

**The prevalence of diarrhoea and drinking water quality in Darbandikhan city, Iraq**Sabah S. Mohammed^{1*}, Yadgar H. Hama-karim², Mohammed I.M. Gubari³¹Department of Nursing, Darbandikhan Technical Institute, Sulaimani Polytechnic University, Sulaimaniyah, Iraq²Department of Community health, Technical college, Sulaimani Polytechnic University, Sulaimaniyah, Iraq³Department of Community medicine, College of medicine, University of Sulaimani, Sulaimaniyah, Iraq

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ABSTRACT

Water pollution in Iraq has been accused to be the reason of many infections and outbreaks. The causes of the pollution itself could be related to environment, human made and wastes. The aim of this study is to determine the quality of drinking water and the bacteriological characteristics of water in Darbandikhan city. One hundred and sixty-six water samples, collected from the different sources were tested for the presence of coliform bacteria as an indicator for pathogen contamination. Most probable number index was used for coliform enumeration. Samples were collected from one hundred and sixty-one diarrhoeal patients admitted to the general hospital in Darbandikhan district. The questionnaires designed to review characteristics of diarrhoeal cases were administered to patients alongside oral interviews. The data were analyzed by STATA software application. Forty-six percent (46%) of the diarrhoeal cases used tap water as source of drinking water, while the reminder (54%) used other sources of water for the same purpose. All the risk factors such as water source, quantity of the water, duration of water storage and chlorination were associated with diarrhoea. Almost half of the cases were children and three quarter were adults. This study indicated that the majority of water sources in Darbandikhan city are not suitable for drinking; although net pipe system supplied chlorine significantly, it has been proven that the tap water from the homes is not suitable for consumption.

Keywords: Diarrhoeal cases, Drinking water, water sources, water pollution, Darbandikhan Lake.

Introduction

World Health Organization (WHO) and The United Nations Children's Fund (UNICEF) have recorded that 11% of the population in the world do not have access to safe water.¹ Contamination of natural water sources by pathogens is a worldwide public health problem, leading to waterborne outbreaks of gastroenteritis.¹ Still inadequate water supply and microbial contamination is a primary concern of developing countries.² Furthermore, the presence of heavy metals such as lead, cadmium, chromium, mercury, and arsenic in drinking water sources; in most of the continents with different proportion; above normal ranges will have a detrimental effect on human health.^{3,4} Unfortunately, few studies have been conducted for chemical contamination in Iraq due to high costs and lack of statistics.⁵

Water pollution in the North of Iraq can be due to environmental pollution, human and industrial wastes.⁶ In addition, there are other challenges caused by neighboring countries; Iran and Turkey for example could pollute and reducing water flow from their sources.⁷

Darbandikhan dam accumulates water from two main sources, Sirwan River flowing in from Iran alongside Halabja city and Tanjero from Sulaimani city have been polluted by human wastes in the past decades, leaving Darbandikhan Lake as the only source of tap water. The Darbandikhan lake have been contaminated by heavy metals.⁸ In Darbandikhan, the tap water supply from the lake are not consumed by most residents directly because the colour, taste and odour of the

water changes especially during summer. Although, there are not many articles on water pollution by heavy metals in Darbandikhan lake but, a study reported elevated levels of heavy metals in the water samples and fishes of the lake, especially in the summer season, which indicated that the water of the lake, used as a source of drinking water by the citizens in the past, was contaminated.⁹ Thus, the majority of the citizens use commercial filters for tap water filtration because the tap water supplied by water pipe nets delivered to residents are not purified or filtered. Therefore, many of the residents of the city are using other sources of drinking water such as springs and wells, but for many residents, access to these other sources is difficult. Presently, there is no study related to these other sources except tap water for drinking purpose. Therefore, it is crucial to know whether the water the people drink currently is safe for consumption. The aim of this study is to determine the quality of drinking water in Darbandikhan city and to investigate the characteristics of diarrhoeal patients who were admitted to hospitals and their association with the water sources.

Materials and Methods*Sample and data collection*

The data were collected in two parts; one was water sample collection from various sources to be tested for water quality. The second part was the questionnaire designed to identify the correlation between diarrhoeal cases and drinking water sources. One hundred and sixty-one (161) diarrhoeal patients of both genders were recruited in July and August, 2019 based on data obtained from the statistical unit at the Darbandikhan Director of Health most of the patients with cases of diarrhoea were registered in the summer season of the last five years. The sample size was calculated by Epi info version 6.1. The convenience sampling was used for sampling.

All of the subjects were interviewed to ascertain the source and nature of drinking water they consumed. On the other hand, the water

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samples were collected to determine the quality of the drinking water from different sources such as the reservoir, tap water, well, bottle, spring, domestic water tank and domestic filter.

