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TECHNICAL NOTE

Water–health relationships in developing countries: a case study in Tulkarem district in Palestine

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This study focuses on quantitative and qualitative determinants of drinking water in the Tulkarem district of Palestine, and the effect of water pollution on the health of its inhabitants. Five hundred drinking water samples were obtained from the records of the Public Health Department/Ministry of Health (MoH) at Tulkarem district for the year 1999, which were collected from different sources in the district. The samples were examined for free chlorine residual concentration, total coliforms and faecal coliforms. Data of water-related diseases was obtained from the records of public health clinics in the district. Many of the examined samples were unacceptable according to the Palestinian and WHO standards. It was found that (60.6%) of the samples have concentrations of free chlorine residual less than 0.2 ppm, which is the minimum concentration, recommended by WHO. Out of these samples, 34% and 9.2% were contaminated with total coliforms and faecal coliforms respectively. It was obvious that the prevalence of water-related diseases is much higher in the areas with contaminated or nonchlorinated drinking water than in other areas.

Keywords: Faecal coliforms; total coliforms; free chlorine residual; water-related diseases; developing countries; Palestine.

Introduction

Water is considered one of the most important and sensitive issues in the Middle East, where increasing water deficiency and deterioration of the available water are imminent. A major issue is that water resources are very limited and do not meet the existing population's needs, not to mention generations to come. This is an obvious and acute problem in Palestine, which suffers from both water deficiency and contamination.

Water is an indispensable commodity, which should be easily accessible, adequate in quantity, free of contamination, safe, inexpensive and readily available throughout the year in order to sustain life (World Health Organization (WHO) 1986, 1996, 1997).

One of the world's most critical problems today is the acute shortage of clean fresh water: All–for domestic purposes, industry and agriculture–need water (Smith 1985). It will be an important issue to set limits on water use, to introduce standard charges both for clean water

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and for the discharge of polluted waste, and to establish nation-wide service for water quality control (WHO 1993).

A housing conditions survey conducted in the year 2000 indicated that the percentage of households connected to the public water network in the Palestinian Territories was 89.8% (Palestinian Central Bureau of Statistics (PCBS) 2002), while it was 84.8% in 1999 (PCBS 2000).

Groundwater is the main source of fresh water and is of primary importance to the Palestinians (Palestinian Water Authority (PWA) 1994; Jerusalem Media and Communication Center (JMCC) 1994).

Standards are expressed in terms of microbiological, chemical and physical characteristics of the water. In a normal practice it is important to detect and enumerate what is called 'indicator bacteria'. These bacteria are excreted in large numbers by warm-blooded animals, irrespective of whether they are healthy or sick. The presence of indicator bacteria in water is indicative of faecal contamination of water. The most commonly used indicator bacteria are the coliforms. Water is tested either for the presence of the total coliform group or for the presence of faecal coliforms only. Faecal coliforms, mainly *Escherichia coli*, are a subgroup of the total coliform group. One must distinguish clearly between the examination of chlorinated and unchlorinated water supplies. If one is examining a chlorinated water supply one knows that, if the chlorination process is working correctly, all coliform organisms will have been killed. The World Health Organization (WHO 1971, 1997) and the Palestinian Standards Institution (PSI 1997) suggest the following standards for treated drinking water:

(a) Water entering the distribution system should contain no coliform organisms;
(b) Water at the tap should contain no coliforms in 95% of samples taken in any one year and it should never contain more than 10 coliforms/100 ml or any *Escherichia coli*/100 ml.

Most gastrointestinal (GI) infections that may be transmitted through drinking water are transmitted via the faecal–oral pathway. Differentiation of bacteria that constitute the coliform group is sometimes necessary to determine the nature of the pollution (WHO 1984).

Improvements in the quantity of water were felt on the endemic diseases such as diarrhoea in children, cholera and typhoid in adults, diseases which mainly spread when not enough water is available to maintain a good standard of hygiene. Other forms of disease, which can be controlled by better hygiene, are not water-borne, such as trachoma and skin infection (Mcfeters and Toranzos 1997; Othman 2000; Al-Kahah 2001).

According to the MoH (1998), diarrhoea disease still accounts for about 3% of infants' death in the West Bank and Gaza Strip of Palestine. The three intestinal parasites are locally *Trichuris trichuria*, *Entamoeba histolitica* and *Giardia lamblia*. The prevalence of child mortality rate per 10,000 population from diarrhoea is about 0.5 in the West Bank and Gaza Strip.

