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ASSESSMENT OF PHYSICOCHEMICAL PARAMETERS OF SURFACE WATER SOURCES IN KUSTI TOWN- SUDAN

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ABSTRACT

Provision of ample safe water supplies is considered as a basic human right. This is an operational study on drinking water quality that carried out in Kusti town, White Nile state Sudan. The study aimed to determining the various physical and chemical quality parameters For surface water sources of Kusti town, to evaluate their suitability For domestic purposes, in accordance to the WHO guidelines and SSMO for drinking water for a period of 12 months, and to explain the effect of seasonal changes on these characteristics in order to identify the possible contamination risk of raw water and distribution system. Twelve (12) water samples were collected from the raw water sources, network and extensions on seasonal basis, as four samples per season. May, August, and January are the peak months of summer, rainy and winter seasons respectively. Seasonal data were obtained from Sudanese Metrological Authority. The gained data were analyzed for the estimation of Colour, Odour, Taste, Turbidity, Total Suspended Solids, Total Dissolved Solids, Hardness, Electrical Conductivity, pH, Biochemical Oxygen Demand, Dissolved Oxygen, Ammonia, Nitrate, Nitrite, Manganese, Total Alkalinity, Excess Alkalinity, Calcium, Chloride, Fluoride, Potassium, Iron, Sulphate, Sodium, and Copper), all testes were carried out according to the standard methods for the analysis of Water and wastewater (APHA). Results of physicochemical parameters complied with WHO guidelines and SSMO standards in all seasons except for low concentrations of Fluoride as F^- which ranged between 0.25 to 0.47mg/l in all seasons, and high concentrations of total Iron (as Fe) in all samples which ranged between 1.2 to 2.4 mg/l in all seasons, all samples showed high concentrations of BOD which ranged between 1.3 to 30 mg/l with higher concentration in winter season. Conclusion: White Nile water from physicochemical point of view is suitable for household's activities and complies with standards.

KEYWORDS: Drinking Water, Surface water, Physicochemical, Seasonal variations**,** SSMO standards, WHO guidelines and SMWW.

INTRODUCTION

Provision of ample safe water supplies is considered as a basic human right for his existence as well as for his social, economic and health development.[1]

A water supply is an essential requirement for all people. Determining how much is needed, is one of the first steps in providing that supply. Human health and welfare, food security, industrial development and the ecosystems on which they depend, are all at risk, unless water and land resources are managed more effectively in the present decade and beyond than they have been in the past.[2]

Access to safe water supply has been one of the top priorities in developing countries over the past three to four decades; billions of dollars have been invested in pursuit of the goal of “universal service.” And yet the general consensus at the 2002 United Nations World Summit on Sustainable Development was that the current reality as well as the situation expected in the near future is far from that goal.[3]

Rivers and lakes are very important part of our natural heritage. They have been widely utilized by mankind over the centuries, to the extent that very few, if any are now in a natural condition.[5]

A continuous monitoring of water quality is very essential to determine the state of pollution in our rivers.[2]

Any characteristic of water that affects survival, reproduction, growth and production, influence management decisions, causes environmental impacts or reduces product quality and safety can be considered a water quality variable.[4]

Water quality parameters provides current information about the concentration of various solutes at a given place and time and provide the basis for judging the suitability of water for its designated uses and to improve existing conditions, optimum development and management for the beneficial uses.[4]

Surface runoff as well as ground water ultimately will reach streams, rivers and lakes. Surface water is open to pollution from human and animal life, vegetations, plant and algae. Many rivers in tropical areas have high amounts of suspended solids and turbidity, especially under flood conditions.[5]

Drinking water is never pure. Water naturally contains minerals and microorganisms from the rock, soil and air with which it comes in contact. Human activities can add many more substances to water. But drinking water does not need to be pure to be safe. In fact, some dissolved minerals in water can be beneficial to health.[6] Whether or not drinking water is safe will depend on which impurities are present and in what amount . Unsafe drinking water constitutes one of the health problems of our country and diseases related water being widely spread.[7]

Water pollution refers to a change in the natural qualities of water as a result of its contamination with external elements, to an extent that makes it unsuitable for use and ingestion; it can be the consequence of natural phenomena, but most frequently it appears as a result of human activity.[8]

The specific pollutants that can have negative effects upon the health state of the population (injury, disease or death) represent risk factors and can be grouped in the following categories: microbiological pollutants (bacteria, viruses, parasites) and chemical pollutants (toxic chemical substances). They can be identified and their level of toxicity and particular effects can also be established.[6]

Clean drinking water is a basic human right. However, water quality remains a controversial issue even in the United States. Water is essential to the well-being of humankind, vital for economic development, and a basic requirement for the healthy functioning of all the world's ecosystems.[9]

The aims of this study are to investigate the hazards associated with contaminated drinking water to lead to safe drinking water. Therefore, the importance of this study is to fill the gap of lack of studies in such field in Kusti town and other places as well.

