Journal of ENVIRONMENTAL Treatment Techniques

J. Environ. Treat. Tech.
ISSN: 2309-1185

Journal web link: http://www.jett.dormaj.com

The Potability of Groundwater in Bayelsa State, Central Niger Delta Nigeria: A Review

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Received: 19/04/2015 Accepted: 08/06/2015 Published: 30/06/2015

Abstract

Water is an important resource required by all living organisms for growth, and survival. Water meant for drinking is called potable water. Two basic sources of Potable in the Niger Delta are surface and groundwater. The potability of water is generally based on their physiochemical, heavy metals and microbial quality. In the Niger delta, the major source of potable water is groundwater. Therefore this study reviewed the challenges associated with water potability in Bayelsa State, Central Niger Delta, Nigeria. The study found that besides turbidity, arsenic, total iron and pH; other parameters complied with their respective WHO and Standard Organization of Nigeria (SON) permissible limits. Also, the some potable water had indicated microbial counts beyond WHO and SON permissible limits. Water parameters having values exceeding WHO and SON standards are deem contaminated. Hence persistent consumption of such water without appropriate remedy, could lead to adverse acute or chronic health effects. Hence this study concludes that groundwater meant for drinking purposes should constantly monitored prior to consumption, and treated appropriately.

Key words: Potable water, Contaminant, Niger delta, Bayelsa State, water-borne diseases.

1 Introduction

Water is an essential resource to the life of all living organisms on earth. As established in literature, about 75% of the earth is filled with water [1]. But unfortunately potable water shortage still persists in most developing countries [2]. Statistical data regarding water scarcity shows that about 1.0-1.2 billion people in the world lack access to potable water [3-5]. It was also established that about 1.2-2.4 billion people lack access to safe drinking water [6], while in Africa, there are over 300 million people who lack access to potable water [5, 7]. Furthermore, since the 1970s several cities in Nigeria have been experiencing water shortages, they include but not limited to Aba, Port-Harcourt, Kano, Ibadan etc. [8].

Some compounding factors are responsible for the inadequacy of potable water: but two major factors include; rapid urbanization [8, 9], and increasing population, agricultural and industrial activities [7, 10]. It was further estimated that the availability of potable water in the Niger Delta has decreased from 10 L/person/day in 1994 to 5.5 L/person/day in 2000 [8]. Inadequacy of potable water or poor water quality can result to substantial problems like, toxicity, poor agricultural productivity and health problems such as outbreak of diseases [1, 2, 10].

Some researchers have revealed that water borne diseases such as typhoid, dysentery, cholera and diarrhoea are on the rise in the Niger Delta [1, 8]. While diarrhoea have been reported as the global second leading cause of under 5 mortality, with an estimated 1.5-1.8 million mortality per year [1, 2]. Groundwater in the preferred source of potable water in the Niger delta, due to the fact that it is less prone to contamination as a result of its natural filtration [11]. The Niger Delta region is blessed with large quantity of groundwater from shallow aquifer, but the region is still challenged by water inadequacy due to the commercialization of available potable water, making it unavailable to indigent people. Bayelsa state is characteristically a wetland, yet there are no functional central potable water supply systems. Hence, the main source of water for domestic use remains untreated water, as well as water from private and commercial boreholes [1, 11].

The Niger Delta has two hydrological regimes, the inland and coastal area. Both regimes experience poor water quality which grossly limits their potability [1]. Several authors have reported that the persistent and indiscriminate disposal of sewage and municipal solid waste in the region may result to the anthropogenic pollution of groundwater in the Niger delta [3, 4, 8, 12, 13]. There could be several challenges associated with the fortuitous consumption of contaminated water, including toxicity, which could affect body organs [14, 15]

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deleterious taste, odour and colour etc [16], as well as the outbreak of water borne diseases. This study encompasses the problems associated with the potability of groundwater in Bayelsa state, Central Niger delta Nigeria.

