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Assessment of drinking water quality at public schools at Jenin Directorate of Education, Palestine

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ABSTRACT

The aim of this study was to assess drinking water quality at the public schools in Jenin Directorate of Education. A questionnaire was distributed to schools according to drinking water sources, location of school (rural and urban), and grade levels of schools. 59 samples of drinking water were collected from the schools faucets and analyzed. The results showed that the schools' drinking water sources include: municipal water only, purchased tanker truck water, agricultural wells, direct from Mekorot Company, and rainwater harvesting. All of the physical and chemical parameters met the PSI and WHO Guidelines except the total hardness as 20% of the schools exceeded the Palestinian standard values of 400 mg/L as $CaCO_3$. Also free residual chlorine concentrations in the water of 70% of the schools were less than the recommended WHO values in the range of 0.6–1.0 mg/L. Schools purchasing tanker truck water or use agricultural wells, rainwater harvesting had total coliform and fecal coliform in their water. Higher percentage of the schools in rural area had total and fecal coliforms (30% and 23.3%, respectively) than the schools in urban area (20.7% and 13.8%, respectively). A significant relationship between the interruption in municipal water supply and water contamination was found.

Keywords: School; Drinking water; Water quality; Water supply

1. Introduction

Education is an influential factor in the development of individuals and societies. The Sustainable Development Goal number 4 was set to "ensure that, all girls and boys complete free primary and secondary schooling by 2030" [1]. Over the past decade, major progress was made towards increasing access to education and school enrollment rates at all levels. Nevertheless, about 260 million children were still out of school in 2018 – nearly one fifth of the global population in that age group. Healthy school environment, which provide a sufficient amount of clean drinking water satisfying their daily water needs, is a major issue for the achievement of this goal. Access to safe drinking water at school is an important issue since children spend most of their day there [2]. Drinking water quality affects the children's health and it is an indicator whether the supervision on drinking water is appropriate or not.

Contamination of drinking water at schools is a dangerous issue that represents a significant health risk and exposes children to water borne diseases [3]. Water borne diseases such as cholera and typhoid may lead to epidemic if they spread in societies [4]. Each year about 1.5 million children under 5 y around the world die because of diarrhea diseases [5,6]. Diarrhea diseases affect adversely the academic and social development of children, affect their learning process at school and their performance as the rate of absence from school increases [7]. Drinking water is essential for

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helping children enroll on time, complete their education, and realize their cognitive potential [6].

In Palestine, several physical, political and socioeconomic issues deny the Palestinians from having a continuous sufficient water supply [8]. According to a study carried out by the UNICEF, the perception of the Palestinian school principals was that regular water quality monitoring is highly required as they worry that water quality at schools might not be meeting the WHO standards [9]. Indeed, the water quality of the drinking groundwater wells in Palestine are suitable for drinking [8]. However, water supply in Palestine is intermittent, so water storage tanks are commonly used to balance the supply-demand patterns; also in the schools as 79% of the schools in the West Bank have storage tanks [9]. Providing water intermittently can compromise water quality in the distribution system [10] and in the storage tanks as well [11]. In Palestine, 95.9% of the schools are supplied with water from water networks and 33.9% of the schools obtain water delivered by tank trucks as well [12]. The water storage tanks in the Palestinian schools are usually washed with soap and water once a semester. This is not enough, however, to guarantee the water quality [9].

According to the Palestine Standards Institution, PSI, drinking water should be tested continuously to ensure that it is free from pathogens and the concentration of specific compounds such as free residual chlorine is within the allowable limits set by the guidelines [13]. However, water of only 73.6% of the schools in the West Bank had been tested parameters. The Ministry of Health carried random water quality tests without considering the multiplicity of water sources in the region. Private vendors provide many schools with drinking water that might not had been monitored which led to the probability of providing unsafe drinking water to the schools [9].

The main objective of this research was to assess the chemical, physical and microbial quality of drinking water from the various sources in the schools of Jenin Directorate of Education, as a case study. This study did not include the content of the metals, organic residues such as pesticides (since some agricultural wells were used for water supply to schools), and this should be included in a further study Jenin Governorate suffers from severe shortage in water resources. Of the 80 localities in Jenin, only 69 of them have water distribution network. So not all governmental schools in Jenin governorate are connected to public water networks. Many schools get water from different sources such as the private vendors. Jenin city and the surrounding villages that are served with water networks, suffer from interruption in water supply over the year [14]. In addition, 33 localities have old water networks where the probability of water leakage is high [12].

