Short Communication

International Journal of Research in Pharmaceutical Sciences

Published by JK Welfare & Pharmascope Foundation

Journal Home Page: www.ijrps.com

Drinking Water and Sanitation Practices in North-Western Part of Kottayam District - A Cross Sectional Epidemiological Study

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Article History:

Received on: 04 Dec 2021
Revised on: 28 Jan 2022
Accepted on: 12 Feb 2022

Keywords:

Drinking water, Escherichia coli, Epidemiological, Waterborne diseases

Abstract

Safe drinking water and good sanitation facilities are prime factors for a healthy community. This will in turn limit the spread of diarrhoeal diseases. The purpose of the present cross-sectional epidemiological study was to obtain baseline data on drinking water in Vaikom, Kottayam district, Kerala, India. In this study, thirty households were surveyed and the targeted participants were mothers of the households with children under the age of five. Drinking water samples were collected and analyzed for bacterial contamination by membrane filtration (MF) techniques. 40% of the households used borehole water, while 33.3% used household tap water, 16.7% used healthy water and 6.7% depended on tanker truck water as a drinking water source. Only 3.3% uses bottled water as the primary drinking water source.73% of the water samples collected from tanker truck source are contaminated with *Escherichia coli*(*E.Coli)* and 61% of well water samples are contaminated with *E.coli*. For the bottled water category, it was seen only 2% was contaminated. Any presence of *E.coli* in the potable water means it is not safe to use. Continuous monitoring of water quality and effectiveness of the treatment processes, and following regulations, are essential to ensure that the water quality meets the set standards.

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ISSN: 0975-7538

DOI: https://doi.org/10.26452/ijrps.v13i2.495

Production and Hosted by

IJRPS | www.ijrps.com

INTRODUCTION

Water plays an important role to maintain humans in healthy conditions. Clean drinking water is one of the basic needs of human beings. The percentage of freshwater available on earth is 3%. In that, 68% is groundwater and 30% is surface water. Approximately 22% of the freshwater found at the earth's terrestrial surface is stored as groundwater. At the United Nations conference in Mar del Plata in 1977, which launched the International Drinking-Water Supply and Sanitation Decade, this philosophy was adopted unambiguously: "*all peoples, whatever their*

stage of development and social and economic condition, have the right to have access to drinking water in quantities and of a quality equal to their basic needs" [1].

The Constitution of India has given priority to the provision of clean drinking water, with Article 47 conferring the duty of providing clean drinking water and improving public health standards to the citizens of India. Water is defined as unfit for drinking, as per Bureau of Indian Standards (BIS) IS-10500-2012, if it is bacteriologically contaminated or if chemical contamination exceeds maximum permissible limits. In India, the Composite Water Management Index (CWMI) of NitiAayog, has confirmed that 70% of India's water supply was contaminated. Globally, India ranked 120^{th} among 122 countries in Water Quality Index (WQI) according to December 3^{rd}, 2019. Food Safety and Standards Authority of India (FSSAI) is an autonomous body established under the Ministry of Health and Family Welfare, Government of India. It has been established under the Food Safety and Standards Act, 2006, consolidating statutes related to Food Safety and Regulation in India. They have specified various plastic materials in which only the potable water should be stored. Some of the main types of containers are High Density Polyethylene (HDPE), Low density polyethene (LDPE), Polypropylene (PP), Polystyrene (PS) and Polyethylene Terephthalate (PET).

Drinking water quality in Punjab state, which ranked highest with 97.6%households having access to safe drinking water, while Kerala state ranks with only 33.5% households having access to safe drinking water. In developing countries, 90% to 95% of all cesspools and 70% of all industrial wastes are dumped untreated into the nearby surface waters.

In underdeveloped nations, almost 1.1 billion people use unsafe drinking water, contributing to millions of deaths [2]. An estimated 2.6 billion people lack adequate sanitation globally. Continued and regular microbiological monitoring of potable water for pathogenic bacteria is required to prevent the spread of waterborne diseases. Those most susceptible to waterborne illnesses are children, the elderly, pregnant women, and immunocompromised individuals. One of the five reasons which lead to the illness or maybe death of a child is of water-related diseases only. Approximately 5000 people die every day from waterborne diarrhoeal illnesses.

