Assessment of Water Supply and Microbial Quality of Water Among Schools in The Rural Kathmandu Valley, Nepal

Silvanus V, Gupta RK, Shreshta SR

Department of Community Medicine, Nepal Medical College and Teaching Hospital

Corresponding author: Dr Vinutha Silvanus, Assistant Professor, Department of Community Medicine, Nepal Medical College and Teaching Hospital, Jorpati, Kathmandu, Nepal; Email: Silvanus.v@gmail.com

ABSTRACT

Safe and sufficient drinking water has implications across all Millennium Development Goals (MDGs), especially in reducing child mortality, combating infectious diseases and to ensuring environmental sustainability. The aim of this study was to assess the water supply and microbial quality of the water in selected schools across rural Kathmandu valley. Twenty three school health surveys were carried out during the study period, which included both government and privately run schools. The total number of students attending the various schools was 6227 overall. Forty six water samples were collected and tested using the Multiple tube test method for detecting total coliforms. It was observed that 65.09% of the schools had access to 'improved water supply' namely piped water and tube wells. Nine (81.81%) of the schools purirified the water at end-use point. Only two methods of purification were found to be in practice, Euroguard (60%) and Ceramic filter (40%). None of the schools carried out disinfection of the drinking water sources. The total coliform (TC) positive rate for source water samples was 91.30% and for drinking water samples was 65.21%. The TC positive rate for piped water samples was 88.88%, tube well samples was 83.33% and open well was 87.50%. Seasonal variation in the microbial quality of source and drinking water was observed as water samples collected during the months of May, June, July and August were the most heavily contaminated. The detection of total coliform bacteria indicating faecal contamination of drinking water sources in the schools poses a health risk to the students and school staff alike. We recommend disinfection of drinking water sources especially during the monsoon season and regular maintenance of water purification filters to ensure proper action. Solar water disinfection may be an easy, low-cost option for providing safe water in schools.

Keywords: Microbial water quality, School health survey, Water supply

INTRODUCTION

Safe and sufficient drinking-water, along with adequate sanitation and hygiene have implications across all Millennium Development Goals (MDGs), from eradicating poverty and hunger, reducing child mortality, improving maternal health, combating infectious diseases, to ensuring environmental sustainability. As the world turns its attention to the formulation of the post-2015 Sustainable Development Goals (SDGs) much remains to be done particularly to reduce inequalities across populations:748 million people lack access to improved drinking-water and it is estimated that 1.8 billion people use a source of drinking-water that is faecally contaminated.[1] The WHO defines a health-promoting school as "one that constantly strengthens its capacity as a healthy setting for living, learning and working."[2] Provision of safe and sufficient water, sanitation, and shelter from the elements are basic necessities for a healthy physical learning environment. Equally important is the protection from biological, physical, and chemical risks that can threaten children's health.[3] More than 1.4 billion children from age 5 to 14 years, approximately 87 % of them live in developing countries, where many of the biggest environmental challenges exist. The school age children's environment expands beyond their homes and care centres. Several potential environmental risks are particularly associated with children in this age period.[4] Infectious diseases carried by water are risks that children and school personnel face at schools throughout the world.[5] The groundwater in Kathmandu, Nepal, is unsafe to drink due to presence of coliform bacteria.[6] Schools, particularly those in rural areas, often completely lack drinking-water and sanitation facilities, or have facilities that are inadequate in both quality and quantity.

MATERIALS AND METHODS

This study aims at assessing the water supply and bacteriological quality of water in selected schools across rural Kathmandu valley. The study was conducted between April 2012- December 2014. Schools within the vicinity of a teaching hospital in Kathmandu valley were listed out and contacted for carrying out a school health survey. Schools which consented to the survey were

Type of school/Type of water supply	Piped water supply	Tube well	Open well	Total Surveys
Government	3 (50%)	1 (16.67%)	2 (33.33%)	6
Private	6 (35.29%)	5 (29.41%)	6 (35.13%)	17
Total	9 (39.13%)	6 (26.09)	8 (34.78%)	23

