International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

(Research Article)

Check for updates

Evaluation of chemical parameters in drinking water at White Nile State, Sudan during 2022-2023

Mazahir EA Mohammed [1,*], Amna HI Babeker [2] and Abdelaal AH Ali [3]

[1] Assistant Prof, King Khalid University, College of Applied Medical Science, Department of public health, University of El Imam El Mahdi, College of Public Health.

[2] Assistant Prof, King Khalid University, College of Applied Medical Science, Basic Medical Department, Gadarif University, Sudan, Education College, Biology Department

[3] PHD, University Of Gazira, Sudan, Rae Environmental Company Services, Project Manager, KSA.

International Journal of Science and Research Archive, 2025, 14(03), 928-934

Publication history: Received on 08 February 2025; revised on 15 March 2025; accepted on 17 March 2025

Article DOI: https://doi.org/10.30574/ijsra.2025.14.3.0732

Abstract

The evaluation of the chemical parameters in the drinking water is an important task to evaluate the quality of water commonly with the physical and biological parameters. The aim of this study was to evaluate of the chemical parameters in drinking water at White Nile State (Kosti and Rabak Cities) during February 2022 and October 2023. Five random samples of drinking water were collected from each City. The quantity was 250 ml and were collected in 250 ml clean and aseptic plastic containers. Chemical tests involved: pH, Cl, bicarbonate (HCO3-), hardness, total dissolved solids TDS, sulphate (SO4-), and Ca++ following the standard devices, methods and solutions These tests were conducted in the Laboratories of University of Gezira. The tested chemical parameters of Kosti and Rabak drinking water samples collected during February 2022 showed that, all parameters were matched with the standards of quality, except, TDS of Rabak and Pb of both cities which exceeded the upper allowed limits. During Oct. 2022, Feb. 2023 and Oct. 2023, the obtained values were also matched with the standards of quality, except, hardness and Pb of both cities which exceeded the upper allowed limits, in addition to Chloride which was noticed to be significantly more concentration in Kosti city drinking water than Rabak drinking water. Cl, Hardness, TDS and Pb were the most serious problems in the White Nile drinking water. The quality evaluation for the drinking water, whatever the city, should be routine work, and the pollution sources should be detected and treated immediately.

Keywords: Evaluation; Chemical parameters; Drinking water; White Nile State

1. Introduction

Lack of clean water supply, sanitation and hygiene are major causes for the spread of waterborne diseases in a community. The fecal–oral route is a disease transmission pathway for waterborne diseases [1].

The human body contains from 55 - 78% water, depending on body size. To function properly, the body requires between one and seven liters. Most of this is ingested through foods or beverages other than drinking straight water [2]. The two main water sources used in Sudan: groundwater and surface water Drinking Water Safety Strategic Framework in Sudan aim to provide strategic direction to the scaling up of access to safe drinking water. This will be through providing drinking water systems that are appropriately designed which effectively protect the drinking water at all times to minimize fecal contamination and elevated levels of toxic chemicals; and through ensuring that treatment processes are effective and sustainable [3].

* Corresponding author: Mazahir EA Mohammed

During 2015, Homaida and Goja [4] in Ed-Dueim town investigated the physicochemical parameters (e.g. Turbidity, electrical conductivity, pH, temperature, total dissolved solid, chloride, fluoride, calcium, iodine, magnesium and sulfate), and the results show all the values except turbidity falls below the maximum limit of Sudanese Standard Metrology Organization (SSMO) and WHO guideline standard. From the results, it may be concluded that the drinking water in Ed-Dueim town has adequate physical and chemical quality and suitable for drinking.

Another similar study done by Siddig [5] to investigate the drinking water quality of Kosti city distributed via the pipeline of water network. The data obtained showed iodine deficiency and probably the peculiarly elevated prevalence of endemic goiter in Kosti city. The turbidity level ranged from (10.5 – 62.5) thus exceeding the permissible level of WHO standards (5 NTU). The concentration of minerals such as chloride ranged from (6.6 10.6 mg/L), sulphate (8.0 - 14.0. mg/L), calcium (9.6 - 23.0 mg/L), alkalinity (61.7 - 87.5 mg/L), fluoride (0.28 - 0.49 mg/L), magnesium (3.2 - 7.0 mg/L), ammonia (0.01 - 0.023 mg/L), TDS (80.75 - 125.1) and hardness (34.33 - 82.23 mg/L). All these values fall below thresholds value of national and international standards of WHO and Sudanese Standards and Metrology Organization (SSMO) standards.

