THE JOURNAL OF RESEARCH REVIEW

P-ISSN: 3006-2632	E-ISSN: 3006-2640
Vol. 1. No. 04 (Oct-Dec) 2024	Page 434-441

Assessment Of Drinking Water Quality And Waterborne Diseases In Primary Schools Of District Khyber, Khyber Pakhtunkhwa, Pakistan

Junaid Afridi	M.Phil, Department of Environmental Sciences University of Peshawar Junaidafridi774@gmail.com
Furqan Khan	M.Phil, Department of Environmental Sciences University of Peshawar. furqankhalil669@gmail.com
Syed Asimullah	M.Phil, Department of Environmental Sciences University of Peshawar. syedasimullah2@gmail.com
Jamshed Khan	M.Sc, Department of Environmental Sciences University of Peshawar. jamshedafridi350@gmail.com

Abstract: *The purpose of this study was to assess the drinking water quality and assess the prevalence of water-borne diseases in primary schools in the district Khyber. A simple random - sampling technique was used for selection of schools and 63 schools were selected (8%) for in-depth investigation. Three drinking water samples were collected from each school and were analyzed for physical, chemical parameters and coliform bacteria. The World Health Organization's (WHO) drinking water quality standards were found to be met by all of the physical and chemical parameters. Among all the Schools, 34% of the schools were found positive for coliform bacteria. By comparing government and public (private) schools, drinking water in 41% of government school was unsafe while (25%) private schools water was found unsafe in terms of drinking water quality. To assess the drinking water quality and prevalence of waterborne diseases, a questionnaire survey was also conducted in the selected schools. The data from the questionnaire revealed that there were three main sources of water, tube well, dug well and spring. 30% of schools have no access to clean drinking water and 70.8% have no water quality monitoring system in the schools. It also revealed that Diarrhea was the most common waterborne disease among the school children. It is recommended to regularly disinfect water storage facilities and to monitor water quality on a regular basis and make the available water safe for drinking.*

Keywords: Pakistan, Afghanistan, Waterborne, World Health Organization

Introduction

Unsafe drinking water, inadequate sanitation, and poor hygiene practices are significant contributors to the global burden of disease. Contaminated water, harboring pathogens, parasites, and toxic substances, serves as a breeding ground for various waterborne illnesses, including cholera, typhoid fever, and poliomyelitis. These diseases often spread through the consumption of contaminated water or food, contaminated by fecal matter, pesticides, or other pollutants(1)

Children's health is directly affected by drinking water quality.(2) A school's physical surrounds, psychological support system, learning environment, and health-promoting atmosphere—which prioritizes disease prevention and health promotion for both staff and students—all contribute to a safe and healthy learning environment.(3)

Drinking water quality is very important for people's health and wellness(4). Schools with Water, Sanitation, and Hygiene (WASH) facilities can contribute to the well-being and educational achievements of pupils.(5)In developing regions, primary school-aged children often face a deficiency of safe drinking water leading to a high prevalence of waterborne illnesses and poor performance in school. A significant portion of a child's daily schedule is allocated to attending middle and primary school. The use of drinking water at school has a significant role in the growth, development, cognitive function, and academic achievement of students.(6)

Waterborne diseases give rise to illness that leads to morbidity and mortality in children under the age of 5 in less developed nations.(7)