MATERIALS AND METHODS

This is an operational study, conducted to identify drinking water quality problems, using the World Health Organization (WHO) guidelines and Sudanese Standards.

The study conducted in Kusti town which located at the White Nile State. Sudan. on the western bank of the White Nile River, about 105 km south of Al-Duwaym and 300 kilometre south of Khartoum. (www.fullworld.eu/city?i=2133720&n=Kusti,2008).

Water samples from different location include (Raw water (Upstream), Treated water, Untreated water intakes (Downstream), distribution system (end of network), were drawn to represent study population.

The guidelines used for comparison take into account the experiences of surveillance system programs in remote and pre-urban communities.[10]

The objective of such surveillance system is to assess the quality of the supplied water at the points of use, so that both samples after treatment and before used were taken, any significant differences between the two have important implications for remedial interventions strategies.[12]

Results of physicochemical analysis are of no value if the samples tested are not properly collected and stored. Sampling procedures, and methods of sample preservation and storage were done following the guidelines and standards of WHO, the time between sampling and analysis was kept to a minimum.[7]

A totals number of (12) samples drawn randomly from treatment plant intake, downstream after the plant intake with at about 700 meter, one from network and treated water from the plant outlet.[12]

Distribution of physicochemical sample from water source:

Seasons	Summer	Winter	Rainy	Total
Number of samples	4	4	4	12

The sample volume was (2) litters that subjected to physicochemical analysis, in addition to (4) samples for BOD and DO tests , 2 litter for each. The analysis were carried out according to standard methods for the examination of water and wastewater SMWW (APHA).[1]

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

Physical parameters analyzed includes TDS, TSS, Colour, Oudour, Taste, and Electric Conductivity.[13]

Chemical parameters analyzed includes, Total Hardness, Sulphate, Chloride, Ammonia as N, Sodium, Total iron as Fe^{+2},Fe^{+3}, Nitrite, Nitrate as Nitrogen, Fluoride, Calcium, Cupper, Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO) , pH, and Magnesium.**[11]**

The ethical clearance was obtained from the ethical committee of the Khartoum University, Sudan.

RESULTS

Table 1: Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO) for raw and untreated water samples, during the summer season

NO	Sample location	BOD mg/L	DO mg/L
1	Raw water from plant intake (upstream)	3.6	4.6
2	Downstream (Untreated water intakes)	8.5	6.9

Temperatures 32.7 °C DO 7.16 mg/l BOD less than 3 mg/l (References values according to temperature degree.[2, 3, 5]

***T*able 2: Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO) for treated water during summer season**

NO	Sample location	BOD mg/L	DO mg/L
1	Treated water – from plant out let	1.3	6.7
2	Net work (End of net work)	3.5	8.0

Temperature 32.7°C DO = 7.16 mg/l BOD less than 1 mg/l (References values according to temperature degree.[2, 3, 5]

Table 3: Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO) for raw and untreated water samples, during the rainy season

NO	Sample location	BOD mg/L	DO mg/L
1	Raw water from plant intake (upstream)	2.4	8.5
2	Downstream (Untreated water intakes)	2.65	8.9

Temperatures 27.5°C DO 7.95 mg/l BOD less than 3 mg/l (References values according to temperature degree.[2, 3, 5]

Table 4: Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO) for treated and net work water samples, during the rainy season

NO	Sample location	BOD mg/L	DO mg/L
1	Treated water - from plant out let	1.7	9.0
2	Net work (End of net work)	2.01	8.7

Temperature 27.5°C DO 7.95 mg/l BOD less than 1 mg/l (References values according to temperature degree.[2, 3, 5]

Table 5: Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO) for raw and untreated water samples, during the winter season

NO	Sample location	BOD mg/L	DO mg/L
1	Raw water from plant intake (upstream)	30	7.4
2	Downstream (Untreated water intakes)	16.3	7.1

Temperature 24.8°C DO 8.24 mg/l BOD less than 3 mg/l (References values according to temperature degree.[2, 3, 5]

Table 6: Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO) for treated and net work water samples, during the winter season

NO	Sample location	BOD mg/L	DO mg/L
1	Treated water-from plant out let	0.0	8.0
2	Net work (End of net work)	25	7.5

Temperature 24.8°C DO 8.24 mg/l BOD less than 1 mg/l (References values according to temperature.[2, 3, 5]

Table 7: Results of Physical parameters according to the seasonal variation for River water samples, Kusti town-Sudan.