This study was performed to ascertain the microbiological quality of drinking water, in addition to some chemical characteristics. The aim was to find out if the drinking water quality throughout the Tulkarem district communities is safe for drinking and to investigate the effect of water pollution on the health of the Tulkarem district population. The analysis tries to explore this issue through presentation of results obtained by analysing the clinical records and collected samples from some of the communities of the Tulkarem district in Palestine. The

presence of some of the classical bacteriological indicators has been verified, including faecal pollution and total coliforms.

Materials and methods

Data about water quality was collected from the records of the Department of Environmental Health within the Ministry of Health (MoH) at the Tulkarem district directorate. The collected data was for the year 1999. The data was reviewed, cleaned and revised with the help of Environmental Health Department workers. Water samples were collected from the different locations of the communities in the district. Water samples were held in sterile bottles and sent to the laboratory of public health in Ramallah city on the same day of collection. The Environmental Health Department workers usually did free chlorine residue test on site.

The samples were collected from extracted water from 18 ground water wells, 20 reservoirs, and many other different places such as houses, pharmacies, restaurants, factories, and schools. The data was coded and entered into the computer and analysed using the statistical analytical system SPSS.

Information about water-related diseases and their incidence rate in 1999 was obtained from the records of public health clinics of the Ministry of Health distributed in the Tulkarem district.

According to the PCBS (1999), the total population of the Tulkarem district was about 137,381 persons in 1999. The Tulkarem district is divided into four areas, which are:

(a) Tulkarem City, including Shwaika, Dunnaba, Eirtah, Ektaba villages, and Tulkarem and Nur Shams Refugee camps;
(b) Al Kafriat area, including Kufr Jamal, Kufr Aboush, Kufr Zibad, Faroun, Kour, El Rass, and Kufr Sour villages;
(c) Wadi Al Sheir area, including Anabta, Ramin, Kufr Ellabad, Beit Lied, Balaa, Shoufeh, and Sefarin villages;
(d) Al Shaarawia area, including Qafin, Zita, Attil, Nazlet Eisa, En Nazla Sharqia, Elar, Saida, Dir Algosoon, Al Jarushia, and Baqa Alsharkia villages.

According to the PCBS (1999), the distribution of Palestinian built-up areas in the Tulkarem district in 1999 was 26.3% urban, 12.4% including two refugee camps, and 61.3% rural.

Results

Reviewing the records for the year 1999 revealed that the Environmental Health Department had tested 500 water samples. These samples were examined for free chlorine residuals, total coliforms, and faecal coliforms for some of these samples.

The values of all chemical and microbiological parameters are shown in Table 1. Out of the 500 samples tested for free chlorine residual, 303 (60.6%) had a concentration less than 0.2 ppm, 195 (39%) were between 0.2–0.8 ppm and two samples had a concentration more than 0.8 ppm. This means that only 39% of the drinking water in the Tulkarem district was acceptably disinfected within the limits of standards. This result directly reflects the presence of microbiological contamination of the drinking water sources (Moe 1997). It is worth mentioning here that some of the chlorinating pumps were faulty and others were incorrectly operated.

Table 1. Range values, frequencies and percentages of free chlorine residual (FCR) (ppm), total coliforms and faecal coliforms (TC and FC) (n/100 ml)

Range values, frequencies and percentages								
Free chlorine residual			*TC*			*FC*		
0 – 0.1	303	60.6	0 – 3	358	71.6	0	454	90.8
0.2 – 0.8	195	39	4 – 50	89	17.8	1 – 10	30	6.0
> 0.8	2	0.4	51 – 50,000	53	10.6	11 – 100	12	2.4
			> 50,000	–		101 – 1,000	4	0.8
						> 1,000	–	–
Total	500	100.0		500	100.0		500	100.0

From the cross tabulation between the free chlorine residual and the faecal coliforms and total coliforms, it was found that in the 303 (60.6%) samples with free chlorine residual concentration between 0.0 – 0.1 ppm, 67% had TC between (0 – 3)/100 ml, 16% had TC between (4 – 50)/100 ml, and 17% had TC between (51 – 100)/100 ml. It was also found that 90.8% of the samples with FCR range between 0.0 – 0.1 ppm were without faecal coliforms and 9.2% were contaminated with FC.

