MERIT RESEARCH JOURNALS
www.meritresearchjournals.org

Merit Research Journal of Environmental Science and Toxicology (ISSN: 2350-2266) Vol. 6(1) pp. 031-049, April, 2020
Available online http://www.meritresearchjournals.org/est/index.htm

DOI: 10.5281/zenodo.3779288

Review

Leaving no One Behind? Drinking Water Challenge on the Rise in Niger Delta Region of Nigeria: A Review

Raimi Morufu Olalekan[1,4], Dodeye Eno Omini[2], Efegbere Henry Akpojubaro[3], Odipe Oluwaseun Emmanuel[4], Deinkuro Nimisingha Sanchez[5], Babatunde Anu[6] and Ochayi Ekoja Owobi[7]

[1&4]Department of Community Medicine, Environmental Health Unit, Faculty of Clinical Sciences, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria.

[2]Department of Geography and Environmental Management, Faculty of Environmental and Technology, University of the West of England, United Kingdom.

[3]Department of Community Medicine, Edo University, Iyamho, Edo State, Nigeria.

[4]Department of Environmental Health Science, Kwara State University, Malete, Kwara State, Nigeria.

[5]Department of Civil and Environmental Engineering, University of Strathclyde, Glasgow, United Kingdom.

[6]Action Against Hunger, Yobe State, Nigeria

[7]Department of HIV Medicine, Lead ART Clinician (DREAM Clinic) Daughters of Charity Health Care Services of Saint Vincent de Paul Hospital Kubwa, F.C.T Abuja, Nigeria

***Corresponding Author's Email: ola07038053786@gmail.com**

Abstract

Despite having come of age only recently, it would be a truism, but also accurate, to state that only ten (10) years left to accomplish the Sustainable Development Goals (SDGs), 2020 marks a decade to show action. The **decade of action require rapid accelerating sustainable solutions for all the global biggest challenges which is fully embraced in the twenty-first century, as issues of water are gaining new prominence in the Niger Delta as local communities respond to growing public concerns about drinking water pollution, failing infrastructure, and the perceived inability of local, state, MNOCs and federal governments to fix the problems. While contaminated water is becoming a worsening problem of global concern that disproportionately affects many Indigenous communities in the Niger Delta and the access of almost all 210 million Nigerians residents to reliable, safe drinking water distinguishes Nigeria in the twentieth century from that of the nineteenth century; nonetheless, current trends seem to strain water resources over time, especially on a regional basis. Semantically, water being a finite resource having to serve exponentially more people and usages, and so ensuring everyone has access to a reliable supply is crucial to human survival and sustainable progress. However, chemical pollutants in drinking water have been linked to water poverty and to many different adverse health outcomes, including leukaemia, lymphoma, bladder cancer, breast cancer, and reproductive problems. Chemical pollutants remain a problem in countries like Nigeria as each community in the Niger Delta faces threats to their water quality from different sources of pollution, and may benefit from a community-based water-quality monitoring program to better inform them of their water quality. Remarkably, the adoption of the United Nations Sustainable Development Goals (SDGs) in 2015 marked a new level of political recognition of the importance of water to development. For the first time, this included a target to ensure access to affordable, reliable and sustainable water for all – collectively known as Sustainable Development Goal 6. Therefore, thinking about water should take the concept of multiplicity as an analytic starting point rather than as a revelation.**

Keywords: Sustainable Development Goals, Chemical pollutants, Water poverty, Reproductive problems, Niger Delta

INTRODUCTION

Water, being complex is perhaps the single most decisive factor in its continued existence and is linked to almost everything in the world and the swift pace of urbanization and industrialization has contributed substantially toward

the elevation of water pollution levels, especially in the developing countries. Yet, it is vital for reducing the global burden of disease and improving the health, welfare and productivity of populations. Also, water is at the heart of adaptation to climate change, serving as the crucial link between the climate system, human society and the environment. Without proper water governance, there is likely to be increased competition for water between sectors and an escalation of water crises of various kinds, triggering emergencies in a range of water-dependent sectors. In several countries, the presence or absence of adequate and sufficient supply of water and improved sanitation facilities has a disproportionate effect on the lives of women and girls for three main reasons. First, women and girls are usually responsible for collecting water, which is frequently very time-consuming and demanding. Second, women and girls are more susceptible to risk of abuse and attack while using a toilet or open defecation site. And thirdly, women have specific hygiene needs during menstruation, pregnancy and child rearing. Without adequate drinking water, adequate sanitation and hygiene facilities at home and in the workplaces, disproportionately, it is harder for women and girls to enjoy safe, productive, healthy lives, water resources and services are vital to achieving global sustainability. Taking account of economic growth, social justice and environmental sustainability, water-related issues are possibly the most important human health and environmental justice concerns facing the human population today, and continue to gain importance internationally. The world is facing a serious water crisis, caused in large part by the global mismanagement of water resources (United Nations, 2003). This problem will continue to deteriorate unless urgent action is taken. The concern about our water resources is so great that former U.N. Secretary General Boutros Boutros Ghali said in 2002 that “water will be more important than oil in this century” (Talking Points, 2003). The water pollution not only endangered the lives of the Niger Delta residents, creating one of the largest public health crises and environmental justice disasters, it also re-awakened the country to poor quality infrastructure and inadequate safeguards protecting drinking water in our homes, schools, and communities. But complexity should not hinder understanding: Water is a precondition for human existence and the sustainability of our planet. Water is an important component of sustainable development and plays a critical role in socio-economic development, healthy ecosystems and for human health. It is important to reduce the global burden of disease and improve human health, well-being and population productivity. Water is also at the heart of adaptation to climate change and is an important link between climate, society and the environment. Without proper water management, there may be increased competition for water between host communities and an escalation of water-related problems of different kinds, resulting in a significant increase in a range of water-dependent sectors. The physical world of water is closely associated with the socio-political world, where water is often the main source of risk management, including famine, migration, epidemics, inequalities and political uncertainty. Water is a finite resource having to serve exponentially more people and usages, and so ensuring everyone has access to a reliable supply is essential to human survival and sustainable development. As water resources become more stretched, the energy and food sectors’ dependence on water, and the fact that all three underpin several of the Sustainable Development Goals, means that decision-makers in all three domains are now increasingly focusing on water resource management, ecosystem protection and water supply and sanitation as part of their policy and practice. It is interesting to note that the adoption of the United Nations Sustainable Development Goals (SDGs) in 2015 means a new level of political significance and the importance of water to development. For the first time, this includes ensuring that people have access to safe, affordable, reliable and sustainable water for all – collectively known as Sustainable Development Goal 5, or SDG 5. But, according to the World Health Organization (WHO) and the United Nations International Children’s Emergency Fund (UNICEF) of approximately 7.3 billion people around the world, some 2.1 billion, almost three out of every ten people have less than adequate access to safe drinking water, while 4.5 billion, about six out of every ten people, lack safely managed sanitation service (WHO, 2017). The lack of access to WASH is also a major contributor to health, hygiene, education and mortality rates. Every year over 340,000 children under the age of five, nearly 1,000 children die daily from diarrheal diseases from poor hygiene, poor sanitation or unsafe drinking water (WHO, 2017). “Many challenges are inherent to the Niger Delta water: floods, contamination and poor quality,” etc. Water use has been declining since 1980 regardless of population growth, and this is all related to management.”

Now, residents of Oil and Gas communities in the Niger Delta region of Nigeria, are facing the same frightening reality: for a number of years they have been drinking water contaminated with lead, which is known to cause developmental delays in babies and children, as well as a litany of health problems for adults. This is getting more attention because it is an oil rich region. “In the Niger Delta, more than a million children have been exposed to this water; this may even get bigger,” “In young children, lead-contaminated water causes cognitive and developmental issues that are irreversible, which become a major problem and since the region is now beginning to be aware of the health risks associated with lead and Ingested lead can cause a myriad of health problems because it interferes with signaling from the brain, causing children to develop learning disabilities. Pregnant women who are exposed to lead poisoning

have exposed their unborn babies to risks, and it also fosters neurodegenerative diseases in adults, such as Parkinson's and studies has it that about 95% of deadly diseases in the human body is associated with the consumption of liquid content and over 25 million Nigerians are diagnosed to die by highly chemicalized products.

Physical Setting of the Niger Delta

Oil which has become a major engine of economic growth in Nigeria and around the world, but also has a major potential significant impact on the environment, predominantly in this era of globalization. As the worldwide demand for oil has skyrocketed during the 21stcentury and 4th industrial revolution, the commodity has appreciated. Often referred to as black gold (Parsons, 2010), of which many nations greatly desired crude oil. The attention that oil spills receive in developed countries is important, but the impairment caused by these spills, such as the one that affected the Gulf Coast of the United States in 2010, is not sensitive to the pollution that routinely affects the Niger Delta (Safina, 2011). Bringing it home, Nigeria, a geographic space of inequality where wealth and suffering both coexist in abundance with so much wealth is reported to have vast natural wealth with about 445,000 barrels' capacity per day means that the refineries are barely producing 24,698 barrels per day, indicating gross under performance and has been a basis for economic and national development, yet many Nigerians suffer so much on a range of poverty issues in the country (see figure 1 below). Considering this facts, the United Nations report that people are multidimensionally poor when they are poor in many respects including education, health, access to potable water, nutrition, electricity, their assets, among other indices.

About 69% of Nigeria's or about 2.7 billion people (almost half of the world's population) live in poverty which is expected to cost $2/day. Although oil is believed to bring economic development to other nations, much of the region is rich in oil, such as Latin America, Africa, and the Middle East, remain impoverished, corrupt, and underdeveloped (Dell, 2004). Countries rich in natural resources i.e. oil and mineral typically have a high income disparities and poverty rates is higher, mortality, and malnutrition than countries that does not depend on such resources (Dell, 2004). Additionally, oil-rich countries with mono product economies have higher rates of corruption in governments, lower levels of education, substandard health care systems, larger sovereign debts, elevated military spending, and increasing incidences of civil war (Kennedy and Tiede, 2013). This is further linked to the scenario that although the Niger Delta bears the burden of generating mammoth oil revenues the country earns; the area represents one of the extreme conditions of poverty in the country where wealth and suffering both coexist in abundance (see figure 7). Interestingly, the need for crude oil in modern society had effects more than any specific natural resource with the exemption of water (Obi, 2010). Oil being a non-renewable resource; the profits however, generated from the value ought to build capacity for equitable wealth distribution in the Niger Delta (Eweje, 2007; Orogun, 2010). The wide scale of farmlands contamination, wetlands i.e. creeks, swamps, and rivers in the Niger Delta is the result of crude oil exploration, refining, and other allied business activities in the region (Snapps, 2011). The milieu is a natural, human habitat, and its resources guarantee human survival (Oshwofasa et al., 2012). In the study of Niger Delta region (NDR) of Nigeria, Onwubiko et al. (2013) and Premoboere and Raimi (2018) acknowledged that environmental change can affect habitat, social development, customs, and norms. On August 3, 2011, the United Nations News service revealed that the current pollution of the wetlands ecosystem in the Niger Delta by oil multinationals, and Shell Petroleum Development Corporation (SPDC) in particular, will necessitate no less than 30 years to clean up. The environmental degradation impact on the rural economy (commercial fishing, boat-construction, and farming) of the Niger Delta has suggested that multinational oil corporations (MNOCs) and other stakeholders offer the opportunity for diversification of business (Babatunde, 2010). The cause of armed insurgency, entrenched poverty, deteriorating living conditions, and underdevelopment in one of Africa's most resource rich regions is linked to the role of multinational oil corporations (MNOCs) and the State of Nigerian (Akhigbe, 2013).

