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Impact of Cemetery on the Physioco-Chemical Properties of Water in Port Harcourt Metropolis, Rivers State, Nigeria.

Amadi, Moriah Donu; Emeruem, Jane and Weje, Ikezam Innocent
Department of Urban and Regional Planning,
Rivers State University Port Harcourt

Abstract

Cemeteries are haven for lifeless bodies of humans since at expiration of life; human corpses become waste and require proper way and place of disposal like any other waste. Though cemeteries play significant role of housing the dead and other benefits, cemeteries have their downside which includes its contamination potentials to ground water. The present study examined the impact of cemetery on the physioco-chemical properties of water in Port Harcourt metropolis, Rivers State, Nigeria. The study leans on quantitative research paradigm while the research design is quasi experimental research design. Primary data was obtained through direct observation by the researchers, and water samples collected at designated points within the study area. To delineate our sampling area, concentric rings of 100 meters apart up to 400 meters radius was introduced to get settlements around the cemetery area from which water samples were collected from thirteen points for laboratory investigation. Findings from the study revealed that the physioco-chemical properties of water do not change as one move away from the cemetery area. The values of all the parameters examined were within the WHO limit even though there was evidence of elevated value of lead and acidity. Although, the presence of Lead, ,elevated pH and COD in the water around the cemetery area may not have resulted from the cemetery, there is need to treat water in this area to bring up the pH and Lead to WHO desirable levels for portable water since water acidity and Lead in drinking water can affect man's health adversely.

Key words: Cemetery; Death, Acidity; water contamination, Land-use, Locational impact;

1. Introduction.

A cemetery is a haven for lifeless bodies of humans. At expiration of life, human corpses become waste and require proper way and place of disposal like any other waste. Cemetery offers the abode for the disposal of such waste. In this regard, a cemetery is an institutional land use for deposition of corpses or human remains. According to Marten (2019), cemeteries can be considered landfills of sorts, as there is a higher-than-normal concentration of potentially contaminative materials located in one place.

Although the major activity that occurs in a cemetery is the interment of corpses, cemeteries are also places of historical importance capable of fostering social relationship. According to Fee (2016), cemeteries have a deep historical connection to the local community. It makes opportunities available for people to understand the past and helps to provide understanding into how people lived within the community. Cemeteries worldwide provide the place for the interment of beloved friends, spouses; relatives etc. and bring closure to the bereaved.

In spite of these benefits, improper location of cemeteries may have negative impact on the socio-economic and health of residents around cemetery areas due to its contamination potential to ground water. After expiration or death, the human corpse, underground, begins the process of putrefaction (decomposition). In addition to the corpse, the coffin, which may have been treated with varnishes, sealers and preservatives; embalming fluids, which may contain arsenic, mercury or formaldehyde, mercury from amalgam dental fillings and non-ferrous metals such as silver, platinum, palladium and cobalt from Jewelry and orthopedic implants; fertilizers from landscaping at the cemeteries; chemical substances applied in chemotherapy; pathogenic bacteria and viruses, are all buried (Marten 2019). These additional corpse accessories may increase the contamination potential of the soil and water within and around a cemetery.

Jonker and Olivier (2012) and Neckel, Gonçalves Ribeiro, Silva and Cardoso (2016), are of the view that contamination of water occurs when a cemetery is located close to a source of ground water. Contaminated water, if consumed without any form of treatment, can have deleterious health implications for the users.

The World Health Organization (WHO) proposes that human or animal remains should not be buried within 250 m of any well or water abstraction point. The Port Harcourt City cemetery and, the military cemeteries have all been swallowed into the urban area and are found in close proximity to residential, commercial and institutional developments. This close proximity poses contamination risk to the private boreholes in the adjoining buildings from which water is abstracted for drinking and other domestic uses. This study examined the impact of cemetery on the physioco-chemical properties of ground water with a view to ascertaining if the values of water parameter in the study area are within the WHO limit for drinking water and also to ascertain if water properties vary as one move away from the cemetery.

2. Study area

The study area is Port Harcourt metropolis. This study area is defined by Latitude: 4°42′0″ N to 4°57′ 0″ N and Longitude: 6°54′0″ E to 7°9′0″ East of Greenwich Meridian. It is bounded in the North by Ikwerre and Etche Local Government Areas, in the South by Okrika Local Government Area, in the East by Eleme and Oyigbo Local Government Areas and in the West by Emohua and Degema Local Government Area (figure 1). Its estimated mean altitude is 12 km above average sea level (Weli & Efe, 2015). It falls almost entirely within the lowland rain forest ecological zone and is flanked in the east, west and southern limits by mangrove swamp forest (Ayotamuno, and Gobo, 2016)

The climate of this study area belongs to the tropical climate zone which is characterized by high temperature and precipitation. Rainfall is significant most months of the year. Precipitation here is about 2708 mm/106.6 inch per year. Heavy and persistent rainfall enhances the movement of nutrients, chemical, toxins etc. towards an aquifer because water is the medium through which these substances move. Through the action of infiltrating rainfall, adsorbed pathogenic organisms from the decayed corpse can escape from the soil, mix with the groundwater's beneath the cemeteries and migrate considerable distances. Movement of contaminants to the aquifer is less likely to occur in arid regions due to sparse precipitation as compared to this study area where rainfall is heavy and persistent.

The geology of the study area consists basically of alluvial sedimentary basin and basement complex (Eludoyin, Wokocha & Ayolagha, 2011). The study area belongs to the Niger Delta Basin formations. The geology of the study area is relevant to this study because, the type of soil that underlies the base of the grave to the water aquifer beneath the grave will partly determine its contamination status. Soils that are porous and permeable will facilitate movement of substances from the decayed corpse through the vadose zone to the aquifer.

Port Harcourt metropolis is endowed with oil, gas and other natural resources. Consequently, it is an important industrial and commercial center and a key center for the oil industry. The presence of oil and gas and increased economic activities led to an increase in population of the area that also results to expansion of settlement close to cemetery area. Again, as the population of the area increase due to good economic climate, more deaths are expected. This further stretches the demand for burial space of the cemetery.

