ADITUM
Enrich your Research

International Journal of Epidemiology and Public Health Research | Research Article

Assessment of ground water quality for drinking purposes based on turbidity and water quality index in Shendi City, River Nile State, Sudan.

Abdallah Ahmed Adam Belal [1, 2, *], Ahmed Mohammed Hussein[1, 3], Adam Dawria Ibrahim [3,4]
[1]Public Health Department, College of Health Sciences, Saudi Electronic University, Riyadh, Saudi Arabia.
[2]Environmental Health Department, Faculty of Public Health, Shendi University, Shendi, Sudan
[3]Public Health Department, Faculty of Public Health, Shendi University, Shendi, Sudan.
[4]Public health department, College of health Sciences, King Khalid University, (KSA).

Article Info

Received: August 02, 2024
Accepted: August 09, 2024
Published: August 26, 2024

***Corresponding author:** Abdallah Ahmed Adam Belal, 1Public Health Department, College of Health Sciences, Saudi Electronic University, Riyadh, Saudi Arabia, 2Environmental Health Department, Faculty of Public Health, Shendi University, Shendi, Sudan.

Citation: Abdallah Ahmed Adam Belal, Ahmed Mohammed Hussein, Adam Dawria Ibrahim. (2024) "Assessment of ground water quality for drinking purposes based on turbidity and water quality index in Shendi City, River Nile State, Sudan.". International Journal of Epidemiology and Public Health Research, 5(2). DOI: 10.61148/2836-2810/IJEPHR/076

Abstract:

Water is a basic of life so all water resources that used for drinking purposes must be test and check continuously to insure its free from harmful agents that may be impact on human health and its validity to consumption for human being and its level of quality. Although ground water is considering microbial safe it need to analyzing and monitoring. Monitoring of ground water is done by collecting water samples and analysis these samples. This descriptive and analytical research was carried out to measure level of turbidity in ground water. One hundred and fifty samples of ground water were taken and tested per season (Fifty samples for each season), samples of water were collected and analyzed according to standard methods for examinations of water, in current study we used photometer device for determination levels of turbidity. This study revealed that: the quality of ground water in study area is fit for drinking purpose based to WHO and SSMO guidelines for drinking water in summer and winter seasons. While the quality of ground water is poor and unsuitable for drinking purpose without treatment in autumn season. According to the findings, the current study recommended that: Local authority of Water safety in study area should be maintains on quality of ground water in summer and winter seasons, and improving the quality of currently drinking water in autumn season by providing appropriate treatment processes to make ground water suitable for drinking purpose.

Keywords: groundwater; permissible level; water quality index; season; shendi city; indicator

Introduction:

Groundwater is the basic resource of water for drinking and domestic purposes. Several areas, worldwide depend on groundwater , especially those have shortage in surface water supply and mostly inadequate for drinking purposes , '[Zhou et al., 2020; Subba Rao et al., 2020]. Ground water may be subjects to deferent types of contamination; this contamination is spread and consider impact issue on both national and international scales [Gao et al., 2020; He et al., 2020]. There are many activities such as , erratic rainfall, the rapid growth of urbanization, intensive irrigation activity, excessive usage of fertilizers and unplanned industrialization, population growth, man-made/anthropogenic and geogenic pollution often lead to a large amount of groundwater contamination [Gao et al., 2020; Kumar et al., 2020; Subba Rao et al., 2020; Wu et al., 2019]. Monitoring process of groundwater sources is important due to it gives valuable information on characteristics of water safety and regular change in water quality, water quality categories, and treatment options for polluted water [Suk and Lee