Evidently, oil discovery has resulted in socioeconomic disparities and environmental degradation in the region with the current animosity for oil companies (Ako, 2012). The region continued an ongoing quagmire from the ceaseless Nigerian government inertia. Fifty years of independence and increased oil production have made agriculture and fishing industries unproductive, contaminates sources of drinking water and agricultural fields, forcing inhabitants to consume food and water that are contaminated (Jernelov, 2010). The most common acute effects of exposure to crude oil are nausea, vomiting, dizziness, headaches, and respiratory problems (Solomon and Janssen, 2010; Olalekan *et al.,* 2018). The negative effects are more serious from long-term exposure include cancer, respiratory diseases, skin diseases, and death (Ana et al., 2009; Olalekan *et al.,* 2019). Health problems caused by oil pollution can take several forms, including air pollution from gas flaring (Abdul-Wahab et al., 2012), water and land pollution from spills and pipeline damage (Abdus-Salam et al., 2010; Adedeji and Adetunji, 2011; Nduka and Orisakwe, 2011), and mental health problems from the stress caused by physical and economic hardships that result from living in

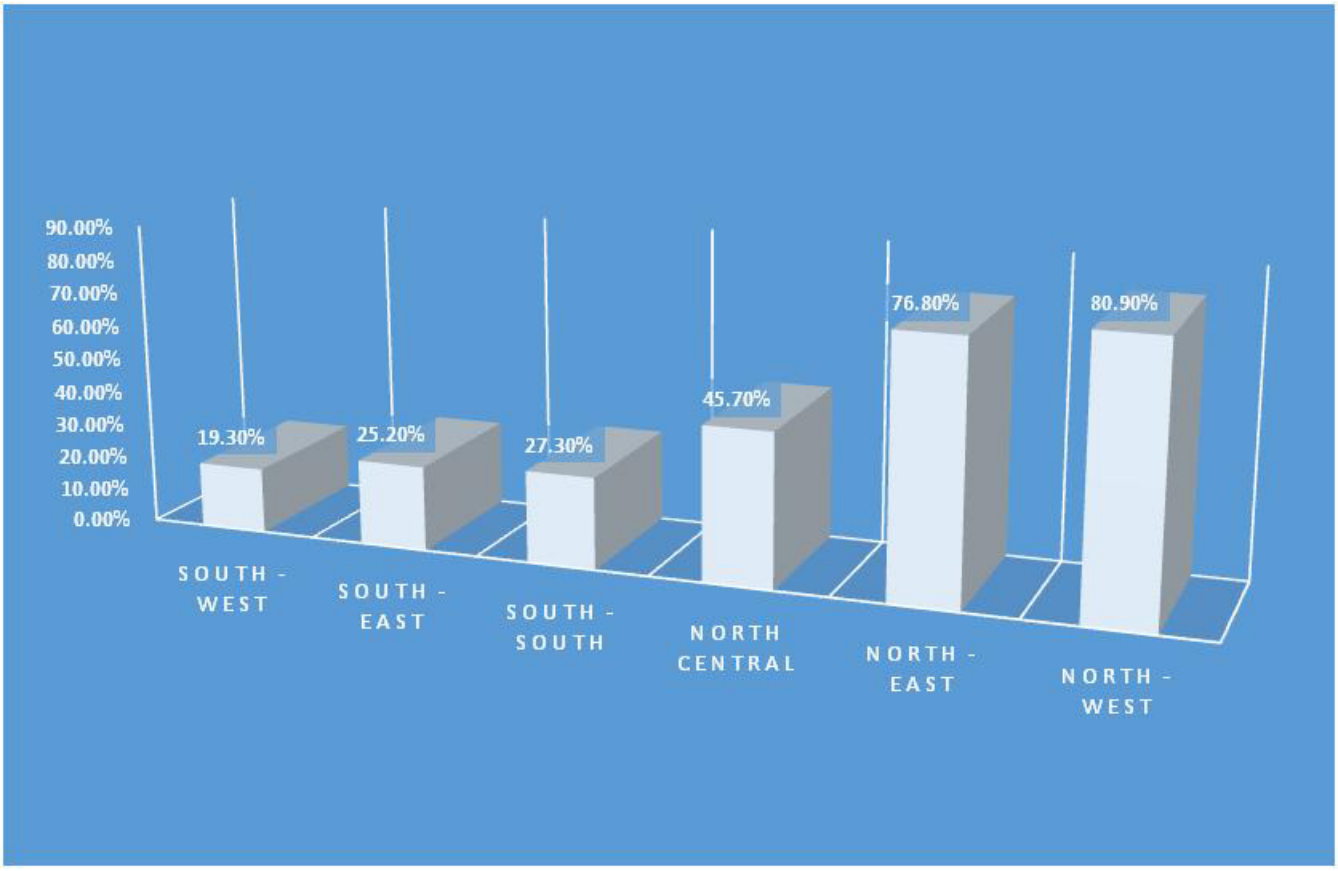


Figure 1. United Nations Global Multidimensional Poverty Index for Nigeria on Poverty Rates.

oil polluted regions (Gill et al., 2011; Grattan *et al.,* 2011; Shreve, 2011; Premoboere and Raimi, 2018).

Prior to independence in 1960, Nigerian were 95% self-sufficient with products of agriculture and fishing accounting for more than 75% goods of Nigerian export (Eneh, 2011). While oil production represents more than 80% of the national total revenue, oil companies also triggered 62.8% of the oil spills, which were environmentally destroying the area (Eneh, 2011; Olufemi, 2010; Premoboere and Raimi, 2018). The region has become the utmost environmentally impoverished due to oil production in Nigeria (Idemudia, 2011; Premoboere and Raimi, 2018). The Niger Delta is the region at the southernmost tip of Nigeria with an enormous wetland representing nine of the 36 states in Nigeria, or 7.5% of Nigeria, and home to over 31 million people (Olufemi, 2010). The area is located along a 560 kilometer coastline adjacent to one of the most sensitive wetland regions in the world (Olufemi, 2010). Persistent annual oil spills, which average more than 150 per year, destroyed the productivity of the land and water of the area (Murphy, 2013; Premoboere and Raimi, 2018).

The Niger Delta region of Nigeria lies between latitude 3°N and 6°N and longitude 5°E and 8°E (see figure 2 below). The Niger Delta is one of the ten (10) most significant wetland and coastal marine ecosystems in the world; moreover, it is one of the most inhabited deltas in the world. It is largest in Africa's and the world's third largest after the Netherlands and Mississippi delta. The wetland area covers approximately 70,000 square kilometres (Akpan, 2005) and the national territory covers an area of approximately 112,110 km^2which corresponds to approximately twelve percent of the total area of Nigeria's (NDDC, 2006). It represents about ninety percent of the coastline of Nigerian. It is a classic accurate delta, typically less than 15meter contour across its entire extent and it is characterized by extensive interconnectivity of creeks, deltaic tributaries, flood plains, mangrove swamps and other coastal features. The Niger Delta has been declared an important protected area for the Western Coast of Africa due to its extraordinary biodiversity and unique geography. It harbors a large family and wildlife species, especially important and fascinating variety of birds, some of which are endemic to Nigeria. Birds species recorded in Nigeria include about 940 species, of which 4 are endemic and 5 are rare or accidental (Idris, 2007).

The Niger delta fragile ecosystems is one of the most complex in the world; it has many unique characteristics, and is known for its sandy coastal ridge barriers, brackish

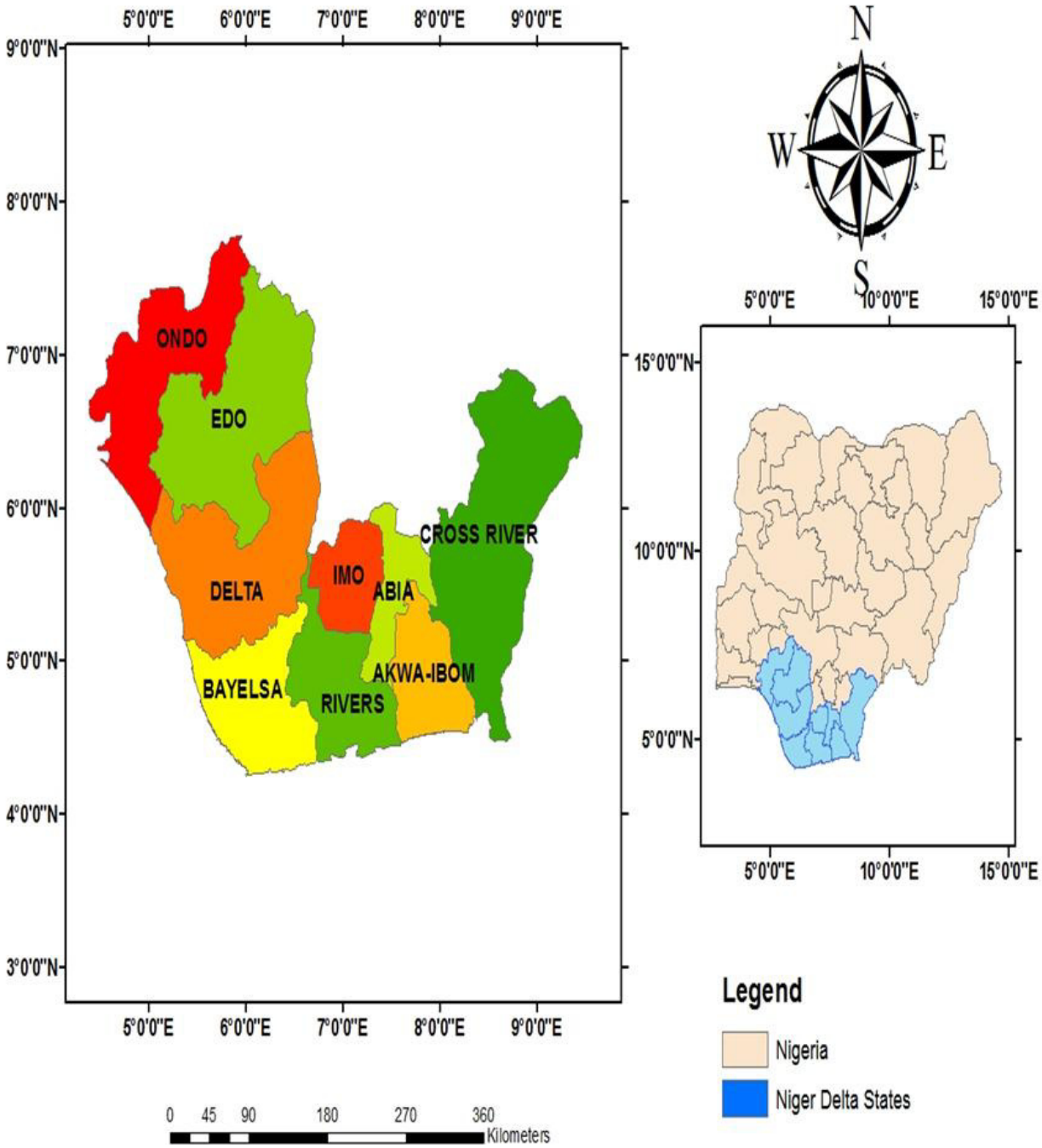


Figure 2. Map of Nigeria numerically showing states typically considered to be part theNiger Delta, including:Abia, Akwalbom, Bayelsa, Cross Rivers, Edo, Delta, Imo, Ondo and Rivers.

