International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 5 May 2021, pp: 1075-1081 www.ijaem.net ISSN: 2395-5252

Bacteriological Assessment of Borehole Water in Mai Idris Alooma Polytechnic and Its Environs

Ayuba Dimza
(B.Sc. Microbiology, HND Biology/Microbiology) Department of Science Laboratory Technology Mai Idris Alooma Polytechnic Geidam, Yobe State, Nigeria

Submitted: 05-05-2021 Revised: 18-05-2021 Accepted: 22-05-2021

ABSTRACT: The increase in water – borne diseases in Yobe State has necessitated the need to ascertain the safety of the potable water used in the state. Therefore, this study was aimed at assessing the microbiological quality of the borehole water from various sources within and outside Mai Idris Alooma Polytechnic, Geidam, Yobe State, Nigeria.Water samples were collected from 8 boreholes within and around Mai Idris Alooma Polytechnic, Geidam, including Girls Hostel Borehole (WMP1), School of Environmental Borehole (WMP2), Boys Hostel Borehole (WMP3) and Polytechnic Main Bore hole (WMP4), all within Mai Idris Alooma Polytechnic, Geidam. Others were from Rest-house Estate Borehole (OMP1), Low-cost Housing Borehole (OMP2), Post Office Borehole (OMP3) and Gedu Area Borehole (OMP4), all outside Mai Idris Alooma Polytechnic, Geidam. Standard microbiological analysis was carried out for the detection and enumeration of total aerobic mesophilic bacterial counts and coliform counts. Both macroscopic examination for physical morphology and microscopic examination through Gram staining were carried out. Biochemical examinations such as indole test, methyl red test, voges – proskauer test, citrate utilization test, coagulase and catalase tests were carried out for the characterization of the isolates and the results were subsequently matched with the Bergy's manual of determinative bacteriology for confirmation. The results of the total aerobic mesophilic, coliform and faecal counts of borehole water within Mai Idris Alooma Polytechnic, Geidam shows that Polytechnic main borehole water had higher aerobic bacterial counts (0.85 x 10^2cfu/ml) and total coliform counts (7MPN/100ml), while boreholes water outside Mai Idris Alooma Polytechnic shows that, Low-cost Housing Borehole water had higher aerobic bacterial counts (1.33 x 10^2cfu/ml) and total coliform counts (11MPN/100ml) when compared to other sampling points. Results of the biochemical tests of borehole water sampled both within and around Mai Idris Alooma Polytechnic revealed the presence of gram negative bacteria including Escherichia coli, Salmonella Spp. and Klebsiella pneumonia, where E. coliwas the most occurring bacteria (39.4%) followed by K. pneumonia (30.30%)and Salmonella Spp. (30.30%). These findings portend danger to public health, because the isolated organisms could be pathogenic. Therefore, public enlightenment on the need to ensure standards of health and safety measures during borehole construction, periodic maintenance, keeping of dumpsites, pit latrines, suck – away and drainages away from the boreholes, along line strict observance of personal and environmental hygiene are recommended.

Key words: Bacteria, Boreholes water, Coliform, Mai Idris Alooma

I. INTRODUCTION

Water is an essential requirement in the maintenance of metabolic functions and homeostasis in living cells (Ajobiewe et al., 2019). About 60% of the weight of human body is composed of water in adult males, 50% in females and 70% in new born infants (Svagzdiene et al., 2010). In another study, the percentage of water observed in different body parts revealed that muscular tissues had 75% of water; brain contains 90% water, bones 22% water, and blood 83% (Joshi and Katyar et al., 2013). Similarly, according to the reports of European Food Safety Authority, EFSA (2010) on the dietary reference values for water, the approximate human dietary requirements of water is estimated to be 2 liters per day for an average adult. That may be the reason why, regular intake of adequate amount of water is essential in the maintenance of good health and well – being (Ajobiewe et al., 2019). In Nigeria, 48% of Nigerians depend on surface water for domestic uses, 57% utilized hand dug wells, 20% harvest rains, 14% pipe borne municipal water, while 14% relied on borehole water sources (Federal Government of Nigeria Official Gazette, 2007).