Study population

All 161 diarrhoeal cases were treated in Shaheed Tofiq Bag Hospital during July and August, 2019. Each of the cases admitted to the hospital differed in their period of stay, the questionnaires were filled by researchers and the patients medical record files were reviewed to complete necessary information. The patients' views regarding water sources were also recorded. The study attempted to include all cases of diarrhoea admitted to the hospital during the period of the research. The study excluded all diarrhoea cases that had not been admitted to the hospital or those that visited private healthcare centers for treatment.

Ethical consideration

The study was granted permission by the Darbandikhan health director - a representative of the ministry of health in the local government area. The study was also approved by the ethics committees of Sulaimani polytechnic university at Darbandikhan technical institute under the approval number (DTI-ND: 629). All subjects had the right to consent to be part of the study. Those that refused to consent were excluded from the study and their medical records were not considered for the study.

Drinking water tests

Darbandikhan is divided into fourteen zones. From all the regions, 166 water samples were collected to investigate the microbial quality of the water. Samples were tested in the Preventive Health Center of the Directorate of Health in Darbandikhan by using multiple-tube tests. Samples were collected for two weeks and tested within one hour of collection. *Escherichia coli* (*E. coli*), haemotolerant or faecal coliform and total coliform bacteria were used as indicators of faecal contamination in drinking water. Total coliform count in the water samples was analyzed by using a standard protocol of multiple-tube technique (five) of the most probable number (MPN) test. After the samples were diluted, they were added to Durham tubes for gas collection. Formation of the gas in one of the five tubes indicates the existence of coliform bacteria with amount of 2.2 MPN for each 100 mL. The presence of gas in two, three, four or five tubes will increase the amount to 5.1, 9.2, 16 or >16, respectively.^{10,11}

Statistical analysis

Statistical analysis was performed using STATA version 13.1. General characteristics of the patients were presented in terms of frequency and percentage. The chi-square test was used to examine the relationship between diarrhoea and water related covariates. A p-value of ≤ 0.05 was considered statistically significant.

Results and Discussion

Bacteriological quality of different drinking water sources in Darbandikhan city

One-third of the three main water storage reservoirs were not suitable for drinking which was equal to one half of the number of water samples. Less than one-third of the pipe-borne water supplied to the residents were safe for human consumption. All the 31 samples that were taken from the different wells in places not supplied with pipe-borne water were contaminated with coliform bacteria. On the contrary, all the 14 samples of bottled water (in three different volumes) that were available in the market were free of pathogens. However, the 38 samples which were taken from the spring around the city were not fit for drinking and were bacteriologically polluted. About four-fifth and one-fifth of water from domestic water tanks and filters, respectively were safe for drinking. There was no evidence of the presence of *Vibrio cholerae* in all the samples mentioned.

Regarding the chlorination of the drinking water, only one quarter (41 out of the total 166 samples) had optimum residual chlorine levels which were in the range of 0.2 to 0.5 mg/L according to WHO guideline for drinking-water quality.¹² Almost all chlorinated water came from places where pipe-borne water were supplied. While approximately two-third (107 samples) of the drinking water was below the optimal limit and about one-tenth (18 samples) were over the upper limit of the normal range (Table 1).

Water-related characteristics of the cases and their association with diarrhoea

The most used water source by diarrheic patients was tap water. About one-third of them (32.92%) had drunk from pipe-borne water, followed by well water which was the second most frequently used source of drinking water (30.42%). Whereas, those who had used more than one source of drinking water, including the sources mentioned above or others, consisted of 17.39% of the total cases. About one-third (33.54%) of the patients added chlorine to water in their homes. In terms of water storage, 90.68% of the residents with cases of diarrhoea, stored the water for three days or less before they refilled, used or changed the water. As a protective measure for diarrhoea, 82.61% of the patients installed domestic filters in their houses. Only 4.35% of the patients were not convinced that their water supplies were sufficient (Table 2). The association of diarrhoea with these potential risk factors is shown in the (Table 2). Types of water sources, non-use of chlorine, water storage for more than three days and insufficiency of stored water were related to diarrhoea.