Chi squared 0.5261;df; 2 p=0.7687 NS

then included in the study. The survey was carried out by the faculty, post graduate and undergraduate students posted in the Department of Community Medicine. Water quality assessment was carried out as a part of the school environmental and health survey. One sample (1 liter) from source of water supply and one sample (1 liter) of drinking water was collected using aseptic techniques in sterile Winchester quart bottles during each survey. Multiple tube test method for detecting Total Coliforms (As per National Drinking Quality Standards and Directives, 2005), was used.[7] Measured quantity of sample water 0.1 ml, 1 ml and 10 ml were inoculated in 3 tubes each, containing McConkey's lactose bile salt broth (dry media) with bromocresol purple as an indicator. The tubes were incubated for 48 hours. The tubes showing colour change or gas formation or both were taken as positive. The result obtained was compared with the Modifi ed McCrady's table and the MPN INDEX was calculated. As per the WHO guidelines for drinking water quality, in all water directly intended for drinking, E. coli or thermotolerant coliform bacteria must not be detectable in any 100 ml sample.[8] But guidelines explicitly state that a relaxation of up to 10 fecal coliform (fc) bacteria per 100ml is acceptable in community-managed un-chlorinated supplies. The recommended limit of 10fc/100ml is classified as "low risk" to health by WHO.[9] The water quality was then assessed as satisfactory when the MPN Index was less than 3; 3-10 was suspicious and more than 10 was labeled as unsatisfactory. Data was entered in Epi Info 7 and data analysis was carried out accordingly.

RESULTS

Twenty three school health surveys were carried out during the study period, each of 2 days duration. A total of eleven schools were covered out of which 4 were Government schools and 7 were privately run schools. The schools were located in Arubari (26%), Boudha (8.7%), Gokarna (26.09%), Kapan (26.09%), Mahankal (8.7%) and Nayapati (4.35%). The total number of students attending the various schools was 6227. A total of 46 water samples were collected during the study period. The type of water supply among the schools during the study period was, 39.13% had piped water supply, 26.09% used water from a tube well and 8 (34.78%) used water from an open well situated in the school premises (Table 1). Nine (81.81%) out of the schools surveyed purifi ed the water for drinking purpose. Only two methods of purification were found to be in practice during the surveys, Euroguard (60%) and Ceramic filter (40%). Ceramic filter was used by 75% of the government schools and 67 % of the private schools used Euroguard to purify the drinking water (Table 2).

Table 2. Method of water purification

Type of school/ Method	Ceramic Filter	Euroguard	Total
Government	2 (75%)	1 (25%)	3
Private	2 (33.33%)	4 (66.66%)	6
Total	4	5	9

Fisher Exact test 2 tailed; p value= 0.2553 NS

MPN Index of the source water samples (n=23) was examined for bacterial quality: 15 samples (65.22%) had an MPN Index of 1100. Only 2 samples had an MPN Index of 0. The total coliform (TC) positive rate for source water samples was 91.30%. The TC positive rate for piped water samples was 88.88%, tube well samples was 83.33% and open well was 87.50%. MPN Index of the drinking water samples (n=23) examined for bacterial quality. The minimum value was 0 and the maximum value was 460, 34.78% of the samples were of satisfactory quality. In 21.74% of the samples, the MPN was 240 and in 17.39% MPN was 460. The total coliform positive rate for drinking water samples was 65.21 and 88.88% of the source water samples were of unsatisfactory quality. It was observed that 56.18% of the drinking water samples were of unsatisfactory quality, 13.05% were of suspicious quality and 34.78% were of satisfactory quality (Table 3).

Table 3. Bacterial Water quality assessment based on MPN Index

Water Sample/Water Quality	<3 Satisfactory	3-10 Suspicious	>10 Unsatisfactory	Total samples
Source water	2	0	21	23
Drinking water	8	3	12	23
Total	10	3	33	46

Seasonal variation of bacterial quality of source and drinking water: The water samples collected during the months of May, June and July were the most heavily contaminated and only the samples collected in February were not contaminated. (fig 1 and 2) and 25% of the water samples purified by a ceramic filter were of satisfactory quality, whereas, 62.5% were of suspicious quality and 12.5% of unsatisfactory quality.