2. Materials and methods

2.1. Study area

In this research, 59 schools in Jenin Directorate of Education were selected to assess drinking water quality and evaluate the current water situation at schools (Fig. 1). The sample size was calculated based on the normal distribution at a confidence level of 95%, so the results can be generalized to other schools. The schools cover all the geographical region of the directorate including 34 schools of primary level and 25 schools of secondary level. According to location of schools, there are 29 schools in urban and 30 schools in rural areas [15].

The studied schools were selected based on the following classification:

- Level of school (primary and secondary),
- Community type (urban and rural),
- Geographical region (Jenin city, and the eastern and western villages of Jenin).

The choice of schools in each part of the study area was based on the total population of students and number of schools.

Jenin governorate obtain water from groundwater wells, Mekorot Water Company, springs, and rain water harvesting. During period of water interruption, people purchase tanker truck water that is usually of unknown source [12].

Visits to the selected schools were made during the period of January 28, 2018 until March 10, 2018 to collect drinking water samples and to distribute the questionnaire.

2.2. Questionnaire

A structured questionnaire was administered to the 59 schools' principals or to the teachers involved in the environmental health issues at the schools as recommended by the principals. The questionnaire was written in Arabic, the mother language of the respondents. The questionnaire included general information about the schools; the location

Fig. 1. The West Bank map including Jenin Governorate.

of school, grade levels, drinking water sources, and other questions addressing how they manage drinking water at the schools, and about the surrounding environment. The validity of the questionnaire was measured by interviewing key persons from the Ministry of Health, the Ministry of Education, and the Joint Services Councils to give feedback before distributing the questionnaires. The Statistical Package for the Social Sciences (SPSS) software version 19 was used for data analysis. SPSS had been used to generate descriptive statistics, and to conclude the relationship between the related variables in the questionnaire.

2.3. Water quality analysis

Drinking water samples were collected from the 59 studied schools. The samples were collected from the faucets after being disinfected with alcohol and waiting a few minutes before taking the samples. The samples were tested for different physical (pH, electrical conductivity, turbidity, free residual chlorine), physical/chemical (hardness) and microbiological (TC, FC) parameters. Sampling was carried out during the period of January 28, 2018 until March 10, 2018. The water samples were collected in 1,000 mL Pyrex sterilized glass bottles, stored in a cooler of about 4°C and transported to the lab of Birzeit University for analysis. Triple replicates were used for the analysis of each parameter. The pH, EC, and turbidity parameters were examined *in situ*, using a thermometer, a portable digital pH meter, an EC meter, and a turbidity meter. Total and fecal coliforms counts were measured by the membrane filtration technique. All parameters were analyzed according to the standard methods as shown in Table 1 [16]. The used instruments were always calibrated before being used in the field and in the lab.

2.4. Risk factors

To determine the reasons behind contamination of drinking water at schools, statistical analysis were conducted to identify significant correlation between ten risk factors that maybe behind the contamination of drinking water and microbiological water quality (the presence of TC, FC). Cross tabulation between the risk factors in the research and the presence of TC and FC were done, the percentage of contamination was calculated when this factor was (Yes) and when it was (No), then the χ^2 tests were done to check if the variations in percentage was statistically significant or not.

3. Results and discussion

3.1. Schools' drinking water sources at Jenin Directorate of Education

The results of schools drinking water sources according to different grade levels and schools' locations are illustrated in Table 2.

The results presented in Fig. 2 reveal that only 69% of the public schools in the Jenin Directorate of Education use

Table 1
School drinking water quality parameters, measuring instruments and methods

Parameter	Test/Instrument model and manufacturer	Standards method no. [16]
pH meter	pH meter: pH 197 (WTW, Germany)	Eq. to AWWA ST Meth 4500
Electric conductivity (EC)	EC meter: HI 98360 (HANNA, Romania)	Eq. to AWWA ST Meth 2510
Turbidity	Turbidity meter: HI 9341 (HANNA, Romania)	Eq. to AWWA ST Meth 2130
Total free chlorine	Choloremetric: HI 93414 (HANNA, Romania)	Eq. to AWWA ST Meth 1427
Hardness (Ca^{2+} + Mg^{2+})	ICP: AVIO 200 (Perkin Elmer, USA)	AWWA ST Meth 2340
Total fecal coliform	Membrane filtration	AWWA ST Meth 9222

Table 2
Schools drinking water sources in Jenin Directorate of Education according to grade level and school location

