

Measuring the Health Impact of Drinking Water Sources in El-Fashir, Sudan

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Abstract

The study aimed to assess the physical and chemical condition of drinking water in El-fashir city, Sudan. The parameters studied are; Electrical conductivity (EC), nitrates, pH, Total Dissolved Solid (TDS) and fluorine were analyzed at water points and in the laboratory. Results were processed on SPSS software. The study revealed the pH results, which were distributed between 6.8 to 8 for samples from hand pumps 1 and 2 and tank water, respectively. The residual chlorine concentration (RC) in the water supply system of the selected stations ranged between 0.2 to 0.6 mg /L. The concentration of nitrate level ranged from 3. 4.5 mg/L, which is within the acceptable range of the standards for WHO and SSMO standards. The study also determined the level of fluorine, which ranged between 0.17 - 0.41 mg/L, which is within the acceptable range of the standards for WHO and SSMO standards. This study found that all results fall within the permissible limits of the standards of WHO and SSMO standards except the hand pumps.

Keywords— *Water Quality, Drinking Water, TDS, Nitrate, Conductivity, Turbidity, Fluoride.*

Introduction

Water is one of the most vital of all-natural resources known on earth. It is essential to all living organisms, human health, food production, most ecological systems and economic development⁽¹⁾. The safety of drinking water is vital for the health issues. The safety of drinking water is affected by numerous impurities, which included physical, chemical and microbiological. Such impurities cause serious health problems⁽²⁾. Water is vital to maintain life, and it must be accessible, safe,

adequate and available. Improving the accessibility to safe drinking water can result in appreciable benefits for human health. Major efforts should be made to achieve high quality drinking-water^(2,3).

Water covers 75% of our planet, yet, only a small fraction is available as fresh water. Where the majority of water (97%) is found in the oceans (too salty), the remaining 3% of water is fresh where 99.9 % of this water is locked up in the poles, or is so deep (buried) underground that it is too costly to extract⁽¹⁾.

Sources of Water categories of naturally occurring water resources as groundwater, dug wells, borehole wells, spring water, rainwater and surface water. Potable or drinking water “defined as the water delivered to the consumer that can be safely used for drinking and domestic’s purposes”. In Sudan, the main sources of water are ground water, surface water (rivers and

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streams) depending heavily on the rainfall. Furthermore, the clean water supplies are managed by specific water cooperation, and the quality of the water is monitored by authorities ⁽³⁾.

Access to water supply is an essential need and a human right. Joint Monitoring Programmers for water supply and sanitation stated that billions of people worldwide are lasting to suffer from poor access to water, sanitation and hygiene and according to UNICEF and the World Health Organization (WHO) reports ⁽⁴⁾. One of the targets of Sustainable Development Goal (SDG) 6.1, which is concerned mainly with water supply, “is to achieve universal and equitable access to safe and affordable drinking water for all by 2030” ⁽⁵⁻⁷⁾. Water quality considered safe and fit for human consumption if all parameters being in standards and according to national and international guidelines as explained in the bellow table1, which expressed the standards for selected parameters include among others EC, pH, R. Chlorine, Turbidity, TDS, Nitrate etc. These parameters can affect the drinking water quality if the concentrations higher than the safe limits seted by the World Health Organization (WHO) and SSMO ⁽⁸⁾.

During the last years, it has been observed that water sources were exposed to pollution due to the increasing urbanization and human activities. These pollutants are classified as organics, inorganics, radionuclides, disinfectants and microorganisms ⁽⁴⁾. The inorganic chemicals are the major pollutant in drinking water ⁽⁵⁾. Heavy metals accumulate in human organs and nervous system which hinders the normal functions where it causes health problems ⁽²⁾. Moreover, the heart diseases, kidney-related problems, and cancer are related to the traces of metals such as chromium (Cr) and cadmium (Cd) reported as water-related diseases ⁽⁶⁾. Fluoride can have an adverse effect on tooth enamel and may give rise to mild dental fluorosis. In general, dental fluorosis does not occur in temperate areas at concentrations below 1.5–2 mg/L of drinking-water ⁽⁹⁾.

The present study aimed to assess the physio-chemical characteristics of water samples collected from diverse drinking water sources in the study area El-Fashir Sudan, and to compare the results obtained with the local (national) and international standards and guidelines.