1999; Kaown et al. 2012]. As a consequence of, intake of polluted drinking water is occurrence several health problems in varied locations and areas around the world [Adimalla and Qian, 2019b;Wu et al., 2020; Yadav et al., 2019]. A number of studies have reported the importance of using various methods not only to quantify the groundwater quality but also to evaluate the pollution sources and vulnerable distribution [Badeenezhad et al., 2019; Egbueri, 2020; Subba Rao and Chaudhary, 2019]. Turbidity in water is caused by deferent suspended particles like clay, silt, finely organic and inorganic matter, soluble colored organic compounds, plankton and other microscopic organisms. If the turbidity of water is more than 5 NTU we need to some kind of treatment to remove turbidity because is necessary before water subjects to disinfection by chlorine, due to its effects, both on the acceptability of water to consumers and the selection of efficiency of treatment processes, particularly the efficiency of disinfection with chlorine [WHO, 1997]. High levels of turbidity in drinking water can create nutritional value and provide habitat for pathogens. So if not removed excessive turbidity can promote regrowth of pathogens in the water source and leading to waterborne disease outbreaks, that may be caused significant cases of intestinal illnesses worldwide. Increase levels of turbidity measurements in drinking water can demonstrate a numerous things such as a decrease in source water quality, improper water treatment or defect in the water supply system [CDW, 2012]. High levels of turbidity in groundwater does not proven pathogen presence only but gives information on general water quality and also it consider as an indicator of surface influence on groundwater quality [Martin,Allen, et al.,2008]. All water sources that intent to use for drinking purpose should be monitoring and make control process for turbidity in the distribution supply including at the consumer's points. For effective operation of the drinking water supply, turbidity levels should be approximately 1.0 NTU or less entering the distribution system [CDW, 2012]. Turbidity can be used as an indicator for conditions that permit potential microbiological growth in the water supply system [EPA, 2006].

2. Water quality index:

(WQI) Quality of water can be classified into differ scales that indicate the status of water quality with the help of WQI. The conceptual of WQI was first used by Horton [1965], as following scales Water quality rating Grading 0–25 Excellent, water quality 26–50 Good, water quality 51–75 Poor, water quality 76–100 Very poor, water quality >100 Unsuitable water quality (Bharti and Katyal 2011; Gibrilla et al. 2011; Lumb et al. 2011a, 2011b; Sahu et al. 2011; Sen 2011; Maruthi Devi, et al.2011;Srivastava et al. 2012; Dede et al. 2013). The main aim of WQI is to convert the complex water quality data into understandable and usable information by which major people can know the status of water sources in a particular region [Vasanthavigar et al. 2010; Akoteyon et al. 2011; Islam, s. et al. 2011; Balan et al. 2012]. The weighted arithmetic index method was used for the calculation of WQI using the following: Eq. [1] (Brown et al. 1970).

WQI = Wi Qi / Wi [1] The unit weight (Wi) for each water sample is calculated by the following formula: Wi = K/Si,[2] Where K is appropriately constant and Si is the standard permissible value of the *i* the parameter. The quality rating (Qi) of Eq. [1] is then calculated as under: Qi = 100 [(Vi − Vo/Si − Vo)], [3]

Where Vi is estimated concentration of *i* the parameter in the analyzed water and Vo is the ideal value of this parameter in pure water. All ideal values are taken as zero for drinking water except pH = 7.0 [Laskar and Gupta 2011; Tyagi et al. 2013].

2. Materials and Methods:

2.1 Study design : A descriptive –cross sectional study

2.2 study area:

Shendi Town it is the third largest Town in River Nile State, it located about 176 km north of Khartoum [capital of republic of Sudan] , and 130 km south of El damer (capital of River Nile State). It is in the arid zone of Sudan with annual rain fall ranging between 0 and 119mm per year.(Suleiman ,2011). Shendi town has no sewerage system and it has a distribution system of drinking water; the whole Town depends on ground water as source of drinking.

2.3 Study population: water sources**,** water supply system and household facilities.

2.4 sample size determination: Sample size was determined according to WHO guidelines, therefore 150 samples were examined based on total of population in study area.

