Quality of Pipe Water Supply in "Albu-Aitha" Rural Area of Baghdad

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Abstract:

Background: Water is essential for life, since it is used for public water supply, rural use, irrigation and industry. Preparing water for human consumption is a major industry and water is still a major environmental health problem in developing countries, where unsafe water is still responsible for water-born diseases in children in neonatal life and under age of 5 years old. In addition, concern is growing in developing countries about the health implications of a host of other contaminants particularly toxic chemicals.

Objectives: The present survey in "Albu-Aitha" rural area attempts to assess the quality of pipe water supply in term of chlorination efficiency, bacteriological and chemical characteristics.

Method: The village is supplied by three field water purification plants. A field survey was carried out during summer 2002. A total of 9 water samples were taken from each of the 3 plants, 3 were taken from inside the plant and the remaining 6 were taken 2 km. outside the plants in either directions (north and south). Chlorination efficiency measurement was done by chloroscope. A coliform bacilli bacterial count was done. Auto-analyzer and simple quantitative and qualitative analysis methods were used for chemical contamination. Atomic absorption and flame photometric technique methods were used for identification of toxic chemicals.

Results: The range and mean concentration of the chemicals tested were all within the acceptable limits of the internationally reported reference values in the 3 water purification plants. No evidence of toxic chemical contamination was observed. The total dissolved salts (TDS) and the nitrates (NO_3^-) showed an obvious increase (although not significant statistically) in its mean value at the 2 Km distal point of measurement compared to its intra-plant value.

Chlorination efficiency in Al-Naser plant ranged between 0.2 to 1.2 ppm and therefore was satisfactory. The other two plants showed ineffective chlorination. A statistically significant reduction in mean chlorine concentration was observed at the distal point (2 Km outside) compared to its intra-plant value in all the 3 plants. Bacteriological study showed a mean bacterial coliform count of around 5 / 100 ml in Om-Asapher and Old-Albu-Aitha plants, both inside and distally.

Conclusion: The water consumed by Albu-Aitha population is of poor quality due to coliform bacterial contamination and may lead to detrimental effects on the health status of these people. The piping system used for distributing water from the 3 water purification plant is defective and may be responsible for organic and/or biologic contamination of pipe water. Chlorination is inefficient in 2 of the 3 examined plants.

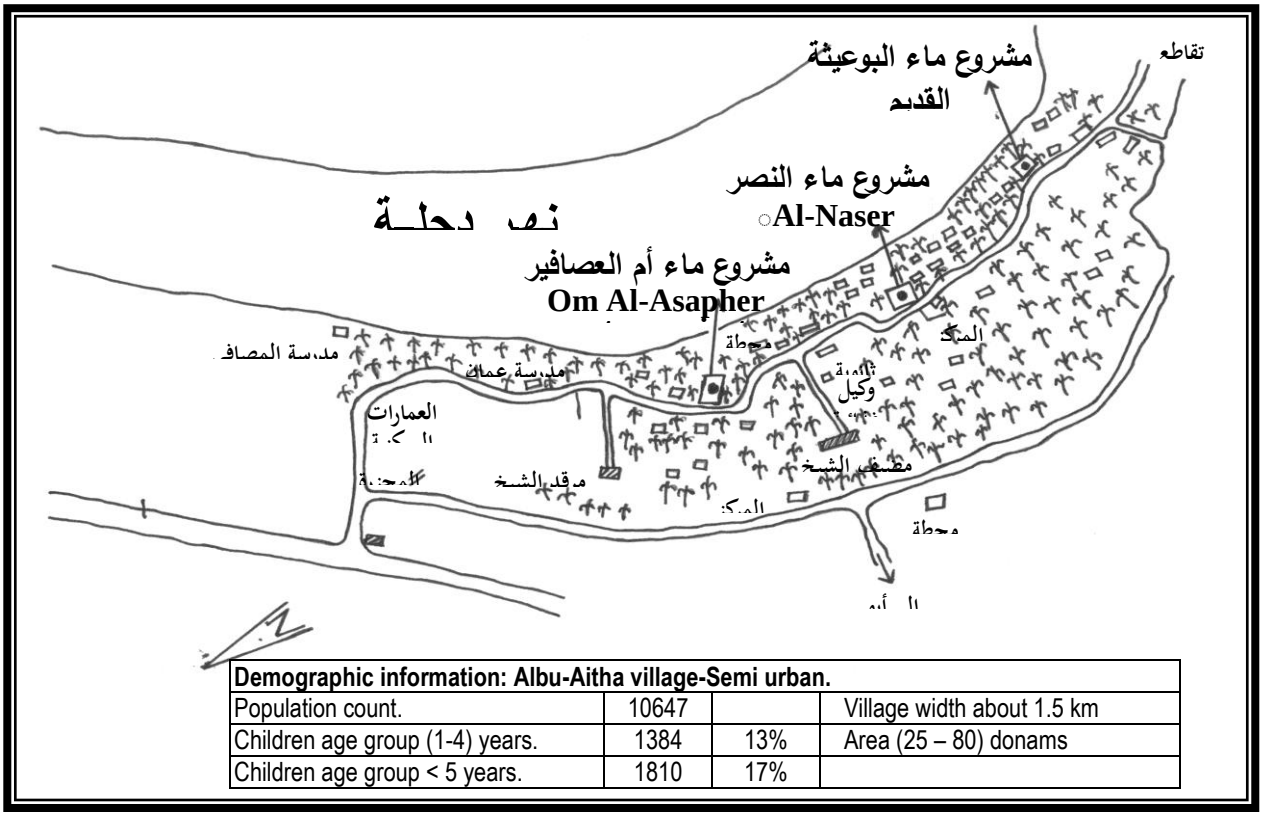
Key words: Water quality, chlorination efficiency, water purification plants, Iraq.