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 5 May 2021, pp: 1075-1081 www.ijaem.net ISSN: 2395-5252

Increase in human population has exerted an enormous pressure on the provision of safe water for drinking (Umeh et al., 2005). Moreover, it is an indisputable fact that drinking water must be free of harmful contaminants, such as pathogenic microorganisms, toxic substances, physical and chemical residues, undesirable odor, color and taste (Ajobiewe et al., 2019; Codex, 2009). Similarly, the widespread reports of pollutants in groundwater have increased public health concern about the safety of groundwater (Onwughara et al., 2013). Children are generally more vulnerable to intestinal pathogens and it has been reported that about 1.1 million children under the age of 5 die every year due to diarrheal diseases (Steiner et al., 2006). Ground water contamination via Leachate can transmit pathogenic microorganisms, because many of those plowing the boreholes cannot afford to dig wells deep enough to reach clean aquifers (Onwughara et al., 2010). Ground water contamination is one of the leading worldwide causes of deaths and diseases which accounts for the deaths of more than 14,000 people daily (Larry, 2006; Steiner et al., 2006).

Potable water is an essential ingredient for good health and the socio-economic development of man (Onwughara et al., 2013). In developing countries, the quality and quantity of pipe borne water for consumption is worsening due to inadequacy of water treatment plants, direct discharge of untreated sewage into water bodies and inefficient management of piped water distribution system (Ajobiewe et al., 2019; Aderibigbe et al., 2009). Many diseases are perpetuated via the faecal – oral route of transmission in which the pathogens are shed only in human faeces (Adetunde and Glover, 2010). Some of the microorganisms that are concerned with water borne diseases include Escherichia coli, Salmonella sp., Shigella sp., Vibrio cholerae, Entamoeba histolytica, Giardia lamblia and Balantidium coli (Ajobiewe et al., 2019; Adetunde and Glover, 2010). For instance, presence of E. coli is usually used as an indicator for the contamination of water, food, etc. (Maigari, 2006).

Microbiological quality assessment of water is of great concern because water – related diseases continue to be of major health challenges globally. Similarly, the fact that contamination of groundwater is not easily perceived and noticeable as those of the surface water, contamination of groundwater is least recognized as environmental problems (Adeyemi et al., 2007). Therefore, assessment of drinking water is paramount as it emphasizes the protection of public health. Hence, the present study was aimed at analyzing the microbiological quality of the borehole water from various sources within and outside Mai Idris Alooma Polytechnic, Geidam, Yobe State, Nigeria.

II. MATERIAL AND METHODS

Collection of Water Samples

Water samples were collected from eight (8) boreholes within and around Mai Idris Alooma Polytechnic, Geidam. The samples collected were from Girls Hostel Borehole (WMP1), School of Environmental Borehole (WMP2), Boys Hostel Borehole (WMP3) and Polytechnic Main Bore hole (WMP4), all within Mai Idris Alooma Polytechnic, Geidam. Others were from Rest-house Estate Borehole (OMP1), Low-cost Housing Borehole (OMP2), Post Office Borehole (OMP3) and Gedu Area Borehole (OMP4), all outside Mai Idris Alooma Polytechnic, Geidam. Samples were aseptically collected with the use of sterile sample bottles in which the sampling procedure involves the use of cotton wool soaked in 70% (v/v) ethanol to sterilize the plunger of the tap where the water is running. The tap was then allowed to gently run for two minutes and flow into sterile plastic bottles (Cheesbrough, 2006). The samples were covered immediately and then transported to laboratory with ice packs to avoid denaturation and unwarranted proliferation of bacteria.

Bacteriological Quality Determination: Enumeration of Total Mesophilic Bacterial Counts

The total aerobic mesophilic bacterial counts was determined by pour plate technique using standard methods as described by the American Public Health Association, APHA (2005). The samples were transferred into duplicate Petri dishes and labeled accordingly, followed by pouring about 15ml of molten nutrient agar, homogenized by gentle spinning of the plates, solidified, incubated at 37^{o}C for 24 hours and the plates containing 30 – 300 colonies were counted. The number of colony forming units per ml of a sample (cfu/ml) was determined.