2.5 Water sample collection:

Water samples were collected according to the WHO Guidelines for drinking water quality assessment (WHO, 1993). Water samples were collected from all ground water sources, distribution system and storage facilities , Samples were stored in 500-ml plastic bottles (high-density polyethylene bottles recycled from similar, bottled distilled water products), cleaned with liquid detergent, and rinsed with distilled water and air dried. A "control wash" was employed by prerinsing the collection bottle 3 times with 20 ml of the sample water before final collection. Bottles were filled completely to the brim to avoid inclusion of air, and bottles were capped tightly and appropriately labeled. Samples were stored overnight in the refrigerator, not cooler than 4°C, and were tested within 24 h.

2.6 Water samples analysis:

Turbidity was measured according to standard methods for examination of water by the following steps: Filtered a portion of the sample through a GF/B filters paper, Filled a test tube with filtered sample and retain for use as the BLANK tube, Filled a test tube with unfiltered sample to the 10 ml mark, Selected a turbidity choice on photometer and took photometer reading as NTU.

2.7 Data analysis:

Data were analyzed by computer using both Microsoft Excel and Microsoft word, and then the results are displayed in tables and other statistical graphs.

Results

Sampling location	Number of tested samples	Turbidity level /NTU		Percentage %	
		< 5 NTU	> 5 NTU	< 5 NTU	> 5 NTU
Sources(Wells)	22	**20**	**2**	**90.9**	**9.1**
Storage facilities	6	**6**	**0**	**100.0**	**0.0**
Distribution system	22	**20**	**2**	**90.9**	**9.1**
Total	50	**46**	**4**	**92.0**	**8.0**

Table 1: results of samples analysis for Turbidity level in summer season.

The above table demonstrates that 92% of tested samples are indicated water turbidity within permissible level and 8% of them indicated water turbidity above permissible level.

Sampling location	Number of tested samples	Turbidity level /NTU		Percentage %	
		< 5 NTU	> 5 NTU	< 5 NTU	> 5 NTU
Sources(Wells)	20	**17**	**3**	**85.0**	**15.0**
Storage facilities	9	**9**	**0**	**100.0**	**0.0**
Distribution system	21	**19**	**2**	**90.5**	**9.5**
Total	50	**45**	**5**	**90.0**	**10.0**

Table 2: results of samples analysis for Turbidity level in autumn season.

The above table demonstrates that 90% of tested samples are indicated water turbidity within permissible level and 10% of them indicated water turbidity above permissible level.

Sampling location	Number of tested samples	Turbidity level /NTU		Percentage	
		< 5 NTU	> 5 NTU	< 5 NTU	> 5 NTU
Sources(Wells)	18	**16**	**2**	**88.9**	**11.1**
Storage facilities	9	**8**	**1**	**88.9**	**11.1**
Distribution system	23	**21**	**2**	**91.3**	**8.7**
Total	50	**45**	**5**	**90.0**	**10.0**

Table 3: results of samples analysis for Turbidity level in winter season.

The above table demonstrates that 90% of tested samples are indicated water turbidity within permissible level and 10% of them indicated water turbidity above permissible level.

WQI value rate	Water quality	Summer		Autumn		Winter	
		Samples	%	Samples	%	Samples	%
0-25	Excellent	21	42	14	28	26	52
26-50	Good	19	38	26	52	12	24
51-75	Poor	5	10	4	8	4	8
76-100	Very poor	1	2	1	2	3	6
Above 100	Unfit for drink	4	8	5	10	5	10
Total		**50**	**100**	**50**	**100**	**50**	**100**
General WQI		**39.1**		**50.9**		**36.7**	

Table 4: Turbidity levels measurement over the seasons

The above table shows that WQI based on turbidity levels indicated that water quality is excellent and good in summer and winter seasons but however it is unfit for drinking in autumn season.