Introduction:

Approximately 70% of earth is covered by water, but only 3% is not salty and is therefore potentially available for consumption by human, plants and animals. Of this 3%, under 1% of water on earth is available for human use [1]. Water is essential for life due to the fact that water can be used for many purposes. It is used for public water supply, rural use, irrigation and industry [2]. Preparing water for human consumption is a major industry [2] and water is still a major environmental health problem in developing countries [2,3]. In the developed countries the introduction of disinfection practices shortly after 1900 virtually eliminated many infectious diseases that were transmitted through ingestion of water [2,3,4,5].

In developing countries unsafe water is still responsible for water-born diseases in children in neonatal life and under age of 5 years old [5]. In addition, concern is growing in developing countries about the health implications of a host of other contaminants particularly toxic chemicals [2]. The problem of evaluating exposure to toxic chemicals is that their effects will be complicated by the problems of latency in appearance and the lack of definitive data on dose response relationships [6,7].

The present survey in "Albu-Aitha" rural area attempts to assess the quality of pipe water supply in term of chlorination efficiency, bacteriological and chemical characteristics.



Demographic information: Albu-Aitha village-Semi urban.			
Population count.	10647		Village width about 1.5 km
Children age group (1-4) years.	1384	13%	Area (25 – 80) donams
Children age group < 5 years.	1810	17%	

Figure 1: Map chart of Albu-Aitha village**.**

Method:

The total population of "Albu-Aitha" village is 10647. Children under the age of 5 years constitute 30% of the total population. The village is supplied by three field water purification plants[8], fig 1. A field survey was carried out during summer 2002. Data was collected during the survey concerning geographical reconnaissance, population demography, industries near by, sites and names of water supply field plants.

The locations of the field plants were measured as a distance from the entrance of the village; 6 km., 7.5 km. and 9.5 km. for Om-Al-Asapher, Al-Naser and Old-Albu-Aitha plants respectively. A total of 9 water samples were taken from each of the 3 plants, 3 were taken from inside the plant and the remaining 6 were taken 2 km. outside the plants in either directions (north and south) according to formally standardized regulations[6,7,9].

Direct measures of chlorine efficiency inside the plants were done.

The residual chlorine was measured in the distal points where the distribution pipes reached. Chlorination efficiency measurement was done by chloroscope.

The volume of water sample for bacteriological analysis was 250 cm^3, while that for chemical composition and toxic chemicals analysis was 1000 cm^3.