2. Material and methods

2.1. Study location

White Nile State (WNS) which located in the southwestern part of Sudan [30o 8'– 30o 13' N and 28: 22 – 28 E], were selected to conduct the current study.

2.2. Study design

A cross-sectional study, conducted during Feb. 2022 and Oct 2023.

2.3. Sampling of drinking water

Samples were taken from five (5) random locations that are selected within Kosti city and Rabak cities from sources people usually used it for drink. The quantity was 250 ml for each, and it was kept in cleaned plastic containers in aseptic conditions as was suggested by CAWST [6].

2.4. Chemical properties

Chemical tests were run at the Applied Chemistry Laboratory to determine: pH, Cl, bicarbonate (HCO_3^-), hardness, total dissolved solids TDS, sulphate (SO_4^-), and Ca^{++} following the standard devices, methods and solutions.

2.4.1. pH

pH for the sampled waters were determined using a pH meter.

2.4.2. Electric Conductivity (EC)

EC of drinking water was determined by calibration of the conductivity meter as per the directions given by the manufacturer's manual.

2.4.3. Hardness

According to Vogel [7], 25 ml of drinking water sample was put in a conical flask, then 1 to 2 ml buffer solution followed by 1 ml inhibitor and a pinch of Eriochrome black T were added and titrated with standard EDTA (0.01M) till wine red colour changes to blue, then the volume of EDTA required (A) was noted. A reagent blank was run, and the volume of EDTA (B) was also noted. The volume of EDTA required by sample was calculated, C = A – B. Calcium hardness was also calculated by taking 25 ml sample in a conical flask, and 1 ml NaOH was added to raise pH to 12.0 then a pinch of muroxide indicator was added and titrated immediately with EDTA till pink colour changed to purple. Similarly, the volume of EDTA used (A1), (B1) and C1 were calculated.

$$\text{Total hardness as } CaCO_3 \text{ (mg /l)} = [D \times C \times 1000] / \text{volume of sample in ml}$$

(D = mg $CaCO_3$ equivalent to 1 ml EDTA titrant (1 ml 0.01 M EDTA ≡ 1.000 mg $CaCO_3$))

2.4.4. Total dissolved solids (TDS)

TDS was also determined by calibration of the conductivity meter as per the directions given by the manufacturer's manual.

2.4.5. Chloride (Cl)

According to Vogel [7], about 1 g of sample was weighed in a glass beaker of 250 ml, covered with a watch glass. 50 ml of HNO_3 (1:2) was added. 5 ml of the standardized 0.05 M $AgNO_3$ solution were added by means of a pipette. The suspension was allowed to boil for 1 minute more and filtered over filter paper, previously washed with HNO_3. The filtrate was received in the 500 ml filtration flask. The final volume of the filtrate was adjusted to 200 ml, allowed to cool down to room temperature. To the filtrate, 20 drops of the indicator solution were added, stirred vigorously and titrated with the 0.05 M NH_4SCN solution. The titration was stopped when a drop of the thiocyanate solution produces a slight red brown colour, which does not disappear with agitation. The spent volume (V1) of the NH_4SCN solution was recorded. A blank test was run using the procedure described above with the same reagents, but without sample. The spent volume (V2) of NH_4SCN solution was recorded corresponding to the blank test.

$$\% Cl = \{3.55453 VAg MAg (V2-V1)\}/m V2$$

where:

- VAg = volume of $AgNO_3$ solution titrated with 25 ml sample
- MAg = Molarity of $AgNO_3$ solution titrant
- V1 = volume of NH_4SCN solution used in the sample
- V2 = volume of NH_4SCN solution used in the blank
- m = mass of sample (g)

2.4.6. Sulphate (SO_4^-)

Following Vogel [7], 50 ml of water sample was placed in 400 ml beaker. The pH was adjusted with HCl (1:1) to (4-5) using pH meter the solution was then heated to boiling. Warm barium chloride ($BaCl_2$) solution was then added while stirring until complete precipitation. The solution was kept overnight then filtered using filter paper. The residue was cooled in a desiccator and weighed.