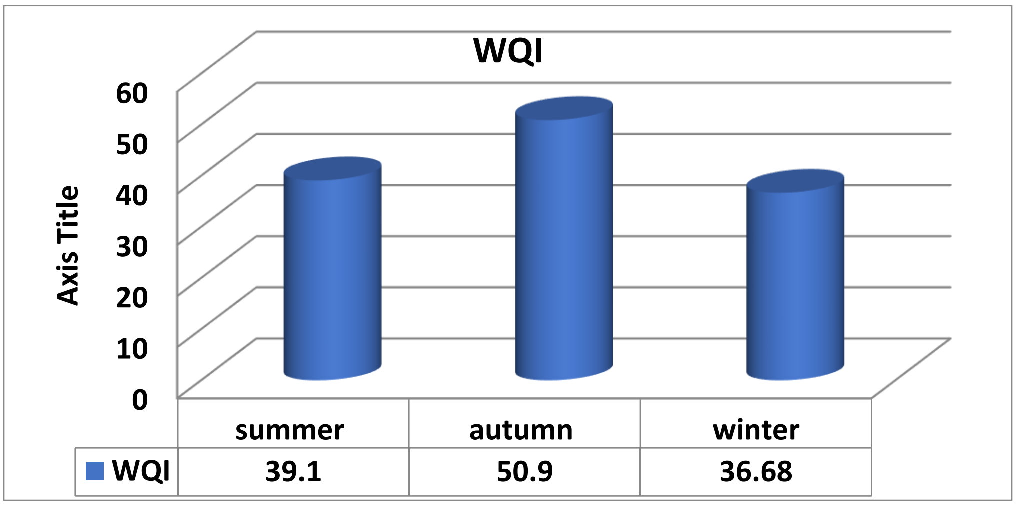

Figure 1: comparison of water quality index (WQI) based on turbidity levels per seasons

4. Discussion:

The current study found that 92% and 90% of examined water samples were demonstrated that turbidity level under and within permissible levels in summer and autumn- winter seasons respectively , this is good an indicator for ground water quality according to WHO and SSMO guidelines for drinking water quality. While 8% and 10% from tested water samples of ground water showed that turbidity levels above than allowed levels in summer and autumn- winter respectively, once turbidity levels are high this is may be an indicator to presence of high load of microorganism like virus, parasite and bacterial, that responsible for causing various diseases. These microbial agents can cause health problem for consumers and lead to water- borne diseases, and endemic gastrointestinal illness is also associated with the turbidity of water.

Our present study according to water quality index (WQI) showed that majority of examined samples (42%, 52% and 52%) they were appeared that quality of ground water is (excellent, good and excellent) in summer, autumn and winter seasons respectively, while on other hand 8% and 10% of tested samples are indicated that the quality of ground water in study area unsuitable for drinking purpose in summer and autumn- winter seasons. Overall our current study based on values of general WQI (36.68, 39.1 and 50.9) (figure 1) was indicated that the quality of ground water is good in summer and winter and poor in autumn seasons, this seasonal variation in water quality may be attribute to direct influence of surface water during heavy rainfall, that will experience rapid movements during recharge periods or after rain events.

The present study shows that there is variations in turbidity levels of ground water per seasons, these changes in turbidity levels are don't indicate pathogens presence only but they can provides general information about water quality and also used as an indicator of surface influence on ground water quality. This finding agrees with statement reported by Martin, Allen et al., 2008 (annual variation in water quality may be due to direct influence of surface water during heavy rainfall, also may be due to spring runoff and some others natural geological factors, which results in increase in turbidity due to dynamic velocity.

Conclusion:

The study concluded that the quality of ground water in study area based on turbidity measurements is fit for drinking purpose during summer and winter seasons according to WHO and SSMO guidelines. While the quality of ground water is poor and unsuitable for drinking purpose without treatment in autumn season.

Recommendations:

Depend on the findings of current study researchers are recommended : Civil Water Corporation in study area should be maintains on quality of ground water in summer and winter seasons, and must be improving the quality of currently drinking water in autumn season by subjecting it to appropriate treatment processes to become suitable for drinking purpose.

Conflict of interests: None

Acknowledgments:

The authors send their thanks to family of (Environmental health and food control directorate) for their administrative help. Also, we would like to thank the family of the Ministry of Health- River Nile state for providing laboratory facilities. We send many thanks to all those who are supported, contributed, and helped us in this study.