Auto-analyzer and simple quantitative and qualitative analysis methods were used for chemical contamination. Atomic absorption and flame photometric technique methods were used for identification of toxic chemicals [5,7,9,10,11].

Results:

As shown in **table 1,** the range and mean concentration of the chemicals tested were all within the acceptable limits of the internationally reported reference values in all the 3 water purification plants. Selected toxic chemicals, namely: Arsenic (As), Lead (Pb), Mercury (Hg), Chromium (Cr) and Cyanide were tested for and were all negative. No statistically significant differences were observed between the mean measurement inside the water plant and 2 Km outside (along the pipe distribution system). The total dissolved salts (TDS) and the Nitrates (NO_3^-) showed an obvious increase (although not significant statistically) in its mean value at the 2 Km distal point of measurement compared to its intra-plant value.

Chlorination efficiency in Al-Naser plant ranged between 0.2 to 1.2 ppm and therefore was satisfactory for both, inside and residual chlorine 2 km outside.

The other two plants showed ineffective chlorination, with a mean value of 0.23 and 0.2 ppm inside Om-Asapher and Old-Albu-Aitha plants and absence of any trace of residual chlorine at the distal point.

A statistically significant reduction in mean chlorine concentration was observed at the distal point (2 Km outside) compared to its intra-plant

value in all the 3 plants. The reduction was very marked in Al-Naser plant (0.85 ppm), although the mean concentration of redual chlorine was still satisfactory, **table 2.**

Bacteriological study showed a mean bacterial coliform count of around 5 / 100 ml in Om-Asapher and Old-Albu-Aitha plants, both inside and distally. Coliform bacterial contamination was not detected in Al-Naser plant, **table 3.**

Table 1: The mean concentration of selected chemicals inside & 2 km outside each water purification plant.

	Al-Naser Water plant		Om-Al-Aasapheer Water plant		Old Al-Bu-Aitheh Water plant	
	Inside plant (n=3)	2 Km outside (n=6)	Inside plant (n=3)	2 Km outside (n=6)	Inside plant (n=3)	2 Km outside (n=6)
1. Total hardness ($CaCO_3$ in mg/L) – Reference range for safe water (100-500 mg/L)						
Range	(148 – 155)	(130 – 170)	(150 – 156)	(132 – 172)	(149 – 156)	(130 – 185)
Mean +/- SD	151 +/- 3.6	150.8 +/- 14.3	152.7 +/- 3.1	152 +/- 14.1	152 +/- 3.6	156.7 +/- 19.8
Difference in mean between inside and outside=	-0.2		-0.7		4.7	
P (t-test) for difference=	0.99[NS]		0.94[NS]		0.71[NS]	
2. Total Dissolved Solids (TDS in mg/L) – Reference range for safe water (500-1500 mg/L)						
Range	(530 – 560)	(530 – 570)	(530 – 562)	(531 – 571)	(531 – 561)	(520 – 560)
Mean +/- SD	543.3 +/- 15.3	556.7 +/- 15.1	544.3 +/- 16.3	558.2 +/- 14.8	543.7 +/- 15.5	547.5 +/- 14.4
Difference in mean between inside and outside=	13.4		13.9		3.8	
P (t-test) for difference=	0.25[NS]		0.24[NS]		0.72[NS]	
Cations						
3. Ca^{++} Ion conc. (mg/L) – Reference range for safe water (0.0-100 mg/L)						
Range	(50 – 65)	(50 – 65)	(50 – 66)	(52 – 66)	(51 – 61)	(48 – 65)
Mean +/- SD	58.3 +/- 7.6	57.5 +/- 5.2	59 +/- 8.2	58.3 +/- 5	57.3 +/- 5.5	55.3 +/- 6.9
Difference in mean between inside and outside=	-0.8		-0.7		-2	
P (t-test) for difference=	0.85[NS]		0.88[NS]		0.68[NS]	
4. Mg^{++} Ion conc. (mg/L) – Reference range for safe water (0.0-50 mg/L)						
Range	(20 – 35)	(20 – 35)	(20 – 36)	(20 – 36)	(28 – 32)	(22 – 35)
Mean +/- SD	28.3 +/- 7.6	26.7 +/- 6.1	29 +/- 8.2	27.3 +/- 6.2	30 +/- 2	28.3 +/- 4.8
Difference in mean between inside and outside=	-1.6		-1.7		-1.7	
P (t-test) for difference=	0.73[NS]		0.74[NS]		0.59[NS]	
5. Fe^{+++} Ion conc. (mg/L) – Reference range for safe water (0.1-1 mg/L)						
Range	(0.2 – 0.4)	(0.2 – 0.5)	(0.3 – 0.4)	(0.1 – 0.5)	(0.2 – 0.4)	(0.2 – 0.6)
Mean +/- SD	0.3 +/- 0.1	0.35 +/- 0.14	0.33 +/- 0.06	0.32 +/- 0.16	0.3 +/- 0.1	0.37 +/- 0.16
Difference in mean between inside and outside=	0.05		-0.01		0.07	
P (t-test) for difference=	0.6[NS]		0.87[NS]		0.54[NS]	
Anions						
6. Cl^- ion conc. (mg/L) – Reference range for safe water (200-600 mg/L)						
Range	(225 – 240)	(230 – 260)	(225 – 241)	(230 – 261)	(228 – 242)	(232 – 248)
Mean +/- SD	231.7 +/- 7.6	242.5 +/- 11.7	232.3 +/- 8.1	243.2 +/- 12.2	234 +/- 7.2	241.3 +/- 5.8
Difference in mean between inside and outside=	10.8		10.9		7.3	
P (t-test) for difference=	0.2[NS]		0.14[NS]		0.1[NS]	