Season	SUMMER SEASON 2008				RAINY SEASON 22008				WINTER SEASON 2009			
Sample location / Parameters	White Nile down stream	End of net work	Raw water Intake	Treated water storage tank	White Nile down stream	End of net work	Raw water Intake	Treated water storage tank	White Nile down stream	End of net work	Raw water Intake	Treated water storage tank
Colour TCU	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Conductivity µS/cm	170	160	160	160	170	160	160	160	240	175	185	170
Odour	Un	Un	Un	Un	Un	Un	Un	Un	Un	Un	Un	Un
pH	7.6	7.4	7.9	7.9	7.4	7.4	7.9	7.9	7.8	7.9	7.9	7.4
T.S.S mg/l	0	0	20	20	20	20	20	20	20	60	20	20
Taste	Un	Un	Un	Un	Un	Un	Un	Un	Un	Un	Un	Un
T.D.S mg/l	102	98	97	96	102	96	95	96	145	105	110	105
Turbidity *NTU*	14	8.4	10	4.5	14	8.4	10	4.5	77.8	6.6	5.1	7.0

C = Colorless, Y = Yellow = Objectionable taste Un = Unobjectionable taste.

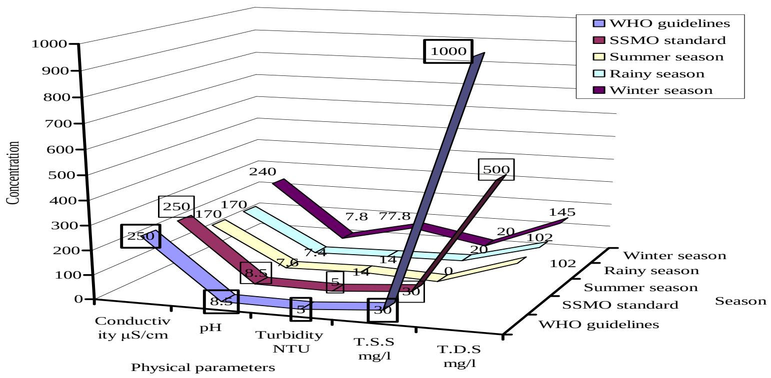

Figure 1: Physical parameters results according to the seasonal variation for treated water (plant outlet) samples, compared with WHO guidelines and SSMO standard, Kusti town-Sudan.

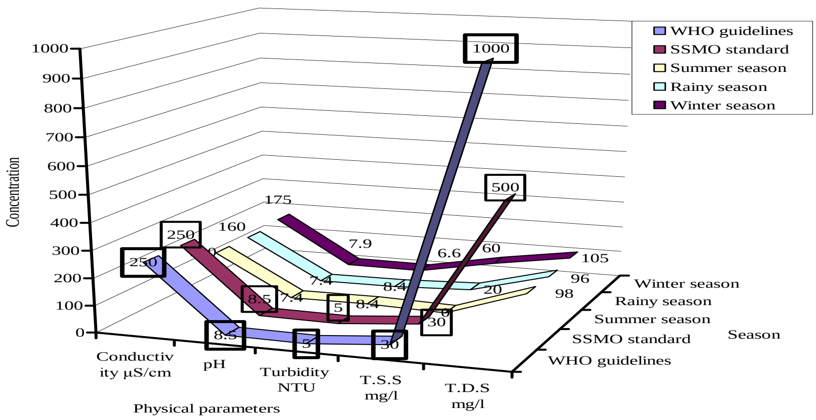

Figure 2: Physical parameters results according to the seasonal variation for the White Nile (downstream) water samples, compared with WHO guidelines and SSMO standard.

