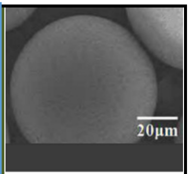
JOBIMB, 2022, Vol 10, No 2, 10-14
https://doi.org/10.54987/jobimb.v10i2.750

HIBISCUS PUBLISHER

JOURNAL OF BIOCHEMISTRY, MICROBIOLOGY AND BIOTECHNOLOGY

Website: http://journal.hibiscuspublisher.com/index.php/JOBIMB/index



JOBIMB VOL 10 NO SP2 2022
ZnO nanoparticle

Disease Risk Levels of Drinking Water Sources in Some Rural Communities in Kwara State, Nigeria

Eniola, K.I.T.[1,2]*, Awe, S.[2], Olawale, K.A.[3] and T.M. Kayode-Isola[4]

[1]Environmental and Public Health Research Laboratory, Department of Biological Sciences, Joseph Ayo Babalola University, Kilometre, 36 Akure Ilesha Rd, Ikeji, Nigeria.
[2]Department of Microbiology, Faculty of Pure and Applied Sciences, Kwara State University Rd, 241103, Malete, Kwara, Nigeria.
[3]Microbiology Unit, Department of Science Technology, Federal Polytechnic, 250101, Offa, Kwara, Nigeria.
[4]Department of Natural Science Education, College of Science Education, Lagos State University of Education, AOCOED, Oto/Ijanikin, Ojo, Lagos, Nigeria.

*Corresponding author:
Eniola, K.I.T,
Environmental and Public Health Research Laboratory,
Department of Biological Sciences,
Joseph Ayo Babalola University,
Kilometre, 36 Akure Ilesha Rd,
Ikeji,
Nigeria.
Email: kennyeniola@gmail.com

HISTORY

Received: 27 July 2022
Received in revised form: 21 Aug 2022
Accepted: 10 Nov 2022

KEYWORDS

Groundwater
Nigeria
Health
Rural
E. coli

ABSTRACT

Human health, which can be affected by access to safe drinking water, or lack of it, is an area of common interest to the sustainable development goals (SDG, 6 target 1) and One health Initiative. Hence, this study examined the disease risk associated with drinking water sources in some rural agrarian communities in Kwara State, North-central Nigeria. Water from commonly used drinking water sources in the selected communities were tested for physicochemical properties (pH, Turbidity and Total dissolved solids content), and bacteriological quality. The health risks of the water sources were assessed in terms of presence and count of *E. coli*. Groundwater sources (wells and boreholes) were the predominant sources of drinking water in the communities. Only three (motorized boreholes) among the twenty-five water sources examined were free of coliforms. *E. coli* was found in thirteen water sources (a pond and twelves wells); with *E. coli* counts ranging from 2- 15 cfu/mL. The study revealed the need for urgent interventions to ensure the communities have access to safe water. The rural communities still depend heavily on groundwater as sources of drinking water, most of where portend had high level of disease risk.

INTRODUCTION

Water is one of the important and indispensable commodities that support the existence of life on earth. The United Nations at its conference in 1977, unambiguously adopted that: "all peoples, whatever their stage of development and social and economic condition, have the right to have access to drinking water in quantities and of a quality equal to their basic needs." This is known as the human right to water (or water right) and entitles everyone to safe, sufficient, acceptable, physically accessible, and affordable water for personal and domestic uses [1]. Clean and safe water as a necessity for all living beings and an important natural resource for the sustainability of life and a healthy economy has been highlighted by Pahwaringira *et al*. [2] and Edokpayi *et al*. [3].

Whereas the issues of access to water as envisaged in the Millennium Development Goals appeared to have been achieved ahead of the target year, water quality was neglected. However, in the Sustainable development goals (SDGs) provision has been made for water quality in Target 6.1: "to by 2030, achieve universal and equitable access to safe and affordable drinking water for all [4]. This is a clear recognition that the quality of drinking water cannot be overlooked when assessing the role of water in public health. The quality of drinking water has always been a major public health concern, especially in developing countries where access to improved water supply and sanitation is very low [5].