Drinking water source	Total number of schools	School grade level		School location	
		Primary school	Secondary school	Urban	Rural
Municipal water only	41 (69%)	23 (67.6%)	18 (72.0%)	23 (79.3)	18 (60.0%)
Purchased tanker truck water only	4 (7%)	1 (2.9%)	3 (12.0%)	0 (0.0%)	4 (13.3%)
Direct from Mekorot only	2 (3%)	2 (5.9%)	0 (0.0%)	0 (0.0%)	2 (6.7%)
Agricultural wells only	1 (2%)	1 (2.9%)	0 (0.0%)	0 (0.0%)	1 (3.3%)
Municipal water + purchased tanker truck water	6 (10%)	5 (14.7%)	1 (4.0%)	4 (13.8%)	2 (6.7%)
Municipal water + rain water harvesting	3 (5%)	1 (2.9%)	2 (8.0%)	2 (6.9%)	1 (3.3%)
Municipal water + agricultural wells	1 (2%)	0 (0.0%)	1 (4.0%)	0 (0.0%)	1 (3.3%)
Rain water harvesting + purchased tanker truck water	1 (2%)	1 (2.9%)	0 (0.0%)	0 (0.0%)	1 (3.3%)

municipal water. While 7% purchase tanker truck water, 3% get water directly from Mekorot Company, 2% use agricultural wells, 10% use both municipal water and purchase tanker truck water. Other schools make up 5% use both municipal water and rain water harvesting wells, 2% use both municipal water and agricultural wells as water source, and 2% use rain water harvesting and purchase tanker truck water. Accordingly, the results reveal that some schools use only municipal water and some other make use of other sources on top of municipal water. In addition, the results show that the water demands of some schools were met by municipal water supply, but other schools need additional water sources. According to the schools principals and teachers, the difference is related to the number of students in the schools as big schools suffer from water deficiency more than smaller schools. Another factor was the availability of municipal water in the school neighborhood, which is also influenced by the topography, water sources, availability of storage tanks, etc. A detailed water demand study in the schools is recommended to elucidate why schools are looking for additional sources.

In a similar study conducted in Jordan for the assessment of public schools drinking water showed that 91% of the surveyed schools consume water from the public water network, while 2% purchase tanker truck water to cover their need for water because they are not connected to the water network, 6% depend on public water network in addition to purchase tanker truck water [17].

Secondary schools had slightly higher coverage of municipal water services of 72% as compared to the primary schools of 67.6% (Figs. 3 and 4). Similarly, one of six secondary schools compared to one of four primary schools do not have drinking water service globally [18]. Likewise, in Taiwan 57% of the schools above senior level use tap water while 34% of schools under junior level use tap water [2]. This might be because students in the secondary schools consume more water than students in the primary schools [19].

Among the investigated 29 schools in urban areas, 79.3% use municipal water as drinking water source. While, among the 30 schools in rural areas, 60% use municipal water. Figs. 5 and 6 show the multiplicity of drinking water sources in the schools in the rural areas compared to those in the urban areas due to the absence of public water networks in the rural areas that obliges schools to seek for other sources of drinking water.

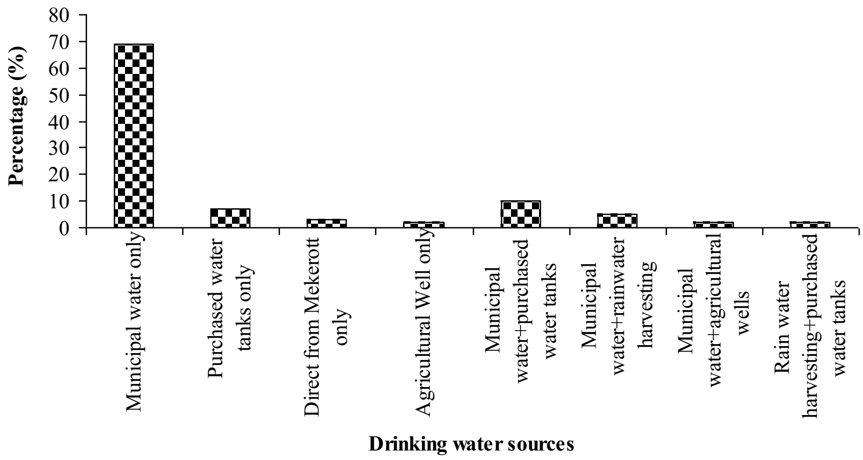

Fig. 2. Drinking water sources of public schools at Jenin Directorate of Education.

