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SEASONAL VARIATIONS OF PHYSICOCHEMICAL PARAMETERS IN GROUND WATER - KUSTI TOWN-SUDAN

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Abstract: Over the past 15 years, evidence has accumulated that the nation's ground water resource, which supplies more than 50 percent of the population's drinking water, is threatened not only by excessive overdrafts but also by contamination caused by past and present industrial, agricultural, and commercial activities.
Unsafe drinking water is one of the health problems of Sudan in general and in Kusti town in particular, where water related diseases are widely spread. This study is aimed to identify drinking water quality and its seasonal variations within Kusti town.
Methods: Study design: it is a descriptive cross-sectional study. Study population: water samples were collected seasonally using known statistical methods to represent the study area within Kusti town.
Physico-chemical analysis: From groundwater one sample was collected seasonally totaling 3 samples. All analysis was conducted according to the standard methods for the examinations of water and wastewater.
Results: The main findings of the study were: Samples collected from the groundwater source did not comply with WHO guidelines or Sudanese standards.
Conclusion: The supplied water quality in Kusti town varied seasonally with different health impacts, and didn't suitable for human consumption unless subject to intensive treatment.
Keywords: Ground water, Physicochemical, Analysis, Contamination, SMWW, SSMO.

Introduction

Over the past 15 years, evidence has accumulated that the nation's ground water resource, which supplies more than 50 percent of the population's drinking water, is threatened not only by excessive overdrafts but also by contamination caused by past and present industrial, agricultural, and commercial activities (**NATIONAL ACADEMY PRESS, 1994**).

The sources of water supply may be conveniently divided into two major types surface or ground water **(Escritt, 1972)**:

The ground water supplies include: Dug, bored, driven and drilled wells, rock and sand or earth springs and Infiltration galleries, **(Al Layla *et al.*, 1977)**.

Groundwater from deep and confined aquifers is usually microbially safe and chemically stable in the absence of direct contamination; however, shallow or unconfined aquifers can be

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subjected to contamination from discharges or seepages associated with agricultural practices, on-site sanitation or sewerage, and industrial wastes (**WHO, 2011**).

A number of studies revealed levels of nitrates in the range of 20 -200 mg/l of nitrates. But this is rare, most of the higher levels of nitrates are found in ground water. The levels in ground water tend to be much steadier during the year (**WHO, 1984**).

The levels in ground water tend to be much steadier during the year (**WHO, 1984**). Nitrite is seldom present in surface waters at significant concentrations but may be present in ground waters.

Ammonia may be found in natural surface waters, but is more frequently found at elevated concentrations in anaerobic ground waters. At the pH of most natural waters,

ammonia (NH_3) dissolves rapidly in water to form equilibrium with the ammonium cation (NH_4^+).

Ammonia in the environment originates from metabolic, agricultural (**Deborah, 2005**) and from disinfection with chloramines. Natural level in ground and surface waters are usually below 0.2mg/l, anaerobic ground water may contain up to 3mg/l (**WHO, 1995, 1993**). Ammonia in water is an indicator of possible bacterial, sewage and animal waste pollution, toxicological effects are observed only at exposure above 200mg/Kg of body weight (**UNESCO, 2007**).

Many ground waters contain 0.1-1.0mg/l of ammonia as N. The odour threshold of ammonia in water is 1.5mg/l; the threshold for taste is 35mg/l. Chloramines have an unpleasant biting odour at concentrations in water above 0.2mg/l. To restrict chloramines forming in the distribution system by the reaction of FACR and ammonia, the ammonia content should be less than 0.3mg/l.

Based on aesthetic considerations (odour threshold), the concentration of ammonia (measured as ammonium ion) should not exceed 1.5mg/l. **WHO (2004)** states that ammonia in drinking water is not of immediate health relevance, and therefore no health based guideline value is proposed.

The presence of chloride in natural waters can be attributed to dissolution of salt deposits, discharge of effluent from chemical industries, sewage discharge, irrigation drainage, contamination from refuse leaches, and sea water intrusion in coastal areas. Each of these sources may result in local contamination of both surface and ground water. The chloride iron is highly mobile. High chloride content may be damaging to metallic pipes and structures as well as being harmful to growing plants. The chloride content of rainwater can exceed

20mg/l, especially in windy coastal areas. The taste threshold of chloride in water is dependent on the associated cation but is in the range of 200-300mg/l. Chloride is generally present at low concentrations in natural surface waters. Concentrations in unpolluted water are often less than 10mg/l (**WHO, 1984**). Based on aesthetic considerations (taste and corrosion), the chloride concentration in drinking water should not exceed 250mg/l.

