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EFFECT OF SOLID WASTE DUMP ON THE QUALITY OF SURFACE WATER (A CASE STUDY OF INE-RIVER IN UGWUAJI, ENUGU SOUTH LOCAL GOVERNMENT AREA IN ENUGU STATE)

[1]Engr. Dr. Odenigbo Celestine Emeka
[1]Department of Civil Engineering, Enugu State University of Science and Technology.

ABSTRACT: The presence of chemicals in surface water and drinking water is an important factor in determining the risk posed by landfills sites. This study assessed the concentrations of physio-chemical, bacteriological parameters and heavy metals in surface water quality from the dumpsite at Ugwuaji, Enugu South Local Government Area in Enugu state. Specifically, the study assessed the concentrations of physical parameters, chemical parameters, bacteriological parameters, and heavy metals in the surface water at the dumpsite and compared their level of compliance with WHO and NSDWQ standards. The study used eight (8) surface water samples collected at varying distances: 0m, 10m, 20m, 30m, 40m, 50m, and 60m respectively away from the dumpsite, and one control sample collected at 15m upstream from the dumpsite. Nine (9) physical parameters including temperature, turbidity, taste, colour, odour, electrical conductivity, total dissolved solids, total suspended solids, and total solids; eleven (11) chemical parameters: pH, acidity, alkalinity, calcium hardness, magnesium hardness, total hardness, chloride, nitrate, phosphate, sulphate and dissolved oxygen; ten (10) heavy metals: Mn, Zn, Cu, Mg, Pb, Fe, Cr, As, Cd and Al; and three (3) bacteriological parameters: E. Coli, total coliform and total plate count e35i after 24hours. Statistical tools employed in the data analyses were descriptive statistics: mean and standard deviations, and inferential student's t-test. The data analysis was aided by Statistical Package for Social Sciences (SPSS) version 25.0. All examined parameters in each sample in relation to distance from the landfill and varying levels of concentration were presented in graphical format. Result shows that many constituents in the water exceeded the control limit thereby making the water not drinkable by the people within the vicinity. Based on these findings, the study suggested that the water should be treated properly before consumption. Also, since there are high concentrations of heavy metals in the water samples, it was recommended that human consumption of the water is very dangerous to human health.

KEYWORD: Percolation, Infiltration, Leachate, Hazardous Wastes, Aquifers, Waste Prevention, Waste Re-Use, Waste Recycles, Dumpsites, Physico-Chemical

I. INTRODUCTION

Waste is anything, which is no longer of use to the disposer. It can also be defined as any unavoidable material resulting from an activity, which has no immediate economic demand and which must be disposed of (Uroupa et al., 2020). Waste is commonly classified into three. These are solid waste, liquid waste and gaseous wastes. Solid waste has become an important issue in Nigeria. Piles of wastes are often found by roads, rivers and many other open spaces in cities, and this is causing significant health and environmental problems. The urban population is growing at an alarming rate. While the Nigerian population is increasing by about 2.8% per annum, the rate of urban growth is as high as 5.5% per annum (Imam et al., 2007).

Solid wastes are residual from homes, businesses and institutions and referred to as trash, garbage, rubbish, refuse, discards and throwaways that are no longer of any relevance to the disposer. For example, broken bricks, broken glass and bottles, can, plastics, paper, battery casings, plantain skin, and nylon (Hassein et al., 2018; Adedibu, 1982). Liquid wastes are waste dissolved in water emanating from industrial processes known as effluent, domestic liquid, acid waste and waste oil from workshop (Uroupa et al., 2020).

Gaseous wastes are waste substances like air (neither solid nor liquid) that move freely to fill any available space. Examples are wastes resulting from gas flaring, particulate dust, waste gases from stack, cement factories, stone crushing excavation activities, lime dust, asbestos dust, acid fumes and cigarette fumes, cigarette, smoke from motor exhaust, smoke from burning firewood and smoke from incinerator (Uroupa et al., 2020).

Open dumping of solid waste remain the prevailing form of waste disposal in developing countries like Nigeria. Contamination of water bodies has become an issue of serious environmental concern (Akpoveta et al., 2010)

Solid wastes comprises all the waste arising from human and animal activities that are normally solid, discarded as useless or unwanted materials or substances that are left or discarded after use, also included are by-products of process lines or materials that may be required by law to be disposed off (Okecha, 2000). Solid waste can be classified in a number of ways, on the basis of source, environmental risks, utility and physical property. On the basis of source which is commonly used, solid wastes are classified as: municipal solid wastes, industrial solid wastes, agricultural solid wastes, mining and mineral wastes, construction and demolition wastes, healthcare wastes, radioactive (Nuclear) wastes, human and animal wastes and these concentrations were high because of lack awareness, lack of treatment facilities, lack of regulation of waste disposal and mismanagement in the infrastructure of water distribution (Yu Shuang Ren. et al, 2022).

The generation of solid waste from household, industries, markets, abattoir and shops result in improving the standard of living of the inhabitants. These solid wastes can as well contaminate ground water (Agwu & Njoku, 2017). Improper management of municipal solid waste serves as a breeding ground for diseases, vectors and contribute to global climatic change through methane generation and can even promote urban violence (World Bank, 2022). Disposing these wastes can be very tasking and have been a major problem in developing countries, and in some developing countries these wastes are left uncollected. It takes a well-organized environment to inculcate the habit of healthy disposal of our Municipal waste, but irrespective of that, we should put into consideration the harm we are causing if Municipal solid waste is not properly disposed. These leachates consist largely of solids, microbial organisms and in some situations chemicals and shallow wells are more dangerously polluted (Agwu & Njoku, 2017).

Since urban population is increasing due to various factors like better employment opportunities, and concentration of industries than the rural areas. Municipal solid waste management gets the lowest priority, mainly because disruptions and deficiencies in it do not directly and immediately affect public life and cause public reaction (Gwisai et al., 2019).

Assessment of water quality and some Compounds that affect ground water quality are considered with the analysis of these physical, chemical and biological parameters of ground water. It is a common situation in the African continent that majority of the people are living in environments where the available water resources do not meet global standard (Sawyerr et al., 2017). Surface water is the commonest potable source around the world. The chemical composition of surface water is an indicator of how suitable it is for the consumption, for human beings, animals and plants (Batabyal & Chakraborty, 2015).

Man's activities on the environment often results in pollution and degradation. Sustainable utilization of the world's resources and conservation for future generation requires prevention and control of pollution and degradation (Agunwamba, 2001). One of the areas of primary interest is surface water pollution.

Lack of proper municipal bodies to manage the solid waste generated from residential, commercial and institutional activities, therefore the populace decided to dump their solid waste in any available space within the community, by so doing it get accumulated with time. Therefore, supply of adequate fresh water in large quantity to meet the increasing population's demand and maintaining the quality is now a thing of concern (Elinge et al., 2011). The chemical composition of groundwater is an indicator of how suitable it is for the consumption, for human beings, animals and plants. Hence, contamination of ground water through the infiltration of leachates via the soil and rocks needs to be avoided. It normally takes many years and takes place within a particular distance from the dump site. Since pipe borne water is not readily available in many parts of the country and even in the urban areas the pipe water supply is not adequate (Adelekan, 2010). With these problems there is need for another source of water supplies which is ground water, but due to lack of proper waste management control the surface water is usually affected by the refuse dump site. Water is said to be polluted when the water body is adversely affected by both the organic and inorganic contaminants (Oliver & Ismaila, 2011).

Waste is generated universally and is a direct consequence of all human activities. The disposal of solid waste into the landfill has been recognized as the major source of surface water contamination. Waste disposal by landfill has led to the pollution of surface water resources under a wide range of condition around the globe (Ntambi et al., 2020). Realistically, there are no ways of dealing with waste that have not been known for many years. Essentially, incineration, source reduction, recycling, composting and landfills usually are common with potential technology and capability of the concern society. The depression into which solid wastes are often dumped include valleys, old quarries sites, excavations, or a selected portion within the residential and commercial areas in many urban settlement where the capacity to collect, process, dispose of, or re-use solid waste in a cost-efficient, safer manner is limited (Chodaton Zinsou Marthe Dominique, et al, 2022). Landfills have historically been the primary method of waste disposal due to its convenience and the threat of surface water contamination was not initially recognized. However, the landfill of today is far different from a simple hole in the ground into which garbage is dump in developed nations. A landfill is a system that is designed and constructed to dispose of discarded waste by burial in land to minimize the release of contaminants to the environment. Hence, waste is generated universally and is a direct consequence of all human activities. Also wherever people exist, waste must be generated and managed either fully or partially. And its rate of generation corresponds roughly with levels of income (Olusegun et al., 2018).

II. LITERATURE REVIEW

2.1 PHILOSOPHY OF WATER

Water is the most abundant environmental resource on earth but its accessibility is based on quality and quantity, as well as space and time. Water is the most relevant natural resources to the existence of man. Without it nothing would survive on the earth. The volume of water which is available in portable forms is found in water from the ground, springs, rivers and lakes, the proportion of which is only about 3% (Behailu et al., 2017). It may be available in various forms and quantity but its use for various purposes is the subject of quality. About 70% of the human body and about 60-70% of plant cells is made up of water (Smith & Edger, 2022).

It is one of the determinants of human settlement, existence and activities on the earth. Its quantity is fixed but dynamic in formation and storage. Of all the environmental concerns that developing countries face, the lack of adequate, good quality water remains the most serious (Markandya, 2004). Water is a substance composed of the chemical elements hydrogen and oxygen and existing in various forms like gaseous, liquid, and solid states. It is one of the most plentiful and essential of compounds. As a tasteless and odourless liquid at room temperature, it has the important ability to dissolve many other substances. Once contaminated, surface water may forever remain polluted without remedy or treatment. Water is one of the main determinants of human earth system. Diseases may spring up through water pollution, especially surface water contamination, and rapidly spread beyond human expectation because of its flow mechanism (Afolayan et al., 2012). One of the major factors that make the earth habitable for humans is the presence of water. Forming the major component of plant and animal cells, it is the basis of life and therefore the development of water resources is an important component in the integrated development of any area.

Water is critical to our daily lives and is an extraordinary compound in nature. It covers 71% of Earth (USGS, 2019). Water is the most important resource of a country, and of the entire society, since no life is possible without water. It has this unique position among other natural resources, because a country can survive in the absence of any other resource, except water (Garg, 2009).

According to the National Water Policy (2020), in the planning and operation of systems, water allocation priorities should be broadly as follows: drinking, recreation, pollution, control, irrigation, hydropower, ecology, agro-industries and non-agricultural industries, navigation and other uses.

About 68.7% of the fresh water is tied up in polar ice caps and glaciers, and a further 30.1% is underground as groundwater, most of which is not available for use (Gleick, 1996). Rivers and lakes constitute a mere 0.32%, atmospheric moisture 0.03% and soil moisture 0.05%.The major sources of water are surface water (oceans, rivers, streams, seas and brooks), groundwater, snow and ice, and lakes. However their exploration and exploitation varies from place to place based on their state of existence. Groundwater plays a vital role for urban and agricultural water supply. It accounts for about 0.5% of total hydrosphere, approximately 6.73 x10km3 in volume (Ayoade, 2003). It constitutes a major portion of the earth’s water circulatory system known as hydrological cycle and occurs in permeable geologic formation known as aquifers i.e. formations having structure that can store and transmit water at rates fast enough to supply reasonable amounts to wells mount on it (Afolayan et al., 2012).

Wastes of different types, mostly solid wastes are the major input of dumpsites/landfills. With respect to the hydrological analysis of surface water, it flows from areas of higher topography towards areas of lower topography, thereby bringing about the examination of the degradable material which form leachate and contaminate the surface water of the study area.

If the population growth, standard of living, and productivity are in line with consumption and waste generation, waste receiving reservoir (landfill) is likely to remain and continue to be a crucial point source of surface water pollution, unless sanitary landfills are provided. Landfill is a practice adopted as a substitute to ocean outfall of sewage, domestic and industrial waste, after the outlawing and termination of the latter due to its effect on the lives in the ocean (Ogundiran & Afolabi, 2008). Rapid population growth through urbanization and industrialization is one of the major factors responsible for increased Municipal Solid Waste (MSW). Increasing population, industrialization and changing consumption pattern are resulting in the generation of increasing amounts of solid waste and diversification of the type of the solid waste generated.

According to Afolayan et al. (2012), the environmental degradation caused by inadequate disposal of waste can be expressed by the contamination of surface and groundwater through leachate, soil contamination through direct waste contact or leachate, air pollution by burning of wastes, spreading of diseases by different vectors like birds, insects, rodents or uncontrolled release of methane by anaerobic decomposition of waste. In less developed countries, almost 100 per cent of their Municipal Solid Waste is land filled.

It was also documented in literature that about 87% of Nigerian allegedly used unsanitary disposal system (Oyekan & Sulyman, 2015). These wastes could be transported by runoff during precipitation into pits and drainage (Babayemi & Dauda, 2009; Michael, 2018), or even infiltrates through the soil which they constitute major environmental problems like surface water pollution (Kola-Olusanya, 2012). The volume of waste generated is largely attributed to several compounding factors which includes; population density, income, urbanization, industrialization, attitude and legislation of the catchment area (Adedibu, 1986).

Uncontrolled dumping of municipal solid waste particularly in non-engineered open dumps is a major practice in many developing countries. In particular, inadequate solid waste management is a major environmental problem in Lagos metropolis where properly designed waste facilities are inexistent (Ikem et al., 2002; Sangare et al., 2018; Oyelami et al., 2013). Wastes are typically deposited in non-engineered dumpsites from where emanating leachates containing dissolved organic matters, inorganic compounds (such as ammonium, calcium, magnesium, sodium, potassium, iron, sulphates, chlorides and heavy metals like cadmium, chromium, copper, lead, zinc and nickel).The concentration of these substances in leachate are subject to large variation (Agunwamba, 2001), and xenobiotic organic substances can enter the soils to pollute surface and ground water.

Surface water is a valuable resource often used for industry, commerce, agriculture and most importantly for drinking. Often, the raw water used for domestic purposes is vulnerable to contamination due to the human influence resulting in pollution. Surface water pollution is mainly due to the process of industrialisation and urbanisation that has progressively developed over time without any regard for environmental consequences (Ahmed-Rashed, 2018). In recent times, the impact of leachate on surface water and other water resources has attracted a lot of attention because of its overwhelming environmental significance. Leachate migration from wastes sites or landfills and the release of pollutants from sediments (under certain conditions) pose a high risk to the surface water resources if not adequately managed (Ikem et al., 2002).

Surface water protection is a major environmental issue. Open dumps are the oldest and most common way of disposing solid wastes, and although in recent years thousands of them have been closed, many are still being used (Al-Sabahi et al., 2009). The frequently used municipal solid waste disposal methods include: composting, sanitary landfill, and pyrolysis, reuse recovery, incinerator and recycling (USEPA, 2007). Waste management has become increasingly complex due to the increase in human population, industrial and technological revolutions while the processes that control the fate of wastes in the soil are complex and many of them are poorly understood. Issues such as nutrients and other chemicals release rates, leaching of nutrients and metals through macropores as suspended solids, and sludge organic matter effects on the sorption degradation are often not understood by many researchers (Mohammed et al., 2009). The leaching of hydrophobic organics, long term bioavailability, and fate of metals fixed by soil organic matter need to be studied to gain a better approach in surfacewater pollution handling (Ikem et al., 2002).

Toxic chemicals that have high concentrations of nitrate and phosphate derived from the waste in the soil can filter through the dump and contaminate both the ground and surface water. Insects, rodents, snakes, scavenger birds, dust, noise, or bad odour are some of the aesthetic problems associated with sanitary landfills. Emissions of methane (CH_4), carbon IV oxide (CO_2) and leachate contamination of ground water are the environmental issue. The volume of solid waste generated in Enugu, South eastern Nigeria has increased significantly over time from the estimated quantity of 60,000 metric tons per year in 1996 to 75,000 metric tons in 2006 because of the increasing population as well as the industrial and economic development. The total assessment revealed that about 80% of the total waste is organic in nature, followed by 15.72% of plastic/nylon, and about 1% of metal (Olanrewaju & Ilemobade, 2009).

Surface water forms that part of the natural water cycle present within underground strata or aquifers. Unfortunately, groundwater is all too often considered out of sight and out of mind. Of the global quantity of available freshwater, more than 98% is groundwater stored in pores and fractures of rock strata. Surface water is also an important source for industry and agriculture uses as well as Recharge Rivers experiencing low flows. Groundwater is not only abstracted for supply or river regulated purposes, it also naturally feeds surface-waters through springs and passages into rivers and it is often important in supporting wetlands and their ecosystems.

Removal or diversion of surface water can affect total flow. A reduction in either quality or quantity of the discharging groundwater can significantly influence surface water quality and the attainment of water quality standards. Surface water and groundwater are therefore intimately linked in the water cycle, with many common issues. The protection of surface water quality is of paramount importance. If surface water becomes polluted, it is difficult, if not impossible, to rehabilitate. The slow rate of groundwater flow and low microbiological activity limit any self-purification as in case of surface water

The risk of surface water pollution is increasing both from disposal of waste materials and from widespread use by industry and agriculture of potentially polluting chemicals in the environment. Pollution can occur whether discrete, point sources, such as from the landfilling of wastes. Point sources join the pollution transport route at discrete and identifiable locations. Point sources include industrial, sewer networks and treatment plant effluent. Their quality and quantities can be directly measured (Agunwamba, 2001). One of the dreaded consequences of rapid urbanization has been the problem of solid waste management, particularly in terms of environmental nuisance combined with the health hazard and its implications. Waste management has therefore become an endemic problem that characterizes Nigerian cities.

Coupled with the lack of capital and appropriate technology for environmentally friendly waste management practices has left most state governments like Enugu relying on the use of landfills for solid waste disposal. And in most cases the landfills are not properly engineered and operated to accepted world standards. Landfill practices, because of its cost effectiveness have become the most favourable choice particularly in Enugu, after previous attempt at incineration failed. The untreated rubbish being placed in the landfill voids comprises biodegradable solids such as vegetable, paper and metal, inert solids such as glass and plastics and other unclassified materials constitute a great threat to underground water quality.

Such contamination occur through leakage; which is formed when rain water infiltrates the landfill and dissolves the solute fraction of the waste and the soluble product formed as a result of the chemical and biochemical processes occurring within the decaying wastes. The resultant effluent will however impose their Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) on the ground water. Recent studies have shown that the COD and BOD of such wastes may be in the region at 12,000mg/L and 700mg/L respectively with the concentration of inorganic chemical substances like ammonia, iron and manganese varying according to the hydrology of the site and chemical and physical conditions within the site.

The concentration according to a recently emplaced wastes has been put as: Sulphate 460mg/L, Magnesium 390mg/L, Chloride 2100mg/L, Iron 160mg/L, Sodium 2500mg/L and Calcium 1150mg/L. Also, a tip of 1000m^3 of rubbish has been calculated to yield 1.25 tonnes of potassium and sodium, 0.8 tonnes of calcium and magnesium, 0.7 tonnes of chloride, 0.19 tonnes of sulphate and 3.2 tonnes of bicarbonate (Brown et al., 1992). Thus, it can be appreciated that disposal of waste in landfill sites can produce large volumes of effluents with a high pollution potential. For this reason, the location and management of these sites must be carefully controlled.

Enormous amounts of solid waste produced in and around Enugu metropolis areas are dumped nearer to Ugwuaji solid waste landfill site. This municipal solid waste normally termed as “garbage” is an inevitable byproduct of human activity which is disposed through dumping. Solid waste land filling is the most common method of solid waste disposal. The landfill sites nearer to Ugwuaji are open dumpsites, because the open dumpsites have low operating costs and lack of expertise and equipment provided no systems for leachate collections. Open dumps are unsightly, unsanitary, and generally smelly. As leachate percolates through the underlying soil strata of the landfill, many of the chemical and biological constituents originally contained in it, will be removed by the filtering and adsorptive action of the soil strata. The degree of removal of pollutants from the leachate will usually depends on the characteristic of the soil strata, especially its clay content (Santosh & Rajeshwari, 2006). However, because of inherent potential risk involved in allowing leachate to percolate to the groundwater, (even with the removal of some of its organics and chemicals), it is always better to either eliminate the production of leachate or to collect and treat it separately. The unpleasant nature of the dumping site attracts scavenging animals, rats, insects, pigs and other pests. Surface water percolating through the trash can dissolve out or leach harmful chemicals that are then carried away from the dumpsites in surface or subsurface runoff. Among these chemicals heavy metals are particularly insidious and lead to the phenomenon of bioaccumulation and biomagnifications. These heavy metals may constitute an environmental problem, if the leachate migrates into the surface water. The location of the landfill sites closed to the stream threatens to contaminate the surface water.

A water pollutant is a chemical or physical substance present in it at the excessive levels capable of causing harm to living organisms. The physical hazards are the dissolved solids and suspended solids. The chemical hazards are the copper, manganese, lead, cadmium, phosphate, nitrate, etc. As the public health concern, the surface water should be free from physical and chemical hazards. The people in and around the dumping site are depending upon the surface water for drinking and other domestic purposes. The soil pollution arises due to the leaching of wastes from landfills and the most common pollutant involved is the metals like copper, lead, cadmium, mercury etc. The contamination of surface water, ground water and soil is the major environmental risk related to unsanitary land filling of solid waste. The study of impact of solid waste on water quality of Bishnumati and surrounding areas in Kathmandu, Nepal reveals that the river is heavily polluted.

2.2 WATER QUALITY

Caravello et al. (2016) reported that the water quality of rivers in the Khumbu Valley has deteriorated microbiologically as well as chemically. Emmanuela et al. (2010) submit that surface waters of the Khumbu Valley were free of chemical contamination of human origin. According to Caravello et al. (2016), observed alterations of water quality were likely caused by fecal pollution (organic human waste) in correspondence with increased tourism-related anthropic pressures.

Another source of surface water and groundwater contamination with respect to nutrient flows, which are of paramount importance to the condition and development of the ecosystem and organic pollution, derives from livestock rearing and the use of animal organic wastes as agricultural fertilizer. Animal dung is indeed essential as fertilizer to sustain agricultural productivity on thin, fragile mountain soils (Byers & Sainju, 1994). Although, the use of chemical fertilizers is currently still uncommon in SNPBZ, the excrement of around 2000 domestic animals, mainly sheep and yaks living inside the park, is used by local people as organic fertilizer (Watanabe, 2005; Byers, 2005).

