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Abstract

The physico-chemical properties, microbiological quality and protective structures of deep-well water sources in selected urban barangays of Calbayog City, Samar, Philippines were evaluated. Results revealed that physico-chemical characteristics of deep well water sources in barangays Aguit-itan, West Awang, Central and East Awang in terms of pH, temperature and total dissolved solid passed the permissible limits of the Philippine National Standards for Drinking Water (PNSDW). However, turbidity, salinity, dissolved oxygen, biochemical oxygen demand and total suspended solids exceeded the PNSDW. For Microbiological analysis (*MPN/100 mL*) such as total coliform, *E.coli* and fecal coliforms, results were beyond the PNSDW. Water samples were contaminated with different microbial contaminants and not acceptable for drinking and cooking purposes. Deep-well water sources of the four selected urban barangays are not suitable for drinking if untreated but can be used for bathing and washing clothes. Protective structures help minimized adulterations but with the presence of houses nearby the deep-wells and the establishment of septic tanks in near houses may leak and contaminate the deep-well water source and could result to presence of fecal coliforms.

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Introduction

Water is the major constituent of all living things and basically needed for various purposes. However, water also houses the largest number of living organisms when compared with other habitats and ecosystems (Sunday, Spencer, Kingsley, Edet & Amaka, 2014). The demand for quality drinking water had changed considerably with the development in olden days. The only requirement of drinking water was that it should be free flowing and non-turbid. The need for better environment and health cannot be over emphasized with increasing

industrialization, urbanization, and growth of population. Urbanization has direct impact on water bodies as the settlement takes place around the vicinity of water bodies and due to lack of space people have tendency to encroach upon the lake (Pavendan et al. 2011). Potable water is defined as water that is free from diseases producing microorganisms and chemical substances deleterious to health (Sunday et al. 2014) and that potable water is suitable (from both health and aesthetic considerations) for drinking and cooking purposes (DENR, 1994). The Philippines reported that generally, the quality of ground water and marine coastal waters is good but surface water quality deterioration in the urban areas need to be addressed, although there are signs of improvement in some waters based on monitoring results conducted by the Sagip ilog Program. As a whole, partner countries in the region are making the protection of drinking water sources to be of top priority policy area (Leopoldo et al. 2017). The lack of safe drinking water and adequate sanitation measures lead to a number of diseases such as cholera, dysentery, salmonellosis and typhoid, and every year millions of lives are claimed in developing countries. The evaluation of potable water supplies for coliform bacteria is important in determining the sanitary quality of drinking water. Presence of high levels of coliform counts indicates a contaminated source, inadequate treatment or post-treatment deficiencies. Due to inability of governments to meet the ever-increasing water demand, most people in rural areas resort to ground water sources such as boreholes as an alternative water resource. Ground water resources are commonly vulnerable to pollution, which may degrade their quality (Palamuleni & Akoth 2015). However, ground water represents an important source of drinking water and its quality is currently threatened by a combination of over-abstraction and microbiological and chemical contamination (Aydin 2007). In the Philippines, people living in the rural and urban areas are dependent on ground water as their source of water. The water is widely utilized for various rural and urban domestic purposes such as drinking, cooking, washing, bathing, and in agriculture and industry. Access to safe drinking water is not only essential for the promotion and protection of public health but is a basic human right. Provision of safe water supply prevents the transmission of waterborne pathogens and reduces the exposure of individuals to chemical and physical hazards that could be ingested through contaminated drinking water (De Vera 2015). The provision of potable water to the rural and urban population is necessary to prevent health hazards. Before water can be described as potable, it has to comply with certain physical, chemical and microbiological standards, which are designed to ensure that the water is palatable and safe for drinking (Sunday et al. 2014). Hence, the study was conducted to determine the potability of deep-well water sources through determination of the physico-chemical characteristics, microbiological quality and evaluation of protective structures on deep-well water sources of the four (4) selected urban barangays of Calbayog City, Samar, Philippines.