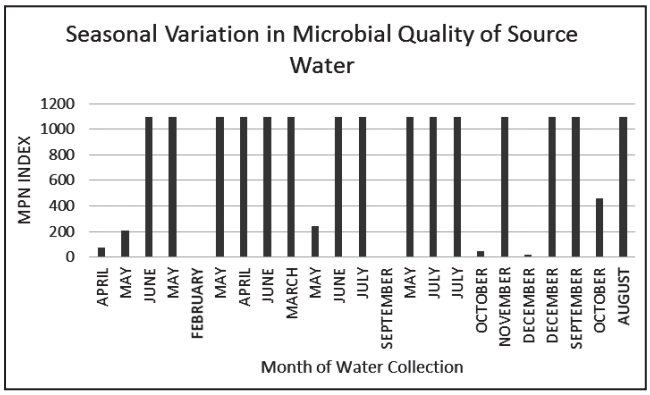

Fig 1. Water samples collected during the months of May, June, July, August and September

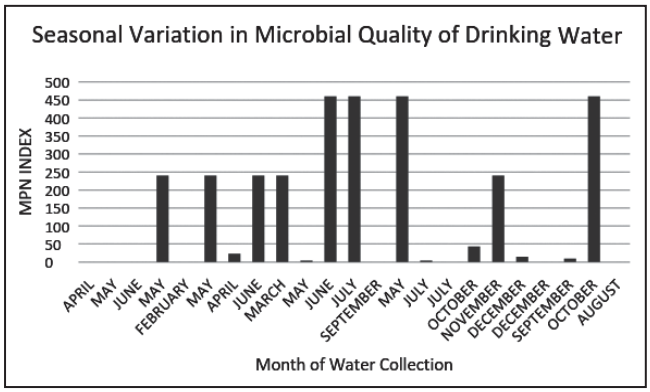

Fig 2. Drinking water samples collected during May, June, July and October were heavily contaminated

Of the water samples purifi ed by a Eurogard filter, 50% were of satisfactory quality, 33.33% were of suspicious quality and 3 were of unsatisfactory quality. (Table 4).

Table 4. Microbial water quality assessment after purification

Method of Purification/ Water Quality	<3 Satisfactory	3-10 Suspicious	>10 Unsatisfactory	Total
Ceramic filter	2 (25%)	5(62.5%)	1(12.5%)	8
Euroguard	6 (50%)	4(33.33%)	2(16.67%)	12
Total	8	9	3	20

