CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF STUDY

Recreational water refers to rivers, lakes and coastal waters. People use recreational waters for activities like swimming, surfing, water skiing, white water sports, underwater diving, sailing, boating and shellfish gathering. Recreational water can be contaminated with fecal pathogens (such as bacteria and virus) from human sewage and animal manure, causing different illness in aquatic organisms and in man as well. (Lee *et al*., 2002). Anyone can be affected but young children, older adults and people with low immune systems are more vulnerable. More harmful diseases like hepatitis A can also be contracted from contaminants in the water. Algal blooms from excess nutrients may also cause health effects, through contaminated shellfish or toxins produced by cyanobacteria.

Cyanobacteria also known as blue-green algae, blue-green bacteria or cyanophytes, are part of a primitive group of organisms which according to fossil records have existed for approximately 3.5 billion years (Lane *et al*., 2010) They are not true algae, they are gram-negative bacteria which contain chlorophyll and perform photosynthesis. Many cyanobacteria have a characteristic bluish-green color because of phycocyanine pigment contained in the cells and hence the name, blue-green algae, while some species may appear red due to the presence of the carotenoid and phycocerythin pigments (Falconer *et al*., 2005). Cyanobacteria species display a remarkable diversity in cell morphology or form. The unicellular cyanobacteria have spherical, ovoid or cylindrical cells that can occur single-celled or may divide into regular

colonies or filaments, also called trichomes. Trichomes can be straight, or coiled. The life cycle of cyanobacteria requires water, carbon dioxide, inorganic substances (such as phosphorus and nitrogen) and lights. Although energy metabolism is primarily through photosynthesis where sunlight and carbon dioxide are used to produce energy-rich molecules and oxygen, some species can survive in complete darkness, while others have heterotrophic abilities. Some have specialized cells called heterocyst's which enables them to fix atmospheric nitrogen. These cells are indicated in a filament of *anabaena circinalis.*

Cyanobacteria can survive nearly anywhere on earth from freshwater to saltwater and brackish water, from rainforest to the desert, in the air, in soil and other terrestrial habitats. They can also thrive under the harsh conditions in many regions that are affected by drought and climate change. Various cyanobacteria have the capacity to grow at a range of depths; this ability varies with species and is strongly influenced by nutrient and light availability (either the turbidity or the charity of the water). Different factors that contribute to cyanobacteria growth are light intensity, water temperature, P^H, carbon dioxide concentration, nutrient availability (nitrogen, phosphorus, iron and molybdenum), physical characteristic of the water body (shape and depth), water column stability, water flow rate (river) or horizontal movement due to inflows of wind (reservoirs and lakes) and aquatic ecosystem structure and functions. If several of these factors occur simultaneously, cyanobacteria growth will be optimized and potential bloom condition may be present.

1.2 AIM OF STUDY

This study was designed to study the diversity of cyanobacteria and there morphology in three (3) recreational waters in Bayelsa State (Ox bow Lake, Swali River and River Nun along Amassoma axis).

1.3 OBJECTIVE OF THE STUDY

1. To highlight the diversity of cyanobacteria in the three (3) recreational waters in Bayelsa State.
2. To highlight the different cyanobacteria morphology in the three (3) recreational waters in Bayesla State.

1.4 STATEMENT OF THE PROBLEM OF THE STUDY

Microorganisms are found everywhere in nature. Some are pathogenic in nature and can multiply freely, others exists as transient microorganism while some exist as facultative anaerobes. In three (3) different locations (Ox bow Lake, Swali River and River Nun along Amassoma axis), shows diversity of different cyanobacteria and there morphology. Toxins produced by cyanobacteria can cause the dead of freshwater organisms which in turn affect humans that consumes these freshwater organisms and also making the freshwater unsafe for use. Therefore the problem lies in the management of the recreational waters by informing the public of the risks associated with cyanobacteria blooms and the toxins they produce.

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 METHOD

Three different recreational centers were sampled within Yenagoa, Bayelsa State. Ox bow Lake, Swali River and River Nun along Amassoma axis.

3.1.1 COLLECTION OF SAMPLE

A total of nine (9) water samples were collected, three (3) from each location. These samples were collected and put in a cooler containing an ice block and transported to the laboratory immediately.

3.1.2 MEDIA PREPARATION

Three different culture media was used in the study, they include BG11, Agar agar and nutrient agar. All media were prepared according to the manufacturer's instructions.