Materials and Methods

Sample collection

Twelve water samples were collected from different locations. Out of which, the four samples were selected from urban barangays in Calbayog City, Samar, Philippines. Three location sites with deep-well water source were identified in each barangay and labelled site 1 to 12 covering all the four selected urban barangays of Calbayog. The samples were collected in sterile mineral plastic bottle containers and were submitted on the same day to the Department of Science and Technology (DOST), Regional Office No. VIII, Testing and Calibration Services, Regional Standard and Testing Laboratory in Palo, Leyte and analyzed immediately. All numerical values obtained from laboratory analyses of water parameters were compared with the values set by PNSDW (2007) of DENR and DOH. This is to find out whether the quality of deep well water samples passed or failed the national standards.

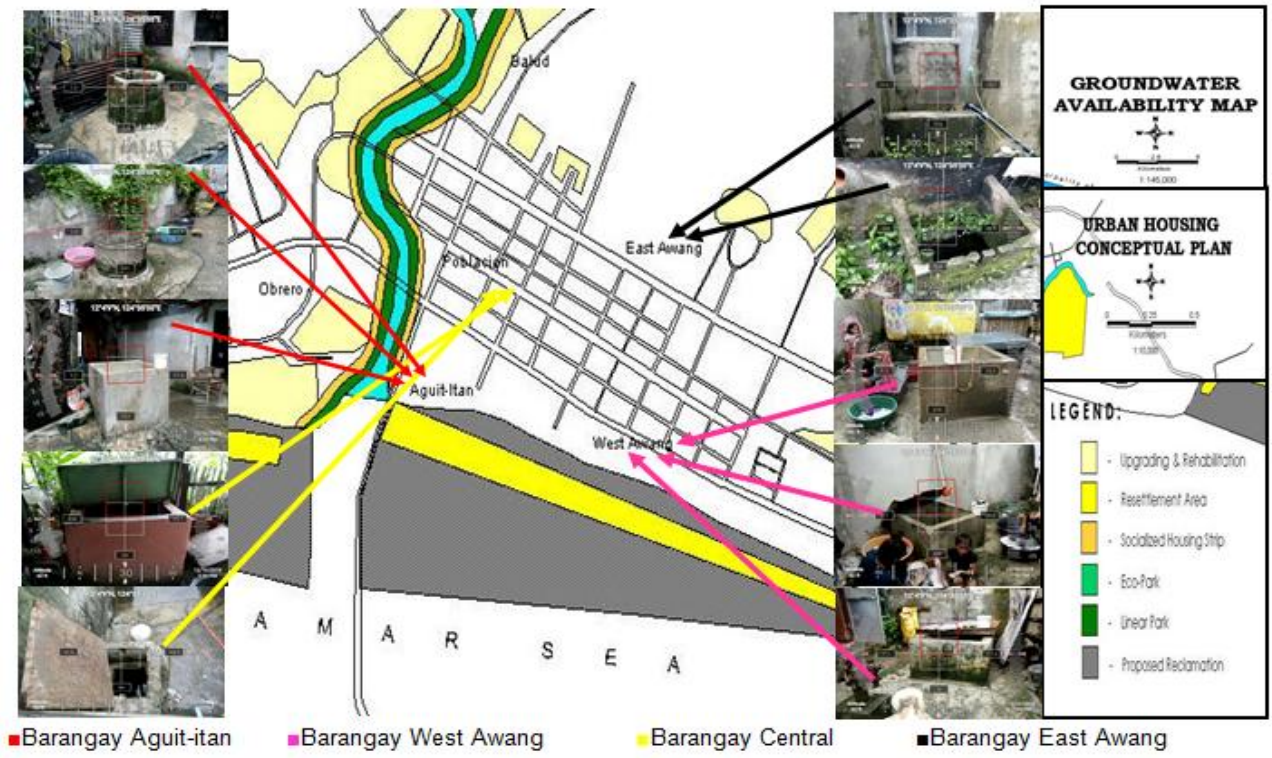

Figure 1. Map of Calbayog City Samar indicating the four selected urban barangays sites of deep-well water sources namely Barangay Aguit-itan, Barangay West Awang, Barangay Central and Barangay East Awang