Chi square value=1.713 p=0.427 NS

DISCUSSION

During our survey, we found that all of the 11 schools had access to water supply. Among them, 65.09% of the schools had access to an 'improved water supply.' There was no significant difference between government and private schools' water supply. (Table 1) WHO defines improved water supply as characterized by (i) a significant increased probability that the water is safe (ii) that it is more accessible (iii) some measures against contamination are being taken to protect the water source (stand post, borehole, protected spring or well, or collected rainwater).[10] Access to improved (piped) drinking water facilities in Nepal varies across social groups and place of residence. However, access is better in urban (58 percent) than rural (41 percent) areas. Access to clean water (proportion of population using an improved drinking water source) in Nepal was 46% in 1990, 73% in 2000 and increased to 85% in 2012.[11] Although improved water supply is the best measurable standard, it does not guarantee safe water supply, as seen in our study. Better water supplies and sanitation in schools, in rural areas in particular, are important in ensuring school attendance. The amount of water available is as important as its quality. According to the WHO Guidelines sufficient water should be available at all times for drinking, personal hygiene, food preparation, cleaning and laundry. In day-schools 5 litres per person per day for all schoolchildren and staff is the basic quantity of required water. Water-washed diseases arise from insufficient water to permit regular washing of the hands, face, body and clothes, and cause skin and eye infections.[12] Jasper C *et al* performed a systematic review of the literature on the effects of water and sanitation in schools. There is a reported decrease in diarrheal and gastrointestinal diseases with increased access to adequate sanitation facilities in schools.[13] In our study, a majority of the schools surveyed (81.81%) purified the water for drinking purpose. Only two methods of purification were found to be in practice during the surveys, namely Euroguard (60%) and Ceramic filter(40%). None of the schools were disinfecting the drinking water or the source using chemicals. (Table 2) There is no available data on methods of water purification among schools in Nepal. However, according to a USAID study, only about 10% of the households in Nepal treat their drinking water. Even in major urban centers like Kathmandu, only 29% treat their drinking water through various means.[14] In our study, the microbial quality assessment of the water revealed heavy contamination of the source water. 91.30 % of the source water samples crossed the ideal WHO criteria and 71.73% of source water samples crossed the WHO 'acceptable' guidelines. (Table 3) Similarly, the assessment of the drinking water samples revealed that only 34.78% of the samples were of satisfactory quality after purification. There was no significant difference between the two methods of purification. (Table 4) Prasai *et al* evaluated the quality of drinking water of Kathmandu valley and reported that total plate and coliform count in 82.6% and 92.4% drinking water samples respectively were found to cross the WHO guideline value for drinking water.[15] Pant BR in a study to assess the quality of groundwater in the Kathmandu Valley, Nepal found that the total coliform bacteria enumerated in groundwater significantly exceeded the drinking-water quality standard and observed maximum coliform (267 CFU/100 mL) in shallow wells.[16] In our study, we observed a seasonal variation in the microbial quality of source and drinking water. The water samples collected during the months of May, June, July and August were most heavily contaminated. Karki and Tiwari reported that

acute diarrhoea becomes epidemic during the rainy season in Kathmandu. Among 349 patients with gastrointestinal disease, 26.0% were found to have bacterial infection, out of which, 25.1%, 0.28%, 0.28%, and 0.28% were found to be *Vibrio cholerae* 01, *Vibrio cholerae* 0139, *Shigella dysenteriae* and *Escherichia coli* respectively. Cholera cases were found almost throughout the year in the city though the numbers increased during the rainy season. It was highest during July (34.6%) followed by August (32.35%), September 32% and June (6.89%).[17] Rai *et al* in a large scale study in bacterial contamination of drinking water in Nepal reported a total coliform positive rate of 87% in the central district region, which included Kathmandu valley. Total Coliform positive rate of 80% was reported for mineral or Euroguard treated water.[18] Results indicated that 91.30% of the source water samples and 65.21% of drinking water samples in the schools were contaminated with thermotolerant coliforms and presumptive *E. coli.* The detection of total coliform bacteria in piped water, tube well and open well, which are drinking water sources in schools pose health risk to the students and school staff alike. It is estimated that if everyone in the world had access to a regulated piped water supply and sewage connection in their houses, 1863 million days of school attendance would be gained due to less diarrhoeal illness.[19] The World Health Organization has issued guidelines for water, sanitation, and hygiene implementation in schools in low cost settings.[14] Implementation of these regulations at the national level could result in improved water and sanitation conditions in schools. Such regulations would serve to overcome barriers to education, particularly in low resource settings where schools, teachers, and administrators may not recognize the potential impact of water and sanitation on health and education. The conditions required for clean water are well known but are often unachievable. Recommendations to boil water are of little value in a society where fuel is expensive and scarce. Achievable measures are often those concerned with handling of available water. Solar water disinfection may be an easy, low-cost, small-scale and immediate technique for providing safe water.[20] We have intimated the study results to the school authorities and advised them to take adequate care to disinfect the source of water supply. We have also recommended regular maintenance of purifi cation equipment to ensure proper action. Regular assessment of the water quality and disinfection especially during the monsoon and summer season was emphasised. Age appropriate health education was also imparted to the school children during the survey on personal hygiene, hand washing, food and water safety.

