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Assessment of the Effect of Sewage Disposal on the Quality of Water Obtained From Groundwater Source, Namely Boreholes in Michael Okpara University of Agriculture, Umudike Metropolis

Inekwe G., Amadi C.G., Nebonta C. and Udensi N.K.
Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria
Corresponding Author: Inekwe G

ABSTRACT: *This study examined the effect of sewage disposal on the quality of water obtained from groundwater source, namely boreholes in Michael Okpara University of Agriculture, Umudike (MOUAU), Umudike metropolis, with a view to determining the portability of the water. It specifically examined the bacteriological status of groundwater in MOUAU, Umudike metropolis with respect to distance from sewage (waste water) source, the physiochemical parameters of groundwater quality in MOUAU, Umudike metropolis with respect to sewage (waste water) source, and the groundwater quality in MOUAU, Umudike metropolis based on World Health Organization's (WHO) permissible water quality standards. Laboratory analysis of the borehole water samples were carried out and the results of the water quality assessment showed that the temperature in all the locations ranges between 27^{o}C and 28.12^{o}C and the turbidity of all the water samples were higher than the control and slightly above the 5NTU recommended by WHO. The pH values of the borehole water samples showed that none of the water samples from the locations is within the WHO recommended range (6.5-8.5) despite the varying distances between boreholes and waste water tanks. It was also observed that the pH values increased with decrease in distance. The total dissolved solids of all the locations analyzed were all within the acceptable range of values for both that of WHO and FAO, and had no direct relationship with the distance of the borehole from the wastewater. The results of the sulphate showed that there were no direct relationships between the distance of the borehole and the source of the wastewater source. It was therefore recommended that the boreholes should not be sited anywhere 30km from the wastewater sources and that the quality of water be constantly monitored as the deterioration of water in physical and chemical properties is often slow and not readily noticeable as the water system adapts to the change until an apparent alteration of the water occurs. Such activities that pollute the water should be avoided to prevent water contamination.*

KEYWORDS: *Water Quality, Sewage Disposal, Groundwater Source, Borehole*

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I. INTRODUCTION

Water is one of the most important natural resources because it is observed to be a key to prosperity and wealth (Arbues et al., 2003). It sustains life in the same way that food does (Abane, 2005) and provision of safe drinking water is the aim of every government. Water also facilitates other natural cycles including the hydrological, biogeochemical and climatic cycles. According to the World Resources Institute (2002), water is the commonest resource on earth and it is not only essential for life but has become interwoven with human livelihoods in various unexplainable ways. Biologically, water is a nutrient, forms a greater portion of our diet and that results in forming 70% of our body weight. So, any environmental factor that affects the activity, structure or physical state of water poses a threat to life (Somero et al., 1992). Also, any human activity that reduces the quantity and quality of water may affect its access and management at all level (WWC, 2005).

The World Health Organization (2006) Guidelines for Drinking-Water Quality states that "Safe drinking water is water that does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life states suitable for all usual domestic purposes, including personal hygiene."

(Kramer et al., 2011) found out that water supply and safe disposal of excreta are the most important problems that developing countries face especially with the increasing technological advancement, urbanization and the increasing global population. Nigeria is endowed with water resources from various sources which include groundwater, surface waters (like rivers, streams and ponds), rain water and springs and the qualities of these water bodies vary widely with respect to location and environmental factors. Like many developing countries in sub-Saharan Africa, it is unfortunate to note that, the reasonable endowment of water resources in Nigeria is at variance with access to safer drinking water and sanitation by the citizenry.

The rate of urbanization in Nigeria characterized by high population concentration, increasing industrial and agricultural activities coupled with environmental pollution/degradation and indiscriminate disposal of all kinds of wastes pose serious pollution threats, especially in urban areas, with all its concomitant health hazards on the quality of ground water. Consequently, there is high dependency on untreated groundwater abstracted through hand dug wells and borehole systems. Against this backdrop, this study will examine the effect of sewage disposal on ground water quality in MOUAU, Umudike metropolis which has experienced an increase in population in recent times due to influx of migrants from neighbouring states for education purposes. Similarly, the study area is experiencing infrastructural development, hence attracting more human population. These combined factors are increasing pressure on the environmental resources with an increase in waste generation and disposal within the urban metropolis. Moreover, few studies of ground water pollution are available in literature in the study area. There is need to establish the current status of the quality of groundwater and the effect of sewage disposal on the groundwater quality.