Material and methods

Study area description

The research was conducted in El-fashir city “which ↑ is the capital city of North Darfur, Sudan” ⁽¹⁾. The geographic coordinates are Latitude: 13° 37’ 40” N and Longitude: 25° 20’ 57” E Lat/Long (dec): 13.62793,25.34936 Köppen. With an estimated population of over 500,000 people, (2013), It considered as the capital city as while as the economic hub of North Darfur. and an agricultural marketing point in the surrounding region.

Sampling and analytical procedure

The samples were collected during August 2017, from 7 sources, such as tap (piped) water, tanks water, tape-stand and Hand pumps used for domestic purposes. Samples were treated using standard methods (collected, stored and transferred to the laboratory). The collection was in clean screw capped glass bottle, insulated ice chest with ice packs was used from the collection of samples. The collected samples were labelled with date and code and kept at 4°C until analyzed. Immediately after sample collection, taste, turbidity, temperature, pH, conductivity and TDS, Residual chlorine, were tested on sites. Nitrate and Fluorine were analyzed at the lab. The physio-chemical parameters were determined according the Standard Methods for the Examination of Water WHO and SSMO. Then comparing the results with SSMO and WHO.

Determination of Physio-chemical Parameters

- Analysis of pH levels: the measurement of pH was done on site by using a portable pH meter. Calibration was by standard buffer solutions; pH= 4 and 7, with temperature adjustments.
- Conductivity and TDS were carried out at 25°C by conductivity meter (Jenway 470) after calibration with calibration solution.
- Determination of Turbidity: Turbidity was measured using Palin test Portable Turbidity Meter.
- Free Chlorine measured by using color comparator; with added one DPD No 3 tablet, crushed and mixed to dissolve, and then stands for few minutes allowing full colour development; Free chlorine reacts

with diethyl-p-phenylene diamine (DPD) in buffered solution to produce a pink coloration. The intensity of the colour is proportional to the free chlorine concentration, then the reading was taken in the usual manner.

- Nitrate and Fluoride concentration: Nitrate and Fluoride values were determined by using spectrophotometer 7500. Procedure is mentioned in Chen et al., 2016⁽¹⁰⁾.

Table 1: Physio-chemical parameters standards for WHO and SSMO.

S/N	Items	SSMO standards mg/L	Standard specifications according to the World Health Organization	
			Lower Concentration Permitted mg/liter	Highest Concentration Permitted mg/liter
1	Color	Colorless	Colorless	Colorless
2	Taste	Palatable	Palatable	Palatable
3	Smell	Palatable	Palatable	Palatable
4	EC	<1400 μ S/cm	<1400 μ S/cm	1500 μ S/cm
5	pH	6.5- 8.5	6.5- 8.5	8.5
6	R. Chlorine	0.5	0.5	0.5
7	Turbidity	5 NTU	<5 NTU	5 NTU
8	TDS	<300 mg/L	300 mg/L	1000 mg/L
9	Temperature	25oC	25oC	25oC
10	Nitrate	10	>10	10
11	Fluoride	1.5	1.5	1.5

Results & Discussion

The results of water quality analysis for the various samples collected from different sources of water are shown in the table 2. The results are illustrated in table 2. pH values were all the samples ranged between 6.8 and 8, the lowest and the highest values are from samples (hand Pumps 1&2) and (tank water), respectively. According WHO and NDWQS pH range is between 6.8 and 8.5 which consistent with our results (Table 1).

This result is consistent with the study conducted in the State of Perak, Malaysia the pH values ranged between 7.01 and 8.21⁽⁸⁾. pH is classified as the most essential parameter of water quality; pH measurement is related to the alkalinity or acidity of water. Acidic water causes corrosion of the metallic plumbing system and pipes. Whereas, alkaline water shows disinfection properties⁽¹¹⁾.

