Physicochemical Analysis of the Drinking Water of Al Gedarif City, Sudan

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ABSTRACT

In the present study the highest residual chlorine level (0.2) was detected in the city inlet and the circular line of the Atbara River sources. The taste, color and odor were found acceptable, although, the ground water is a bit salty and the raw water of the main stream of Atbara River, is always brown in color, especially in the autumn season.

The highest turbidity value was recorded for the main stream of Atbara River, while, the maximum electric conductivity was found in Al Azasza boreholes. The total dissolved solids were greater in the ground water sources compared to that of the surface water sources. However, the total alkalinity and hardness values were higher in the ground water of Al Azaza boreholes than that of all the other sources. On the other hand, the mineral contents (calcium, potassium, magnesium and sodium) were higher in the ground water. Fluorides, chlorides and bicarbonates were also higher in ground water. Similarly, were the contents of nitrates, nitrites and ammonia? However no carbonates were detected in Al Azaza and Abu Naja nor in Al Saraf dam raw water.

Keywords: Physicochemical analysis, Drinking water, Al Gedarif city.

INTRODUCTION

Not all natural water is suitable for human drinking, because it may contain physical, chemical and biological agents, which may harm humans (Internet, 2009). Safe drinking-water has been historically the most critical single environmental element in protecting health of the public against communicable diseases (Emro, 1996).

In the assessment of drinking-water quality for the physical parameters, the sensations of taste and odor are complementary. In general, the sense of taste is most useful in detecting inorganic constituents of drinking-water, while the sense of smell is more useful in detecting organic constituents (WHO, 1988). Algae are the most frequent causes of taste and odor problems in surface supplies (Hammer, 1986) .

Color in drinking-water may be due to the presence of colored organic substances, usually humics; metals such as iron and manganese, or highly colored industrial wastes (WHO, 1988 and Hussein, 2002).

Turbidity is a good measure of sedimentation, and filtration efficiency (Evison and James, 1977). Abdel Rahim (2000) measured the turbidity for water from Almogrun, Alkalakla Algalaa, Algadisya, Um-Ushur and Jebel Awlia. The values were 17.6, 0.6, 0.0, 1.2 and 0.8, respectively.

Although no health-based guideline value is proposed for pH, eye irritation and exacerbation of skin disorders have been associated with pH values greater than11 (WHO, 1993). Values of pH for water from the Niles ranged from 7.1 to 8.1, from wells ranged from 7.3 to 8.5 and that of tap water was 6.7 (El Hassan *et al*., 1984).

Electric conductivity (EC) depends on the presence of ions, their total concentration, mobility and valence (Ibrahim, 2000). However, Abdel Magid *et al*. (1984) measured the EC at 25º C for water from the Nile, from wells, and from tap. The values were 0.15 to 0.17, 1.2 to 3.05 and 0.17 mmhos/cm , respectively.

The chemical parameters include the total dissolved solids (TDS) which comprises inorganic salts (principally calcium, magnesium, potassium, sodium for cations, and carbonates or bicarbonates, sulphates, chlorides and nitrates for anions) and small amount of organic matter that is dissolved in water (WHO, 1993). These also cause hardness.

The total alkalinity of water, on the other hand, was defined as its capacity to neutralize acids. However, no limits were set for alkalinity level in water (Twort *et. al*., 1985 and Ibrahim, 2000). Thousands of organic and inorganic chemicals have been identified in drinking-water supplies around the world, many in extremely low concentrations (Internet, 2008). The chemicals selected for the development of guideline values include those considered potentially hazardous to human health, those detected relatively frequently in drinking-water, and those detected in relatively high concentrations (WHO,1995).

MATERIALS AND METHODS

The sites from which the samples were collected are as follows:

Cites of Atbara river (AR):

ARMS= Main steam, ARTW= Treated water, ARS38=Station 38, ARCI=City inlet, ARMV= Main reservoir, ARNL= Northern line, ARNZ= Zeer of Northern line, ARSL= Southern line, ARSZ= Zeer of southern line, ARCL= Circular line, ARCZ= Zeer of circular line.

Cites of Al Saraf dam (SD): SDET= Elevated tank

Cites of Dalassa dam (DD): DDET= Elevated tank.