Iron in water it occurs mainly in the divalent and trivalent (Ferrus and Ferric) states. The concentration of iron in well aerated water is seldom high, but under reducing condition; which may exist in some ground water, lakes or reservoirs and in the absence of sulfide and carbonate, high concentration of soluble Ferrus iron may be found. Concentrations of iron more than 1mg/l have been reported to occur in ground water. The presence of iron in natural waters can be attributed to the dissolution of rocks and minerals, acid mine drainage, landfill leaches, sewage or iron related industries (**WHO, 1984**).

Iron has a taste threshold of about 0.05 to 0.1 mg/l in water, and becomes objectionable above 1mg/l. High iron concentrations give water an undesirable rust brown appearance, and can cause staining of laundry and plumbing fittings, fouling of ion exchange softeners, and blockages in irrigation systems. Growths of iron bacteria, which concentrate iron, may cause taste and odor problems, and lead to pipe restrictions, blockages and corrosion. The presence of iron in drinking water supplies is objectionable (**WHO, 1984**).

Study area:

Ground water within Kusti city is found in depth ranging from 200 -250feet and the unconfined aquifer on depth reaches 20 meters. According to Directorate of Water Research Department, White Nile State, the ground water found within Kusti town in not more than 20 meters deep for the unconfined aquifer and geologically formatted from sand clay layers, produce saline water with TDS > 5000 mg/l. Yield of a shallow well fitted with a handpump is about 500 gallons per hour. Furthermore, Kusti town represent delta for Khor Abouhabel, therefore its geological formation is sand clay, which yield low quantities of water (**Personal contact**).

Sample:

A totals number of 3 samples collected from Ground water, only one handpump in the study area, so samples were taken for three seasons.

Physical and chemical parameters were analyzed by using plainest- photometer 8000, titration, pH-meter, Turbidity-meter, Conductivity-metr, Atomic Absorption Spectrophotometer (AAS) is to be used for the determination of trace metals namely Fe, Mg, Cu, Na and K, and Flammable Spectrophotometer is to be used to determine the anions (SO_4^{2-}, and NO_2).

Physical parameters analyzed were:

TDS, TSS, Color, Oudour, Taste, and Electric Conductivity Ewc, tests were done according to the standard methods for the examination of water and wastewater (**APHA, 2005**) and results recorded.

Chemical parameters analyzed were:

Total Hardness, Sulphate, Chloride, Ammonia as N, Sodium, Total iron as Fe^{+2},Fe^{+3}, Nitrite, Nitrate as Nitrogen, Fluoride, Calcium, Cupper, pH, and Magnesium, analysis were done according to the standard methods for the examination of water and wastewater (**APHA, 2005**) and results recorded.

Records:

Information was gathered from geology and ground water department White Nile-Kusti deals with geological formation of the study area and ground water availability. Finally, revised treatment plant records, historical and up-to-date, network maps and laboratory records, which reflect the efficiency of treatment plant.

Data management and analysis:

Data collection, revision, and completion were done on daily basis to assure an accurate and complete data before leaving the study area.

Results:

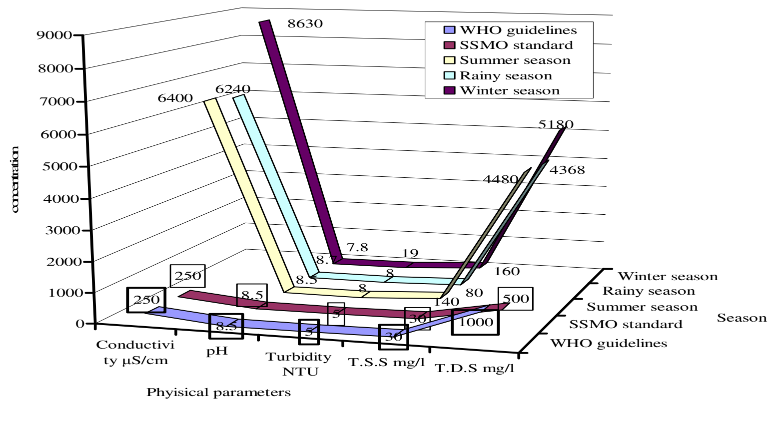

Figure 1: Physical parameters results according to the seasonal variation for the ground water samples, compared with WHO guidelines and SSMO standards, Kusti town-Sudan.

