Uniport Journal of Engineering and Scientific Research (UJESR)

Vol. 2, Issue 1, December/2018
ISSN: 2616-1192

(www.ujesr.org)

© Faculty of Engineering, University of Port Harcourt, Nigeria.

Assessment of Water Quality of Boreholes in Choba Campus Hostels of University of Port Harcourt

Ugwoha, E.[1] and Nwike, C.O.[2]
[1,2]Department of Civil & Environmental Engineering, University of Port Harcourt, P.M.B. 5323, Nigeria
Corresponding author's email: ugwohaej@gmail.com

Abstract

This study was conducted to determine the quality of borehole water used in the three hostels of Choba campus of the University of Port Harcourt. The water analysis was carried out on samples collected from each hostel for physical parameters (true colour, odour, turbidity, total suspended solids (TSS), temperature and total dissolved solids (TDS)), chemical parameters (pH, electrical conductivity, salinity, alkalinity, total hardness, chloride, nitrate, phosphate, biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), Iron, lead and arsenic) and biological parameters (total coliform and faecal coliform) using standard methods. Results obtained showed that all physical parameters were within the WHO standards. All chemical parameters were within the WHO permissible limit except for pH (3.97 – 4.49) for all hostels' borehole that showed high acidity and DO (3.97 – 4.81mg/l) for Block A-C hostel and Medical hostel boreholes that were below the WHO minimum standard of 5 mg/l. Based on the result of total hardness, water from all three hostels' boreholes were considered soft water. The biological parameters were below detection, indicating that there was no obvious biological contamination. The calculated water quality index showed that the quality of the hostels' borehole water ranged from poor quality to unsuitable for drinking due to high acidity. The ANOVA carried out showed that there was no significant difference in water quality between the three hostels' boreholes. It is therefore recommended that the boreholes should be treated for the reduction of acidity before use.

Key words: *Assessment, Groundwater, Boreholes, Water Quality, Choba, Uniport*

1. Introduction

Water is vital for all known forms of life and moves through a cycle of evaporation, precipitation and runoff (Gedney et al., 2006). Water needs to be available at almost every moment of existence but the availability of water in space and time is limited by environmental factors such as climate, geography of an area and physical conditions. A few other factors that could affect the availability of water are the efficiency by which it is conserved and used and the affordable technological solutions which permit its exploitation. According to WHO (2018), about 2 billion people do not really have access to potable water supply. Water being a basic need of every living thing, makes it necessary to ascertain its quality in relation to its effects to the consumer. Accordingly, standards and guidelines in water quality stem from the need to protect human health (Kiely, 2007).

An important source of potable water in Africa which constitutes about two-third of the freshwater resources of the world is groundwater (William, 2014). Groundwater is the water that is present beneath the earth's surface, existing in the soil's pore spaces and in rock formations' fractures. It is known that 98% of the world's freshwater is accounted to groundwater which provides a reasonably constant supply for domestic use, livestock and irrigation and is not likely to dry up under natural conditions (William, 2014). Groundwater is commonly extracted via boreholes and wells. These structures, with depth ranging from 45 – 50 meters, distort the natural flow field and create a path that opens an additional possibility of mass transfer between rock formations / aquifers, surrounding and atmosphere (Berthold, 2010; Akpoveta et al., 2011). This reveals that there could be possible traces of pollution in the groundwater especially as it is collected via boreholes or wells by the interaction between the water molecules and rock formations and surrounding atmosphere.

Contamination of water has increasingly become an issue of serious environmental concern (Akpoveta et al., 2011). The habit of indiscriminate waste disposal, poor agricultural practices, septic tanks, pit latrines and graves near boreholes and poor well construction contribute to borehole water contamination (Sunnudo-Wilhelmy and Gill, 1999; Egwari and Aboaba, 2002; Singh and Mosley, 2003; Lu, 2004). These account for the presence of coliform bacteria in borehole water and lead to possible diseases if consumed without any form of treatment. According to WHO (2018), contaminated water can transmit diseases such as diarrhea, cholera, dysentery, typhoid and polio. Among these water-related diseases, diarrhea has a higher death possibility percentage. This shows that it is important to certify the quality of water used for domestic purposes to prevent these deadly diseases.