or saline mangroves, freshwater, permanent and seasonal swamp forests as well as lowland rainforest. The whole region is traversed and crisscrossed by a large number of rivers, rivulets, streams, canals and creeks. The Niger Delta is the main centre of oil production activity and therefore the centre of Nigeria's economy, accounting for a greater percentage of Nigeria's foreign exchange revenues and more than eighty percent of government revenue. The term Niger Delta has become a somewhat ambiguous term; this is due to the fact that there are currently different interpretations of the limit and physical frontier of the Niger Delta. The limits have changed over time and for a variety of purposes. There are presently varieties of definitions for the area covered by the Niger Delta. The cartographic or geographic Niger Delta consists of the area supplied with water from the River Niger and Benue as they flow together after Lokoja (the Confluence) to

empty their contents into the Atlantic Ocean. These rivers (now joined) break up at Ebuetor into the Rivers Nun and Forcados. The cartographic Niger Delta thus is that portion of the landmass (including water), traversed by the Rivers Nun and Forcados (including the tributaries) (Dadiowei, 2009). For obvious reasons, the Niger Delta region is defined as comprising the area covered by the natural delta of the Niger River and the areas to the east and west, which also produce oil. In this sense, the natural limits of the Niger River Delta can be determined on the basis of its geology and hydrology. It is estimated that the northern frontiers are located close to the bifurcation of the Niger River at Aboh, while the western and eastern frontiers are around the Benin River and the Imo River, respectively. According to Ebeku (2005), Premoboere and Raimi (2018) the Niger Delta can be described as lowland located in southern part of Nigeria. He also described the Niger Delta as a triangle between Ndoni and Aboh descending eastwards to Qua Iboe River and westward to the Benin River, which lies on the shores of the Atlantic coast. According to Ebeku and some authors, the core Niger Delta is made of three states, Rivers, Delta and Bayelsa states, while the rest states are designated peripheral Niger Delta. There is also a broader definition of the Niger delta which applies to all the oil producing states in Southern Nigeria and other states deemed important for reasons of administrative convenience, political expedience and development planning. This designation extends the land area to 75,000 square kilometers. This definition is used by the NDDC and will be used in this study. Therefore, the Niger Delta comprises of nine states, namely, Abia, Akwalbom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo and Rivers (see Figure 2 above).

Framing the Issues of Water Quality in the Niger Delta

"What is the human price of the water related pollution in the Niger Delta." There is need to put water criminals on trials. Hence in Nigeria we need to extend the corporate manslaughter Act to allow for the prosecution of senior politician and CEOs of large multinational companies who kill others by expanding pollution industries. Despite the world's rapidly growing cities are in low-income countries where authorities and utilities can have limited capacity to plan for and control urban expansion and its impacts on water demand. Some of them are linked to the size of the population, which not only increases but also changes in characteristics, in particular with regard to the increase in sensitivity to waterborne contaminants. Thus, with the increased demand for water, there is increased pressure to ensure that drinking water is maintained at an acceptable level of protection to public health. Meanwhile, changing practices and highly concentrated sectors of the population and industry are providing a significant pool of new emerging pollutants. These, combined with improved synthetic agents, confront us with the potential of three million chemicals that must change the way we think about these problems. In Niger Delta, slums residents often share environmental risks, such as those from pollution and they experience the so called neighborhood effect. The quality of drinking water and its availability are a reflection of where one lives. Its access and availability of safe drinking water has largely been taken for granted because of its perceived abundance. Oil bearing areas are faced with so many environmental problems caused by pollution which arises from oil activities such as drilling mud, fluids used in production as well as chemicals used to control corrosion or to separate oil from water and general industrial wastes together with the problems of gas flaring and incidents of oil spills or blow outs (Aworawo, 1999; Raimi and Sabinus, 2017; Morufu and Clinton, 2017; Premoboere and Raimi, 2018; Olalekan *et al.,* 2018; Olalekan *et al.,* 2019) and most especially where, when and how to dispose these generated waste during the course of oil exploitation activities. Thus, oil extraction and production has cause great contamination of streams and rivers through the discharge of various drilling materials used in stimulating production activities into the environment (Premoboere and Raimi, 2018; Raimi *et al.,* 2019). The controversial fact in present day is that people in the oil bearing communities always believed that the oil exploration activities is causing a significant damage such as outbreak of disease that resulted to early death among the people and damages to agricultural products, which therefore result to low agricultural yield. As a result, they neglect their influential activities that damage the environment (Premoboere and Raimi, 2018; Olalekan *et al.,* 2019). There have been so many oil spill and improper human practices (i.e, direct disposal of waste into water bodies) that have been taking place in these areas (Raimi *et al.,* 2019). It has been found that there are certain environmental problems which are not directly attributed to oil industry activities but arises as a result of natural terrain and hydrology of the area (UNDP, 2006). Some of them are flooding, siltation, occlusion, erosion and shortage of land for development but oil-related environmental effects overtake these environmental problem. It has been suggested that the situation has worsened in recent years in terms of deteriorating economic, environmental conditions and social tension in our communities due to advent of oil production in the Niger Delta area of Nigeria brought about by deforestation, ecological degradation, threatening the renewable natural resources and ecosystem (ANEEJ, 2004). These affect the hydrology of the seasonally flooded fresh water swamp and brackish water of the mangrove forest, resulting in destruction of crops, destroying fishing grounds and damaging the drinking water supplies. It can be identified that chemicals, oily residue and sludge generated in the oil

production process if not properly treated and disposed of, carry high pollution and health risks (Olalekan *et al.,* 2018; Odipe *et al.,* 2018; Henry *et al.,* 2019). It is therefore, high time much attention be focused on environmental degradation resulting from oil activities and its impacts on the environmental implication on the livelihood of the people of the oil bearing area. At the same time, reports indicate that much of the environmental pollution in the oil bearing areas is due to oil spillage resulted from accidental human error and equipment failure (UNDP, 2006). Therefore, massive oil spills in the river area have done untold damage to the aquatic ecosystem, mostly the mangrove swamp forest zone. In generally, people have complained about the negative environmental effect arising from incidence of oil spillage; where the depletion of aquatic or ground water resources, forest and mangrove swamps have a long term effect as expressed by some community leader in oil bearing communities of Igo-Awoye that occurred in August 2004. At present, the main cause of spill could not be ascertained as incessant oil spills have always been the order of the day in the oil rich areas. In addition, people have endured severe hardship since the occurrence of the spill, fishing activities have been truncated and their major domestic water source has been heavily polluted. Notable among the affected communities are Azagbene, Tebu, Burugbene, Tanagbene, Azitubo, Ekinebiri, Eseibon and Makushifasin etc located on the fringe of the Pennington River. Hence, improving drinking water is a basic need of human development, health and wellbeing, therefore it is an internationally accepted human right (WHO, 2001). Yet too many people lack access to this basic and yet fundamental human right. As access to fresh water is becoming a political problem, rather than a technical one. Water as a human right is also a management problem, a cultural problem, rather than a resource problem in most cases. Figure 2

Article 25 of UN Declaration envisages that “everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, and housing and medical care and necessary social services, and the right to security in the event of ... circumstances beyond his control.” (United Nations, 1948). Almost all countries have signed this document. Now, the million dollars question of whether water is really a fundamental human right or a commodity; it is a privileged service that you can only get if you can. Although water is not explicitly mentioned, the right to food also includes water, since water is essential to human life and therefore meets the requirements of principles of the declaration. In Figure 3 below, the results are important in many ways, such as poor water quality, which is associated with health problems with the attendant effects on productivity. The UNDP (2006) reports that 24 percent of rural people and half of the urban population of the Niger Delta have access to drinking water. This is in line with the findings of the Bayelsa State Micro Credit Administration Agency poverty survey, which found that only a small percentage of rural residents have access to safe water (see Figures 3 and 6).In addition, primary care centers in the Niger Delta are in the ratio of one facility to 9,805 or one facility to 43 settlements. Similarly, secondary health care facilities are located in the ratio of one facility to 131, 174 or one facility to 48 settlements. Insufficient water supplies create economic problems because families spend a lot of money to purchase water. In Bayelsa State for example, a household of five members spend about ₦12000 monthly to purchase water, when the minimum wage is ₦18000. In Delta and Rivers State, it is about ₦21000 monthly. Equally, on the supply of potable water, studies by Ibaba (2010) shows that respondents were unanimous in rating democratic governance very low. Thus, 93% of the respondents noted that the supply of potable water have not successfully improved (figure 4 and 5): only 7% of the respondents disagree. This is also true of the provision of health facilities, where 83.9% of the respondents insisted that it has not improved in all the three states. This is consistent with the earlier findings on lack of access to social amenities.

Classifications of Water Pollutant and Specific Consequences

Progress towards the achievement of most sustainable development goals requires significant improvement of water management across the globe. As the proportion of the population who have gained access to safe water was only 29% (UNICEF and WHO, 2015) and at least 2.1 billion people globally are estimated to be lacking access to improved, safe and readily available sources of drinking water at home that is free of bacterial contamination (WHO and UNICEF, 2017). A mere 12 percent of the world’s population uses 85 percent of its water, and these 12 percent do not live in the developed countries (Maude, 2001). As a result, 400 million children have no access to safe water and 1.4 million children die yearly as a result of lack of access to safe drinking water and adequate sanitation (UNICEF, 2005). Many companies around the world own or operate a water system that costs about $200 billion a year. Yet, they represent almost 7 percent of the world population, which creates a very large untapped market (John, 2002). Equally, the annual global burden of water borne diseases has been estimated at 2.4 million deaths and 73 million disabilities (WHO, 2004; Raimi *et al.,* 2017). There is a growing body of evidence and research suggesting that improved sources of drinking water in many cases were not entirely safe (Raimi *et al.,* 2017; Raimi *et al.,* 2019; Olalekan *et al.,* 2019). Contamination of drinking water can take place during the distribution from the point of production to the consumers tap as well as due to