Table 2: Laboratory Test Results

S/N	Sources	Results							
		EC (µs/cm)	pH	R. Chlorine (mg/l)	Turbidity (NTU)	TDS (mg/l)	Temperature	Nitrate (mg/l)	Fluoride (mg/l)
1	Tap 1 (Public Net)	440	7.8	0.6	1	570	26	3	0.41
2	Hand Pump 1	2130	6.8	0	2	1491	27	4.1	0.17
3	Tape-stand	484	7.6	0.2	1.5	577	26	4.1	0.17
4	Tank	814	8	0	2	570	26	3.5	0.41
5	Tap 2 (Public Net)	440	7.8	0.6	1	566	25	3	0.41
6	Tap 3	440	7.8	0.5	1	550	28	3	0.41
7	Hand Pump 2	2130	6.8	0	2	1495	27	4.5	0.17

The study showed the concentrations of residual chlorine (RC) in the study area water supply system for the selected stations which were varied between 0.2 to 0.6 mg/L. Most RC concentrations of these hand pumps and ground tanks were zero, while the tap-stand was 0.2 mg/L which is less than acceptable limits in WHO, and in the tap of the public net was 0.6 mg/L which is higher than acceptable limits in WHO. In general, the concentrations of Residual Chlorine are likely to be less

in the far distance points from Water Supply Plant (WSP) comparing with near points to WSP. According to WHO, municipal potable water supplies are usually chlorinated to provide a residual concentration between 0.5 to 2.0 ppm to provide continual protection throughout the distribution system from the treatment plant to consumer taps ⁽¹²⁾. Figure 1 shows a comparison between RC and pH for different water sources in El-fashir.

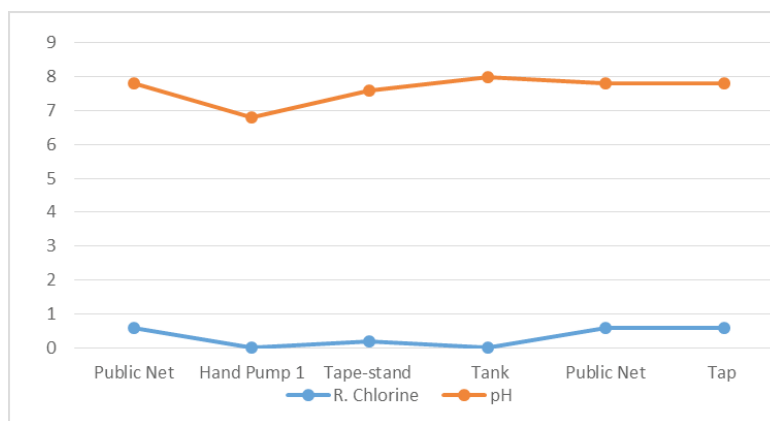


Figure 1 Comparison between RC and pH for different water sources in El-fashir.

The present study pointed out the level of Electrical Conductivity represents the number of dissolved salts in the water. The presence of dissolved solids included chloride, calcium, and magnesium in water samples to enhance carrying the electric current. According to NDWQ, the maximum acceptable level of conductivity is 1000 μ S/cm. The results ranged from 440 μ S/cm to 2130 μ S/cm, and the average conductivity value is 982.6 μ S/cm (Table 3). The lowest and highest conductivity values correspond to Hand Pumps 1&2 and Public net samples, respectively.

It is expected to find high mineral contents in mineral water, resulting in higher conductivity values. The hand Pumps values cross the acceptable limit in WHO but still within acceptable limits in other references. Conductivity does not have a direct impact on human health but high conductivity affects the quality of the water by giving mineral taste to the water (2,8). Figure 1 shows the Comparison between RC and pH for different water sources in El-fashir.

Table 3 Descriptive statistics of the parameters under study:

Parameters	Mean	SD
EC	982.5714	795.12323
pH	7.5143	0.50143
Free Residual Chlorine	0.286	0.3024
Turbidity	1.500	0.5000
TDS	830.571	450.8924
Temperature	26.4286	0.97590
Nitrate	3.54286	0.550325
Fluoride	0.3071	0.12829

Total Dissolved Solids (TDS): contains mainly of inorganic salts such as carbonates, bicarbonates, sulphates, phosphates and nitrates of calcium, magnesium, sodium, potassium, iron and a small quantity of organic matter diluted in water. The values of TDS ranged from 550 to 1495 mg/L. The levels of TDS exceeded the allowed lowest limit recommended by WHO and SSMO (< 300 mg/L), where the hand pumps samples exceed the highest allowed limit (1000 mg/L) recommended by WHO and SSMO for drinking water. The mean total dissolved solids concentration in the study area was found to be 830.6 mg/L. The concentration of TDS in

the present study was in contrast to the results found in the study conducted in Ethiopia where it ranged between 114.7 and 121.2 mg/L. The mean total dissolved solids concentration in the Wondo Genet campus was found to be 118.19 mg/l, which is within the limits of WHO standards (13). High values of TDS in groundwater are generally not dangerous to human health, but the high values of TDS may affect people health who are suffering from chronic kidney diseases, heart diseases and may cause laxative or constipation effects (13,14). The finding indicates that the relation between EC and TDS in drinking water was statistically significant, $p < 0.000$.