Borehole is the major source of water in the Choba campus hostels of the University of Port Harcourt. Currently, the physical, chemical and biological characteristics of the borehole water is unknown. Therefore, the aim of this work is to determine the quality of the borehole water available to students residing in the Choba campus hostels of the University of Port Harcourt. Accordingly, students in these hostels and the governing body of the University will have the full knowledge of the quality of the hostels' borehole water as well as measures of adequate treatment where necessary.

2. Materials and methods

2.1. Study area

This study was conducted in Choba campus of the University of Port Harcourt, Rivers State of Nigeria with geographic coordinates of 4°53'42''N and 6°54'32''E. Geologically, the site is underlain by the coastal plain sand, overlain by soft-firm silty clay sediments belonging to the Pleistocenic formation. The general geology of the area essentially reflects the influence of movements of rivers in the Niger Delta and their search for lines of flow to the sea with consequent deposition of transported sediments (Reyment, 1965; Short and Stauble, 1967). The surface deposit in the area comprises silty-clays (Etu-Efeotor and Akpokodje, 1990). The near surface silty clays are subjected to mild desiccation during the dry season. Substantial seasonal variations in moisture are expected in the area. This could result in some false enhancement of strength in the dry season. The sandy layers underlying the top clay are predominantly medium to coarse grain sizes, fairly graded and found to exist in various states of compaction. The soils in this wetland have voids saturated with water and boreholes dug to 45-50 metres. The study area features a tropical wet climate with very lengthy and heavy rainy seasons and very short dry seasons. Only the months of December and January truly qualifies as dry season months in the area. The harmattan, which climatically influences many cities in West Africa, is less pronounced in the study area. Port Harcourt's heaviest precipitation occurs during September with an average of 367 mm of rain. December on average is the driest month of the year, with an average rainfall of 20 mm. Temperatures throughout the year in the area are relatively constant, showing little variation throughout the course of the year. Average temperatures are typically between 25 °C - 28 °C.

The Choba campus of the University of Port Harcourt consist of mainly three (3) hostels, namely Medical hostel, Kwame Nkurumah Extension and Block A-C. Each of the hostels consist of averagely forty-four (44) rooms, with four (4) occupants (students) per room. This yields an average of one hundred and seventy-six (176) to one hundred and eighty (180) students per hostel. A total of five hundred and forty (540) students make use of the hostels' borehole water for bathing, drinking and other domestic activities.

2.2. Collection and analysis of water samples

The water samples were collected from the borehole using sterilized plastic water bottles (750ml). An air space of 2.5cm was left in the water bottles to create space for oxygen so that organisms in the water samples do not die before testing in the laboratory. Water sample was collected from all the boreholes from each hostel and labeled accordingly. The water samples were immediately sent to the laboratory in an insulated bag to prevent external factors like high temperatures from changing some of the water parameters. Analysis commenced within 12 hours of sampling (APHA, 1998). All analyses were done in duplicate.

2.2.1. Physico-chemical analysis

Physico-Chemical parameters such as pH, total dissolved solids (TDS), dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), hardness, fluoride, iron and nitrate were measured. A multi-purpose pH meter model D46 (pH/MV/OC meter) was used to determine the pH of the borehole water. A 4-HMD TDS meter was used to determine the TDS of the water samples. Nitrate (NO3-N), calcium hardness as calcium carbonate (CaCO3), iron, and fluoride were analyzed using the Wagtech test instructions. Palin test kit and Wagtech photometer 5000 were used to determine the frequency readings. Respective calibration charts were then used to determine concentrations of these parameters.

The DO, COD and BOD were measured using the azide modification method (APHA, 2012), sealed digestion and spectrometry (ASTM D1252-06, 2012) and a 5-day BOD test (APHA, 2012), respectively. All analysis commenced on the same day of sample collection.