The aim of this study is to assess the effect of sewage disposal on the quality of water obtained from groundwater sources, specifically boreholes in MOUAU, Umudike metropolis, with a view to determining the portability of the water.

The specific objectives are: (i) to analyze bacteriological status of groundwater in MOUAU, Umudike metropolis with respect to distance from sewage (waste water) sources, (ii) to examine the physiochemical parameters of groundwater quality in MOUAU, Umudike metropolis with respect to distance from sewage (waste water) sources, and (iii) to assess the groundwater quality in MOUAU, Umudike metropolis based on World Health Organisation's (WHO) permissible water quality standards.

The study is very critical and momentous, because of the rapid increase in the number of boreholes which constitutes a substantial source of drinking water for public utilization in MOUAU, Umudike Metropolis. Therefore, if the major source of the water supply can be polluted with current existing waste disposal systems, then it can lead to outbreak of different kinds of diseases.

The following hypotheses are formulated for the purpose of this study: $\mathbf{H_1}$: there is no significant difference between the water parameters in the study area with the World Health Organisation's (WHO) permissible water quality standards; $\mathbf{H_2}$: the concentration of water parameters does not vary among low, medium and high density populations of the study areas.

II. LITERATURE REVIEW

Water Quality

The term water quality is used to express that which makes it suitable for the needs of the consumer (Osei and Marfo, 1995) without the risk from microbiological or chemical content. The World Health Organization's drinking water guidelines (WHO, 2006) specify levels for physical, chemical and microbiological purity of potable water. Anthropological and natural activities can have much influence on the quality of the tap and borehole water. The most essential of the natural influences are geological, hydrological and climatic, since these affect both the quantity and quality of the available water.

In Nigeria, groundwater is abstracted from all the Hydrogeological Provinces in the country (Agyekum, 2004). According to reports by Kortasi (1994), the main structures for accessing groundwater in Nigeria are boreholes, hand-dug wells and dig-outs and this was made up of about 10,500 boreholes, 45,000 hand-dug wells and some dig-outs. These numbers of abstraction systems were increased to 71,500 in the year 2000 and comprised of 11,500 boreholes and 60,000 hand-dug wells (Dapaah-Siakwan and Gyau-Boakye, 2000). Currently, the number of boreholes in the country is over 15,000 though the costs limit its usage.

Reports in 2000 reveal that groundwater sources (mainly boreholes and hand-dug wells) constitute 33% of the main sources of drinking water supply in Nigeria. It is estimated that over 95% of groundwater use in the country is for domestic purposes. It is also used for irrigation of crops. These irrigators are mostly small-scale farmers who use shallow groundwater for their small plot sizes that have vegetables like cabbage, spring onions, carrots, tomatoes, green pepper, okra and shallots for readily available markets in nearby cities and towns. Agodzo et al., (2003) reported that ropes/buckets and low powered pumps are the devices used in accessing such shallow groundwater to irrigate shallots and other vegetables on average farm sizes ranging from 0.08 ha to 1.5

ha on year round basis. Watering of livestock with groundwater is not widespread in Nigeria but limited to the certain regions such as Upper East, Upper West, and Northern regions. Livestock reared in these areas include goats, cattle, sheep and pigs; are allowed to range in search of food and water. About 70% of Nigeria's 1.34 Million Heads (MH) cattle (2003 estimated figure) and 40% of other livestock and poultry are produced in these three (3) regions and are watered exclusively using groundwater. Usage of groundwater for industries is very recent and is gradually on the increase in Nigeria.

Recent studies have shown that over nine million people have inadequate access to potable water in Nigeria. The government of Nigeria has also indicated that urban areas are overpopulated as a result of movement of people from rural areas in search of greener pastures. This proves that an adequate supply of safe water (by Nigeria Water Company Limited) to the inhabitants would be very difficult.

Table 1.0 below describes the distribution of drinking water access in Nigeria in more detail.

Source of drinking water	Nigeria	Urban	Rural
Pipe-borne	41.6	80.3	18.8
Well	33.9	10.8	47.2
Natural Sources	24.6	8.8	33.9
Total	100.0	100.0	100.0

Source: Nigeria Statistical Service (2003).