Assessing the health risk of water supplies can provide scientific information for the management and protection of rural water sources [6]. Homaida and Goja [7] identified contamination of water bodies with feacal materials, industrial

https://doi.org/10.54987/jobimb.v10i2.750

sewage, domestic and agricultural wastes as one of the serious problems faced by the populace in developing countries. Pal *et al.* [8] reported that microbial contamination of groundwater can occur due to sewage outfalls, and agricultural runoff. Bacterial contamination of drinking water is a significant public health problem in rural areas of sub-Saharan Africa [9]. Obeta [10] reported an alarming state of safe drinking water deprivation among the residents of rural communities in Nigeria.

In setting health-based targets for microbial safety pathogens of feacal origin are the principal concerns because short-term peaks in pathogen population may increase disease risks considerably and can trigger outbreaks of waterborne disease; which is a major burden on human health: especially infants, young children, debilitated people, and the elderly [11]. WHO [12] defined safe drinking water as "water that does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages". WHO [11] suggested that improving access to safe water can be an effective part of poverty alleviation strategies; and identified access to safe drinking-water as an important health and development issue at national, regional and local levels.

Dinka [13] opined that more than 1 billion people did not have access to safe water. UN water [14] estimated that 2 billion people around the world lack safe drinking water. Hutton [15] and UN Water [16] highlighted the socioeconomic impact of access to safe drinking water. They indicated that investment in urban drinking water would give a $3 return for every $1 invested, and investment in rural basic drinking water would give a $7 return for every $1 invested. Bamigboye *et al*. [17] reckoned that because groundwater is the source of water to poor citizens in Nigeria; it is essential to ascertain its suitability as source of drinking water. Therefore, this study assessed drinking water in some rural agrarian communities in Kwara state, Northcentral Nigeria and determined the associated health risk associated with them using Colilert and Petrifilm test based defined chromogenic substrate.

MATERIALS AND METHODS

Study area and Water Sampling

The study involved ten (10) rural agrarian communities: Alenibare (8.4540°N, 4.5999°E), Bolohunduro (8.4489°N, 4.6286°E), Gbosun (8.1831°N, 4.6831°E), Igbonna (8.8831°N, 4.25°E), Ilota (8.4162°N, 4.7339°E), Kanmonu (8.1623°N, 4.6681°E), Kere-aje (8.435°N, 4.681°E), Ogbondoroko (8.3587°N, 4.5140°E), Reke-Oja (8.2613°N, 4.5418°E) and Temidire (8.4831°N, 4.3497°E) in Kwara State, North-central Nigeria. Each of the communities was visited to identify the sources of drinking water, which were assessed as recommended by WHO [18]. Water sample was collected from each water source into sterile 100ml Whirl pak as described by WHO [19] and Metcalf and Stordal [20]. Sampling was done between October 2021 and April 2022.

Assessment of Physicochemical and Bacteriological qualities of Water Samples

The pH, Turbidity, and Total dissolved solids content of the different water sources were determined using HACH 2000 meter. Bacteriological quality of each of the water sources was assessed based on presence and counts of *E. coli* and coliforms using 10ml Colilert presence/ Absence test and 1ml Petrifilm *E. coli*/ Coliform quantitative test [20]. The Chromogenic substrate contained 4-methy-umbel1fieryl-f-D-glucuronide (MUG) that is specific for β-glucuronidase in *E. coli,* and Ortho-nitro-phenol-beta D-Galactopyranoside (ONPG) utilized by coliforms. Water that gave negative ONPG test, negative MUG test and 0 *E. coli* in Petrifilm test is considered safe for drinking as it is. Water that gave positive ONPG test, but negative MUG test and 0 *E. coli* in Petrifilm test is considered to have moderate disease risk and may be consumed as it is. Water that gave a positive ONPG and MUG tests and 1- 10 *E. coli* in Petrifilm test is considered to have a high disease risk. Water that gave positive ONPG and MUG tests, and more than 10 *E. coli* in Petrifilm test is considered to have a very high disease risk [20, 21]

RESULTS

The most commonly used source of water used in the communities is the well (64%), others are boreholes (hand-pumped and motorized) and a pond in only one community (**Fig. 1**). Refuse dumps were observed within the catchment of two of the water sources. Animal dung was found within the catchment of one of the sources. Pools of stagnant water were observed within the catchment of ten of the water sources. Ten of the water sources had casing (borehole) or ring (well), however, only nine of them had covering. A drainage or septic tank was found within proximity of two of the water sources. The physical characteristics of the various water sources in the communities are shown on **Table 1**.