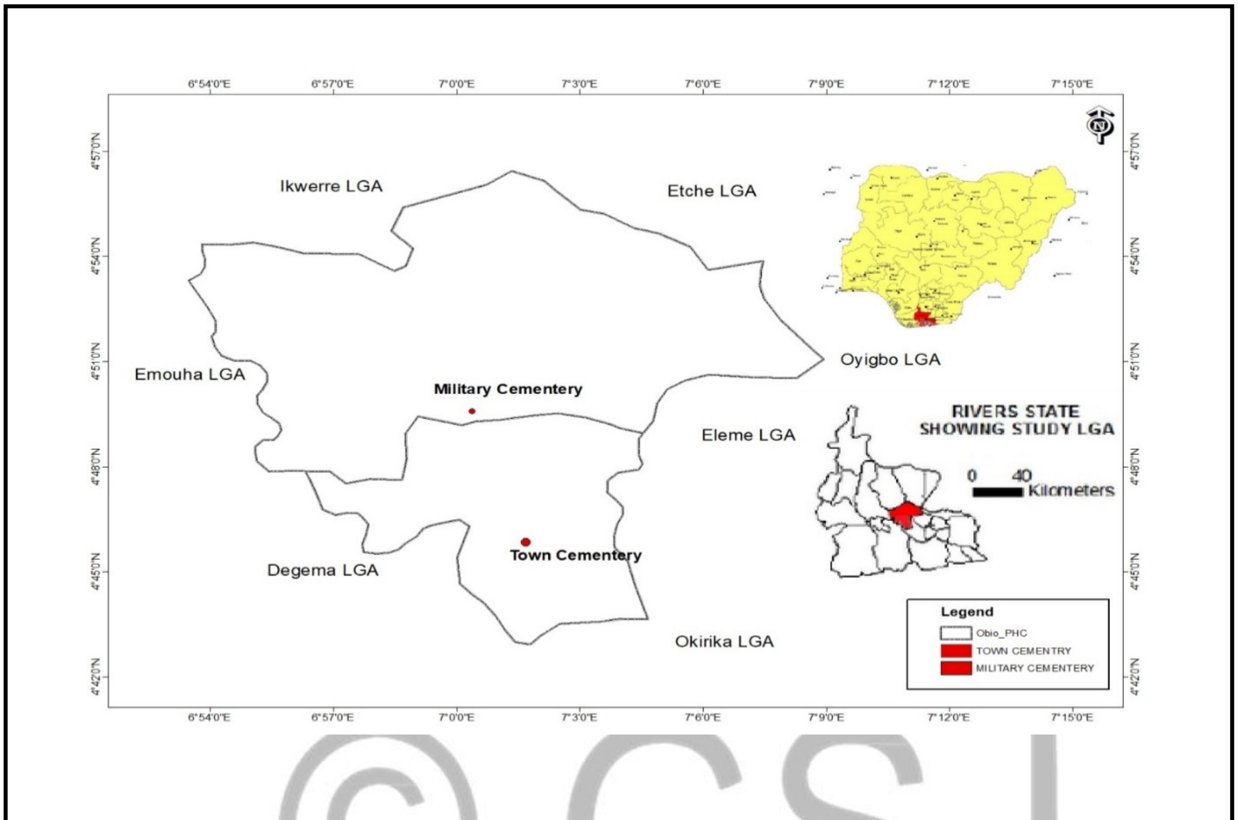

Figure 1: Study area
Source: Department of Urban and Regional Planning, River State University.

3. Conceptual/ theoretical Orientation and Literature Review

3.1. The Concept of Death

Death Science (2020), defines death as the permanent end of all functions of life in an organism or some of its cellular components. Death is the end of life, the cessation of life (Shieljr,2020). Death is an on-going phenomenon in the history of humanity. Although life is inevitably subject to termination and demise, there are differences in the way individuals and groups believe and perceive death. The differences in the way people understand or perceive death is based on religious, cultural or scientific philosophy (Ekore & Lanre-Abass, 2016). From the perspective of science, death is permanent end of all functions of life in an organism. From the religious perspective, different religious groups have belief about death that pertains to their religious philosophy, what is important however is that death is the cessation of physical life in consonance with the scientific philosophy of death. So, the dead is powerless and harmless.

3.2. The Hydrological Cycle

The hydrologic cycle is the process, powered by the sun's energy, which moves water between the sky, land and the oceans (Rosemberg 2019). It is concerned with the circular movement of water above and beneath the soil surface through the process of Evaporation, Transpiration, Condensation, Precipitation, Runoff, and Infiltration. According to Okafor and Onwuka (2013), the hydrologic cycle is water movement that occurs between the land, sea or ocean and air which is propelled by the power emanating from the sun.

In the process of the cycle, water suspended in the atmosphere falls as rain, snow or due to the ground surface when certain conditions are met. Part of the water flow into rivers and lakes, some seep into the soil, some are absorbed by plants, some percolate further through soil layers to form underground water. Underground water flows into rivers, lakes and any body of water. From these sources and plants, water evaporates into the atmosphere, condenses and falls back as precipitation and the cycle continues. As water embarks on this journey in all stages, it carries dissolved or suspended particles along with it.

The concept of hydrologic cycle is relevant to this study because one of the negative impacts of cemeteries on the environment is related to water quality (contamination). In the course or process of this cycle, pollution occurs; toxic materials, bacteria, viruses etc. are transported to the underground aquifer. In the same manner, contaminants from decaying cadaver can percolate to a nearby underground aquifer and cause contamination.

3.3. History of Cemetery in Nigeria

Prior to the advent of the western civilization, the cultural practice of Nigerians was to bury the deceased within their environment amongst the living: either near or within their homes, except those buried in what was considered 'evil forest' due to certain reasons. According to Onwuanyi, Ndinwa and Chima (2017) some families sought to demonstrate greater care for their dead ones; these families would choose a room in the family house and bury the deceased. It is a tradition that survives in many villages till today, in spite of the influence of western civilization. With the emergence of civilization and western influence, this custom was extended to interments in cemeteries.