In Pakistan, the degradation of drinking water quality is exacerbated by the increasing population size and rapid industrialization. Contaminated water serves as the predominant source of numerous diseases, including diarrhea, gastroenteritis, and typhoid(8).According to recent research, drinking water supplies in schools are frequently alarmingly contaminated with microbes, which puts kids at risk for waterborne illnesses like cholera, typhoid, diarrhea, and gastroenteritis.(9) The burden of waterborne diseases particularly diarrheal diseases among children remains high where substantial population lacks access to WASH services.(10)More than five million people die annually due to waterborne diseases. It's due to lack of safe drinking water supply systems (liew et al. 2006). The global issue of inadequate sanitation and unsafe drinking water remains a significant concern, as it is closely linked to high rates of both mortality and morbidity. Among the affected population, children under the age of five are particularly vulnerable. It is notable that a substantial proportion of mortality and morbidity cases occur within this age group.(11) The World Health Organization (WHO) has given data that indicates the annual death toll from water-related illnesses is approximately 3.4 million. Among this figure, around 2.2 million deaths occur, with children constituting 90% of the affected population. The deaths mostly affect individuals residing in developing nations and are primarily caused by diarrheal diseases such as cholera, typhoid, and dysentery, which are directly linked to the consumption of contaminated water sources.(12) Diseases brought on by contaminated drinking water place a significant cost on human health. The health of those who are particularly vulnerable, such as children, the elderly pregnant women, those with chronic diseases, etc., can be adversely affected by pollutants in drinking and drinkable water. For instance, the societal impact of aquatic infectious diseases like cholera and typhoid may result in several epidemics.(13) In the context of Pakistan, an estimated annual mortality rate of approximately 250,000 children below the age of five is attributed to diarrheal causes. The prevalence of waterborne diseases and illnesses has led to increased expenditures on health care facilities and increased poverty levels within rural communities.(14)

Researches show that water and sanitation services are responsible for high Level of diseases in the third world countries.(15) Disease outbreaks in different parts of the developing world can be caused by poor water quality. Throughout the world millions of people die due to waterborne diseases.(16) The issue of water contamination is more worsened as the economy expands, hence exerting an adverse effect on the overall quality of drinking water. Based on a study, it has been shown that approximately half of all worldwide diseases can be linked to the consumption of drinking water that has been contaminated.(16) The two major challenges facing developing countries are poor drinking water quality and limited water resources. It is reported that poor drinking water quality and sanitation is the major cause of spreading waterborne diseases which includes cholera, dysentery and hepatits A and E.(17) Children's social and physical environments at school have an impact, making this a crucial area to research and target interventions to stop. The spread of infectious diseases.(18) Various schools act as reservoirs for diseases brought on by poor water supply, sanitation, and hygiene. Rural schools either lack access to drinking water or have water that is of poor quality and quantity.(19)

According to estimates from the World Health Organization, just 20% of Pakistan's population has access to clean drinking water.(20) Lack of water supply and poor water quality might result in a variety

of health issues. Water that is hazardous has a high infant death rate. As a result, the quality of drinking water should be absolutely lacking of any pathogenic microorganisms or physico-chemical elements in concentration that have a negative impact on health.(21)One of the initial objectives Sustainable development goal 6 (SDG6) which was developed by united nation general assembly in 2015, is access to clean, affordable drinking water for all people. Approximately 70% of the population living in Pakistan rely on groundwater as their primary source of water supply. However, the excessive extraction of groundwater is leading to a considerable decline in the water table.(14) Water pollution arises from various sources, including the discharge of sewage and wastewater from industries, the runoff from land surfaces, and other human activities that change the physical characteristics (such as color, taste, and odor) and chemistry of water. The presence of pollutants and contaminants in water has been found to be associated with the spread of waterborne diseases such as cholera, typhoid fever, malaria, amoebiasis, and diarrhea.(22)Groundwater is the main source of supplies in the majority of urban areas in Pakistan. This groundwater has been polluted with many pathogens, including viral, bacterial, and protozoan agents. As a result, the presence of these pathogens leads to a significant number of deaths, with around 2.5 million fatalities occurring annually due to endemic diarrheal diseases.(23)

More than half of the 6 million people in Khyber Pakhtunkhwa's districts of Peshawar, Mardan, Charsadda, and Nowshera are currently facing a lack of adequate access to potable water. The other part of the population obtains its potable water supply from tube wells, which are exposed to contamination by heavy metals and biological contaminants coming from local sources such as toilets, damaged underground sewerage pipes, and the infiltration or percolation of contaminated surface water. In certain rural areas of the Charsadda district, the water table has been observed to have a depth of only 4 metres. This shallow water table increases the potential for contamination from agricultural chemicals, particularly heavy metals such as sulphate (SO4) and nitrate (NO3).(24)