2 Potability of Water

Water quality, otherwise known as potability can be defined as the chemical, physical and biological properties of water as it concerns safe consumption. It also involves the process of assessing their physical, chemical and biological properties in relation to the natural quality and health effects. Johnson et al., [17] reported that water quality is largely dependent on the indigenous geology, ecosystem, as well as human activities. Although the potability of water may be dependent on the intended use of the water. For instance, much attention given to water required for direct human consumption compared to water used for industrial and other environmental purpose [18]. Notwithstanding, there are two basic contaminant indicators (elemental and microbial), whose presence or absence determines the quality of water. Microbial contaminants in water includes pathogenic bacteria, fungi and viruses, while elemental contaminants includes metals as well as organic chemical contaminants from industrial processes such as; pesticides and herbicides; and radioactive contaminants [18]. Water Quality Standards have been established by the World Health Organization (WHO) in order to regulate potability of water.

2.1 Microbiological Problems associated with water Potability

Coliform bacteria are commonly used bacterial indicator of sanitary quality of foods and water. They are defined as rod-shaped Gram-negative non-spore forming bacteria which can ferment lactose with the production of acid and gas when incubated at 35-37°C [19]. Coliforms can be found in the aquatic environment, in soil and on vegetation; they are universally present in large numbers in the faeces of warm-blooded animals. Coliforms are themselves not normally causes of serious illness, they are easy to culture and their presence is used to indicate that other pathogenic organisms of faecal origin may be present. Faecal pathogens include bacteria, viruses, or protozoa and many multicellular parasites. Faecal coliforms are microscopic organisms that live in the intestines of all warm blooded animals, and in animal wastes or faeces eliminated from the intestinal tract [20]. Faecal coliforms may indicate the presence of disease carrying organisms which live in the same environment as the faecal coliform bacteria. The measurement is expressed as the number of organisms per 100 ml sample of water (N/100ml). Dryton [21] found out that faecal contamination in Lilongwe River was generally high with values in excess of 300 counts/100ml, in all streams that were sampled.

2.2 Some Heavy Metals and the problems they pose to water Potability

Heavy metals refer to any metallic chemical element that has relatively high density and is toxic at a very low concentration. Most metals undergo a process called methylation; with the aid of microbes they are bio-accumulated and converted from non-toxic metallic state to a toxic organo-metallic state. As a results of their bioaccumulation, they biomagnify along the trophic level of the food chain. Some heavy metals includes; Arsenic (Ar) iron (Fe), zinc (Zn), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg) and cadmium (Cd). The presence of heavy metal in water is an indication of contamination and the persistent consumption of such water will result to adverse health effects (Table 1).

3 Critical Discussion of Water Quality in Bayelsa State

3.1 Hydrogeology of the Niger Delta

The Niger delta lies within latitudes 04° N and 05°, 02N and longitudes 006°, 15E and 006°, 24E. It is characterized by sedimentary formations with a thickness of about 8000 metres and include from bottom to top, Akata Formation, Agbada Formation, Benin Formation. Which is Oligocene to Pleistocene in age. It consists predominantly of freshwater continental friable sands and gravel that are of excellent aquifer properties, with occasional intercalation of shales [7], it is predominantly unconfined and it does not exceed a thickness of 120 metres [7]. The Niger delta has two basic hydrological regimes (Coastal and Inland). The potability of surface water in the Niger delta has been characterised by high level of contamination, hence the need to resort to groundwater [38]. Generally, water enters the ground through infiltrating precipitation and percolation [7]. Furthermore ground water of the Delta is dissected by a dense network of rivers and creeks, which create a condition of delta-wide hydrological continuity [7].

The characteristics of the prevailing rock, aquifer specific yield and retention capacity, water chemistry is largely dependent on the geology of the environment [39]. Also man made activities is essential input for determine the quality of natural resources like ground water. Typically groundwater is a product of geological formations [40]. The hydraulic conductivities of the sand vary from 3.82×10^{-3} to 9.0×10^{-2} cm/sec, which indicates a potentially productive aquifer [7]. Specific capacities recorded from different areas within this formation vary from 6700 lit/hr/m to 13,500 lit/ hr/m [41]. Limited fluctuation in the level of Niger delta groundwater reflects the high amounts of annual precipitation [7]. It is characterized by sedimentary basin that is virtually riverine and estuarine and fishing is the major occupation of the inhabitants of the area [42]. The ground water of the Niger delta (especially Bayelsa state), is characterized by high iron concentration. According to Agedah et al. [43] Bayelsa state for instance, the ground water table ranged from 4 – 60 feet and 5 – 100 feet during the rainy and dry season respectively depending on the location, and relative topography.

