ISSN: 2287-688X

Annals of
Plant Sciences

Volume 11, Issue 04 (2022) pp. 5040-5050

Research Article

# Diversity and Life Forms of Aquatic Macrophytes in Relation to Physicochemical Parameters of River Ethiope in Delta State, Nigeria

**Agbogidi, O. M[1], Nwabueze, A.A[2], Edema, N. E[1], Erhenhi, A.H[1] and Obi-Iyeke, E.G[1]**

[1]*Department of Botany, Faculty of Science, Delta State University, Abraka*
[2]*Department of Fisheries, Faculty of Agriculture, Delta State University, Abraka*

**Abstract**

The life forms and diversity of aquatic macrophytes in line with the physicochemical parameters of River Ethiope were investigated. Aquatic macrophytes from three stations: Umuaja (upstream), Abraka (mid-stream) and Amukpe (downstream) were manually collected from three sites in each station along the bank of the river by hand and machete, sieve for the floating, submerged and emergent species for a period of three months November, 2018 to January, 2019. Also, samples of water were collected using sterile 250 ml corked bottles from study locations. Results show that twenty six taxa of macrophytes exhibiting four major life forms: embankment, emergent, submerged and floating were recorded from River Ethiope. In Abraka, 22 macrophytes were encountered, 11 in Amukpe and 5 in Umuaja. Fifteen families namely: Poaceae, Nymphaeaceae, Cyperacea, Ruppiaceae, Ranunculaceae, Menyanthaceae, Pontederiaceae, Amaranthaceae, Convolvulaceae, Nephrolepidaceae, Lamariopsidaceae, Zonteraceae, Hydrocharitacea, Araceae and Onagraceae were observed. Poaceae and Nymphaeaceae were more abundant (+++) while Araceae and Onagraceae were the least abundant (+). Water level, speed, transparency, pH and total alkalinity were significantly ($P<0.05$) different in each of the three locations. There was strong positive relationship between air and surface temperature with water level throughout the period of study. The study revealed that minimal monthly variations in physicochemical parameters existed in each of the three stations and that River Ethiope is a biodiversity hot spot. This study is useful for the continued assessment and ecosystem observation of the physicochemical properties of River Ethiope as it affects the macrophytes in the river.

**Keywords:** *Water quality, macrophytes, River Ethiope, diversity.*

## Introduction

Physicochemical parameters are regarded as one of the most significant factors capable of changing the aquatic environment showing wide temporal and spatial differences (Rameshkumar. *et al.,* 2019). Physicochemical parameters are abiotic components which describe the quality of the bodies of water. Water quality can be impacted by various environmental variables that may directly or indirectly affect the aquatic organisms. The hydrodynamics of aquatic ecosystems have been reported to vary with soils, climate, hydrology, water chemistry, topography, vegetation and other factors including anthropogenic activities (Banner and MacKenzie, 2000).

Aquatic macrophytes are plants which under normal conditions, germinate and grow in water and are big enough to be seen with naked eyes (Agbogidi, 2005). They include plants growing in water emerged, submerged or floating forms along with those on the river bank (Bamidele and Agbogidi, 2002; Agbogidi, 2014). They are found in all water bodies including flowing and standing, fresh,

***Corresponding Author:**
**Agbogidi, O. M;**



DOI: http://dx.doi.org/10.21746/aps.2022.11.4.4

brackish and marine waters of all climatic zones and usually possess features that enable them survive in such environments. Aquatic macrophytes growing in the rivers are well-known to induce substantial changes to the water quality. The connection between water quality variables and macrophytes represents a major characteristic of river systems, which has significant consequences for river flow and ecological functioning. Nutrient influx encourages the development and establishment of aquatic macrophytes communities, while sediments formed by deposition of silt provide substratum for root growth (Bako and Oniye, 2004). Excess nutrients can leads to eutrophication and results in bloom of submerged macrophyte, which is an indicator of local environmental conditions (Sondergaard. *et al.,* 2010).

Although the development and spread of these macrophytes in aquatic environment is a natural phenomenon, in recent years there have been growing concerns about aquatic macrophytes and the quality of water as a result of the activities of man such as agriculture, forestry operations, constructions and urbanization programmes (Collins and Walling, 2007). Uedeme-Naa. *et al.,* (2011) reported that alterations in the macrophyte community due to enhanced nutrients in the body of water resulting from human activities is common place in many areas of the world, requiring proper ascription of the cause of such alterations in the flora, which is vital for management decisions. There is therefore a need to observe the physicochemical parameters of water bodies at regular intervals to determine its nutrient level as it affects the assemblage and density of macrophytes. This study investigates the life forms and diversity of aquatic macrophytes in connection to physicochemical parameters of River Ethiope.