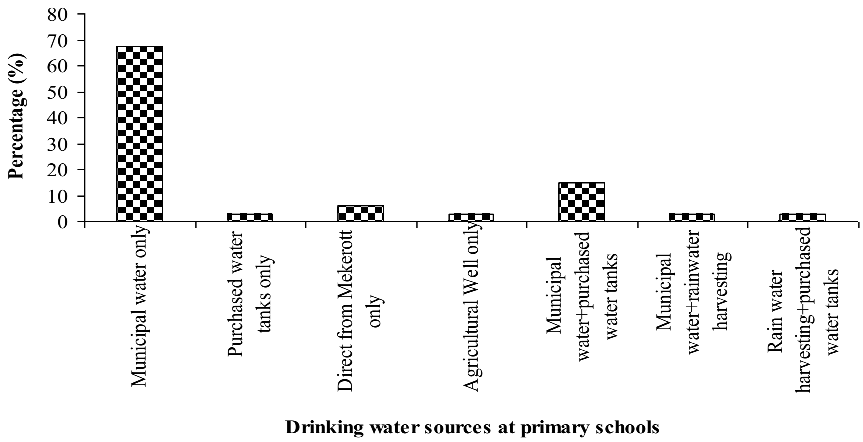

Fig. 3. Drinking water sources of primary schools at Jenin Directorate of Education.

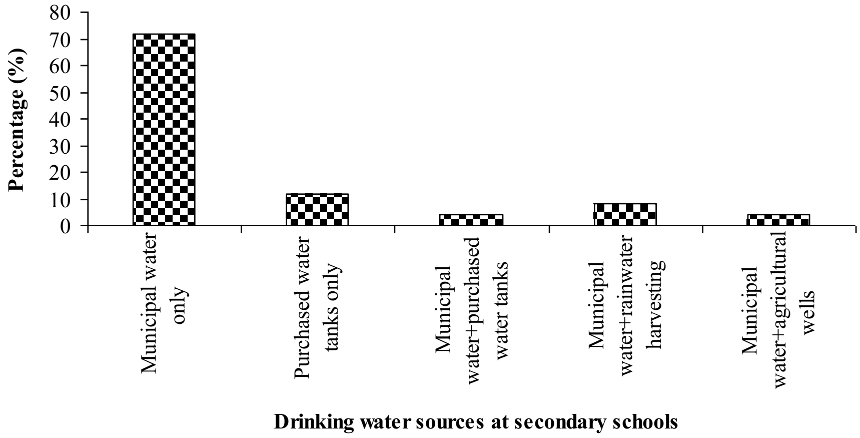

Fig. 4. Drinking water sources of secondary schools at Jenin Directorate of Education.

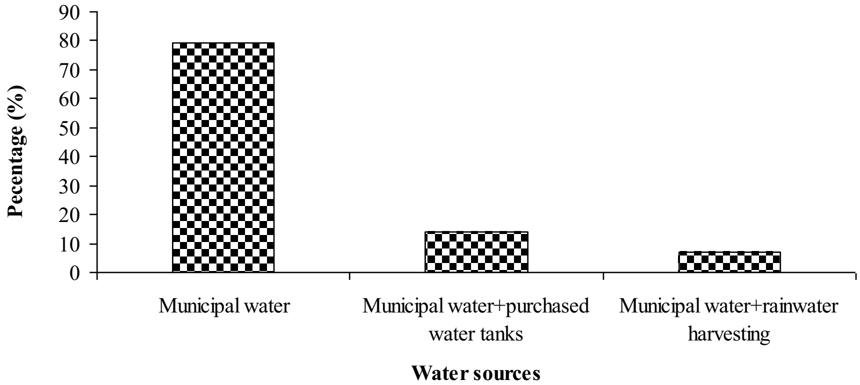

Fig. 5. Drinking water sources of schools at urban area in Jenin Directorate of Education.