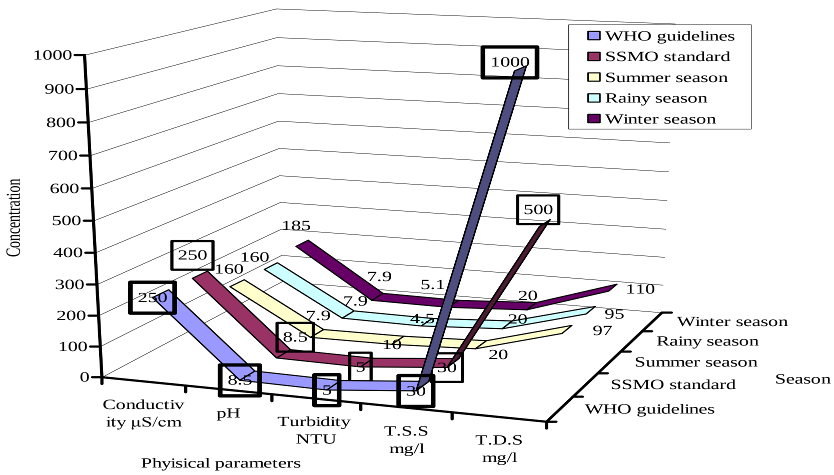

Figure 3: Physical parameters results according to the seasonal variation for net work (end of net work) water samples, compared with WHO guidelines and SSMO standard.

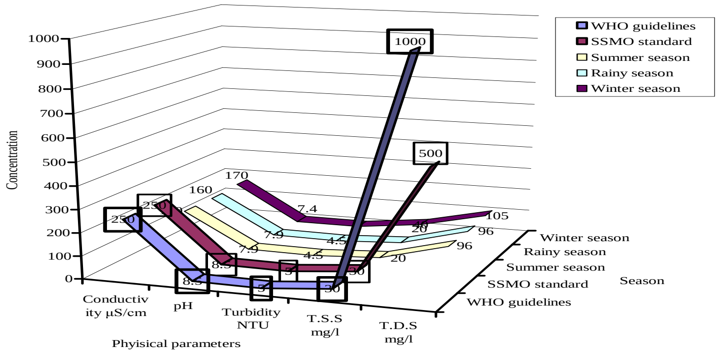

Figure 4: Physical parameters results according to the seasonal variation for raw (Upstream) water samples, compared with WHO guidelines and SSMO standard.

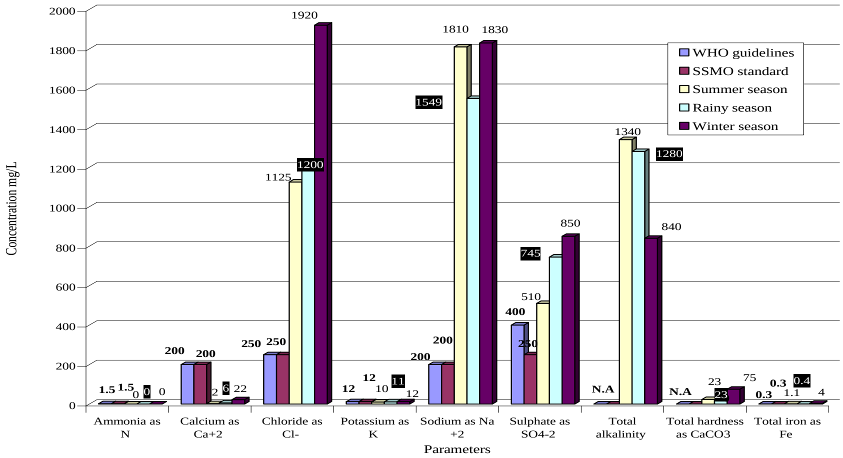

Figure 5: Substances and parameters in ground water samples that may give a reason to complaints by consumers, results according to the seasonal variation, compared with WHO guidelines and SSMO standard.