3.1.3 BG11 AND AGAR AGAR

About 1.5g BG11 was weighed using the electronic weighing balance, 0.5g of agar agar was also weighed and added to the 1.5g of BG11 and dissolved in 540ml of distilled water (this was done to enable the BG11 solidify) it was then autoclaved at 121^{o}C for 15 minutes according to the manufacturers instruction, it was then cooled to 45^{o}C in a water bath and poured into sterile petri dishes aseptically and allowed to solidify.

3.1.4 NORMAL SALINE

About 0.85g of sodium chloride (Nacl) was dissolved in 1000ml of distilled water.

3.1.5 SERIAL DILUTION

A 3-fold serial dilution of each water sample was made using 9 ml normal saline, for the enumeration of the cyanobacteria present in each sample. And 1ml each from the sample was diluted into 10^{-1}, 10^{-2}, and $10^{-3.}$ From 10^{-3}, 1ml was pipetted into each petri dishes of molten BG11 (45°c) and swirled thoroughly to allow an even distribution after which, it was incubated at 37°c for 5days.

3.1.6 MICROBIAL COUNT

Microbial count was carried out to determine the microbial concentration in a given sample from each recreational center. This was done after 5days of incubation when visible growth was noticed. Different colonies were counted from all the samples.

3.1.7 PURE CULTURE PREPARATION

About 16.8g of nutrient agar was weighed using the electronic weighing balance and dissolve in 540ml of distilled water. It was then autoclaved at 121°C for 15minutes according to the manufactures instruction, it was then cooled to 45°C and poured into a sterile petri dish aseptically and allowed to gel.

Distinct colonies from the cyanobacteria growth were aseptically transferred using a sterile wire loop into new petri dishes containing the newly prepared agars using streak plate method. The plates were kept in the incubator after streaking for 24 hours at 37^{o}C.

3.2 IDENTIFICATION OF CYANOBACTERIA

3.2.1 GRAM STAIN

The gram staining reaction is used to help identify pathogens in specimen and cultures by their grams reaction (Gram positive or Gram negative) and morphology.

Distilled water was introduced on the sterile glass slide using a sterile 5ml string, sterile wire loop was used to collect the colony and placed on the slide (smear), and air dried and heat by passing it over the Bunsen flame and stained using Grams reagents. First, the smear was covered with crystal violet for 30-60 seconds and washed off with clean water. Secondly, the slide was flooded with lugos iodine for 30-60 seconds and washed off with clean water and decolorized quickly with acetone-alcohol and washed off immediately. The smear was finally counter stained with safranin for 1-2 minutes and washed off with clean water. The slides were placed in a draining rack to be air dried and later transported to the oven for complete drying.

3.2.2 MICROSCOPIC IDENTIFICATION

The dried slides were transported to the microscopic bench for proper identification. They were examined with oil immersion under the microscope using (x100) objective lens. Cyanobacteria either showing a filamentous, spherical, ovoid or cylindrical shape.

3.3.3 MORPHOLOGICAL IDENTIFICATION

Morphology deals with the form and structure of an organism. Using the microscope, the different morphology where observed. Filamentous, spherical, ovoid or cylindrical shape.

3.4 PHYSIOCHEMICAL ANALYSIS

This is to determine the different parameters in the water sample. They include pH Salinity, conductivity, nitrate (NO_3), phosphate (PO_4), iron (Fe), manganese (Mn).

1. **Determination of pH**

   A standard pH meter was calibrated into two (2) buffer solutions pH (4 and 9). The calibrated electrode was then dipped in the water sample. A steady pH readout was taken as the pH of the water sample.

2. **Determination of salinity and conductivity**

   The conductivity meter, also have the capacity to measure the salinity of water samples. The probe of the meter was zeroed in deionized water to have zero readout. The meter was then switched over to conductivity in $UScm^{-1}$ and a steady readout is recorded as the conductivity of the water. The salinity was also measured in the same manner.

3. **Test for nitrate (NO_3)**

   The spectrophotometer was set at 470nm. The nitrate tablet was crushed and 10min for color development at the end of which the % transmittance was measured and the concentration of NO_3 was read off from the concentration chart.

4. **Determination of phosphate (PO_4)**

   Into a10ml volumetric flaks, tablets 1 and 2 of the phosphate K_I+ was added and crushed to dissolve. The water samples were added and made up to the

mark and left on the bench for color development. The spectrophotometer was then set at 660nm. The absorbance values were taken and the amount phosphates in the water samples were determined from a standard curve prepared from standard phosphate solution.