$$SO_4^{-2}/L\ (mg) = (BaSO_4 \times 411.5 \times 1000)\ /\ ml\ of\ sample$$

Where: 411.5 is a gravimetric factor

2.4.7. Bicarbonate (HCO_3^-)

According to Collins [8], 50 ml of water sample were titrated with 0.01639 normal H_2SO_4 using phenolphthalein and methyl orange as indicator. Taking (A) as the mls of acid used in titration and (B) the additional acid used in the methyl orange titration.

Bicarbonate (HCO_2) = 20 x (B-A)

2.4.8. Ca and Pb determination

The tests for determination of Ca and Pb in the drinking water samples were conducted in the Central Laboratory using Shimadzu Atomic Absorption Spectrophotometer device as was explained by Gerenfes and Teju [9].

2.5. Data analysis

The obtained data were subjected to suitable statistical tools (simple descriptive statistics and least significant differences) so as to evaluate the quality characteristics of White Nile State (Kosti and Rabak cities) drinking water.

3. Results

The tested chemical parameters of Kosti and Rabak drinking water samples collected during February 2022 (Table, 1) showed that, all parameters were matched with the standards of quality, except, TDS of Rabak and Pb of both cities which exceeded the upper allowed limits.

That of Oct. 2022 (Table, 2) and Feb. 2023 (Table 3) also matched with the standards of quality, except, Hardness and Pb of both cities which exceeded the upper allowed limits. The same in addition to Chloride which was noticed to be in significantly more concentration in Kosti city drinking water than Rabak drinking water during Oct. 2023 (Table 4).

Table 1 Chemical characteristic of Kosti and Rabak drinking water (Feb. 2022)

Parameter	**Kosti samples**	**Rabak samples**	**Standards**
pH	6.88 ± 0.12	6.8 ± 0.12	6.5 – 8.5
Chloride (ppm)	35.3 ± 7.2	22.0 ± 9.1	5 - 35
Bicarbonate (ppm)	219.4 ± 24.5	182.6 ± 8.0	30 - 400
Hardness (mg/L)	170 ± 19.8	172 ± 21.8	80 - 150
TDS (mg/L)	107.6 ± 10.6	164 ± 5.1*	80 - 150
Sulphate (mg/L)	0	0	5 - 35
Pb (ppm)	574.4 ± 29.5	520.8 ± 51.0	0 – 0.025*
EC (µS/cm)	230.2 ± 19.4	215 ± 2.9	Up to 3000
Ca (ppm)	21.6 ± 2.7	20.8 ± 2.3	10 - 35

Table 2 Chemical characteristic of Kosti and Rabak drinking water (Oct. 2022)

Parameter	**Kosti samples**	**Rabak samples**	**Standards**
pH	7.22 ± 0.1	7.44 ± 0.1	6.5 – 8.5
Chloride (ppm)	25.5 ± 0.7	27.7 ± 0.7	5 - 35
Bicarbonate (ppm)	280.6 ± 14.9	340.4 ± 14.5	30 - 400
Hardness (mg/L)	236 ± 11.6	560 ± 24.5	80 – 150*
TDS (mg/L)	81 ± 2.4	80 ± 2.7	80 - 150
Sulphate (mg/L)	0	0	5 - 35
Pb (ppm)	271.6 ± 22.6	125.2 ± 26.3	0 – 0.025*
EC (µS/cm)	236.2 ± 24.1	212.2 ± 6.6	Up to 3000
Ca (ppm)	27.8 ± 1.4	34.8 ± 8.3	10 - 35

Table 3 Chemical characteristic of Kosti and Rabak drinking water (Feb. 2023)

Parameter	**Kosti samples**	**Rabak samples**	**Standards**
pH	7.0 ± 0.1	6.96 ± 0.1	6.5 – 8.5
Chloride (ppm)	23.4 ± 0.8	39.1 ± 4.6	5 - 35
Bicarbonate (ppm)	207.4 ± 14.9	219.2 ± 15.4	30 - 400
Hardness (mg/L)	166 ± 2.4	166 ± 2.4	80 – 150*
TDS (mg/L)	102.4 ± 4.9	150 ± 6.3	80 - 150
Sulphate (mg/L)	0	0	5 - 35
Pb (ppm)	488.8 ± 75.5	520 ± 81.7	0 – 0.025*