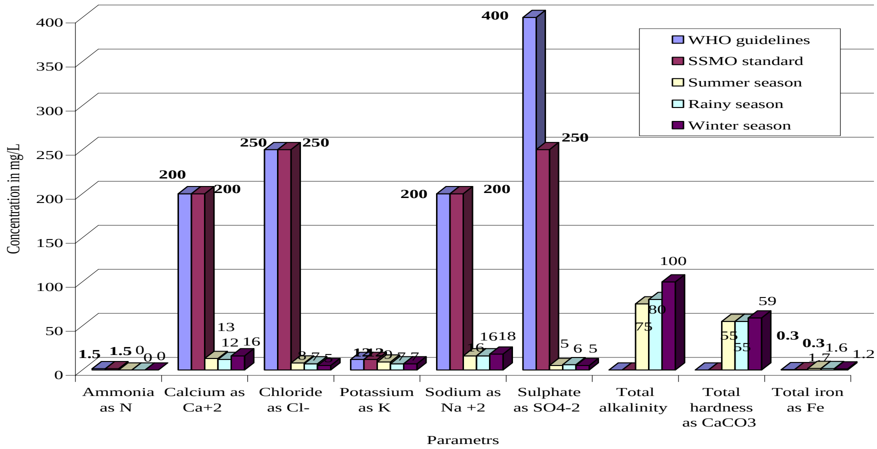

Figure 6: Substances and parameters in White Nile water (Downstream) samples that may give reasons to complaints by consumers, results according to the seasonal variation, compared with WHO guidelines and SSMO standard.

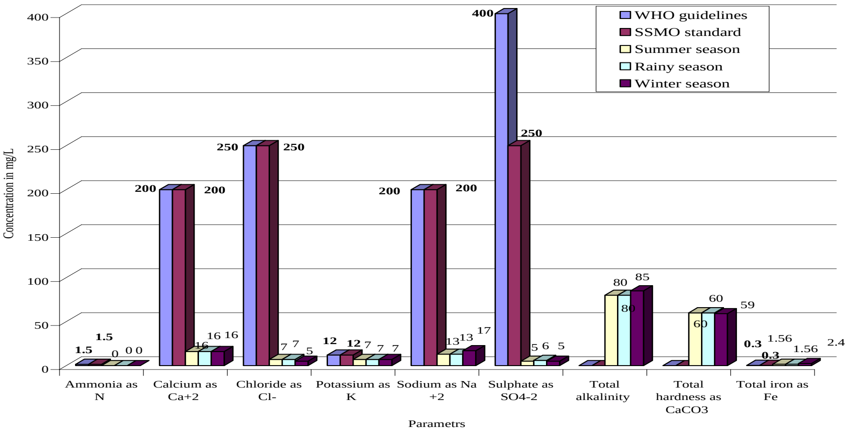

Figure 7: Substances and parameters in treated water samples (plant outlet) that may give reasons to complaints by consumers, results according to the seasonal variation, compared with WHO guidelines and SSMO standard.

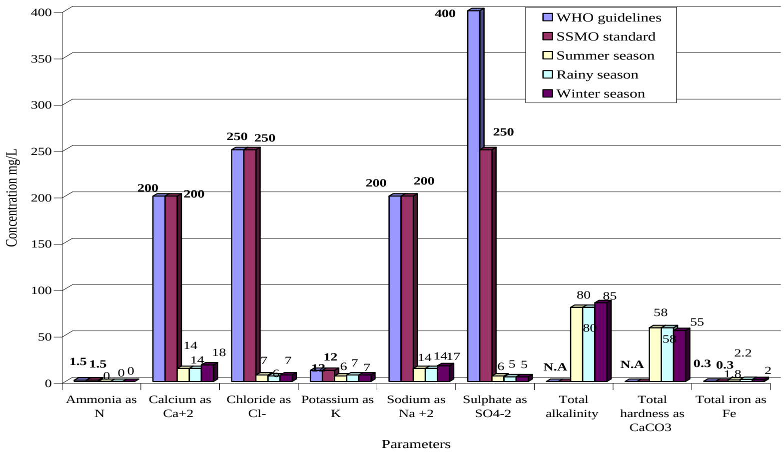

Figure 8: Substances and parameters in end of network water (Network) samples that may give reasons to complaints by consumers, results according to the seasonal variation, compared with WHO guidelines and SSMO standard.