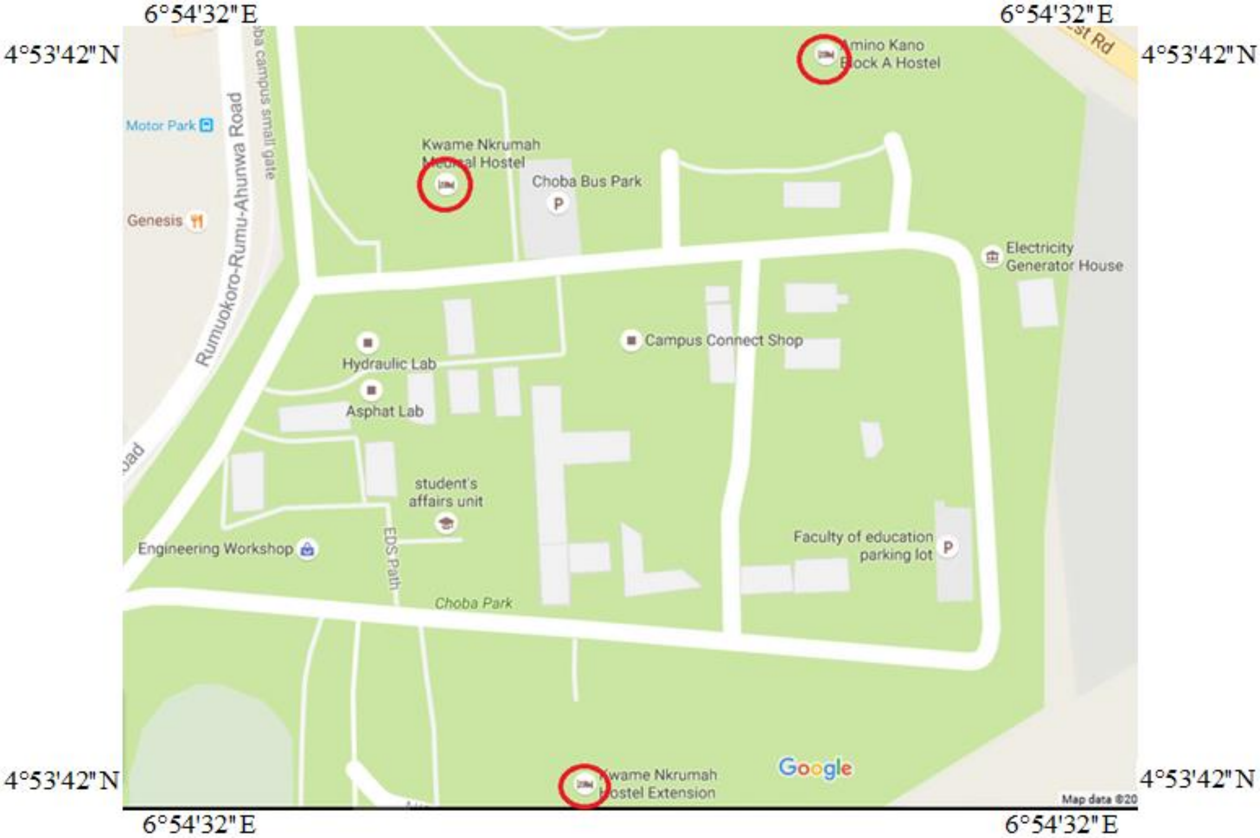

Fig. 1: Map of Choba campus showing the three student's hostels

2.2.2. Biological analysis

Indicator organisms, total coliforms and faecal coliforms in colony forming units/100ml (cfu/100ml) were analyzed from the water bottles using Wagtech Potalab 2 (APHA, 1998).

2.3. Determination of water quality index (WQI)

The weighted arithmetic WQI method classifies water quality according to the degree of purity by using the most commonly measured water quality variables. WQI was calculated using Equation (1):

$$WQI = \Sigma QiWi/\Sigma Wi \quad (1)$$

where Qi is the quality rating scale and Wi is the unit weight.

The Qi for each parameter was calculated using Equation (2):

$$Qi = 100[(Vo - Vi)/(Si - Vi)] \quad (2)$$

where Vi is the estimated concentration of the ith parameter in the analyzed sample, Vo is the ideal value of this parameter in pure water (Vo = 0 except for pH = 7 and DO = 14.6mg/l), and Si is the recommended standard value of the ith parameter.