With the coming of colonialism and missionaries activities that accompanied it, the colonial masters introduced the use of cemeteries in Nigeria (Cosmas 2016). They acquired plots of land (as cemeteries) for the purpose of burying their colleagues and household members whose corpse could not be conveyed back (for any reason) to their countries of origin. The Missionaries designated and used part of church property as a burial ground to inter their family members, clergy and some members as can be observed even today in some church yards. Some Nigerians who became converts to Christianity adopted the Christians' way of burying the dead and so were buried in the cemetery acquired by the church.

There is a legal basis for development of cemetery in Nigeria. Prior to Nigerian independence, (Colonial era), the Town and Country Planning Ordinance 1917 of Northern Nigeria Section 67 (8) provided that "No part of the cemetery shall be constructed near to any dwelling house than the prescribed distance of 200 yards (approximately 183m), except with the consent in writing of the owner, lessee, and occupier of such house" (Habila, & Kevin 2018).

The Nigerian Urban and Regional Planning Law of 1992 Section A (part iv, no 53sub sections a and b) states that the 'Control Department shall be responsible for any unauthorized development on any land use (especially public land uses and open spaces like, green area, cemetery spaces, gardens and parks). Section A. part 4 no 73-is about maintenance and utilization of waste land for public uses including cemetery' (Habila, & Kevin 2018).

In Post independence Nigerian, one of the roles of Local Governments as established by the 1999 constitution is the creation and maintenance of cemeteries and burial grounds (Saulawa, Danjuma, Musa, & Haruna 2018). To accomplish this, each Local Government Area was to developed bye-laws or regulations that would guide the detailed operations of cemeteries or burial places. Section 246 of the Criminal Code Act, Cap. 77 Laws of the Federation of Nigeria 2004 which is applicable in Rivers State also has it that 'no citizen is permitted to bury any corpse in any house, building or premises, yard, garden, compound or within one hundred yards (91.44meters) of any dwelling house or any open space situated within a township without the consent of the President or the Governor'

The subject area-cemetery has perhaps not elicited much interest among scholars in spite of the impact that cemeteries have on the human environmental sphere. According to Opio (2015), as corpse decomposes, chemicals including ammonia, formaldehyde (from embalmment) chloride, metals etc. leach out in the first year and if groundwater is near to the surface, that can cause serious contamination. For Üçisik and Rushbrook (2018), human corpses may cause groundwater pollution not because of any specific toxicity they possess, but by increasing the concentrations of naturally occurring organic and inorganic substances to a level sufficient to render ground waters unusable or unpotable.

Empirical studies such as those of Vaezihir and Simozar (2016), Turajo and Dammo, (2019) among others have revealed that locating cemeteries very close to potable water sources contaminates them. Vaezihir and Simozar (op cit) for instance, examined the contamination potentials of the Tabriz cemetery in Iran during the fall of 2011 and spring of 2012. Twenty-four groundwater samples were collected during two rounds of sampling in October 2011 and May 2012 from the sampling locations which included well, gallery and spring. Two samples were taken at each location for chemical analysis and the second for biological analysis. The results revealed high concentrations of calcium, magnesium, sulfate, nitrate, chloride and fluoride ions etc which were attributed to the impact of cemetery.

Zume (2011) assessed the potential risks of burial practices on groundwater quality in Benue State, north-central Nigeria. The result of the water chemistry analyses revealed phenol concentrations significantly higher than the drinking water limit. Going by the NSDWQ (2015) set limit of 0.001 mg/L, more than half (57%) of the 14 samples are significantly phenol contaminated which may be suggestive of graveyard influence.

Writing on burial Practice and its effect on groundwater pollution in Maiduguri, Nigeria, Turajo and Dammo, (2019) investigated the effects of burial practices on groundwater within the vicinity of an active municipal cemetery in the Gwange area of the Maiduguri metropolis. Groundwater quality measurement from boreholes located at varying radial distances from the cemetery was conducted. The result revealed high levels of pH (9.5), EC (1874 μs/cm), NO_3 (67.4 mg/l), NO_2 (0.92 mg/l), PO_4 (344.5 mg/l), and NH_4 (1.03 mg/l) in groundwater samples. Didia and Weje (2020) carried out a survey on the effects of refuse dump on ground water Quality within the Rivers State University Campus, Port Harcourt, Nigeria. Their findings showed that there is variation in the values of parameters for bore holes at the dumpsite compared to those away all of which fell short of the WHO and Standard Organization of Nigeria minimum requirement for drinking water. These variations were attributed to the effect of wastes dump close to this water source.

Idehen, and Ezenwa (2019) investigated the impact of burial practices on water quality in Benin City, Nigeria. Groundwater samples were collected from boreholes located by the peripheral area of Third Cemetery in Benin City and a reference site approximately 4 km away using standard methods. Their findings indicates that with the exception of SO4, CaCO3, Fe and DO, the concentrations of other parameters Mn, Cu, Ni, Zn DO, BOD etc) were higher in water samples obtained from the peripheral area of Third Cemetery than that from the reference site. The study recommends the need to reduce the number of people whose death could be linked to consumption of polluted groundwater by paying attention to obvious risk to residents who live close to cemeteries.

To best of our knowledge, no study has been conducted on the possible impacts of Military and Port Harcourt city cemeteries on ground water quality in the study area. This is considered a gap which the present study seeks to fill.

4. Methods and materials

This research adopted the quantitative paradigm while the research design is quasi experimental research design. The study relied on Primary Data obtained through direct observation by the researchers, and water samples collected at designated point within the study area.

To delineate our sampling area (settlements), concentric rings of 100 meters apart up to 400 meters radius were introduced into the study area to help guide the sampling points (see figures 3 and 4). Seven water samples were collected in the military cemetery area while six were collected in the Port Harcourt City cemetery area making a total of thirteen sampling points. Samples were collected within the cemetery, ‘Up gradient’ and ‘Down gradients’ in the both cemeteries. A hand-held global positioning system (GPS) was used to locate each sample collection point and geo-referenced.