EC (µS/cm)	221.6 ± 7.3	234.4 ± 17.4	Up to 3000
Ca (ppm)	21.6 ± 2.0	22.4 ± 4.3	10 - 35

Table 4 Chemical characteristic of Kosti and Rabak drinking water (Oct. 2023)

Parameter	**Kosti samples**	**Rabak samples**	**Standards**
pH	6.98 ± 0.2	6.9 ± 0.2	6.5 – 8.5
Chloride (ppm)	35.3 ± 7.2	42.6 ± 2.5*	5 - 35
Bicarbonate (ppm)	268.4 ± 14.9	275 ± 7.8	30 - 400
Hardness (mg/L)	214 ± 20.1	472 ± 36.5	80 – 150*
TDS (mg/L)	104.1 ± 11.9	153 ± 8.0	80 - 150
Sulphate (mg/L)	0.5 ± 0.02	0.49 ± 0.04	5 - 35
Pb (ppm)	526.4 ± 64.4	475.2 ± 41.5	0 – 0.025*
EC (µS/cm)	243.8 ± 22.1	223 ± 3.7	Up to 3000
Ca (ppm)	26.2 ± 1.5	30.8 ± 4.9	10 - 35

4. Discussion

The drinking water of Kosti and Rabak that collected after winter season showed good physical quality, as same as that collected after autumn season except the slight problem in color (less transparent). The tested chemical parameters of Kosti and Rabak drinking water that collected after winter season showed good quality except, some parameters like Cl, Hardness, TDS and Pb which considered as the most serious problem in the White Nile water.

Drinking water quality standards describes the quality parameters set for drinking water. Ground water is the major sources of drinking water. 65% of human body made by water. Out of the total water consumed by human beings, more than 50 % of it is consumed for industrial activity and only a small proportion is used for drinking purposes [10]. Good Quality of Drinking water is very necessary for improving the life of people and to prevent from diseases [11]. 70% surface of earth is covered by water, Majority of water available on the earth is saline in the nature only 3 % of exists as fresh water. Fresh water has become a scare commodity due to over exploitation and pollution. Pollution of surface and ground water is great problem due to rapid urbanization and industrialization. In present review it is emphasize the various parameter of drinking water by various agencies [12].

Rokade and Ganeshwade [13] reported the ranges of water quality as followed: pH ranged from minimum of 6.6 to maximum of 8.4, chlorides from 132.5 to 820.4 mg/l, hardness ranged from 74 to 281 mg/l, CO_2 from 2.1 to 5.09, BOD from 4.437 to 112.432 mg/l, sulphate 0.192 to 5.12 mg/l, nitrates 0.5 to 1.012. The minimum pH value of 6.3 mg/l was found during winter season and maximum of 8.93 mg/l in summer. The pH shows general decline from upstream to downstream. The electrical conductivity of drinking water should be 200 to 800 (µS/cm), while the TDS should be less than 300 (mg/L). Ca should be 20 – 30 mg/l in the drinking water. From the data collected it can be concluded that the inverse relationship, which is known to exist between pH and CO_2, is not existing in the present investigation.

Human activities have, in many ways, exerted increasing pressure on water environment. The chemical contaminants in drinking water have been noticed during the last decades, such as industrial activities (oil, gas exploitation and ship activities). These contaminants can be divided into two main categories: compounds that are known to be hazardous to the environment and therefore are regulated, and chemicals that are not yet regulated, due to the lack of information to support a reliable environmental risk assessment [14].

Ali *et al.* [15] evaluated the physical, chemical and microbiological quality of drinking water of Kosti, with collaboration of Blue Nile National Institute for Communicable Diseases, University of Gezira. They found signs of pollution and poor filtration treatment of water.

During 2022, contamination of White Nile water with lead (Pb) was also detected by the Central Laboratory, University of Gezira when they examined several fish meats collected from the White Nile River of Kosti city for their nutrient mineral contents and heavy metals [16].