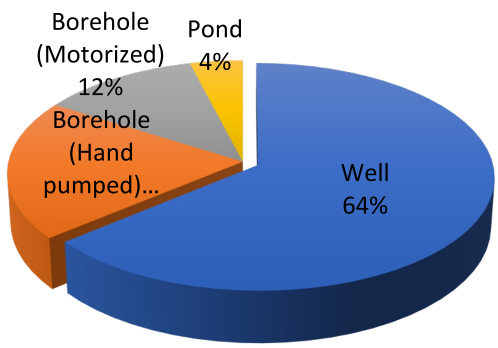


Fig. 1. Sources of water commonly used for drinking and other domestic purposes in the communities.

Table 1. Physical properties of various water sources in the communities.

SN	Location and Sources of Water	Refuse dump	Animal dung	Stagnant water	Casing	Covering	Proximity to drainage /septic tank
1.	Alenibare Hand pumped borehole	-	-	+	+	+	No
2.	Alenibare Well 1	-	-	+	-	-	No
3.	Alenibare Well 2	-	-	-	+	+	No
4.	Bolohunduro Hand pumped borehole	-	-	+	+	+	No
5.	Bolohunduro Well	-	-	+	-	-	No
6.	Gbosun Motorized BH	-	-	-	+	+	No
7.	Gbosun Well	-	-	-	+	+	No
8.	Ilota well 1	-	-	+	-	-	No
9.	Ilota well 2	-	-	+	-	-	No
10.	Ilota pond	-	+	-	-	-	No
11.	Igbonna garage hand pumped borehole	-	-	+	+	+	No
12.	Igbonna garage motorized borehole	-	-	-	+	+	No
13.	Kere-aje Well 1	+	-	-	-	-	Yes
14.	Kere-aje Well 2	-	-	+	-	-	No
15.	Kere-aje motorized borehole	-	-	-	+	+	No
16.	Kanmonu Hand pumped borehole	-	-	+	+	+	No
17.	Kanmonu Well	-	-	-	-	-	No
18.	Ogbondoroko Well 1	-	-	-	-	-	No
19.	Ogbondoroko Well 2	-	-	+	-	-	No
20.	Ogbondoroko Well 3	-	-	-	-	-	No
21.	Ogbondoroko Well 4	-	-	-	-	-	Yes
22.	Ogbondoroko Well 5	-	-	-	-	-	No
23.	Reke-Oja hand pumped borehole	-	-	-	+	-	No
24.	Temidire Well 1	+	-	-	-	-	No
25.	Temidire Well 2	-	-	-	-	-	No

The physicochemical properties of the various water sources in the communities are shown on Table 2. The pH of the water sources ranged between 5.9 and 7.1; water from the boreholes had pHs between 5.9 ± 0.10 and 7.1 ± 0.00, while water from the well had pHs between 6.0 + 0.10 and 7.1 ± 0.50, the pond water had pH of 6.1 ± 0.45. Turbidity ranged between 2.0 and 3.9 NTU, water from the boreholes had turbidity between 2.0 + 0.00 and 3.9 + 0.26, while water from the well had turbidity between 2.2 + 0.17 and 73.2 + 0.17, the pond water had turbidity of 2.7 + 0.20. Total dissolved solid content ranged between 51 and 81 mg/l. Water from the boreholes had total dissolved solids content between 51 + 0.16 and 67 + 0.00 mg/l, while in water from the wells, it ranged between 53 + 0.17 and 81 + 0.26 mg/l, the pond water had total dissolved solids content of 75 + 0.17mg/l.

The occurrence of coliforms and *E. coli* as well as *E. coli* counts of the various drinking water sources are shown on Table 3. Twenty-two of the water sources showed the presence of coliform (ONPG positive), the three water sources free of coliform (ONPG negative) were motorized boreholes. Thirteen of the water sources showed the presence of *E. coli* (MUG positive); these consist of twelve well and the pond, all the boreholes were free of *E. coli* (MUG negative). Population of E. coli in the water sources varied between 2 and 15 *E. coli*/ ml. The wells had count that ranged between 2 and 14 *E. coli*/ ml, the pond had the highest count (15 *E. coli*/ ml).