In Kerala, the groundwater caters to 80% of the rural and 50% of the urban communities for their drinking and domestic needs. Most of them are using dug wells and rarely via bore wells. More than 500 million litres of industrial effluents are being dumped daily into the river, besides untreated human excreta. Microbial pathogens are one of the major health risks associated with wastewater. The common diseases related to water may include Diarrhoea, Dysentery, Typhoid, Scabies, Malaria etc. Kerala is endemic for Waterborne diseases like enteric fever and viral hepatitis. Apart from acute diarrheal diseases, all show seasonal trends, with aggravation during the summer season. Cases of cholera have also been reported from within the state. Direct or indirect exposure to contaminated water has been reported to cause a wide range of health-related problems, including cancer, gastrointestinal problems, dermatological problems, neuronal toxicity, birth defects and infections etc [3–6].

Most waterborne infections (like Cholera, Typhoid, Hepatitis, Poliomyelitis etc,) can be due to a lack of safe drinking water [7–9]. The transmission of waterborne diseases is still a major concern, regardless of worldwide efforts and modern technology to produce safe drinking water. Studies showed that around 3.1% of deaths and 3.7% of disabilities worldwide are attributable to unsafe water, poor sanitation and hygiene [1, 10]. The drinking water contamination with faecal matter is one of the major reasons for spreading infectious diseases [8]. Faecal contamination of water is identified by the isolation of organisms that occurs only in faeces (*Escherichia coli*, *Clostridium perfringens* and *Streptococcus faecalis*.). The finding of *E. coli* or *Clostridium perfringens* and *S. faecalis* is sufficient evidence that the water is not safe [11]. WHO also has classified water samples into different risk types according to coliform count? The most widely tested microorganisms are total coliform, E.coliand Enterococci [12].

E.Coli is a gram-negative, facultative anaerobic, rod-shaped, coliform bacterium. Most *E.coli* is harmless, but some serotypes can cause severe food poisoning to their hosts. *E.coli* is expelled into the environment with faecal matter. Regulations and standards for drinking water safety and safe use of recreational water have been set to minimize human health risk hazards [13–16]. Ideally, drinking water should not contain any microorganisms known to be pathogenic—capable of causing disease—or any bacteria indicative of faecal pollution. The detection of *E-coli* provides definite evidence of faecal pollution. The World Health Organisation (WHO) reports that in economically developing countries, each year 1 in every 10 children dies before the age of 5 because of water-related diarrhoeal diseases [17, 18].

Kerala, located in the southwestern tip of India, occupies only 1.2 % (3,287,263 sq. km) of India's land area. 3% of the country's population inhabits here. The average rainfall in Kerala is 3000mm, the bulk of which (70%) is received during the south-western monsoon (June -September). State also gets monsoon from the north-eastern monsoon (October -December). One of the five reasons which lead to the illness or maybe death of a child is water-related diseases only. Recent problems of decline in the water table, groundwater contamination, seawater intrusion etc., are being reported at many places.

Vaikom taluk is situated at the north-western corner of the Kottayam district (central Kerala). It has two types of land areas-midland and lowland. The average annual rainfall in the lowland ranges from 900mm (south) to 3500mm (north) and in the midland ranges from 400mm (south) to about 6000mm (north). Source-wise, 70% - 80% of households are sustained by traditional groundwater, while 10% - 15% depends on piped water supplied by the government sources, and only 5% depends on the traditional surface and other water sources.

MATERIALS AND METHODS

Study site

This study was conducted in Vaikom, Kottayam district, Kerala, India.

Study Design

A cross-sectional epidemiological study to obtain baseline data on drinking water in Vaikom was conducted from January to March 2018 using a structured questionnaire. The information was collected by in-depth interviews of targeted participants, mothers with children less than five years old. From each surveyed house, a sample of drinking water was collected and it was tested for bacteriological quality by using the MF technique.

Cross-sectional studies are snapshots of a population's status that assesses information on disease exposure [19]. For analysis of cross sectional-studies, disease prevalence can be calculated. Prevalence means familiarity in the percentage of diseased people in the total population. The diarrhoeal prevalence is defined as the percentage of people who were suffering from diarrhoea within one month of the time of the study and it was calculated by dividing the total number of diarrhoeas affected people by the total number of people in all surveyed homes. Similarly, the prevalence in the children under five years was calculated by dividing the total number of children under five years suffering from diarrhoea by the total number of children under five years in all surveyed homes. The diarrhoeal prevalence in households is defined as one or more people suffering from diarrhoea divided by the total number of households. The knowledge level of households about diarrhoeal causes also was calculated.