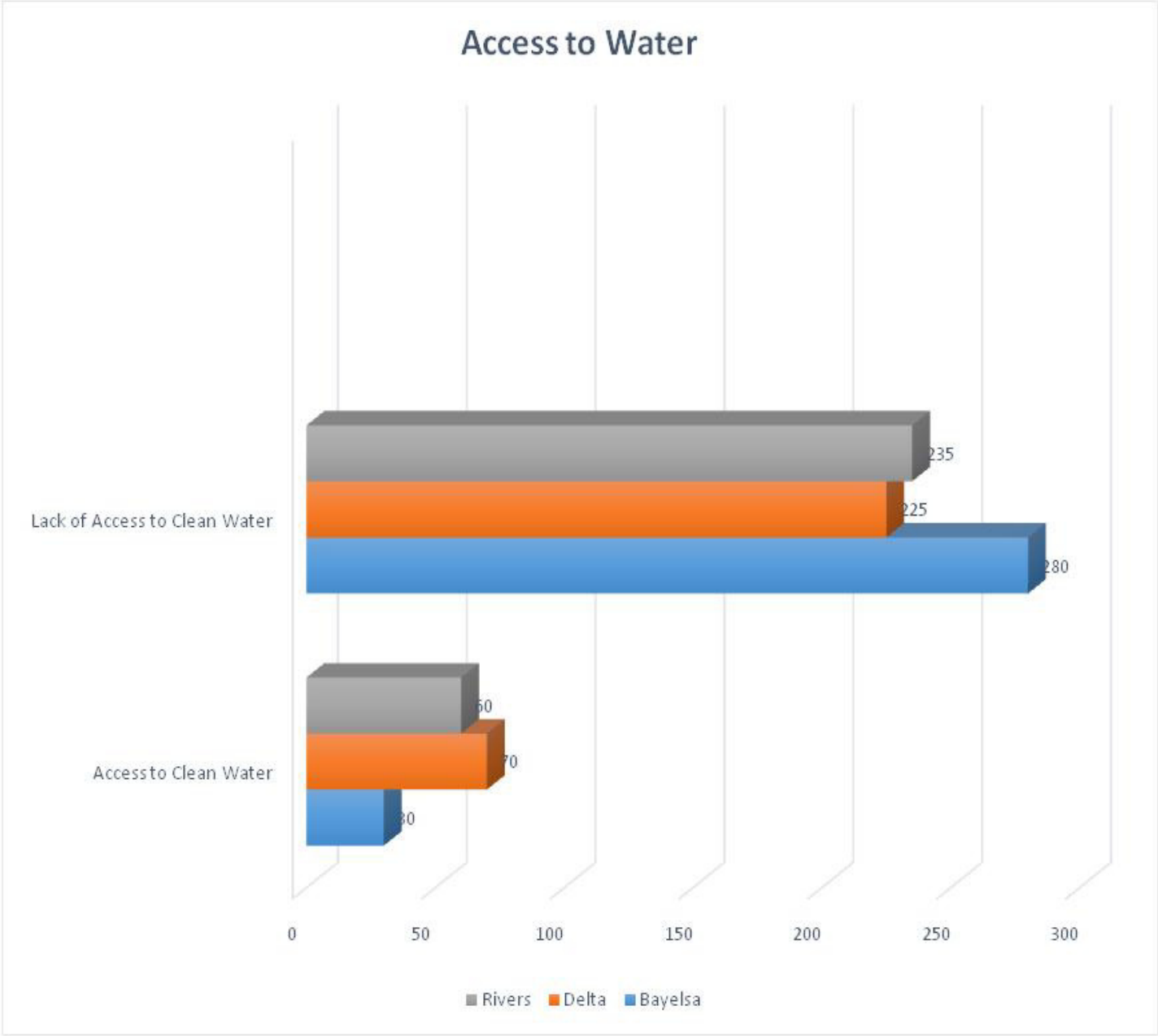


Figure 3. Water Access in three (3) Niger Delta States

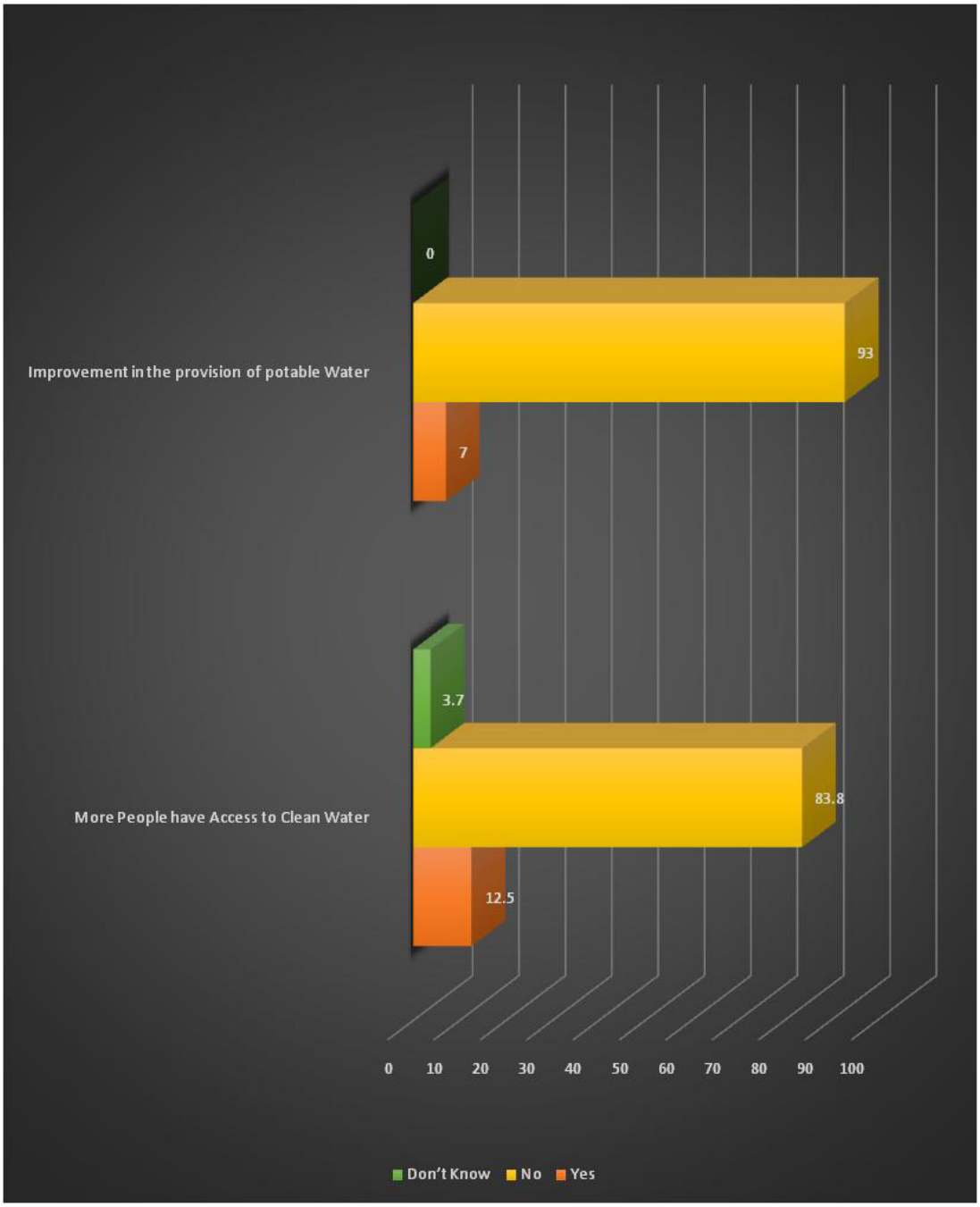
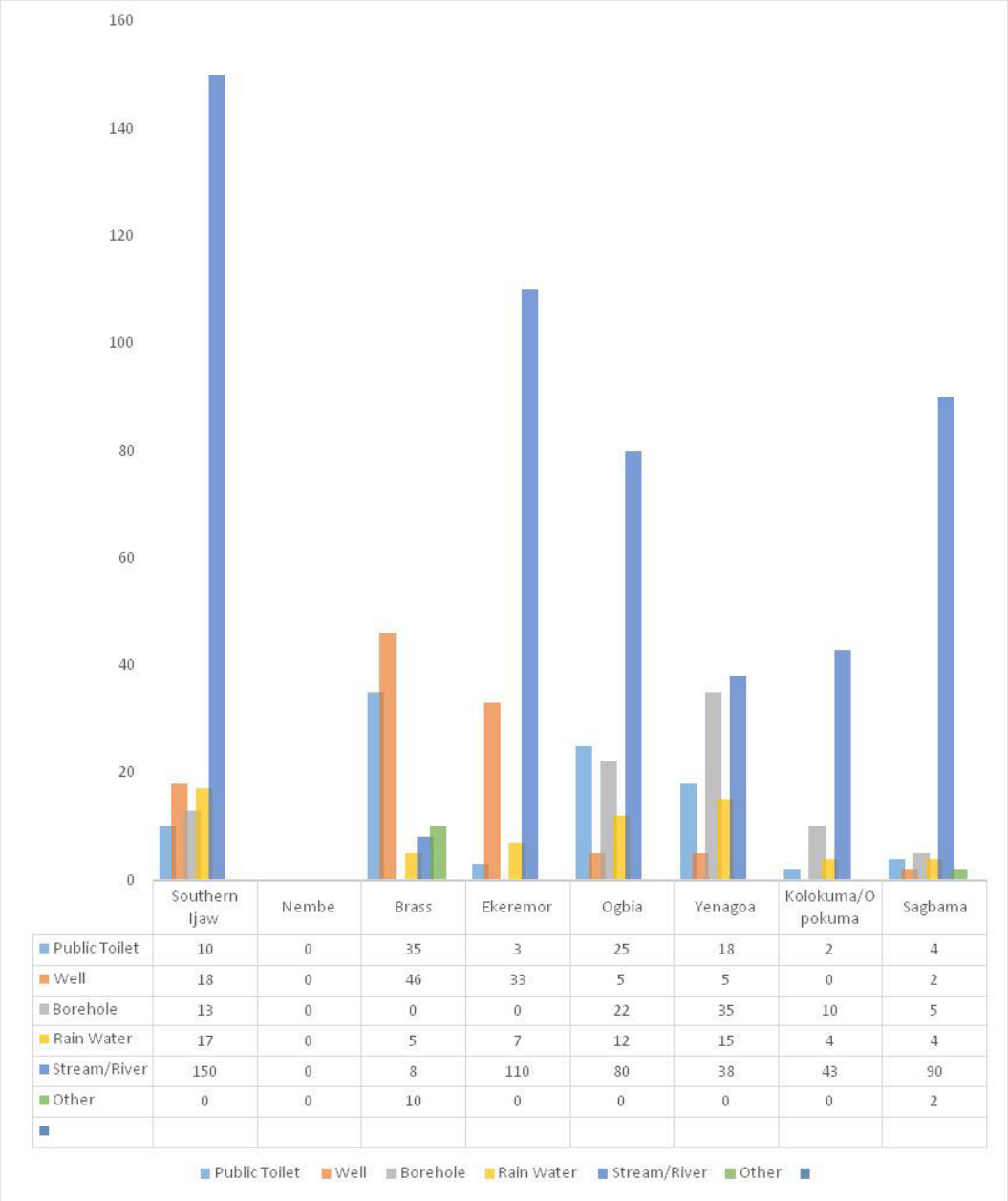


Figure 4. Water Access in Bayelsa State



	Southern Ijaw	Nembe	Brass	Ekeremor	Ogbia	Yenagoa	Kolokuma/Opokuma	Sagbama
Public Toilet	10	0	35	3	25	18	2	4
Well	18	0	46	33	5	5	0	2
Borehole	13	0	0	0	22	35	10	5
Rain Water	17	0	5	7	12	15	4	4
Stream/River	150	0	8	110	80	38	43	90
Other	0	0	10	0	0	0	0	2