Enumeration of Total Coliform Counts

Detection and enumeration of coliform was carried out according to the method described by American Public Health Association, APHA (2005). Coliform count was determined using the three tube assay of the Most Probable Number (MPN) technique. Presumptive coliform test was carried out using MacConkey broth. A set of 9 test tubes each containing 9ml of lactose broth and an inverted Durham tubes were autoclaved to expel air and to sterilize. One (1ml) from the diluents 10^{1}

was transferred to the first 3 test tubes representing double strength broth lactose broth (DSLB), then 1ml from the diluents 10^2 to the second set of test tubes and then 10^3 to the third set of test tubes as third diluents, both representing single strength broth lactose broth (SSLB). These 9 test tubes were incubated at 37°C for 24 hours in which tubes that showed gas and acid production after 24 hours were recorded as coliform positives. Estimate of most probable number of coliform per 100 ml of sample (MPN/100ml) was determined by comparing the number of gas positive tubes with the Most Probable Number (MPN) Table.

Enumeration of Total Faecal Coliform Counts

A loop full from gas positive tubes was streaked on to Eosine methylene blue (EMB) agar plate and incubated at 37ºC for 24 hours after which colonies which formed bluish black color with green metallic sheen, and reddish colonies were isolated on an agar slant, sub-cultured into tube of lactose broth, incubated at 45ºC and then the tubes were observed after 24 hours for gas production.

Identification and Confirmation of Isolates

Both macroscopic examination for physical morphology and microscopic examination through Gram staining were carried out. Biochemical examinations such as Indole test, Methyl red test, Voges – Proskauer test and Citrate Utilization test, Coagulase and Catalase tests were carried out for the characterization of the isolates and the results were subsequently matched with the Bergy's manual of determinative bacteriology for confirmation (Buchanan and Gibbons, 1974).

Indole Test

Indole test was conducted by preparing a Tryptone broth drawn in to test tubes, sterilized by autoclaving, inoculated with loopful of suspension and incubated at 37° C for 24 hours. Three drops of xylene was added in tubes, shaken vigorously and kept for the separation of two layers. One millilitre of Kovac's reagent was added where the formation of pink colour ring shows positive Indole test.

Methyl Red Test

Methyl red test was conducted by preparing Glucose phosphate broth, dispensed in test tubes, sterilized, inoculated with test culture, incubated at 37°C for 24 hours and 5 drops of methyl red indicator was added to the medium for the formation of red color.

Voges-Proskauer Test

Voges-Proskauer test was conducted by inoculating tubes with the bacterial culture followed by incubation for 48 hours at 37°C. One (1 ml) from each culture tube was pipette into clean separate tubes. Drops of Barrit's solution A was added to each tube containing glucose phosphate broth followed by the addition of an equal amount of solution B into the same tube. The tubes were shaken at 30 seconds interval where development of a pink color, which turns red in 1–2 hours, after vigorous shaking was indicative of positive results.

Citrate Utilization Test

Citrate Utilization Test was conducted by distributing Simmon Citrate Agar into test tubes, sterilized at 121.5°C for 15 minutes, held in slanted position, inoculated with the given bacterial culture and incubated at 37°C for 24 hrs. Color changes of the media from green to blue shows positive result.

III. RESULTS AND DISCUSSION

The results of the total aerobic mesophilic, coliform and faecal counts of borehole water within and around Mai Idris Alooma Polytechnic, Geidam is as presented in Table 1. Within Mai Idris Alooma, WMP4 had higher aerobic bacterial counts (0.85 x 10^2cfu/ml) and total coliform counts (7MPN/100ml). Boreholes water outside Mai Idris Alooma Polytechnic shows that, water sampled from OMP2 had higher aerobic bacterial counts (1.33 x 10^2cfu/ml) total coliform counts (11MPN/100ml) when compared to other sampling points. However, the distributions of total coliform counts was found to be higher in sampling points WMP1, WMP2, WMP4, OMP2, OMP3 and OMP4, all of which are having 2 cfu/ml. These agrees with the findings of Sunday and Oyinade (2020), Rohmah et al. (2018), Arwenyo et al. (2017) who also reported similar values of total coliforms in different groundwater samples in their studies.