Cites of Al Azaza boreholes (ZB): ZBCT= Al Azaza boreholes collection tank

Cites of Abu Al Naja boreholes (NB): NBCT= Abu Naja boreholes collection tank

The residual chlorine was made only for Atbara river sources and was measured with a pool tester (checked comparator coulor tester), using a color desk (Lovebird Company). The other physical parameters included in this investigation were: Taste, Odor, Color, Turbidity, pH and Electric conductivity (EC).

The taste of the water samples as well as odor and color were determined by sensory evaluation. The turbidity measurements were made with a 2100 NIS Turbidimeter (Hach instrument, U.S.A.), using the method described by Hach (2004). The pH was measured in the laboratory with a pH meter (Pota test pH meter, Wagtech U.S.A.).The electric conductivity (EC) was measured in µs/cm, at 25º C using a conductivity meter (47 Cond. Meter, Jenway Company, and USA).

The chemical parameters involved the total dissolved solids (TDS) in mg/L which were measured at 25º C using the TDS Meter 5031 (Ezodo Company). The chemical concentrations of some compounds in water (fluorides, nitrates, nitrites and ammonia) were detected by the DR/4000 U Hach Spectrophotometer using related reagents, following the methods described in the Hach (2004), at different wave lengths. Titration methods were applied for total hardness, total alkalinity, calcium, magnesium, carbonate, bicarbonate and chloride as described in the methods of APHA (1989), using a digital titrator (665 Dosimat, Metrohm). Sodium and potassium were determined by flame photometry method, using corning-400 flame photometer (Vogel, 1978).

RESULTS

Chlorine treatment was made only for the Atbara River sources. The residual chlorine was found in the range of 0.0 – 0.2 mg/L (Table, 1). Generally, no residual chlorine was detected in the main stream of Atbara River (ARMS) and zeer waters during the different seasons. The highest content (0.2) was detected in the city inlet (ARCI), during the winter of the two years and the autumn of the first year and it was also detected in the northern (ARNL) and circular lines (ARCL), during the summer of the first year. However, the residual chlorine in the other sources of Atbara River was found less than 0.2 mg/L (Table, 1).

The results of the Physical parameters were shown in Table (2). The taste of all samples was acceptable, except in Al Azaza (ZBCT) and Abu Al Naja (NBCT) boreholes, which showed a salty taste. No odor was detected in the water samples taken from the different sources of Al Gedarif city drinking-water, according to the personal judgment of the author. According to color, it is only the main stream of Atbara River (ARMS), which was always brown in color. Turbidity values in NTU for the water sampling sites were ranging from 0.22 to 578. The highest value was recorded for the main stream of Atbara River (578), while the lowest was found for Al Saraf (SDET) dam (0.22). The pH values of all samples were in the range of 7.0 – 8.3. The highest value was recorded for the main stream of Atbara River, while the lowest was recorded for Abu Al Naja boreholes.

The highest value of electric conductivity in µs/cm for the water sampling sites was found in Al Azaza boreholes (1357), followed by Abu Al Naja boreholes (830), Dalassa dam (810), Al Saraf dam (594), then the treated water of Atbara River (564) and the main stream of Atbara River (465).

The results of the chemical parameters are shown in Table (3). Values of the total dissolved solids in mg/L for the water sampling sites varied between 816 in Al Azaza boreholes to 276 in the main stream of Atbara river.

The highest value of the total hardness in mg/L for the water sampling sites was recorded for Al Azaza boreholes (459.2), followed by Abu Al Naja boreholes (346.6), Dalassa dam (318), treated water of Atbara River (238.6), Al Saraf dam (221.2), then the main stream of Atbara River (197.4). The first three sources were considered as extremely hard, whereas the other three ones were very hard.

The total alkalinity of the water sampling sites in mg/L was ranging from 188.2 for the main stream of Atbara River to 726.8 for Al Azaza boreholes. Medium values were recorded for Abu Al Naja boreholes, Dalassa dam, Al Saraf dam and treated water of Atbara River.