Microbial Quality of Water

The quality of water has implications for crop productivity; soil productivity and consumers' health. The FAO and WHO guidelines on quality of water are the basis for national guidelines in many countries. Underground water can be contaminated with a myriad of different components such as pathogens, organic compounds, synthetic chemicals, nutrients and heavy metals.

A number of microorganisms and thousands of synthetic chemicals have the potential to contaminate ground water. Drinking water bacteria and viruses can result in illnesses such as hepatitis, cholera, or giardiasis. Methemoglobinemiaor, "blue baby syndrome", an illness affecting infants, can be caused by drinking water that is high in nitrates. Benzene, a component of gasoline, is a known human carcinogen. The serious health effects of lead are well known- learning disabilities in children; nerve, kidney, and liver problems; and pregnancy risks. Concentrations in drinking water of these and other substances are compared with WHO allowable limits. Preventing contaminants from reaching the ground water is the best way to reduce the health risks associated with poor drinking water quality.

III. MATERIALS AND METHODS

The study area, Michael Okpara University of Agriculture (MOUAU) and its environment, is situated in Ikwuano LGA. The study area is located at latitudes 05^{o}24 and 05^{o}30N and longitudes 7^{o}32 and 7^{o}37E in the rainforest area of Southeast agricultural zone of Nigeria (Agro Climatic data 1996 from NRCRI, Umudike). The area covers about 100,000m^2. The project area has a humid tropical climate, with marked wet and dry seasons. The raining season spans for eight months from March to October and the dry season starts from November and ends in February. The average annual rainfall for Umudike ranges from 1512.2mm to 2731.4mm within 22 years period (Agroclimate data, 1996) from NRCRI Umudike. The raining season has the peak occurring in July and September with a break in August. The average annual temperature of Umudike is 26.7^{o}C while the average annual evaporation (Pitcher) is 2.63ml and the average annual sunshine in hours is 4.7 hours. The geology of the study area is sedimentary to the formation of coastal plain sand. Land is used for arable crop production.

The water samples that were used for the analysis were collected from four (4) different locations in Umudike environment, all of the samples were borehole water. The locations were MOUAU IBB Hostel's Borehole (BH1), MOUAU Old Female Hostel Borehole (BH2), NDDC Hostel Borehole (BH3) and P.G. Hostel Borehole (BH4). The control was collected where borehole was sited from waste water sources, all in Umudike environment. The sampling was done between 8.00am and 11.00am in the morning, using one (1) liter sterilized sampling cans. At the sampling points, the cans were rinsed with the water samples to be collected from various sources before sampling and the cans were filled to the brim. This was done according to the rules and ethics of the International Standard Organization (ISO).

The materials used for the analysis included: Thermometer, Turbidimeter, pH meter, Electrical Conductivity Meter, Spectrophotometer, Autoclave, Water bath, Analytical balance, Lab Oven, Evaporating dish, Filter Papers, Dessicators, Dissolved Oxygen Meter, Reagents, Buffer Solutions, Mediums, Slide Plates, Glass wares, Colony Counter, Micro Pipette, Incubators.

Laboratory analysis of the borehole water samples carried out investigated physical, chemical and biological parameters.

Water quality parameters were determined in the following ways: **Temperature** was determined at the point of sampling using a mercury in glass thermometer with calibration 0 – 100°C; **Turbidity** was measured in the laboratory using a turbidimeter model 2100A; **Salinity** of the samples was determined using the portable dissolved oxygen meter, adjusting it appropriately; **pH** was measured with a standardized digital pH meter; **Electrical conductivity** was measured using the conductivity meter; **Total Dissolved Solids** was measured by first filtering a given volume of the samples, weighing it into a known mass of an evaporating dish and then evaporating the sample to dryness and weighing the final product; the difference in weight between the first and final readings gave the Total Dissolved solids in mg/l; **Total Suspended Solids** was measured by weighing a given volume of the samples and filtering them, after this was done, it was then reweighed and the difference gave the total suspended solids; **Hardness** which is the measure of **Ca^+** and **Mg^+**hardness was determined using the EDTA (Ethylene Diamine Tetracetic Acid) titration method; **Dissolved Oxygen** was determined using the portable dissolved oxygen meter; **Biochemical Oxygen Demand** was determined by first determining the dissolved oxygen content of the samples, then a known quantities of the samples were incubated with the exclusion of light at 20°C for five (5) days; the final oxygen contents were then determined and the difference gave the Biochemical Oxygen Demand of the samples in mg/l.