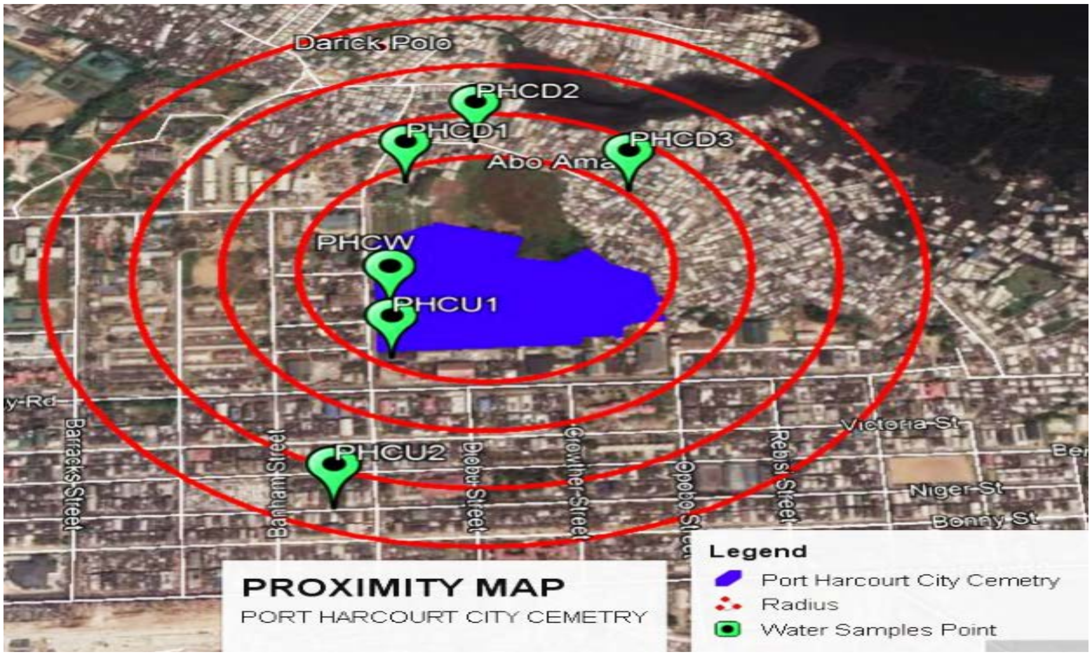

Figure 2: Water Sampling Points at the Port Harcourt City Cemetery Area.

Figure 3: Water Sampling Points at the Port Harcourt City Cemetery Area.
Source: Authors field work (2021)

To obtain water sample from a borehole, the nozzle of each of the borehole tap was swabbed with cotton wool soaked in 70% ethanol. The tap was turned on and allowed to run for two minutes after which, sterilized containers were carefully uncapped and held under the running tap.

To collect sample water from a well, a clean rope was tied to the neck of the sample bottles. A sample bottle was tied to a piece of iron with clear masking tape (to enable easy sinking) and lowered in the well. Next, the filled bottle was carefully decanted into smaller sample bottles. The samples were labeled at the collection points, preserved in ice packed coolers and transported to the Institute of Pollution Studies in Rivers State University laboratories for physicochemical and Bacteriological analysis. Water samples were collected in one phase.

The Water Parameters measured include: pH, Total Hardness, Nitrate (**NO_3)**, Calcium (Ca), Sulfate (SO_4^2), Sodium (Na), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Lead (pb), Total Coliform Bacteria, Fecal Coliform Bacteria and Total Heterotrophic Bacteria (THB)

The standard for measuring the water parameter is the World Health Organization Standards Guidelines for Drinking Water Quality fourth edition (2017); the Nigerian Standard for Drinking Water Quality (NSDWQ).

The Procedures/Test methods used to analyze chemical parameters included: Atomic absorption spectroscopy (AAS), Turbidimetry, Winkler's method etc. Atomic Absorption Spectroscopy (AAS) is a technique used to determine metals and measure the concentration of solutes in solution. Titration also known as volumetric analysis is a common laboratory technique of quantitative chemical analysis that is used to determine the unknown concentration of an identified analyte. In Determining and enumeration of Total Bacterial Count, Lactose broth medium were used for cultivation of bacteria. Bacterial count was achieved with the method of serial dilution, spread plate method and physical counting of the coliform forming units.

To determine if the physioco-chemical characteristics of water in the area changes as one move away from the cemetery, the distance of each point in kilometer was determined while the Pearson Product Moment correlation technique (PPMC) was used to ascertain if there is any relationship between water characteristics and distance from cemetery. Findings of research were presented in charts, tables to enhance understanding.

5. Result and discussion

Table 1 is the result of water analysis and WHO allowable limit for the various water parameters investigated for military and Port Harcourt city cemeteries respectively. From the result, it was observed that the values of the various water parameters investigated varied in both Military and Port Harcourt city cemeteries. The water analysis revealed that most parameters examined (Calcium, Sulfate, Nitrate, Coliform bacteria colonies etc.) except for Lead and heterotrophic bacteria were within the WHO standard for potable water.

Further investigation indicates that for calcium the values obtained from the field ranges from < 0.001-31.81mg/l as against WHO recommended value for calcium in drinking water of 200-

300mg/l. (Figure 5). The low values of calcium may be ascribed to low calcium in the soil at the aquifer level.

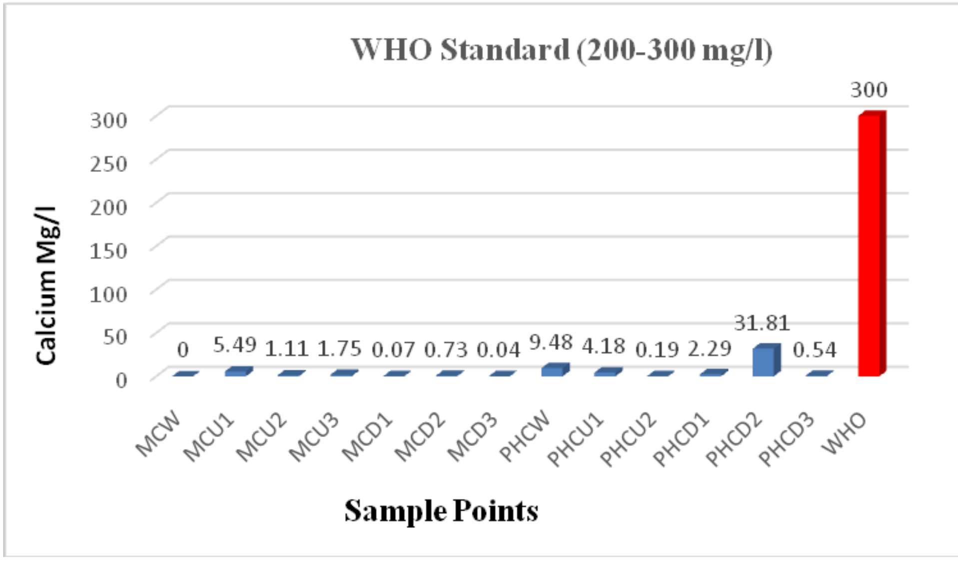

Figure 5: Values of Calcium in Water in the Study Area

Source: Researcher's Field work, (2021)