Table 2. Physicochemical properties of water sources in the communities.

SN	Location and Sources of Water	pH	Turbidity NTU	TDS mg/l
1.	Alenibare Hand pumped borehole	6.5 ± 0.10	2.2 ± 0.12	51 ± 0.16
2.	Alenibare Well 1	6.0 + 0.10	2.7 ± 0.22	55 ± 0.17
3.	Alenibare Well 2	6.1 + 0.20	2.5 ± 0.10	53 ± 0.17
4.	Bolohunduro Hand pumped borehole	6.0 + 0.10	3.0 ± 0.10	58 ± 0.00
5.	Bolohunduro Well	6.2 + 0.20	2.9 ± 0.17	63 ± 0.23
6.	Gbosun Motorized BH	6.9 + 0.20	2.0 ± 0.00	53 ± 0.00
7.	Gbosun Well	6.5 ± 0.50	3.1 ± 0.02	65 ± 0.17
8.	Ilota well 1	6.2 ± 0.20	2.8 ± 0.02	72 ± 0.10
9.	Ilota well 2	6.7 ± 0.40	2.4 ± 0.10	56 ± 0.26
10.	Ilota pond	6.1 ± 0.45	2.7 ± 0.20	75 ± 0.17
11.	Igbonna garage hand pumped borehole	7.1 ± 0.00	2.1 ± 0.17	52 ± 0.23
12.	Igbonna garage motorized borehole	6.9 ± 0.30	2.0 ± 0.26	59 ± 0.26
13.	Kere-aje Well 1	6.2 ± 0.40	3.2 ± 0.17	78 ± 0.00
14.	Kere-aje Well 2	6.5 ± 0.00	2.5 ± 0.10	81 ± 0.26
15.	Kere-aje motorized borehole	5.9 ± 0.10	3.9 ± 0.26	65 ± 0.44
16.	Kanmonu Hand pumped borehole	6.1 ± 0.32	2.1 ± 0.00	67 ± 0.00
17.	Kanmonu Well	6.0 ± 0.10	2.4 ± 0.10	69 ± 0.10
18.	Ogbondoroko Well 1	6.3 ± 0.30	2.6 ± 0.20	72 ± 0.26
19.	Ogbondoroko Well 2	6.1 ± 0.10	3.0 ± 0.26	75 ± 0.20
20.	Ogbondoroko Well 3	6.3 ± 0.00	2.4 ± 0.26	68 ± 0.17
21.	Ogbondoroko Well 4	6.6 ± 0.30	2.2 ± 0.17	71 ± 0.00
22.	Ogbondoroko Well 5	6.2 ± 0.36	2.7 ± 0.17	65 ± 0.20
23.	Reke-Oja hand pumped borehole	6.1 ± 0.10	2.3 ± 0.20	59 ± 0.10
24.	Temidire Well 1	7.1 ± 0.50	2.2 ± 0.26	58 ± 0.26
25.	Temidire Well 2	7.0 ± 0.20	2.3 ± 0.10	62 ± 0.00

Table 3. Presence and Populations of *E. coli* in Drinking water sources.

S/N	Location and Sources of Water	Colilert		E. coli count/ml
		ONPG	MUG	
1.	Alenibare Hand pumped borehole	+	-	0
2.	Alenibare Well 1	+	+	3
3.	Alenibare Well 2	+	-	0
4.	Bolohunduro Hand pumped borehole	+	-	0
5.	Bolohunduro Well	+	+	2
6.	Gbosun Motorized BH	-	-	0
7.	Gbosun Well	+	-	0
8.	Ilota well 1	+	+	6
9.	Ilota well 2	+	+	5
10.	Ilota pond	+	+	15
11.	Igbonna garage hand pumped borehole	+	-	0
12.	Igbonna garage motorized borehole	-	-	0
13.	Kere-aje Well 1	+	+	13
14.	Kere-aje Well 2	+	+	8
15.	Kere-aje motorized borehole	-	-	0
16.	Kanmonu Hand pumped borehole	+	-	0
17.	Kanmonu Well	+	-	0
18.	Ogbondoroko Well 1	+	+	6
19.	Ogbondoroko Well 2	+	-	0
20.	Ogbondoroko Well 3	+	+	5
21.	Ogbondoroko Well 4	+	+	8
22.	Ogbondoroko Well 5	+	+	3
23.	Reke-Oja hand pumped borehole	+	-	0
24.	Temidire Well 1	+	+	14
25.	Temidire Well 2	+	+	2