Table 1: Bacteriological aspects of drinking water in Darbandikhan

Drinking water sources	No of samples ^a (Districts)	Chlorine (mg/L)			<i>E. Coli</i> ^b		<i>Thermo T. Coliform</i> ^b		<i>T. Coliform</i> ^b		Safe to drink	
		<0.2	0.2-0.5	>0.5	N.G	>2.2	N.G	>2.2	N.G	>2.2	yes	no
Water storage reservoirs	8 (3)	0	6	2	4	4	4	4	4	4	4	4
Tap water	36 (14)	1	23	12	34	2	29	7	22	14	25	11
Well	31 (14)	31	0	0	12	19	9	22	0	31	0	31
Bottle	14 (3)	14	0	0	14	0	14	0	14	0	14	0
Spring	38 (7)	38	0	0	28	10	28	10	0	38	0	38
Domestic water	23 (8)	7	12	4	23	0	23	0	11	12	19	4
Domestic filter	16 (4)	16	0	0	16	0	16	0	3	13	3	13

^a Each number of sample represents five real samples take for testing

^b Most probable number (MPN) technique five broth tubes was used

Demographic characteristics of diarrhoeal patients

There was no much difference in the gender distribution of the diarrhoea patients admitted to the hospital. Males were 49% of the cases while females were 51%. However, most of the diarrhoeal conditions occurred among children. Seventy-seven (77) cases out of the 161 hospitalized patients were children which accounted for 47.83% of the overall percentage. Then, students were the second occupational category with diarrhoea (18%), while housewives who had the most contact with water admitted to hospital were 14.29%. The median age of the cases was 10 years (IQR 3 – 25 years). Nearly three-fifth (60%) of the illness happened in families that were crowded (had more than 5 members) (Table 3).

Medical characteristics of diarrhoeal cases

Six of the cases treated (3.73%) were outpatient which did not need to stay at the hospital. Most of the ill persons stayed one night in the hospital (70.8%). However, those who needed to be admitted to hospital for 2 days, and 3 or more days were 20.5% and 4.97%, respectively. In terms of travel history within one week of contracting the disease, 30 cases (18.63%) had travelled. And about one-fifth of the patients (20.5%) ate outside their home where they were prone to getting exposed to contaminated or polluted water. Among the 155 cases that stayed at the hospital, none had history of previous medication; therefore, medication-induced diarrhoea was ruled out and hence not considered as a risk factor. Diarrhoea continued in 62 cases (38.5%) for more than 2 days, those who had diarrhoea for one day or less was 32.3% of the study group. Whereas, those who had diarrhoea for 3 days, and for 4 or more days were 16.77% and 44.72%, respectively (Table 4).

It was found that patients who drank tap water presented with the highest cases of diarrhoea (46.0%), those who drank well water had the second highest prevalence of the illness (39.8%), while those who drank tank water had the lowest prevalence of the disease (1.9%).

Bacteriological examination of water sources is used globally to evaluate and monitor the quality and safety of various water sources, many potential pathogens might be associated with water consumption, therefore, the screening of drinking water samples is essential. In addition, various indicator organisms (bioindicators) used to assess the risk of most water-borne diseases are related to polluted water sources, some microbial pathogens such as *E. coli* and coliform are highly implicated in water contamination.¹³ According to WHO guideline for water quality, all water directly intended for drinking, the total coliform bacteria number must not be detectable in any 100 mL sample. The tap water (net distribution system) was poorly treated (Table 1). The study showed that water sources such as well and springs were untreated water samples and are unfit for drinking.¹²

Table 2: Water related characteristics of diarrhoeal cases

	Frequency (%)	χ^2 value	P value
Water sources		13.731	0.017
Tap	53 (32.9)		
Well	48 (29.8)		
Spring	21 (13)		
Tanker	1 (0.6)		
Bottle	10 (6.2)		
Mix	28 (17.4)		
Chlorination		6.851	0.009
Yes	54 (33.5)		
No	107 (66.5)		
Water storage		15.359	0.000
≤ 3 days	146 (90.7)		
> 3 days	15 (9.3)		
Domestic Filter		1.368	0.242
Used	133 (82.6)		
Not Used	28 (17.4)		
Sufficiency		12.677	0.000
Yes	154 (95.7)		
No	7 (4.3)		
Total	161		

A previous study demonstrated that the various water sources such as spring and well were unsuitable for drinking.¹⁴ In this article the well and spring water were contaminated with coliform bacteria (Table 1). The sources of drinking water had been significantly different for diarrhoeal cases; patients consuming tap water were at the highest level as the chlorination of the water system from the storage tank and water distribution were not good and leakage might have happened in the net pipe distribution throughout the city. Furthermore, in some areas, the net of the pipes are too old and the leakage that may occur could lead to contamination with the sewage system.¹⁵ The contamination of the storage tanks in homes could be another reason for high prevalence of diarrhoea in this group because water was distributed 2 to 3 times per week and the families are obliged to store it for more than three days.¹⁶

Table 3: Socio-demographical characteristics of the studied group

	Frequency	Percentage
Gender		
Male	79	49
Female	82	51
Occupation		
Children	77	47.83
Student	29	18.01
Housewife	23	14.29
Others	32	19.87
Marital status		
Single	120	74.53
Married	41	25.47
Age (Median)	10	(3 – 25) ^b
Family Size		
<5 members	96	59.63
=>5 members	65	40.37
Total	161	