The Wi for each parameter was calculated using Equation (3):

$$Wi = K/Si \quad (3)$$

where K is the proportionality constant and can also be calculated using Equation (4):

$$K = \frac{1}{\Sigma(1/Si)} \quad (4)$$

2.4. Level of pollution analysis using pollution index

Pollution index (Pi) was used to show the level of pollution of borehole water by each parameter. The critical value being 1.0 and values greater than 1.0 indicate significant degree of pollution while values less than 1.0 show no pollution (Akpoveta et al., 2011). Pi according to Akpoveta et al. (2011), is expressed as a function of the concentration of individual parameter values against the baseline standard (WHO permissible value):

$$Pi = \frac{Concentration}{Standard} \quad (5)$$

The statistical significance of pollution was then affirmed by one-way T-test to compare each parameter value with the WHO permissible standard for drinking water (WHO, 1993). Classification of water hardness as calcium carbonate and micro-biological pollution levels categorized by (USEPA, 1986) and (DWAF, 1996) respectively were also used to analyze the pollution levels of the borehole water.

3. Results and discussion

3.1. Physical parameters

The result of the physical parameters of the Choba campus hostels borehole water is summarized in Table 1. All measured physical parameters are within the WHO standard. The measured parameters are similar for all boreholes except for TDS which is more than twice higher in Block A-C hostel compared to Medical hostel and Kwame Extension. Generally, the TDS is high compared to previous studies within the study area (Ugwoha and Emete, 2015). This could be as a result of sewage release or increased agricultural and industrial activities which are known anthropogenic activities that could lead to increase in TDS (WHO, 2003).

Table 1: Summary of physical parameters of borehole water samples

Parameters	Medical Hostel		Block A-C		Kwame Extension		WHO Std.
	Sample A	Sample B	Sample A	Sample B	Sample A	Sample B	
True colour (HU)	clear	clear	clear	clear	clear	clear	Colourless
Odour (-)	odourless	odourless	odourless	odourless	odourless	odourless	Odourless
Turbidity (NTU)	0.01	0.01	0.01	0.01	0.01	0.01	5
TSS (mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	10
Temp. (°C)	23.98	23.98	24.69	24.69	24.38	24.38	25
TDS (mg/l)	11	11	41	40	12	12	600

3.2. Chemical parameters

The result of the chemical parameters of the borehole water from Choba campus hostels is summarized in Table 2. Generally, all chemical parameters are within the WHO permissible limit except for pH for all hostels' borehole and DO for Medical hostel and Block A-C hostel boreholes. The pH range of 3.97 - 4.49 for all hostels' borehole water which is less than the WHO minimum standard of 6.5 indicates that all three boreholes water are acidic and can corrode (USGS, 1999). Similar result was reported for water from urban boreholes elsewhere (William, 2014). The acidity could be due to sulphate interactions within the local rock or the percolation of acid rain to groundwater. Consumption of such acidic water could result in delicate health consequences. DO of Medical hostel and Block A-C hostel boreholes water is below the minimum standard of 5. According to SCW (2018), DO may be reduced because the water becomes too warm or because there are too many bacteria. Since the temperature (Table 1) and the biological parameters (Table 3) for all three hostels' borehole water are within the WHO permissible limits, the decrease in DO of Medical hostel and Block A-C hostel boreholes water could be due to biological oxidation of organic matter (Basavaraddi et al., 2012). According to Rose and Long (1988), low DO could have effect on the borehole water quality by regulating the valence state of trace metals and by constraining the bacterial metabolism of dissolved organic species. Generally, water from all three hostels' boreholes are considered soft water. According to USGS (1999), water is considered soft if it contains 0 – 60 mg/l of hardness.

3.3. Biological parameters

The result of the biological parameters of the borehole water from Choba campus hostels is summarized in Table 3. Generally, all analysed biological parameters (total and faecal coliforms) are below the detection limit of the standard method (APHA, 1998) employed. This implies that the total and faecal coliforms of all three hostels' borehole water are within the WHO permissible limit of zero and therefore could be used for domestic purposes.