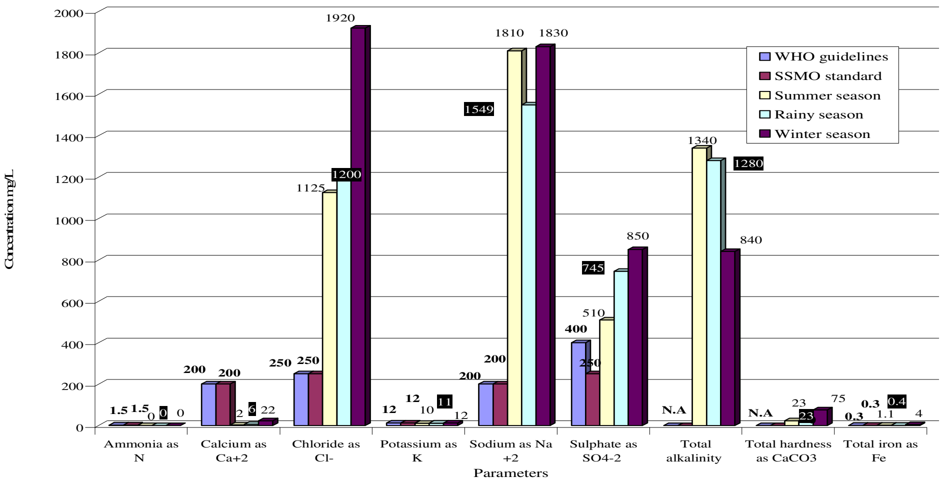

Figure 2: Substances and parameters in ground water samples that may give a reason to complaints by consumers, results according to the seasonal variation, compared with WHO guidelines and SSMO standards, Kusti town-Sudan.

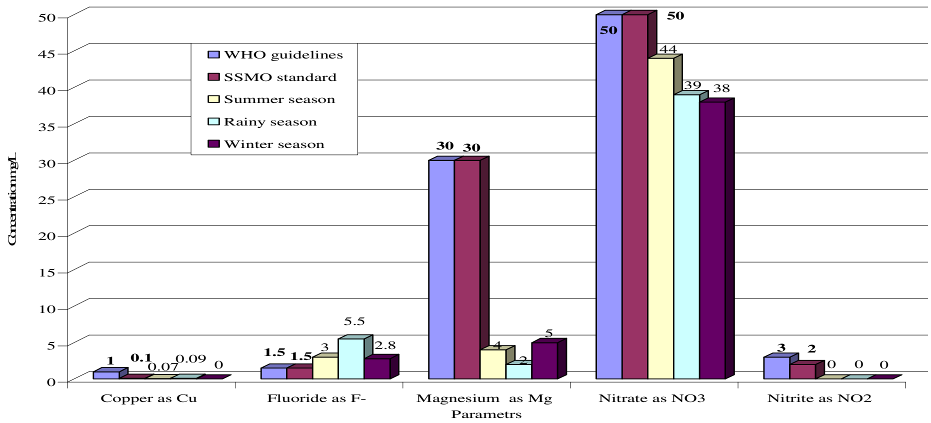

Figure 3: Chemicals of health significance in ground water samples, inorganic constituents, results according to the seasonal variation, compared with WHO guidelines and SSMO standards, Kusti town-Sudan.

Table 1: Substance and parameters in drinking water that may give a reason to complaints by consumers, results according to the seasonal variation for water samples, Kusti town-Sudan

Seasons / Parameters mg/l	Summer	Rainy	Winter	Means	STDV	S.E	SSMO standards	WHO guidelines
Ammonia as N	0	0	0	0	0	0	1.5	3
Calcium as Ca^{+2}	2	6	22	10	10.58	6.11	-	26-85
Chloride as Cl^-	1125	1200	1920	1415	438.95	253.43	250	250
Excess alkalinity as $NaCo_3$	1395	1257	810	1154	305.8	176.55	-	80
Potassium as K	10	11	12	11	1	0.58	-	-
Sodium as Na	1810	1549	1830	1729.67	156.78	90.52	200	200
Sulphate as SO_4^{-2}	510	745	850	701.67	174.09	100.52	250	250
Total alkalinity as $CaCO_3$	1340	1280	840	1153.33	273.01	157.63	-	less than 50
Total hardness as $CaCO_3$	23	23	75	40.33	30.02	17.34	-	60-120
Total iron as Fe	1.1	0.4	4	1.83	1.91	1.10	0.3	0.3
Copper as Cu^{+2}	0.07	0.09	0	0.053	0.047	0.03	1.5	2
Fluoride as F^-	3	5.5	2.8	3.77	1.50	0.87	1.5	1.5
Magnesium as Mg^{+2}	4	2	5	3.67	1.53	0.89	-	2-48
Nitrate NO_3^- as N	44	39	38	40.33	3.22	1.86	50	50
Nitrite NO_2^- as N	0	0	0	0	0	0	2	3
Colour TCU	C[1]	C	Y[2]	NA[3]	NA	NA	15	-
Conductivity µS/cm	6400	6240	8630	7090	1336.08	771.38	-	-
Odor	Un	Un	Un	-	-	-	Acceptable	Acceptable
pH	8.5	8.7	7.8	8.34	0.47	0.27	6.5-8.5	6.5-8.5
T.S.S	140	80	160	126.67	41.63	24.04	-	-
Taste	O[4]	Un	Un[5]	NA	NA	NA	Acceptable	Acceptable
T.D.S	4480	4368	5180	4676	440.05	254.07	1000	1000
Turbidity *NTU*	8	8	19	11.67	6.35	3.67	5	5