Study Area Description

Khyber is a district in northern Pakistan, bordered by Afghanistan, Peshawar, Kurram, and Orakzai. It is delineated by the Suffaidkoh Mountain range to the north, Kurram to the west, the River Kabul to the east, and the Peshawar valley to the south. The district spans 2,567 square kilometers and is divided into three tehsils: Bara, Jamrud, and Landi Kotal. (25) Socio-economically, the district shows substantial poverty, with 33.7% of households extremely poor, 12.3% ultra-poor, and 32.2% poor; as of June 2011, 51.9% of families were below the poverty line, with poverty depth and severity at 10.52% and 3.7%, respectively (26) (27) Cultural norms are stringent, particularly affecting women who adhere to purdah and have restricted mobility and decision-making roles. The predominant ethnic group is Pushtun, including Afridis, Shinwaris, Mollagoris, and Shilmanis, with land being a critical yet contentious resource. Major income sources include transportation and livestock farming, and education is undervalued due to security concerns (NHA, 2018). As of 2007, Khyber had the highest literacy rate among tribal areas at 34.2%, though female literacy was significantly lower at 10.1%, with limited access to middle and secondary schools for females.(25) The 2017 census recorded a population of 986,973, with a density of 212 people per square kilometer and an average household size of 9.9. The majority of the population is Muslim (98.5%), with minor communities of Sikhs (1.9%) and others (0.2%) (NHA, 2018). The climate is semiarid subtropical continental highland, experiencing significant seasonal temperature variations, with summer temperatures ranging from 25°C to over 40°C and winter temperatures from 4°C to 18.35°C. Rainfall is concentrated in March, April, July, and August, with an average annual total of approximately 400mm.(28)

Materials and methods

In this study, water samples were collected from 63 randomly selected primary schools, both public and private, across the Khyber District, using a simple random sampling technique to ensure a representative sample. The schools included a balanced mix of boys' and girls' institutions. Three types of water

samples—source, storage, and tap—were collected from each school in 800 ml polyethylene bottles, with groundwater samples taken after running the pump for 5-10 minutes to obtain representative samples. These samples were transported to the laboratory within 24 hours and refrigerated upon arrival. A questionnaire survey was administered to the head teachers of each school to gather information on drinking water quality, the incidence of waterborne diseases among students, and the availability and monitoring of water storage facilities.

Laboratory analyses were conducted to determine total dissolved solids (TDS), electrical conductivity (EC), pH, turbidity, chloride, nitrate, total hardness, and the presence of coliform bacteria, using digital instruments and standard methods from the American Public Health Association (APHA, 2012). Instruments were calibrated before each use. For pH measurements, buffer solutions of pH 4, 7, 10, and 12 were prepared and used for calibration. TDS was determined using the gravimetric method, while turbidity was measured with a nephelometric method. Chlorides were analyzed using the argentometric titration method, and nitrates were measured via ultraviolet spectrophotometry. Total hardness was determined by the EDTA titrimetric method.

For microbial analysis, pre-sterilized plastic bottles were used to collect samples for coliform bacteria testing. The membrane filtration method was employed, using lauryl sulfate broth and a series of sterilizing solutions to ensure equipment cleanliness. Filtered samples were incubated at 35°C for 24 hours to count total and fecal coliform colonies. The study's comprehensive approach provided a detailed assessment of the water quality in Khyber District's primary schools, aiming to identify potential health risks and inform strategies for improving water safety and management in the region.

Results

All the selected physical parameter (PH, Electrical conductivity, Turbidity and total dissolved solids) and chemical parameter (Total hardness, chloride and nitrate) were found to be within the permissible limits as recommended by WHO (World health organization).Total coliform concentrations range from 5 CFU/100ml to 90 CFU/100ml. All of the elementary schools' drinking water sources were confirmed to be safe and negative for total coliform and fecal coliform. However, six (9.52%) of the schools' storage and end users were positive for total coliform only while 34.92% of schools were found positive for both total coliform and fecal coliform.The sources of drinking water of primary schools of district Khyber were free of both total coli form and fecal coliform. While the storage and end user of 16 schools (25%) were contaminated with both total coliform and fecal coliform.so the drinking water of 34.92% of schools is unsafe for drinking. The concentration of both fecal coliform of all positive water sample of storage and end user ranges from3 CFU/100ml to 63CFU/100ml.