The level of turbidity shown in Table 2. Turbidity is related to the cloudiness of water caused by a variety of particles. All the results below the maximum standard limit set by WHO and SSMO⁽⁵⁾. Nephelometric Turbidity Units (NTU)), where the lowest value was 1 NTU, and the highest value was 2 NTU which represents the samples from taps and hand pumps. These results were consistent with the result observed from the study conducted in Jordan where the turbidity value ranged between 0.05–4.8 NTU⁽¹⁵⁾. High-quality drinking water must have a low level of turbidity to maintain human health. The study also revealed the level of Nitrate in raw water, and mainly it is a form of N₂ (of its oxidizing state). The values were 3 - 4.5 mg/L it is in the range of acceptable levels of WHO and SSMO standards (10 mg/L). Nitrates in water indicate the presence of entirely

oxidized organic matter. The excess level of nitrates can cause Methemoglobinemia as a blue baby disease. Although nitrates levels that affect infants do not posture a direct threat to older children and adult people, they do indicate the potential presence of other more serious residential or agricultural pollutants such as bacteria or pesticides⁽¹⁶⁾. The study also pointed out the level of fluoride the values ranged between 0.17-0.41 mg/L (mean= 0.31±0.12 mg/L), it is in the range of acceptable levels of WHO and SSMO standards (1.5mg/L). This result consisted of the results of a survey conducted in Behshar City the values ranged from 0.12 to 0.39 mg/L (mean 0.25±0.06 mg/L)⁽¹⁷⁾. Figure 2 shows the exceedance values for Nitrate and Fluoride above WHO limit for water samples from El-fashir.

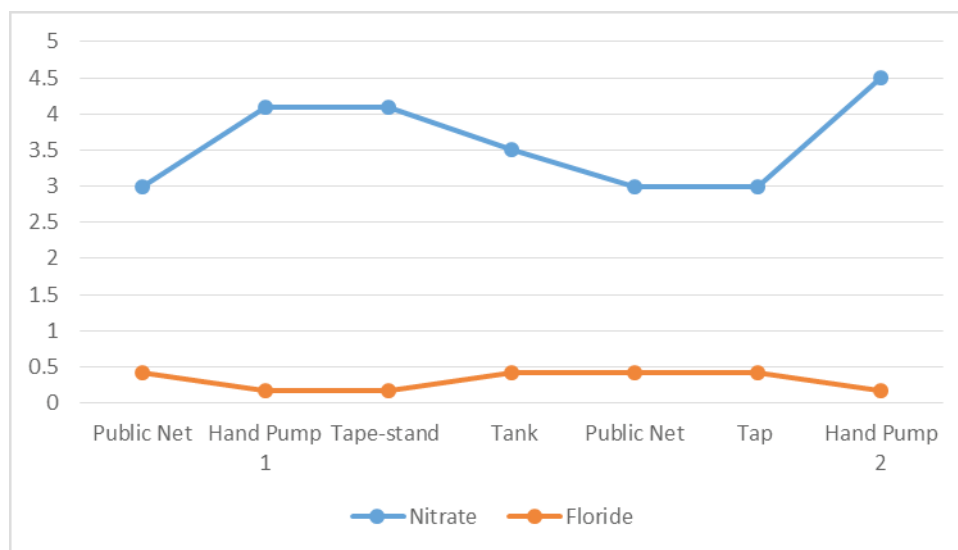


Figure 2 Exceedance values for Nitrate and Fluoride above WHO limit for water samples from El-fashir

Conclusion

The levels of water quality parameters such as pH, temperature, turbidity, fluoride and nitrate were found for all samples collected from different sites in the city of El-fashir within the limits recommended by WHO and SSMO, while the conductivity and TDS were found to be at the acceptable levels in all locations except for hand pumps were it exceed the recommended limits. It is also important to conduct further tests to check for other potential water contaminants such as chemicals, microbial and radioactive materials to complete the study on water quality at El-fashir city.

Declaration of Competing Interest : The authors declare that they have no conflicts of interest to disclose.

Funding; there is no financial support.

Ethical Clearance: Taken from State Ministry of Health.

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