5. Determination of iron (Fe) and manganese (Mn)

The samples were digested (wet digestion and filtered into 100ml volumetric flasks and made up to the mark. The solutions were taken to Port-Harcourt for AAS and analysis (Atomic Absorption Spectrophotometric Analysis.

3.5 Description of the Project Area

The study was carried out in three different recreational waters in Bayelsa State (Ox bow Lake, Swali River and River Nun along Amassoma axis). Each location has three points of sample collection, up-stream, mid-stream and down-stream, with their latitude and longitude. For Ox bow Lake, up-stream (4º.92ˈ03.349ˈˈN, 6º.27ˈ69.317ˈˈE), mid-stream (4º.90ˈ57.923ˈˈN, 6º.27ˈ75.788ˈˈE,), down-stream (4º.90ˈ30.929ˈˈN, 6º.27ˈ41.067ˈˈE). For Swali River, up-stream (4º.91ˈ32.911ˈˈN, 6º.27ˈ09.548ˈˈ E), mid-stream (4º.91ˈ78.497ˈˈN, 6º.26ˈ66.386ˈˈE), Down-stream (4º.91ˈ78.497ˈˈN, 6º.26ˈ66.386ˈˈE). For River Nun along Amassoma axis, Up-stream (53º.27ˈ34ˈˈN, -7º.77ˈ83.2031ˈˈS), Mid-stream (4º.96ˈ57.483ˈˈN, 6º.10 ˈ76.546ˈˈE), down-stream (4º.965ˈ7483ˈˈN, 6º 10ˈ76.546ˈˈE).

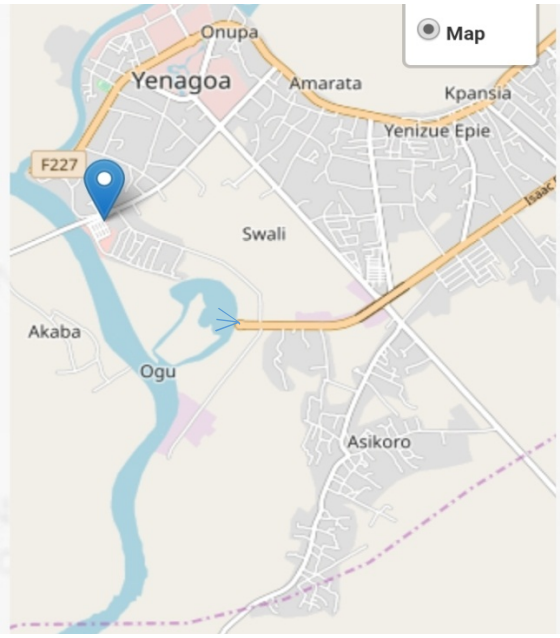


Fig 1. Up-stream (Ox bow lake)

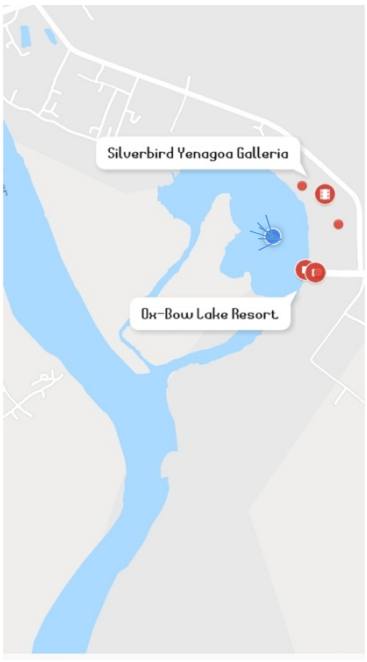


Fig 2. Mid-stream (Ox bow lake)

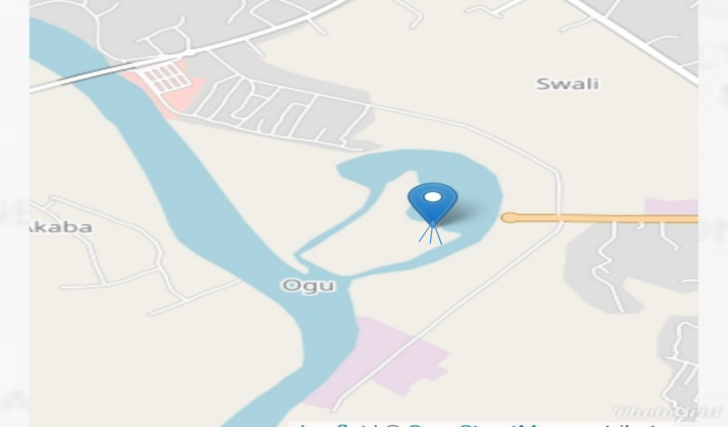


Fig 3. Down-stream (Ox bow lake)