2.2.1 WATER QUALITY STANDARDS IN NIGERIA

The Nigerian Standard for Drinking Water Quality (NSDWQ) was approved by the Council of the Standards Organization of Nigeria in 2007 specifying upper and lower limits of contaminants known to pose a risk to the wellbeing of individuals (NIS, 2007). Table 2.1 provides a comparison of the World Health Organization's standard of water quality with that of the Nigerian Standard for Drinking Water Quality. From Table 2.1, minor differences exist between World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ), in the standards of measuring the minimum and maximum concentration of water quality.

Table 2.1 Water quality variables and their standard limits

S/N	Parameter	UNIT	WHO	NSDWQ
1	Temperature	^{O}C	25	NS
2	pH	NS	6.5-8.5	6.6-8.5
3	Electrical conductivity	(µScm-1)	1000	1000
4	Total suspended solid (TSS)	Mg/l	3.0mg/l	Ns
5	Total hardness (TH)	Mg/l	100mg	150mg/l
6	Chloride (Cl^-)	Mg/l	250mg/l	250mg/l
7	Nitrate ($N0_3^-$)	Mg/l	10mg/l	50mg/l
8	Dissolved Oxygen (O_2)	Mg/l	2.0mg/l	Ns
9	Iron (Fe)	Mg/l	0.03mg/l	o.3mg/l
10	Lead (Pb)	Mg/l	0.01mg/l	0.01mg/l
11	Total Acidity	Mg/l	Ns	Ns
12	Total Alkalinity	Mg/L	200mg/l	Ns
13	Sodium (Na^+)	Mg/l		
14	Phosphate(P04-)	Mg/l	5mg/l	Ns
15	Sulphate($S0_3^{-2}$)	Mg/l	250mg/l	100mg/l
16	Copper(Cu)	Mg/l	0.5mg/l	1mg/l
17	Calcium(Ca^{2+})	mg/l	200mg/l	Ns

Source: World Health Organization (2006) and Nigerian Industrial Standard (2007)
Key: NS = Not Specified

2.3 IMPACTS OF SOLID WASTE ON PUBLIC HEALTH AND ASTHETICS

Public health concerns are related primarily to the infestation of the area used for the storage of solid waste with vermin and insect that are often serve as potential reservoir of disease. By far the most effective control measure of both rats and flies is sanitation. Typically, this involves the use of containers with tight lids, the periodic removal of biodegradable materials (usually with less than 8 days) which is especially important in area with warm climates (Yu Shuang Ren et al., 2022). Aesthetic considerations are related to the production of odour and the unsightly conditions can develop when adequate attention is not given to maintain the sanitary conditions. Most odours can be controlled through the use of container with tight lids and with the maintenance of a reasonable collection frequency. If odour persists, the contents of the container can be sprayed as a temporary expedient. To maintain aesthetic conditions the container should be scrubbed and washed periodically (Yu Shuang Ren et al., 2022).

Direct handling of solid waste can result in various types of infections and chronic diseases with the waste worker and the rag picker being the most vulnerable. Hazardous waste are those which are harmful to human health or living organism because of the non-degradability, persistence in nature, ability for biological magnification, lethal and ability to cause detriment cumulative effects. Hazardous waste includes radioactive substances, chemical such as acid and bases; biological waste such as outdated drugs and hypodermic needles (Agunwamba, 2001). In fact, direct exposure can lead to diseases through chemical exposure as the release of chemical into the environment leads to chemical poisoning. Many studies have been carried out in the various parts of the world to establish a connection between health and hazardous waste. Waste from Agriculture and Industries can also cause serious health risks other than this co disposal of industrial hazardous waste with municipal waste can expose people to chemical and radioactive hazards. Uncollected solid waste can also obstruct storm water runoff, resulting in the forming of stagnant water bodies that becomes the breeding ground of diseases. Waste dumped near a water source also causes contamination of the water body or the surface water source. Direct dumping of untreated waste into rivers, seas and lakes results in the accumulation of toxic substances in the food chain through the plant and animal that feeds on it.

Direct handling of solid waste can result in various types of infectious and chronic diseases with the waste workers and the rag pickers being the most vulnerable. Exposure to hazardous waste can affect human health, children being more vulnerable to these pollutants. In fact, direct exposure can lead to diseases through chemical exposure as the release of chemical waste into the environment leads to chemical poisoning. Many studies have been carried out in various parts of the world to establish a connection between health and hazardous waste. Waste from agriculture and industries can also cause serious health risks. Other than this, co-disposal of industrial hazardous waste with municipal waste can expose people to chemical and radioactive hazards. Uncollected solid waste can also obstruct storm water runoff, resulting in the forming of stagnant water bodies that become the breeding ground of disease. Waste dumped near a water source also causes contamination of the water body or the ground water source. Direct dumping of untreated waste in rivers, seas, and lakes result in the accumulation of toxic substances in the food chain through the plants and animals that feed on it.

Disposal of hospital and other medical waste requires special attention since this can create major health hazards. This waste generated from the hospitals, health care centres, medical laboratories, and research centres such as discarded syringe needles, bandages, swabs, plasters, and other types of infectious waste are often disposed with the regular non-infectious waste. Waste treatment and disposal sites can also create health hazards for the neighbourhood. Improperly operated incineration plants cause air pollution and improperly managed and designed landfills attract all types of insects and rodents that spread disease. Ideally these sites should be located at a safe distance from all human settlement. Landfill sites should be well lined and walled by clay liner or synthetic liners to ensure that there is no leakage into the nearby ground water sources (Santosh & Rajeshwari, 2006).

Recycling too carries health risks if proper precautions are not taken. Workers working with waste containing chemical and metals may experience toxic exposure. Disposal of health-care wastes require special attention since it can create major health hazards, such as Hepatitis B and C, through wounds caused by discarded syringes. Rag pickers and others who are involved in scavenging in the waste dumps for items that can be recycled may sustain injuries and come into direct contact with these infectious items. The group at risk from the unscientific disposal of solid waste include – the population in areas where there is no proper waste disposal method, especially the pre-school children; waste workers; and workers in facilities producing toxic and infectious material. Other high-risk group includes population living close to a waste dump and those, whose water supply has become contaminated either due to waste dumping or leakage from landfill sites. Uncollected solid waste also increases risk of injury, and infection. In particular, organic domestic waste poses a serious threat, since they ferment, creating conditions favourable to the survival and growth of microbial pathogens.

2.3.1 DISEASES

Certain chemicals if released untreated, *e.g.* cyanides, mercury, and polychlorinated biphenyls are highly toxic and exposure can lead to disease or death. Some studies have detected excesses of cancer in residents exposed to hazardous waste. Many studies have been carried out in various parts of the world to establish a connection between health and hazardous waste.

2.4 EFFECTS OF SOLID WASTE ON SURFACE-WATER QUALITY

Soluble components of solid waste in contact with water will change the surface water quality either directly or indirectly by infiltration of contaminated surface water. Solid waste will pollute surface-water also in regard to hygienic conditions. As to the distribution of contagious diseases waste deposits are probably minor hazards. The extent and intensity of contamination depends on the following factors (Dan-Zeng et al., 2021).

a) Chemical and physical quality of waste material;
b) Man's variable pattern of waste disposal and of accidental release of contaminants in the ground;
c) Duration and surface size of contact between waste material and water in the saturated and unsaturated zone of the ground varying in time;

d) Behaviour of the contaminants in the surface water and in the saturated and unsaturated zone of the ground;
e) Chemical and physical properties of soil and rock environment varying in space;
f) Influences of microorganisms in the saturated and unsaturated zone varying in time;
g) Quality of water percolating from surface water or from other aquifers into an aquifer of specific character varying in time;
h) Climatic conditions varying in time;
i) Hydrological conditions varying in time and in space;
j) Man's variable pattern of water development from wells.

Besides the chemical and physical properties of waste materials, the position of the waste site as to the surface-water is of greatest importance for the intensity of contamination. The waste is leached to the greatest extent when deposited in the surface-water, to the least in the case of a waste dump above water table.

2.5 GROUNDWATER AS A RECHARGE TO SUFACE WATER

Groundwater is water that exists in the pore spaces and fractures in rocks and sediments beneath the Earth's surface. It originates as rainfall or snow, and then moves through the soil profile into the groundwater system, where it eventually makes its way back to surface streams, lakes, or oceans. It is naturally replenished from above, as surface water from precipitation, streams, and rivers infiltrate into the ground. Groundwater is a long-term storage of the natural water cycle as opposed to short-term water reservoirs like the atmosphere and fresh surface water (http:www.lenntech.com/drinking/standards, 20th January, 2014.1159hrs). The pore spaces within which the groundwater is contained are referred to as aquifer.

Groundwater is defined as fresh water (from rain, melting of ice and snow) that soaks into the soil and is stored between pore-spaces, fractures and joints found in within rocks and other geological formations. Groundwater occurs in various geological formations, the ability of geological formations to store water is a function of its textural arrangement. The source of groundwater most times could be linked to surface run-off and infiltration of rainwater into the subsurface and streams from which it leads to the establishment of the water table and serve as a primary supplier of streams, springs lakes, bays and oceans. The textural arrangement (uniformly or tightly arranged texture, loosely arranged texture) found within most geological formations and rocks have a strong role to play in *water retention* and *storative* capacity of any rock or geological formation. Rocks/Geological formation with uniformly or tightly arranged texture have high water retaining ability (porosity) but less transmitting or mobility ability (permeability) while those with higher porosity and higher permeability have sufficiently enough to yield significant quantities of groundwater to wells and springs as such any geological formation with such characteristic is been referred to as an Aquifer. Let us now consider other definitions for aquifers and look at the different types that exist based on its classification and what influences these classifications (Adebayo & Adepelumi, 2018).

An aquifer according to word web dictionary refers to any underground layer of water-bearing rock or geological formation that yields sufficiently groundwater for wells and springs. According to geological terms an Aquifer could be referred to as a body of saturated rock or geological formation through which water can easily move (permeability) into wells and streams. The top of the water level in an aquifer is called the water table. An aquifer fills with water from rain or melted snow that drains into the ground which in turn recharge the surface water. In certain areas, water could pass through the soil of the aquifer while in other areas it enters through joints and cracks in rocks where it moves downwards until it encounters rocks that are less permeable. Aquifers generally are known to serve as reservoirs and could dry up when people drain them faster than they are been refilled by nature (Adebayo & Adepelumi, 2018)

Surface water pollution is the introduction or presence of organic, inorganic, biological, radiological or physical foreign substances in water that tend to degrade its quality. Among heavy metals in Municipal Solid Waste (MSW) leachate, lead presents the greatest threat for pollution of surface water that serves as domestic water supply. Leachate from some municipal solid waste (MSW) landfills contains sufficient concentrations of lead. Leachate contaminated surface water contain high level of lead that impair the use of the surface water for domestic water supply (Magda & Gaber, 2015). Most concern over groundwater pollution has centered on pollution associated with human activities like haphazard of wastes followed by incineration of the wastes.

This practice is meant to reduce the volume of the waste so as to increase the lifespan of the dumpsite; a practice which increases contamination risk to groundwater and constitutes potential environmental and public health problems. It also destroys the organic components and oxidizes the metal wastes and in the process, enriches the ashes left behind in metal. Odukoye et al. (2020) pointed out that leachate from such dumpsites constitutes major sources of heavy metal pollutants to both soil and aquatic environment. Depending on the environmental conditions, such pollutants reach groundwater aquifers through the infiltrating and percolating water. The degraded environment thus increases groundwater pollution.

Saltwater encroachment associated with over drafting of aquifers or natural leaching from naturally occurring deposits is considered under natural sources of groundwater pollution and is equally important. The sources of groundwater pollution include, natural, agricultural, industrial and residential. Natural groundwater contains some impurities, even if it is unaffected by human activities (Li, D.

Karunanidhi et al., 2021). The types and concentrations of natural impurities however; depend on the nature of the geological material through which the groundwater moves and the quality of the recharge water. Surface water moving through bedrock and soil may pick up a wide range of compounds such as magnesium, calcium and chlorides.

2.6 EFFECTS OF LEACHATE POLLUTANTS ON HEALTH

Water naturally contains small amounts of dissolved substances like zinc, calcium, magnesium and even impurities like silt, sand and microbial substances under normal circumstances. These quantities are considered safe for human use; however, when they exceed threshold limits, then the water is polluted (Manoj & Avinash, 2012). Metal ions and their complex exhibit a wide range of toxicity to organisms ranging from sub lethal to lethal, depending upon time of exposure and the ambient temperatures. For example, the heavy metals; Pb, As, Cd, Cr, Mn, Ni, and Hg are highly toxic even in low concentrations (Nyandwaro, 2017). Cadmium and lead are some of the heavy metals that are hazardous to human health for example; long term exposure to lead can cause severe disruption of biosynthesis of hemoglobin and anemia, high blood pressure, damage to kidneys, miscarriages, brain damage, sperm damage in males and disruption of nervous system. Mercury can cause brain and kidney damage as well as interference with the nervous system, birth defects, miscarriages, and damage to deoxyribonucleic acid (DNA); while elevated manganese levels can disrupt the nervous system and regeneration of hemoglobin (GSADH, 2005). When these pollutants are dumped haphazardly in landfills, the resulting leachate easily percolates into surface water thus causing surface water pollution. Leachate from ash landfills is likely to have elevated pH and to contain more salts and metals than other leachate. Household batteries and fluorescent tubes make a small quantity of landfill wastes by volume but are a significant source of pollutants (Odukoye et al., 2001). More than 80% of mercury in solid wastes can in fact be traced to electronic substances, especially batteries (Manoj & Avinash, 2012).

The other surface water pollutants of concern are the pathogens and nutrients. Pathogens such as *E-coli* forms mainly come from sewage. *E.coli* as a portion of the coli form bacteria group originating in the intestinal tract of warm blooded animals is an indicator of the bacteriological contamination of domestic water supply. Their presence in domestic water is of great concern because of the many diseases they cause to human beings. Similarly, nitrogen limits the oxygen carrying capacity of red blood cells in infants causing a condition referred to as methemoglobinemia or blue baby syndrome (Osu & Okoro, 2011).

2.7 EFFECTS OF DUMPSITE AND DOMESTIC WASTE LEACHATE ON SURFACE WATER

Any waste treatment system generates residues that eventually need to be land filled. The landfill is the only final sink of any waste; nonetheless, it can only hold on to the title as the ultimate sink for waste as long as it does not release its leachate (Agunwamba, 2006). Unfortunately, this is not the case in practice for example, in Tanzania; sites where agrochemicals were ineptly stored are still polluting water and soil (NEMC, 1998). According to Kaseva and Mbuligwe (2002), leachate from the now closed and abandoned Tabata and Vingunguti solid waste disposal sites in Dar es Salaam City pollute the Msimbazi River more than ten years after the former was decommissioned. Guidelines and specifications for planning, design, operation, and closure as well as post-closure care requirements of disposal sites for all types of wastes are detailed in the literature (Bagchi, 2004; Corbit, 1993; LaGrega, 1994). Through leaching, contaminants are transferred from a stabilized matrix such as waste dumpsite to a liquid medium such as water (LaGrega et al., 1994).

Waste dumpsites and pit latrines are some of the major sources of pollutants to surface water. Nitrogen and phosphorous compounds are present in significant amounts in all domestic waste water and mainly come from human excreta and detergents. They easily contaminate surface water through migration of leachate from dump site (Osu & Okoro, 2011).

2.8 COMPOSITION OF DOMESTIC WASTEWATER

Domestic sewage is composed of black and grey water where black water is that from the toilets and grey water is from bathrooms and kitchen. These waters are basically composed of organic matter with traces of inorganic substances. The raw wastewater also contains nutrients such as nitrogen and phosphorous. Such impurities do pollute groundwater and surface waters through migration to water bodies. Sewage is about 99.9% water but the specific pollutant composition of domestic wastewater varies both in the constituents and their concentration (Gray, 2009).

2.8.1 Nitrogen in Wastewater

Nitrogen does exist in wastewater in many forms like organic nitrogen, ammonia, nitrites and nitrates. Nitrogen is usually measured as Kjeldhal nitrogen. This is the sum of organic nitrogen and ammonia nitrogen present. Total nitrogen is the sum of Kjeidhal nitrogen and the oxidized nitrogen. In raw wastewater and settled wastewater, there is no oxidized nitrogen present and therefore the total nitrogen is equal to the Kjedhal nitrogen (Gray, 2009). In terms of water quality, the nutrients are considered pollutants when their concentrations are sufficient to allow excessive growth of aquatic plants especially algae. It lowers the attractiveness of the water body as drinking water supply because of its viability as a habitat for other living things. It leads to Eutrophication of water bodies through nutrient enrichment which is a big threat to human health when such sources are used for domestic purposes. The algal blooms that result eventually die and decompose thereby lowering the levels of dissolved oxygen (DO). The dissolve oxygen (DO) can be lowered to levels too low to sustain normal life forms. The algae and decomposed organic matter add colour, turbidity, odour and objectionable tastes to the water. The nitrogen in the form of nitrates in water can be converted into highly toxic nitrites in infant's intestinal tracts when consumed (Agunwamba,2006). Nitrate is a compound that naturally occurs and has many human-made sources. Nitrate is in some lakes, rivers, and groundwater in Minnesota. You cannot taste, smell, or see nitrate in water. Consuming too much nitrate can be harmful—especially for babies. Consuming too much nitrate can affect how blood carries oxygen and can cause methemoglobinemia (also known as blue baby syndrome). Bottle-fed babies under six months old are at the highest risk of getting methemoglobinemia. Methemoglobinemia can cause skin to turn a bluish color and can result in serious illness or death. Other symptoms connected to methemoglobinemia include decreased blood pressure, increased heart rate, headaches, stomach cramps, and vomiting.

The following conditions may also put people at higher risk of developing nitrate-induced methemoglobinemia: anemia, cardiovascular disease, lung disease, sepsis, glucose-6-phosphate-dehydrogenase deficiency, and other metabolic problems.

2.8.2 Organic Matter in Wastewater

Most organic materials are water soluble. They may come from natural sources or they may result from anthropogenic activities. Most natural organics consist of the decayed products of organic solids while synthetic organics usually come from agricultural activities. The soluble organics can either be biodegradable or non-biodegradable. The biodegradable organics are those that can be utilized as food by naturally occurring micro-organisms within a reasonable time and they usually consist of proteins, starch, fats, acids, esters, alcohol and aldehydes which may be end products of initial microbial decomposition of plant and or animal tissues. Alternatively, they may result from industrial or domestic wastewater effluents. Some of these products cause colour, taste and odour in water but the most significant problem associated with them is the action of microorganisms on them. The amount of oxygen used by the microorganisms while utilizing the organics is referred to as biochemical oxygen demand (BOD).

The organic matter concentration in wastewater is expressed through measurements of the oxygen consumed during the decomposition. The parameters used in characterizing the amount of organic matter in such wastewaters are the Biochemical Oxygen Demand (BOD), the chemical oxygen demand (COD), the Total Organic Carbon (TOC) and the Theoretical Oxygen Demand (ThOD). The daily per capita output of organic wastes is about 30-50 grams as BOD, and about half of it is associated with urine and faeces and half with grey water (Pickford, 1986).

The BOD refers to the amount of oxygen consumed over a five day period and is the parameter used in characterizing the organic matter in wastewater. The five-day test for BOD, is done by placing wastewater samples into two standard bottles of 300ml. One sample is analyzed immediately to measure the initial amount of dissolved oxygen in the wastewater often using a Winkler titration (Sha et al., 2011).

Chemical Oxygen Demand (COD) is another parameter used for the characterization of wastewater. It refers to the oxygen equivalent of the organic matter in wastewater that can be oxidized chemically using potassium dichromate in an acid solution (usually sulphuric acid). This method is however less specific since it measures everything that can be chemically oxidized rather than just the levels of biologically active organic matter but a mathematical relationship is usually worked out for the particular wastewater to translate COD to the time-consuming BOD (Jorgensen & Johnsen, 1989).

2.8.3 Pathogens in Domestic Wastewater

Pathogens are disease causing organisms. Their presence and concentrations in wastewater is reflected through biological indicators called "indicator organisms". The *Escherichia coli* (E.coli) originate from intestinal tract of warm blooded animals and are usually an indicator of the presence of pathogens in water. In the United States of America, a standard of no coli form in 100ml of water has been used as a threshold for safe water (Gray, 2009). The World Health Organization (WHO, 2006) and the Kenya Bureau of Standards (KEBS, 2006) guidelines of zero coli form per 100ml are recommended for drinking water. The presence of coli forms in water does not necessarily mean that pathogenic organisms are present in the water but is an indicator that such pathogens might be present (Sha et al., 2011).

2.8.4 Physical Characteristics of Heavy Metals in Wastewater

Physical characteristics of waste water are the solid contents, color, temperature and odour. Domestic water is usually grey to yellow–brown depending on the time of the day (Gray, 2009). Waste water temperatures do vary with season and the source but generally they are warmer than the air temperatures except for very warm months, since the specific heat capacity of water is much greater than that of air. Raw sewage is turbid and has small but visible particles of organic material which settles readily from the suspension. Total solids include those materials that are left behind in a container when water evaporates usually at a temperature of 103-105 degrees Celsius (Weiner & Mathews, 2007). The total solids consist of insoluble and suspended solids and soluble compounds dissolved in water. In waste water, about 40 percent of the solids are suspended.

In the work of Chukwujindu et al. (2007), total concentration of heavy metals was determined by mineralization of 1.0 gramme of the sediment using aqua-ragia. The digest was subsequently diluted to 50 mL mark using ultra-pure distilled water. The concentration of Cd, Pb, Cr, Ni, Cu, Fe Zn in the solution was determined using graphite furnace atomic absorption spectrophotometer equipped with D2 background correction system. The heavy metals; Pb, As, Cd, Cr, Mn, Ni, and Hg are highly toxic even in low concentrations (Nyandwaro, 2017). Cadmium and lead are some of the heavy metals that are hazardous to human health for example; long term exposure to lead can cause severe disruption of biosynthesis of hemoglobin and anemia, high blood pressure, damage to kidneys, miscarriages, brain damage, sperm damage in males and disruption of nervous system. Elevated manganese levels can disrupt the nervous system and regeneration of hemoglobin (GSADH, 2005). When these pollutants are dumped haphazardly in landfills, the resulting leachate easily percolates into groundwater thus causing groundwater pollution.