^b IQR: Inter Quarter Range**Table 4:** Distribution of the medical and some other characteristics of the studied group

	Frequency	Percentage
Travel		
Yes	30	18.63
No	131	81.37
Eat outside		
Yes	33	20.50
No	128	79.50
Hospital admission & medication		
Yes	156	96.89
No	5	3.11
Length of stay in the hospital		
Admitted at the same day	6	3.73
One day	114	70.80
Two days	33	20.50
≥ 3 days	8	4.97
Duration of diarrhoea		
One day	52	32.30
Two days	62	38.51
Three days	27	16.77
≥ 4 days	20	44.72
Other Signs & symptoms		
Abdominal pain	0	0.00
Fever	0	0.00
Total	161	

The second most common cause of diarrhoea in the city was drinking from well water. The underground and surface water are not safe too because there is evidence of underground and surface water being contaminated by chemicals and biological substances.¹⁷ Families who sourced water for drinking and cooking purposes for one or two weeks or longer without chlorination, are also at the risk of contracting diarrhoea due to microbial contamination of the water.¹⁸

Globally, consumption of bottled water has highly increased, therefore bottles are prepared by water factories and these types of water were purified, but, the consumption of bottled water was low according to the data obtained from this study, this may be attributed to the economic status of most of the families as they are not able to afford bottled water for drinking and cooking purposes. Other diarrhoeal cases might have happened due to food poisoning or mixed usage of bottled water with unhealthy water.¹⁶

Some remote areas of the city are not provided with pipe-borne water systems. Water is supplied to them by tankers, and cases admitted to the hospital from these districts were very low (Figure 1). There was no evidence that water supplied by tankers added chlorine to their water. Over the past decades, it has been proven that chlorination could potentially be harmful but it is still used as a disinfectant especially in developing countries.¹⁷

Finally, tap water consumers had fewer diarrhoea cases in comparison with other water sources because the tap water system employed chlorination for purification – a process which is under strict monitoring by the local water director in Darbandikhan city (Figure 2).

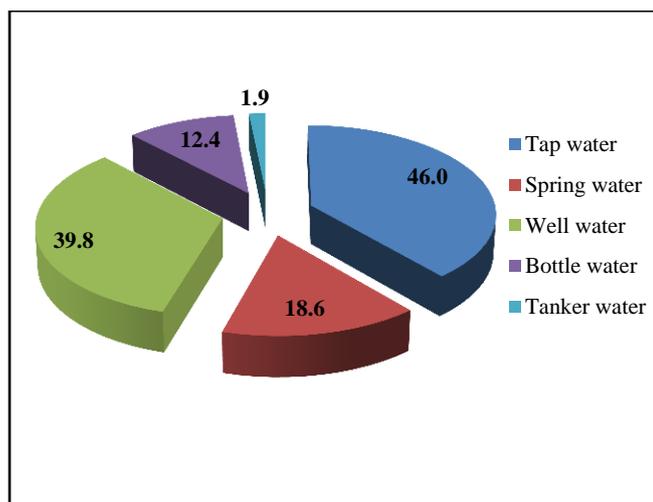


Figure 1: Percentage of diarrhoeal patients according to their usage of water source

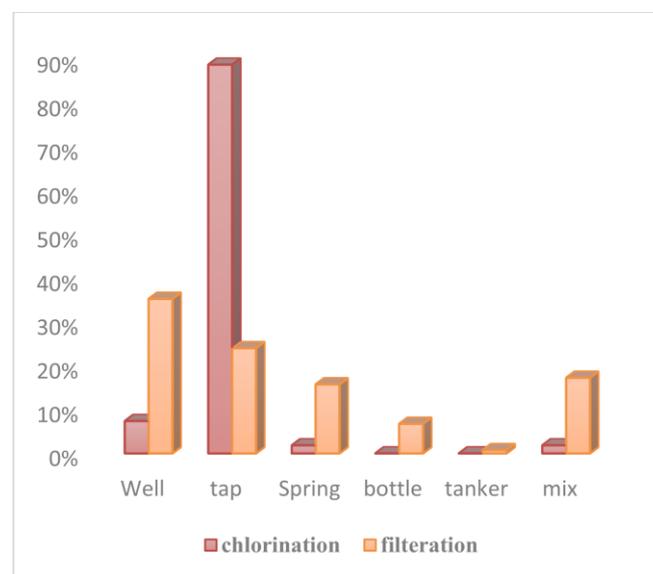


Figure 2: Percentage of chlorination & filtration of water sources

Conclusion

In this study, it was demonstrated that diarrhoea is highly prevalent in Darbandikhan city, Iraq because the water consumed from different sources by the inhabitants are contaminated. Although, treated pipe-borne water is supplied to the city, the household drinking water sources are not safe for consumption.

Conflict of interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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