Results of the mineral contents were also shown in Table (3). Calcium contents in mg/L ranged from 11.3 in Al Saraf dam to 44.8 in Abu Al Naja boreholes. Magnesium contents ranged from 27.3 mg/L in Abu Al Naja boreholes to 87 mg/L in Al Azaza boreholes. The highest amount of sodium in mg/L was recorded for Al Azaza boreholes (188). However, the lowest sodium values were recorded for the treated water (31.5) and the main stream of Atbara River (30). The highest Potassium content (37 mg/L) was found in Al Azaza boreholes, however, no potassium was detected in Al Saraf and Dalassa dams.

Table 1. Residual chlorine (mg/L) in water collected from the sources of Atbara River during the three seasons for two years.

Sample Site	Year 1			Year 2		
	Summer	Autumn	Winter	Summer	Autumn	Winter
ARMS	0.0	0.0	0.0	0.0	0.0	0.0
ARTW	0.1	0.1	0.1	<0.1	< 0.1	0.1
ARS38	0.1	0.1	0.1	<0.1	< 0.1	> 0.1
ARCI	0.1	0.2	0.2	0.1	< 0.1	0.2
ARMV	> 0.1	0.1	0.1	0.1	0.1	0.1
ARNL	0.2	> 0.1	> 0.1	0.1	> 0.1	> 0.1
ARNZ	0.0	0.0	0.0	0.0	0.0	0.0
ARSL	> 0.1	0.1	0.1	0.1	0.0	> 0.1
ARSZ	0.0	0.0	0.0	0.0	0.0	0.0
ARCL	0.2	0.1	0.1	0.1	0.0	0.1
ARCZ	0.0	0.0	0.0	0.0	0.0	0.0

Table 2. Physical parameters of the water samples collected from the five Main sources of Al Gedarif city drinking-water.

Sources / Parameters	ARMS	ARTW	SDET	DDET	ZBCT	NBCT
Taste	Nil	Nil	Nil	Nil	salty	salty
Odor	Nil	Nil	Nil	Nil	Nil	Nil
Color	Bro	Nil	Nil	[illegible]	Nil	Nil
Turb. (NTU)	578	5.45	0.22	0.67	1.28	0.4
pH	[illegible]	[illegible]	8.1	7.3	7.1	7.0

EC (µs/cm)	465	564	594	810	1357	830

The chloride concentrations in mg/L for the water sampling sites was ranging from 7.7 for Al Saraf dam and 73.45 for Al Azaza boreholes, while medium values were recorded for the rest of the sources. Fluoride levels (mg/L) in the samples ranged from 0.0 in the treated water and the main stream of Atbara River to 1.6 in Al Azaza boreholes. The highest bicarbonate was recorded for Al Azaza boreholes (726.8 mg/L), followed by Abu Al Naja boreholes (404.5 mg/L), Dalassa dam (354 mg/L), Al Saraf dam (341), the treated water (189.8) and the main stream of Atbara River (178.2). However, no carbonate was detected in Al Azaza boreholes, Abu Al Naja boreholes and Al Saraf dam. In contrast, in the Dalassa dam the carbonate concentration was at its maximum (26.8). The nitrate concentrations varied between 2.1 mg/L in the treated water of Atbara River and 65 in Dalassa dam. No nitrites were detected in the main stream of Atbara River, although they were 1.2 mg/L in Al Azaza boreholes.

Table 3. Chemical parameters (mg/L) of the water samples collected from the main five sources of Al Gedarif city drinking-water.

Sources / Parameters	ARMS	ARTW	SDET	DDET	ZBCT	NBCT
TDS	2	338	357	4	816	500
Total hardness as $CaCo_3$	197.4	238.6	221.2	318.2	459.2	346.6
Total alkalinity as $CaCo_3$	188.2	198.1	341.3	380.8	726.8	404.5
Calcium	29.98	36.07	11.3	37.8	40.65	44.8
Magnesium	29.8	36.1	46.9	54.5	87	27.3
Sodium	30	31.5	66	71.5	188	68
Potassium	4	4	0.0	0.0	37	31
Chloride	24.7	33.4	7.7	29.8	73.45	52.8
Fluoride	0.0	0.0	0.49	0.46	1.6	0.8
Bicarbonate (HCo_3)	178.2	189.8	341.3	354	726.8	404.5
Carbonate (Co_3)	10	8.3	0.00	26.8	0.00	0.00
Nitrate (No_3)	15	2.1	22	65	25	12
Nitrite (No_2)	0.00	0.0002	0.014	0.026	1.2	0.9
Ammonia (NH_4)	0.13	0.01	0.05	0.07	0.24	0.08

Ammonia was detected at a concentration (mg/L) of 0.13 in the main stream of Atbara River, while it was 0.01 in the treated water of Atbara River. In Al Azaza boreholes, Abu Al Naja boreholes, Dalassa dam and Al Saraf dam it was 0.24, 0.08, 0.07 and 0.05, respectively.