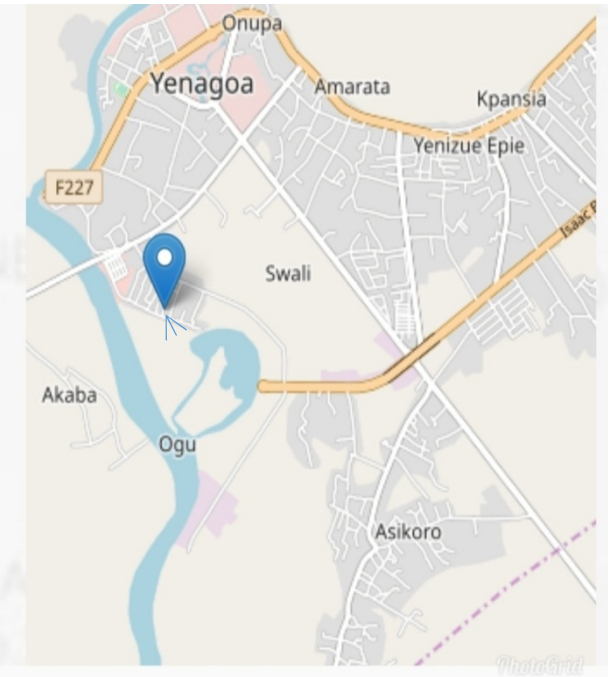


Fig 4.Up-stream (Swali River)

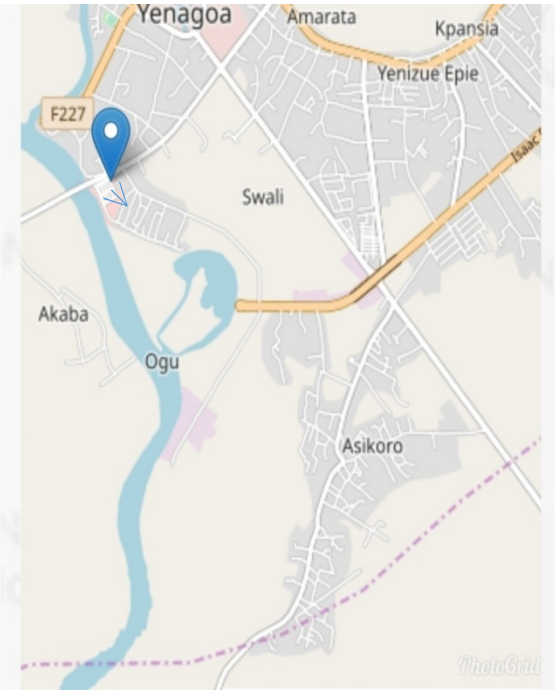


Fig 5.Mid-stream (Swali River)

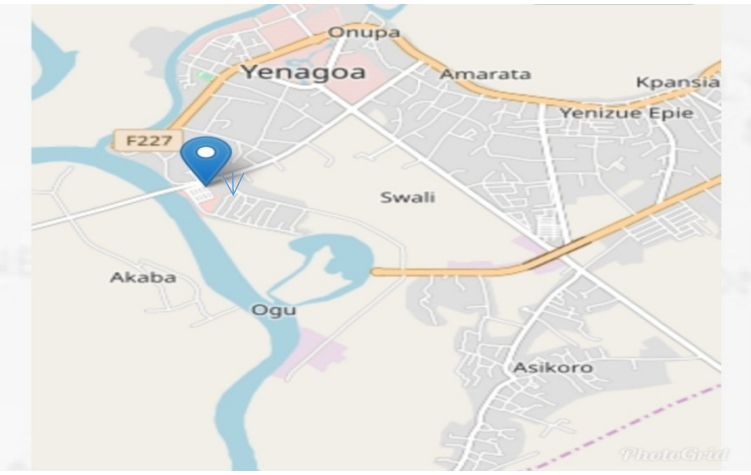


Fig 6.Down-stream (Swali River)