Heavy metals accumulate in the environment in different geochemical forms that is; water soluble, exchangeable carbonate-associated, Fe-Mn oxide-associated, organic-associated and residual forms (Osu & Okoro, 2011). Measurements of metal in aquatic environments are an important monitoring tool to assess the degree of pollution (Nyandwaro, 2017). The toxicity and mobility of heavy metals in soils depend not only on the total concentrations but also on their specific chemical form, binding state, metal properties, environmental factors and soil properties like pH and organic matter content (Osu & Okoro, 2011).

Also, heavy metals exist in water in colloidal, particulate and dissolved phases with their occurrence in water bodies being either of natural or anthropogenic origin (J. C. Akan,et al 2010). They include Iron (Fe), Cobalt (Co), Copper (Cu), Magnesium (Mg) Manganese (Mn), Aluminum (Al), Chromium (Cr), Arsenic (As), Beryllium (Be), Zinc (Zn), Cadmium (Cd), Lead (Pb), Mercury (Hg), Strontium, Thallium, Tin, Titanium, Bismuth, etc. Heavy metal toxicity can have several health effects in the body. Heavy metals can cause serious health effects with varied symptoms depending on the nature and quantity of the metal ingested (Adepoju-Bello and Alabi, 2005). The most common heavy metals that humans are exposed to are aluminum, arsenic, cadmium, lead and mercury.

Aluminum has been associated with Alzheimer's and Parkinson's disease, senility and presenile dementia. Arsenic exposure can cause among other illnesses or symptoms, cancer, abdominal pain and skin lesions. Cadmium exposure produces kidney damage and hypertension. Lead is a cumulative poison and a possible human carcinogen (Bakare-Odunola, 2005) while for mercury, toxicity results in mental disturbance and impairment of speech, hearing, vision and movement (Hammer and Hammer, 2004). It can damage and alter the functioning of organs such as the brain, kidney, lungs, liver, and blood. Long-term exposure of the body to heavy metal can progressively lead to muscular, physical and neurological degenerative processes that are similar to diseases such as Parkinson's disease, multiple sclerosis, muscular dystrophy and Alzheimer's disease (Mahmood & Malik, 2014). Also, chronic long-term exposure of some heavy metals may cause cancer.

In the study carried out by Iyasele and Idiata (2016), assessing the borehole water quality in Edo South and Edo North Areas of Edo State, using 30 samples, of which were analyzed for both Physico-chemical and Microbial constituents of water quality. Their result shows that the Turbidity, Ammonium, Cadmium, Chlorine, Lead, EC, TDS, Zinc and Total hardness levels did not constitute pollution, since they were all within the WHO limit. Although the pH, Iron and Microbial level shows a level that constitutes pollution and that exceed the limit for consumption, and as such the water analysis of borehole water for Benin City area needs mild treatment to become fit for drinking.

Also, Ijeh and Onu (2013) assessed the pollution levels of groundwater in parts of Imo River Basin, South Eastern Nigeria. Twenty five samples of groundwater were obtained from various boreholes in the study area and subjected to physico-chemical analysis using standard laboratory techniques. The values of the physico-chemical parameter were correlated with the World Health Organisation (WHO) values. Their result shows that the level of pollution is relatively high in Owerri. They noted that pollution level may be due to increased pollution arising from increased domestic activity, fertilization and industrial waste in the area. Therefore, they recommended that there should be environmental interventions through public health education by community based health workers, awareness and sensitization campaigns be carried out for improved household and community sanitation in the area. Also, adequate solid disposal method should be adopted, phasing out open dumpsites to safeguard public health from water borne diseases.

Tukura et al. (2014) carried out the assessment of Heavy Metals in Groundwater in Nasarawa State, Nigeria, using water samples collected from fifty two boreholes in twelve Local Government Areas and were analyzed for the heavy metal concentrations. They noted that the metals levels in water were above SON and WHO recommended limit for drinking water. Metal levels above the standards might be attributed to surface contamination originating from anthropogenic and geological sources. Therefore, they suggested that further monitoring of the heavy metal levels in water from the boreholes in the area is required.

Furthermore, Akpoveta et al. (2011), assessed the quality of borehole water from the University of Benin, Benin City, Okobi and Eluemelor vicinities of Agbor respectively. Water samples were collected three times at monthly intervals between December 2009 and February 2010 for the three sampling points, respectively. Physico-chemical characteristics were determined using their respective standard methods of analysis while heavy metal levels were determined using Atomic Absorption Spectrophotometer. The result from their analysis shows that the borehole water from the area were found to be safe in the parameters studied except for calcium and manganese which exceeded acceptable WHO limits. Parameter such as chloride, sulphate, nitrate, ammonium, sodium, lead, cadmium, copper, zinc, chromium, iron, arsenic, nickel, pH, BOD, DO were below pollution levels when compared with the World Health Organization (WHO) and federal environmental protection agency maximum allowable levels for drinking water. However, the pollution index values for calcium and manganese indicated that borehole waters are polluted in these metals. It is therefore recommended that the borehole water from the three boreholes studied be subjected to purification and treatment processes to reduce calcium and manganese levels before exposure to public use.

III. METHODOLOGY

3.1 Materials and Methods

3.1.1 Physical Analysis

General appearance

Determination of General Physical Appearance

Method: Visible Characteristics detection by the unaided eye.

Apparatus: The Unaided eye (Human eye only)

Procedure:

i. Carefully observed the general physical appearance of the water sample.
ii. Checked for visible characteristics that my hinder the aesthetic value and acceptability profile of the water sample.
iii. Used appropriated terms to briefly describe presence of color, turbidity, suspended solids, organisms, sitt, sediments, floating material, similar particulate matter.

Turbidity

Method: Nephelometric method

Apparatus: Digital Turbidity meter, glass wares.

Procedure:

i. The water sample was measured into a glass beaker
ii. Distilled water sample was measured out. This should serve as blank.
iii. The blank was first measured and noted.
iv. Then the water sample was measured and recorded accordingly.

Taste

Determination of Taste

Method: Organoleptic method

Apparatus: Human organs of taste (mouth and tongue) glass wares

Procedure:

i. The water sample was mixed properly by shaking
ii. A portion of the water sample was used to rinse the glass wares.
iii. Another portion of the sample was measured out and poured into a glass wares.
iv. This portion was drank and swallowed.

Temperature

Determination of Temperature

Method: Temperature was measured using a thermometer.

Apparatus: Thermometer, Glass wares

Procedure:

i. The thermometer was rinsed with distilled water and blotted dry.
ii. The thermometer was the rinsed in a small beaker with a portion of the sample
iii. Sufficient amount of the sample was poured into a beaker
iv. The thermometer was immersed into the beaker containing the amount of the sample to be measured.
v. The temperature reading of the sample indicated on the thermometer was read off and recorded accordingly

Odour

Determination of Odour

Method: Organoleptic Method

Apparatus: The human nose and glass wares

Procedure:

i. The water sample was mixed properly by shaking
ii. A portion of the water sample was used to rinse the glass wares
iii. Another portion of the sample was measured out and poured into an open glass wares (100ml beaker) container.
iv. This open container containing a portion of the sample was brought very close to the nose to check for odour.
v. The result was recorded.

Electrical conductivity

Determination of electrical conductivity

Method: Conductivity was measured using a conductivity meter.

Apparatus:

Conductivity meter, glass wares

Procedure:

i. The conductivity meter was rinsed with distilled water and blotted dry. The conductivity meters probe was then wetted thoroughly by immersing it or rinsing it with a portion of the sample.
ii. The sample was mixed and sufficient (50ml) amount of the sample was then poured into a 100 beaker.
iii. The conductivity meter's wetted probe was then immersed in the glass beaker containing the sample to be measured.
iv. The conductivity meter switched on and the reading taken and recorded.

Total Dissolved Solid (TDS)

Determination of Total Dissolved Solids

Method: Total Dissolved Solids dried at 180^0C

Apparatus: Evaporating dishes (porcelain, 90mm diameter), Drying Oven, Glass-Fiber filter disks, filtration apparatus, Desiccator, Analytical balance, Magnetic stirrer with TFE stirring bar.

Procedure:

A well- mixed sample is filtered through a standard glass fiber filter, and the filtrate is evaporated to dryness in a weighed dish and dried to constant weight at 180^0 C. The increase in dish weight represents the total dissolved solids.

3.1.1.2 Chemical Analysis

pH

Determination of pH

Method: pH was measured by electrometric method using laboratory pH Meter Hanna Model H1991300 (APHA; 1998), 100m Beaker.

Procedure:

i. The electrodes were rinsed with distilled water and blotted dry.
ii. The pH electrodes were then rinsed in a small beaker with a portion of the sample.
iii. Sufficient amount 50ml of the sample was poured into small beaker (100ml beaker) allow the tip of the electrodes to be immersed to the mark depth of about 2cm, the electrodes was at least 1cm away from the sides and bottom of the beaker.
iv. The temperature adjustment dial was adjusted accordingly
v. The pH meter was turned on and the pH of the sample recorded.

Total Alkalinity

Determination of Total Alkalinity

Method: Total Alkalinity (Titremetric Method)

Apparatus: Titration apparatus, 0.02NH_2SO_4 Acid, Methyl Orange indicator, Glass wares.

Procedure:

All glass wares were pre-washed and rinsed with the expected solution it will contain in the course of the procedure. 100ml of sample was dispensed into a 250ml Erlenmeyer (conical) flask.

Three (3) drops of methyl orange indicator solution or a pinch of the powder was added to the solution and it turned yellow. Carefully, titration against 0.02N of H_2SO_4 was done until an end point of orange red colour appearance. The volume of 0.02N H2SO4 solution used was noted and served as the titre value.

The total alkalinity in mg/l $caco_3$ was calculated:

$$\text{Mg/l } CaCo_3 = \frac{N \, x \, T \, x \, 50000}{Vol.of \ sample \ used}$$

Where, N = Normality of Acid

T = Tire value

Iron

Determination of Iron

Method: Atomic absorption spectrophotometer

Apparatus: Flame Aspiration Atomic Absorption Spectrophotometer water 100ml sample beaker, glass wares.

Procedure:

i. Mix sample thoroughly by shaking
ii. Measures out 100ml aid pour into a 100ml beaker.0

3.2 Methods of Data Analysis

The data analysis commenced with simple statistical measure of the mean and standard deviations of the variables; after which, comparative t-test statistical estimation was performed.

The test statistic for the t-test follows the formula specified in Spiegel (1974) as;

$$t = \frac{\bar{X} - U}{S}\sqrt{N-1} \qquad \text{Equation 3.1}$$

Where; $\bar{X}$ is the obtained mean for each parameter

U is the World Health Organisation's (WHO) or Nigeria Standard of Drinking Water Quality (NSDWQ) limiting value,

S is the standard deviation of the water samples for each parameter extracted from the water sample.

N is the total number of cases observed in the field which is twenty in this study.

The statistical data analyses were aided by Microsoft Excel and Statistical Package for Social Sciences (SPSS) for windows, version 25.0.

IV. PRESENTATION AND ANALYSIS OF RESULTS

In this chapter, the researcher presents the quantitative data of bacteriological, physical, chemical parameters, as well heavy metals concentrations obtained from laboratory analyses of the water samples collected from 8 dumpsites (including the control) in the study area and in comparison with the World Health Organisation (2006) and Nigeria Standard Quality Water (NSDQW) recommended standards (2007). The data are as presented in Table 4.1. They are the basic data from where the analyses were carried out and results obtained.

Table 4.1 Presentation of Data/field Results of the sampled Physical Parameters

Samples	Turbidity (NTU)	Taste	Temp. (ºC)	Colour	Odour	Conductivity (µs/cm)	TDS (mg/l)	TSS (mg/l)	Tot. Solid	Dist. (m)
A	1.00	Unobj.	28.0	Colourless	Unobjectionable	556.0	295.22	0.037	295.257	0
B	0.91	Unobj.	27.1			428.1	280.07	0.031	280.101	10
C	0.62	Unobj.	26.9			403.6	265.9	0.030	265.930	20
D	0.5	Unobj.	26.5			400.0	239.92	0.026	239.946	30
E	0.57	Unobj.	26.2			391.0	214.77	0.0256	214.796	40
F	0.42	Unobj.	25.8			363.0	186.62	0.0211	186.641	50
G	0.39	Unobj.	24.9			336.0	174.47	0.0191	174.489	60
H (Control)	0.215	Unobj.	25.4			105.0	102.33	0.009	102.339	15
WHO standard	5.0	Unobj.	Ambient			1000	500	-	1000	
NSDWQ	-	Unobj.	Ambient			1000	-	-	-	

Note: Unobj. = Unobjectionable

Dist. = Distance

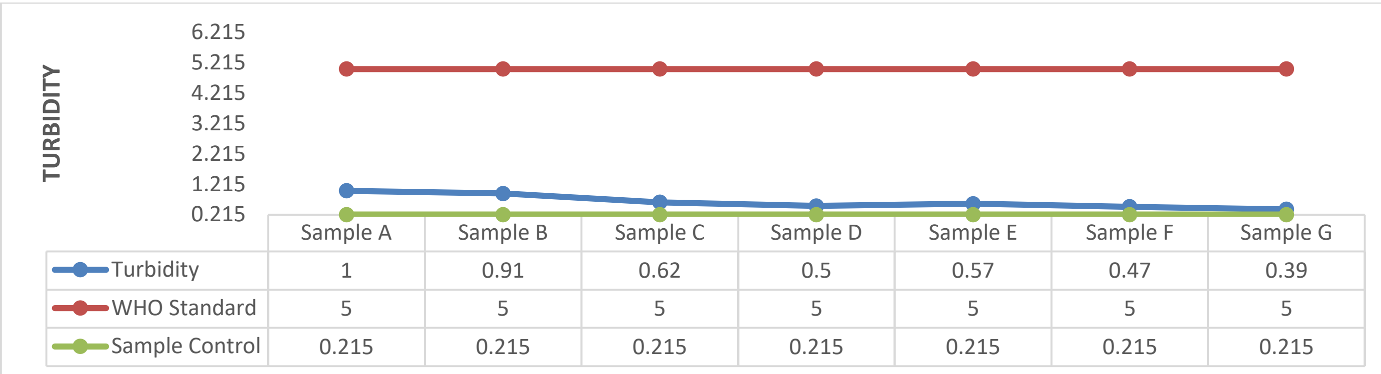
H Sample is the control from the upper stream

4.2 Analysis and Interpretation of Results

4.2.1 Results of Physical Parameters of surface water

Turbidity

Fig 1: Line plot of Turbidity vs Standards



Source: Researcher's computation

Fig 1 is the line plot of samples when considering the Sample control and the WHO Standard for the tubidity. From the plot, it suggest that a better comparison would be between the samples and control (as the standard) since there is wide gap between the WHO standard and the samples when considering turbidity as the parameter.

Table 4.1: Comparison of Turbidity with Control Sample and WHO/Nigerian Standard

	Descriptive statistics		t-test: Test Value = 0.215					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Turbidity	.63714	.230486	.422143	4.846	6	.003	.20898	.63531
	Test Value (WHO standard) = 5.0							
			-4.362857	-50.081	6	.000	-4.57602	-4.14969

Normality test estimates					
Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.244	7	.200*	.882	7	.238

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

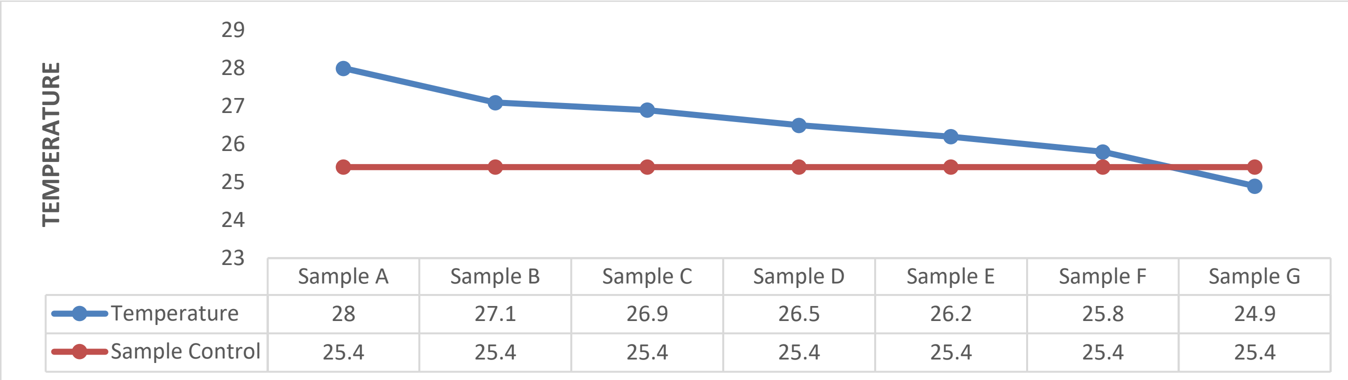
Source: SPSS 25.0 computation

In table 4.1, one-sample t-test statistics was used to see if the different samples for turbidity differed from the standard control which was defined as the sample control of 0.215. According to Shapiro Wilk's Test ($P>0.05$), the sample scores were normally distributed, and there were no outliers in the data. The mean of the samples for turbidity (**0.63714** ± 0.230486), which is higher than the standard mean (sample control), was statistically significant by 0.422 (95% CI, 0.20898 to 0.63531), $t(6) = 4.846$, $p = 0.003$. The t-test result also indicates that the concentrations of turbidity are significantly below WHO permissible standard ($t(6) = -50.081$, $p<0.001$).

Turbidity is the index of clearness of the water sample. Clear sparkling water with no opacity is preferred potable water for human consumption. Based on the samples collected, the turbidity level lies between 0.39NTU and 1.00NTU. The critical value as stipulated by WHO is 5.00NTU while NSDWQ has no specific critical value. However, our result shows that the water becomes less turbid as we move away from the dumpsite. Meanwhile, these values are within the critical standard of WHO (2006) and NSDWQ (2007) recommended standard for drinking water of 5.0 NTU.

Temperature

Fig 2: Line plot of Temperature vs Standard



Source: Researcher's computation

Fig 2 is the line plot of samples when considering the control Sample with the Temperature. From the plot, control sample is emolyed as the only standard for comaprison with the samples i.e (Sample A to Sample G). It is obvious that sample F and sample G are approximately the same with the sample control.

Table 4.2: Comparison of Temepratire with Control Sample

	Descriptive statistics		t-test: Test Value = 25.4					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Temperature	26.48571	.992352	1.085714	2.895	6	.028	.16794	2.00349

Normality test estimates

Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Statistic	df	Sig.	Statistic	df	Sig.
.125	7	.200*	.995	7	.999

**. This is a lower bound of the true significance.*

a. Lilliefors Significance Correction

Source: SPSS 25.0 computation

From table 4.2, a one sample t-test was used to see if the different samples for temperature differed from the standard which was defined as the sample control of 25.4. According to Shapiro Wilk's Test (P>0.05), the sample scores were normally distributed, and there were no outliers in the data series. The mean of the samples for temperature is (**26.48571** ± 0.992352), which is higher than the standard mean (Sample control), was statistically significant by 1.085714 (95% CI, 0.16794 to 2.00349), t(6) = 2.895, p =0.028.

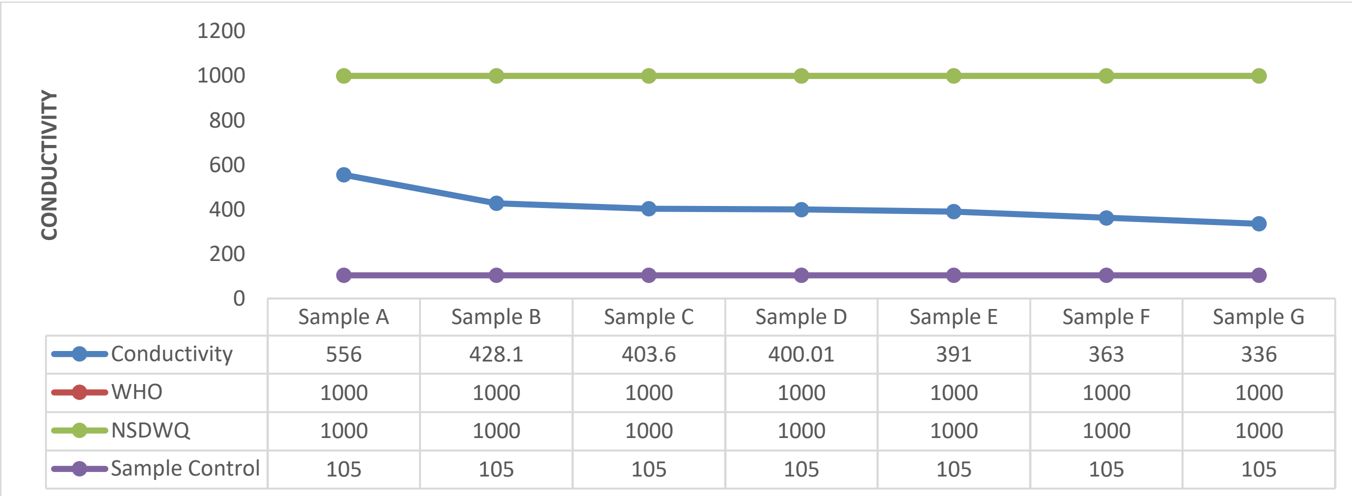
Generally, the temperature of water indicates pollution if it is higher than normal. The WHO (2006) and NSDWQ (2007) limit for drinking water, noted that temperature should not be above 30˚C. From our result, the temperature reading of the water samples in the study area ranges from 24.9˚C to 28.0˚C. These values were all below the WHO (2006) and NSDWQ (2007) permissible limit of 30˚C for drinking water. The temperature was seen to be on a steady drop as we move away from the dumpsite. This shows the presence of micro-organisms in the water.