It can be seen that, the total aerobic bacterial counts of the borehole water samples ranged from 0.60 to 1.33×10^2 cfu/ml. This was found to be lower than the report of Eniola et al. (2007) for stored borehole water samples in a similar work in Nigeria, who obtained a range of 5.0×10^2 to 7.0×10^2 cfu/ml. Erah et al. (2002) in a study conducted on the quality of ground water in Benin City, found unacceptable levels of aerobic bacteria and fungi present in borehole water of Teboga District of Benin City, Edo State, Nigeria. From the finding of this study it can be seen that, all of the samples in the present study were having count within the limit of 100 cfu/ml allowed for potable water by the Nigerian Standard for Drinking Water Quality, NSDWQ (2007). However, the finding from this study also shows that all the borehole water samples had faecal coliform, and according to the NSDWQ (2007), an ideal drinking water should not contain a single faecal coliform. Similarly, the range of total coliform counts (<3 MPN/100ml – 11 MPN/100ml) exceeds the recommended values by World Health Organization (WHO) where a ranged of <10CFU/100ml is recommended. The occurrence of these bacteria may be attributed to the environmental sources, because anthropogenic activities around the boreholes, suggests that the environments surrounding them may be contaminated and littered with various forms of refuse. Similarly, most of the boreholes studied are very close to sanitary pipelines, which may transverse the septic tank absorption fields. Sunday and Oyinade (2020) noted that, the sewer and the cast pipes for the transportation of water are usually subjected to leakages, and sometimes experience accidental backflow or back seepage of polluted water. This may occur from toilets and wash bowls, resulting in the contamination of water supply pipes through leakages (Sunday and Oyinade, 2020). Hence, fecal coliform bacteria might be introduced into the boreholes. Although the depth of the boreholes studied are unknown, shallow depth of less than 40 m could also be the reason why these boreholes may be contaminated, because it contradicts the 40 m minimum depth recommendation for reaching clean aquifers (Obioma et al., 2020). Thus, the depth of borehole may be an important factor for determining bacterial contaminants in borehole water.

Results of the biochemical tests of borehole water sampled both within and around Mai Idris Alooma Polytechnic revealed the presence of gram negative bacteria including Escherichia coli, Salmonella Spp. and Klebsiella pneumonia (Table 2). The presence of pathogenic microorganisms in borehole water can be attributed to poor hygiene and sanitary practices around these sources of water. All the isolated bacteria belongs to members of Enterobacteriaceae that are commonly present as pathogens which form part of the normal flora of the skin, upper respiratory tract and intestinal tract (Maigari, 2006). For instance, the presence of Escherichia coli in water suggests presence of enteric fecal contamination (Maigari, 2006). This organism is the major causative agent of diarrhoea, urinary tract infection, hemorrhagic colitis and haemolyticuraemia syndrome (Ivey et al., 2006). On the other hand, Salmonella species are associated with typhoid fever while Klebsiella pneumoniae is the causative agent of chest infection and occasionally, severe broncho Pneumonia with lung abscesses (Sunday and Oyinade, 2020).