Table 2: Summary of chemical parameters of borehole water samples

Parameters	Medical Hostel		Block A-C		Kwame Extension		WHO Std.
	Sample A	Sample B	Sample A	Sample B	Sample A	Sample B	
pH	4.49	4.46	3.97	3.95	4.2	4.16	6.5-8.5
Conductivity (µS/cm^3)	22	28	82	90	23	21	250
Salinity	4	4	29	29.10	4	3.99	250
Alkalinity (mg/l)	0.035	0.034	0.05	0.07	0.025	0.023	250
Total Hardness (mg/l $CaCO_3$)	1.82	1.81	3.75	3.75	1.27	1.25	100-300
Chloride (mg/l)	29.82	30.00	24.85	24.64	24.85	24.85	250
Nitrate (mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	50
Phosphate (mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	50
BOD	0.01	0.01	0.01	0.01	0.01	0.01	5
COD	0.01	0.01	0.01	0.01	0.01	0.01	10
DO (mg/l)	4.81	4.80	3.97	3.99	5.01	5.00	5
Fe (mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.3
Pb (mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01
As (mg/l)	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table 3: Summary of biological parameters of borehole water samples

Parameters	Medical Hostel		Block A-C		Kwame Extension		WHO Std.
	Sample A	Sample B	Sample A	Sample B	Sample A	Sample B	
Total Coliform	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0
Faecal Coliform	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0

Table 4: Summary of WQI of the borehole water of the different hostels in Choba campus

Borehole	WQI	Rating
Medical Hostel Sample A	68.61226	Poor Water Quality
Medical Hostel Sample B	69.04781	Poor Water Quality
Kwame Extension Sample A	75.12058	Very Poor Water Quality
Kwame Extension Sample B	75.98884	Very Poor Water Quality
Block A-C Sample A	137.2885	Unsuitable for Drinking
Block A-C Sample B	135.5652	Unsuitable for Drinking

Table 5: Analysis of variance

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	494.468887	2	247.2344	1.089901	**0.343952**	3.178799
Within Groups	11568.9058	51	226.8413			
Total	12063.3747	53				

3.4. WQI rating

The WQI of the borehole water of the different hostels is summarized in Table 4. The WQI showed that the borehole water samples ranged from poor quality to unsuitable for drinking. This WQI ranking correlates with the pH of the borehole water samples (see Table 3). The borehole water sample with the highest acidity (Block A-C) had the worst WQI ranking and viz vasa. More so, the calculation of WQI without pH gave better rating for all borehole water samples. Therefore, it is concluded that the poor water quality rating of the borehole water samples is due to the acidity. Hence, it is recommended that water from the boreholes should be treated for the reduction of acidity before use.

3.5. Statistical analysis

A one-way analysis of variance was carried out on the measured water parameters from the three hostels' borehole water and the result is presented in Table 5. The p-value (0.343952) obtained is greater than the Alpha value (0.05) thus a null hypothesis is accepted which means that there is no significant difference between the water quality of the boreholes in the three hostels of Choba Campus of University of Port Harcourt. Therefore, this result corroborates the recommendation of Section 4 that all three boreholes should be treated before use.

4. Conclusions

The borehole water from the three hostels of Choba campus of University of Port Harcourt were analyzed to ascertain their suitability for use by students. The result of the physico-chemical parameters showed that the borehole water from all hostels are soft but acidic with a pH range of 3.97 – 4.49 outside the WHO permissible limits of 6.5 – 8.5. The result of the biological parameters showed that there is no biological pollution of all three hostels borehole water. The calculated water quality index (WQI) ranged from 65 to 137. The Medical hostel and the Kwame Extension hostel were less than 100 and rated as poor and very poor water quality respectively while Block A-C hostel had an average WQI value of 136.4 which indicates that the water is unsuitable for drinking purpose. The ANOVA carried out showed that there was no significant difference in water quality between the three hostels' boreholes. Therefore, it is recommended that water from the boreholes in the three hostels of Choba campus of University of Port Harcourt should not be used as drinking water except it is treated to reduce the acidity.