3.2 Physicochemical quality of Ground water in Bayelsa state Nigeria

One major parameter that determines the quality of potable water is its physical and chemical parameters. Table 2 presents a review of the physicochemical quality parameters of ground water from Bayelsa state Nigeria.

From the foregoing, both surface and groundwater Bayelsa state has been characterised by high level of iron with a corresponding acidic pH [1]. Another challenge is saline intrusion and elevated levels of nitrates, ammonia and chlorides [44]. Also, Amangabara and Ejenma [7] reported elevated levels of magnesium (Mg), Calcium (Ca), Bicarbonate (HCO_3) and hydrogen ion in Bayelsa state. Furthermore, there had been significant increase of Total Dissolved Solids (TDS) (up to 2900mg/l) and hydrocarbon content – oil and grease from 1.8mg/l in 2006 to 71mg/l the Niger delta due to petroleum exploration activities [45]. Iron and chloride elevation of groundwater were also reported [46, 47]. In Bayelsa State, leachability of contaminant to groundwater had been reported by [48, 49].

Table 1: Some heavy metals and their deleterious effects

Heavy Metals	Route of exposure	Health Effects	References
Iron	Natural aquifer occurring metalloid in	Genetic, lung, metabolic diseases, development of a benign pneumoconiosis.	[1, 2]
Zinc (Zn)	From industrial and agricultural activities such as mining, coal, waste combustion and steel processing paint, fertilizer, dye, rubber, wood preservatives, ointments.	Allergy dermatitis, pulmonary cancer, kidney and Liver dysfunction.	[22-24]
Arsenic (As)	Metabolized and incorporated into the food chain through a process known as methylation	skin cancer, diabetes, and cardiovascular, neurological, respiratory disease	[20, 25-28]
Lead (Pb)	lead wastes, cell batteries; lead solders, lead gasoline and lead based paints	Kidney and Nervous system dysfunction. loss of memory, nausea, insomnia, anorexia, weakness of the joints, irritation, and cancer	[10, 22, 23, 29-31]
Copper (Cu)	it may leach to the environment as industrial waste originating from electrical wiring, wood preservatives, leather tanning and fabric	Hypertension, kidney, liver and neurological dysfunctions, anaemia, stomach and intestinal irritation, complication.	[22, 24, 32]
Mercury (Hg)	Environmental contamination of mercury arise from industries, medical, petrochemical as well as agricultural activities	neurological and renal dysfunction	[25, 32, 34, 35]
Cadmium (Cd)	it may be leached as geologic deposit from rocks, as coal and petroleum and often in combination with zinc	bone and renal dysfunctions	[18, 36, 37]
Chromium (Cr)	Contaminants of chromium may also originate from paint pigments, cement, paper, rubber, metal plating, leather tanning, textile pigments etc.	Allergic dermatitis, pulmonary cancer. liver and kidney dysfunction	[23, 24, 30-32]

Basically, the potability of groundwater is largely dependent on its chemistry [7]. The chemistry of groundwater is determined by such hydrologic, climatic and hydrogeologic factors such as; the type of aquifer, the mode and source of recharge as well as the porosity and permeability of the soil [48, 50]. Besides pH and total most of the general physiochemical properties of the ground water usually complies with the World Health Organization and Standard organization Limit for potable water [2]. Generally, most resident of the state treat their borehole water prior to use so as to reduce the iron concentration. Some of them typically use single and a few others use multiple tank trickling filter for treatment. However, there are still other that do not treat the water at all. Notwithstanding, routing testing of some acclaimed potable water still revealed some vital parameters that do not conform with SON and WHO stated limits [1, 2]. The pH values is govern by the behaviour of several other important parameters of water quality including ammonia toxicity, chlorine disinfection efficiency, and metal solubility (EPA, 2001), and extremes of pH can affect the palatability of a water (Ohimain et al., 2014).