Epidemiological Study

Survey Overview

In order to perform epidemiological analysis, a questionnaire was developed to obtain the necessary data from homes. General information was collected about the household to obtain basic data for the study. Total numbers of the household and children under five years were recorded for data analysis. These data were used to calculate diarrhoeal prevalence and knowledge. Diarrhoea is an indicator of waterborne illness. The total number and ages of infected people with diarrhoea in the last month were recorded. The overall knowledge level about the diarrhoeal illness of participants was also assessed by asking about the cause of diarrhoeal illness. Participants were asked about hand-washing practices, including soap for hand washing. Participants were questioned about household drinking water use and practices. Participants were also asked about the drinking water source sometimes used that may cause waterborne disease [20–22].

Household surveys collected information about their water storage containers and storage practices. The pathways of recontamination of drinking water during storage were also assessed by asking about the storage practices and how they take water from the containers. From the primary data collected from the household surveys, a questionnaire was used to calculate diarrhoeal prevalence in people, the diarrhoeal prevalence for children under five years, knowledge about the diarrhoeal cause, appropriate hand cleaning, and always using improved water source is calculated by using the following formula,

Diarrhoeal Prevalence in people

$$= \frac{No\ of\ people\ with\ diarrheal\ illness}{No\ of\ people\ in\ all\ household\ surveyed}$$

Diarrhoeal Prevalence in households

$$= \frac{No\ of\ households\ of\ one\ person\ with\ diarrheal\ illness}{No\ of\ people\ in\ all\ households\ surveyed}$$

Diarrhoeal Prevalence for children under five

$$= \frac{No\ of\ children\ under\ five\ with\ diarrheal\ illness}{No\ of\ children\ under\ five\ in\ households\ surveyed}$$

Diarrhoeal cause knowledge

$$= \frac{No\ of\ correct\ respond\ to\ cause\ of\ diarrheal\ illness}{Total\ no\ of\ respondents}$$

Appropriate hand cleaning

$$= \frac{People\ wash\ hands\ before\ cooking\ and\ after\ using\ toilet}{Total\ no\ of\ people\ surveyed}$$

Table 1: Epidemiological Study

Household Information	Average number of people in household	6
	Average number of children under 5 years	2
	Average expenses for drinking water per person per month	Rs. 100/month
Diarrhoeal Prevalence and Knowledge	Diarrhoeal prevalence (people)	8/200x100 = 4%
	Diarrhoeal prevalence (households)	5/200x100 = 2.5%
	Diarrhoeal prevalence for children under 5 years	6/60x100 = 10%
	Knowledgeable about diarrhoeal causes	14/30x100 = 46.7%
Hygiene and Sanitation	Appropriate hand-washing	28/30x100= 93.3 %
Drinking Water Practices	Household tap water	10/30 x 100 = 33.3%
	Well	5/30 x 100 = 16.7 %
	Borehole water	12/30 x 100 = 40%
	Tanker truck water	2/30 x 100 = 6.7%
	Bottled water	1/30 x 100 = 3.3%
Water Quality Perception and Household Water Treatment	Believes water is safe without treatment	21/30 x 100 =70%
	Believes water is not safe without treatment	9/30 x 100 =30%
Water Storage Containers	Plastic containers	26/30 x 100 = 86.70%
	Steel containers	7/30 x 100 = 23.33%
	Copper containers	2/30 = 6.7%

Water Quality Testing

Collection of Water Samples

In this study, we collect water samples from all the surveys done in homes and categorize the sample according to the source. From each source, six samples were selected randomly and checked for microbiological quality and compared with the standards [13, 23].

Membrane filtration (MF) method

MF method was used to measure bacterial contamination, the specifically total amount of coliform and *E.coli* in drinking water. 100 mL of each water sample were filtered through a sterile membrane filter to retain the bacteria on the surface of the membrane filter. The membrane was removed aseptically and placed on a MacConkey medium. It was then incubated at 37°C for 24 hrs. Then counted and recorded Coliform colonies growing on the surface of the membrane as Coliform density that is known as the Total Coliform (TC) colonies per 100 mL or colony forming unit (CFU). After 24 hours of incubation at 37°C, TC colonies are highlighted red by the dye 2,3,5-Triphenyltetrazoliumchloride (TTC) and EC colonies are highlighted blue by the reaction of a β-glucuronidase enzyme on 5-Bromo-4-Chloro-3-Indolyl-β-D-glucuronide.