DISCUSSION

The results of the taste showed that only Al Azaza and Abu Al Naja boreholes were salty. Hammer (1986) added that the presence of taste in water supply may be affected by a variety of organic chemicals found in nature, or resulting from industrial wastes, or products of biological growths. However, no odor was detected in any of the samples. According to the WHO (1988), the odor and taste in drinking-water supplies may be associated primarily with the raw water and the treatment method.

Regarding the color changes, only the main stream of Atbara River was brown. This is due to the high amount of silt carried with water. However, in domestic water, color is undesirably acceptable and was found to dull clothes and stain fixtures (Hammer, 1986).

A higher turbidity level was recorded in the main stream of Atbara River during the rainy season. The rise in the turbidity values in the surface water during the rainy season was positively correlated with the microbial densities (El Tom, 1997 and Ahmed Alhag, 2005). It can protect the microorganisms against disinfection and will stimulate growth of bacteria. It will also give rise to a significantly higher chlorine demand (WHO, 1999). The pH levels of the drinking-water samples remained rather stable with neutral or slightly alkaline reactions for all sources, within the range between 7.0 – 8.3 which is an accepted level as according to both the Sudanese and the International standards for drinking-water (WHO, 1997).

Different levels of electric conductivity were found in the different sources with the highest value in Al Azaza (1357 µs/cm) boreholes. These variations may be due to differences in the geological parameters. WHO (1993) stated that the concentration of total dissolved solids (TDS) is directly related to conductivity. On the contrary, very less values of electric conductivity were detected by Abdel Magid *et al*. (1984) for the Nile, wells and the tap water, at Khartoum.

Overall, the water samples taken from the five different main sources that supply Al Gedarif city with drinking-water varied from each other in their total dissolved solids, total hardness, total alkalinity, and in the amount of cations and anions. However, the values of most of these parameters were higher in the underground waters, than in the surface waters. Finally, they were found within the levels recommended by the local and the International public health agencies.

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التحليل الفيزيائي الكيميائي لمياه شرب مدينة القضارف

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الملخص

وجد في هذا البحث أن أعلى مستوى للكلورين المتبقي (0.2) كان في مياه الخط في مدخل المدينة الرئيسي والخط الدائري من مصدر مياه نهر عطبرة. ووجد كذاك أن طعم مياه شرب مدينة القضارف ولونها ورائحتها كانت مقبولة. علماً أن المياه الجوفية كانت مالحة نوعاً ما، في حين كانت المياه الخام لنهر عطبرة بنية اللون ، خاصة في فصل الخريف.

لقد تم تسجيل أعلى معدل للعكارة في الماء الخام لنهر عطبرة وأعلى مستوى للموصلية الكهربية في ماء آبار العزازة. هذا وكانت نسبة المواد الصلبة الكلية المذابة أكثر في مصادر المياه الجوفية مقارنة بمياه المصادر السطحية. ومع ذلك فقد وجد أن قيم القلوية الكلية والعسر الكلي كانت أعلى في المياه الجوفية ، مقارنة مع مصادر المياه الأخري. ومن ناحية أخرى وجد أن مستوى المعادن(الكالسيوم، البوتاسيوم، الماغنيسيوم والصوديوم) كان عالياً في المياه الجوفية. وكانت نسبة الفلوريدات والكلوريدات و البيكربونات هي أيضاً عالية في المياه الجوفية لآبار العزازة.وكذلك كانت محتويات النترات والنيتريتات والنشادر (الامونيا) ومع ذلك لم يتم تسجيل الكربونات في المياه الخام للآبار العزازة وأبوالنجا ، ولا حتى في مياه سد السرف.