In a questionnaire survey, 69.2% of respondents reported having access to clean drinking water, while 30.8% did not. Most participants (86.2%) indicated that their schools have water storage facilities, although 13.8% reported the absence of such facilities. Primary sources of drinking water include tube wells (35%), dug wells (22%), spring water (12%), and hand pumps (3%). However, 70.8% of respondents noted that water quality monitoring is not conducted regularly, with only 10.8% confirming some form of monitoring at various intervals. Among storage options, plastic water tanks are the most common (50.8%), followed by groundwater tanks (16.9%), above-ground tanks (18.5%), water coolers (4%), and pots (2%). While 49.2% of head teachers reported regular cleaning of storage facilities, 50.8% said maintenance is inconsistent. A small percentage (12.3%) of schools have modest-scale water treatment facilities, and 9.2% of respondents noted some government or non-government oversight of water quality. The majority of respondents (70.8%) are aware of waterborne illnesses, though 29.2% are not. Data from health sources indicate that diarrhea (40%) is the most common waterborne illness among schoolchildren, followed by hepatitis A (33.8%), typhoid (10.8%), and dysentery (6.2%). Concerns about waterborne illnesses vary, with 27.7% of respondents reporting cases, 32.3% denying any cases, and 40% expressing doubts. Additionally, 30.8% of teachers have received training on preventing waterborne illnesses, while 69.2% have not. Only 29.2% of respondents reported parental

concerns about water quality, suggesting that communication with parents regarding water safety remains important.

Discussion

Waterborne infections are most common in infants and early children, especially when they are living in unhygienic environments.(29) Access to clean water and sanitation facilities are two examples of hygiene practices that have a significant impact on children's health.(30)

A similar study was conducted on drinking water quality in Rohri city, Sindh, Pakistan. Analysis of groundwater samples revealed total coliform (TC) and E. coli (Ec). Bacteriological analysis used membrane filtration and spread plate count (SPC). Prior to storage, groundwater samples were contaminated with 25% TC and 12.5% Ec. All post-storage groundwater samples were contaminated with 100% TC and 41.6% Ec.(31) In our study 41% of the government schools and 25% of private schools storage were found to be contaminated with both total and fecal coliform.

In another study the drinking water quality in, water sources, treatment facilities, school locations, and grade levels of 42 schools were examined. Only 45 percent of schools were found to get their drinking water mostly from tap sources, and 26.2% of the water tested negative for microorganisms. The tap water used by schools below the junior high school level was slightly more turbid than the standard value, but all other physical and chemical parameters (pH value, turbidity, soluble total solid, total hardness, and free available residual chlorine) and metal contents (Mn, Zn, Cu, Fe, Mg, and Ca) met the domestic standards.(32) in our study both physical including turbidity and chemical parameters were found within the permissible limits. In contrast, our sample were tested positive for microorganism.

In a similar study Peshawar it was found that the daily and annual risks of hepatitis A for primary school students were classified as moderate to high, and that the general drinking water quality in Sindh's primary schools was found to be noticeably bad.(33) In our study it was also found that the drinking water quality was unsafe in term of microbiological parameters. Data from the questionnaire revealed that 33.8% children were affected by HAV, second most common waterborne disease in our study area.

In a similar study for microbial pollution in drinking water in some parts of Pakistan was conducted. It was found that the primary source of pollution in the drinking water system supplies was widespread discharge of sewage, particularly faeces. According to the study's findings, which account for around 80% of all cases that are recorded and contribute 33% of death rates, human-induced activities are the main cause of waterborne diseases.(34) Our study also concluded that pipe leakage and poor sanitation services are the main cause of waterborne diseases prevalence.

A similar survey carried out in Tanzaniz revealed that just 16% of respondents boil their water before consuming, whereas the bulk of respondents rely on public water sources (i.e., 40% on public taps and 36.9% on public water kiosks). Additionally, those surveyed acknowledged the significance of hand washing at crucial moments. Merely 31.7% and 72.6% of people wash their hands with soap prior to and following meals, respectively. As per the self-reporting of the respondents, diarrhoea accounted for 10.5% of the commonly recognised WASH incidence. Other reported cases were cholera (8.2%) and typhoid (2.3%), which primarily affected children under the age of five (14.5%(32) Our study also showed that 49% of the schools have no hand washing facilities with soap. Similarly diarrhea was the most common waterborne diseases found in children.