Colour

The entire water samples that were collected from the stream (Ile river) close to Ugwuaji solid waste landfill site were colourless, with unobjectionable tastes and odourless. This shows that they met recommendations; hence, they are not dangerous to health.

Electrical Conductivity

Fig 3: Line plot of Conductivity vs Standard



Source: Researcher's computation

Fig 3 is the line plot of samples when considering the Sample control, NSDWQ and the WHO Standard for the Conductivity. From the plot its obvious there is wide gap between the samples and all the standard employed when considering conductivity as parameter of surface water.

Table 4.3: Comparison of Conductivity with Control Sample and WHO/Nigerian Standard

	Descriptive statistics		t-test: Test Value = 105					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Conductivity	411.10143	70.500447	306.10143	11.487	6	.000	240.8994	371.30347
	Test Value (WHO/Nigerian standard) = 1000							
			-588.898571	-22.100	6	.000	-654.10061	-523.69653

Normality test estimates

Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.262	7	.159	.843	7	.107

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

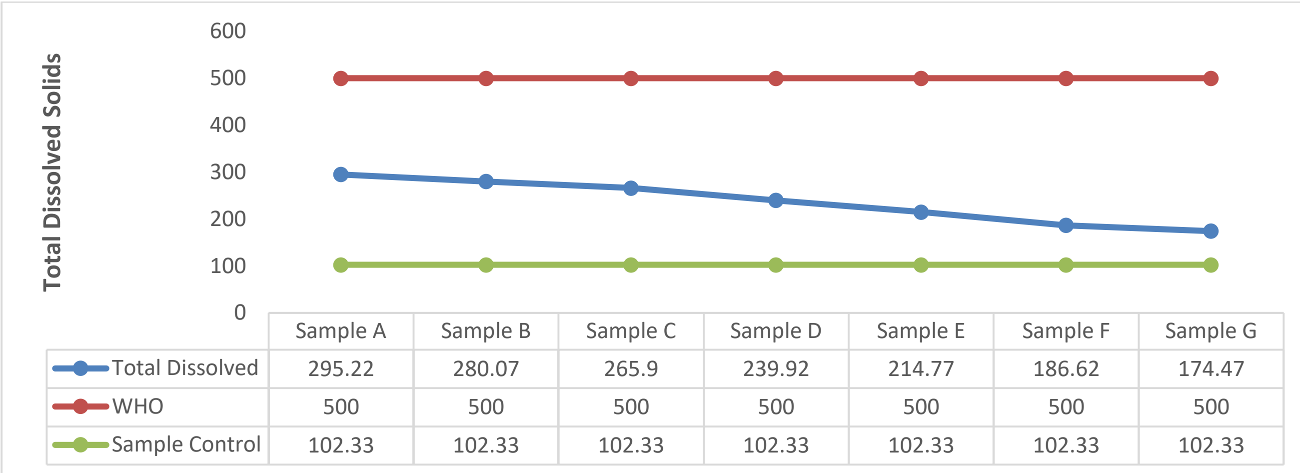
Source: SPSS 25.0 computation

As shown in table 4.3, the mean of the samples for conductivity is (**411.10143** ± 70.500447). The mean difference was 306.101429, which is above the control sample value of 105. However, in comparison with WHO/Nigerian standard, the mean difference was -588.898571. The Shapiro Wilk's normality test ($P>0.05$) indicates that the sample scores were normally distributed, and there were no outliers in the data series. The t-test estimate confirmed that electrical conductivity of the surface water samples are significantly above the control by 0.422 (95% CI, 240.89939 to 371.30347), $t(6) = 11.487$, $p < 0.001$. Meanwhile, based on WHO/Nigerian permissible standard of 1000μS/cm, it was confirmed that the electrical conductivity in the surface water was significantly below WHO/Nigerian recommended standard ($t(6) = -22.100$, $p < 0.001$).

This parameter shows the quantity of conductive materials in the water sample. The conductivity is usually high if the materials are dissolved and are also solid that they can conduct electricity. It is then an index of water pollution whether the sample is physically clean or not. Clean water that is solute-laden will have high conductivity. Also, opaque or dirty water with materials that can conduct current will also show strong electrical conductivity. The standard of conductivity of as set by WHO (2006) and NSDWQ (2007) is 1000μs/cm. In the dumpsite studied, the value of electrical conductivity obtained ranges from 336μs/cm at distance 60m to 556μs/cm at distance zero meter. This result shows that Electrical Conductivity in the area conforms to the WHO (2006) and NSDWQ (2007) recommended standard for drinking water. Hence, the water may not undergo treatment before consumption.

Total Dissolved Solids

Fig 4: Line plot Total dissolved solid vs Standards



Source: Researcher's computation

Fig 4 is the line plot of samples when considering the Sample control and the WHO Standard for the Total dissolved solids. From the plot its obvious there is wide gap between each of the samples and all the standard employed when considering total dissolved solids as parameter of surface water.

Table 4.4: Comparison of Total dissolved solids with Control Sample and WHO Standard

	Descriptive statistics		t-test: Test Value = 102.33					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Total dissolved solids (TDS)	236.71000	46.601250	134.380000	7.629	6	.000	91.28103	177.47897
	Test Value (WHO standard) = 500							
			-263.290000	-14.948	6	.000	-306.38897	-220.19103
Normality test estimates								
Kolmogorov-Smirnov[a]			**Shapiro-Wilk**					
Statistic	df	Sig.	Statistic	df	Sig.			
.163	7	.200*	.942	7	.654			
**. This is a lower bound of the true significance.*								
a. Lilliefors Significance Correction								

Source: SPSS 25.0 computation

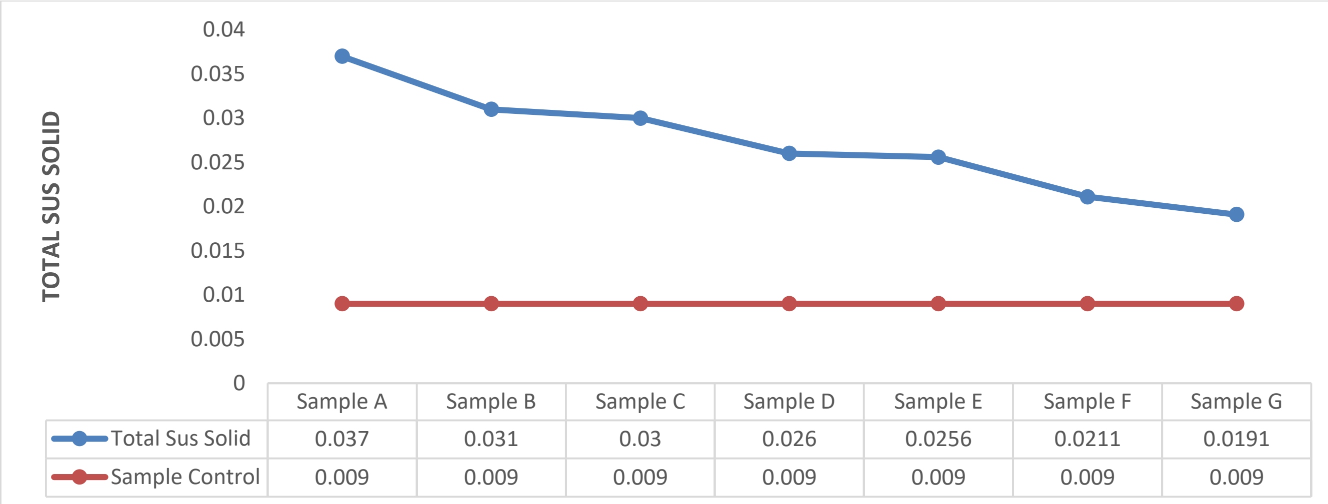
In table 4.4, a one sample t-test was used to see if the different samples for Total dissolved solid differed from the control sample. From the Shapiro Wilk's test result (P>0.05), the sample scores were normally distributed, and there were no outliers in the data series. The mean of the samples for Total dissolved solid is (**236.71** ± 46.601250), which is higher than the standard mean (control). The variation was statistically significant by 134.38 (95% CI, 91.28103 to 177.47897), $t(6) = 7.629$, $p < 0.001$. Meanwhile, based on WHO recommended standard, the TDS of the samples are significantly below WHO permissible limit ($t(6) = -14.948$, $p < 0.001$).

Water is a universal solvent and will over time dissolve and take up the chemicals in the rocks where it is found or over which it flows. The value of TDS obtained from the water samples in the study area ranges from 174.47mg/l at distance 60meters away from the dumpsite to 295.22mg/l in at the starting spot (0 meter). However, the WHO (2006) and NSDWQ (2007) benchmark for total dissolved solids is 500mg/l. It shows that there is low amount of dissolved solids which implies good shielding of the water points.

Total Suspended Solids

This variable is a measure of the suspended matter in a water sample. Water carries and contains impurities as suspensions, floating or dissolved matter. Figure 5 below presents the graph as obtained from the water samples for this study.

Fig 5: Line plot of Total Suspended solids vs Standard



Source: Researcher's computation

Fig. 5 is the line plot of samples when considering the Sample control as the standard for the Total suspended solid. From the plot sample, there is a wide gap between the samples (Sample A to Sample G) and the sample control.

Table 4.5: Comparison of Total suspended solids with Control Sample

	Descriptive statistics		t-test: Test Value = 0.009					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Total suspended solids	.02711	.006125	.018114	7.825	6	.000	.01245	.02378

Normality test estimates

Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Statistic	df	Sig.	Statistic	df	Sig.
.144	7	.200*	.970	7	.897

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

Source: SPSS 25.0 computation

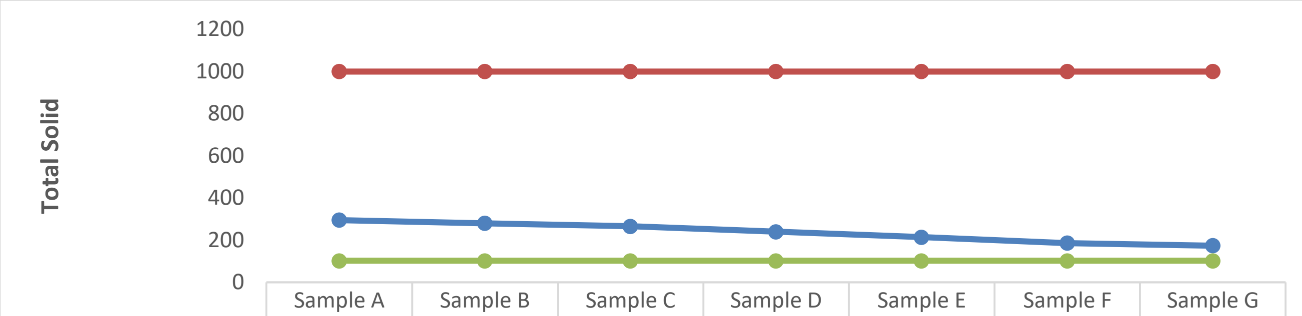
The result in table 4.5 shows that the mean and standard deviation of the samples for total suspended solid is (**0.02711** ± 0.006125). The mean difference is 0.018114 which is positive, thus, indicating that the values from the samples are above control. Based on the Shapiro Wilk's Test (P>0.05), the sample scores were normally distributed, and there were no outliers in the data. However, the one sample t-test confirmed that variation by 134.38 (95% CI, 0.01245 to 0.02378), $t(6) = 7.825$, $p < 0.001$ is statistically significant.

The total suspended solids of the water samples in the study area range from 0.0191mg/l to 0.037mg/l. This shows that the water at the dumpsite is clean as observed from the low turbidity, and the colourless nature of the water samples.

Total Solids

Total solids include those materials that are left behind in a container when water evaporates usually at a temperature of 103-105 degrees Celsius (Weiner & Mathews, 2007). The graphical representation of the data series obtained from the dumpsite is as shown in figure 6 below:

Fig 6: Line plot for Total solids vs Standard



	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	Sample G
Total Solid	295.257	280.101	265.93	239.946	214.7956	186.6411	174.4891
WHO	1000	1000	1000	1000	1000	1000	1000
Sample Control	102.339	102.339	102.339	102.339	102.339	102.339	102.339

Source: Researcher's computation

Fig 6 is the line plot of samples when considering the Sample control and WHO as the standard for the Total solids. From the plot sample control comaprison with the samples i.e (Sample A to Sample G). It is obvious that there is a close similarities between samples and the sample control which is the standard for total sus solid. However there is a wide gap between the WHO standard and that of the samples for total solid of surface water.

Table 4.6: Comparison of Total solids with Control Sample and WHO Standard

	Descriptive statistics		t-test: Test Value = 102.339					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Total solids	236.7371	46.607190	134.39811	7.629	6	.000	91.29365	177.50258
	Test Value (WHO standard) = 1000							
			-763.262886	-43.328	6	.000	-806.36735	-720.15842

Normality test estimates					
Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.163	7	.200*	.942	7	.654

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

Source: SPSS 25.0 computation

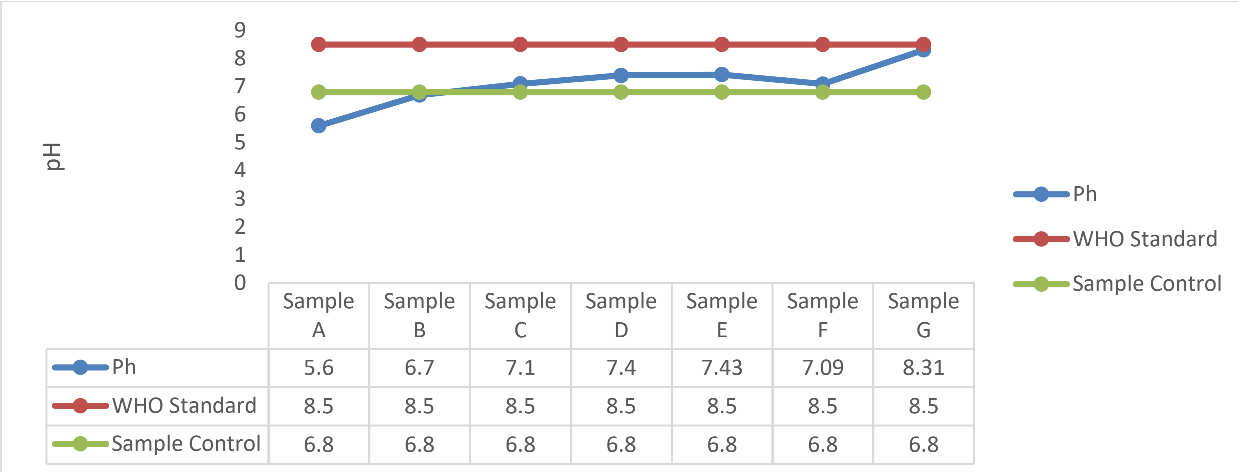
In table 4.6, the mean of the samples for total solid is (**236.73711** ± 46.607190). The mean difference is positive (i.e., 134.398114), which shows that that sample values are above the control value. Estimate of Shapiro Wilk's Test ($P>0.05$), indicates that the sample scores were normally distributed, and there were no outliers in the data series. By 134.398 (95% CI, 91.29365 to 177.50258), $t(6) = 7.629$ and $p < 0.001$, the variation is significantly higher than the standard mean (Sample control).

Consequently, the t-statistic of $t(6) = -43.328$ with associated probability value $p<0.001$, affirmed that the total solids in the water samples are significantly below WHO permissible standard (1000mg/l). The 95% confidence interval estimate is given by -763.2628 (95% CI, −806.36735 to −720.15842).

4.2.2 *Results of chemical parameters of surface water*

pH

Fig 7: Line graph of pH vs Standards



Source: Researcher's computation

Fig 7 is the line plot of samples when considering the Sample control and the WHO Standard for the pH. From the plot, it is seen that a better comaparison would be between the samples and samples control (as the standard) however there is no wide gap between the WHO standard and the samples when considering pH as the parameter.

Table 4.7: Comparison of pH values with Control Sample and WHO Standard

	Descriptive statistics		t-test: Test Value = 6.5					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
pH	7.09000	.823853	.590000	1.895	6	.107	-.17194	1.35194
	Test Value (WHO standard) = 8.5							
			-1.410000	-4.528	6	.004	-2.17194	-.64806

Normality test estimates

Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.214	7	.200*	.937	7	.613

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

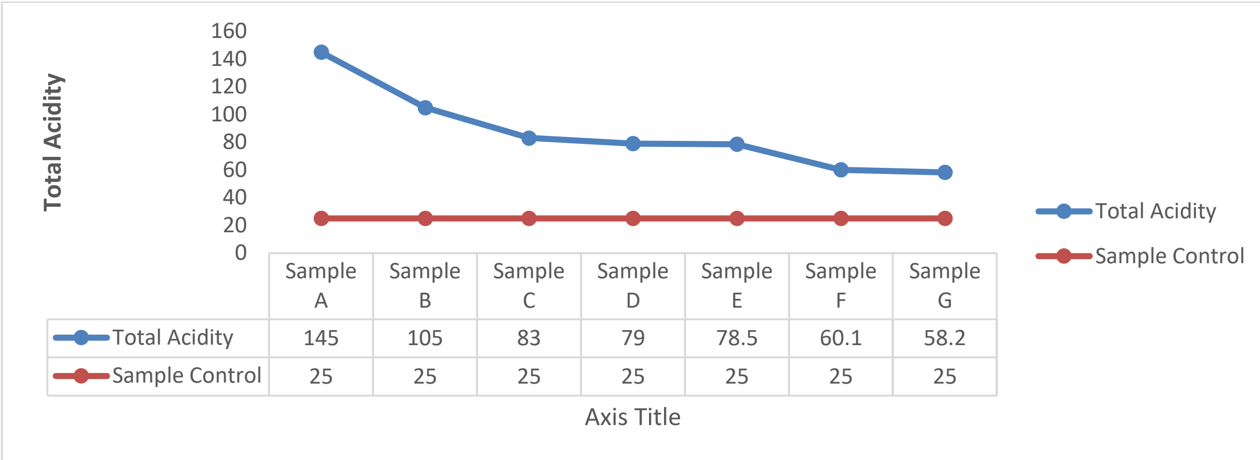
Source: SPSS 25.0 computation

In table 4.7, the mean±standard deviation for pH value from various distances (0 meter, 10 meters, 20 meters, 30 meters, 40 meters, 50 meters, and 60 meters) representing samples A, B, C, D, E, F, and G respectively is **7.090**±0.823853. The mean difference of the samples from control is 0.590. Then, a one sample t-test was used to see if the different samples for pH differed from the standard control. The result confirmed no significant difference by 0.590 (95% CI, -0.17194 to 1.35194), $t(6) = 1.895$, $p = 0.107$. Also, comparison of the pH values in the water sample with WHO standard indicates that the sample values were significantly below WHO permissible standard (by By -1.410 (95% CI, -2.17194 to -6.4806), $t(6) = -4.528$, $p = 0.004$); hence, they are within acceptable standard. The Shapiro Wilk's normality test result (with $p>0.05$) shows that the sample scores were normally distributed, and there were no outliers in the data series.

The pH measures the concentration of hydrogen ions in the water sample. The pH recommended limit for drinking water by WHO (2006) and NSDWQ (2007) is 6.5-8.5. In this present study, the pH values range from 5.6 at distance zero to 7.09 at distance 60 meters away from the dumpsite. Thus, the pH value for the control sample is 8.31. This confirms that the water sample at distance zero has slight acidic contents. As we move 10meters away from the dumpsite, the acidic content disappears. However, since most of the pH values do not lie in the acidic zone (i.e., below 7.0), we can deduce that the water samples from the dumpsite are not acidic, and are in conformity with the WHO (2006) and NSDWQ (2007) permissible limits for drinking water.

Total Acidity

Fig 8: Line plot of Total Acidity vs Standards



Source: Researcher's computation

Fig 8 is the line plot of samples when considering the Sample control as the standard for the Total Acidity. From the plot, it suggest that there is a wide difference between the samples and samples control (as the standard) when considering Total Acidity as parameter of surface water.

Table 4.8: Comparison of Total Acidity values with Control Sample

	Descriptive statistics		t-test: Test Value = 6.5					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Total Acidity	86.97143	29.981367	61.971429	5.469	6	.002	34.24329	89.69957

Normality test estimates

Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Statistic	df	Sig.	Statistic	df	Sig.
.267	7	.141	.866	7	.170

**. This is a lower bound of the true significance.*

a. Lilliefors Significance Correction

Source: SPSS 25.0 computation

Table 4.8 above present result of samples of total acidity collected at various distances in comparison with the control sample value. From the result, the mean±standard deviation for total acidity value is **86.97143** ± 29.981367. The mean difference of the samples from control is 61.971429. Then, a one sample t-test was used to see if the different samples for total acidity differed from the standard control. The result confirmed a significant difference by 61.97 (95% CI, 34.24329 to 89.69957), $t(6) = 5.469$, $p=0.002$. Specifically, the sample values were significantly above the control. However, Shapiro Wilk's normality test result (with $p>0.05$) shows that the sample scores were normally distributed, and there were no outliers in the data series.

Acidity refers to the quantum of free hydrogen in the water samples. There is no standard stated by WHO (2006) and NSDWQ (2007). Water must not be acidic. The levels of acidity in the sampled water ranges from 58.2g/l at distance 60m away from the dumpsite to 145g/l at distance zero. In comparison with the control (25g/l), it shows that the water is too acidic and therefore cannot be recommended for drinking.