DISCUSSION

Findings from this study showed that residents of the communities depended on groundwater (wells and boreholes) as major source of water for drinking and other domestic purposes. This is a confirmation of the report of Akpoveta *et al.* [22] that borehole and well water served as major sources of drinking water in most of the town and villages in Nigeria, which they attributed to non-availability of municipal water supply. Preference for groundwater among majority of rural population is common in Countries across sub-saharan Africa, Obeta [10] attributed this to the consideration that groundwater is naturally protected from bacterial contamination and a reliable source during drought. Gwimbi *et al*. [9] similarly reported that ground water sources were the preferred source of water in rural villages of Mohale Basin, Lesotho. The absence of piped municipal supply in the communities appears to buttress the submission of Obeta [10] which highlighted poor piped water services provision and the poor state of water infrastructure in rural communities. He showed that most households (82.6%) lacked access to piped drinking water and depended on unprotected water sources.

The pH values (5.9 to 7.1) obtained were generally within the Nigerian national guideline for drinking water [23]. The value of pH obtained in this study are similar to those reported by Bamigboye *et al*. (17) for groundwater sources in Ogbomoso, Oyo state, and by Abegaz and Midekssa [5] for rural community drinking water source in Guto Gida district, Ethiopia. The pH values obtained give assurance that water from these sources can be effectively disinfected with chlorine. The efficacy of disinfection with chlorine is highly pH-dependent and becomes less effective when the pH exceeds 8.0 [19].

The turbidity (2.0 to 3.9 NTU) and total dissolved solids content (51 to 81 mg/l) of the various water sources were within the acceptable limit of 5 NTU and 500mg/L respectively [23]. Turbidity affects acceptability of water [19]; the low turbidity of water from these sources perhaps id the reason for the general acceptance of water from these sources in all the communities. It is common belief that water which is clean and clear is safe. Turbidity (particulate matters) can also influence the efficiency of disinfection with chlorine and can inhibit UV disinfection. High levels of turbidity can protect microorganisms from the effects of disinfection, stimulate the growth of bacteria and give rise to a significant chlorine demand [12].

The presence of coliform in majority (88%) of the water source is similar to the report of Abegaz and Midekssa [5], who reported total coliform in 90.6% of their water samples. The coliform group includes both faecal and environmental species; although they are not useful as an index of faecal pathogen, they can be used to assess the cleanliness and integrity of distribution systems and the potential presence of biofilms [11]. The presence of coliform in the water sources suggests contamination of the water sources. Contamination of ground water sources is an important environmental problem which is hardly recognized because it is not readily detected, and the pathways of contamination are not noticeable as those affecting surface water [24]. The contamination of the groundwater sources observed in this study may be due to the conditions of the water sources and human activities within catchment of the water sources (**Table 1**).

In particular the absence of casing/ring, the absence of well cover and lack of protection of the water sources from humans and animals can contribute to poor quality of water from the wells. The study carried out by Tamunobereton *et al.* [25] revealed that human activities could affect the quality of underground water.

The occurrence of *E. coli* in this study is similar to the result obtained by Bamigboye *et al.* (17) who reported *E. coli* in well and Boreholes in Ogbomoso. Similarly, Abegaz and Mideksa [5] reported faecal coliform in 87.5% of well water samples they examined. Gwimbi *et al.* [9] reported *E. coli* in water from all sources they examined including those classified as protected, however in this study *E. coli* was not detected in any of the boreholes (hand pumped and motorized). Global and National drinking water guidelines (11; 23) require that water for drinking should not contain *E. coli* (feacal coliform); which is taken as definitive evidence of feacal contamination and the potential presence of pathogen [11]. Hence, most water sources may be regarded as unsafe for drinking.