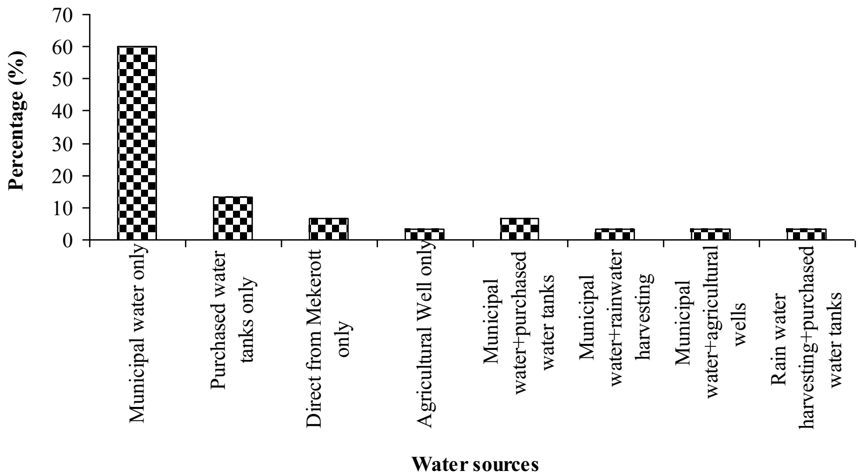

Fig. 6. Drinking water sources of schools at rural area in Jenin Directorate of Education.

3.2. Schools' drinking water quality analysis

The drinking water quality parameters of the various water sources used in the investigated schools and the corresponding Palestinian standards and the WHO guideline values are presented in Table 3. Tables 4 and 5 present the schools average values of the drinking water physical and chemical properties in relation to the schools locations and grade levels. The results are explained as follows:

3.3. pH

The pH values of all tested water samples were in the range of 7.5–8.4, which have met the Palestinian standards and the WHO allowable limits.

Table 3
Drinking water physiochemical and microbiological properties and the Palestinian Drinking Water Standards and WHO guideline values at the schools of Jenin Directorate of Education

Parameter	Mean (STD)	Range	Palestinian standards [13]	WHO guidelines [20]
Turbidity (NTU)	0.83(0.71)	0.23–4.09	up to 5	up to 5
Cl_2 (mg/L)	0.13(0.17)	0.00–0.67	0.2–0.8	0.6–1.0
pH	8.19(0.20)	7.50–8.42	6.5–8.5	6.5–8.5
Electrical conductivity (µS/cm)	594(312)	168–1,736	Up to 2,000	Up to 2,000
Hardness (ppm)	266(119)	73–468	400	n.a.*
Total coliforms (CFU/100 mL)		0.0–TMC	0–3	0.0
Fecal coliforms (CFU/100 mL)		0.0–TMC	0.0	0.0

n.a.*: not available; TMC, stands for too many to count.

Table 4
Average school drinking water physical and chemical properties with respect to school location

Drinking water source	pH	Turbidity (NTU)	Electrical conductivity (µS/cm)	Hardness (mg/L)	Residual chlorine (mg/L)
Municipal water					
Schools in urban area	8.0	0.90	585	282	0.11
Schools in rural area	8.2	0.80	516	237	0.17
Purchase tanker truck water					
Schools in urban area	–	–	–	–	–
Schools in rural area	8.2	0.87	629	201	0.03
Direct from Mekorot					
Schools in urban area					
Schools in rural area	7.9	0.33	356	163	0.46
Agricultural wells					
Schools in urban area	–	–	–	–	–
Schools in rural area	8.3	1.1	657	220	0.03
Municipal water + purchase tanker truck water					
Schools in urban area	8.1	0.51	682	316	0.04
Schools in rural area	8.2	0.66	661	273	0.21
Municipal water + rain water harvesting					
Schools in urban area	8.0	0.96	781	397	0.03
Schools in rural area	7.6	0.68	879	468	0.21
Municipal water + agricultural wells					
Schools in urban area	–	–	–	–	–
Schools in rural area	8.2	1.7	1,736	464	0.15
Rain water harvesting + purchase tanker truck water					
Schools in urban area					
Schools in Rural area	7.9	1.1	170	73	0.02
Palestinian standards [13]	6.5–8.5	>5	>2,000	400	0.2–0.8

*Palestinian standard institution guideline.

3.4. Turbidity

The turbidity values of the tested water were between 0.23–4.0 NTU, which are within the Palestinian and WHO limits. The results revealed statistically significant relationships between turbidity and the presence of total coliform (χ^2 = 455.775, df = 405, P = 0.041) and fecal coliform (χ^2 = 499.247, df = 450, P = 0.054). In addition, the results revealed that there is a statistically significant relationship between turbidity and drinking water sources (χ^2 = 364.573, df = 315, P = 0.028). Tamimi reported a statistically significant relationship between Turbidity in water and incidence of diarrhea disease when they tested the harvested rainwater quality in Palestine [21]. Turbidity higher than 1 NTU might affect the disinfection process efficiency. However, turbidity less than 5 NTU is acceptable in regions of limited water resources [20].