Hardness is a natural characteristic of water which can enhance its palatability and consumer acceptability for drinking purposes. Health studies in several countries in recent years indicate that mortality rates from heart diseases are lower in areas with hard water [51]. These days, the analysis comprises the determination of calcium and magnesium which are the main constituents of hardness. Also, iron can also contribute to hardness, their concentrations are normally so low in this context that they can be ignored. In general, the concentration of total hardness is lower that the permissible limit of 150 mg/l recommended by SON.

Chloride exists in all natural waters, the concentrations varying very widely and reaching a maximum in sea water (up to 35,000 mg/l Cl) [51]. In fresh waters the sources are mainly from soil and rock formations and sewage containing high amounts of chloride. Typically, **c**hloride does not pose a health hazard to humans and the principal consideration is in relation to palatability. The chloride level found in groundwater in Bayelsa state is below 250 mg/l Cl recommended by SON, however at this concentration the water will begin to taste salty and becomes more objectionable. The presence oil and grease found in groundwater indicate pollution. However, the concentration and physical parameters will give an indication of potential source of the contamination. An author have reported a concentration above the WHO permissible value of 0.01 mg/l in ground water in Bayelsa state, Nigeria. The high level of oil and grease is largely due to petroleum exploration activities in the Niger delta.

Nitrate is found in groundwater sources. In Bayelsa state, its concentration is below 50mg/l recommended by SON. Typically small amount of nitrate is found in natural waters is of mineral origin, most coming from organic and inorganic sources, the former including waste discharges and the latter comprising chiefly artificial fertilisers [51]. High concentration of nitrate in waters to be used for drinking will render them hazardous to infants as they induce the "blue baby" syndrome (methaemoglobinaemia).

Oxygen related parameters that determine water quality include dissolved oxygen, biochemical oxygen demand and chemical oxygen demand. The concentration of dissolved oxygen chemical oxygen demand found in ground water in Bayelsa state is lower than WHO permissible limit of 6mg/l and 40mg/l respectively. However, the concentration of biochemical oxygen demand is higher than WHO limit of 0.002 mg/l. dissolved oxygen, biochemical oxygen demand and chemical oxygen demand. Dissolved oxygen in ground water have no direct health implication. The chemical oxygen demand is a reflection of the pollution index with regard to nutrients, turbidity and oxygen present.

Temperature is the degree of coldness or hotness of a body. The temperature of ground water from Bayelsa state is within the ambient temperature of the region. Temperature is a function of the surface area, and time of sampling of the water as well as time for determine its gauge. Total dissolved solid is the amount of matter or materials/substance that were unable to dissolve in the water. The quantity/concentration of total dissolved solid depend on several parameters especially nutrient such as nitrate, ammonium, chloride, etc. Typically, the concentration of total dissolved solid is lower than the permissible limit recommended by SON and WHO. Total suspended solid is the amount of materials that found floating the ground water. The concentration of the total suspended solid in the ground water ranged from 0.5 – 4.2 mg/l. There is no specific limit for this parameter.

Turbidity is a measure of clay particles, sewage solids, silt and sand washings, organic and biological sludges found in the environment/soil etc. The turbidity of the ground water is Bayelsa state is higher than permissible value of 5 NTU recommended by SON. Turbidity is a major water quality indicator because by direct seeing the water give a condition of the water. Salinity is a measure of amount of salts in the ground water. The salinity of the ground water in Bayelsa state is lower that the permissible value recommended by SON. The presence of a high salt content may render a water unsuitable for domestic, agricultural or industrial use, or may affect its suitability [51].

The presence oil and grease found in ground water indicate pollution. However, the concentration and physical parameters will give an indication of potential source of the contamination. An author have reported a concentration above the WHO permissible value of 0.01 mg/l in ground water in Bayelsa state, Nigeria. Alkalinity is a measure of the ability of the water samples of the water to neutralize strong acids in an arbitrarily designated pH or an indicator end point. The concentration of alkalinity from ground water in Bayelsa state is below the permissible value of 500mg/l recommended by WHO.