5. Conclusion

The chemical parameters of Kosti and Rabak drinking water showed good quality except, Cl, Hardness, TDS and Pb considered to be the most serious problem in the White Nile water. The quality evaluation for the drinking water, whatever the city, should be routine work, and the pollution sources should be detected and treated immediately.

Compliance with ethical standards

Acknowledgments

Thanks are extended to the staff of Applied Chemistry Laboratory and Central Laboratory Laboratories, University of Gezira, Sudan.

Disclosure of conflict of interest

No conflict of interest to be disclose.

References

[1] WHO (2012). Guidelines for drinking-water quality. WHO (Fourth edition incorporating the first addendum ed.). Geneva. ISBN 9789241549950

[2] Rhoades, R. A. and Tanner, G. A. (2003). Medical Physiology (2nd ed.). Baltimore: Lippincott Williams and Wilkins. ISBN 978-0-7817-1936-0.

[3] UNICEF and WHO (2017). Safely managed drinking water, thematic report on drinking water 2017. file://pmjaf/Downloads/safely-managed-drinking-water-JMP-2017-1-20(1).pdf.

[4] Homaida, M. A. and Goja, A. M. (2015). Microbiological Quality Assessment of Drinking Water at Ed-Dueim Town, Sudan. NY Sci. J., 6(5):10-16. http://www.sciencepub.net/.3.

[5] Siddig, A. A. H.; Magid, T. D. A.; EL-Nasry, H. M.; Hano, A. I. and Mohammed, A. A. (2018). Biodiversity in Sudan. 1st ed., Apple Academic Press, pp. 22. ISBN 9780429469800

[6] CAWST, the Centre for Affordable Water and Sanitation Technology (2013). Introduction to Drinking Water Quality Testing Manual. Available at: creativecommons.org licenses.

[7] Vogel, A. I. (1989). Vogel's textbook of quantitative inorganic analysis. 5th ed. Co published in the United States with John Wiley and Sons, Inc., New York

[8] Collins, W. D. (1945). Notes on Practical Water Analysis. US Geological survey. https://pubs.usgs.gov/wsp/0596h/report.pdf.

[9] Gerenfes, D. and Teju, E. (2018). Determination of Some Selected Heavy Metals in Water, Oreochromis niloticus and Labeobarbus intermedius Samples from Abaya and Chamo Lakes. Journal of Natural Sciences Research, 8(21): 85-95. www.iiste.org.

[10] Manoj, J. K.; Poonam, D. and Ruchi, T. (2014). Testing and Analysis of Drinking Water Quality of Underground Water located near Rural Area of Risali Chhattisgarh, India, International Research Journal of Environment Sciences, 3(5): 44-47.

[11] Mohamed, H. M. and Zahir, H. A. (2013). Study of ground water quality at Dindigul Town Tamilnadu, India. Int. Res. J. Environment Sci., 2(1): 68-73.

[12] Gupta, S. and Shukla, D. N. (2006). Physico-Chemical analysis of sewage water and its effect on seed germination and seedling growth of Sesamum indicum. J Nat-Ras. Develop., 1:5-19.

[13] Rokade, P. B. and Ganeshwade, R. M. (2005). Impact of pollution on water quality of Salim Ali Lake at Aurangabad, Uttar Pradesh. Journal of Zoology, 25(2): 219-220.

[14] Batuira, M.; da Costa, F.; Armando, C. D.; Teresa, A. and Rocha-Santos, P. (2022). Environmental monitoring approaches for the detection of organic contaminants in marine environments: A critical review. Trends in Environmental Analytical Chemistry, 33: e00154. https://doi.org/10.1016/j.teac.2022.e00154.

[15] Ali, A. A. H.; Kehail, M. A. A. and Mohammed Ali, M. E. A. (2021). Quality of drinking water of Kosti city, White Nile State, Sudan, collected during February 2021. Magna Scientia Advanced Biology and Pharmacy, 2(2): 32–36.

[16] Malik, A.; Yasar, A.; Tabinda, A. and Abubakar. M. (2012). Water-borne diseases, cost of illness and willingness to pay for diseases interventions in rural communities of developing countries. Iranian Journal of Public Health, 41(6): 39–49.