Table 5
Average school drinking water physical and chemical properties with respect to school grade levels

Drinking water source	Test Palestinian Standards [13]	pH 6.5–8.5	Turbidity (NTU) > 5	Electrical conductivity (μS/cm) > 2,000	Hardness (mg/L) 400	Free residual chlorine (mg/L) 0.2–0.8
Municipal water						
Primary schools		8.1	0.83	571	276	0.14
Secondary schools		8.1	0.89	534	244	0.13
Purchased tanker truck water						
Primary schools		8.2	0.56	1,208	342	0.00
Secondary schools		8.13	0.98	436	154	0.03
Direct from Mekorot						
Primary schools		7.9	0.33	356	163	0.46
Secondary schools						
Agricultural wells						
Primary schools		8.3	1.1	657	220	0.03
Secondary schools						
Municipal water + purchased tanker truck water						
Primary schools		8.1	0.56	746	338	0.08
Secondary schools		8.1	0.59	322	122	0.15
Municipal water + rain water harvesting						
Primary Schools		7.7	0.52	825	387	0.02
Secondary schools		7.9	1.0	808	437	0.12
Municipal water + agricultural wells						
Primary schools						
Secondary schools		8.2	1.7	1,736	464	0.15
Rain water harvesting + purchased tanker truck water						
Primary schools		7.9	1.1	170	73	0.02
Secondary schools						

3.5. Electrical conductivity

The EC values of the tested water samples were between 168–1,735 μS/cm. These values are within allowable limits set by the WHO guidelines and the Palestinian Drinking Water Standards [13,20].

3.6. Total hardness

In this research, the schools in the rural areas using either rainwater harvesting or agricultural wells water have the highest total hardness of around 468 mg/L as $CaCO_3$ that is higher than the Palestinian maximum limit for total hardness is 400 mg/L. Schools in rural areas using rainwater harvesting in addition to purchasing tanker truck water have the lowest value of hardness of 73 mg/L as $CaCO_3$. There is a significant relationship between the value of total hardness and the source of drinking water (χ^2 = 315.182, df = 249, P = 0.012), and that is confirmed by the WHO that natural and treated waters vary widely in levels of minerals content, begins with very low levels in naturally soft and softened to higher levels in naturally hard waters [20]. According to the WHO, water with hardness above 120 mg/L is a hard water and may results in scale deposition in the pipe work and distribution system and in the water roof tanks. When heating hard water, calcium carbonate scales precipitate on the surfaces of the boiling systems. Soft water, with a hardness of less than 60 mg/L is corrosive to water pipes considering other factors such as pH and alkalinity [20].

The nanofiltration membranes are capable of retaining the total hardness present in groundwater [22].

3.7. Free residual chlorine

The results of free residual chlorine concentrations in the schools tested water were very low except 4.9% of the schools that depend on municipal water with a mean value of 0.56 mg/L of Cl_2, and schools in rural areas that have direct access of water from Mekorot Company with a value of 0.63 mg/L of Cl_2. Similarly, Chung reported that approximately no residual chlorine could be noticed in all tested schools in his research in Pingtung County, Taiwan [2]. The availability of chlorine in drinking water is essential for safety reasons. When the concentration of chlorine in water is around 2–3 mg/L, a nuisance odor can be smelled. The free residual chlorine concentration in drinking water should be between 0.6–1.0 mg/L as recommended by the WHO [20]. Most of the time, the source water meet the guidelines, but the concentration of free residual chlorine decrease in the distribution network.

Apparently, the chlorination process does not take into account the biochemical reactions, like chlorine reaction with ammonia, that happen in the water in pipelines, and so very low free chlorine residual amounts reach the taps [8]. Therefore, post chlorination is recommended by adding chlorine in the schools' water tanks to comply with the Palestinian standards and WHO guidelines.

3.8. Microbial detection

Total coliforms were found in the water of 15 schools, representing 25.4% of the total schools of 59. While fecal coliforms were found in the water of 11 schools, representing 18.6% of the total schools. Coliforms must be undetectable in drinking water [13,20]. The biologically contaminated water should not be supplied to schools, but similar to the free residual chlorine and hardness water quality improvement, disinfection using chlorination and nano-filtration treatment of water at the schools are recommended.