Potassium and sodium are monovalent cation need by body for heath growth and development. The concentration of these monovalent cations is lower than the permissible limit of 200 mg/l stipulated by SON. In Yenegoa town within the region, Amangabara and Ejienna [51] noted from the analyses of the physico-chemical concentrations in wells to be a reflection of the hydrochemical faecis of groundwater of the area. The ionic trend of the area is $Ca>HCO3>Na>K>Mg>Cl>SO_4$.

3.3 Heavy Metals

Table 2 also presents the concentration of heavy metals found in ground water in Bayelsa state, Nigeria. The concentration of arsenic often exceed the permissible limit of 0.01 mg/l by both WHO and SON. Arsenic is a trace element found at variable concentrations in the atmosphere, soils and rocks, natural waters [28]. Several inorganic and organic compounds contain arsenic and they are relatively harmful to the environment and biological species. Common oxides of metal containing arsenic is used in the manufacture of pesticides and insecticides include sodium arsenite ($NaAsO_2$) used for locusts, arsenic (III) oxide (As_2O_3) used for rodents, calcium arsenate [Ca (AsO_4)] used for cotton boll weevil and the potato beetle [53]. High exposure of arsenic could cause diseases such as cardiovascular, hematological, neurological, respiratory, gastrointestinal and birth disorders, dermatitis and cancer [28].

Unlike arsenic the concentration of chromium is below the permissible limit for potable water recommended by WHO and SON. Typically, the chromium occurs naturally in their ore, but could arise from discharges of wastes from electroplating, tanning, textile, paint and dyeing plants. Chromium is toxic, to a degree which varies with the form in which it occurs, whether as the trivalent Cr III or the hexavalent Cr VI form [51]. Also the concentration of copper found in the groundwater of the state is lower than the permissible limit. Basically, copper is an essential element required for normal functioning of the body and other levity organisms. Copper is present naturally in metalliferous areas but more often its presence in waters is due to attack on copper piping. The challenge associated with high levels of copper in water is galvanic corrosion of tanks [51].

Table 2: General physicochemical characteristics of Ground water in Bayelsa state, Nigeria

Parameters	Mean	Dry season (November – March)	Wet season (April – October)	Untreated	Single Trickling treatment	Double Trickling treatment		WHO Accepted Limits	WHO Max. Permissibe limits	SON Limit (permissible limits)
	[52]	[7]		[2]			[3]	Standard permissible Limits		
Physical Properties										
pH	6.16	6.027143	6.384286	4.39 – 5.17	5.49 – 6.55	6.09 – 6.90	6.97	7.0 - 8.5	9.2	6.5 – 8.5
Temperature ℃	-	28.35143	28.22857	26.24 – 27.41	28.35– 29.64	27.45–29.40	-	28	-	Ambient
T/Hardness, mg/l	63.57	21.67143	17.95714	-	-	-	69.29	500	-	150
Mg hardness, mg/l	-	-	-	-	-	-	13.48	-	-	-
Ca hardness, mg/l	-	-	-	-	-	-	55.81	-	-	-
TDS (mg/l)	450.29	5.485714	6.585714	48.00 –96.00	12.58 –23.36	18.21 –28.17	-	500	-	500
TSS (mg/l)	-	2.148571	4.154286	1.60 – 3.20	0.57 – 1.27	0.37 – 0.77	-	-	-	-
Turbidity (NTU)	-	1.855714	4.401429	23.35 –30.17	12.29 –18.08	7.14–11.85	0.33	5	25	5
Conductivity, uS/cm	900.42	6.341429	15.71857	-	-	-	-	0 – 40	-	1000
Salinity (mg/l)	-	0.007714	0.000571	24.39 –35.87	9.83 –13.59	11.54 –17.24	-	400	-	-
Dissolved Oxygen	-	4.08	4.342857	4.14 – 4.48	2.76 – 5.68	5.31 – 7.78	-	6	8	-
Oil and grease (mg/l)	-	7.018571	5.43	-	-	-	-	0.01	-	-
Chemical Properties										
BOD5 (mg/l	-	6.614286	5.128571	0.08 – 0.43	0.08 – 0.23	0.05 – 0.11		0.002	0.05	-
COD (mg/l)	-	6.141429	6.88	-	-	-	-	40	-	-
Alkalinity, mg/l	32.5	15.92857	9.52	-	-	-	-	500	-	-
NH_3- (mg/l)	-	0.261857	0.248571	-	-	-	-	0.05	-	-
NO_3 (mg/l)	0.2	0.136857	0.283286	2.95 –4.31	2.31 –3.53	1.20 –3.25	0.00	45	0	50
$S04^{2-}$ (mg/l)	3.89	16.86286	14.91429	-	-	-	-	0.05	-	100
HCO_3^- (mg/l)	96.6	30.17857	28.27	-	-	-	-	-	-	-
Cl^- (mg/l)	10.07	21.49857	18.20143	-	-	-	1.58	-	-	250
K^+ (mg/l)	12.22	14.48143	34.55429	-	-	-	-	-	-	200
Na^+ (mg/l)	24.00	41.67286	22.01571	-	-	-	-	-	-	200
Ca^{2+} (mg/l)	9.15	50.20714	26.10286	-	-	-	-	75	200	-
Mg^{2+} (mg/l)	3.76	4.164286	18.96143	-	-	-	-	30	150	0.20
Heavy Metals										
Iron (Mg/l)	0.23	0.967143	0.5407	5.32 – 9.96	1.67 – 2.00	0.05 – 0.31	0.06	0.1	1	0.3
Lead (mg/l)	-	-	-	<0.01	<0.01	<0.01	-			0.01
Copper, mg/l	-	0.001	0.001				-	0.05	1.5	1
Manganese, mg/l	-	0.000286	0.00	-	-	-	-	0.05	0.5	0.2
Zinc, mg/l	-	0.007571	0.004	0.01 - 1.06	0.24 – 1.36	0.05 – 0.21	-	5	15	3
Mercury, mg/l	-	-	-	<0.01	<0.01	<0.01	-	-	-	0.001
Chromium, mg/l	-	0.001286	0.00071	0.01 – 0.04	<0.01- 0.04	<0.01	-	0.05		0.05
Arsenic, mg/l	-	-	-	0.01 – 0.04	<0.01 – 0.04	<0.01	-	0.01	0.01	0.01