Among the twenty-five drinking water sources investigated, only the three motorized boreholes were found safe for consumption as they are. Ten of the water sources (five boreholes and five wells) had low risk, nine (wells) had high disease risk associated with them, and three other sources (the pond and two wells) had very high disease risk. The disease risks associated with the drinking water sources used in the communities is shown in **Fig. 2**. This corroborates the submission that millions of people still take water from unprotected wells and springs, lakes, ponds, rivers and streams [26]. Findings from this study corroborate the submission that access to water has increased but the quality of water has not received necessary attention; so, residents in most of the communities consume unsafe water.

Consumption of contaminated (unsafe) water is linked to transmission of diseases. Therefore, ameliorative intervention is required to ensure that safe water is made available to these communities to achieve the SDG 6. It has been highlighted that provision of microbially safe water should be the priority in improving community access to water [12]. The destruction of microbial pathogens is essential [19], simple interventions such as disinfection of the water using chlorine preparations, or boiling can improve the microbiological quality of the water.

Provision of, and sustaining access to safe drinking water would require a holistic water safety plan (WSP) that engages the community. Typically, WSPs are designed to minimize direct contamination in source waters, reduce or remove contamination by treatment, and prevent contamination during storage, distribution and handling [27]. Pal *et al.* [8] referred to WSP as the most effective means of consistently ensuring the safety of a drinking-water supply through the use of a comprehensive risk assessment and risk management approach that encompasses all steps in water supply from catchment to consumer. Community engagement is necessary because initially safe water can become contaminated during transit to home or during storage at home [11]. The chromogenic nature of Colilert and Petrifilm tests can be used to enlighten residents of the communities about safe handling and storage of drinking water especially at household-level.

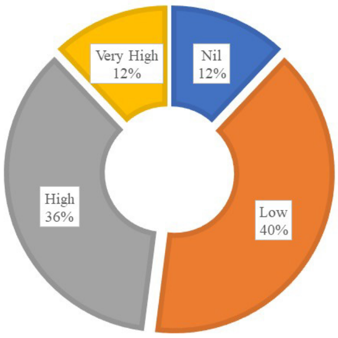


Fig. 2. Disease risk of sources of water commonly used for drinking and other domestic purposes in the communities.

CONCLUSION

Rural communities in developing Countries still largely depend on groundwater sources for their uses. Many of the ground water sources are potentially unsafe for consumption as they are contaminated with microorganisms of feacal origin. Addressing the target of SDG 6.1 would not only require improving access to safe water, but the water quality at source must also be improved which can be achieved by source protection. In addition, water collected should be treated at the household level and stored safely.

ACKNOWLEDGMENT

We appreciate Prof Robert Metcalf, President of International Water and Health Alliance for providing all the PML kits used for this study.