For Nitrate, the values obtained ranges from 0.61 to 2.71 mg/l while WHO recommended maximum value for Nitrate in drinking water of 50mg/l. These values are low and desirable. These levels may be attributed to low nitrate in the soil at the aquifer level. As the depth of the soil increases, the concentration of the leachates decreases. The low nitrate level implies that there is no health threat resulting from nitrate related contamination (figure 6).

Table 1: Physioco-Chemical Parameters of water samples in Port Harcourt metropolis

S/N	SAMPLE Code	Sample Physico-Chemical Parameters						
		SAMPLE Coordinates	**PH**	**BOD mg/l**	**COD mg/l**	**Nitrate mg/l**	**Sulfate mg/l**	**Calcium Mg/l**
WHO Standards			6.5-8.5	6-9	7.5	50	200	200
NDWS 2015			6.5-8.5	-	-	50	100	-
1	MCW	N-0278884 E-0533695	4.65	3.5	19.20	1.40	5.1	<0.001
2	MCU_1	N-0278647 E-0533794	6.47	2.5	9.60	2.15	4.1	5.49
3	MCU_2	N-0278473 E-0533489	4.64	4.2	41.60	1.47	7.5	1.11
4	MCU_3	N-0278297 E-0533624	4.69	1.5	2.02	2.38	2.0	1.75
5	MCD_1	N-0279100 E-0533800	4.83	1.5	2.41	2.71	0.9	0.07
6	MCD_2	N-0279205 E-0533774	6.69	3.0	28.80	2.15	0.1	0.73
7	MCD_3	N-0279431 E-0533757	5.21	2.5	28.80	0.62	-0.6	0.04
8	PHCW	N-0281130 E-0526733	4.33	6.0	28.80	2.70	4.5	9.48

9	$PHCU_1$	N-0281133 E-0526713	4.30	4.5	18.00	2.79	6.2	4.18
10	$PHCU_2$	N-0281097 E-0526458	6.00	1.5	3.83	1.63	7.6	0.19
11	$PHCD_1$	N-0281163 E-0527050	5.49	2.0	3.20	1.59	3.4	2.29
12	$PHCD_2$	N-0281242 E-0527131	4.71	9.0	67.20	1.14	23.5	31.81
13	$PHCD_3$	N-0281420 E-0527035	4.66	2.0	3.19	0.61	0.6	0.54

Note: < = Less than detection limit
Source: Researcher's Field Survey, (2021)

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Table 1: Physioco-Chemical Parameters of water samples in Port Harcourt metropolis (contd)

S/ N	SAMPLE Code	SAMPLE GPS Coordinates	Sodium mg/l	Total Hardness Mg/l	Lead Mg/l	THB (MPN/100ml)	TCB (MPN/100ml)	TFB (MPN/100ml)
WHO Standards			200	100-300	0.01	-	0	0
1	MCW	N-0278884 E-0533695	26.34	2.4	0.832	145	Nil	Nil
2	MCU_1	N-0278647 E-0533794	29.15	16.3	0.289	9	Nil	Nil
3	MCU_2	N-0278473 E-0533489	20.34	6.3	0.255	1	Nil	Nil
4	MCU_3	N-0278297 E-0533624	13.14	7.2	0.679	107	Nil	Nil
5	MCD_1	N-0279100 E-0533800	25.57	1.8	0.411	145	Nil	Nil
6	MCD_2	N-0279205 E-0533774	21.57	3.2	0.073	3	Nil	Nil
7	MCD_3	N-0279431 E-0533757	17.96	2.2	0.193	O	Nil	Nil
8	PHCW	N-0281130 E-0526733	15.41	29.9	0.418	1	Nil	Nil

9	$PHCU_1$	N-0281133 E-0526713	33.40	16.1	0.270	0	Nil	Nil
10	$PHCU_2$	N-0281097 E-0526458	57.20	21.7	0.439	0	Nil	Nil
11	$PHCD_1$	N-0281163 E-0527050	5.49	22.2	0.509	1	Nil	Nil
12	$PHCD_2$	N-0281242 E-0527131	4.71	89.0	0.297	3	Nil	Nil
13	PHCD3	N-0281420 E-0527035	4.66	3.9	0.379	3	Nil	Nil

Note: TCB = Total Coliform Bacteria, FCB = Fecal Coliform Bacteria, THB = Total Heterotrophic Bacteria.
Source: Researcher’s Field Survey, (2021)