Discussion

According to WHO (1993) standards, the results of this study show that only 39% of the tested drinking water samples have FCR within the limits of standards. It was also found that 17.8% of the samples contained low risk of contamination ((4 – 50)/100 ml), and 10.6% were contaminated with intermediate risk ((51 – 100)/100 ml) with TC, respectively. Out of the 500 samples tested for FC, it was found that 6% contained low risk contamination ((1 – 10)/100 ml), 2.4% intermediate risk ((11 – 100)/100 ml), and 0.8% high risk ((101 – 1,000)/100 ml) contamination, respectively.

It was noticed that none of the samples were examined for faecal streptococci or sulphite-reducing clostridia as recommended by PSI (1997), when samples are contaminated with faecal coliform. According to WHO (1984) and PSI (1997), it is recommended that the drinking water should not contain enteric viruses, three of the intestinal protozoa that are pathogenic for humans and can be transmitted by drinking water: *Entamoeba histolytica, Giardia Spp*. and *Balantidium coli*, all helminthes that can be infectious in humans and free-living organisms including plankton and macroinvertebrates. It was noticed that none of the samples were examined for any of the above-mentioned indicators.

In 1996, only 30% of the Tulkarem district population were connected to sewage networks, while the others were using cesspits and open channels for wastewater disposal. However, sewer lines are not extensively distributed and don't cover the whole area (Applied Research Institute (ARIJ) 1996).

According to ARIJ (1996), only 60% of the houses in Tulkarem city were connected to the sewage networks in 1996. There are only 25 km of sewage lines in Tulkarem city. This leaves a requirement of approximately 40 km within the city (in Shuwaika, Dunnaba, and Eirtah, which have no connections). However, there is 50% leakage in the sewerage system in Tulkarem City.

Seventy per cent of the Tulkarem population (mainly in villages) use cesspits for sewage disposal. In some villages (Al Jarushia, En Nazla Sharqia, Ramin), wastewater is drained into the roads. Wastewater from cesspits is usually emptied by vacuum tanker and disposed of into wadis (valleys). Dumping of wastewater in wadis in Attil village damaged the agricultural land and contributed to the pollution of most of the water wells there.

Contamination of groundwater aquifers and springs as result of wastewater percolation is a serious problem in several areas of the Tulkarem district. Another problem associated with percolation of wastewater into the ground is the pollution of rain-fed cisterns. Pollution occurred in some villages of Tulkarem (Atill, Baqa Alsharkia, Nazlet Eisa), where the rain-fed cisterns are located a few metres away from the cesspits.

There was a pollution of water resources in the Showika, Anabta and Al Shaarawia areas of the Tulkarem district. Behind the Showika and Anabta wells there is wastewater drainage from Wadi Al Zomar, and there are also open channels for wastewater disposal from the nearby area. These contribute to the pollution of water resources in these areas.

In the Attil area, in spite of two existing chlorinating pumps that operate and are checked daily, there was still a high degree of water contamination from wastewater. The people of that area drain their wastewater directly into the wadi. Some of the population in Attil used piles to drill holes about 30–40 m deep into the ground (the same level as the ground water table) to dispose of their wastewater. Schools in that area suffered some health problems due to water contamination. The Health Department had made big efforts to overcome some health problems that prevailed in the area that year, such as increased incidence of diarrhoea due to *Entamoeba histolytica* and *Giardia*.

Nazlet Eisa is another area facing the same problem as the Attil area. There is a high wastewater pollution of the water resources. All tested samples from this area showed severe contamination. In Baqa Alsharkia there are no water resources. They buy water from neighbouring areas like Attil and Nazlet Eisa, and therefore are at increased risk of health hazards too.

Faroun area is suffering from a bad wastewater drainage system. Most of the houses have cesspits; these are emptied by vacuum tanks and their contents disposed into open areas, which affect the groundwater quality. In the year 1999, Faroun, Qafin, Zita, and most of the communities in the Tulkarem district were without piped water, and Anabta had an old sewage system.

The most common and widespread danger associated with drinking water is contamination, either directly or indirectly, by sewage, by other wastes or animal excrement. If such contamination is recent, and if among the contributors there are carriers of communicable enteric diseases, some of the living causal agents may be present. The drinking of water so contaminated or its use in the preparation of certain foods may result in further cases of infection (WHO 1984).

To supplement what has been mentioned above, information about water-related diseases and their incidence rate in 1999 was obtained from the records of public health clinics of the Ministry of Health, distributed in the Tulkarem district as shown in Tables 2 and 3, respectively.