Pakistan's water quality is seriously harmed by faecal and microbiological contamination from a variety of sources, which presents health hazards to the entire country. According to a research conducted in Karachi, 96% of water samples had total coliform, which has caused a high rate of waterborne illnesses in the city's population, including diarrhoea, vomiting, and skin problems. Our study also showed that 34% of the schools water were found contaminated with fecal coliform. (35)

Conclusion

Based on our thorough assessment of the drinking water quality and prevalence of waterborne diseases in primary schools within the district of Khyber, Khyber Pakhtunkhwa, Pakistan, we concluded that while the water is safe in terms of physical and chemical parameters, it is unsafe in terms of coliform bacteria contamination. Our study revealed that 34% of the sampled schools had coliform contamination, with 25% of private schools and 41% of government schools affected. The main water sources identified were tube wells, dug wells, and springs. Alarmingly, only 30% of schools had access to clean drinking water, and 70.8% lacked a means for checking water quality. According to our questionnaire data, 87.7% of schools have no system to monitor their drinking water quality. Diarrhea, the most common waterborne disease, affects 40% of schoolchildren. Additionally, 80% of schools lack any water quality improvement efforts, and 49.2% have no hand washing facilities with soap. These findings underscore the urgent need for comprehensive water quality monitoring and improvement initiatives in schools to safeguard children's health.

References

Madamanchi D. Water, sanitation, and hygiene (WASH) strategies in the fight against waterborne diseases in the young and old. Journal of Family Medicine and Primary Care. 2024;13(8):3481-2.

Hanif A, Nakano Y, Matsushima M. The benefit of clean water on child health: An empirical analysis with specific reference to Escherichia Coli water contamination. Water Resources and Economics. 2024;47:100249.

Bakır B, Babayigit MA, Tekbaş ÖF, Oğur R, Kılıç A, Ulus S. Assessment of drinking water quality in public primary schools in a metropolitan area in Ankara, Turkey. International journal of health sciences and research. 2015;5(4):257-66.

Ahmed J, Wong LP, Chua YP, Channa N, Mahar RB, Yasmin A, et al. Quantitative microbial risk assessment of drinking water quality to predict the risk of waterborne diseases in primary-school children. International journal of environmental research and public health. 2020;17(8):2774.

Subramanyam AA, Somaiya M, De Sousa A. Mental health and well-being in children and adolescents. Indian Journal of Psychiatry. 2024;66(Suppl 2):S304-S19.

Kaushik A, Mullee M, Bryant T, Hill C. A study of the association between children's access to drinking water in primary schools and their fluid intake: can water be 'cool'in school? Child: care, health and development. 2007;33(4):409-15.

Manetu WM, Karanja AM. Waterborne disease risk factors and intervention practices: a review. Open Access Library Journal. 2021;8(5):1-11.

Atif M, Ayub G, Shakoor F, Farooq M, Iqbal M, Zaman Q, et al. Evolution of waterborne diseases: A case study of Khyber Pakhtunkhwa, Pakistan. SAGE Open Medicine. 2024;12:20503121241263032.

Kristanti RA, Hadibarata T, Syafrudin M, Yılmaz M, Abdullah S. Microbiological contaminants in drinking water: Current status and challenges. Water, Air, & Soil Pollution. 2022;233(8):299.

Needs H. Interventions to Mitigate Burdens of Waterborne and Water-Related Disease. Textbook of Children's Environmental Health. 2024:378.

Zahid J. Impact of clean drinking water and sanitation on water borne diseases in Pakistan. 2018.

Al Osman M, Yang F, Massey IY. Exposure routes and health effects of heavy metals on children. Biometals. 2019;32:563-73.

Bilal M, Iqbal I, Rana RM, Rehman SU, Haidery Q, Ahmad F, et al. A comprehensive review of effects of water stress and tolerance in wheat (Triticuma estivum L.). Tropical Plant Research. 2015;2(3):271-5.