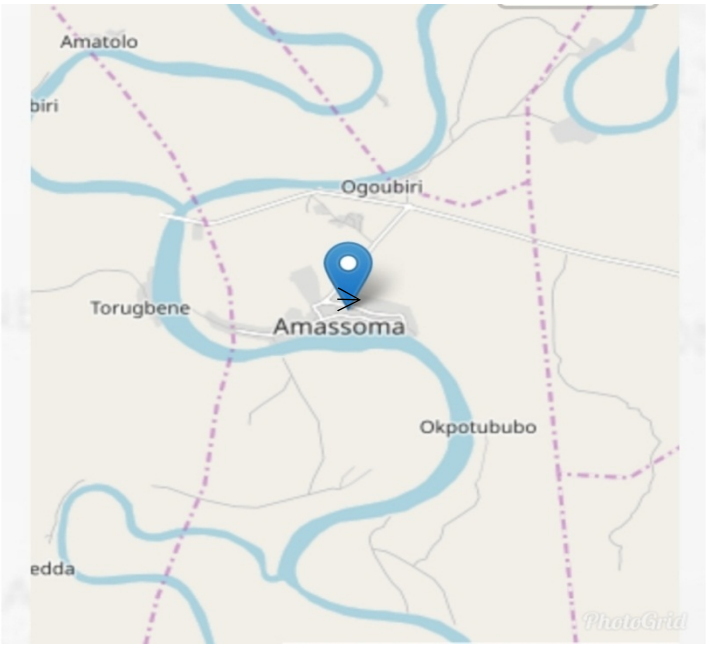


Fig 7.Up-stream (Amassoma)



Fig 8. Mid-stream (Amassoma)

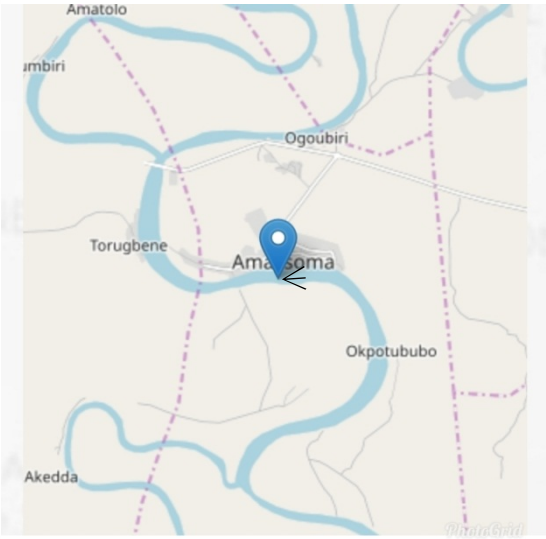


Fig 9. Down-stream (Amassoma)

CHAPTER FOUR

4.0 RESULTS

4.1 Cyanobacteria load of the water samples

All water sampled in this study had Cyanobacteria isolated from them. However, the cyanobacteria load of the water samples varied in each location. The microbial load from Ox bow Lake ranges between 3.3×10^4 - 4.9×10^4 cfu/ml, Swali River ranges from 3.1×10^4 - 5.6 $\times10^4$cfu/ml, River Nun along Amassoma axis ranges from 5.5×10^4 - 5.6×10^4cfu/ml.

TABLE 1: CYANOBACTERIAL COUNT AT THREE DIFFERENT RECREATIONAL WATER (Ox bow Lake, Swali and River Nun along Amassoma axis)

Ox bow Lake	**UP STREAM**	**MID STREAM**	**DOWN STREAM**
TCFU	4.9×10^4	4.4×10^4	3.3×10^4
Swali River			
TCFU	5.6×10^4	3.8×10^4	3.1×10^4
Amassoma River			
TCFU	5.6×10^4	2.7×10^4	5.5×10^4

TABLE 2: MICROSCOPIC IDENTIFICATION OF CYANOBACTERIA IN THREE (3) DIFFERENT RECREATIONAL WATERS IN BAYELSA STATE

Ox bow Lake	UP STREAM	MID STREAM	DOWN STREAM
	Stichosiphon	*Hydrococcus*	*Synechocystis*
	Microcystis	*Plectonema*	*Cyanobium*
	Woronichinia	*Chroococcus*	*Coelosphaerium*
Swali River	*Planktothrix*	*Aphanocapsa*	*Microcystis*
	Nostochopsis	*Coelosphaerium*	*Chroococcidiopsis*
	Tolypothrix	*Stigonema*	*Spirulina*
Amassoma	*Calothrix*	*Spirulina*	*Microcystis* **River**
Radiocystis	*Microcystis*	*Cylindrospermopsis*	
	Woronichinia	*Radiocystis*	*Oscillatoria*