The frequency of occurrence of the isolated bacteria species from borehole water sampled both within and around Mai Idris Alooma Polytechnic is as presented in Table 3. The result of WMP1 within Mai Idris Alooma Polytechnic, Geidam, shows that, the frequency of occurrence of E. coli and Salmonella Spp. was even (4.55%, each) and higher than the frequency of occurrence of K. pneumonia (1.52%). For borehole water examined from WMP2, the occurrences of E. coli and K. pneumonia was even (3.03%, each) but lower than the occurrence of Salmonella Spp. (6.06%). For borehole water sampled from WMP3 the frequency of occurrence of E. coli was higher (4.55%) was higher than the frequency of occurrence of Salmonella spp. (3.03%) and K. pneumonia (3.03%). However, the frequency of occurrence of borehole water sampled from WMP4 was even for E. coli, K.pneumonia and Salmonella spp. where each had 3.03% frequency of occurrence. For borehole water sampled from OMP1, E. coli had higher frequency (6.06%) when compared to K. pneumonia (4.55%) and Salmonella spp. (4.55%). For borehole water sampled from OMP2 E. coli had higher frequency (7.58%) when compared to K. pneumonia (3.03%) and Salmonella spp. (1.52%). For borehole water sampled from OMP3, E. coli (6.06%) and K. pneumonia (6.06%) had higher frequency when compared to Salmonella spp. (3.03%). For borehole water sampled from OMP4, E. coli (4.55%) and K. pneumonia (4.55%) had lower frequency when compared to Salmonella spp. (6.06%). Overall, the most occurring bacteria was found to be E. coli (39.4%) followed by K. pneumonia (30.30%)and Salmonella Spp. (30.30%).

These findings corroborates with previous reports such as those of Sunday and Oyinade (2020), Okorafor et al. (2012) as well as Agbabiaka and Sule, (2010), in their studies on bacteriological characteristics of selected streams and boreholes in Malete of Kwara State, Calabar of Cross Rivers State and Ilorin of Kwara State, respectively; where they reported high occurrence of coliform contamination in all the water analyzed. The finding is also in agreement with the studies of Joshi and Katyar (2013) as well as Sohani et al (2012), all in India, who carried out the microbiological analysis of surface water by using samples from variable sources of different regions, wherein they observed a high prevalence of coliform group of bacteria namely E. coli, Enterobacter, Klebsiella, Salmonella and Shigella. These occurrences of coliform in borehole water could probably be associated to the pipes used for water distribution which may be corrosive or damaged thus, allowing seepage of microbial contaminants into the boreholes. This was more vividly agreed by Obioma et al. (2020) who maintains that damaged pipes allow leakage causing contamination of microbial pathogens into the body of aquifers. Hence, a major factor to be considered when planning for the safety of borehole water. Moreover, observation from this study supports the fact that high mesophilic bacterial counts in water may reflects high coliform counts, as evinced in the present study in all the borehole waters examined.

Table 1: Bacteriological Counts of Borehole Water within and around Mai Idris Alooma Polytechnic, Geidam

Sampling Points	Total Viable Bacterial Counts (cfu/ml)	Total Coliform Counts (MPN/100ml)	Total Faecal Coliform Counts (cfu/ml)
WMP1	0.73	<3	2
WMP2	0.61	<3	2
WMP3	0.60	<3	1
WMP4	0.85	7	2
OMP1	0.74	7	1
OMP2	1.33	11	2
OMP3	1.21	7	2
OMP4	1.24	10	2

Table 2: Results of the Biochemical Tests of Borehole Water Sampled within and outside Mai Idris Alooma Polytechnic, Geidam

Catalase	Coagulase	Citrate	Indole	Gas	Motility	Gram	Cocci /rod	Colony	Presumed Organism
+	-	-	+	+	+	-	Rod	Pink	Escherichia coli
+	-	+	-	+	-	-	Rod	Colourless	Salmonella Spp.
+	-	+	-	+	-	-	Rod	Pink and Mucoid	Klebsiella pneumonia

Key:
+ means positive
-- means negative

Table 3: Frequency of Occurrence of Bacteria Isolated from Borehole Water within and around Mai Idris Alooma Polytechnic, Geidam

Sampling Points	Occurrence (%) E. coli	Salmonella Spp.	K. pneumonia	Total(%)
WMP1	3(4.55)	3(4.55)	1(1.52)	7(10.61)
WMP2	2(3.03)	4(6.06)	2(3.03)	8(12.12)
WMP3	3(4.55)	2(3.03)	2(3.03)	7(10.61)
WMP4	2(3.03)	2(3.03)	2(3.03)	6(9.09)
OMP1	4(6.06)	3(4.55)	3(4.55)	10(15.15)
OMP2	5(7.58)	1(1.52)	2(3.03)	8(12.12)
OMP3	4(6.06)	2(3.03)	4(6.06)	10(15.15)
OMP4	3(4.55)	3(4.55)	4(6.06)	10(15.15)
Overall	26(39.40)	20(30.30)	20(30.30)	66(100.00)