Iron is one of the most abundant element found in Niger Delta environment mainly due to geological formation. In Bayelsa state especially the concentration is so high that nearly all the water tank for ground water is coloured reddish brown, which indicate the presence of oxidize iron. As such the concentration of iron in the region often exceed the permissible limit of 0.3 mg/l recommended by SON.

The objections to iron are primarily organoleptic, but there has been recent medical concern about high levels in drinking water. Iron concentration in over 90% of the samples was above the permissible limit for drinking water and would require treatment [52]. So far, literatures have not reported lead in ground water in Bayelsa state, hence it concentration is far below the permissible limits. Lead is one of the most commonly determined heavy metals that can accumulates in body. High concentration could lead to lead poisoning and other disease conditions.

Manganese is found widely in soils and is a constituent of many ground waters. It, too, may be brought into solution in reducing conditions and the excess metal will be later deposited as the water is re-aerated [51]. The presence of manganese above the limits results to taste challenge. However, the concentration of manganese found in groundwater sources in Bayelsa state is below the permissible limit recommended by SON. Mercury is a non-essential element that are not required by living thing. Studies have shown that mercury is absence in ground water in Bayelsa state, Nigeria. Mercury have bioaccumulation properties i.e accumulation of organo-mercury compounds. Selenium is non-essential element found in the environment. A concentration of ≤0.08 mg/l have been reported from untreated ground water in Bayelsa State, Nigeria. Zinc is an essential metal required by living organisms. Zinc are found is diverse form of environment including soil and water. The concentration of zinc found in ground water in Bayelsa state and its environs is below the permissible value stipulated by SON and WHO [2].

3.4 Microbial quality of Groundwater in Bayelsa State

Microbes are ubiquitous, and the type of microbes found in a particular environment is an indication of possible source of contaminants, environmental conditions such as pH and temperature. Again most microbes are known to be pathogenic especially in immunocompromised patients. The population of heterotrophic bacteria is high as well as total fungi. Also, the presence of fecal coliforms suggest the presence of fecal material in the ground water.