TABLE 3: THE PHYSIOCHEMICAL PROPERTIES OF THE WATER SAMPLE

Sample code	pH	Salinity	Conductivity	NO_3	PO_4	Fe	Mn
Amassoma							

UP STREAM	**6.88**	**4.09**	**68.56**	**0.122**	**0.257**	**0.128**	**0.011**
MID STREAM	**6.36**	**0.11**	**61.81**	**0.114**	**0.857**	**0.156**	**0.014**
DOWN STREAM	**6.56**	**00.4**	**64.4**	**0.124**	**0.188**	**0.144**	**0.021**
Ox Bow Lake							
UP STREAM	**6.74**	**0.33**	**73.81**	**0.127**	**0.454**	**0.135**	**0.012**
MID STREAM	**6.73**	**0.03**	**72.93**	**0.132**	**0.158**	**0.127**	**0.051**
DOWN STREAM	**6.67**	**0.04**	**82.80**	**0.136**	**0.250**	**0.158**	**0.016**
Swali							
UP STREAM	**6.65**	**0.07**	**61.72**	**0.134**	**0.155**	**0.152**	**0.015**
MID STREAM	**6.74**	**0.06**	**63.62**	**0.196**	**0.175**	**0.144**	**0.020**
DOWN STREAM	**6.28**	**0.07**	**56.98**	**0.110**	**0.240**	**0.142**	**0.011**

TABLE 4: MORPHOLOGICAL IDENTIFICATION OF CYANOBACTERIA ISOLATED

	ORGANISM	MORPHOLOGY
1	*Stichosiphon*	Cylindrical
2	*Microcystis*	Spherical
3	*Woronichinia*	Spherical
4	*Hydrococcus*	Oval
5	*Plectonema*	Filamentous
6	*Chroococcus*	Spherical
7	*Cyanobium*	Cylindrical
8	*Synechocystis*	Cylindrical
9	*Coelosphaerium*	Spherical
10	*Nostochopsis*	Irregular
11	*Tolypothrix*	Filamentous
12	*Aphanocapsa*	Spherical
13	*Coelosphaerium*	Spherical

14	*Stigonema*	Spherical
15	*Microcystis*	Spherical
16	*Cylindrospermopsis*	Filamentous
17	*Planktothrix*	Filamentous
18	*Spirulina*	Helical
19	*Chroococcidiopsis*	Filamentous
20	*Radiocystis*	Spherical
21	*Woronichinia*	Spherical
22	*Spirulina*	Helical
23	*Microcystis*	Spherical
24	*Dolichospermum*	Filamentous
25	*Microcystis*	Spherical
26	*Radiocystis*	Spherical
27	*Oscillatoria*	Filamentous

CHAPTER FIVE

5.0 **DISCUSSION, CONCLUSION AND RECOMMENDATION**

5.1 **DISCUSSION**

Cyanobacteria are formerly called blue-green algae. They are group of bacteria species that are found everywhere especially in waters, ranging from freshwater to brackish water to salt water. The majority of cyanobacteria are aerobic photoautotrophs. They have existed over 2 billion years ago and according to report they were the first organisms to colonize rocks (Lane *et al.,* 2010). The present study however, shows the diversity of different cyanobacteria species in three (3) recreational waters in Bayelsa State, namely Ox Bow Lake, Swali River and River Nun along Amassoma axis.

From table 1, the cyanobacteria load in CFU/ml in Ox bow Lake is, 4.9×10^4, 4.4×10^4, and 3.3×10^4 at the Up-stream, Mid-stream, and Down-stream respectively. Also the cyanobacteria load for Swali River is, 5.6×10^4, 3.8×10^4, and 3.1×10^4 at the Up-stream, Mid-stream, and Down-stream respectively. And on River Nun along Amassoma axis, 5.6×10^4, 2.7×10^4, 5.5×10^4 were recorded at the Up-stream, Mid-stream, and Down-stream respectively. Cyanobacteria load was higher in River Nun along Amassoma axis, this may be due to the presence of NO_3 and PO^4 and Fe. However, Swali River recorded more cyanobacteria than Ox bow Lake. River Nun along Amassoma axis and Swali River showed a slight difference on the cyanobacteria load, this may be as a result of excess eutrophication and also