Funding: None

References:

1. Adimalla, N., Qian, H., 2019b. Groundwater quality evaluation using water quality index (WQI) for drinking purposes and human health risk (HHR) assessment in an agricultural region of Nanganur, south India.)
2. Akoteyon IS, Omotayo AO, Soladoye O, Olaoye HO 2011. Determination of water quality index and suitability of urban river for municipal water supply in Lagos-Nigeria. Eur J Sci Res 54(2):263–271
3. Badeenezhad, A., Radfard, M., Passalari, H., Parseh, I., Abbasi, F., Rostami, S., 2019. Factors affecting the nitrate concentration and its health risk assessment in drinking groundwater by application of Monte Carlo simulation and geographic information system. Hum. Ecol. Risk Assess. 1–14. BIS, 2012. Drinking water-specification. Bureau of Indian standards, New Delhi IS: 10500. Bureau of Indian Standards Manak Bhavan, 9 Bahadur Shah Zafar Marg New Delhi 110002.
4. Balan IN, Shivakumar M, Madan Kumar PD,2012. An assessment of groundwater quality using water quality index in Chennai, Tamil Nadu, India. Chron Young Sci 3(2):146–150
5. Bharti N, Katyal D, 2011. Water quality indices used for surface water vulnerability assessment. Int J Environ Sci 2(1):154–173
6. Brown RM, McClelland NI, Deininger RA, Tozer RG ,1970. Water quality index: do we dare? Water Sew Works 117(10):339–343
7. Dede OT, Telci IT, Aral MM, 2013. The use of water quality index models for the evaluation of surface water quality: a case study for Kirmir Basin, Ankara, Turkey. Water Qual Expo Health 5(1):41–56
8. Devendra Dohare, et al., 2014. Analysis of Ground Water Quality Parameters: A Review, Research Journal of Engineering Sciences, 3(5), 26-31, ISSN: 2278-9472
9. Egbueri, J.C., 2020. Groundwater quality assessment using pollution index of groundwater (PIG), ecological risk index (ERI) and hierarchical cluster analysis (HCA): a case study. Groundwater for Sustainable Development 10, 100292.
10. EPA'Environmental protection Agency' 2006. Distribution system monitors of drinking water quality , U S EPA office of ground water and drinking water.
11. Gao, Y., Qian, H., Ren, W., Wang, H., Liu, F., Yang, F., 2020. Hydrogeochemical characterization and quality assessment of groundwater based on integrated-weight water quality index in a concentrated urban area. J. Clean. Prod. 260, 121006.
12. Gibrilla A, Bam EKP, Adomako D, Ganyaglo S, Osae S, Akiti TT, Kebede S, Achoribo E et al ,2011. Application of water quality index (WQI) and multivariate analysis for groundwater assessment of the Birimian and Cape coast granitoid complex: Densu River Basin of Ghana. Water Qual Expo Health 3(2):63–78
13. 12. He, X., Li, P., Wu, J., Wei, M., Ren, X., Wang, D., 2020. Poor groundwater quality and high potential health risks in the Datong Basin, northern China: research from published data. Environ. Geochem. Health. https://doi.org/10.1007/s10653-020- 00520-7
14. Islam, S., Rasul, M.T., Alam, M.J.B. and Haque, M.A. 2011. Evaluation of Water Quality of the Titas River Using NSF Water Quality Index. Journal of Scientific Research,Vol.3, No.1, pp.151-159.
15. Kaown D, Hyun Y, Bae G, Oh CW, Lee K ,2012. Evaluation of spatiotemporal trends of groundwater quality in different land uses using Kendall test. Geosci J 16(1):65–75
16. Kumar, R., Mittal, S., Sahoo, P.K., Sahoo, S.K., 2020. Source apportionment, chemometric pattern recognition and health risk assessment of groundwater from southwestern Punjab, India. Environ. Geochem. Health. Langenegger, O., 1990. Groundwater quality in rural areas of western Africa. UNDP project INT/ 81/026, 10.
17. Laskar HS, Gupta S ,2011. Water Quality of Jalingachhara and Baluchuri streams of district Cachar, Assam, North East India. Assam Univ J Sci Technol Biol Environ Sci 7(1):1–9
18. Lumb A, Sharma TC, Bibeault JF ,2011a. A review of genesis and evaluation of water quality index (WQI) and some future directions. Water Qual Expo Health 3(1):11–24
19. Lumb A, Sharma TC, Bibeault JF, Klawunn P ,2011b. A comparative study of USA and Canadian water quality index models. Water Qual Expo Health 3(3–4):203–216
20. Martin J. and Allen S. A . 2008. Turbidity and microbiology risk in drinking water , ministerial technical advisory committee, Columbia.
21. Maruthi Devi, C.H.; Usha and Madhuri, T. 2011. Nature, Environment and Pollution Technology,10,481.
22. Sahu M, Mahapatra SS, Sahu HB, Patel RK ,2011. Prediction of water quality index using neuro fuzzy inference system. Water Qual Expo Health 3(3–4):175–191