Coliform count

The most probable number (MPN) method as recommended by APHA (1998) was used in determining the coliform counts of the water samples. The materials and media used for the analysis consisted of the following: Fermentation tubes with aluminum caps, Durham tubes, MacConkey Broth (Single and double strength) inoculating loop, bunsen burner and syringes (10, 5 and 2 ml). The most probable number tube fermentation techniques were performed in three stages: Presumptive test, confirmative test and completed test.

IV. RESULTS AND DISCUSSION

The results of the physicochemical and biological parameters of the borehole water samples from the selected boreholes in MOUAU are presented in the table 4.1

Parameters	Location	1 05' 28.849 007' 32.525	2 05' 28.849 007' 32.527	3 05' 28.850 007' 32.516	4 05' 28.851 007' 32.525	05' 28.840 007' 32.525	WHO (2008)	FAO (1997)
	Altitude (m)	115	116	117	118	116		
	Distance of bore from the wastewater tank	6 m	12 m	24 m	36 m	Control		
Colour		-	-	-	-	-	5	35
Temp °C		27.75	27.4	28.2	27.4	27.5	-	-
Turbidity (NTU)		5.4	5.2	5.4	5.6	3.0	5	-
EC (μs/cm)		133.15	88.05	76.13	45.25	33.2	1000	2000
TDS (mg/l)		64	52	46	48.	68	600	-
pH		6.44	6.20	5.44	4.85	6.70	6.5-8.5	5-9
Salinity (mg/l)		132.25	135.0	138.0	139.03	148.0	600	-
Alkalinity (mg/l)		58.4	44.8	42.8	36.8	26.4	-	-
Hardness (mg/l)		117.5	122.5	125.5	128.5	126.5	500	-
BOD (mg/l)		3.4	3.4	3.2	3.6	2.4		

Ca (mg/l)	68.7	72.6	66.5	73.85	63.8	10	-
Mg (mg/l)	122.6	134.8	128.7	123.4	133.2		
SO_4 (mg/l)	30.7	30.8	30.7	35.9	30.8	250	-
Chloride (mg/l)	214	211	217	218.	183	250	-
Phosphate (mg/l)	0.04	0.03	0.03	0.02	0.001	-	5
E. Coli	2.27 $X10^3$	1.91 $X10^3$	ND	ND	ND	-	6

Table 4.1: The Summary of the Parameters Analyzed for Water Samples and the Standards

Note: **ND** is **"not detectable"**

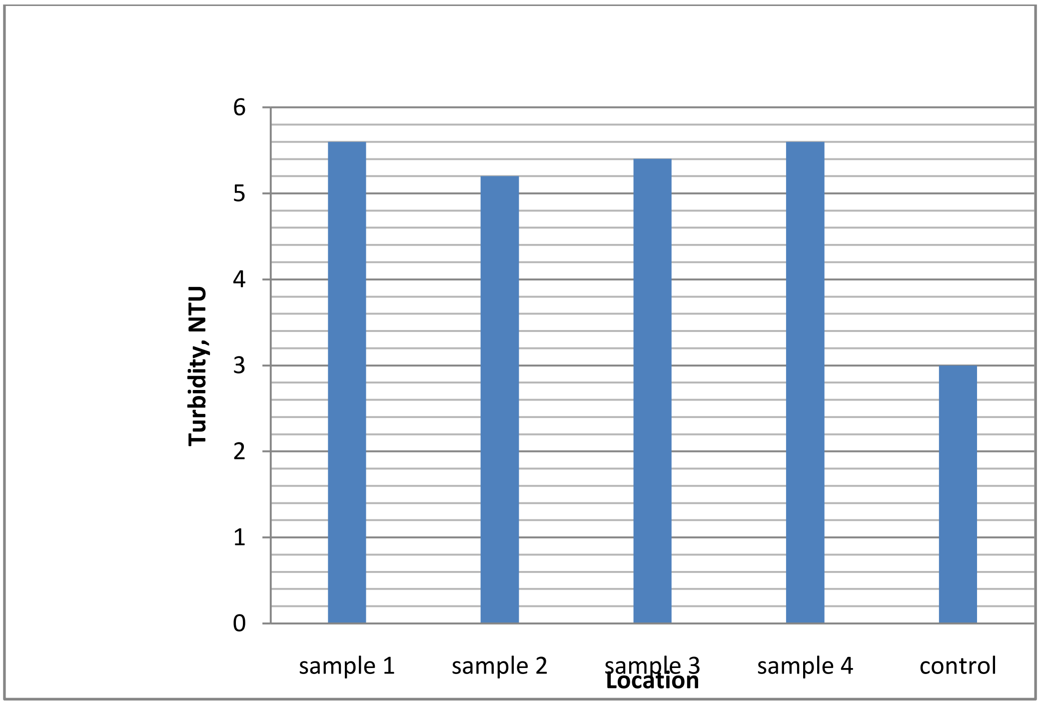
Pollution has posed a major challenge in our environment, affecting the drinking water sources as well as the farm land for agriculture in Nigeria and beyond**.** The cause and effect relationship between a water constituent and the observed problem then results in an evaluation of quality of degree of acceptability. The results of the water quality assessment of the borehole water are presented in Table 4.1.