Physico-chemical analysis

Deep-well water sources from selected urban barangays in Calbayog City Samar were analyzed for salinity, pH, temperature and turbidity using the tools and instruments of the College of Arts and Sciences, Environmental Science and Agriculture Laboratory, Northwest Samar State University. Salinity (ppt) was measured with the use of handheld refractometer. pH was measured using the

Hanna portable pH meter and temperature (℃) using the thermometer.

For the turbidity, Secchi disk was used to analyze with indices such as very clear, clear and not clear. The transect meter was also used to measure the depth of the deep-well water sources. Three readings were recorded on all parameter readings upon collection to replicate the samples. Water samples for Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), Total Suspended Solid (TSS) and Total Dissolved Solid (TDS) were submitted to DOST Regional Office No. VIII, Testing and Calibration Services, Regional Standard and Testing Laboratory. Physico-chemical analysis of water samples submitted to DOST were determined through these methods, biochemical oxygen demand using Five-day BOD test (Azide Modification-Dilution Technique, SMEWW Method 5210B), total suspended solids (Gravimetric method, SMEWW 2540D).

Microbiological analysis

Microbial analysis for total coliform, *E. coli*, and fecal coliform were submitted to DOST Regional Office No. VIII, Testing and Calibration Services, Regional Standard and Testing Laboratory. These microbial analyses were determined using Multi-tube Fermentation Technique wherein undiluted samples were inoculated to fermentation tubes with appropriate volume of Lauryl Sulfate Broth incubated at (35 ± 0.5)℃, (48 ± 3) h.Tubes exhibiting growth or gas formation were further confirmed using Brilliant Green Lactose Bile Broth incubated at (35 ± 0.5)℃ , (48 ± 3) h for estimated Total Coliform, EC Medium (HiMedia) and Tryptone water medium incubated at (44.5 ± 0.2)℃ for (24 ± 2) h for estimated fecal coliform and *E. coli*, respectively. The result was reported as most probable number per 100 mL of sample (MPN/100 mL), which is an estimated mean density of coliform in the samples based on probability formula

Protective structure determination

Availability of protective structures in each location site of deep-well water sources was recorded at about 25 meters vicinity to determine the establishments within the area. Presence of protective structures particularly covers and gates of deep-well water sources on every site were recorded.

Statistical analysis

Data for physico-chemical analysis was subjected to Analysis of Variance (ANOVA) using Statistical Tool for Agricultural Research program (STAR, 2014) to determine variations on potability of different deep-well water sources. Comparison of means was done using Least Significant Difference ($p<0.05$).

Results and Discussion

Physico-chemical analysis of deep-well water sources

Temperature and pH of all selected urban barangays were within the acceptable criteria by 30°C and 6.5-8.5 limits respectively based on PNSDW (2007). For salinity, the values of all barangays are within the set standard and in acceptable criteria by 0-0.5 ppt. Barangay Aguit-itan is the only barangay who have very clear turbidity result while only the deep-well water source of barangay East Awang was not clear. The very clear turbidity result of

Barangay Aguit-itan was attributed to its high salinity reading (0.233 ppt) compared to the other three barangays (Figure 2).

Table 1. Physico-chemical characteristics of deep-well water sources in selected urban barangays of Calbayog City based on Philippine National Standards for Drinking Water (PNSDW)