high value of the physiochemical parameters (pH, $NO_{3,}$ PO^4 and Fe) obtained. In River Nun along Amassoma axis, (*spirulina, oscillatoria, microcystis, cylindrospermopsis)* the river is a major source of waste disposal, which enhances eutrophication, waste from the market area, individuals and firms. Run-offs from waste dumped in open location flow down to the river during rainy season, the nutrients in the waste may trigger toxic cyanobacteria blooms and further reduce the water quality. The concentration of NO_3 appeared to be the most important factor for the occurrence and abundance of cyanobacteria (Briand *et al.,* 2002). In Swali River, the level of pH, $NO_{3,}$ PO^4, Fe were also high due to waste disposal which enhances the growth of different cyanobacteria isolated in our study such as; *Microcstis, planktothrix, spirulina, tolypothrix*. Although in Ox bow Lake, the physicochemical parameters are reduced but still permit the growth of certain cyanobacteria such as (*Hyrdococcus, plectonema, microcystis, cyanobium)*; this may be due to the amount of sunlight, temperature, short wavelength radiation. Waste disposal into the lake, during flooding, could produce the nutrient which may have encouraged the cyanobacterial growth and toxin production in this water bodies (Neilan *et al.*, 2013). However, all the three recreational water produces different cyanobacteria; *Microcystis* was dominant in all the rivers.

In table 5, the physiochemical analysis of water samples were tested. pH, PO^4, NO_3 salinity, conductivity, Fe and Mn. The physiochemical factors influences the growth and toxin occurrence of the different cyanobacteria, some increases their growth while others decreases their growth, PO^4 and NO_3 increases the growth of cyanobacteria when the concentration is high, some causes the production of toxin, Cyanobacteria temperature has a maximum growth rates above 25^{o}C (Butterwick *et al*., 2005). Iron is an essential element to all life. *Microcystis* utilize high affinity transport system during time of iron limitation. According to Ouellette *et al.,*

*(*2003), there may be a relationship between reduced iron and increased toxin production in *Microcystis.* The physiochemical analysis of iron is low in our study; this may be reason for the increase in toxins production. A decrease in iron from the physiochemical analysis favors the growth of cyanobacteria especially for *Microcystis* that was present in all samples.

Among microorganisms, cyanobacteria and other photosynthetic prokaryotes are exceptional in that they lack the ability to grow at low pH value. A very limited number of cyanobacteria do grow at pH 4-5, but must cyanobacteria growth is optimal at high pH values between 6.3- 7.0 (Tonk *et al.*,2007).

Salinity served as a barrier in restricting the occurrence and geographical distribution of toxic cyanoHABs. However, freshwater cyanobacteria such as *Anabaena* and *Nodularia* have wide salinity tolerance range (5-20) (Tonk *et al.,* 2007). Nitrate (NO_3) and phosphate (PO_4) affects the growth of *Microcystis* by increasing in size when nitrate concentration is high (Beversdorf *et al.,* 2013). Phosphate has been widely implicated as having a dominant, eutrophication and HAB formation, leading to tight regulation on phosphate inputs from agricultural, urban and industrial sources (Paerl *et al.,* 2013). However, in *Microcystis*, studies have been observed that phosphate reductions alone are not enough to stop eutrophication and the formation of HABs.

Microcystis is one of the most common harmful algal blooming species in the world (Moisander *et al.,* 2009). Yet its growth dynamics are poorly understood. Toxic strains of *microcystis* release highly potent hepatotoxins or toxins damaging to the liver, called microcystins, which can severely impact the health of aquatic wildlife. *Microcystis* is a high producer of microcystins, and is one of the widest

spread fresh water hepatotoxic species in the world (Moisander *et al.*, 2009). Other toxins produced by cyanobacteria are neurotoxin and dermatotoxin.