Temperature

The temperature of water has extremely important ecological consequences. Temperature exerts a major influence on the aquatic organisms with respect to selection, level of activities and occurrence. Temperature also is an important influence on water chemistry. The results of the temperature in all the locations ranges between 27.4^{o}C and 28.12^{o}C.

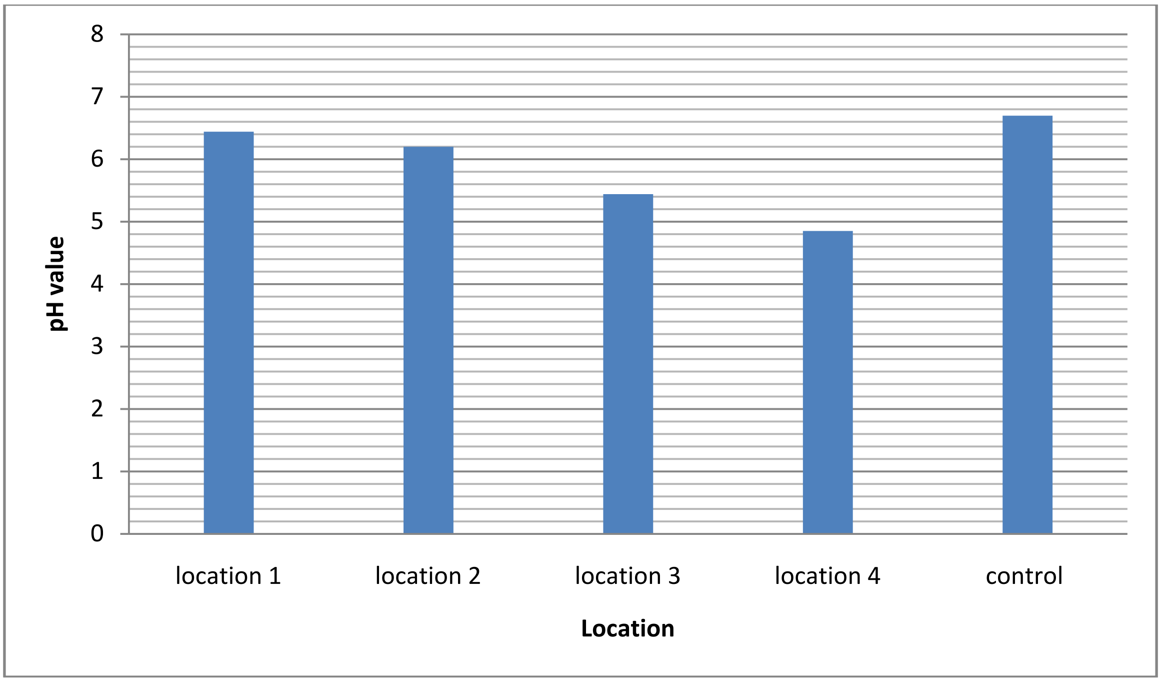
Turbidity

The results show that the turbidity of all the water samples were higher than the control and slightly above the 5NTU recommended by WHO.