Barangays	pH	Temp (°C)	Salinity (ppt)*	DO (mg/l)	BOD (mg/l^b)	TSS (mg/l$^+$)	TDS (mg/L)	Turbidity	Depth (m)
AGUIT-ITAN	6.09	27.22	0.233^a	4.4	4.46	<1.00	468	Very Clear	0.579
Remarks	W	W	W	W	NW	W	W		
WEST AWANG	6.06	28.66	0.122^b	5.42	0.3	1	455	Clear	0.731
Remarks	W	W	W	NW	W	W	W		
EAST AWANG	6.04	26.66	0.133^b	4.45	0.16	<1.00	393	Not Clear	3.169
Remarks	W	W	W	W	W	W	W		
CENTRAL	6.06	27.99	0.113^b	3.86	4.92	2.5	353	Clear	1.996
Remarks	W	W	W	W	NW	NW	W		
PNSDW	6.5-8.5	30	0-0.5	4-5	≤3	1	≤500	-	-

Note: *Acidity (pH), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Suspended Solid (TSS), Total Dissolved Solid (TDS), Remarks - Within (W), Not Within (NW), Unobjectionable (-)*

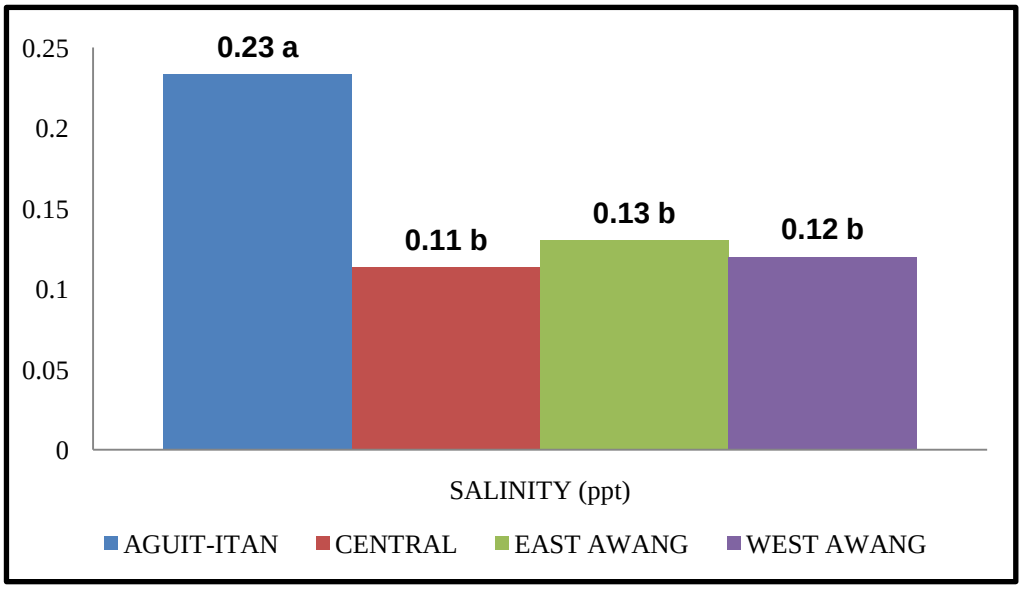

Figure 2. Salinity of Deep-Well Water Sources of Barangay Aguit-itan, Barangay Central, Barangay East Awang and Barangay West Awang, Calbayog City, Samar, Philippines

One of the possible reasons of barangay East Awang having unclear turbidity result was because of its depth. The depth of it had the deepest mean depth of 3.169 meters compared to the remaining three barangays ranging from 0.579 meters to 1.996 meters. These remaining three barangays revealed to have shallow deep-wells because of everyday usage for activities such as washing clothes and other domestic purposes. Moreover, in terms of dissolved oxygen (DO), only barangay East Awang (5.42 mg/L) exceeded the PNSDW at 4-5 mg/l as well as barangay Central for Total suspended solids (TSS) at 2.50 mg/l compared to the PNSDW (2007) of 1 mg/l. Meanwhile, barangay Aguit-itan (4.46 mg/l) and barangay Central (4.92 mg/l) were not within the acceptable limit of biochemical oxygen demand (≤3 mg/l) based on PNSDW (Table 1). Tonog & Poblete (2015) explained that low DO in water maybe due to a warm condition and can be an indication of too much bacteria from sewage or organic discharges. Warm water condition increases molecular activity which pushes DO to evaporate and bacteria consume DO causing it to decrease. Since high DO results to the better taste of drinking water site, deep-well water source of barangay East Awang has the best taste among the sites studied. Salinity result on the other hand passed the permissible standard by 0-0.5 ppt of PNSDW (2007). This result was further analyzed using Least Significant Difference (LSD) at 5 % level of significance to determine the specific barangay with the highest Salinity reading. Result showed that barangay Aguit-itan significantly has more salinity as compared to other three barangays (Figure 2). The possible reason why barangay Aguit-itan had the highest salinity reading was because it has approximate to the sea and is also associated with lesser counts of *E. coli* (12 MPN/100 ml) based on microbial analysis (Table 2). Other possible sources of salinity in ground water are from agriculture and natural sources. Ground water contains naturally-occurring salts from dissolving rocks and organic materials. Some rocks dissolve very easily, ground water in these areas can naturally be very high in salinity (De Vera 2015).