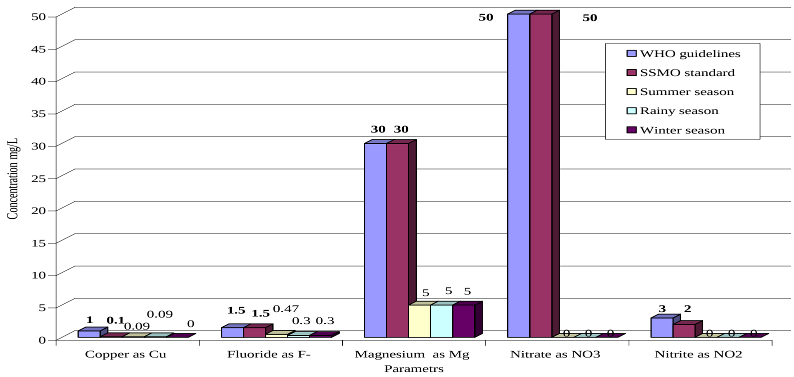

Figure 9: Chemicals of health significance in raw water (plant intake-Upstream) samples, inorganic constituents, results according to the seasonal variation, compared with WHO guideline and SSMO standard.

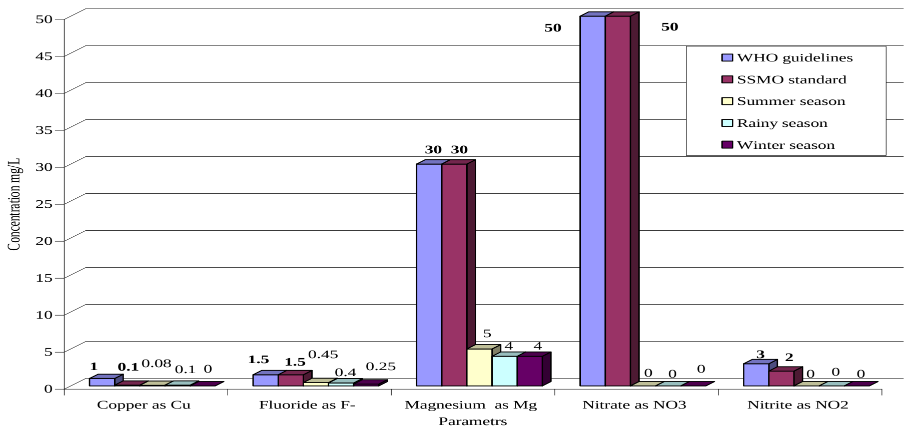

Figure 10: **Chemicals of health significance in treated water samples (plant outlet), inorganic constituents, results according to the seasonal variation, compared with WHO guideline and SSMO standard**.

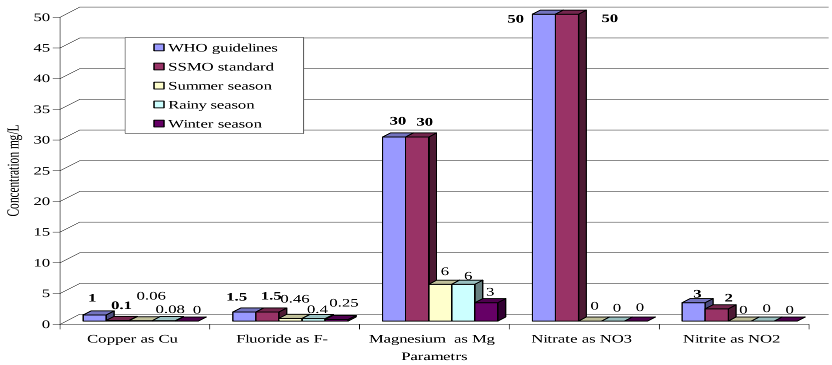

Figure 11: Chemicals of health significance at the end of net work (Net work) water samples inorganic constituents, results according to the seasonal variation, compared with WHO guideline and SSMO standard.

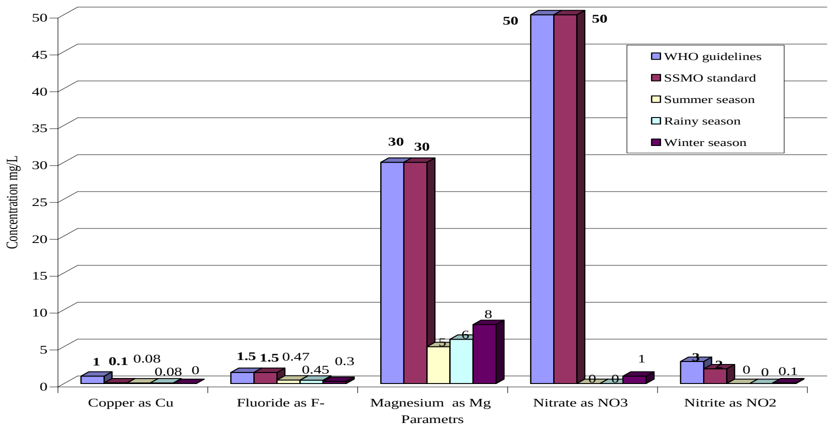

***Figure* 12: Chemicals of health significance in White Nile water samples (Downstream) – inorganic constituents, results according to the seasonal variation, compared with WHO guidelines and SSMO standard.**