	Al-Naser Water plant		Om-Al-Aasapheer Water plant		Old Al-Bu-Aitheh Water plant	
	Inside plant (n=3)	2 Km outside (n=6)	Inside plant (n=3)	2 Km outside (n=6)	Inside plant (n=3)	2 Km outside (n=6)
7. NO_3^- ion conc. (mg/L) – Reference range for safe water (0.0-40 mg/L)						
Range	(20 – 25)	(20 – 30)	(21 – 25)	(21 – 31)	(21 – 24)	(22 – 28)
Mean +/- SD	22.3 +/- 2.5	25.8 +/- 3.8	22.3 +/- 2.3	26.3 +/- 3.7	22.3 +/- 1.5	25.3 +/- 2.4
Difference in mean between inside and outside=	3.5		4		3	
P (t-test) for difference=	0.2[NS]		0.21[NS]		0.14[NS]	
8. SO_4^- ion conc. (mg/L) – Reference range for safe water (200-400 mg/L)						
Range	(220 – 248)	(240 – 340)	(231 – 240)	(231 – 261)	(231 – 260)	(230 – 246)
Mean +/- SD	232 +/- 14.4	289 +/- 52.4	235.3 +/- 4.5	244.5 +/- 10.3	243.7 +/- 14.8	239.3 +/- 7.3
Difference in mean between inside and outside=	57		9.2		-4.4	
P (t-test) for difference=	0.12[NS]		0.19[NS]		0.56[NS]	
9. PO_4^- ion conc. (mg/L) – Reference range for safe water (0.00-0.05 mg/L)						
Range	(0.01 – 0.02)	(0.01 – 0.03)	(0.01 – 0.03)	(0.01 – 0.02)	(0.01 – 0.03)	(0.01 – 0.04)
Mean +/- SD	0.013 +/- 0.006	0.018 +/- 0.008	0.017 +/- 0.012	0.015 +/- 0.005	0.02 +/- 0.01	0.023 +/- 0.01
Difference in mean between inside and outside=	0.005		-0.002		0.003	
P (t-test) for difference=	0.35[NS]		0.77[NS]		0.66[NS]	

Note: 1. The following toxic chemicals were tested for and were missing (negative) from all water samples tested: Arsenic (As), Lead (Pb), Mercury (Hg), Chromium (Cr) and Cyanide.
2. NO_2 was also negative

Table 2: The mean concentration of residual chlorine inside and 2 km outside each water purification plant.