Table 3 presents the population of microbial count found in ground water in Bayelsa state, Nigeria. This is possible to high ground water table found in Bayelsa state. Most indigenes of the area also lack good toilet system. Sometimes the suck away of toilet system is located close to ground water sources (i.e submergible pump head). The presence of coliforms will indicates the presence of microbes include E. coli, Faecal Staphylococci i.e *Streptococcus faecalis*, *Clostridium* species etc. typically this organisms are indicator organisms that are used in monitoring the pollution level in the water sources.

Table 3: Microbial counts found in Ground water sources in Bayelsa state, Nigeria

Total count	Untreated	Single treatment	Double treatment
Total Heterotrophic Bacteria, cfu/ml	1.19 – 9.33 x10^5	0.1 – 9.0 x10^3	0.00 – 1.7 x10^3
Total fungi, cfu/ml	4.17 – 9.27 x10^3	3.70 – 7.77 x10^2	0.67 – 3.1 x10^2
Total coliform, MPN/100ml	163 – 243	14 – 44.67	5.03 – 10.07
Fecal coliform, MPN/100ml	60.33 – 69.00	3.33 – 10.33	0.00 – 2.00

Adapted from Ohimain et al. [2]

3.5 Management of Groundwater Contaminants in the Niger delta

Management and protection of groundwater quality has been a major problem in Nigerian especially in rural area and coastal cities. Wastes remain a major pollutant of the ground water, which find their way into the water through infiltration. Waste dumpsites are not properly designed nor constructed as landfill sites [40]. Therefore, wastes dumped at dumpsites over the years are expected to have biodegenerated and generate leachates which could become point source of pollution into soil and groundwater [54]. The rate and characteristics of leachate production depends on a number of factors such as solid waste composition, particle size, degree of compaction, hydrology of the sites, age of the landfill, mixture and temperature of the condition and availability of oxygen [55]. This is traced to leachate from dumpsite. Angaye et al. [10] determined the quality of leachate entering surface water and concluded that the characteristics of heavy metals were high as well as the microbial counts. High concentration levels of turbidity, hardness, alkalinity, pH, calcium, nitrate, magnesium, zinc, phosphate and coliform were noted in the well close to dumpsite and evidence of leachate contamination.

The contamination of groundwater in the Niger delta is liable due to the nature of the terrain, which is characterised by shallow aquifer and high level of precipitation. Hence, the contamination of groundwater is liable due to the lechability of toxic waste, arising from industrialization and high population without adequate waste management policies and strong litigation to deter offenders [10]. The hysterical use of land, industrialization, indiscriminate release of toxic chemical, deforestation have impacted negatively on the quality of water resources [56]. There are several sources through which contaminants enters the environment (soil, water and air). Notwithstanding these sources can be classified into two major groups (point sources and nonpoint sources). In point source pollution the pollutants originates from a defined source or specific location e.g. pipe [57]. On the other hand, non-point Sources are unspecific sources, at low concentrations compared to point sources points [58]. They originate from unpredicted runoff (leachates) which makes their mitigation difficult. Jennings and Kahle [59], established that the contaminant load of point sources pollution can be determined from the sampling and flow rate at the point of entry to a receiving water body; as such it is easy to mitigate point source pollution compared to non-point source pollution due to specificity [60].

4 Conclusions

This study reviewed the quality of potable water in Bayelsa state. Unfortunately, this study revealed the physicochemical parameters of some acclaimed potable water were above the recommended SON and WHO limits. They include oil and grease, total iron, iron, arsenic, selenium, biological oxygen demand and pH. The occurrence of these contaminants above their threshold limit is associated to the geology and the geochemistry of the area as well as the rate of urbanization, landfill/dumpsite leachates, organic matters and seasonal influence. More worrisome is the fact that best-available potable water in Bayelsa state are either commercialized or only available to the affluent people. Notwithstanding, prolong consumption of contaminated water has become a major concern to public health. Considering the fact that water is a major requirement for human existence. Some infectious and non-infectious diseases have been linked to consumption of contaminated water. These diseases includes but not limited to; typhoid, dysentery, cholera and diarrhoea. Others includes; systemic dysfunction of the cardiovascular, metabolic, pulmonary, nervous, gastrointestinal diseases, Respiratory systems. Also genetic disorder has also been reported.

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