most of the tested water was found to have a higher number of coliform bacteria, even 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 under the age of five. Water pollution is the most serious public health issues in Nepal. The disease caused by contaminated water is among top ten most prevalent diseases in Nepal (MoHP, 2008). 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

CONCLUSION

The data obtained from physico-chemical analysis of water samples were within national standard and WHO guideline. However, arsenic total hardness, total alkalinity, ammonia, Chloride, Nitrate were not in satisfactory level. The study showed coliform contamination to be the major problem with drinking water. The bacteriological pollution indicator *E. coli* was also found in drinking water. Microbiological analysis showed the water was not safe for drinking without purification. There were fewer bacteria and chemical contaminant found in deep aquifer and piped/tap water than shallow hand pumps. Despite its extensive contamination, the shallow aquifer will still have to be used as a drinking-water source until other sources are developed. It will be necessary, of course, to find affordable treatment methods for water from the shallow aquifer, which could provide residents with an adequate supply of safe drinking water.

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