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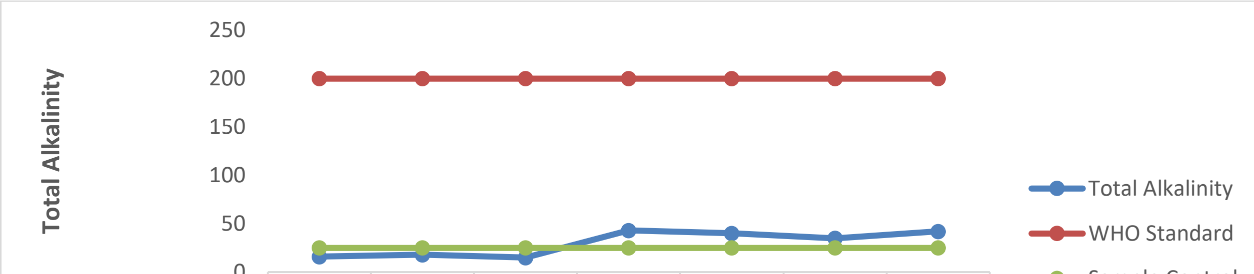
Total Alkalinity

Fig 9: Line plot of Total Alkalinity vs Standards



	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	Sample G
Total Alkalinity	16	18	15	43	40	35	42
WHO Standard	200	200	200	200	200	200	200
Sample Control	25	25	25	25	25	25	25

Source: Researcher's computation

Fig 9 is the line plot of samples when considering the Sample control as the standard for the Total Alkalinity. From the plot, it suggets that the samples and samples control (as the standard) when considering Total alkalinity as parameter of surface water is approximatley the same. Also there is a wide difference between the WHO standard and samples of the total alkalinity.

Table 4.9: Comparison of Total Alkalinity values with Control Sample and WHO Standard

	Descriptive statistics		t-test: Test Value = 25					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Total Alkalinity	29.85714	12.928374	4.857143	.994	6	.359	-7.09961	16.81389
	Test Value (WHO standard) = 200							
			-170.142857	-34.819	6	.000	-182.09961	-158.18611

Normality test estimates					
Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.249	7	.200*	.806	7	.047

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

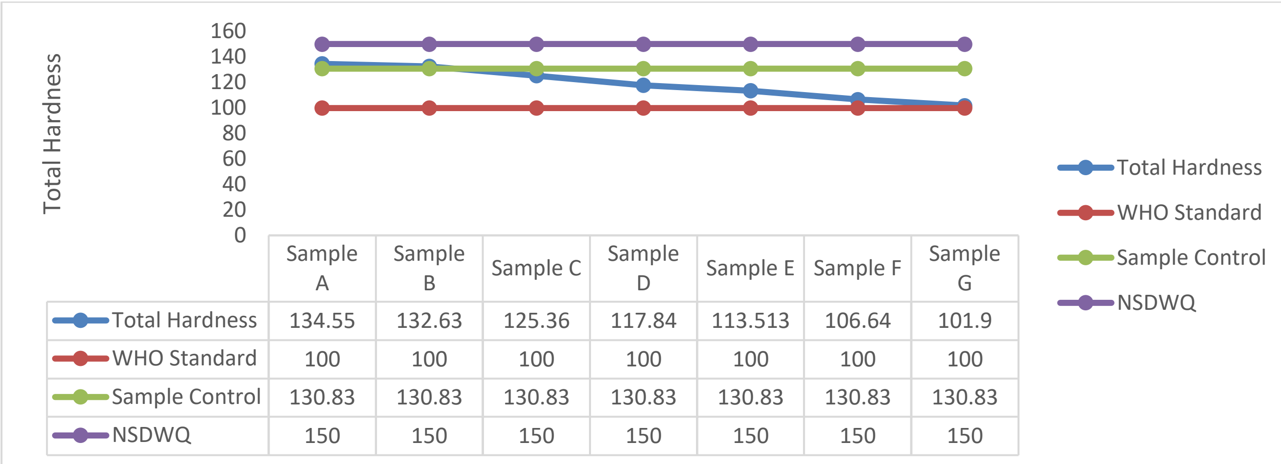
Source: SPSS 25.0 computation

Table 4.9 is the result of samples of total alkalinity collected at various distances in comparison with the control sample value. From the result, the mean±standard deviation for total alkalinity value is **29.85714** ± 12.9283. The mean difference of the samples from control is 4.857 and the data series were confirmed to be normally distributed by Shapiro Wilk's normality test ($p>0.05$). Then, a one sample t-test was used to see if the different samples for total acidity differed from the standard control. The result confirmed that the alkaline contents in the water is insignificantly above the control level by 4.8571 (95% CI, -7.09961 to 16.81389), $t(6) = 0.994$, $p=0.359$. Meanwhile, comparison of the Total Alkalinity sample values with WHO standard indicates that the sample values were significantly below WHO acceptable standard by −170.142857 (95% CI, -182.09961 to -158.18611), $t(6) = -34.819$, $p <0.001$.

Alkalinity measures the state of water towards the brackish and of the scale away from acidity; in other words, the amount of alkaline materials in the water, mainly sodium and potassium salts. Here, the conventional is that drinkable water should not be brackish or alkaline. From our samples, the alkalinity of the water in the study area ranges from 15g/l at distance 20m away from the dumpsite to 43g/l at distance 30m away from the dumpsite. These values are far below the WHO (2006) recommended standard of 200g/l. The NSDWQ has no specified standard. However, the water is brackish and contains alkaline, therefore unhealthy for drinking.

Total Hardness

Fig 10: Line plot of Total Hardness vs Standards



Source: Researcher's computation

Fig 10 is the line plot of samples when considering the Sample control as the standard for the Total Hardness. From the plot, it suggets that the samples and sample control (as the standard) when considering Total Hardness as parameter of surface water is approximatley the same. Also, there is no much difference between the WHO standard/NSDWQ standard and samples of the total Hardness.

Table 4.10: Comparison of Total Hardness with Control Sample, WHO and Nigerian Standard

	Descriptive statistics		t-test: Test Value = 25					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Total Hardness	118.91900	12.547347	-11.91100	-2.512	6	.046	-23.51536	-.30664
	Test Value (WHO standard) = 100							
			18.91900	3.989	6	.007	7.3146	30.5234
	Test Value (Nigerian standard) = 150							
			-31.08100	-6.554	6	.001	-42.6854	-19.7466

Normality test estimates					
Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.148	7	.200*	.946	7	.692

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

Source: SPSS 25.0 computation

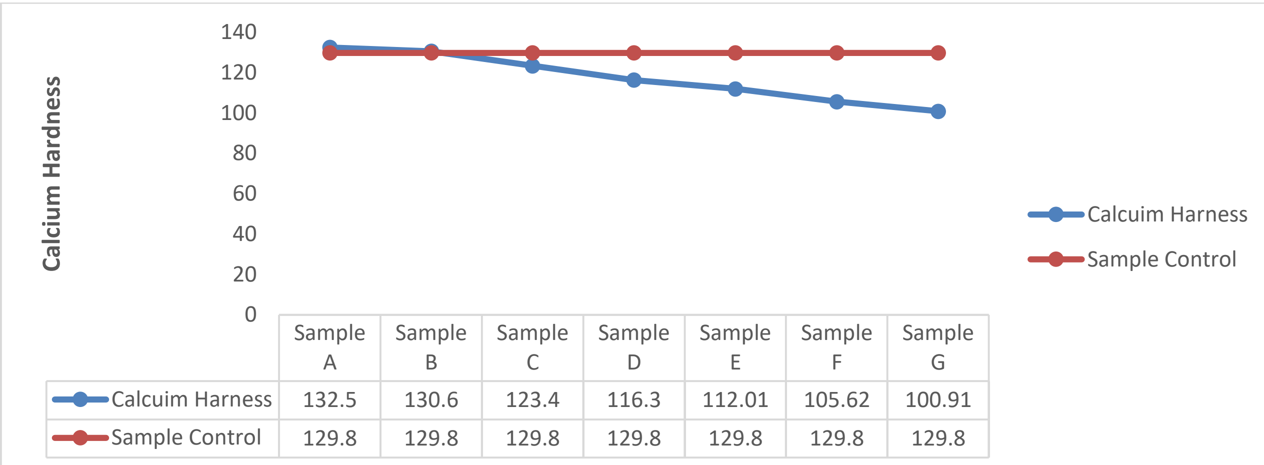
Based on table 4.10 result, the mean±standard deviation for total hardness value is **118.919**±12.547347. The mean difference of the samples from control is -11.911. The data series by Shapiro Wilk's normality test estimate (with p>0.05) were verified to be normally distributed and without outliers. Then, a one sample t-test was used to see if the different samples for total hardness differed from the standard control. Result of the t-test confirmed that the total hardness in the water are significantly below the control level by -11.911 (95% CI, −23.51536 to −0.30664), t(6) = -2.512, p=0.046<0.05.

The result which also compared the values from samples of Total Hardness with WHO and Nigerian standards indicates that the sample values of Total Hardness from the surface water at the specified distances were substantially above WHO permissible limit (t=3.989, p=0.007<0.05), but significantly below Nigerian standard (t = −6.554, p =0.001<0.05).

Water hardness relates to the amount of calcium and magnesium compounds present in water. In other words, water is said to be hard if it has high concentration of Ca^{2+} and Mg^{2+} ions, which react with soap to form scum. So, total hardness refers to the quantity of carbonates and bi-carbonates in the water sample. Based on our samples, the Total hardness varies from 101.9mg/l at distance 60m away from the dumpsite to 134.55mg/l at distance zero from the dumpsite. The WHO (2006) and NSDWQ (2007) standard is 100mg/l of the hardening salts. However, the water is classified as hard water. As a result, it is beneficial for coliform counts but does not hold any advantages for people who process food and drinks. Also, if the people living within the study area have no other alternative for drinking water, they should always boil or add lime to the water before drinking it.

Calcium Hardness

Fig 11: Line plot of Calcium Hardness vs Standards



Source: Researcher's computation

Fig 11 is the line plot of samples when considering the Sample control as the standard for the calcium hardness. From the plot, it suggets that the samples and samples control (as the standard) when considering calcium hardness as parameter of surface water is approximatley the same except for sample E, F and G.

Table 4.11: Comparison of Calcium Hardness with Control Sample

	Descriptive statistics		t-test: Test Value = 129.8					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Calcium Hardness	117.3343	12.10489	-12.465714	-2.725	6	.034	-23.66087	-1.27056

Normality test estimates

Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Statistic	df	Sig.	Statistic	df	Sig.
.149	7	.200*	.947	7	.706

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

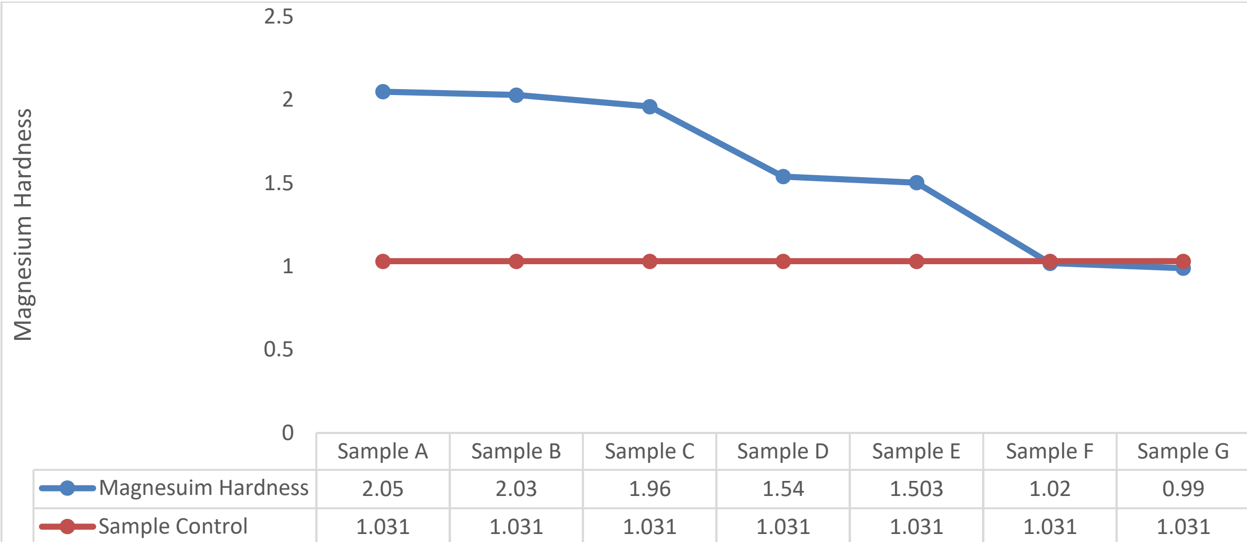
Source: SPSS 25.0 computation

Table 4.11 is the result of samples of calcium hardness collected at various distances in comparison with the control sample value. From the result, the mean±standard deviation for calcium hardness is **117.33429**±12.104891. The mean difference of the samples from control is −12.4657 and the data series were confirmed to be normally distributed by Shapiro Wilk's normality test ($p>0.05$). Then, a one sample t-test was used to see if the different samples for calcium hardness differed from the standard control. The result confirmed a significant difference by −12.4657 (95% CI, -23.66087 to -1.27056), $t(6) = -2.725$, $p = 0.034$. Specifically, the calcium ion in the water is significantly below the control.

As a carbonate that is dissolved in water, Calcium can be obtained in water samples if the radical salts are abstracted. For drinking water, the WHO (2006) and NSDWQ (2007) permissible limit for calcium is 200mg/l. In this present study, the distribution of calcium ion in the water samples ranges from 100.91mg/l at distance 60m away from the dumpsite to 132.5mg/l at distance zero from the dumpsite. These values are still within WHO (2006) and NSDWQ (2007) permissible limit; hence, but are of high concentrations; hence, the water is not classified as hard water.

Magnesium Hardness

Fig 12: Line plot of Magnesuim Hardness vs Standard



Source: Researcher's computation

Fig 12 is the line plot of samples when considering the Sample control as the standadr for the magnesium hardness. From the plot it suggets that the samples and samples control (as the standard) when considering magnesium hardness as parameter of surface water is not the same except for sample F and G that are approximately the same.

Table 4.12: Comparison of Magnesium Hardness with Control Sample

	Descriptive statistics		t-test: Test Value = 1.031					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Magnesium Hardness	1.58471	.454033	.553714	3.227	6	.018	.13380	.97362

Normality test estimates

Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.224	7	.200*	.859	7	.150

**. This is a lower bound of the true significance.*

a. Lilliefors Significance Correction

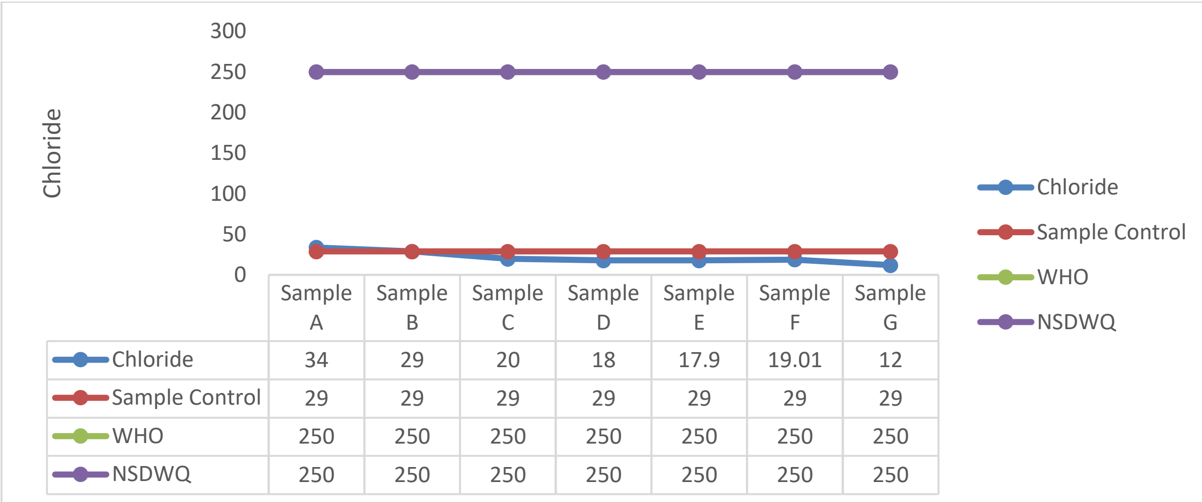
Source: SPSS 25.0 computation

From the result in table 4.12 above, the mean±standard deviation for Magnesium Hardness samples is **1.58471** ± 0.45403. The mean difference of the samples from control is 0.553714. The data series by Shapiro Wilk's normality test estimate (with $p>0.05$) were verified to be normally distributed and without outliers. Then, a one sample t-test was used to see if the different samples for Magnesium Hardness differed from the standard control. Result of the t-test confirmed a significant difference by 0.553714 (95% CI, 0.13380 to 0.97362), $t(6) = 3.227$, $p = 0.018 < 0.05$. Specifically, the sample values were significantly above the control.

The magnesium hardness present in the water lies between 0.99mg/l at distance 60m away from the dumpsite and 2.05mg/l at distance 0m away from the dumpsite. This shows that there is low concentration of Mg^{2+} ions in the water which also affirms that the water is not a hard water.

Chlorides

Fig 13: Line plot of Chloride vs Standard



Source: Researcher's computation

Fig 13 is the line plot of samples when considering the Sample control as the standadr for the chloride. From the plot it suggets that the samples and samples control (as the standard) when considering chloride as a parameter of surface water is approximatley the same. Also, there is a very wide difference between the WHO standard and the sample values of chloride at the various distances in the surafce water.

Table 4.13: Comparison of Chloride with Control Sample and WHO/Nigerian standards

<table>
<tr><td></td><td colspan="2">Descriptive statistics</td><td colspan="6">t-test: Test Value = 29</td></tr>
<tr><td rowspan="2">Parameter</td><td rowspan="2">Mean</td><td rowspan="2">Std. Dev.</td><td rowspan="2">Mean Difference</td><td rowspan="2">t-stat.</td><td rowspan="2">df</td><td rowspan="2">Sig. (2-tailed)</td><td colspan="2">95% Confidence Interval of the Difference</td></tr>
<tr><td>Lower</td><td>Upper</td></tr>
<tr><td>Chloride</td><td>21.41571</td><td>7.487327</td><td>-7.584286</td><td>-2.680</td><td>6</td><td>.037</td><td>-14.50891</td><td>-.65966</td></tr>
<tr><td></td><td colspan="8">Test Value (WHO/Nigerian standard) = 250</td></tr>
<tr><td></td><td></td><td></td><td>-228.584286</td><td>-80.773</td><td>6</td><td>.000</td><td>-235.50891</td><td>-221.65966</td></tr>
<tr><td colspan="9">Normality test estimates</td></tr>
<tr><td colspan="3">Kolmogorov-Smirnov[a]</td><td colspan="3">Shapiro-Wilk</td></tr>
<tr><td>Statistic</td><td>df</td><td>Sig.</td><td>Statistic</td><td>df</td><td>Sig.</td></tr>
<tr><td>.289</td><td>7</td><td>.079</td><td>.895</td><td>7</td><td>.304</td></tr>
<tr><td colspan="9">*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction</td></tr>
</table>

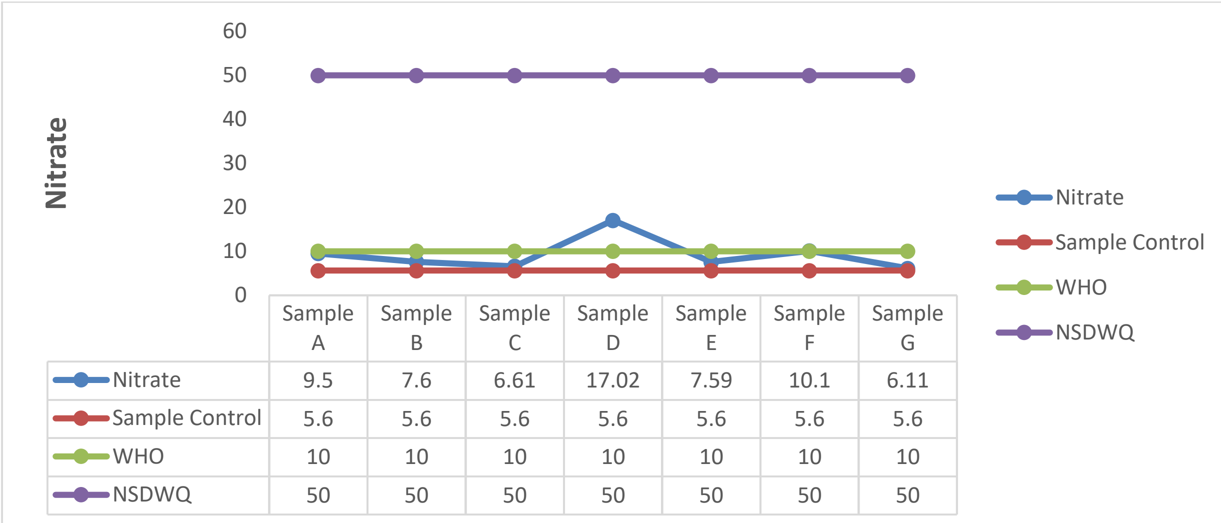
Source: SPSS 25.0 computation

In table 4.13 as shown above, the mean±standard deviation for Chloride as obtained from the various distances is **21.41571** ± 7.487327. The mean difference of the samples from control is −7.584286. Then, a one sample t-test was used to see if the different samples for Chloride differ from the control. The result confirmed significant difference by −7.584286 (95% CI, -14.50891 to -0.65966), $t(6) = -2.680$, $p = 0.037$. Also, the comparison with WHO/Nigerian standards uncovered that the sample values are significantly below WHO permissible standard of 250 ($t(6) = -80.773$, $p < 0.001$). However, Shapiro Wilk's normality test result (with $p=0.304>0.05$) shows that the sample scores were normally distributed, and there were no outliers in the data series.

Chlorides are one of the contents extracted from the groundwater reservoir. They are generally soluble in water and may determine the state of groundwater if found present. The WHO (2006) and NSDWQ (2007) benchmark for chlorides in potable water is 250mg/1. In our study, the distribution of chlorides level in the dumpsite ranges from 12.0mg/l at distance 60m away from the dumpsite to 34.0mg/l at distance zero from the dumpsite. This means that the chloride content of all the water samples is far below and within the critical value of the WHO (2006) and NSDWQ (2007) standard for drinking water, and therefore, poses no health dangers.

Nitrates

Fig 14: Line plot of Nitrate vs Standard



Source: Researcher's computation

Fig 14 is the line plot of samples when considering the Sample control as the standadr for the Nitrate. From the plot it suggets that the samples and all the standards such as Sample control, WHO/NSDWQ (as the standard) when considering nitrate as parameter of surface water is approximatley the same.