DISSCUSSION

Nile water environment is subjected to variations in many environmental and climatic factors such as temperature, dissolved oxygen, light penetration, turbidity, density, etc. These factors are assumed to contribute to water contamination and pollution. The Samples were collected in the peak of each season, as follows, May, August and January which represent the peak of summer, rainy and winter seasons respectively. The study aims to evaluate some of drinking water quality indicators in comparison with the World Health Organization (WHO) guidelines and Sudanese Standards & Metrological Organization (SSMO) standards.[9]

The samples for analysing Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO) were collected from different sites representing all the critical points in the water safety inspection, the result of analysis revealed that, (87.5%) of BOD measurements ranged between one mg/l and 4mg/l and the rest (12.5%) between 4 mg/l and 8mg/l, also 87.5% of DO readings ranging between 6.5 mg/l and 9 mg/l and other (12.5%) ranging between 4 and 6.5 mg/l. This observation was stated by WHO, 2007 " the consequences of high BOD are the same as those for low dissolved oxygen: aquatic organisms become stressed, suffocate, and die stating that; free oxygen (DO) is the single most important gas for most aquatic organisms. When the aquatic organisms exposed to less than 2.0 mg/l free oxygen for few days this may kill most of biota in the aquatic system."

The study showed that, all physical parameters of the samples collected from the intake of water treatment plant complied with WHO and SSMO, MCL in all seasons except the level of turbidity which found as higher (10 NTU) in rainy season. Also Total Suspended Solids (TSS) in winter season recorded 60 mg/l, and those samples collected from the treatment plant outlet complied with WHO and SSMO standards, MCL in all seasons, except TSS which was higher in winter season recording 40 mg/l.

All measurements of physical parameters for the samples collected from downstream, and the end of network were complied with WHO guidelines and SSMO standards in all seasons, except turbidity in downstream water which was higher in winter season recording (77.8 NTU) and slightly high in all seasons. This may be attributed to the discharge of drainage water from the NGO plant(Pump cooling water) and wastes from the fishers boats in addition of high TSS which was recording 60 mg/l in winter season for samples collected from the end of network.

The samples collected from the raw water, downstream, treatment water (plant outlet) and that from the end of network were analysed for chemical parameters that observed within the WHO and SSMO guidelines in all seasons, except the Total Iron concentration which exceeded WHO and SSMO MCL (0.3 mg/l) in all seasons. Highest concentration of iron in downstream water samples may be attributed to leaching of metal from the Nile ships.

The study found that chemical parameters of health significance in samples collected from raw water intake(Upstream), downstream water, treated water (plant outlet), and the end of network, showed low concentration of Fluorides iron which was ranged from 0.25 to 0.47mg/l in all seasons. These concentrations are below the permissible limits for safe drinking water[10] also, the result revealed that high concentration of cupper in summer and rainy seasons, for the above samples, the others parameters were within the permissible limits.

WHO standards for drinking water

Contaminants	US-EPA mg/l	WHO mg/l
Color	Colorless	Colorless
Odor	Odorless	Odorless
Taste	Tasteless	Tasteless
Temperature ºC	--	12 ºC
pH	6.0 – 8.5	6.5 -9.2
DO	4 -6	3
TDS	500	500
TSS	0 -5	5
Cl-	250	200 -500
Nitrate /Nitrite	100	45
Calcium	100	100
Magnesium	30	150
COD	4.0	10
Sodium	200	200
Potassium	--	13
Ewc	300	400
Arsenic	0.05	0.05
Cadmium	0.01	0.05
Fluoride	2.2	1.5
Mercury	0.002	0.001
Iron	0.3	0.3

Source: [WHO, 2008]

Plate: BOD and DO tests for water samples collected from Kusti town-Sudan.

CONCLUSION

White Nile water from physicochemical point of view is suitable for households' activities and purposes as it analysed in compliance with WHO and SSMO maximum contaminants limit (MCL).

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