REFERENCES

1. WHO. Water and Sanitation Hygiene 2014. Available at: http://www.who.int/entity/water_sanitation_health/publications/glaas_report_2014/en/index.html Accessed: 22 March 2016
2. WHO. WHO's Global School Health Initiative: Health Promoting school 1998 WHO/HPR/HEP/98.4 Available at: http://www.wpro.who.int/health_promotion/about/health_promoting_schools_framework/en/ Accessed: 20 March 2016
3. WHO. The Physical School Environment: An Essential Component of a Health-PromotingSchool.Availableat:http://www.who.int/school_youth_health/media/en/physical_sch_environment.pdf Accessed: 20 March 2016)
4. UNICEF/UNEP/WHO.Children in the new millennium Available at: http://www.who.int/iris/handle/10665/42506 Accessed: 20 March 2016
5. Moe CL, Rheingans RD, Global challenges in water, sanitation and health, *J Water Health.* 2006; 4 Suppl 1:41-57.
6. Aryal J, Gautam B, Sapkota N, Drinking water quality assessment, *J Nepal Health Res Council*, 2012 September 2012; 10(22):192-6.
7. WHO/ Department of Water Supply & Sewerage. National Drinking Water Quality Standards, 2005 Available at: http://mowss.gov.np/article/34/national-drinking-water-quality-standards-2062.html Accessed: 22 March 2016
8. WHO. Guidelines for drinking-water quality, 2004, 3rd ed. Vol.1, Recommendations.Geneva.Availableat: http://www.who.int/water_sanitation_health/dwq/GDWQ2004web.pdf Accessed: 20 March 2016
9. WaterAid in Nepal. Protocol - Water quality standards and testing policy 2011. Available at: https://www.bolpatra.gov.np/ppmo/download?alfId=6e103fea-bbe0-4ae3-852f-72aa2e84525d&docId=38842 Accessed: 20 March 2016
10. WHO. Water and Sanitation Hygiene: Are Countries in Asia on Track to Meet Target10oftheMDGs?Availableat:http://www.who.int/water_sanitation_health/publications/aww5.pdf Accessed: 20 March 2016
11. GoN (Government of Nepal). MDGs Acceleration Framework: Improving Access toSanitation2012.Availableat: http://www.np.undp.org/content/nepal/en/home/library/mdg/mdgs-acceleration-framework.html Accessed: 22 March 2016
12. WHO. Guidelines for water, sanitation and hygiene in schools in low-cost settings. 2008Edited by John Adams, Jamie Bartram, Yves Chartier, Jackie Sims Available at:http://www.who.int/water_sanitation_health/publications/wash_standards_school.pdf Accessed: 15 March 2016
13. Jasper C, Le T-T, Bartram J. Water and Sanitation in Schools: A Systematic Review of the Health and Educational Outcomes. *International Journal of Environmental Research and Public Health.* 2012;9(8):2772-2787.
14. USAID. Safe Practises On Water, Sanitation And Hygeine (SAFE-WASH) Project 2015. Available at: https://www.usaid.gov/nepal/fact-sheets/safe-wash-project Accessed: 22 March 2016
15. Prasai T, Lekhak B, Joshi DR, Baral MP. Microbiological analysis of drinking water of Kathmandu valley, *Scientific World,* 2007; 5(5):112-4.
16. Pant BR, Ground water quality in the Kathmandu valley of Nepal, *Environ Monit Assess.* 2011 Jul;178(1-4):477-85.
17. Karki A, Tiwari BR. Prevalence of acute diarrhoea in Kathmandu Valley. *J Nepal Med Assoc* 2007; 46: 175-9.
18. SK Rai, K Ono, J-I Yanagida, S Ishiyama-Imura, M Kurokawa and CK Rai. A large-scale study of bacterial contamination of drinking water and its public health impact in Nepal, *Nepal Med Coll J* 2012; 14(3): 234-240.
19. WHO. Water, sanitation and hygiene links to health. 2004Geneva. Available at: http://www.who.int/water_sanitation_health/publications/facts2004/en/ Accessed: 22 March 2016
20. WHO. Primary school physical environment and health. Available at: http://apps.who.int/iris/bitstream/10665/63720/1/WHO_SCHOOL_97.2.pdf Accessed: 22 March 2016