Figure 5. Main Source of Water for Households in Eight (8) LGAs of Bayelsa State

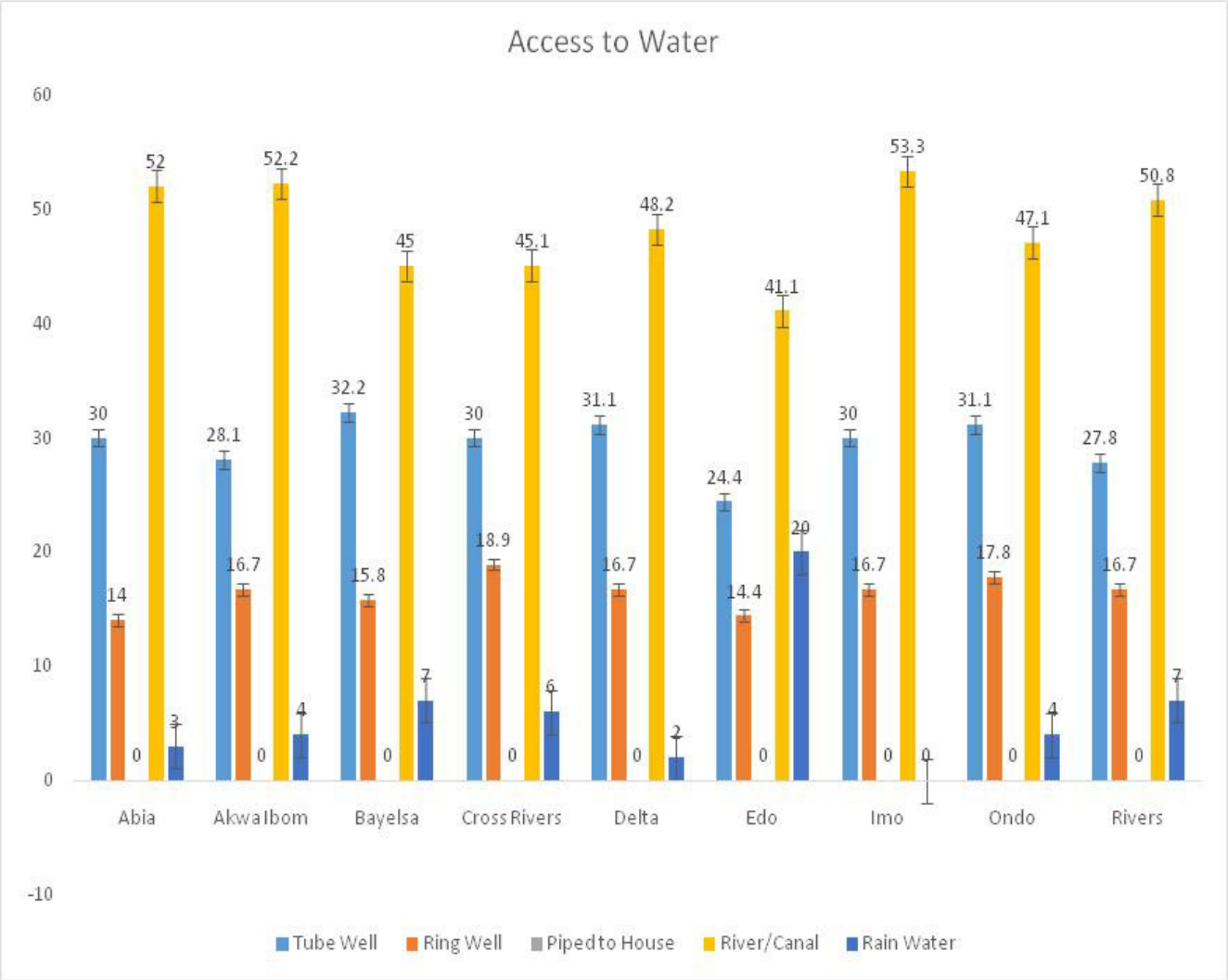


Figure 6. Access to Water in the Niger Delta Region of Nigeria

erroneous practices (see figure 5) of handling and storage of drinking water in household (Levy *et al.,* 2008). Either way, health and well-being are achieved through the access and quality to safe drinking water. This is recognized in the United Nations Sustainable Development Goals for water and health. As a signatory to the UN Goals, Nigeria has a commitment to ensure the access and quality of these resources is attained for all, including indigenous communities living in the Niger Delta Region of Nigeria. The SDGs especially target 6.1, therefore, hope to achieve universal and equitable access to safe and affordable drinking water for all by 2030.

Researches have continued to prove that water resources in the Niger Delta will continue to deteriorate and the amount of water pollution will continue to rise. Something of greater concern is the fact that the infrastructure and management systems are not adequately prepared for the increasing pollution generation (Premoboere and Raimi, 2018; Olalekan *et al.,* 2018; Olalekan *et al.,* 2019; Raimi *et al.,* 2019). According to Dr. Akinwumi Adesina, by 2030, the size of the food and agricultural business in Africa will reach $1 trillion and pollution tends to threaten food security, access to safe drinking and bathing water and poses a major health and environmental management challenges (Allen *et al.,* 2010; Berendonk *et al.,* 2015). Apart from oil, grease, changes in thermal modifications, and acidity, these contaminants include the most important legislative classification entitled “conventional pollutants." Scientists understand the physical and biological properties of these substances, and their ecological and environmental effects on living organisms are considered non-toxic.' Toxic pollutants," means those contaminants that are especially harmful to plant, animal, and human life. These include heavy metals, inorganic chemicals, and non-petroleum based organic chemicals. Listed metals

Table 1. Common Water Pollutant Classifications

Pollutant Category	Examples in Waters
Nutrients	Nitrogen, Phosphorous
Oxygen Depleting Substances	Organic Matter (BOD)
Sediments and Suspended Solids	Soil, Silt
Pathogens: Bacteria	Fecal Coliform E. Coli
Pathogens: Viruses	Hepatitis
Pathogens: Protozoa	Cryptosporidium, Giardia
Pathogens: Dinoflagellates	Pfiesteria
Metals & Inorganic Chemicals	Arsenic, Lead, Copper, Mercury
Toxic Organic Chemicals	Pesticides, Dioxin, PCBs
Thermal and pH Modification	Heated Water Discharge

Source: Adapted from United States EPA (2000)

include cadmium, copper, lead, mercury, and silver. Asbestos is a known inorganic and organic toxic substance, which includes many pesticides and herbicides, as well as dioxin and PCBs. Organochlorines, organophosphates, carbamates, pyrethroids, triazines, and neonicotinoids constitute clear classes of chemical pesticides. More emphasis is applied to the commonly used herbicide “glyphosate,” which is an organophosphate pesticide. Very specific classification of water contaminants, as defined in the Clean Water Act and approved by the EPA. is “nonconventional pollutants." Otherwise specified as 'conventional’ or ‘toxic.’ The most common among them are chlorine, nitrogen, and phosphorous. More specific water pollutant classifications are described in Table 1 above. Excessive loads of any listed pollutant prevent a water body from attaining high quality standards, given that, in high enough concentrations, their presence inadequately protects aquatic life and renders the waterway unsafe for human activities. In addition, for water bodies that are potential or actual sources of drinking water, the majority of these contaminants require substantial expenditures for disinfection and microbial control.

‘Nutrients.’ the first category in table 1, are the mineral elements that plants require for growth. Nitrogen (N). phosphorous (P), and potassium (K) form a sub-classification called macronutrients. These elements are particularly critical for photosynthesis and protein construction, and their concentrations are often a limiting factor in the development of floral. In other words, N. P. and K are often lacking in areas where plants commonly take root, precisely because these minerals are needed in substantial amounts for rapid and sustained growth. However, wells in some part of the Niger Delta, especially those shallower than 70 feet, are exposed to increasing levels of nitrate and are most at the highest risk for bacterial contamination and the food trade is increasingly dependent on unsustainable use of groundwater. Also, the uptick in militancy activities is complicating attempts by health care professionals to stem the spread of infectious, waterborne diseases like dengue fever and cholera that have multiplied (Raimi *et al.,* 2017; Olalekan *et al.,* 2018; Raimi *et al.,* 2019).

Fertilizers, animal wastes, and crop residues are all rich in nitrogen and phosphorous. Runoff and leaching from agricultural facilities can therefore drastically upset the ecological balance of a receiving water body. Without the usual growth limits for macronutrient, aquatic plant production increases rapidly. As organic material eventually dies, bacterial decomposition utilizes dissolved oxygen. This process, known as eutrophication, can induce fish-kills and cause significant damage to the ecosystem. Particularly enriched areas may also exhibit color, turbidity, and odor problems (Raimi and Sabinus, 2017; Morufu and Clinton, 2017; Olalekan *et al.,* 2018). Finally, nitrogen can react with other chemical compounds to form toxic substances. For example, ammonia is harmful to aquatic organisms, and nitrates and nitrites have been linked to “blue baby syndrome,” a potentially life threatening infant illness.

‘Oxygen depleting substances' are some of the threat to the water quality in the Niger Delta. Agricultural runoff, urban wastewater and storm water, and direct industrial effluent emissions often contain large concentrations of depletable organic matter. Biochemical Oxygen Demand (BOD), the most frequent measure of this type of pollution, calculates the amount of oxygen organisms necessary to breakdown a water sample’s organic matter into carbon dioxide, water, and non-degradable compounds. The oxygen depleting contaminants of Biological Oxygen Demand (BOD_5) attempts to measure the most damaging of the conventional pollutants. Likewise, the primary consequences are environmental in nature. The biochemical reactions involved in the decomposition of organic matter deprive the waterway of its dissolved oxygen, and as a result, kill fish and ecosystem damage may become widespread. As a broad rule of thumb, fish-kills occur when fish are exposed to waters containing less than 3 mg/L of dissolved oxygen for periods greater than a few hours. However, levels as high as 5-6 mg/1 can be lethal if cold-water fish are also subject to other water quality impairments (Morufu

and Clinton, 2017; Olalekan *et al.,* 2018).

'Suspended Solids,' another category in table 1 above, are small solids actively suspended in water or those particles located away from their initial location due to transport by wind, water or gravity. The classification can include both organic and inorganic substances, and common examples include soil and silt. Such impairment, usually from agriculture and forestry management, results in increased turbidity and shortages of sunlight availability for aquatic flora and fauna. Other ecosystem effects include gill injuries and the suffocation of fish eggs and bottom dwelling organisms. Economic considerations (in addition to drinking water treatment costs) include recreation losses and reductions in the economic lives of dams and reservoirs. Sediments generally contain toxic substances and suspended nutrients. Thus, sediments can therefore contribute to the damages these contaminants generate (Raimi and Sabinus, 2017; Morufu and Clinton, 2017; Olalekan *et al.,* 2018).

'Pathogens' are disease-inducing microorganisms found in water bodies. The class of pathogenic pollutants includes bacteria, viruses, dinoflagellates, and protozoa. Common bacterial and protozoan contaminants are classically caused by animal and human wastes, and include E. Coli, fecal coliform, giardia lamblia, and Cryptosporidium. Fecal coliforms are not particularly dangerous in their own right, rather, they typically serve to highlight the presence of other pathogens. Gastrointestinal illnesses are the most common health problems associated with the ingestion of or primary contact with, waterborne protozoa and non-coliform bacteria (Odipe *et al.,* 2018). The production and cycling of pathogenic and drug-resistant bacteria will continue to be a major global challenge. This depends on the nature in which food is produced (consuming 70 – 90% of the available fresh water) and most of the water goes back to the system with additional nutrients, pollutants, contaminants and pathogens. Further downstream, agricultural pollution is increasingly associated with human and industrial wastes. Almost 90% of wastes water flows untreated into the densely populated areas such as informal settlements. This has contributed to the growth of freshwater and marine dead zones in the water, leading to further losses in biodiversity and ecosystem resilience, which in turn will undermine prosperity and continued efforts towards a more water quality sustainability (Romina *et al.,* 2018). The emergence of bacterial resistance to antibiotics has become a common occurrence particularly in areas where very effective antibiotic drugs are widely used. Indeed, such incidences have greatly contributed significantly to the rise in antibiotic-resistant bacteria in aquatic environments (Schwartz *et al.,* 2003). The assessment of microbial quality of drinking water is an important major step in the quest to meet this target and major microbial threat is linked to the consumption of water that is contaminated with faeces from either human or animals (Dufonr *et al.,* 2012; Bain *et al.,* 2012). Although, long term solutions will require improvement in water quality and sanitation infrastructures, a great deal can be achieved through more frequent and widespread water quality testing (WHO, 2012).However, there are significant challenges in implementing efficient microbial water quality tests that are appropriate for low-resources setting such as the Niger Delta Region of Nigeria. Yet, microbiologically safe water at the point of consumption continue as a challenge for improving public health. In many Global South including the Niger Delta, inadequate treatment of improved water supplies at the point of distribution often contaminate water with infectious diseases causing pathogen (see figure 7) (Sobsey *et al.,* 2008; Raimi *et al.,* 2017).