Table 4.14: Comparison of Nitrate with Control Sample

	Descriptive statistics		t-test: Test Value = 5.6					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Nitrate	9.21857	3.729573	3.618571	2.567	6	.043	.16929	7.06785
	Test Value (WHO standard) = 10							
			-.781429	-.554	6	.599	-4.23071	2.66785
	Test Value (Nigerian standard) = 50							
			-40.781429	-28.930	6	.000	-44.23071	-37.33215

Normality test estimates					
Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.264	7	.151	.791	7	.033

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

Source: SPSS 25.0 computation

In table 4.14 as shown above, the mean±standard deviation for Nitrate as obtained from the various distances is **9.21857** ± 3.729573. The mean difference of the samples from control is 3.618571. Meanwhile, the mean differences of the samples from the WHO standard (10mg/l) and Nigerian standard (50mg/l) are −0.781429mg/l and −40.781429mg/l respectively. A one sample t-test was used to see if the different samples for Nitrate vary significantly from the control (5.6mg/l), WHO standard (10mg/l) and Nigerian standard (50mg/l). Before, the comparative analysis, Shapiro Wilk's normality test was carried out while the result proved that the data series were normally distributed (with $p>0.05$), and that there were no outliers in the data.

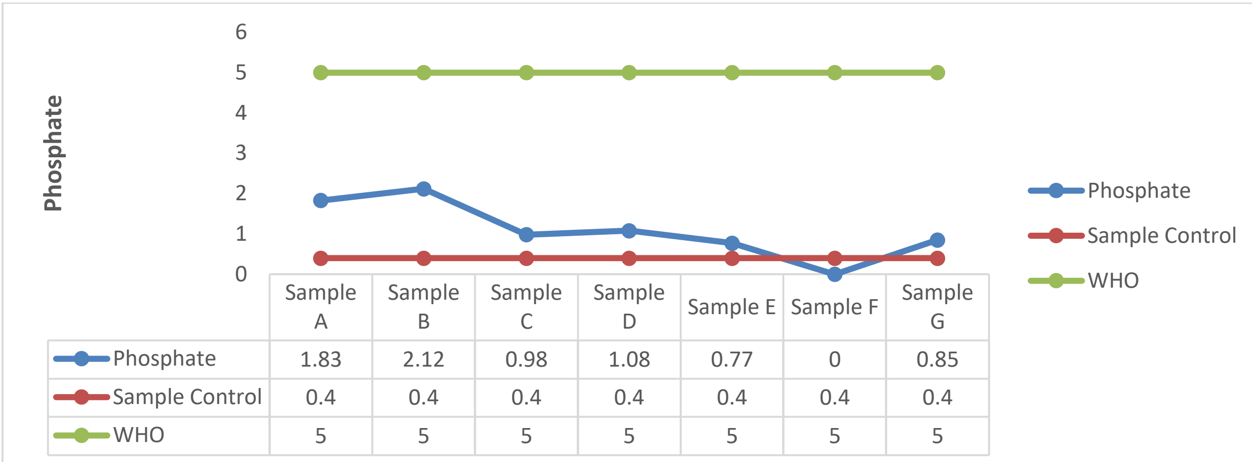
From the t-test result, with the t-statistic value of 2.567 and associated probability value of $0.043<0.05$, it was shown that the samples were significantly higher than the control sample. The result also shows that nitrates concentrations in the surface water samples obtained at various distances were significantly below Nigerian standard ($t=-28.930$, $p=0.000<0.05$), but insignificantly below WHO permissible standard ($t=-0.554$, $p=0.599>0.05$).

Nitrates just like chlorides are very soluble in water. In this present study, the nitrate contents varies from 6.11mg/l at distance 60m away from dumpsite to 17.02mg/l at distance 30m away from the dumpsite. The WHO (2006) permissible standard is 10mg/l, while NSDWQ

(2007) recommended standard is 50mg/l. As shown in our study, the nitrate contents of the surface water samples are within the WHO (2006) standard of 10mg/l but far below NSDWQ (2007) standard of 50mg/l. Therefore, the nitrate content in the sample water is safe for consumption; that is to say, since the values are below NSDWQ (2007) permissible standard, the water is safe for domestic use.

Phosphates

Fig 15: Line plot of Phosphate vs Standard



Source: Researcher's computation

Fig 15 is the line plot of samples when considering the Sample control/WHO as the standard for the phosphate. From the plot it suggets that the samples and samples control (as the standard) when considering Phosphate as parameter of surface water is approximatley the same except for sample A and B. Also, there is a very wide difference between the WHO standard and that of the sample items of comparison for phosphate as a parameter of the surafce water.

Table 4.15: Comparison of Phosphate with Control Sample and WHO Standard

	Descriptive statistics		t-test: Test Value = 0.4					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Phosphate	1.09000	.703420	.690000	2.595	6	.041	.03944	1.34056
	Test Value (WHO standard) = 5							
			-3.910000	-14.707	6	.000	-4.56056	-3.25944

Normality test estimates					
Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.220	7	.200*	.945	7	.681

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

Source: SPSS 25.0 computation

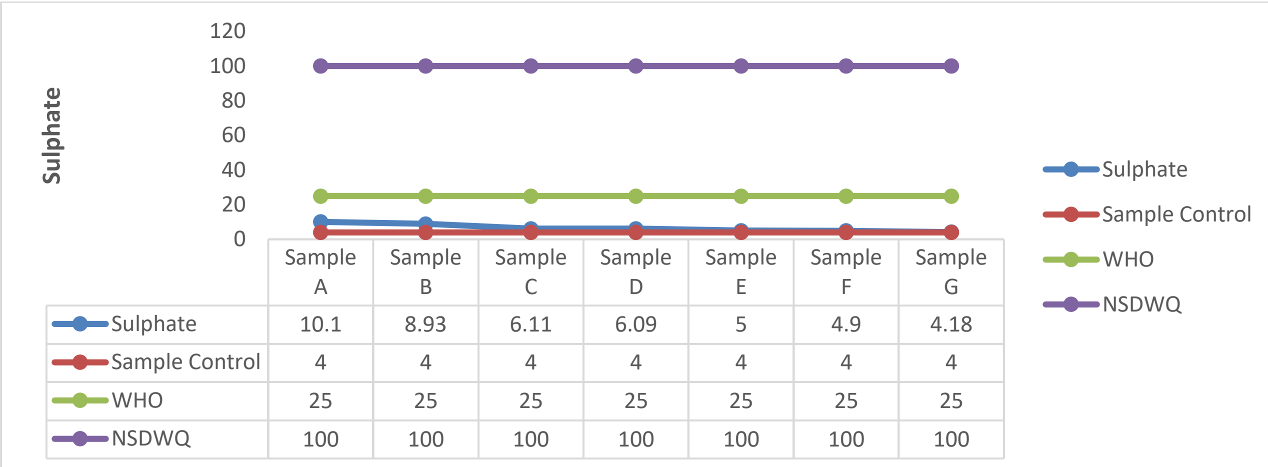
The result in table 4.15 above indicates that the mean±standard deviation of the phosphate samples at various distances is **1.090** ± 0.70342. The mean difference is 0.690, indicating that the sample values are above the control. To obtain a definite result of the level of variation, a one sample t-test was employed. But, before then, the Shapiro Wilk's normality test (with $p>0.05$) confirmed that the sample scores were normally distributed, and that there were no outliers in the data series. However, result of the one sample t-test result (with $t=2.595$, $p=0.041<0.05$) provided that phosphates in the water samples were significantly above the control.

In comparison with the WHO standard, it was ascertained by −3.910 (95% CI, −4.56056 to −3.25944), $t(6) = -14.707$, $p < 0.001$ that the phosphate samples at various distances were significantly below WHO permissible standard of 5mg/l.

The phosphate values from the water samples vary from 0mg/l at distance 50m away from the dumpsite to 2.12mg/l at 10m away from the dumpsite. These values are within the WHO (2006) standard (5mg/l) for drinking water quality. However, NSDWQ has no threshold limit for phosphates in water.

Sulphates

Fig 16: Line plot of Sulphate vs Standard



Source: Researcher's computation

Fig 16 is the line plot of samples when considering the Sample control as the standard for the sulpahte. From the plot it suggets that the samples and samples control (as the standard) when considering sulphate as parameter of surface water is approximatley the same. Also there is a very wide difference between the NSDWQ standard and that of the samples items of comparison for sulphate as a parameter of the surafce water.

Table 4.16: Comparison of Sulphate with Control Sample, WHO and Nigerian Standard

	Descriptive statistics		t-test: Test Value = 4					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Sulphate	6.47286	2.212553	2.472857	2.957	6	.025	.42659	4.51913
	Test Value (WHO standard) = 25							
			-18.527143	-22.155	6	.000	-20.57341	-16.48087
	Test Value (Nigerian standard) = 100							
			-93.527143	-111.839	6	.000	-95.57341	-91.48087

Normality test estimates					
Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.279	7	.105	.874	7	.201

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

Source: SPSS 25.0 computation

As presented in table 4.16 above, the mean±standard deviation of the samples for sulphate is (**1.090** ± 0.70342). The Shapiro Wilk's normality estimates are (S-W stat. = 0.874, p=0.201>0.05), indicating that the sample scores were normally distributed, and there were no outliers in the data series. Estimate of the mean difference in comparison with the control value of 4 is 2.472857. However, since the data series are normally distributed, the t-test estimates by 2.472857 (95% CI, 0.42659 to 4.51913), t(6) = 2.957, p =0.025 confirmed that the sulphate samples obtained were significantly above the control value of 4.

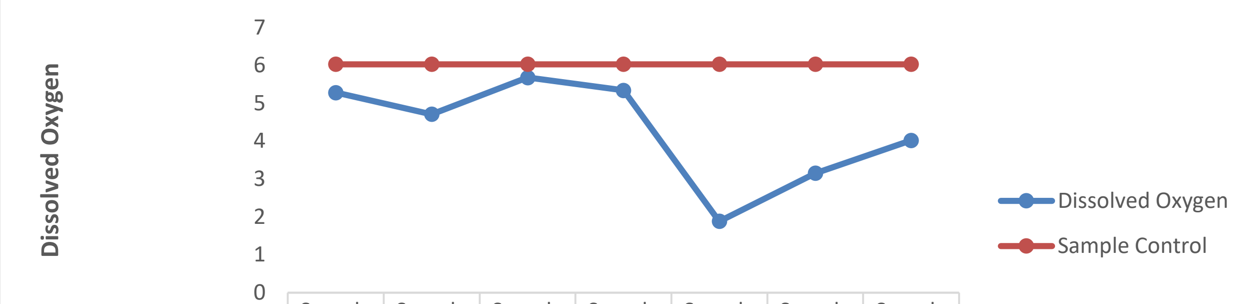
Also, a comparative statistics of the sulphate concentrations in the water samples with WHO and Nigerian standard indicates by −18.527143 (95% CI, -20.57341 to -16.48087), t(6) = −22.155, p<0.001 and −18.527143 (95% CI, -95.57341 to -91.48087), t(6) = −111.839, p <0.001 that the sulphate concentrations in the water samples were significantly below WHO (25mg/l) and Nigerian (100mg/l) recommended standards.

Sulphate is a hard relatively insoluble chemical which causes water hardness. The WHO (2006) and NSDWQ (2007) has a critical value of 25mg/l and 100mg/l respectively for good drinking water. The value of sulphate in the sampled water in our study ranges from

4.18mg/l at distance 60m away from the dumpsite to 10.1mg/l at distance zero. It can be inferred that there are low sulphate contents in the sampled water.

Dissolved Oxygen

Fig 17: Line plot of Dissolved Oxygen vs Standard



	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	Sample G
Dissolved Oxygen	5.28	4.71	5.68	5.34	1.88	3.15	4.02
Sample Control	6.03	6.03	6.03	6.03	6.03	6.03	6.03

Source: Researcher's computation

Fig 17 is the line plot of samples when considering the Sample control as the standard for the dissolved oxygen. From the plot it suggets that the samples and samples control (as the standard) when considering dissolved oxygen as parameter of surface water is approximatley the same for sample A, B, C and D only.

Table 4.17: Comparison of Dissolved Oxygen with Control Sample

	Descriptive statistics		t-test: Test Value = 6.03					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Dissolved Oxygen	4.29429	1.376685	-1.735714	-3.336	6	.016	-3.00894	-.46249

Normality test estimates					
Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.192	7	.200*	.906	7	.367

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

Source: SPSS 25.0 computation

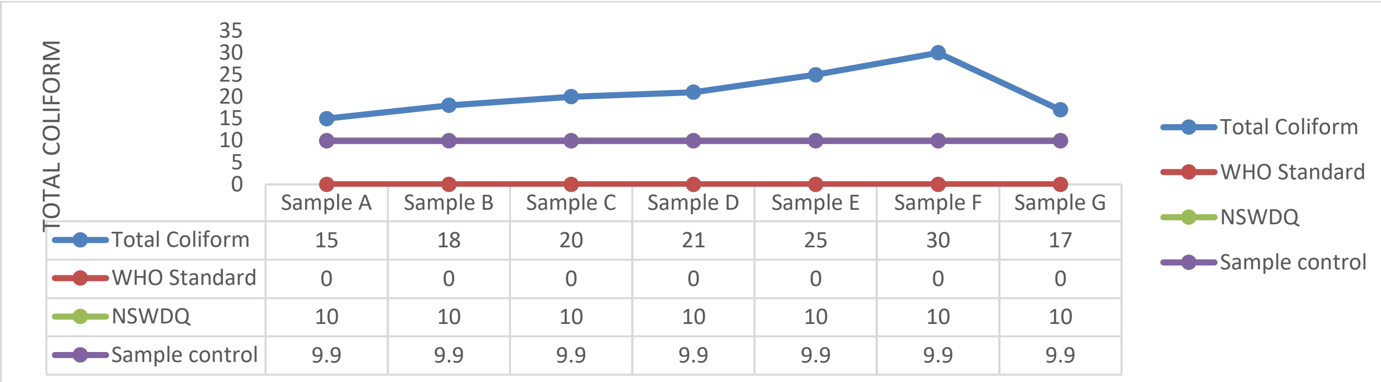
In table 4.17, it was shown that the mean±standard deviation of the samples for Dissolved Oxygen is (**4.294** ± 1.37669). The mean difference estimate in comparison with control value of 6.03 is -1.7357, indicating that the sample values for Dissolved Oxygen at the various distances are below the control value of 6.03. However, further comparison was carried out using one sample t-test since the Shapiro Wilk's normality estimates of (S-W stat. = 0.906, p=0.367>0.05) confirmed that the sample scores were normally distributed, and that there were no outliers in the data series. By -1.7357 (95% CI, −3.00894 to −0.46249), t(6) = −3.336 and p=0.016, it was deduced that dissolved oxygen in the water samples were significantly below the control value of 6.03.

This is the quantity of oxygen in the water sample. It is canter to the BOD and the COD which take away oxygen from the water sample in areas depending on the biochemical characteristics of the water. There is no specified limit of dissolved oxygen both by WHO and NSDWQ. Uchegbu (2012) noted that if BOD is high, then DO should be less. In this present study, the distribution of the dissolved oxygen varies within a range of 1.88mg/l at distance 40m away from the dumpsite to 5.68mg/l at distance zero from the dumpsite. Based on literature, one of the characteristics of polluted water is decrease in dissolved oxygen (DO). However, our result shows that the water is polluted since the amount of dissolved oxygen (DO) decreases on moving away from the dumpsite.

4.2.3 Results of bacteriological parameters of surface water

The pollution level is explained by the presence of coliform (E.coli) in all the water samples.

Fig 18: Line graph of Total coliform vs Standard



Source: Researcher's computation

Fig 18 is the line plot of samples when considering the Sample control and the WHO Standard for the total coliform. From the plot, it suggest that the comparison between the samples and samples control/WHO (as the standard) is wide when considering total coliform as the parameter.

Table 4.18: Comparison of Total Coliform with Control Sample, WHO and Nigerian standard

	Descriptive statistics		t-test: Test Value = 9.9					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Total coliform	20.85714	5.145502	10.95714	5.634	6	.001	6.198347	15.715938
	Test Value (WHO standard) = 0.0							
			20.8571429	10.724	6	.000	16.098347	25.615938
	Test Value (Nigerian standard) = 10.0							
			10.8571429	5.583	6	.001	6.098347	15.615938

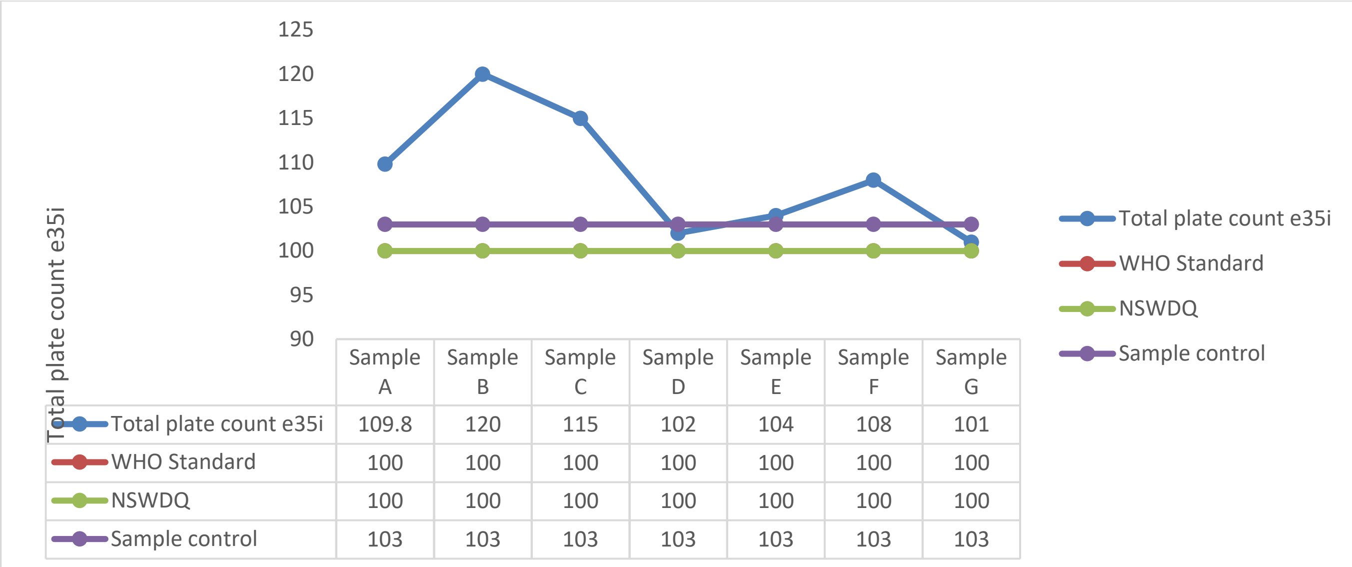
Normality test estimates					
Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.203	7	.200*	.936	7	.603

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

Source: SPSS 25.0 computation

In table 4.18, a one sample t-test was used to see if the different samples for Total Coliform differed from the control samples. The Shapiro Wilk's normality test (P>0.05) indicates that the sample scores were normally distributed, and there were no outliers in the data series. The mean±standard deviation of the samples for total coliform (**20.8571** ± 5.1455), which is higher than the standard mean (Control Sample), indicates that concentrations of total coliform from the surface water at various distances are significantly above the control value ($t(6) = 5.634$, $p=0.001<0.05$), significantly above the WHO permissible standard ($t(6)=10.724$, $p< 0.001$), and also, significantly above Nigerian acceptable standard ($t(6) = 5.583$, $p=0.001$).

Fig 19: Line graph of Total plate count e35i after 24hrs vs Standard



Source: Researcher's computation

Fig 19 is the line plot of samples when considering the sample control and the WHO Standard for the total plate count e35i after 24hours. From the plot, it was shown that the comparison between the samples and samples control/WHO (as the standard) is closely similar from sample D, E, F and G when considering total plate count e35i for bacteriological parameter of surface water.

Table 4.19: Comparison of total plate count e35i after 24hours with Control Sample, WHO and Nigerian Standard

	Descriptive statistics		t-test: Test Value = 103					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Total plate count e35i after 24hours	108.542857	7.0139996	5.5428571	2.091	6	.082	-.944011	12.029725
	Test Value (WHO/Nigerian standard) = 100.0							
			8.5428571	3.222	6	.018	2.055989	15.029725

Normality test estimates					
Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.170	7	.200*	.933	7	.578

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

Source: SPSS 25.0 computation

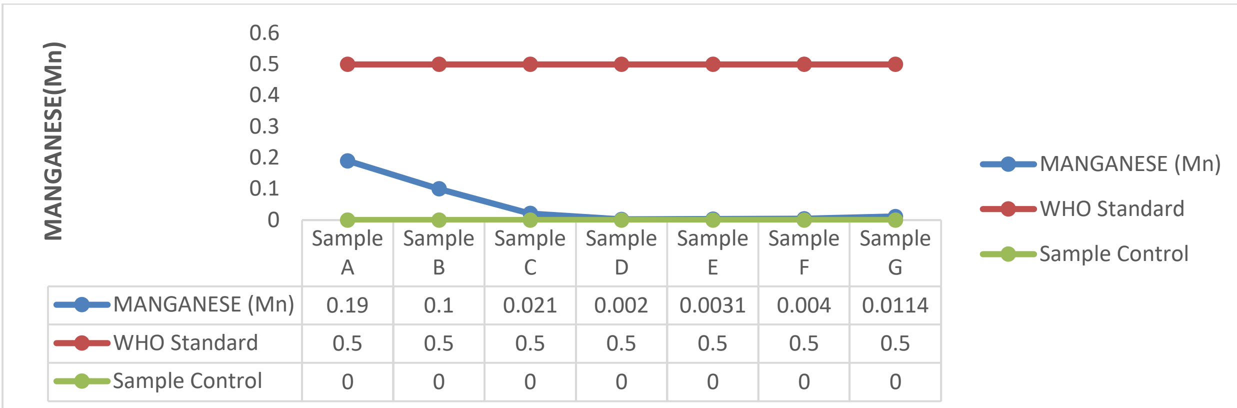
In table 4.19, a one sample t-test was used to see if the different samples for total plate count e35i after 24hours differed from the standard/control. The result affirmed that the concentrations of total plate count e35i after 24hours (with mean = **108.542857** ± 5.5428571) and t-test estimates of (t(6) = 2.091, p=0.082>0.05), were not significantly higher above the control samples, but significantly above the WHO and Nigerian standard (t(6) = 3.222, p=0.018<0.05). However, the Shapiro Wilk's test result with S-W stat. = 0.933 and associated probability value of 0.578>0.05 indicates that the sample scores were normally distributed, and there were no outliers in the data series.