RESULTS AND DISCUSSION

Epidemiological Study

The cross-sectional epidemiological survey collected basic data on water and sanitation practices in Vaikom. 100% of the participants cooperated with the survey with pleasure. The survey results are summarized in Table 1. A total of 30 households was surveyed and the average number of people in the household is 6. The average number of children below five years of age was 2. From the survey results, the diarrhoeal prevalence calculated is 4% and diarrhoeal prevalence for children below five years of age was 10%. 40% of households use borehole water as a drinking water source. 46.7% only know about the diarrhoeal cause. 33.3% of the households use tap water, 16.7% use well water and 6.7% depends on tanker truck water as the drinking water source. Only 3.3% uses bottled water as a primary drinking water source.

Respondents were asked about hand-cleaning practices and satisfactory sanitation facilities. The general assessment about hand-washing was based on whether mothers washed their hands properly and always used soap. The data obtained from the survey shows that 93% of the participants respond positively that they practice hand washing after going to the bathroom, before cooking and before eating. The results showed that the participants

knew the importance of hand-washing. In order to be categorized as appropriate, participants had to respond positively when asked if they always used soap, currently which brand soap in the household, and if they washed their hands at proper times. Though there may have been differences between the responses and actual practices, this valuation method was supposed to be the most appropriate.

The data obtained from the survey shows that 93% practiced appropriate hand-washing. The most common type of storage container was found to be a plastic water tank. Additionally, it was found that 100%of people are practicing proper storage by keeping the vessel always covered and by using the proper method to take water from the container.

The data obtained show that 86.70% of households stored drinking water in plastic containers, 23.33% stored in steel containers and 6.67% stored in copper containers.

Table 2: Water Quality Testing Results

Drinking water Source	E.coli(EC)
Household tap water	TC Present: 31% No TC Present: 69%
Well Water	TC Present: 61% No TC Present: 39%
Borehole Water	TC Present: 48% No TC Present: 52%
Tanker Truck	TC Present: 73% No TC Present: 27%
Bottled Water	TC Present: 2% No TC Present: 98%

Water Quality Testing Results

This epidemiological study collected water samples from all the surveyed homes. It categorized them according to the source of drinking water – Household water, Well water, Borehole water, Tanker truck water and Bottled water. From each source, six samples were selected randomly and checked the microbiological quality.

The microbiological quality testing is summarized in Table 2. The water quality testing results shows that 73% of the tanker truck water, 61% of the healthy water, 48% of the borehole water, 31% of the household tap water was contaminated with *E.Coli*. Only 2% of the bottled drinking water was contaminated with *E.Coli*. The bottled drinking water does contain the only negligible presence of bacteria because they treat the water as per the set guidelines correctly.

Coliforms are a group of bacteria found in soil, on vegetation and in large numbers in the intestines of animals, including humans. Most are not disease-causing organisms, but they act as an indicator of the sanitary conditions of a water supply. *E.coli* as it is, not capable of growing and multiplying in warm and food-laden water. So, the presence of *E.coli in* drinking water indicates faecal contamination. We can confirm the presence of faecal contamination in potable water if the existence of *E.Coli* in it. Any count of same would make the water unfit to drink.

CONCLUSIONS

In conclusion, borehole and household tap water are the primary source of drinking water in the Vaikom area, which has limited freshwater resources. From the study, it is understood that the nearby construction of a cesspit or sewage-disposal tank by the households also leads to the contamination of coliform bacteria in the water sources.

Even if water appears clear, it may not necessarily be safe. Diarrhoeal illness is caused by several exposure pathways. Clean drinking water is one key element that can improve the health of the public. So proper treatment of water should be done, to avoid health hazards. The reports of the above study showed a need for safe water in this area. Also, building rules should not be compromised. Then only the contamination of the different water sources can be prevented. Continuous monitoring of water quality and effectiveness of the treatment processes and following the rules and regulations are essential to ensure that the water quality meets the set standards.

Funding Support

The authors declare that they have no funding support for this study.

Conflict of Interest

The authors declare that they have no conflict of interest.

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