1 Colorless
2 Yellow Color
3 Not applicable
4 Objectionable tastes
5 Unobjectionable taste

Results:

Figure 1: Shows physical parameters results for samples collected from the only ground water source in different seasons, (Summer, rainy and winter) compared with WHO guidelines and SSMO standards, for the parameters; Total Dissolved Solids TDS, Total Suspended Solids TSS, Turbidity, pH, and Electrical Conductivity, tests showed that all the parameters concentration were exceeding WHO and SSMO Maximum Contaminant Levels (MCL) except the pH which was within permissible limits.

Figure 2: Shows the chemical analysis for water samples collected from ground water source in the study area in all seasons (summer, rainy and winter). The determined parameters, Cl - , Na^{+}, SO_4^{-2}, Total alkalinity and Total Iron (as Fe) exceeded WHO and SSMO (MCL) concentrations in all seasons. Cl- which was 1125, 1200 and 1920 mg/l ,Na^{+} which was 1549, 1810 and 1830 mg/l ,SO_4^{-2} which was 510, 745, and 850 mg/L , Total alkalinity which was 1340,1280 and 840 mg/l, and Fe which was 1.0 ,0.4 and 4.0 in summer ,rainy and winter seasons respectively. But Ammonia, Calcium, Potassium, and Total hardness were within the standards.

Figure 3: Demonstrates the determined the concentrations of chemical parameters of health significance for ground water source samples. These concentrations were elevated for the following parameters, F- which was 3, 5.5 and 2.8 mg/l, NO3 which was 44, 39, and 38 mg/l, and Cu+2 which was 0.07, 0.09 and 0.00 mg/l in summer, rainy and winter seasons respectively.

Discussion

The results of the analysis of the only ground water source in Kusti town revealed that all physical parameters examined showed concentrations exceeding standards with highest concentration in winter season for some parameters except lower pH in winter. This type of water will not be desirable by the consumers themselves due to access amount or concentration of such physical contaminants which will lead to change in water color, taste and odors, in addition, the yield of water from this source is very small due to geological formation and underground storage aquifer recharge (Personal contact).

A test regarding chemical parameters that may raise the consumers complains from the ground water samples collected from the study area in different seasons. These exhibited highest concentration for Chloride, Sodium, Sulphate, Total alkalinity, and Total Iron. These tests also exhibits seasonal variation, and highest concentration in winter season for Chloride, Sodium, Sulphate, Total alkalinity, and Total Iron that may attribute to lack of rain in such period of year in the study area.

The samples tested for chemicals of health significance (i.e. Cupper, Fluoride, Magnesium, Nitrate and Nitrite) from the only ground water source, showed highest concentrations that exceeded standards for Fluorides only with seasonal variation and higher concentration reported in rainy season which may be attributed to surface run off, infiltration and leaching of Fluoride from the ground layers, the remaining parameters are within the standards with slight seasonal variation.

Punjab is a typical large state in north-eastern India, neighboring Pakistan. People in this region relied on groundwater as a drinking-water source. **Kumar *et al.*, (2006)** studied the water from 24 different locations and noted that there was a large variation in mineral contents in the well water, with a range of 8– 343 mg/l for calcium and 5–235.6 mg/l for magnesium. This study suggests that even for groundwater from similar geographical locations, the mineral contents can vary markedly **(Cotruvo *et al.*, 2009).**

The mineral contents of water from most Asian drinking-water supplies are generally in the range of 2–80 mg/l for calcium (Ca^{2+}) and below 20 mg/l for magnesium (Mg^{2+}). Several epidemiological investigations on the possible associations between the risk of gastrointestinal tract cancers and minerals in drinking-water, in particular hardness, have been well reported. Studies by Yang and his colleagues showed that there was an inverse relationship between water hardness and various diseases, including coronary mortality, cerebrovascular disease and gastrointestinal tract cancers in Taiwan, China; however, the specific concentrations of calcium, magnesium and other minerals that made up the total water hardness were not given in these reports **(Cotruvo *et al*., 2009).**

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