pH

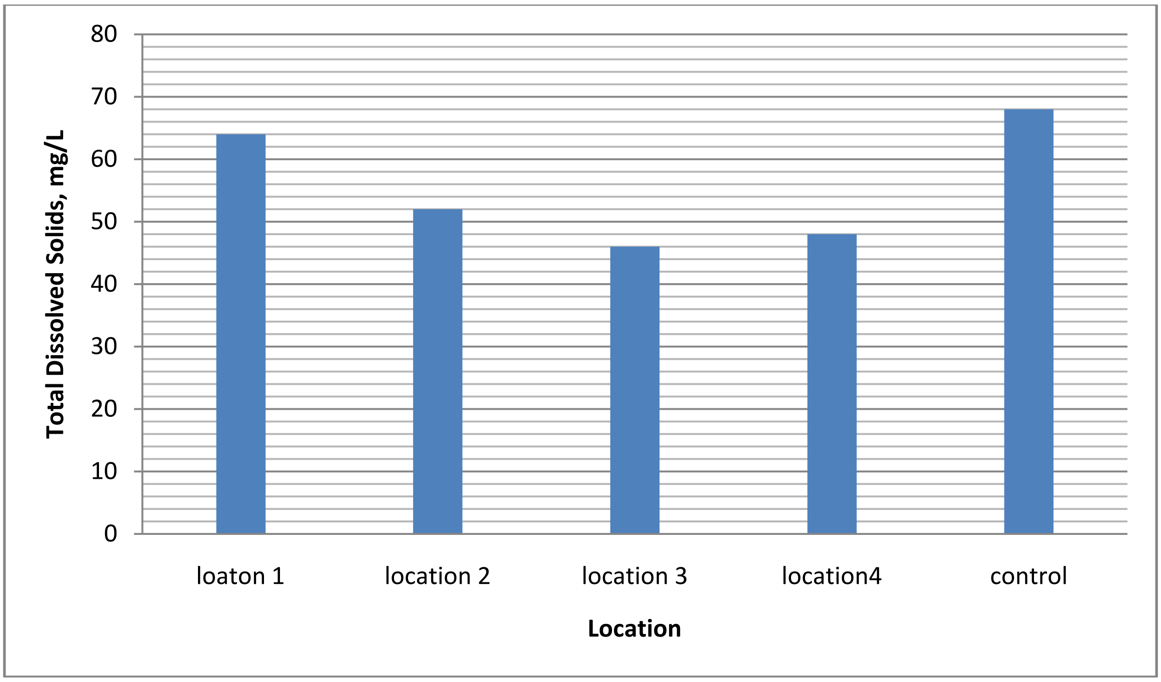
This is an important overall measure of water quality, it can alter corrosivity and solubility of contaminants. The pH values of the borehole water samples show that none of the water samples from the locations is within the WHO recommended range (6.5 – 8.5) despite the varying distances between boreholes and waste water tanks. It was also observed that the pH values increases with decrease in distance. The low pH values indicate that the water in each location is acidic. It also indicates that the water from these sources has corrosive tendencies The enzymes and other proteins of the aquatic organisms in the water which have an optimum pH range will also not be inactivated or denatured. Hence, water organisms within this pH range will survive in these water bodies (Gregory et al., 2005).