The total number of gastrointestinal (GI) infections and worm infestation in the Tulkarem district by the year 1999 was around 5,924 cases, most of them at young ages between 1 month and 15 years.

The total number of GI infections and worm infestations in the studied communities was about 4,208 cases. Those represent 71% of the cases in the Tulkarem district. Although the incidence rate of these diseases is high as shown in Table 3, and increases with the bad quality of

Table 2. Water-related diseases in the clinics of main communities of the Tulkarem district

Community	*Population*	*Monthly patients rate*	*Eye infections*	*Skin infections*	*GI infections*	*Worm infestations*
Tulkarem City	30,146	1,410	542	1,754	972	1,012
Shwaika	5,402	340	50	238	99	70
Dir Algosoon	7,061	550	109	323	129	190
Attil	7,763	640	215	416	263	236
Baqa Alsharkia	3,055	265	171	247	140	62
Zita	2,346	285	118	153	92	108
Nazlet Eisa	1,868	190	60	149	61	71
Qafin	6,525	630	555	583	260	122
Anabta	5,462	530	238	396	137	117
Faroun	2,382	245	245	124	27	40
Total	72,010	5,085	2,303	4,383	2,180	2,028

Table 3. Water-related disease in some communities of the Tulkarem district: Number of cases per person in 1999

Community	*Eye infection*	*Skin infection*	*GI infection*	*Worm infestation*
Tulkarem	1.8	5.8	3.2	3.3
Shwaika	0.9	4.4	1.8	1.3
Dir Algosoon	1.5	4.5	1.8	2.6
Attil	2.7	5.3	3.3	3.04
Baqa Alsharkia	5.6	8.1	4.5	2.02
Zita	5.02	6.5	3.9	4.6
Nazlet Eisa	3.2	7.9	3.2	3.8
Qafin	8.5	8.9	3.9	1.8
Anabta	4.3	7.2	2.5	2.1
Faroun	10.2	5.2	1.1	1.6
Total	3.1	6.08	3.02	2.8

water (Orabi 2000), there are, of course, many other factors which make illness more likely in poor quality housing areas. In the worst areas, sanitation is bad, housing is over-crowded, and therefore, malnutrition is more likely.

Eye and skin infections were also studied; it was found that many patients in those areas were infected with such diseases. The total numbers of eye disease cases were 2,303, and skin disease cases 4,383, which represented higher rates in those localities than in other areas of the district.

There are many other factors in addition to water pollution that may increase the incidence of these diseases, which makes the incidence rate mentioned in Table 3 unreliable because:

(1) The noted cases were only suspected and not confirmed because no stool cultures were done;

(2) The noted cases didn't represent the whole population, because the records referred to insured patients and children under 3 years only; and
(3) Some of the forms of the clinical records were not complete, and some of them were either blank or indecipherable; therefore, the data obtained was not valid for the conclusions obtained about water-related disease.

Conclusions and recommendations

The results of this study show that chlorinating of water resources was a major problem in the Tulkarem district. Some of the chlorinating pumps were defective and others were incorrectly operated. It can be concluded that many of the water resources in the Tulkarem district are threatened by contamination with wastewater due to the lack of collection systems and wastewater treatment in the district. Many of the tested drinking water samples were not within the limits of Palestinian and International regulations for drinking water. Most of the water resources are affected by the current absence of strict regulations, monitoring and control systems. This situation has resulted in the threat to public health and the spread of water-related diseases with high incidence rate due to the spread of micro-organisms and pathogens. This situation changes the value of water, which affects both personal well-being such as freedom from disease to feeling miserable, causing a lowered potential energy output in adult working life due to childhood infection, and its monetary value in commerce and industry.

From the analysis of the previous results the following recommendations can be drawn:

- Studies, which can identify the benefits of a safe and adequate water supply in order to quantify the economic burden of water-related diseases, should be conducted and encouraged.
- The first priority in training or research programmes in developing countries should be given to studying the existing water sources and investigating accessible resources.
- A better and stricter supervision should be implemented by the Ministry of Health and Water Authority.
- Water supply systems should be periodically tested and treated, and if needed, protected and improved.
- Wastewater collection systems and treatment plants should be established wherever possible, mainly for large communities.
- Disposal of wastewater from the cesspits in rural areas should be monitored and controlled.
- Public education in simple personal and applied hygiene should be emphasized.
- Clinical recording systems should be more effective and accurate.

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