4.2.4 Results of Heavy Metals of the Surface Water

Result of analysis of the heavy metals from the surface water samples at various distances from the dumpsite were analyzed as follows:

Manganese

Fig 20: Line plot of Manganese vs Standards



Source: Researcher's computation

Fig 20 is the line plot of samples when considering the Sample control and the WHO Standard for the manganese. From the plot, it shows that a better comaparison would be between the samples and sample control (as the standard) since there is wide gap between the WHO standard and the samples when considering manganese as the parameter of surface water.

Table 4.20: Comparison of Manganese with Control Sample

	Descriptive statistics		t-test: Test Value = 0.00					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Manganese	.04736	.071881	.047357	1.743	6	.132	-.01912	.11384
	Test Value (WHO standard) = 0.5							
			-.452643	-16.660	6	.000	-.51912	-.38616

Normality test estimates					
Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.357	7	.107	.715	7	.105

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

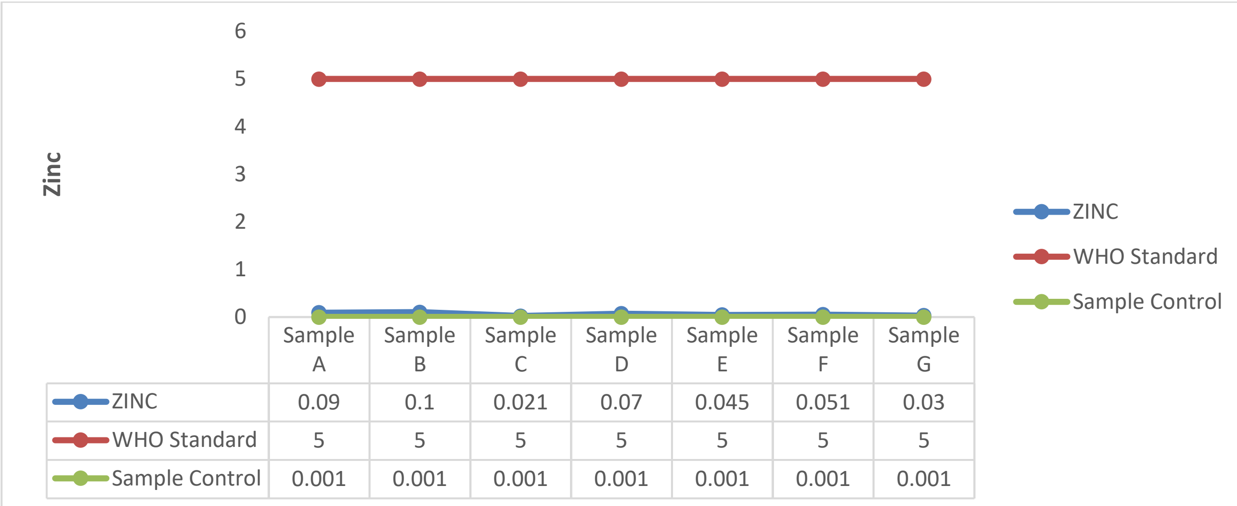
Source: SPSS 25.0 computation

In table 4.20, it shows that the mean±standard deviation of samples of manganese as collected from the surface water is **0.04736** ± 0.071881. The standard deviation is higher than the mean, indicating high volatility of the data series. The t-statistic value of 1.743 with associated probability value of 0.132>0.05 shows that the variations of the sample values were not significantly above the control sample. But in comparison with the WHO standard, the sample values of manganese extracted at various distances from surface water in the area are significantly below WHO permissible standard by −0.452643 (95% CI, −0.51912 to −0.38616), $t(6) = -16.660$, $p < 0.001$. Shapiro Wilk's Test of normality of data series (with $p > 0.05$) confirmed that the sample scores were normally distributed, and there were no outliers in the data series.

Manganese (Mn) at the surface samples of the dumpsite stood at average of 0.047mg/L which is below WHO recommended standard of 0.5mg/l but above the control value of 0.00mg/l. This shows that the water in drinkable although it is not of WHO permissible standard. Increased Manganese (Mn) in drinking water may adversely affect the central nervous system, particularly in children (Rahman et al., 2017).

Zinc

Fig 21: Line plot of Zinc vs Standards



Source: Researcher's computation

Fig 21 is the line plot of samples when considering the Sample control and the WHO Standard for the zinc. From the plot, it is shown that a better comparison would be between the samples and samples control (as the standard) since there is a wide gap between the WHO standard and the samples when considering zinc as the parameter of surface water.

Table 4.21: Comparison of Zinc with Control Sample

	Descriptive statistics		t-test: Test Value = 0.001					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Zinc	.05814	.029729	.057143	5.085	6	.002	.02965	.08464
	Test Value (WHO standard) = 5							
			-4.941857	-439.805	6	.000	-4.96935	-4.91436
Normality test estimates								
Kolmogorov-Smirnov[a]				**Shapiro-Wilk**				
Statistic	df		Sig.			Statistic	df	Sig.
.166	7		.200*			.949	7	.719
**. This is a lower bound of the true significance.*								
a. Lilliefors Significance Correction								

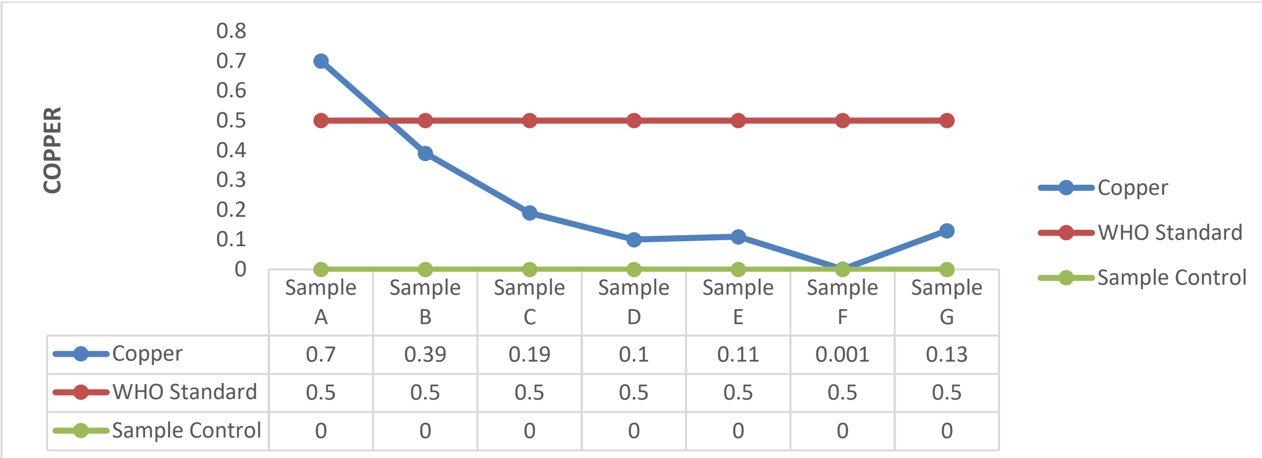
Source: SPSS 25.0 computation

Table 4.21 presents the result of comparison of Zinc concentrations in the surface water with control sample value of 0.001. The result shows that the mean±standard deviation of the Zinc series stood at **0.05814** ± 0.029729. Also, the result, 0.057143 (95% CI, 0.02965 to 0.08464) $t(6)=5.085$, $p = 0.002$, exposed that the sample scores are substantially above the control value; but significantly below WHO acceptable standard as shown by −4.941857 (95% CI, −4.96935 to −4.91436), $t(6)=-439.805$, $p <0.001$. However, the Shapiro Wilk's normality test ($P>0.05$), uncovered that the sample scores were normally distributed, and there were no outliers in the data.

The average value of Zinc (Zn) at the surface sample was 0.058mg/L which is above the control but within the WHO permissible standard of 5.0mg/l. This shows that there is excess Zinc in the water which makes it harmful for the people to consume it (Michael, 2011). But, based on WHO recommended standard, the water is drinkable. Based on literature, zinc is one of the essential elements needed by the body though in excess zinc is found to be dangerous to health which can result to stomach cramps, nausea, vomiting. Ingesting high level of zinc for long can cause anemia, damage of pancreas and decreased level of high density lipoprotein (HDL) cholesterol (ATSDR, 2005).

Copper

Fig 22: Line plot of copper vs Standards



Source: Researcher's computation

Fig 22 is the line plot of samples when considering the Sample control and the WHO Standard for the copper. From the plot, it was shown that no better comparison would be between the samples and sample control (as the standard), except for sample F which is approximatly similar to the sample control. As practically seen in the graph, there is a wide gap between WHO standard and the samples when considering copper as the parameter of surface water.

Table 4.22: Comparison of Copper with Control Sample and WHO Standard

	Descriptive statistics		t-test: Test Value = 0					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Copper	.23157	.238685	.231571	2.567	6	.043	.01082	.45232
	Test Value (WHO standard) = 0.5							
			-.268429	-2.975	6	.025	-.48918	-.04768

Normality test estimates					
Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.283	7	.094	.836	7	.092

**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

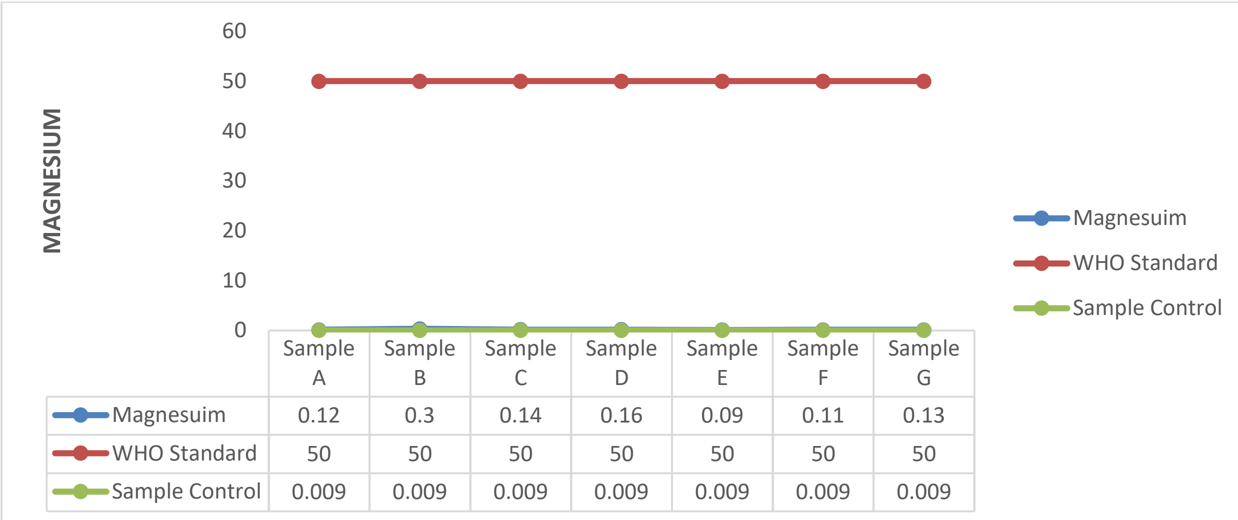
Source: SPSS 25.0 computation

The average concentration of Copper (Cu) in the water sample is 0.232mg/l. Also, presented in table 4.22 are statistics comparing the sample values of Copper with the control sample as well as the WHO standard. As shown in the result, the mean±standard deviation value of Copper from the different samples: sample A, B, C, D, E, F, and G stood at **0.23157** ± .238685. Then, one sample t-test was used to see if the different samples for Copper differed from the control. With a positive mean difference, it shows that the obtained values for the different sample location are higher than the control sample value. Also, the one sample t-test result proved that the copper values as extracted from surface samples were significantly below WHO standard ($t(6)= -2.567$, $p=0.025$). Meanwhile, the Shapiro Wilk's Test (with $p=0.043<0.05$), approved that the sample scores were normally distributed, and that there were no outliers in the data series.

The WHO permissible limit is 0.5mg/l while the control value is 0.00mg/l. This result shows that the copper concentration in the water is high above the control but within the WHO permissible standard. The indication is that the water is polluted but still drinkable based on WHO recommended standard.

Magnesium

Fig 23: Line plot of magnesium vs Standards



Source: Researcher's computation

Fig 23 is the line plot of samples when considering the Sample control and the WHO Standard for the magnesium. From the plot it suggest that no better comaparison would be between the samples and samples control (as the standard). There is also wide gap between the WHO standard and the samples when considering copper as the parameter of surface water.

Table 4.23: Comparison of Magnesium with Control Sample and WHO Standard

	Descriptive statistics		t-test: Test Value = 0.009					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Magnesium	.15000	.069761	.141000	5.348	6	.002	.07648	.20552
	Test Value (WHO standard) = 50							
			-49.850000	-1890.594	6	.000	-49.91452	-49.78548

Normality test estimates					
Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.300	7	.056	.759	7	.116
**. This is a lower bound of the true significance.*					
a. Lilliefors Significance Correction					

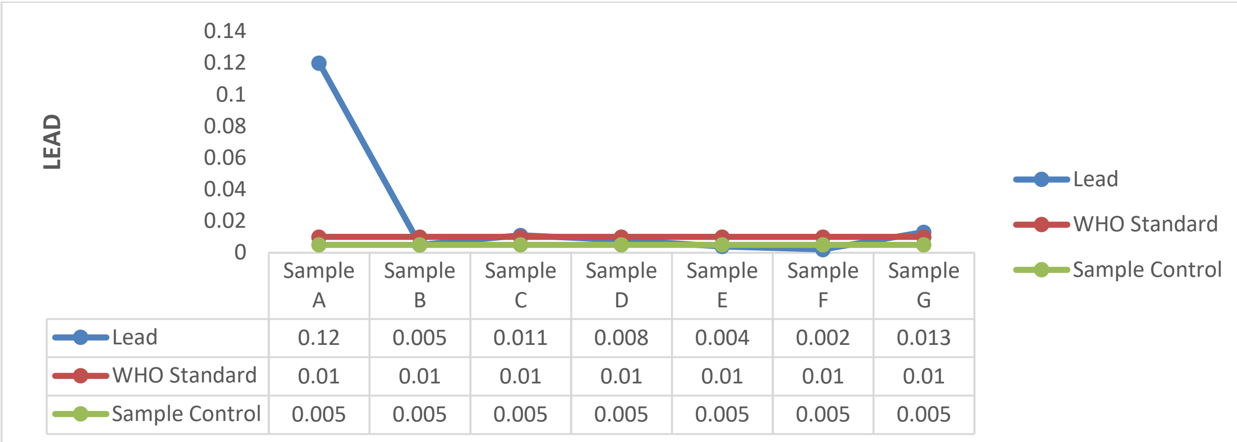
Source: SPSS 25.0 computation

In table 4.23, it was shown that the mean ± standard deviation of magnesium scores from the distant samples stood at (**0.15000** ± 0.069761). Also, one sample t-test which was used to check if the different samples for magnesium differed from the standard control indicates that the values were significantly above the control by 0.1400 (95% CI, 0.07648 to 0.20552), t(6)=5.348, p =0.002. Also, it was affirmed that the magnesium values are significantly below WHO standard (t.-stat. = −1890.594, p <0.0001). However, the sample scores were not normally distributed (Shapiro Wilk's Stat. = 0.759, p=0.116).

Since the concentration of Magnesium (Mg) in the water sample stood at average value of 0.15mg/l, which is above the control, the water is said to be polluted and therefore unhealthy for the people's consumption. This is because, Magnesium when exceed threshold limit is an indication that the water is polluted (WHO, 2009; Michael, 2011). Although, based on WHO (2006) standard, the water can be used for other domestic activities as the zinc concentrations are still below the WHO permissible limit.

Lead

Fig 24: Line plot of Lead vs Standards



Source: Researcher's computation

Fig 24 is the line graph of the Lead samples versus the control and the WHO Standard. From the plot, it was shown that a better comparison is between the samples and the control (as the standard), except for sample A.

Table 4.24: Comparison of Lead with Control Sample and WHO Standard

	Descriptive statistics		t-test: Test Value = 0.0005					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Lead	.02329	.042824	.018286	1.130	6	.302	-.02132	.05789
	Test Value (WHO Standard) = 0.01							
			.013286	.821	6	.443	-.02632	.05289

Normality test estimates					
Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
Statistic	df	Sig.	Statistic	df	Sig.
.452	7	.100	.540	7	.100
**. This is a lower bound of the true significance.*					
a. Lilliefors Significance Correction					

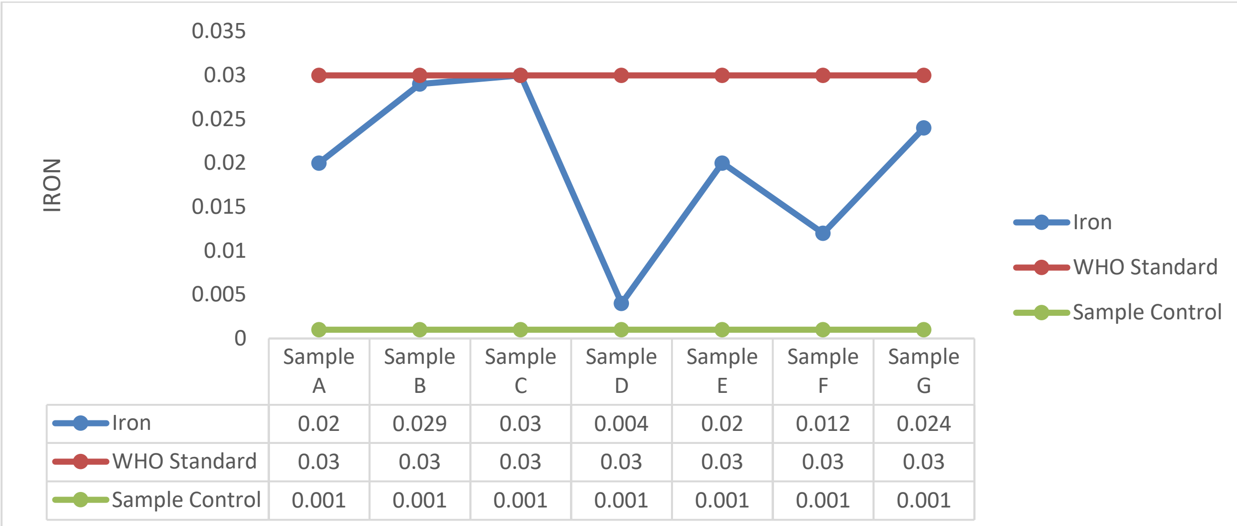
Source: SPSS 25.0 computation

Average lead (Pb) concentration at the surface water samples stood at 0.023mg/l. The comparative result in table 4.24 shows that the mean±standard deviation of the samples for Lead (Pb) is (0.02329 ± 0.042824) with 0.018286 (95% C.I., 0.07648 to 0.20552), which is higher than the control value of 0.005 and WHO standard value of 0.01. Although the variations with control ($t(6) = 1.130$, $p=0.302>0.05$) and WHO standard ($t(6) = 0.821$, $p = 0.443>0.05$) are significantly high. In other words, the value is negligibly high in comparison with the control and WHO permissible standard. However, the Shapiro Wilk's test (with $p>0.05$), indicates that the sample scores were normally distributed, and that there were no outliers in the data series.

Based on literature, Lead plays no physiological role in man and animal system; and thus, not required even at trace levels. This is because, it hampers many metabolic pathways processes. Also, Lead (Pb) poisoning can disrupt the functioning of several tissues, organs and system including the heart, kidneys, bones, intestine, nervous and reproductive system (Papanikolaou et al., 2005; Ozoko, 2015).

Iron

Fig 25: Line plot of Iron vs Standards



Source: Researcher's computation

Fig 25 is the line plot of samples of Iron (Fe) in comparison with the control sample the WHO recommended standard. From the plot, it suggest that no better comparison would be between the samples and WHO standard. There is a wide gap between the WHO standard and the samples when considering iron as the parameter of surface water except for sample B and sample C. meanwhile, the control values are far below the sample values.