The health and livelihood of people depend on the availability of a safe drinking and domestic water supply. In most parts of rural communities in the Niger Delta (figure 7), potable water is a scarce resource. Most people obtain drinking and domestic water from sources, mostly rivers and stream.Drinking water can also be contaminated during collection, transport and storage due to poor hygiene conditions or failing infrastructure (Boisson *et al.,* 2010; Olalekan *et al.,* 2018; Raimi *et al.,* 2019).While viral contamination is a much serious threat in Nigeria and other developing world, it also causes and induce periodic enteric outbreaks. Waterborne pathogens include hepatitis A and human adenovirus, and adverse consequences can occur during both ingestion and recreational contact (Raimi *et al.,* 2017). Gastrointestinal illnesses again are the most common potential health threats. Dinoflagellates, on the other hand, can be more hazardous. These free-swimming, single-celled aquatic organisms are naturally occurring and often harmless, but pfiesteria piscicida has recently generated health concerns. Similarly, the toxins produced by pfiesteria have been linked to the killing of fish. Fish lesions, and human illness. Toxics, including 'metals,' 'inorganic chemicals,' and 'toxic organics compounds,' are by definition particularly those that are dangerous substances. Common examples include polychlorinated biphenyls (PCBs), mercury, lead, and dioxins. Callan and Thomas (2000) define more precisely toxics as contaminants "which upon exposure will cause death, disease, behavioral abnormalities, genetic mutations, or physiological malfunctions in biological organisms or their offspring" (Callan and Thomas, 2000). These definitional health concerns predominately translate into increased cancer rates, reduced fetal viability, and generational genetic diseases. Raimi and Sabinus (2017), Raimi and Clinton (2017), Raimi *et al.* (2018), studied the degradation of groundwater quality due to heavy metals in Ebocha-Obrikom oil and gas producing areas of Rivers State, Nigeria. It was noticed in the study that the concentration of heavy metals, like iron, zinc, copper, chromium and manganese etc. in the oil and gas area was much higher than the permissible limit of NAFDAC

Figure 7. Pictures showing a boy drinking river water.

(2008) and WHO (2008). The inherent dangers of substances toxic to the health of human and aquatic species have been predicted by the fact that many toxins and heavy metals are persistent in nature, bio accumulate, and interact with other chemicals. Persistence, defined in this regard as the absence of natural processes to break down contaminants, implies that pollutants discharged and deposited in years past will continue to interact with aquatic biota into the future (Tietenberg, 2000). Bioaccumulation, the ability of a substance to accumulate in the tissues of an organism's, suggests that pollutants may be harmful to a higher species, such as predatory fish particularly in water bodies where basic pollutants are found in extremely low or undetectable concentrations. Additionally, many chemical compounds display vastly different biochemical properties after fertilization with other natural or synthetic compounds. Therefore, even relatively harmless chemicals can become hazardous in water bodies that would otherwise be contaminated.

'Pesticides. 'In the first category of table 1 above, are substances or combinations of substances used in agriculture or in public health protection programs in order to protect plants from pests, weeds or diseases, and humans from vector-borne diseases, such as malaria, dengue fever, and schistosomiasis. Insecticides, fungicides, herbicides, rodenticides, and plant growth regulators are typical examples (Alewu and Nosiri, 2011). These products are also used for other purposes, such as the improvement and maintenance of non-agricultural areas like public urban green areas and sport fields (Hoffman *et al.,* 2000). Furthermore, there are other less known applications of these chemical substances, such as in pet shampoos, building materials, and boat bottoms in order to eliminate or prevent the presence of unwanted species (Johnston, 2001). Most pesticides are associated with health and environmental issues (Hayes *et al.,* 2006; Alewu and Nosiri, 2011; Zheng *et al.,* 2016), and the agricultural use of certain pesticides has been ignored (Alewu and Nosiri, 2011). Exposure to pesticides may occur through skin contact, ingestion, or inhalation. The type of pesticide, the duration and route of exposure, and the individual health status (e.g., nutritional deficiencies and healthy/ skin lesions) are all determinants of potential health effects. In the life of human or animal body, pesticides can be disseminated, excreted, stored, or bioaccumulated in human body fat (Alewu and Nosiri, 2011; Pirsaheb *et al.,* 2015). The adverse health effects that have been associated with chemical pesticides include dermatological, gastrointestinal, neurological, carcinogenic, respiratory, reproductive, and endocrine effects (Mnif *et al.,* 2011; Sanborn *et al.,* 2007; Thakur *et al.,* 2014). In addition, high occupational, accidental, or intentional exposure to pesticides can lead to hospitalization and death (Gunnell *et al.,* 2007). Residues of pesticides can be found in a great variety of everyday

foods and beverages, including for example, cooked meals, water, wine, fruit juices, refreshments, and animal feeds (Chouraiva *et al.,* 2015). Furthermore, it should be noted that washing and peeling cannot completely eliminate other wastes (Reiler *et al.,* 2015).In most cases, the concentrations do not exceed legislatively determined safe levels (Lorenzin, 2007; Nougadere *et al.,* 2012; Blaznik *et al.,* 2015). However, these "safe limits" may underestimate the real health risk because they are often referred to as simultaneous exposure to two or more chemical substances, which occurs under natural conditions and may have synergistic effects (Kortenkamp, 2007). The presence of pesticides residues has also been found in human breast milk samples, and concerns have been expressed about prenatal exposure and health effects in children (Damgaard *et al.,* 2006; Pirsaheb *et al.,* 2015).

Similarly, Fluoride may be naturally present in water and, in some communities, is added to water supplies to reach the recommended concentration of 0.7mg/L to prevent decay tooth (Health Canada, 2010). Nearly 74% of Americans and 38% of Canadians using municipal waste water are supplied with fluoridated drinking water. Water fluoridation has been reported to reduce the incidence of tooth decay by 26% to 44% (Iheozor-Ejiofor *et al.,* 2015; National Health and Medical Research Council (NHMRC), 2017) in adolescents and 26% (Iheozor-Ejioforetal., 2015) to 27% (NHMRC, 2017) in adults. In addition, fluoride present in almost all natural water supplies, in high concentration does not constitute a common constituent of surface water, but it can occur in detrimental concentrations in groundwater. There are important regional differences in the health effects of consuming varying levels of fluoride and WHO recommends a limit based on the mean average annual temperature of the area. As per the standard, a desirable limit is 1.0mg/l and an upper limit is 1.5 mg/L. Concentration of 1.5 mg/L may cause mottling of the teeth. In a review by the Royal College of Physicians (1976), relatively mild osteoflurotie symptoms were correlated with fluoride levels of 1-3 mg/L in water. Prolonged ingestion of water with high fluoride content causes skeletal fluorosis in adults and children. If no alternative source is found, water should be treated to reduce fluoride level.

Health Effects of Contaminated Water

Water pollution is one of the most devastating problems affecting the environment and health which is caused by petroleum activities in the Delta region. This problem often exists primarily as water is critical to human and industrial development (Abdus-Salam *et al.,* 2010). Over one (1) billion people in emerging world lack access to safe drinking water, most of whom live in Africa (Abdus-Salam *et al.,* 2010). Also, most of the public water taps, which one finds in the slums and squatter settlements brings with them epidemic, contagious diseases because of pollution. Numerous health and social problems develop, especially for the children and the poor when they resort to illegal connections like the bunkering activities in the Niger Delta. Such actions are seen by poor as being "illegal", but the system itself encourages such last-resort actions.

In addition, inadequate access to clean water (see figure 2 and 3) causes momentous suffering and disease, and pollution allied with unsafe water is caused by toxic substances in numerous quantities to be naturally attenuated by the environment (Macer, 2000). Exposure to prolonged toxic compounds seen in unsafe water can lead to acute toxicities, genetic changes, cancer, and birth defects among humans and other organisms (Foudan and Kefatos, 2001; Olalekan *et al.,* 2018). Water pollution is a major cause of concern in developing countries (Adedeji and Adetunji, 2011) and the Niger Delta region water pollution is a by-product of crude oil transport. Petroleum activities, such as dredging, oil exploration, marketing, refining, spills, and gas flaring, are responsible for a substantial amount of water pollution in the Niger Delta (Adedeji and Adetunji, 2011). Crude oil is frequently transported on tankers or through pipelines causing spills and pollution (Slavic Research Center, 1999). Abdus-Salam, Adekola, and Apata (2010) explained this issue: When oil is spilled at sea, it is discharged to coastlines. It destroys seaweeds, invertebrates, fish and their habitats have changed over the years. Sea birds are very resistant to oil and can die from hypothermia, if even the smallest feathers get into the petroleum. Oil pollution can affect the wildlife and vegetation in sundry ways, such as the dissolution of protective fats on the body surfaces of birds (International Tanker Owners Pollution Federation, 2011), absorption of petroleum hydrocarbons through the gills of fish (Heubeck *et al.,* 2003), contamination of wetlands and marshes which is practically impossible to clean up (Chan and Baba, 2009), and the poisoning of plants and animals which depend on the ecosystem (Linden and Palsson, 2013). The settlements around the Delta region lack potable water making it necessary for the population to depend on rivers for their domestic, recreational, and agricultural needs (see figure 7). With a length of approximately 4,100 kilometers, the Niger River is the third longest river in Africa (Linden and Palsson, 2013).The delta river's stretches from Benin to the Bonny River, and the neighboring freshwater swamp is the third largest in the world (Linden and Palsson, 2013). The blatant neglect of providing safe water to the people of the area has led to a study of the well-being of inhabitants of the region. Abdus-Salam *et al.* (2010) conducted a similar study in Ondo State. Abdus-Salam *et al.* evaluated water quality for chemical parameters and heavy metals at six sites in the same ecological zone.

Analysis of water sources were carried out from March

Table 2. Health Problems Associated with Metal Toxicity

Lead/Cadmium	Manganese	Iron	Zinc	Chromium
Nephrotoxicity, neurotoxicity, hypertension, bone development, tooth enamel formation	Parkinson's disease, poor neurologic function, decreased intellectual function, damage to developing embryos	Primary hemochromatosis, secondary hemochromatosis, thalassemia, damage to the heart, liver, and endocrine system; diabetes, heart failure, or death.	Vomiting, diarrhea,	Cancer

Adapted from Nduka and Orisakwe, 2011; Morufu and Clinton, 2017; Olalekan *et al.,* 2018.

2008 to January 2009.