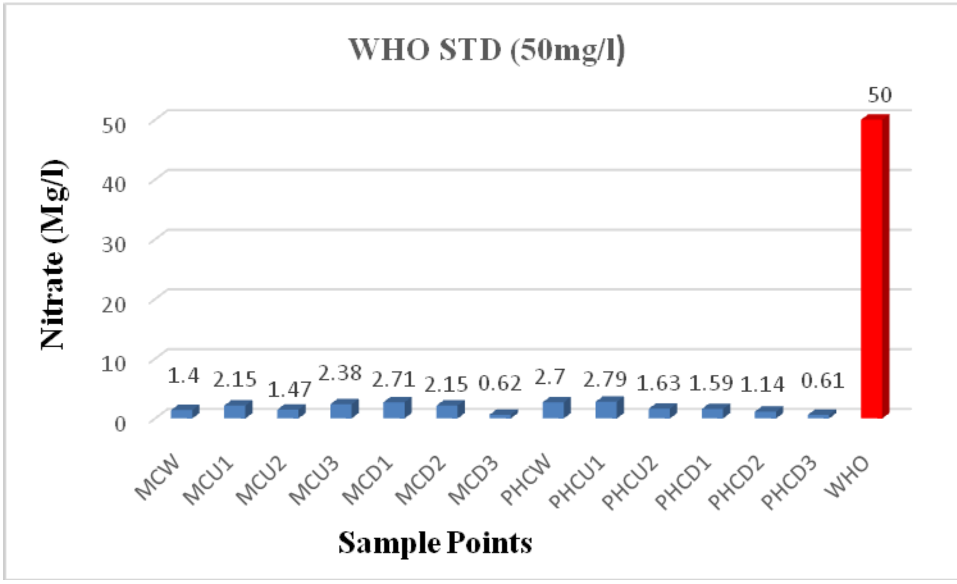

Figure 6: Values of Nitrate in water in Study Area
Source: Researcher's fieldwork (2021)

WHO recommended value for sodium in drinking water is 200-300mg/l. Values above WHO recommended value are considered dangerous. Sodium values obtained from the site ranges from 13.14 to 36.67g/l as seen in figure 7. These levels may be attributed to low Sodium in the soil at the aquifer level.

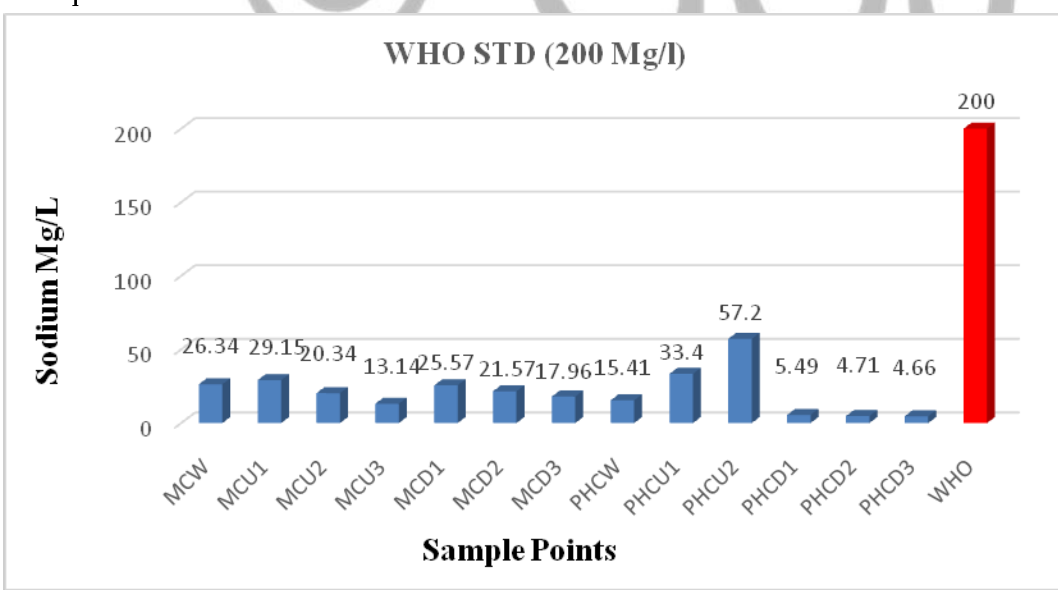

Figure 7: Values of Sodium in Water in the Study Area
Source: Researcher's fieldwork (2021)

The WHO recommended value for sulfate in drinking water is 200mg/l. In the study area, the concentration of sulfate in the water samples ranges from 0.6 to 23.5 (figure 8). These values are low and desirable. Consequently, there is no health threat related to sulfate contamination.

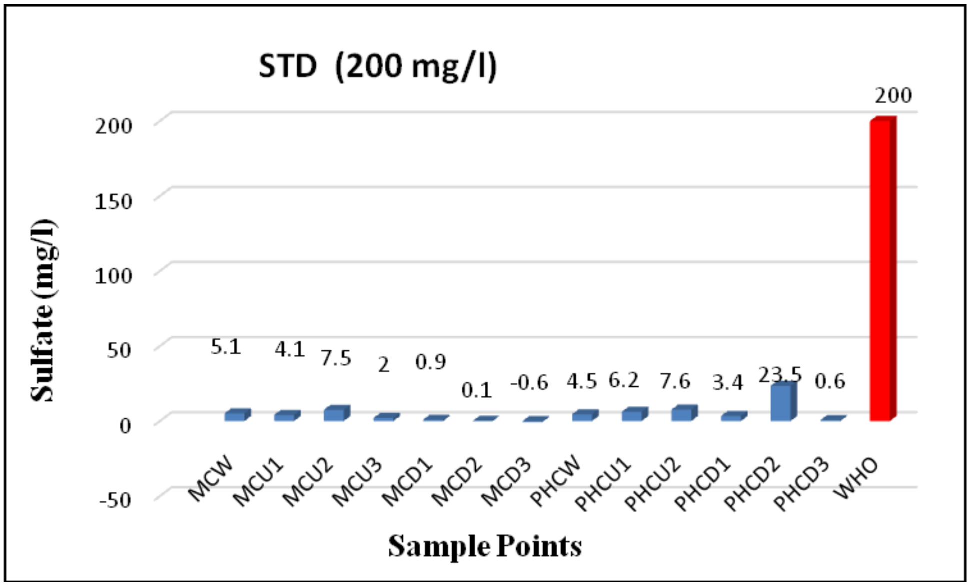

Figure 8: Values of Total Sulfate in water in Study Area

Source: Researcher's fieldwork, (2021)

WHO permissible pH limits is 6.5 to 8.5. The values measured at the different sampled points ranges from 4.30 to 6.69. This result means that water samples measured are acidic. All water sampled do not meet the WHO standard except in Military Cemetery Down gradient 2 (MCD_2), (figure 9) in green pyramid. Water pH is not contamination; rather, it is state of how acidic or alkaline water is. Acidic water is not potable, it is unsafe to drink.