Table 4.25: Comparison of Iron with Control Sample and WHO Standard

<table>
<tr><td></td><td colspan="2">Descriptive statistics</td><td colspan="6">t-test: Test Value = 0.001</td></tr>
<tr><td rowspan="2">Parameter</td><td rowspan="2">Mean</td><td rowspan="2">Std. Dev.</td><td rowspan="2">Mean Difference</td><td rowspan="2">t-stat.</td><td rowspan="2">df</td><td rowspan="2">Sig. (2-tailed)</td><td colspan="2">95% Confidence Interval of the Difference</td></tr>
<tr><td>Lower</td><td>Upper</td></tr>
<tr><td>Iron</td><td>.01986</td><td>.009281</td><td>.018857</td><td>5.375</td><td>6</td><td>.002</td><td>.01027</td><td>.02744</td></tr>
<tr><td></td><td colspan="8">Test Value (WHO standard) = 0.03</td></tr>
<tr><td></td><td></td><td></td><td>-.010143</td><td>-2.891</td><td>6</td><td>.028</td><td>-.01873</td><td>-.00156</td></tr>
<tr><td colspan="9">Normality test estimates</td></tr>
<tr><td colspan="3">Kolmogorov-Smirnov[a]</td><td colspan="6">Shapiro-Wilk</td></tr>
<tr><td>Statistic</td><td>df</td><td>Sig.</td><td colspan="2">Statistic</td><td colspan="2">df</td><td colspan="2">Sig.</td></tr>
<tr><td>.220</td><td>7</td><td>.200*</td><td colspan="2">.929</td><td colspan="2">7</td><td colspan="2">.545</td></tr>
<tr><td colspan="9">*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction</td></tr>
</table>

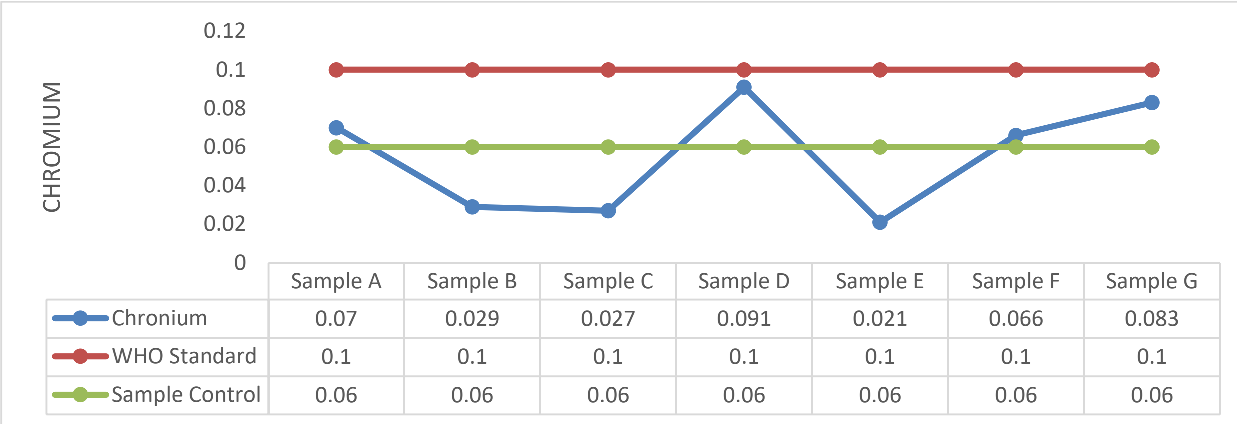
Source: SPSS 25.0 computation

Result of the one sample t-test (table 4.25) was used to see if the different samples for Iron differed from the standard control which was defined as the sample control of 0.001. The estimate shows that the mean±standard deviation of the samples for iron is (**0.01986** ± 0.009281), which is higher than the standard mean (Sample Control), is statistically significant by 0.018286 (95% CI, 0.01027 to 0.02744), t(6) = 5.375, p = 0.002). Furthermore, the one sample t-test was used to compare the concentrations of Iron in the water samples with the WHO recommended standard. As shown in the result, the t(6) = -2.891 and associated probability value (p = 0.028<0.05) confirmed that the Iron concentrations in the water are significantly below the WHO permissible standard. Shapiro Wilk's test (with p=0.545>0.05), affirmed that the sample scores were normally distributed, and there were no outliers in the data series.

Moreover, based on the result, average concentrations of Iron (Fe) at the surface water sample within the dumpsite stood at 0.020mg/l is within WHO permissible standard (0.03mg/l) but above the control value (0.001mg/l). This implies high level of iron in the water which could lead to wide range of health challenges in human (SON, 2015).

Chromium

Fig 26: Line plot of Chromium vs Standards



Source: Researcher's computation

Fig 26 is the line plot of samples when considering the Sample control and the WHO Standard for the chromium. From the plot, it suggest that no better comaparison would be between the samples and sample control (as the standard)/WHO standard and the samples when considering chromium as the parameter of surface water.

Table 4.26: Comparison of Chromium Samples with the Control and WHO Standard

	Descriptive statistics		t-test: Test Value = 0.06					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Chromium	.055286	.0289869	-.0047143	-.430	6	.682	-.031523	.022094
	Test Value (WHO standard) = 0.1							
			-.0447143	-4.081	6	.006	-.071523	-.017906

Normality test estimates

Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Statistic	df	Sig.	Statistic	df	Sig.
.246	7	.200*	.874	7	.200

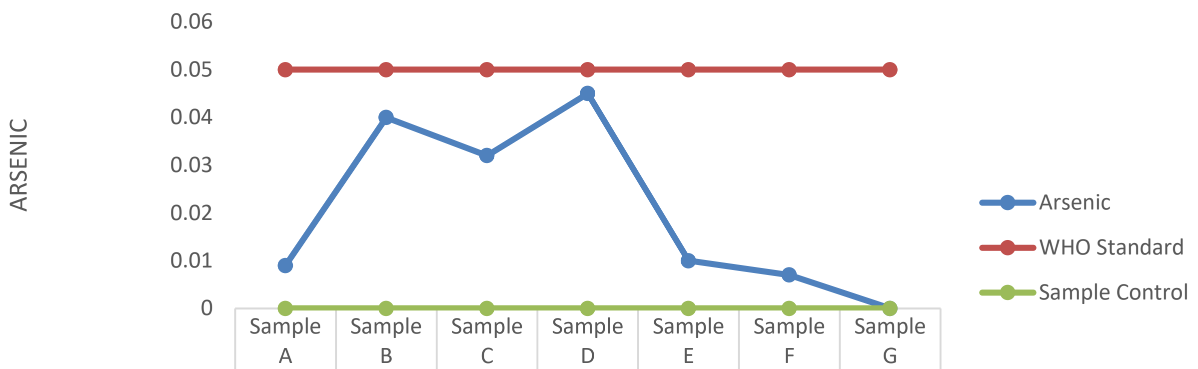
**. This is a lower bound of the true significance.*
a. Lilliefors Significance Correction

Source: SPSS 25.0 computation

The t-test result in table 4.26 ascertains whether the different samples for Chromium differed from the sample control. The result confirmed that the mean±standard deviation of the samples for Chromium is (0.055286 ± 0.0289869), which is lower than the control of 0.06; although the variation is not statistically significant ($p = 0.682 > 0.05$). The comparative result of the sample values with the WHO permissible standard revealed that the Chromium sample values is significantly lower than the WHO permissible standard by -0.447143 ((95% CI, −0.071523 to −0.017906), $t(6) = -4.081$, $p = 0.006 < 0.05$). Shapiro Wilk's normality test result (with $p = 0.200 > 0.05$) indicates that the sample scores were normally distributed, and there were no outliers in the data series.

As shown in the result, the average value of Chromium (Cr) at the surface sample was 0.055mg/L which is negligibly below the control value as well as the WHO permissible limit. Chromium is known to occur in two oxidation states: +3 and +6. Cr (iii) is noted to be non-toxic whereas Cr(vi) has high environmental mobility and can originate from anthropogenic and natural sources. Exposure of animals to Cr(vi) in drinking water induced tumor in alimentary tract with linear and supra-linear responses in the mouse small intestine. The most abundant form of DNA damage induced by Cr(vi) is Cr – DNA adducts which cause mutations and chromosomal breaks (Anatoly, 2011).

Fig 27: Line plot of Arsenic vs Standards



	Sample A	Sample B	Sample C	Sample D	Sample E	Sample F	Sample G
Arsenic	0.009	0.04	0.032	0.045	0.01	0.007	0
WHO Standard	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sample Control	0	0	0	0	0	0	0

Source: Researcher's computation

Fig 27 is the line plot of samples when considering the Sample control and the WHO Standard for the arsenic. From the plot, it suggest that no better comaparison would be between the samples and samples control (as the standard), except for sample G which is approximatly similar to the sample control. There is a wide gap between the WHO standard and the samples when considering arsenic as the parameter of surface water.

Table 4.27: Comparison of Arsenic with Control Sample and WHO Standard

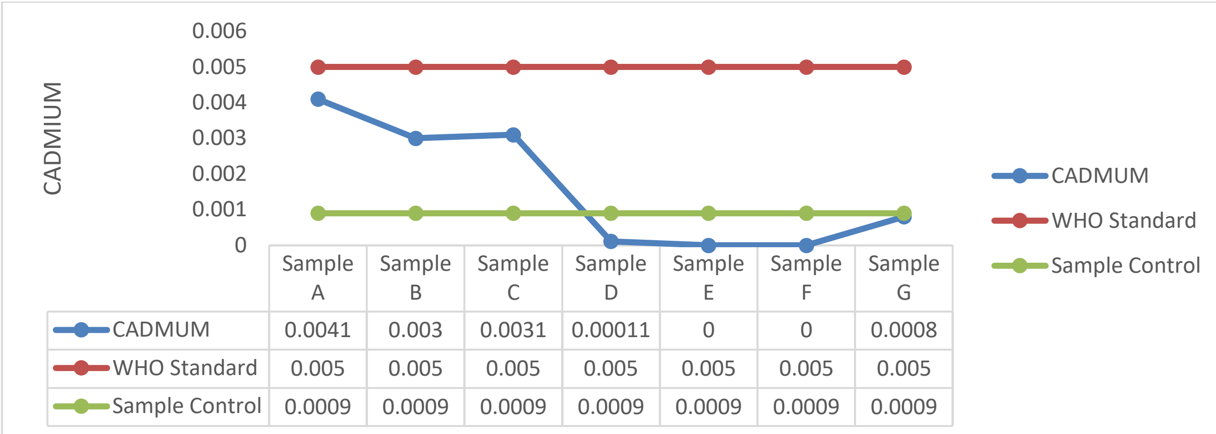
	Descriptive statistics		t-test: Test Value = 0.00					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Arsenic	.020429	.0180634	.0204286	2.992	6	.024	.003723	.037134
	Test Value (WHO standard) = 0.05							
			-.0295714	-4.331	6	.005	-.046277	-.012866
Normality test estimates								
Kolmogorov-Smirnov[a]				**Shapiro-Wilk**				
Statistic	df	Sig.		Statistic		df	Sig.	
.290	7	.078		.871		7	.188	
**. This is a lower bound of the true significance.*								
a. Lilliefors Significance Correction								

Source: SPSS 25.0 computation

The mean±standard deviation of the samples for Arsenic as presented in table 4.27 above is (**0.020429** ± 0.0180634). The average estimate is significantly higher than the control value ($p=0.024<0.05$). but in comparison with the WHO recommended standard, the t-statistic value of −4.331 and associated probability value of $0.005<0.05$ shows that the sample values of Arsenic are substantially below WHO recommended standard of 0.05. In other words, the concentrations of Arsenic in the water sample were on average above the control but below the WHO permissible limit. The Shapiro Wilk's test shows that the sample scores were normally distributed, and there were no outliers in the data ($p=0.188>0.05$).

Cadmium

Fig 28: Line plot of Cadmium vs Standards



Source: Researcher's computation

Fig. 28 is the line plot of samples when considering the Sample control and the WHO Standard for the cadmium. From the plot it suggest that no better comaparison would be between the samples and samples control (as the standard), except for sample G which is approximatly similar to the sample control. There is a wide gap between the WHO standard and the samples when considering cadmium as the parameter of surface water.

Table 4.28: Comparison of Cadmium with Control Sample and WHO Standard

	Descriptive statistics		t-test: Test Value = 0.0009					
Parameter	Mean	Std. Dev.	Mean Difference	t-stat.	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
							Lower	Upper
Cadmium	.001587	.0017530	.0006871	1.037	6	.340	-.000934	.002308
	Test Value (WHO standard) = 0.005							
			-.0034129	-5.151	6	.002	-.005034	-.001792

Normality test estimates

Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Statistic	df	Sig.	Statistic	df	Sig.
.245	7	.200*	.826	7	.073

**. This is a lower bound of the true significance.*

a. Lilliefors Significance Correction

Source: SPSS 25.0 computation

Table 4.28 compares the Cadmium sample values with the control sample. The essence was to ascertain if the different samples for cadmium differed from the standard control. The result affirmed that the mean±standard deviation of the cadmium from the water samples is (0.001587±0.0017530). This value is slightly higher than the control sample, but not statistically significant as provided by 0.0006871 (95% CI, -0.000934 to 0.002308) $t(6) = 1.037$, $p = 0.340$. Also, in comparison with the WHO standard, it was shown that the Cadmium sample values with t-statistic value ($t(6) = -5.151$) and associated probability value ($p=0.002<0.05$) are significantly below WHO permissible limit. The Shapiro Wilk's normality test (with $p=0.073>0.05$), indicates that the sample scores were normally distributed, and there were no outliers in the data series.

From the result, average Cadmium (Cd) concentration at the surface water sample is 0.0016mg/L (>0.0009) and (<0.005), indicating that the value is below WHO recommended limit but above the control value. Generally, high concentration of Cadmium affects the resorption function of the proximal tubules in human and also causes several form of cancer (WHO, 2011). Hence, the water at the dumpsite is polluted for the community consumption but within WHO permissible limit for drinking water.

V. SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Findings

Based on our quantitative analysis, the following findings emerged:

i) Among the physical parameters, Electrical conductivity (EC), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), and Total Solid (TS) levels did not constitute pollution, since they were all within the WHO limit. Rather, Turbidity and temperature levels.

ii) Among the chemical parameters, pH level, alkaline, calcium hardness, nitrates, Chlorine and phosphate levels did not constitute pollution, since they were all within the WHO limit. But rather, the acid levels, total hardness, and magnesium hardness in the water.

iii) All the bacteriological parameters constitute pollution since their values were substantially above the WHO permissible limits.

iv) The heavy metals assessed all have high concentrations in the water as they were all above the control sample, an indication that the water is not good for consumption by the people living within the vicinity. But, in comparison with WHO recommended standard, all the metals except Lead (Pb) was found to constitute pollution as it was the only metal whose contents in the water was above WHO permissible limit for drinking water. The implication is that, if the people in the area must drink the water, it is advisable that they at least boil it before drinking.

5.2 Conclusion

Water naturally contains small amounts of dissolved substances like zinc, calcium, magnesium and even impurities like silt, sand and microbial substances. These constituents are not supposed to exceed the threshold limits; otherwise the water is polluted and hence becomes unhealthy for drinking. Water of good quality is a basic necessity of life, but the recent increasing rate of water pollution draws attention to ascertaining the quality of water used by humans in our contemporary society. This study empirically assessed the physical, chemical and bacteriological effect of solid wastes on surface water quality from dumpsite at Ugwuaji, Enugu South Local Government Area in Enugu state. The study used eight samples at different distances: 0m, 10m, 20m, 30m, 40m, 50m, and 60m with a control sample obtained at 15m away from the dumpsite. The physical parameters considered were temperature, turbidity, taste, colour, odour, electrical conductivity, and total dissolved and suspended solids; the chemical parameters considered were pH value, acidity, alkalinity, calcium and magnesium hardness, chloride, nitrate, phosphate, sulphate, and dissolved oxygen; heavy metals studied were manganese, zinc, copper, magnesium, lead, iron, chromium, arsenic, cadmium and aluminum; while the bacteriological parameters considered were the E. Coli, Total coliform and total plate count e35i after 24hours. The result from their analysis shows that what constituted pollution in the surface water from the dumpsite were turbidity, temperature, acids, total hardness, magnesium hardness, E. Coli, Total coliform, total plate count e35i after 24hours, and the heavy metals especially Lead which exceeded acceptable WHO limits for drinking water. Apart from the Lead, all other heavy metals in the study were only above federal environmental protection agency maximum allowable levels for drinking water. As a result, the emerging conclusion is that the level of pollution is relatively high at the dumpsite.

5.3 Recommendations

Based on the research findings, the following recommendations were made:

i) Since most of the physiochemical, bacteriological and heavy metal constituents in the water were found to be above permissible limits (control) or in non-conformity with WHO (2006) and Nigerian (2007) recommended standards, it is suggested that further monitoring of the constituent levels in water from the dumpsites in the area is required.

ii) There is need for environmental interventions through public health education by community based health workers, awareness and sensitization campaigns which will be focused on improving the household and community sanitation in the area.

iii) Adequate solid disposal method should be adopted, phasing out open dumpsites to safeguard public health from water borne diseases.

iv) It is also recommended that the water from the dumpsites be subjected to purification and treatment processes before exposure to public use.

REFERENCES

Abdul, S., Mallikarjun, N.D. & Kumar, K. V. (2012). Correlation and regression model for Physico-chemical quality of groundwater in the South Indian city of Gulbarga. *African Journal of Environmental Science and Technology, 6(9)*, 353-360.

Adelekan B. A. (2010). *International Journal of Water Resources and Environmental Engineering*, 2(6): 137-147.

Adesina, A. O. G. (2000). Integrated Waste Management System. Groundwater Resource in Lagos State. (undated). Ijora: Water Corporation.

Akpoveta, O. V., Okoh, B. E. & Osakwe, S. A. (2011). Quality assessment of borehole water used in the vicinities of Benin, Edo State and Agbor, Delta State of Nigeria. *Current Research in Chemistry, 3(1)*, 62-69.

Allan, D. (1983). Behaviour of Landfill Leachate. *European Scientific Journal, 8*(11); ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431

Aloke, C., Uzuegbu, I. E., Ogbu, P. N., Ugwuja, E. I., Orinya, O. F. & Obasi, I. O. (2019). Comparative assessment of heavy metals in drinking water sources from Enyigba Community in Abakaliki Local Government Area, Ebonyi State, Nigeria. *African Journal of Environmental Science and Technology*, *13(4)*, 149-154.

Anatoly, Z. (2011). Chromium in drinking water: Sources, metabolism and cancer risks. *Chem. Res. Toxicol.*, 24(10), 1617-1629.

ATSDR (2005). Department of Health and Services, Public health Service. Agency for Toxic Substances and Disease Registry.

Bagchi, A. (1989). Design Construction and Monitoring of Sanitary Landfill. New York, NY: Wiley Interlines Publication.

Batabyal, A. K. & Chakraborty, S. (2015). Hydro geochemistry and water quality index in the assessment of groundwater quality for drinking uses. Water Environ Res. Development (Special publication ed. Vol. 193). London, UK: Geological Society.

Elinge, C. M., Itodo, A. U., Birni-Yauri, U. A. & Mbongo A. N. (2011). *Advances in Applied Science Research,* 2(4), 279-282.

Gore, A. (1992). Earth in the Balance: Ecology and the Human Spirit. boston, MA: Houghton Mifflin.

Hiscock, K. M., & Grischek, T. (2002). Attenuation of groundwater pollution by bank? ltration. *Journal of Hydrology*, 266, 139–144.

Hiscock, K. M., Rivett, M. O., & Davison, R. M. (Eds.). (2002). Sustainable Groundwater

Ibiyemi, A. O. (2000). Evaluating validity of contingent valuation model for household

Ibiyemi, A. O. (2001). Impact of leachate on quality of ground water near Olusosun tipsite in Lagos. *Forum Journal*.

Igbal, M. A. & Gupta, S. G. (2009). *African Journal of Basic and Applied Sciences*, 1 (5-6): 117-122.

Ijeh, B. I. & Onu, N. N. (2013). Assessment of pollution levels of groundwater in parts of Imo River Basin, South Eastern Nigeria. *International Journal of Water Resources and Environmental Engineering, 5(4)*, 194-202.

International, P. A. (1983). The State of the Environment in Nigeria - Solid Waste Management in Fifteen Cities and Urban Areas in Nigeria (No. 2). Lagos: Federal Ministry of Housing and Environment (Environmental Planning and Projection Div.).

Iwugo, K. O. (1986). Groundwater Quality Treatment and Pollution in Nigeria. The Lagos Metropolis Case Study. Paper presented at the First Annual Symposium on Groundwater Resources: Nigeria Water and Sanitation Association, Lagos.

Iwugo, K. O. (1992). Introduction to Environmental Engineering for Developing Countries. London, UK: John Wiley and Sons Limited.

Iyasele, J. U. & Idiata, D. J. (2012). Determining the borehole water quality in Edo South and Edo North areas of Edo state. *Research Journal in Engineering and Applied Sciences*, *1(4)*, 209-213.

Kampax-Krugger, & Associates, S. (1977). Groundwater Resources Investigation of Metropolitan, Lagos.

Lavalin. (Feb. 1992). Organisational Development and Waste Management System Project. Design and Operations of the Oregun Landfill Sites. Lagos.

Longe, E. O., Malomo, S., & Olorunmiwo, M. A. (1986). Hydrology of Lagos. Metropolis Journal. African Earth Science, 6(6), 163 - 174.

Naseri-Rad, E. K., Berndtsson, M. & Nakagawa, K. (2020). Use of heavy metal content and modified water quality index to assess groundwater quality in a Semiarid area. *MDPI, 12(1115)*, 1-22.

Obasi, P. N. & Akudinobi, B. B. (2020). Potential health risk and levels of heavy metals in water resources of lead–zinc mining communities of Abakaliki, South-East Nigeria. *Applied Water Science, 10(184)*, 1-23.

Oliver, N. M. & Ismaila, Y. (2011). *Advances in Applied Science Research*, 2(3), 191-197.

Ozoko, D. C. (2015). Heavy metal pollution of natural waters in Abakaliki, Ebonyi State, Nigeria. *International Journal of Science and Research (IJSR), 4(6),* 482-486.

Papanikolaou, N. C., Hatzidaki, E. G., Belivanis, S., Tzanakakis, G. N. & Tsatsakis, A. M. (2005). Lead toxicity update. A brief review. *Med. Sci. Monitor,* 11(10), RA329.

Rahman, S. M., Kippler, M., Tofail, F., Bolt, S., Hamadani, J. K. & Vahter, M. (2017). Manganese in drinking water and cognitive abilities and behaviour at 10 years of age, 125(5), 057003.

Rao K. J. & Shantaram M. V. (2003). *Workshop on sustainable land fill management, channel,* India, 27-27.

Sawyerr, H. O., Adedotun, A. T., Abiodun SA, & Salami, O. O. (2017). Impact of dumpsites on the quality of soil and groundwater in satellite towns of the Federal Capital Territory, Abuja, Nigeria. *J. Health Pollut., 7(14)*,15–21

SON, (2015). Nigeria Standard for Drinking water Quality Abuja, Standard Organisation of Nigeria.

Tukura, B. W., Ayinya, M. I. G., Ibrahim, I. G. & Onche, E. U. (2014). Assessment of heavy metals in ground water from Nasarawa State. *American Chemical Science Journal, 4(6)*, 798-812.

Uchegbu, S. N. (1998). Environmental management and protection: Precision Printers & Publishers

Willingness-to-Accept near Olusosun Waste Disposal Site, Lagos. Retrieved July 22, 2010.

World Health Organization (2009). Calcium and Magnesium in drinking water: Public health significance. *Epidemiological studies*, 1-180.

World Health Organization (2011). Cadmium in drinking water. Background document for development of WHO guidelines for drinking water