Researchers obtained water from all sources of domestic and agricultural use and found it to be generally unsafe, because of pollution from several sources (Abdus-Salam *et al.,* 2010). Sources of pollution include bedrock modifications, oil spillage, agrochemicals, farm runoff, and boat exhaust (Abdus-Salam *et al.,* 2010). Abdus-Salam *et al.* called for a considerable effort from the Nigerian government and oil corporations to reduce water pollution for three reasons: (a) the river has been a source of food for many inhabitants, (b) transboundary pollution drains into the Atlantic Ocean, and (c) addressing water pollution problem would help to lessen the deplorable environmental conditions. Abdus- Salam *et al.* recommended "appropriate education, monitoring and clean up procedures be carried out on time at these locations wherever there is oil spillage". In another study, Nduka and Orisakwe (2011) studied the heavy metal profiles and physicochemical properties of surface water samples used by indigenous inhabitants at Bayelsa, Delta, and Rivers States. The researchers collected the water samples at intermittent times to account for variations in the river water properties that may occur during the day (Nduka and Orisakwe, 2011). Nduka and Orisakwe report that surface waters in Delta and Rivers State were more polluted than those at Bayelsa. Increased metal levels can affect the water's salinity, redox potential, and pH levels (Nduka and Orisakwe, 2011). The levels of lead, cadmium, chromium, and manganese exceed the threshold limits recommended by the World Health Organization for drinking water (Nduka and Orisakwe, 2011; World Health Organization, n.d.). The ingestion of such metals can pose a threat to public health in many respects (see Table 2; Nduka and Orisakwe, 2011; Morufu and Clinton, 2017; Olalekan *et al.,* 2018).

Linden and Palsson (2013) conducted a new water quality assessment by testing the surface waters, drinking wells, sediment, and biota in Ogoni land, an area in the Niger Delta region comprising of Eleme, Tai, Gokana, and Khana. Researchers measure the water quality parameters, including pH, temperature, dissolved oxygen, and conductivity, at rivers, streams, and ponds (Linden and Palsson, 2013). Examination of the samples showed a significantly increase in the concentration of extractable petroleum hydrocarbons (EPHs) in the majority of water (Linden and Palsson, 2013). Concentrations at high level of EPHs can cause even tolerant organisms to disappear and make the water unsafe for human consumption (United Nations Environmental Programme, 2011). For example, samples from Eleme showed extremely high levels of carcinogen and benzene (Linden and Palsson, 2013). In addition, EPHs concentrations in sediments were also increased in all sample sites (Linden and Palsson, 2013). Linden and Palsson (2013) stated that "the results of the analyses showed that oil contamination was substantial in the study area", and that surface waters, drinking wells, and river sediments were all contaminated. Researchers have also noted that oil pollution causes far-reaching damage to mangroves, where vast expanses of vegetation had died (Linden and Palsson, 2013). Lindon and Palsson's conclusions were not optimistic: "Even if the pollution were to stop, the fact that mangroves and wetlands have been so heavily impacted indicates that a recovery of the affected areas is a matter of several years, perhaps decades".

Similarly, health effects from chemicals in water occur when an individual consumes water containing a harmful amount of a toxic substance. Infant methaemo-globinaemia, caused by the consumption of water with a high nitrate concentration by infants (usually those which are bottle fed), is an example. The occurrence of methaemoglobinaemia is usually related to nitrate (often in groundwater's) which has been derived from extensive use of nitrate fertilizers. Fluorosis, damage to the teeth and bones, results from long-term consumption of water containing excess fluorides (usually from natural sources).

Summary

The supply of reliable safe drinking water in state capitals

like Port Harcourt, Yenagoa and other parts of the Niger Delta States represents one of the outstanding public health achievements of the past century. This capacity builds on the core and mutually reinforcing efforts of public health researchers, engineers and governments at all levels of state and federal to put the necessary infrastructure in place, develop standards and regulations, and implement it effectively. As a result, most people in the state capital today enjoy an unprecedented level of protection and safety in the drinking water they consume. However, this system has been put in place to make the supply of drinking water safe and adequate for years to come. Up to a hundred years later, the Niger Delta has experienced a surge in population growth, which is projected to increase until 2050; a population shift from densely populated urban areas to sparsely populated rural areas; and demands greater water for different needs such as recreation, drinking water consumption, industrial use, and agricultural use. All this has led to the need for additional pressure on the water channels and will probably affect the ability to supply adequate water beforehand. Equally, the goal of achieving significant improvements in the percentage of people with access to clean water supplies has been specifically embedded in the sustainable development goals (SDGs) 2030. Provision of safe drinking water for a community is recognized as a priority protection, effective pathway to health promotion, poverty reduction and to sustain human life (WHO, 2016). Undoubtedly, the provision of safe water for the entire population remains one of the challenges of our era, particularly in the Niger Delta (Raimi *et al.,* 2019). The availability of clean water has become a problem of international concern and without drastic measures, the problem will only get worse. Many communities around the world are suffering from the effects of contaminated water resources, or the lack of adequate water resources and sanitation. Often, it is the poorer communities who feel the greatest negative effects of polluted water resources and other environmental justice issues. Indigenous communities have a higher likelihood of monetary poverty, and thus are often more greatly affected by environmental problems than their non-Indigenous counterparts.

Health problems from polluted water sources are exacerbated by the relative lack of health care in many Indigenous communities. This international problem must be addressed quickly, to prevent further avoidable epidemics of death and disease. This study gathered information from Indigenous communities of Niger Delta through research, interviews and water-quality tests, in order to show the health effects of polluted water resources on Indigenous communities, to determine the water quality issues facing each community, and to lay a framework for future preventative measures. It was determined that the people of Niger Delta are facing important water quality issues that will need to be addressed by current and future generations. The pollution issues affecting water resources influence all communities, rich and poor, Indigenous and non-Indigenous. We must all work together to discover solutions and prevent the further contamination of our water resources. This study will be one small step in improving community health and empowering Indigenous People, by ensuring they have the technology to determine the status of their own water supplies.

CONCLUSION

While oil and gas play an important role in the development of human society, their exploration and trade activities have created severe environmental problems for the planet. Expectedly enough, the decision to incorporate a water based goal (SDG 6) into 17 SDGs is believed to bea clear recognition that water is not only part of many other SDGs but in many aspects their precondition. Within this goal include the fundamental targets for drinking water provision and sanitation but also for environmental sustainability. The water goal is expected to tackle the widespread pollution (GWSP, 2015). However, the current trajectory of increased ground water pollution and the associated risks pose a significant challenge to the realization of meeting the SDGs 6, targets 3 by 2030, through improving water quality by reducing pollution. The paper therefore addresses some of the drinking water challenges from a water perspective. Furthermore, current agricultural practices depend on the widespread use of chemical pesticides associated with adverse effects on human health, wildlife, and natural environment (Pimentel and Burgess, 2014; Goulson, 2014). Current agriculture is now linked to important factors, such as population growth, food security, pesticide-related health risks, pesticide resistance, environmental degradation, and climate change. In addition, common symptoms of a mixture of pesticides with additives or synergistic effects should be studied in more detail research. Scientific uncertainty, the exposure of vulnerable groups and the fact that there is a wide variety of possible mixtures reveal the real complex character of the problem (Sexton, 2012; Hernandez *et al.,* 2013). The combination of substances that may cause carcinogenic or endocrine-disrupting effects may have unwanted adverse health effects. Therefore, the determination of “safe” levels of exposure to single pesticides can negate the actual health effects, while ignoring the chronic exposure to multiple chemical substances. Therefore, State governors in the Niger Delta should paid attention to the concerns raised by citizens, activists, and scientists, and recognized the problem, the public nature of the outcome of contaminated water supplies arising from water quality issues such as rising nitrate, lead, pesticides, fluoride, metaldehyde etc. Governments and regional governmental structure should be the first responders

while development actors should complement the gaps. This alliance is necessary as feelings that national and international Non-governmental organizations are key actors in a community led response, amplifying voices of the most vulnerable. Governments should participate in people's oriented projects rather than people participating in governments 'projects. Water should maintain a shared property resource, shared heritage of all. Yet, there may be costs concomitant with being able to make available the infrastructure and amenities in a sustainable way. Though, water security need to be stress upon meaning that "freshwater, coastal and related ecosystems are protected and improved; that sustainable development and political stability are promoted, that every individual has access to sufficient safe water at a reasonable cost thereby leading to a healthy and productive life and that the vulnerable are protected from the risks of water-related hazards" and Governments need to address these issues. The region should encourage partnerships with national actors, in order to ensure the involvement of affected communities. Critically, this network of local partners should provide a direct pathway to mobilize communities to understand, monitor and respond to the water quality crisis. The simultaneous implementation of control and livelihood activities is a critical lesson learnt from the response of the ongoing Ogoni clean-up should be replicated in other part of the Niger Delta. Policy making with humanitarian intentions coupled with technical knowledge will solve the water problems. The making of decisions and the formation of policy seldom draw on the full range of knowledge. What further needed are multiples forms of networking policies across stake holder communities to help identify innovative approaches, enabling technologies and new institutional, financial and regulatory mechanism for meeting sustainable challenge. The goal should be to bring together business and industry, international institutions, national and state governments, research and scientific institutions etc. so that comprehensive and integrated strategies can be formulated. Strategic collaboration is a necessity; it is not a luxury. Interaction should be reinvigorated between science and technology; business and industry; national governments and International organizations of the global south so that they have a right to drinking water. Another major change is the realization at the international policy-making level that in the era of globalization, sustainable development can only be achieved through close partnership between Governments, the private business sector and civil society. People's participation in planning their own future, poverty alleviation, equality of opportunities, and equitable growth are essential for environmental sustainability. The study also points to the need for comprehensive approach and extensive policy education outreach to state legislators in the Niger Delta impacted by the water quality issues. If we want to reach the SDGs by 2030, concrete steps must be taken today. The review provides a comprehensive overview of major and emerging trends from around the world, with examples of how some of the trend-related challenges have been addressed, their implications for policy-makers, and further actions that can be taken by stakeholders and the international community through closing the gap by looking forward to network in other to deliver on the SDGs.

REFERENCES

Alewu B, Nosiri C (2011). Pesticides and human health. In: Stoytcheva M, editor. Pesticides in the Modern World – Effects of Pesticides Exposure. InTech. p. 231–50. Available from: http://www.intechopen.com/books/pesticides-in-the-modern-world-effects-of-pesticides-exposure/ pesticide-and-human-health.

Allen H R, Donato, J, Wang HH, Clond-Hansen KA, Davies J, Handelsman, J (2010). Call of the Wild: Antibiotic resistance genes in natural environments. Nature Reviews Microbiology 8(4), 251 – 259.

Blaznik U, Yngve A, Eržen I, HlastanRibič C (2015). Consumption of fruits and vegetables and probabilistic assessment of the cumulative acute exposure to organophosphorus and carbamate pesticides of schoolchildren in Slovenia. *Public Health Nutr* 19(3):557–63. doi:10.1017/S1368980015001494.

Callan SI, Thomas JM (2000) Environmental Economics and Management: Theory, Policy, and Applications. Orlando: Dryden Press.

Chourasiya S, Khillare PS, Jyethi DS (2015). Health risk assessment of organochlorine pesticide exposure through dietary intake of vegetables grown in the periurban sites of Delhi, India. *Environ SciPollut Res Int* 22:5793–806. doi:10.1007/s11356-014-3791-x

Damgaard IN, Skakkebaek NE, Toppari J, Virtanen HE, Shen H, Schramm KW, et al (2006). Persistent pesticides in human breast milk and cryptorchidism. Environ Health Perspect 114:1133–8. doi:10.1289/ehp.8741.

Goulson D (2014). Ecology: pesticides linked to bird declines. Nature. 511:295–6. doi:10.1038/nature13642

Gunnell D, Eddleston M, Phillips MR, Konradsen F (2007). The global distribution of fatal pesticide self-poisoning: systematic review. BMC Public Health 7:357. doi:10.1186/1471-2458-7-357.