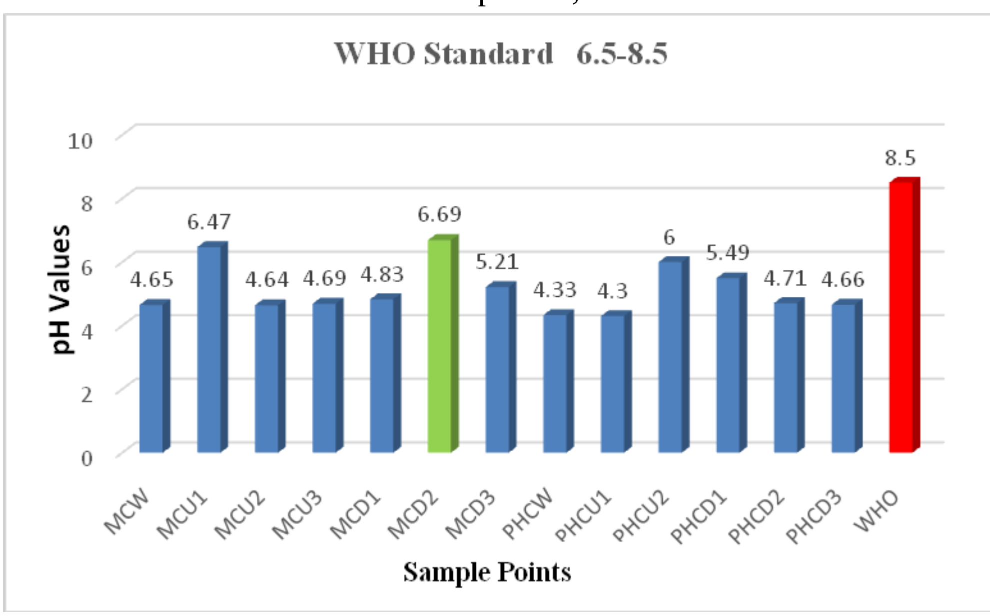

Figure 9: Values of PH of Water in the Study Area

Source: Researcher's Field work, (2021).

Water hardness is the traditional measure of the capacity of water to react with soap. The hardness of water is determined primarily by the amount of calcium and magnesium it contains (WHO 2011). WHO permissible limit is 100-300 mg/l. Values obtained from the study areas ranges from 1.8mg/l to 89.0 mg/l. These values are within the recommended WHO standard. The very low concentration of hardness in water may be due to low levels of calcium and magnesium in the soil at the aquifer level. Though the sample values fall below recommended WHO standard, these values fall within soft water range except sample point PHCD2 which is considered moderately hard. General guidelines for classification of waters hardness are: 0 to 60 mg/L (milligrams per liter) as calcium carbonate is classified as soft; 61 to 120 mg/L as moderately hard; 121 to 180 mg/L as hard; and more than 180 mg/L as very hard (USGS, 2020).
BOD is a measure of the amount of oxygen required to decompose sewage and other organic matter present in a water sample. The recommended range for BOD is 6-9mg/l (Onwugbara,2013). BOD values in the study area ranges from 1.5mg/l to 9.0mg/l (Figure 10). This may be attributed to low level of organic wastes in the water of this area or as a result of the depth at which the water is abstracted which may be far from sources of organic wastes.

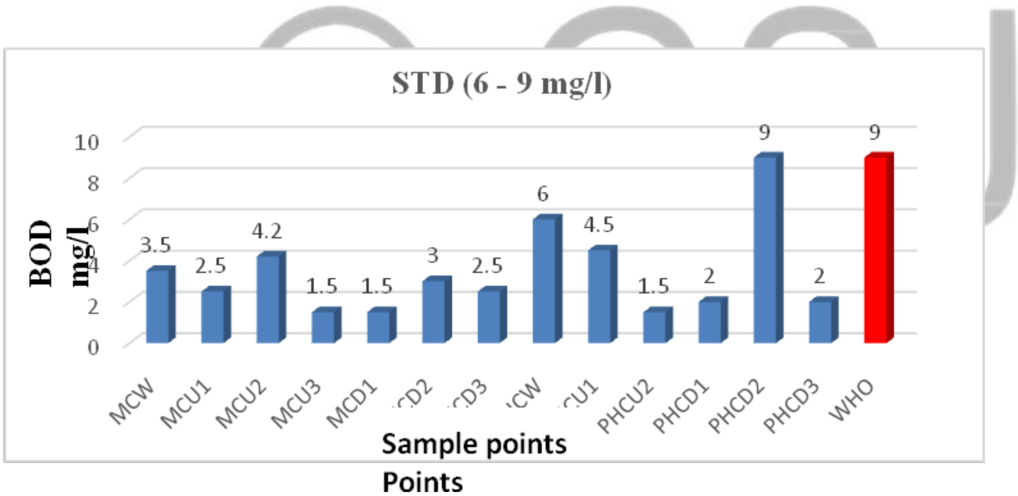

Figure 10: Values of Biochemical Oxygen Demand in Water in the Study Area
Source: Researcher's Field work, (2021)

With respect to Chemical Oxygen Demand COD values obtained ranges from 2.02mg/l to 67.20 while WHO recommended range for COD is 7.5mg/l.(figure 11). The yellow pyramids represent values that are within the recommended range while the blue pyramids represent values above the recommended range. This distribution means that there is some level of contamination in samples with high COD value. High COD value in a water source reveals a deterioration of water quality. COD level in water reveals toxicity and the inadequacy of oxygen available in the water samples (Narasimha et al., 2011). Areas with values greater than the WHO recommended values may have some level of toxicity of chemicals.