Electrical conductivity

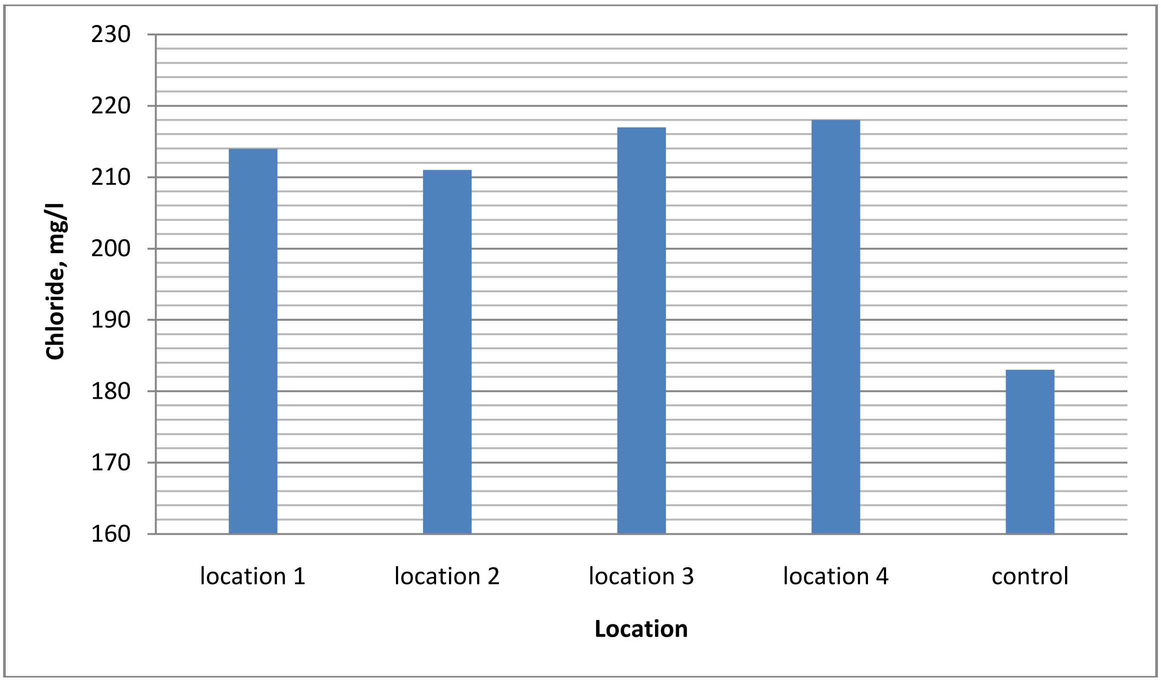
Conductivity is the measure of the activity of all dissolved ionised solids in water. The values of electrical conductivity show that location 1 with 6m distance away from the wastewater source 78.5µshas the highest value of 133.15µs/cm, while location 4 had the least value of 45.25 µs/cm. All of the electrical conductivity values in the locations sampled were within the WHO prescribed value of 1000µs/cm.

Total Dissolved Solids (TDS). This indicates the general nature of salinity of water. Water containing more than 500mg/l of TDS is not considered suitable drinking water supplies. The value of the total dissolved solids of all the location analyzed were all within the acceptable range of values for both that WHO and FAO, and had no direct relationship with the distance of the borehole from the wastewater source.