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 5 May 2021, pp: 1075-1081 www.ijaem.net ISSN: 2395-5252

IV. CONCLUSION AND RECOMMENDATIONS

The bacteriological analysis of the boreholes water within and around Mai Idris Alooma Polytechnic, Geidam, Yobe State revealed the presence of bacteria including Escherichia coli, Salmonella Spp. and Klebsiella pneumonia. These findings portend danger to public health, because the isolated organisms could be pathogenic Therefore, public enlightenment on the need to ensure standards of health and safety measures during borehole construction, periodic maintenance, keeping of dumpsites, pit latrines, suck – away and drainages away from the boreholes along line strict observance of personal and environmental hygiene are recommended.

REFERENCES

[1]. Aderibigbe, S.A., Awoyemi, A.O. and Osagbemi, G.K. (2009). Availability, Adequacy and Quality of Water Supply in Ilorin Metropolis, Nigeria. European Journal of Scientific Research, 23: 528-536.

[2]. Adetunde, L. A. and Glover, R. L. K. (2010): Bacteriological Quality of Borehole Water Used by Students' of University for Development Studies, Navrongo Campus in Upper-East Region of Ghana. Current Research Journal of Biological Sciences, **2**(6):361-364.

[3]. Adeyemi, O., Oloyede, O. B. and Oladiji, A. T. (2007). Physicochemical and Microbial characteristics of Leachate contaminated ground water. Asian Journal Biochemistry, **2** (5), 343-348.

[4]. Agbabiaka, T. O. and Sule, I. O. (2011): Bacteriological Assessment of Selected Borehole Water Samples in Ilorin Metropolis. International Journal of Applied Biological Research,**2**(2):31-37.

[5]. Ajobiewe, H. F., Ajobiewe, J. O., Mbagwu, T. T., Ale, T. and Taimako, G. A. (2019). Assessment of Bacteriological Quality of Borehole Water, Sachet Water and Well Water in Bingham University Community. American Journal of Medicine and Medical Sciences, **9**(3): 96 – 103.

[6]. American Public Health Association (APHA) (2005): Standard Methods for the Examination of Water and Wastewater, 21st Edn., APHA, Washington D C

[7]. Arwenyo, B., Wasswa, J., Nyeko, M., Kasozi, G. N. (2017). The impact of septic systems density and nearness to spring water points, on water quality. African Journal of Environmental Sciences and Technology, **11** (1), 11-18.

[8]. Buchanan, R. E. and Gibbons, N. E. (1974): Bergey's Manual of Determinative Bacteriology. 8th Edition, The Williams and Wilkins Co., Baltimore, p.124.

[9]. Codex., R. (2009). Hazard Analysis and Critical Control Point (HACCP), System and Guidelines for Its Application, 4th Ed., Rome: Codex Alimentarius Commission.

[10]. Cheesbrough, M., (2006). "District laboratory Practice in Tropical Countries." Part 2. Cambridge University Press. 143 – 157.

[11]. Eniola, K. I. T., Obafemi, D. Y., Awe, S. F., Yusuf, I. I. and Falaiye, O. A. (2007). Effects of Containers and Storage conditions on Bacteriological Quality of Borehole Water. Nigerian Journal of Microbiology, 21: 1578 – 1585.

[12]. Erah, P. O., Akujieze, C. N. and Oteze, G. E. (2002). The Quality of Groundwater in Benin City: A baseline study on inorganic chemicals and microbial contaminants of health importance in boreholes and open wells. Tropical Journal of Pharmaceutical Research, 1(2): 75-82.

[13]. European Food Safety Authority, EFSA (2010). Scientific Opinion on Dietary Reference Values for Water, European Food Safety Authority Journal, 8(3): 1459 – 1467.