Azizullah A, Khattak MNK, Richter P, Häder D-P. Water pollution in Pakistan and its impact on public health—a review. Environment international. 2011;37(2):479-97.

Halvorson SJ, Williams AL, Ba S, Dunkel FV. Water quality and waterborne disease in the Niger River Inland Delta, Mali: a study of local knowledge and response. Health & place. 2011;17(2):449-57.

Wen X, Chen F, Lin Y, Zhu H, Yuan F, Kuang D, et al. Microbial indicators and their use for monitoring drinking water quality—A review. Sustainability. 2020;12(6):2249.

Montgomery MA, Elimelech M. Water and sanitation in developing countries: including health in the equation. Environmental science & technology. 2007;41(1):17-24.

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):2772-87.

Adams J, Bartram J, Sims J, Chartier Y. Water, sanitation and hygiene standards for schools in low-cost settings: World Health Organization; 2009.

Razi N, Zahoor R, Abbas G. The Nexus between Fundamental Rights and Necessities of Life: A Case Study of Pakistan. Global Legal Studies Review. 2021;6(1):9-16.

Uniyal D, Aswal J, Chander V, Dobhal R, Srivastava N, Bari K. Drinking Water Quality Assessment in Schools of Garhwal Region Uttarakhand, India. J Env Bio-Sci. 2018;32(1):153-60.

Buor D. Water needs and women's health in the Kumasi metropolitan area, Ghana. Health & Place. 2004;10(1):85-103.

Daud M, Nafees M, Ali S, Rizwan M, Bajwa RA, Shakoor MB, et al. Drinking water quality status and contamination in Pakistan. BioMed research international. 2017;2017(1):7908183.

Khan S, Shahnaz M, Jehan N, Rehman S, Shah MT, Din I. Drinking water quality and human health risk in Charsadda district, Pakistan. Journal of cleaner production. 2013;60:93-101.

KHAN SN, KHAN AN, ULLAH I, RAHMAN AU, QASIM S. IMPACT OF INSURGENCY ON HIGHER SECONDARY EDUCATION: A CASE STUDY OF TEHSIL BARA, KHYBER AGENCY FATA, PAKISTAN.

Alam MM, Hussain S. Estimating the magnitude and correlates of poverty using consumption approach in Khyber Agency (FATA). Developing Country Studies. 2013;3(12):42-53.

Ghani N, Rukanuddin RJ, Ali TS. Prevalence and factors associated with postpartum vaginal infection in the Khyber agency federally administered tribal areas, Pakistan. Journal of Pakistan Medical Association. 2007;57(7):363.

Shah S, Khan M, Rahman H. Epidemiological and hematological investigations of tick-borne diseases in small ruminants in Peshawar and Khyber Agency. Pakistan J adv parasitol. 2017;4(1):15-22.

Edition F. Guidelines for drinking-water quality. WHO chronicle. 2011;38(4):104-8.

Bundy DA. Rethinking school health: a key component of education for all: World Bank Publications; 2011.

Shar AH, Kazi YF, Kanhar NA, Soomro IH, Zia SM, Ghumro PB. Drinking water quality in Rohri city, Sindh, Pakistan. African Journal of Biotechnology. 2010;9(42):7102-7.

Chung P-L, Chung C-Y, Liao S-W, Miaw C-L. Assessment of the school drinking water supply and the water quality in Pingtung County, Taiwan. Environmental monitoring and assessment. 2009;159:207-16.

Awan F, Ali MM, Afridi IQ, Kalsoom S, Firyal S, Nawaz S, et al. Drinking water quality of various sources in Peshawar, Mardan, Kohat and Swat districts of Khyber Pakhtunkhwa province, Pakistan. Brazilian Journal of Biology. 2024;84.

Azizullah A, Khattak MN, Richter P, Häder DP. Water pollution in Pakistan and its impact on public health--a review. Environ Int. 2011;37(2):479-97.

Amin R, Zaidi MB, Bashir S, Khanani R, Nawaz R, Ali S, et al. Microbial contamination levels in the drinking water and associated health risks in Karachi, Pakistan. Journal of Water, Sanitation and Hygiene for Development. 2019;9(2):319-28.