References

1. Akpoveta OV, Okoh BE and Osakwe SA (2011) Quality assessment of borehole water used in the vicinities of Benin, Edo State and Agbor, Delta State of Nigeria. Current Research in Chemistry, 3: 62-69.
2. American Public Health Association (2012) Standard methods for examination of water and wastewater. 22nd edition, American Public Health Association Press, Washington DC.
3. American Public Health Association (APHA), American Water Works Association (AWWA), and the Water Environmental Federation (WEF) (1998). Standard Methods for Examinations of Water and Wastewater, 20th ed. United Book Press, Inc. Baltimore, Maryland.
4. ASTM D1252-06 (2012) Standard Test Methods for Chemical Oxygen Demand (Dichromate Oxygen Demand) of Water, ASTM International, West Conshohocken, PA, 2012.
5. Basavaraddi SB, Kousar H and Puttaiah ET (2012) Dissolved oxygen concentration - a remarkable indicator of ground water pollution in and around Tiptur town, Tumkur District, Karnataka, India. Bulletin of Environment, Pharmacology & Life Sciences, 1(3): 48-54.
6. Berthold S (2010) Synthetic Convection Log- Characterization of vertical transport processes in fluid- filled boreholes. 10, 01217 Dresden, Germany, Journal of Applied Geophysics 72.
7. Department of Water Affairs and Forestry, DWAF (1996) South African water quality guidelines. Volume 1: Domestic water use. 2nd edition. Pretoria, South Africa.
8. Egwari L and Aboaba OO (2002) Bacteriological quality of domestic waters. Rev. SaudePublica, 36(4): 513-520.
9. Etu-Efeotor JO and Akpokodje EG (1990) Aquifer Systems of the Niger Delta. J. Min. Geol. 26(2): 279-294. Gedney, N., Cox, P.M., Betts, R.A., Boucher, O., Huntingford, C. and Stott, P.A. (2006) Detection of a direct carbon dioxide effect in continental river runoff records, *Nature*, 439: 835–838.

10. Kiely G (2007) Environmental engineering. Special Indian Edition. McGraw-Hill Companies, Inc., New York, pp265-266.
11. Lu XX (2004) Vulnerability of water discharge of large Chinese rivers to environmental changes: an overview. Adv. Water Resour. Doi: 10.1007/s10113-004-0080-0.
12. Reyment RA (1965) Aspects of the geology of Nigeria.The Stratigraphy of the Cretaceous and Cenozoic deposits.Ibadan University Press. 23-73.
13. Rose S and Long A (1988) Monitoring dissolved oxygen in groundwater: some basic considerations. Groundwater Monitoring & Remediation, 8(1): 93-97.
14. Sarasota County Wateratlas, SCW (2018) Dissolved oxygen. USF Water Institute, School of Geosciences, College of Arts and Sciences, University of South Florida.
15. Short KC and Stauble AJ (1967) Outline Geology of the Niger Delta. AAPG Bull 51; 761-779.
16. Singh S and Mosley LM (2003). Trace metal levels in drinking water on VitiLevu, Fiji Islands. S. Pac. J. Nat. Sci., 21: 31-34.
17. Sunnudo-Wilhelmy SA and Gill GA (1999). Impact of the clean water Act on the levels of Toxic Metals in Urban Estuaries the Hundson River Estuary Revisited. Environ. Sci. Technol., 33: 3471-3481.
18. Ugwoha E and Emete KC (2015) Effects of open dumpsite leachate on groundwater quality: a case study of Alakahia dumpsite in Port Harcourt, Nigeria. Journal of Environmental Studies, 1(1): 1-8.
19. United States Environmental Protection Agency, USEPA (1986) Method: 130.2: Hardness, Total (mg/L as CaCO3) (Titrimetric, EDTA). Methods for the Chemical Analysis of Water and Wastes (MCAWW) (EPA/600/4-79/020).
20. United States Geological Survey, USGS (1999) Groundwater. U.S. Geological Survey General Interest Publication Reston, Virginia, 1999 revision.
21. William L (2014) Assessment of borehole water quality and consumption in Yei county South Sudan. A thesis submitted in partial fulfilment of the requirements for the award of Master of Science degree in environment and natural resources of Makerere University.
22. World Health Organization, WHO (1993). Guidelines for Drinking Water Quality. 2nd edition, Vol. 1, Recommendations. Geneva.
23. World Health Organization, WHO (2003) Total dissolved solids in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality, WHO/SDE/WSH/03.04/16.
24. World Health Organization, WHO (2018) Fact sheets on drinking water. Available at https://www.who.int/news-room/fact-sheets/detail/drinking-water. 7th February 2018 News Release.