REFERENCES

1. UN Water Human rights to water and Sanitation. https://www.unwater.org/water-facts/human-rights/.(2022a); accessed on 22:02:2022
2. Pahwaringira L, Chaminuka L, Muranda-Kaseke K. The Impacts of Water Shortages on Women's Time-Space Activities in the High Density Suburb of Mabvuku in Harare. wH2O: J Gender Water. 2015; 4. 8
3. Edokpayi JN, Odiyo JO, Popoola EO and Msagati TAM. Evaluation of Microbiological and Physicochemical Parameters of Alternative Source of Drinking Water: A Case Study of Nzhelele River, South Africa. Open Microbiol J. 2018;12, 18-27
4. UNW-DPAC, UN-Water Decade Programme on Advocacy and Communication Water and Health Information brief.2018.
5. Abegaz MT and Mideksa MJ. Quality and Safety of RuralCommunityDrinking Water Sources in Guto Gida District, Oromia, Ethiopia. J Environ Pub Health. 2021; 1- 12, https://doi.org/10.1155/2021/5568375
6. Fuquan N, Guodong L, Huazhun R, Shangchuan Y and Xiuyuan L. Health Risk Assessment on Rural Drinking Water Safety, J Water Resour Pot. 2009; 2,128-135.
7. Homaid MA and Goja AM . Microbiological Quality Assessment of drinking water at Ed-Dueim Town, Sudan. New York Sci J. 2013; 6 (5):10-16.
8. Pal M, Ayele Y, Hadush A, Panigrahi S, and Jadhav VJ. Public Health Hazards Due to Unsafe Drinking Water. Air Water Borne Dis. 2018; 7: 1000138. doi:10.4172/2167-7719.1000138
9. Gwimbi P, George M. and Ramphalile M. Bacterial contamination of drinking water sources in rural villages of Mohale Basin, Lesotho: exposures through neighbourhood sanitation and hygiene practices Environ Health Prev Med. 2019; 24:33
10. Obeta MC. Rural water supply in Nigeria: policy gaps and future directions. Water Policy. 2018; 20 (2018) 597–616
11. WHO- World Health Organization. Guidelines for Drinking-Water Quality: Fourth Edition Incorporating the First Addendum. Geneva. 2017.
12. WHO- World Health Organization. Guidelines for drinking-water quality: incorporating first addendum. Vol. 1, Recommendations. – 3rd ed. WHO: Geneva, Switzerland.2006.
13. Dinka M. Safe Drinking Water: Concepts, Benefits, Principles and Standards. In: Glavan, M., Ed., Water Challenges of an Urbanizing World, IntechOpen, London,2018; 163-181. https://doi.org/10.5772/intechopen.71352
14. UN Water. Water and gender. https://www.unwater.org/water-facts/gender/ Accessed on 28:08:2021
15. Hutton G. Global costs and benefits of reaching universal coverage of sanitation and drinking-water supply. J Water Health 2013; 11(1) 1- 12
16. UN Water Water, Sanitation and Hygiene. https://www.unwater.org/water-facts/water-sanitation-and-hygiene/.2022b; accessed on 21/02/2022
17. Bamigboye CO, Amao JA, Ayodele TA, Adebayo AS, Ogunleke JD, Abass TB, Oyedare TA, Adetutu TJ, Adeeyo AO, Oyedemi AA. An appraisal of the drinking water quality of groundwater sources in Ogbomoso, Oyo state, Nigeria *Groundwater for Sustainable Development* .2020;11 100453
18. WHO- World Health Organization. Revision on drinking water quality guidelines www.who.int/water_Sanitationhealth/dwq/gdwq3/en/print.html. 2004; accessed 10-01-2019
19. WHO- World Health Organization. Guidelines for drinking-water quality 2nd ed. Volume 3 Surveillance and control of community supplies. WHO: Geneva, Switzerland.1997.
20. Metcalf R H and Stordal LO. A Practical Method for Rapid Assessment of the Bacterial Quality of Water. A field-based guide. United Nations Human Settlements Programme (UN-HABITAT) Nairobi, Kenya. 2010.
21. Edberg SC, Rice EW, Karlin RJ, and Allen MJ. *Escherichia coli*: the best biological drinking water indicator for public health protection. J Appl Microbiol. 2000; 88, 1068-1168
22. Akpoveta OV, Okoh BE, and Osakw SA. Quality Assessment of Borehole Water used in the Vicinities of Benin, Edo State and Agbor, Delta State of Nigeria. Curr Res Chem. 2011; 3 (1): 62-67.
23. SON- Standards Organisation of Nigeria Nigerian Industrial Standard NIS 554: *Nigerian Standard for Drinking Water Quality*. Standards Organisation of Nigeria Lagos, Nigeria. 2007.
24. Adeyemi O, Oloyede OB and Oladiji AT. Physicochemical and Microbial Characteristics of Leachate Contaminated ground water. Asian Journal of Biochemistry.2007;2 (5): 343-348.
25. Tamunobereton AI, Uko ED and Omubo VB. Anthropogenic activities implications for ground Water Resource In Okirika, River State. J. Applied Sciences. 2010; 5(3): 204-211.
26. WHO- World Health Organization. Household water treatment and safe storage: Water Sanitation and Health. https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/water-safety-and-quality/household-water-treatment-and-safe-storage.2021.
27. WHO- World Health Organization. Water Safety Plans: Managing drinking-water quality from catchment to consumer. WHO: Geneva, Switzerland.2005.