3.9. Microbial detection with respect to drinking water source

In relation to the water source, out of the 41 schools that use municipal water, the water in 9 schools had total coliforms with a percentage of 22%, and water in 6 schools had fecal coliforms with a percent of 14.6% (Table 6). The contamination of the municipal water might be due to the old water networks and the intermittent water supply. All schools purchasing tanker truck water or use agricultural wells or purchasing tanker truck water and using rainwater harvesting wells had total coliforms and fecal coliforms in their water.

3.10. Microbial detection with respect to school grade level

The results showed that secondary schools were more contaminated than primary schools as shown in Table 7. This was explained by the higher water use by the secondary schools that lead to using water of various sources to meet their demand.

3.11. Microbial detection with respect to school location

The results reveal that more schools in the rural areas had contaminated water than the schools of the urban areas (Table 8). Several reasons might explain this finding:

- Only 60% of the schools in the rural areas depend on municipal water, and 20% purchase water transported by tanker trucks, which are usually of unknown sources of water and/or had not been tested. Also water contamination in the storage tanks, like roof to tanks, that are widely used in Palestine due to intermittent water supply with fecal coliform coming from birds debris had been reported [11]. Chlorine should be added so that

Table 6
School drinking water TC and FC content with respect to drinking water source

Drinking water source	Number of schools	Total coliform detection		Fecal coliform detection	
		Number of contaminated schools	Percentage of contamination (%)	Number of contaminated schools	Percentage of contamination (%)
Municipal water	41	9	22	6	14.6
Purchase tanker truck water	4	4	100	4	100
Direct from Mekorot	2	0	0.0	0	0.0
Agricultural wells	1	1	100	0	0.0
Municipal water + purchase tanker truck water	6	0	0.0	0	0.0
Municipal water + rain water harvesting	3	0	0.0	0	0.0
Municipal water + agricultural wells	1	0	0.0	0	0.0
Rain water harvesting + purchase tanker truck water	1	1	100	1	100

Table 7
School drinking water TC and FC content with respect to school grade level

School classification	Number of schools	Total coliform detection		Fecal coliform detection	
		Number of contaminated schools	Percentage of contamination (%)	Number of contaminated schools	Percentage of contamination (%)
Primary school	34	6	17.6	4	11.8
Secondary school	25	9	36.0	7	28.0

free residual chlorine concentration at point of delivery is not less than 0.5 mg/L. In addition, the tankers must be used only for transporting drinking water [20].

- The absence of sewage networks and the use of cesspits for sewage disposal. Only 6.3% of educational institutions in Jenin governorate dispose wastewater into wastewater networks, while 57.3% use cesspits for wastewater disposal and 36.4% use tight cesspits for wastewater disposal [12].

3.12. Microbial detection with respect to the geographical area affiliated with the school

The results presented in Table 9 show that east Jenin villages have the highest percent of microbiological contamination, while west Jenin villages have the lowest values. On the other hand, only 47.1% of the tested schools in east Jenin villages depend on municipal water, while 23.5% purchase tanker truck water. The rest of the schools use water directly from Mekorot or from agricultural wells or both municipal water and agricultural wells or municipal water with purchasing tanker truck water or purchasing tanker truck water plus rain water harvesting wells. The schools supplied with directly with water from Mekorot is only 2, and so the number of samples might not be adequate to draw a general conclusion. However, the good quality of water supplied by Mekorot is supported by other studies. Differently, the agricultural wells are not supposed to be used for drinking purposes without careful testing, as these wells mostly tap shallow water aquifers that are susceptible to pollution with sewage [8].

The high percent of contamination in east Jenin villages is a result of using different sources of drinking water other than the safest source that is the public water network. Seven villages in east Jenin do not have water networks (Jalboun, Deir abu-dieef, Faqoua'a, Beit qad, Arabboune, Aaba, and Al-Mteile) and so people there depend on different sources of water of poorly, if any, monitored quality.

82.1% of the tested schools in west Jenin villages depend solely on municipal water supplied through water networks. 3.6% use water directly from Mekorot and 3.6% use both municipal water plus purchase tanker truck water, while 10.7% depend on municipal water and rainwater harvesting well together. In Jenin city 71.4% of the schools depend on municipal water and 28.6% use both municipal water plus purchasing tanker truck water.

The results reveal a significant relationship between the geographical areas affiliated with the schools and the presence of total coliform and fecal coliform in the drinking water. This is because of using diverse sources of water.