Plectonema have trichomoes of discoid cells with rounded apical cells inside visible sheath, the filament often occur coiled in tangled masses, reproduced by hormogonia, exhibiting false branching. They produced Aplysiatoxin. *Planktothrix* are filamentous cyanobacteria, they produce microcystins. They do not have specialized cells such as akinetes or mucilaginous. *Cyanobium* produce cyanotoxins, they have a cylindrical shape, and are about 3-100um long. *Oscillatoriale* is a genus of filamentous cyanobacteria named after the oscillation in its movement, they reproduced by fragmentation. They produced cylindrospermopsin. *Cylindrospermopsis* are filamentous cyanobacteria, which are known for their bloom in eutrophic water, the toxin produced is cylindrospermopsin. *Synechocystis* is a genus of unicellular freshwater cyanobacteria; they can grow in both dark and light periods. They produce Type 11 toxin-antitoxin. *Spirulina* produce β-N-methylamino-L- ananine, (BMMA) a neurotoxic compound. They can be used as a feed supplement in the aquaculture, aquarium and poultry industries. *Tolypothrix* are filamentous cyanobacteria which produce cyclodextrin, they produce false branching. The trichomes are composed of cells that are long and cylindrical. The filaments are covered by mucilage that varies in thickness and form wooly mate. *Chroococcodiopsis* are primitive cyanobacteria; they can survive very harsh environment condition including high and low temperature with high salinity. They produce neurotoxins as a byproduct of their metabolism. They can contaminate drinking water.

Exposure of cyanobacteria toxins can be by ingestion, inhalation and dermal contact. Incidental ingestion of water is a particularly high risk for children and activities such as swimming and diving in the shore areas where scums accumulate

are considered high risk for exposure to toxins. Although not considered to be a common occurrence, picnickers who may use lake water for cooking or drinking purposes. However, due to the rarity of occurrence, campers intentionally ingesting lake water and therefore toxin, classified as low potential for exposure.

Toxin is more commonly associated with activities in which water aerosols are formed such as wind surfing, canoeing and sailing. Dermal exposure is likely for all recreational users of lakes and reservoirs involving contacts with the water, where wet suits or bathing suits trap cyanobacteria cells against the body, skin reactions are more likely due to the prolonged contact.

In Table 4, the different cyanobacteria and their morphology were observed. Some are spherical, ovoid or oval, cylindrical, irregular, filamentous, rod. All this morphology where identified using the microscope. After gram staining, they are observed using the 100× oil immersion (objective lens) and 10 × eye pieces. Cyanobacteria having unicellular forms, for example in the order *Chroococcales*, have spherical, ovoid or cylindrical cells. They occur singly when the daughter cells separate after reproduction by binary fission. The cell may aggregate in irregular colonies, being held together by the slimy matrix secreted during the growth of the colony.

5.2 **CONCLUSION**

Recreational water refers to rivers, lakes and coastal waters, often used by people for recreational activities like surfing, water skiing, swimming, sailing, boating, fishing etc. The present study provides baseline information on culturable and

morphological nature of cyanobacteria from recreational waters. The study revealed that occurrence of cyanobacteria has a positive relationship with $NO_{3,}$ PO^4 Fe, pH, Mn, water temperature; sunlight. Also, water from respective recreational waters provides favorable conditions for cyanobacteria growth rather than chemical media alone. The cyanobacteria identified such as *Microcystis, plectonema, cylindrospermopsis, planktothrix, oscillatoria* are capable of causing health effect on skin when come in contact due to the toxins they produce especially during swimming, water skiing. Blooms from excess nutrients may also cause health effect, through contaminated shellfish or toxins produced by cyanobacteria. Further studies can be carried out with the help of molecular identification of the isolates.

5.3 RECOMMENDATION

For recreational users of freshwater bodies, cyanobacteria can present hazards that other types of algae do not. In some conditions, and at certain times of the day, cyanobacteria can float to the surface and form scums which, driven by prevailing breezes can accumulate in bays around the shore edge. This can be particularly problematic for recreational water bodies as the shoreline is the most heavily used area, particularly by young children. There are three different types of exposures to cyanobacteria toxins, ingestion, inhalation, and dermal contact. The greatest concern of them all is through ingestion- whether intentional or incidental.

The 1998 WHO guidelines for recreational waters indicate that due to the different levels of exposure to cyanotoxins, from "chiefly irritative" to the "potentially more severe hazard of exposure to high concentrations of known cyanotoxins". Informing the public of the risks associated with cyanobacteria

scums and toxins is important. The information needs to be readily available to recreational users of water bodies at the time of the risk, and should include the effects and actions the public needs to take to minimize the risk of exposure. It must be noted that not all water bodies should be monitored; therefore information leaflets that raise the general level of awareness of how to recognize a bloom and what precaution to take should be available to minimize risk.



Plate.1. Collection of water sample in Ox bow Lake



Plate.2. Collection of water sample in Swali River



Plate.3. Collection of water sample in River Nun along Amassoma axis

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