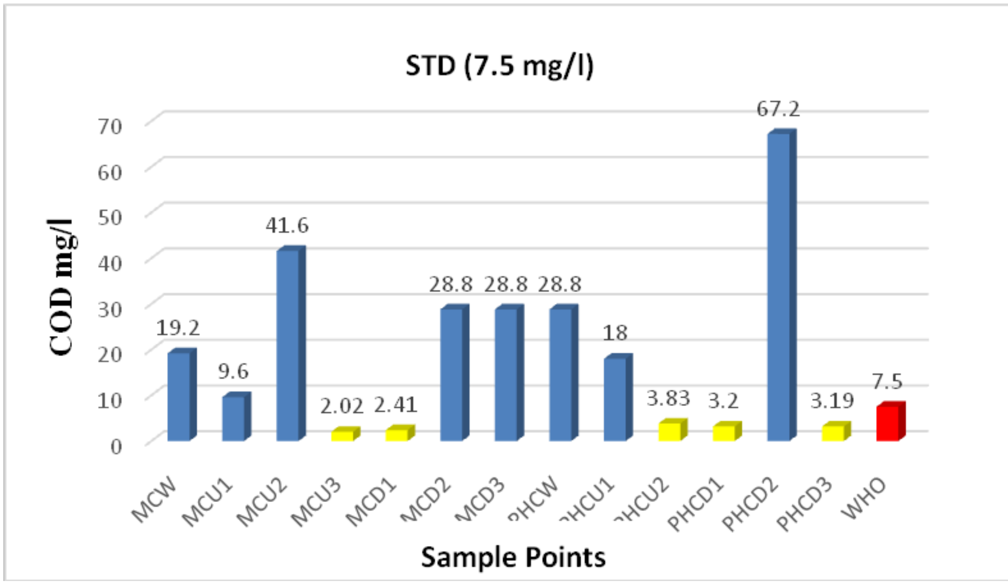

Figure 11: Values of Chemical Oxygen Demand in water in the Study Area
Source: Researcher's Field work,(2021)

WHO recommends 0.01 mg/l as the maximum limit of lead in drinking water. The concentration of lead in the water samples in the study area ranges from 0.073mg/l to 0.832 mg/l (figure 12). All water samples investigated had lead values in excess of WHO recommended values and therefore does not meet standard for good quality drinking water.

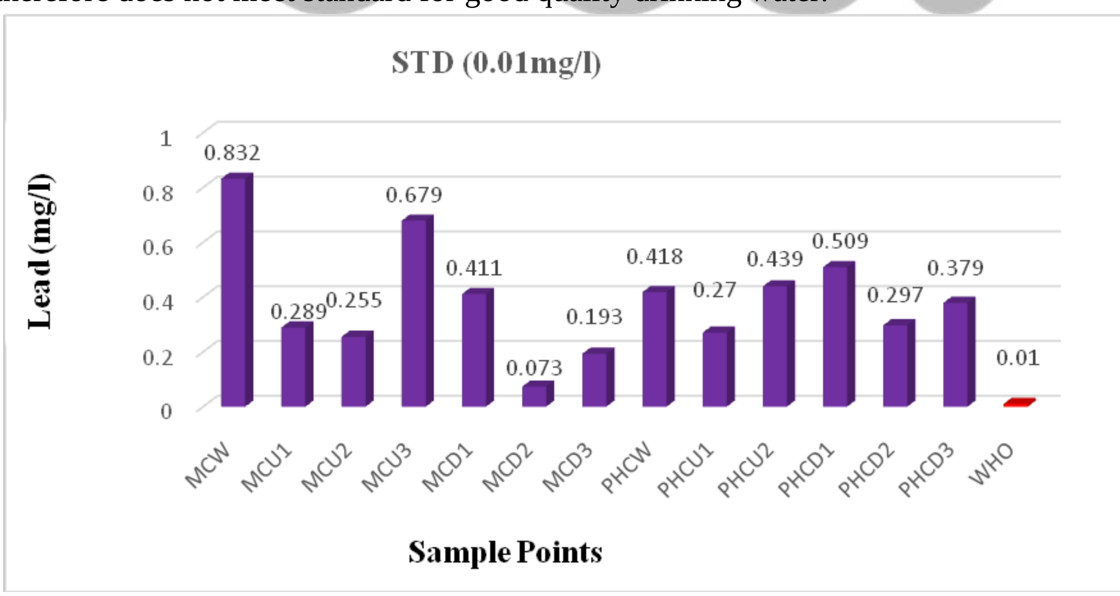

Figure 12: Values of Lead in Water in Study Area
Source: Researcher's fieldwork (2021)

for coli form the acceptable level of coliform forming unit in drinking water is zero coliform per milliliters (0/100 ml) according to WHO Standard of 2011. In the study area, there are no coliforms detected,

Ordinarily, one should expect that the physico-chemical properties of water will change as one move away from the cemetery area. To examine this, the Pearson Product Moment Correlation (PPMC) statistical technique was used. The tested hypothesis is of the form:

H_o: There is no significant relationship between the physiochemical properties of water and distance from the cemetery.

H_1: There is.

Using the Pearson Product Moment Correlation, a correlation co-efficient of 0.13 was obtained indicating a positive but weak relationship between the dependent variable (distance) and independent variable (physico-chemical properties of water). The calculated t-value of 0.25 was obtained as against the t-critical value of 2.29 at 0.05 significant levels and 9 degree of freedom.
Arising from the above, since the t-calculated value of (0.25) is less than the t-critical value of (2.29) at 0.05 significant level, the Null hypothesis is upheld. The conclusion therefore is that there is no significant relationship between the physiochemical properties of water and distance from the cemetery.
This finding is constituent with the values earlier obtained for the various water parameters

Conclusion and recommendations

This study examined the impact of cemetery on the physioco-chemical properties of water in Port Harcourt metropolis. Findings from the study indicate that most of the water parameters examined were within the WHO allowable limits with exception of lead, COD and acidity.
Although, findings revealed contamination of Lead, it was not certain if the cemetery is the source of contamination, giving that all other parameters measured were within WHO recommended range. The discovery of high lead elevation in the study area is in consonance with Egbimhanlu, Sophia, Korede, Adenike, Adegboyega, Omonigho and Efeovbokhan (2020), study of Ayobo cemetery Lagos where an elevated lead concentration was also observed.

More so, findings also indicated that there is no change in physioco-chemical properties of water as one moves away from the cemetery area implying that the presence of cemetery have no adverse effect on water characteristics in the study area.
The presence of lead, high level of acidity, COD and hardness in the water around the cemetery have some implications that must not be over looked. The elevated nature of these compounds beyond the WHO allowable limit means that residents of cemetery area will have to spend more money in treating their water to prevent health anomalies resulting from drinking contaminated water.

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