3.13. Risk factors and degree of contamination

The results presented in Table 10 reveal that there is a significant relationship between the long interruption in municipal water supply and water contamination. Drinking water supply interruptions, because of discontinuity sources or because of engineering inefficiencies, are a major determinant of the quality of drinking water [20].

Intermittent water supply might result in deterioration of water quality, increasing the risk of exposure to contaminated water and consequently increasing the risk of waterborne disease. Daily or weekly interruption can result in low supply pressure and a consequent risk of contamination to occur in the pipes another time [20]. It is also clear that there is no relation between the addition of chlorine

Table 8
School drinking water microbe detection content with respect to school location

School tracking to	School quantity	Total coliform detection		Fecal coliform detection	
		Number of contaminated schools	Percentage of contamination (%)	Number of contaminated schools	Percentage of contamination (%)
Urban	29	6	20.7	4	13.8
Rural	30	9	30	7	23.3

Table 9
Schools drinking water total and fecal coliform content in relation to the geographical area affiliated with the school

Geographical area affiliated with the school	School quantity	*Total coliform detection		**Fecal coliform detection	
		Qualified quantity/percentage (%)	Unqualified quantity/percentage (%)	Qualified quantity/percentage	Unqualified quantity/percentage (%)
East_Jenin	17	8 47.1	9 52.9	10 58.8	7 41.2
West_Jenin	28	25 89.3	3 10.7	26 92.9	2 7.1%
Jenin_City	14	11 78.6	3 21.4	12 85.7	2 14.3

**: (χ^2 = 10.102, df = 2, P = 0.006);
*: (χ^2 = 8.307, df = 2, P = 0.016).

Table 10
Risk factors of microbial contamination in drinking water by the presence of TC, FC

Risk factors		TC (%)	FC (%)	df	χ^2	*P*
Does the school suffer from a long interruption of municipal water continuously	yes	7.7	0.0	1	2.765	0.096
	no	30.4	23.9	1	3.821	0.051
Are drinking water tanks separate from water tanks used for other purposes	yes	27.5	21.6	2	1.035	0.596
	no	16.7	0.0	2	2.121	0.346
Is chlorine added to drinking water	yes	29.4	23.5	1	0.673	0.412
	no	20	12	1	1.263	0.261
Is rainwater collected in the same water tank for drinking if there is a rainwater harvesting mechanism	yes	50	50	1	3.357	0.187
	no	13	12	2	1.857	0.395
If there are wells that collect rain water or water reservoirs in the ground, how close are they to cesspits	yes	16.7	16.7	2	2.173	0.337
	no	0.0	0.0	2	0.376	0.829
Is it necessary to make sure that tanks are periodically closed	yes	26.3	19.3	1	0.706	0.401
	no	0.0	0.0	1	0.474	0.491
Are drinking water tanks periodically cleaned	yes	26.3	19.3	1	0.706	0.401
	no	0.0	0.0	1	0.474	0.491
Are drinking water tanks cleaned after summer vacation	yes	27.8	20.4	2	1.862	0.394
	no	0.0	0.0	2	1.252	0.535
Is the tank or well used for rain water collection is cleaned before rainy season	yes	21.1	21.1	2	3.667	0.160
	no	0.0	0.0	2	1.820	0.402
Is there a special clothing when cleaning tanks	yes	30.8	19.2	2	1.206	0.547
	no	22.6	19.4	2	0.475	0.789

and the presence of contamination in water. The risk of using contaminated water by the schools pupils could be solved for a far extent by enhancing the role of public private partnership [23]. Also, the provision of small storage water tanks, adequate to cover the needs of daily demand volume, can improve performance and water equity as opposed to no storage in stressed networks [24].

4. Conclusions

Drinking water sources of the public schools in Jenin Directorate of Education of include municipal water only, purchased tanker truck water, agricultural wells, direct from Mekorot Company, and rainwater harvesting. All physical and chemical analysis conform to PSI and WHO Guidelines except for the total hardness and free residual chlorine, as 20% of schools exceeded the standards for total hardness. All of the schools that obtain water from purchasing tanker truck water only or rain water harvesting plus purchasing tanker truck water only have total coliform and fecal coliform in their water. While, the schools that obtain water from agricultural wells only have total coliform. These sources of water should be avoided, and when used microbial water quality should be tested. The most reliable water source to avoid health complications is the water supply network. However, the interruption in municipal water supply leads to water contamination. There should be continuous monitoring and testing of schools drinking water quality by the competent authorities.

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