[14]. Federal Government of Nigeria, FGN. (2007). Legal Notice on Publications of the 2006 Census Report, Federal Government of Nigeria Official Gazette, **4**(94): 1-8.

[15]. Ivey, J.L., De Loe, R., Kreutzwiser, R., Ferreyra. C. (2006). An Institutional Perspective on Local Capacity for Source Water Protection, Geoforum, 37, 944–957.

[16]. Joshi, A. and Kathyar, W. (2013). Bacteriological Analysios of Drinking Water. A Conference Paper Accessed from https://www.researchgate.net/publication/236216827 on 11th November, 2020.

[17]. Larry, W. (2006): World Water Day: A Billion people Worldwide Lack Safe Drinking http://environment.about.com/od/environmentalevents/ a/waterdayqa.htm.

[18]. Maigari, A. K. (2006). An Exclusive Interview with Escherichia coli: The Microbiologist, a Publication of Nigerian Association of Microbiology Students, Pp. 13.

[19]. Nigeria Standard for Drinking Water Quality, NSDWQ (2007). Nigeria Standard

for Drinking Water Quality, Nigeria Industrial Standard, Approve by Standard Organization of Nigeria Governing Council. ICS 13. 060. 20, 15-19.

[20]. Obioma, A., Nnenna, T. and Golden, O. (2020). Bacteriological Risk Assessment of Borehole Sources of Drinking Water in Some Part of Port Harcourt Metropolis of Niger Delta, Nigeria. Biomedical Journal of Scientific and Technical Research, **24**(4): 18477 – 18487.

[21]. Okorafor, K.A., Agbo, B.E., Johnson, A. M. and Chiorlu. M. (2012). Physicochemical and Bacteriological Characteristics of Selected Streams and Boreholes in Akamkpa and Calabar municipality, Nigeria. Arch. Appl. Sci. Res., **4**(5), 2115-2121.

[22]. Onwughara, N. I., Ajiwe, V. E., Nnabuenyi, H. O. and Chima, C. H. (2013). Bacteriological Assessment of Selected Borehole Water Samples in Umuahia North Local Government Area, Abia State, Nigeria. Journal of Environmental Treatment Techniques, 1 (2): 117 – 121.

[23]. Rohmah, Y., Rinanti, A. and Hendrawan, D. I. (2018). The determination of groundwater quality based on the presence of Escherichiacoli on populated area (a case study: Pasar Minggu, South Jakarta). Earth and Environmental Sciences 106. The 4th International Seminar on Sustainable Urban Development IOP Publishing IOP Conf. Series

[24]. Sohani, S. and Iqbal, S. (2012). Microbiological analysis of surface water in Indore, India. Res. J. of Recent Sci. 1: 323-325.

[25]. Steiner, T. S., Samie, A. and Guerrant, R. L. (2006): Infectious Diarrhea: New Pathogens and new Challenges in Developed and Developing areas. Clin. Infect. Dis., 43:408–410

[26]. Svagzdiene, R., Lau, R. and Page, R.A. (2010). Microbiological Quality of Bottled Water Brands Sold in Retail Outlet in New Zealan. Water Science and Technology: Water Supply, 10(5): 689-699.

[27]. Sunday, A. and Oyinade, F. (2020). Bacteriological Assessment of Selected Hand-Pumped Boreholes Water Sources in Malete Environs, Kwara State Nigeria. Natural and Applied Sciences Journal, **3**(1): 47 – 58.

[28]. Umeh, C. N., Okorie, O. I. and Emesiani, G. A. (2005). Towards the provision of safe drinking water: The bacteriological quality and safety of sachet water in Awka, Anambra State. In: the Book of Abstract of the 29th Annual Conference & General Meeting on Microbes As Agents of Sustainable Development, organized by Nigerian Society for Microbiology (NSM), University of Agriculture, Abeokuta, pp. 22.

[29]. World Health Orrganization, WHO (2016). Health through safe drinking water and basic sanitation http://www.who.int/water_sanitation_health/mdg1/ en/Accessed 15/01/2019.