Microbiological quality of deep-well water sources

Total coliform, *E. coli* and fecal coliform of deep-well water samples of selected urban barangays in Calbayog City exceeded the limit of the PNSDW (Table 2). This means that all deep-well water sources in this study is unfit for drinking without any treatment. The World Health Organization (1999) basically commends that the total coliform or fecal coliform should not have any traces. Sunday et al (2014) also recommended that ideally, drinking water should not contain any microorganism known to be pathogenic and should be free from bacteria indicative of fecal pollution. However, following the PNSDW, if the total and fecal coliform count exceeded the value of <1.1 most probable number (MPN) per 100 ml, this signifies that the deep-well water sources are microbiologically contaminated and is unfit for human consumption. If coliforms are found in every deep-well water samples, it generally suggests that certain selection of water may be contaminated with feces, either of human or of animal origin (Sunday et al. 2014). This is similar on the results of Tonog

& Poblete (2015) on drinking Water Quality Assessment in Selected Barangays in Laoang, Northern Samar, Philippines with water sources from deep well, pump well and communal faucets based on the physical, chemical and bacteriological properties revealing that most water sources were within the permissible limits in terms of color, odor, pH, Total Dissolved Solids (TDS), salinity, Dissolved Oxygen (DO) and nitrite. However, hardness and alkalinity were beyond the allowable limits and all water samples were positive for fecal coliform. Since barangays Aguit-itan, East Awang, West Awang and Central deep-well water sources were all beyond the allowable limit for drinking (PNSDW 2007), this basically means that water samples are contaminated with *Escherichia coli* and water is not safe for drinking. Water sources in these barangays are not safe because there are bacteria that can cause diarrhea, gastroenteritis, typhoid fever and other water borne related diseases.

Table 2. Microbiological quality of deep-well water sources in selected urban barangays of Calbayog City Samar, Philippines

Parameters	PNSDW & DENR Standard	AGUIT-ITAN	WEST AWANG	EAST AWANG	CENTRAL
Total Coliform (MPN/100 ml)	<1.1	>23.0	>23.0	>23.0	>23.0
E. coli (MPN/100 ml))	≤1.1	12	>23.0	>23.0	16
Fecal coliform (MPN/100 ml))	<1.1	>23.0	>23.0	>23.0	>23.0

Note: *MPN-most probable number per 100 ml, Escherichia coli (E. coli)*

Protective structures and location site of deep well water sources

Some deep well water sources does not have any cover while others were temporarily covered with metal sheets, essentially most of it are built in concrete structures (Fig. 3). Availability of the protected covers were recorded (Table 3) and are evident (Fig. 3) in this study. For the description of location sites, Barangay Aguit-itan deep-well water source is located near a basketball court. It is constructed in a place surrounded by houses within 20 meters the sea port of Calbayog City wherein was estimated within 20 meters from City Hall. On the other hand, the deep well in barangay West Awang is located near a van transportation terminal named Grand tours approximate to the Philippine National Highway (maharlika highway). Barangay East Awang deep well water sources are found in Rama Street with distances in between deep wells of 44 meters and are surrounded by houses. The Barangay Central deep well water sources are located inside the Girl Scout building and in front of the Special Education (SPED) elementary school as well as beside a Magnolia meat shop store. Generally, even more protected deep boreholes are also sometimes polluted by on-site sanitation facilities when there is a hydrologic

connection between deep aquifers and younger geologic layers on the surface where all on-site sanitation systems are sited (Lutterodt et al. 2018).