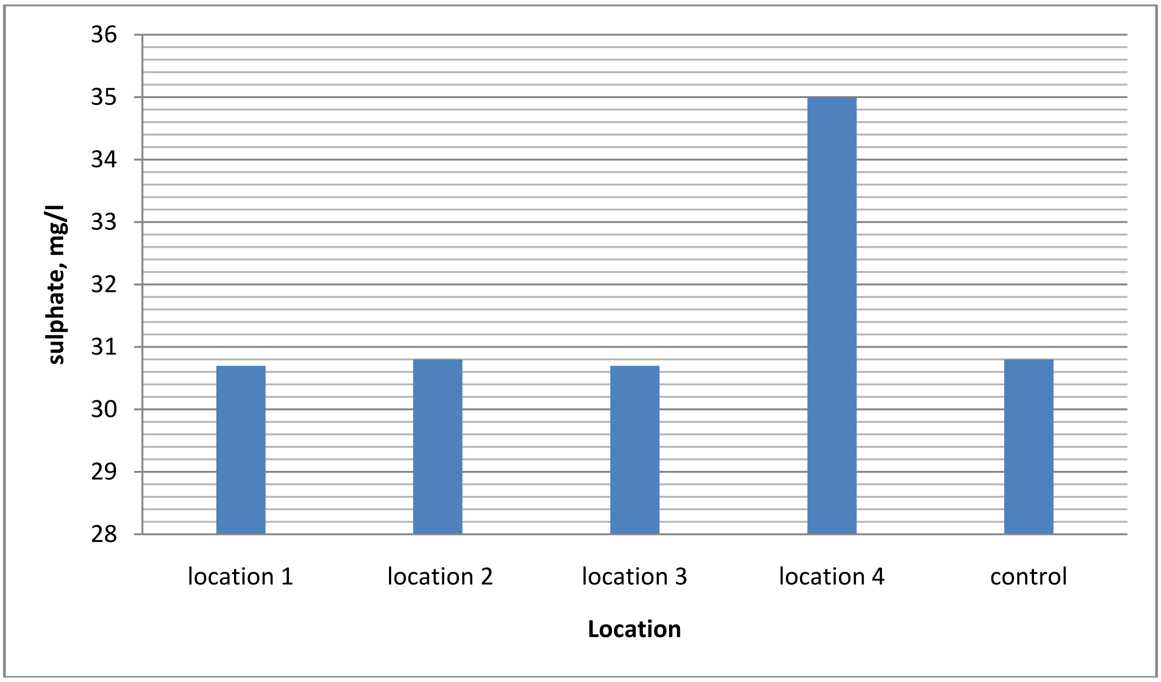
Chlorides

The chloride content of all the water sources sampled fall within acceptable limits of 250mg/l set by WHO. High concentration of chlorides can make water unpalatable and therefore unfit for drinking or livestock watering. The results show that all the values are higher than the value for the control (183 mg/l).



Sulphate

Sulphate is naturally present in underground and surface waters and arises from atmospheric deposition of oceanic aerosols and leaching of sulphide minerals from sedimentary rocks. High concentration of sulphate like chloride may make the water unpleasant to drink. The results show that there were no direct relationships between the distance of the borehole and the source of the wastewater source.



E Coli.

Of the drinking water quality indices, bacteriological parameters are the most vital in terms of health concerns. This is because they are associated with water borne diseases such as Cholera, diarrhoea, hepatitis, among others. Therefore, water sources used for drinking and cleaning purposes should not contain any organism of faecal origin. E.Coli valuesof 2.27 x 10^3cfu100/ml and 1.91x10^3cfu100/ml were detected in location 1 (6m distances) and 2 (12m distance) respectively. This indicates pollution in these water sources. E.Coli is considered to be a species of coliform bacterial that is the best indicator of faecal pollution and the possible presence of pathogens (Bartrain and Balance,1996). E.Coli was not detected in the samples from location 3 (24m distance), location 4 (36m distance) and the control. Thus, the bore hole water from location 3 (24m distance), location 4 (36m distance) and the control is fit for drinking. However, other water sources can be used for agricultural purposes including aquaculture.

V. CONCLUSION AND RECOMMENDATION

The deterioration of water by wastewater or effluents in physical and chemical properties is often slow and not readily noticeable as this study on the assessment and the effect of wastewater on borehole water quality in MOUAU and its environs revealed. Borehole water samples were collected from four locations, 6m, 12m, 24m and 36m distance from wastewater sources and the control was collected from borehole with no waste water sources near it. The results of the water quality assessment show that the temperature in all the locations ranges between 27.4^{o}C and 28.12^{o}C and the turbidity of all the water samples were higher than the control and slightly above the 5NTU recommended by WHO. The pH values of the borehole water samples show that none of the water samples from the locations is within the WHO recommended range (6.5 – 8.5) despite the varying distances between boreholes and wastewater tanks. It was also observed that the pH values increased with decrease in distance. The total dissolved solids of all the locations analyzed were all within the acceptable range of values for both WHO and FAO, and had no direct relationship with the distance of the borehole from the wastewater source. The results show that all the values are higher than the value for the control (183 mg/l).The results of the sulphate show that there were no direct relationship between the distance of the borehole and the source of the wastewater source. Water sources from Locations1 and 2 are contaminated with E. Coli and as such not fit for drinking while that from 3 and 4 are not contaminated as no E.Coli was detected in the samples. This is in agreement with World Health Organization recommendation WHO (1997) that the minimum distance between boreholes and septic tanks should be 30m.

Following the above conclusion, we therefore recommend that the borehole should not be sited anywhere 30km from the wastewater source and that the quality of water be constantly monitored as the deterioration of water in physical and chemical properties is often slow and not readily noticeable as the water system adapts to the change until an apparent alteration of the water occurs (Ahaneku and Animashaun,2013). Such activities that pollute the water should be avoided to prevent water contamination.

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