23. Sen Z ,2011. Groundwater quality variation assessment indices. Water Qual Expo Health 3(3–4):127–133
24. Srivastava PK, Mukerjee S, Gupta M, Singh SK ,2012. Characterizing monsoonal variation on water quality index of river Mahi in India using geographical information system. Water Qual Expo Health 2(3–4):193–203
25. SSMO 'Sudanese Standards Metrology Organization' 2002. Drinking water guide lines, first edition, republic of Sudan, March 2002, Khartoum.
26. Subba Rao, N., Chaudhary, M., 2019. Hydro-geochemical processes regulating the spatial distribution of groundwater contamination, using pollution index of groundwater (PIG) and hierarchical cluster analysis (HCA): a case study. Groundwater for Sustainable Development 9, 100238.
27. Subba Rao, N., Sunitha, B., Adimalla, N., Chaudhary, M., 2020. Quality criteria for groundwater use from a rural part of Wanaparthy District, Telangana State, India, through ionic spatial distribution (ISD), entropy water quality index (EWQI) and principal component analysis (PCA). Environ. Geochem. Health 42 (2), 579–599.
28. Tyagi S, Dobhal R, Kimothi PC, Adlakha LK, Singh P, Uniyal DP ,2013. Studies of river water quality using river bank filtration in Uttarakhand, India. Water Qual Expo Health 5(3):139–148
29. Vasanthavigar M, Srinivasamoorthy K, Vijayaragavan K, Ganthi RR, Chidambaram S, Anandhan P, Manivannan R, Vasudevan S ,2010. Application of water quality index for groundwater quality assessment: Thirumanimuttar sub-basin, Tamilnadu, India. Environ Monit Assess 171:595–609
30. WHO 'World Health Organization'1997. Guide lines for drinking water quality, volume 3, surveillance and control of community supplies, 2nd ed. ,Geneva.
31. WHO 'World Health Organization'1993. Global strategy: Health, Environmental and Development. Approaches to drafting countrylevel strategies for human well being under Agenda 21. WHO Document, Geneva Switzerland.
32. WHO 'World Health Organization' 1993. Guide lines for drinking water quality in distribution system, volume one, Geneva.
33. WHO 'World Health Organization' 2006. Guide lines for drinking water quality, volume 1, a first addendum (recommendations), 3rd ed. , Geneva.
34. Wu, J., Zhang, Y., Zhou, H., 2020. Groundwater chemistry and groundwater quality index incorporating health risk weighting in Dingbian County, Ordos basin of northwest China. Geochemistry 125607.
35. Yadav, K.K., Kumar, V., Gupta, N., Kumar, S., Rezania, S., Singh, N., 2019. Human health risk assessment: study of a population exposed to fluoride through groundwater of Agra city, India. Regul. Toxicol. Pharmacol. 106, 68–80.
36. 35. Zhou, Y., Li, P., Chen, M., Dong, Z., Lu, C., 2020. Groundwater quality for potable and irrigation uses and associated health risk in southern part of Gu'an County, North China Plain. Environ. Geochem. Health. https://doi.org/10.1007/s10653-020