Table 3. Availability of protective structures on deep-well water sources in selected urban barangays of Calbayog City, Samar, Philippines

Barangays	Deep Well	Cover	Gate	Concrete Walls
1.Aguit-itan	1	None	None	Yes
	2	None	None	Yes
	3	None	None	Yes
2.West Awang	1	None	None	Yes
	2	Yes	None	Yes
	3	Yes	None	Yes
3. East Awang	1	None	None	Yes
	2	None	None	Yes
4. Central	1	Yes	Yes	Yes
	2	Yes	Yes	Yes

Note: Yes- Available None- Not available

Figure 3. Protective structures and photos of location sites with deep-well water sources on selected urban barangays of Calbayog City, Samar, Philippines

Water-borne disease could be contracted and spread through drinking and use of contaminated water. Water quality indicates that pollution of the water is increasingly alarming and that it has created serious threat to human health and environment. Bacteriological pollution of drinking water supplies may be either due to the failure of the disinfections of the raw water at the treatment plant, or the infiltration of contaminated water (sewage) through cross connection, leakage points and back siphon-age. Thus, the quality of the water consumed is critical in controlling infectious diseases and other health problems (Sunday et al. 2014).

Conclusion

The physico-chemical characteristics of deep well water sources in selected urban barangays in terms of pH, temperature and total dissolved solid passed the permissible limits of the Philippine National Standard for Drinking Water (PNSDW) and Department of Health (DOH) and Department of Environment and Natural Resources (DENR) standards. However, turbidity, salinity, dissolved oxygen, biochemical oxygen demand, total suspended solids exceeded the PNSDW. Microbiological quality in terms of total coliform, *E. coli* and fecal coliform of barangay Aguit-itan, East Awang, West Awang and Central were beyond the PNSDW. It was found that deep-well water sources were contaminated with different microbial contaminants and not acceptable for drinking. Deep well of every barangay are not suitable for drinking if untreated but can be used for bathing and washing clothes. Protective structures help minimized adulterations but with the presence of houses nearby the deep-wells and the establishment of septic tanks in near houses can leak and contaminate the deep well that can result to presence of fecal coliform.

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References

Aydin A. 2007. The Microbiological and Physico-Chemical Quality of Groundwater in West Thrace , Turkey. *Polish Journal of Environment Study*, *16*(3): 377–383. Retrieved on March 17, 2020 from www.pjoes.com/pdf-87998 21857? filename=themicrobiologicaland.pdf

Department of Science & Technology (DOST). Regional Office No.VIII, Testing and Calibration Services, Regional Standard and Testing Laboratory in Palo, Leyte, Philippines.

DENR administrative order No. 26-a series 1994. Philippine Standards for Drinking Water 1993 under the provision of chapter II, section 9 of PD 856, otherwise known as the Code on sanitation of the Philippines. Retrieved from http:// water.emb.gov.ph/ wp-content/ uploads/2016/07/DAO-1994-26A.pdf

Devangee S, Bhadresha K, Jain NK & Modi HA. 2013. Physicochemical

Analysis of Water from Various Sources and Their Comparative Studies. 5(3): 89-92. Retrieved from https://pdfs.semanticscholar.org/8c51/4dee02573da5310453e38a5c92617ae60a4f.pdf?_ga=2.112271431.2121760329.1588577451-977699090.1588577451

De Vera WM. 2015. Microbiological and Physico-Chemical Quality of Deep well water in Selected Public Elementary Schools. *Asia Pacific Journal of Multidisciplinary Research*, *3*(5): 105-109.