	Al-Naser Water plant		Om-Al-Aasapheer Water plant		Old Al-Bu-Aitheh Water plant	
	Inside plant (n=3)	2 Km outside (n=6)	Inside plant (n=3)	2 Km outside (n=6)	Inside plant (n=3)	2 Km outside (n=6)
Residual Chlorine conc. (ppm) – Reference concentration is 0.2 to 0.8 ppm						
Range	(1 - 1.2)	(0.2 - 0.3)	(0.2 - 0.3)	(0 - 0)	(0.1 - 0.3)	(0 - 0)
Mean +/- SD	1.07 +/- 0.12	0.22 +/- 0.04	0.23 +/- 0.06	0 +/- 0	0.2 +/- 0.1	0 +/- 0
Difference in mean between inside & outside=	-0.85		-0.23		-0.2	
P (t-test) for difference=	<0.001		<0.001		0.001	

Table 3: The mean coliform bacterial count inside and 2 km outside each water purification plant.

	Al-Naser Water plant		Om-Al-Aasapheer Water plant		Old Al-Bu-Aitheh Water plant	
	Inside plant (n=3)	2 Km outside (n=6)	Inside plant (n=3)	2 Km outside (n=6)	Inside plant (n=3)	2 Km outside (n=6)
Count of Coliform Bacilli / 100 ml – Should be negative for safe water						
Range	(0 - 0)	(0 - 0)	(4 - 6)	(4 - 6)	(4 - 6)	(4 - 6)
Mean +/- SD	0 +/- 0	0 +/- 0	4.7 +/- 1.2	5 +/- 1.1	4.7 +/- 1.2	5.3 +/- 1
P (t-test) for difference in mean between inside and outside =	**		0.69*[NS]*		0.41*[NS]*	

Discussion:

It was stated that chlorine concentration inside the plant should be 1 ppm and the residual chlorine at a distal point in the pipe distribution system (2 km outside the plant) should be within a range of 0.2 to 0.8 ppm in ordinary circumstances[2,4,5,6].

Residual chlorine below the previously stated limits would predispose the consumers to the

hazards of water born diseases associated with contaminated water. Al-Naser plant showed efficient chlorination both inside at the distal point of distribution system. The efficient chlorination may explain the absence of coliform bacterial contamination, which was observed in the other 2 plants [2,7]. It was stated that coliform bacilli should be zero/ 100 ml of water to indicate safe water bacteriologically [5,6,7,9].

The mean coliform bacilli bacterial count in Om-Asapher and Old Albu-Aitha was around 5/100 ml, which points out to bacterial contamination and organic (fecal) contamination of water source (river). The bacterial contamination correlated with inefficient chlorination in these plants.

The association between bacterial contamination of water used for domestic purposes and the development of epidemics and water-borne diseases was discussed and established in many literatures [7,10,11].

All the 3 plants, with special emphasis on Al-Naser plant showed obvious and statistically significant reduction in residual chlorine 2 km outside the plant, which may point out to organic contamination of water during its travel in the piping system [7] and the system may be old and defective with multiple breaks in the pipes which predisposes to contamination, especially during periods of low water pressure in the distribution system. Another clue to organic contamination during the travel of water in the distribution system is the obvious increase in mean Nitrates (NO_3^-) between the intra-plant measurement and the distal point measurement.

All three plants showed an acceptable water quality regarding the TDS, total hardness, anions and cations assessment together with absence of selected toxic chemicals.

The water consumed by Albu-Aitha population is of poor quality and may lead to detrimental effects on the health status of these people. Children under 5 years of age are especially vulnerable to the negative health outcomes [10, 11]. The present study concluded:

1-The piping system used for distributing water from the 3 water purification plants is defective and may be responsible for organic and/or biologic contamination of pipe water.

2-Chlorination is inefficient in Om-Al-Asaher and Old Albu-Aitha plants, in which coliform bacterial contamination was found.

3-The chemical composition of water was satisfactory with no evidence of toxic chemicals associated with industries

Further studies are needed to correlate the poor water quality with the health status in the village community, exploring for outbreaks or water-borne diseases.

The relevant authorities need to be informed about the defective distribution system and inefficient chlorination of water plants to take corrective steps.

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