Hayes TB, Case P, Chui S, Chung D, Haeffele C, Haston K, *et al* (2006). Pesticide mixtures, endocrine disruption, and amphibian declines: are we underestimating the impact? Environ Health Perspect. 114:40–50. doi:10.1289/ ehp.8051.

Health Canada, (2010). Guidelines for Canadian Drinking Water Quality: Guideline Technical Document - Fluoride. Air and Climate Change Bureau, Healthy Environments and Consumer Safety Branch, Health Canada, Ottawa, Ontariodoi: CatalogueNo.H128-1/11-647E-PDF.

Henry OS, Odipe EO, Olawale SA, Raimi MO (2019) Bacteriological Assessment of Selected Hand Dug Wells in Students' Residential Area: A Case Study of Osun State College of Health Technology, Ilesa, Nigeria. *Global Scientific Journal,*Volume 7, Issue 1, January 2019, Online: ISSN 2320-9186. www.globalscientificjournal.com

Hernández AF, Parrón T, Tsatsakis AM, Requena M, Alarcón R, LópezGuarnido O (2013). Toxic effects of pesticide mixtures at a molecular level: their relevance to human health. Toxicology (2013) 307:136–45. doi:10.1016/j. tox.2012.06.009.

Hoffman RS, Capel PD, Larson S J (2000). Comparison of pesticides in eight U.S. urban streams. Environ ToxicolChem (2000) 19:2249–58. doi:10.1002/ etc.5620190915.

Iheozor-Ejiofor, Z., Worthington, H. V., Walsh, T., O'Malley,L. Clarkson,J.E.,Macey,R., Alam,R.,Tugwell, P.,Welch,V.G., (2015). Water fluoridation for the prevention of dentalcaries. Cochrane Database Syst. Rev .6,CD010856. https://doi.org/10.1002/ 14651858.CD010856.pub2.

John T (2002), As Multinationals Run the Taps, Anger Rises Over Water for Profit, New York Times, August 26.

Johnston JJ (2001). Introduction to Pesticides and Wildlife. USDA National Wildlife Research Center – Staff Publications. Paper 589. Available from: http://digitalcommons.unl.edu/icwdm_usdanwrc/589

Kortenkamp A (2007). Ten years of mixing cocktails: a review of combination effects of endocrine-disrupting chemicals. Environ Health Perspect 115:98–105. doi:10.1289/ehp.9357.

Lorenzin M (2007). Pesticide residues in Italian ready-meals and dietary intake estimation. J Environ Sci Health B (2007) 42:823–33. doi:10.1080/03601230701555021.

Maude B (2001). Water as Commodity — The Wrong Prescription, The Institute for Food and Development Policy, Backgrounder, Summer 2001, Vol. 7, No. 3).

Mnif W, Hassine AIH, Bouaziz A, Bartegi A, Thomas O, Roig B (2011). Effect of endocrine disruptor pesticides: a review. *Int J Environ Res Public Health*. 8:2265–2203. doi:10.3390/ijerph8062265.

Morufu R, Clinton E (2017). Assessment of Trace Elements in Surface and Ground Water Quality (2017) LAP Lambert Academic Publishing. Mauritius. ISBN: 978-3-659-38813-2. www.omniscriptum.com

National Agency for Food and Drug Administration and Control (NAFDAC) (2008). National Agency for Food and Drug Administration and Control. Ministry safety bulletin. Volume 2. Recommendation, National Agency for Food, Drug, Administration and Control. Lagos, Nigeria.

National Health and Medical Research Council(NHMRC), (2017).PublicStatement 2017 Water Fluoridation and Human Health in Australia.

Nduka JK, Orisakwe OEO (2011). "Water-Quality Issues in the Niger Delta of Nigeria: A Look at Heavy Metal Levels and Some Physicochemical Properties, *Environmental Science Pollution Research, 18*, pp. 237–246. doi:10.1007/s11356-010-0366-3

Nougadére A, Sirot V, Kadar A, Fastier A, Truchot E, Vergnet C, *et al* (2012). Total diet study on pesticide residues in France: levels in food as consumed and chronic dietary risk to consumers. Environ Int 45:135–50. doi:10.1016/j.envint.2012.02.001

Odipe OE, Raimi MO, Suleiman F (2018). Assessment of Heavy Metals in Effluent Water Discharges from Textile Industry and River Water at Close Proximity: A Comparison of Two Textile Industries from Funtua and Zaria, North Western Nigeria. *Madridge Journal ofAgriculture and Environmental Sciences.* 2018; 1(1): 1-6.doi: 10.18689/mjaes-1000101. https://madridge.org/journal-of-agriculture-and-environmental-sciences/mjaes-1000101.php

Olalekan R. M, Adedoyin OO, Ayibatonbira A, *et al* (2019). "Digging deeper" evidence on water crisis and its solution in Nigeria for Bayelsa state: a study of current scenario. *International Journal of Hydrology*. 2019;3(4):244–257. DOI: 10.15406/ijh.2019.03.00187.

Olalekan R. M, Vivien O. T, Adedoyin O. O, *et al.* (2018). The sources of water supply, sanitation facilities and hygiene practices in oil producing communities in central senatorial district of Bayelsa state, Nigeria. *MOJ Public Health*. 2018;7(6):337–345. DOI: 10.15406/mojph.2018.07.00265

Olalekan RM, Omidiji AO, Nimisngha D, Odipe OE, Olalekan AS (2018). Health Risk Assessment on Heavy Metals Ingestion through Groundwater Drinking Pathway for Residents in an Oil and Gas Producing Area of Rivers State, Nigeria. *Open Journal of Yangtze Gas and Oil, 3, 191-206*.https://doi.org/10.4236/ojogas.2018.33017.

Pimentel D, Burgess M (2014). Environmental and economic costs of the application of pesticides primarily in the United States. In: Pimentel D, Peshin R, editors. Integrated Pest Management. New York, Heidelberg, Dordrecht, London: Springer Science + Business Media Dordrecht. p. 47–71.

Pirsaheb M, Limoee M, Namdari F, Khamutian R (2015). Organochlorine pesticides residue in breast milk: a systematic review. Med J Islam Repub Iran. 29:228.

Premoboere EA, Raimi MO (2018). Corporate Civil Liability and Compensation Regime for Environmental Pollution in the Niger Delta. *International Journal of Recent Advances in Multidisciplinary Research Vol. 05, Issue 06, pp. 3870-3893, June, 2018*

Raimi MO, Abdulraheem AF, Major I, Odipe OE, Isa HM, Onyeche C (2019). The Sources of Water Supply, Sanitation Facilities and Hygiene Practices in an Island Community: Amassoma, Bayelsa State, Nigeria. *Public Health Open Access* 2019, 3(1): 000134. ISSN: 2578-5001. DOI: 10.23880/phoa-16000134.

Raimi MO, Sabinus CE (2017). An Assessment of Trace Elements in Surface and Ground Water Quality in the Ebocha-Obrikom Oil and Gas Producing Area of Rivers State, Nigeria. *Int. J. Sci. Eng. Res. (Ijser)*: Volume 8, Issue 6, July Edition. ISSN: 2229-5518.

Raimi MO, Sabinus CE (2017). An Assessment of Trace Elements in Surface and Ground Water Quality in the Ebocha-Obrikom Oil and Gas Producing Area of Rivers State, Nigeria. *Int. J. Sci. Eng. Res. (Ijser)*: Volume 8, Issue 6, July Edition. ISSN: 2229-5518

Raimi MO, Bilewu OO, Adio ZO, Abdulrahman H (2019). Women Contributions to Sustainable Environments in Nigeria. *J. Sci.Res. Allied Sci*. 5(4), 35-51. ISSN NO. 2455-5800. DOI No. 10.26838/JUSRES.2019. 5.4.104.

Raimi MO, Omidiji AO, Adeolu TA, Odipe OE, Babatunde A (2019) An Analysis of Bayelsa State Water Challenges on the Rise and Its Possible Solutions. *Acta Scientific Agriculture* 3.8 (2019): 110-125. DOI: 10.31080/ASAG.2019.03.0572.

Raimi MO, Pigha TK, Ochayi EO (2017). Water- Related Problems and Health Conditions in the Oil Producing Communities in Central Senatorial District of Bayelsa State. *Imperial J. Interdisciplinary Research (IJIR) Vol-3, Issue-6, ISSN: 2454-1362*.

Reiler E, Jørs E, Bælum J, Huici O, Alvarez Caero MM, Cedergreen N (2015). The influence of tomato processing on residues of organochlorine and organophosphate insecticides and their associated dietary risk. Sci Total Environ (2015) 527–528:262–9. doi:10.1016/j.scitotenv.2015.04.081.

Romina K, Federia G, Nastjenjka S, Ivica JMB, Magdalena C, Ana B, Cetinic AC, Raffaele D, Tamara D, Mathieu D, Vesna FJF, Danijela J, Katja K, Jerina K, Martina K, Grozdam K, Manro M, Frano, M., Josip, M., Zivana, N., Marco, P., Marijana P, Robert, P., Ivana, P., Federica, R., Angela, S., Antonietta, S., and Denis S (2018) Oceanographic characteristics of the Adriatic Sea – support to secondary HAOP Spread through natural dispersal. Marine Pollution Bulletin. Hhttps://doi.org /10.1016/j.marpolbul. 2018.10.062.

Sanborn M, Kerr KJ, Sanin LH, Cole DC, Bassil KL, Vakil C (2007). Non-cancer health effects of pesticides. Systematic review and implications for family doctors. Can Fam Physician. 53:1712–20.

Schwartz T, Kohnen, W., Jansen B and Obst, B (2003) Detection of antibiotic-resistany bacteria and their resistance genes in waste water surface water and drinking water biofilms. FEMS Microbiology Ecology. 43(3) 325 -335. https://doi.org/10.1111/1.1574-6941.2003.tb01073x.

Semchuk KM, Love EJ, Lee RG (1992). Parkinson's disease and exposure to agricultural work and pesticide chemicals. Neurology. 42:1328–35. doi:10.1212/WNL.42.7.1328.

Sexton K (2012). Cumulative risk assessment: an overview of methodological approaches for evaluating combined health effects from exposure to multiple environmental stressors. *Int J Environ Res Public Health* 9:370–90. doi:10.3390/ijerph9020370.

Talking Points (2003): Ask Boutros BoutrosGhali." BBC News, June 10, 2003. From http://news.bbc.co.uk/2/hi/talking_point/2951028.stm.

Thakur DS, Khot R, Joshi PP, Pandharipande M, Nagpure K (2014). Glyphosate poisoning with acute pulmonary edema. *Toxicol Int.* 21:328–30. doi:10.4103/0971-6580.155389.

Tietenberg, T (2000). Environmental and Natural Resource Economics. Reading: Addison Wesley.

UNICEF (2005) State of the World' s Children.

United Nations (1948), Universal Declaration of Human Rights, December 10.

United States EPA (2000), Office of Water. "National Management Measures to Control Nonpoint Source Pollution from Agriculture." August.

World Health Organisation (2008) Guidelines for Drinking Water Quality. http://www.who.int/water_sanitation_health/dwq/guidelines/en/

Zheng S, Chen B, Qiu X, Chen M, Ma Z, Yu X (2016). Distribution and risk assessment of 82 pesticides in Jiulong River and estuary. Chemosphere. 144:1177–92. doi:10.1016/j.chemosphere.2015.09.050.