Edberg SC, Rice EW, Karlin RJ & Allen MJ. 2000. Escherichia coli: the best biological drinking water indicator for public health protection. In: Symposium Series (Society for Applied Microbiology), vol. 29, pp. 106S-116S. England.

Gumera LRC, Caballo MLM & Alegre ALI. 2009. Microbiological Assessment of the Springwater of Barangay Bagakay, Ozamiz City. Retrieved fromhttp://local.lsu.edu.ph/institutional_research_office/publications/vol.14no.3/7.html.

Lakshmi P, Reddy MS, Reddy CP & Rao AN. 2016. Studies of Physico-chemical Parameters to Evaluate Quality of Water at Different Zones of Nalagonda District of Telangana, *Indian Journal of Earth*. SciClim Change. 7: 347. doi:10.4172/2157 7617.1000347

Leopoldo GD, Ceniza MS, Besagas R, Asoy AY, Dael NT & Rosario RM Del. 2017. Assessment of Freshwater quality of different deepwell sources in Western Misamis Oriental Philippines. *Science International (Lahore)*, *29*(4): 1003–1006.

Lutterodt G, Vossenberg J Van De, Hoiting Y, Kamara AK, Oduro-kwarteng S & Foppen JWA. 2018. Microbial Groundwater Quality Status of Hand-Dug Wells and Boreholes in the Dodowa Area of Ghana. *International Journal of Environmental Research and Public Health*, 1–12. https://doi.org/10.3390/ijerph15040730.

Palamuleni L & Akoth M. 2015. Physico-Chemical and Microbial Analysis of Selected Borehole Water in Mahikeng, South Africa. *International Journal Research and Public Health*, 8619–8630.https://doi.org/10.3390/ijerph120808619

Pindi PK, Raghuveer P & Yadav AK. 2013. Bacteriological and Physico-chemical quality of main drinking water sources. *Pol. Journal Environment Study*, *13*(4): 1156–1161. https:// doi.org/ 10.4314/ahs.v13i4.42.

Pavendan P, Anbu S & Sebastian C. 2011. Physico-chemical and microbial assessment of drinking water from different water sources of Tiruchirappalli District, South India. *Pelagia Research Library*, 1(1): 183–189.

Philippines National Standards for Drinking Water. 2007. Department of Health Administrative Order No. 2007-0012 Manila, url: http://goo.gl/ic1vOz.

State Water Resources Control Board Division of Water Quality, GAMA Program. 2010. Groundwater Information Sheet.Salinity.http://www.waterboards.ca.gov/gama/docs/coc_salin ity.pdf.

STAR, version 2.0.1 2014. Biometrics and Breeding Informatics, PBGB Division, International Rice Research Institute, Los Baños, Laguna.

Sunday JJ, Spencer NCO, Kingsley O, Edet A O & Amaka DD. 2014. Original Research Article Physico-chemical and microbiological properties of water samples used for domestic purposes in Okada town, Edo state, Nigeria. *International Journal of Current Microbiology and Applied Sciences*, *3*(6): 886–894. Retrieved on March 20, 2020 from https:// www.researchgate.net/ publication/319036665_Original_Research_Article_Physicochemical_and_microbiological_properties_of_water_samples_used_for_domestic_purposes_in_Okada_town_Edo_state_Nigeria.

Tonog MN & Poblete MM. 2015. Drinking Water Quality Assessment in Selected Barangays in Laoang, Northern Samar, Philippines. International Journal of Environmental Science and Development, 6(1): 29–33. https:// doi.org/ 10.7763/ IJESD.2015.V6.556.

World Health Organization. 2011. 4th Ed. Guidelines for Drinking-water Quality. Retrieved from https:// apps.who.int/ iris/ bitstream/ handle/ 10665/ 44584/ 9789241548151_eng.pdf; jsessionid = 40F64A62C654A0FD34927AC80E260 BF8 ? sequence=1.