## Materials and Methods

### Study Area

The study area is River Ethiope, located in Umuaja in Delta State. The river believed to be the deepest Inland waterway in Africa took its source from a watershed at the base of a huge silk-cotton tree (*Ceiba pentandra*) and flows westward for about 100km where it discharges into the River Benin at Sapele (Iloba, 2017; Ojianwuna and Amusan, 2019). Three stations beside River Ethiope selected for the study are:

Umuaja (Upstream) – the main source of the River in Ukwuani Local Government Area located between latitude $5^0 25^1$N and longitude $6^0 49^1$E,

Abraka (mid-stream) - by the bridge located in Ethiope East Local Government Area $5^0 00^1$ and $6^0 30^1$ North and longitude $5^0 00^1$ and $6^0 45^1$E and

Amukpe (downstream) - by the bridge between latitude $5^0 52^1$N and $5^0 57^1$N and longitude $5^0 35^1$ and $5^0 45^1$ in Sapele Local Government Area from where the river discharges into River Benin.

Figure 1 is a map of River Ethiope showing the three sampling stations.

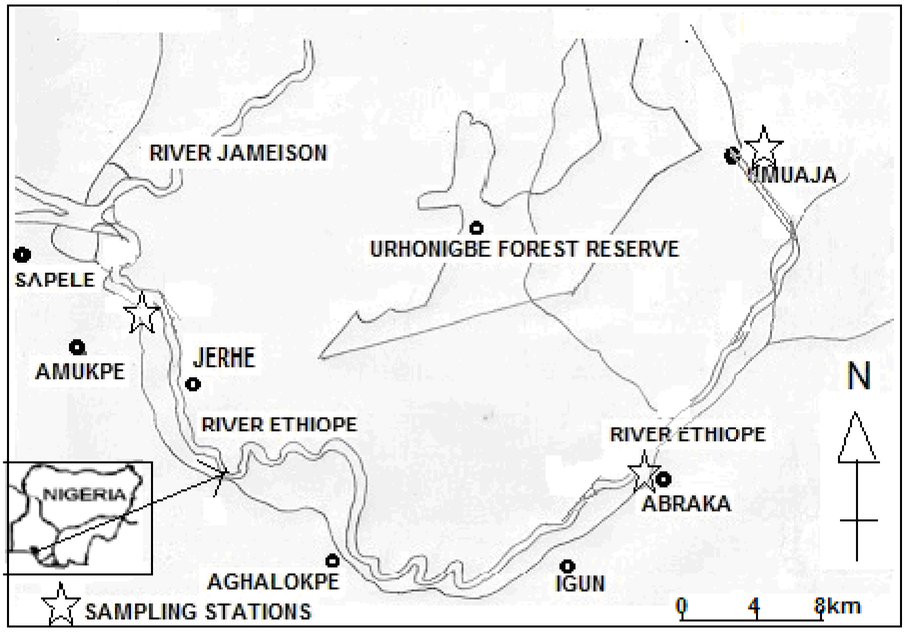


**Figure 1:** R. Ethiope showing the three study stations at Umuaja, Abraka and Amukpe (Adapted from Nwabueze, 2015)

**Determination of Physicochemical Parameters of Water**

The samples of water were collected using sterilized 250 ml corked bottles from three sampling sites of about 200m apart at each of the three study stations between 7.30 am and 11.30 am on monthly basis for three months between November, 2018 and January, 2019 using a composite sampling technique and analyzed for chemical and physical parameters. Air and surface temperatures were determined insitu using Hanna thermometer. The water level was measured with a graduated rope dropped from a canoe at the centre of the river. A timed floater was used for the determination of speed of water flow. Water samples for other parameters were instantly conveyed to the Faculty of Agriculture Research Laboratory for analysis. Total dissolved solid (TDS) was gravimetrically determined by vaporizing a known volume of water to dryness in a pre-weighed crucible on a steam bath, dissolved oxygen (Azide modification method), total alkalinity, nitrate, phosphorus (Tin II colorimetric method), magnesium and calcium were determined according to methods by APHA, (2005).

**Determination of Physicochemical Parameters of Soil**

Soil composite samples were accumulated with augur from 0 – 20cm depth and analyzed for soil basic physico-chemical parameters such as bulk density, particle size, soil pH, temperature, electrical conductivity and % moisture. Particle size distribution by hydrometer method, bulk density by cove method and soil pH in distilled water using a soil liquid ratio of 1:6 phosphate- phosphorus in soil extracts by ascorbic acid method were determined.

**Sampling of Aquatic Macrophytes**

Aquatic macrophytes from three stations: Umuaja (upstream), Abraka (mid-stream) and Amukpe (downstream) were manually collected from three sites in each of the three stations along the bank of the river for three months of the study. Both standing and creeping macrophytes were collected in air tight black cellophane to avoid drying up. While the free floating aquatic macrophytes were collected with sieves, the attached but floating and the submerged were collected with hand and the emergent and embankment were collected with hand and machete. Samples were conveyed in air tight polythene bags and conveyed to the laboratory of the Department of Botany for identification. Macrophytes were recognized by their morphologies and identified (Schuyler, 1984, Chambers. *et al*., 2007). The total number of macrophytes encountered was recorded. Their common names, families and life forms were also documented. The percentage of the life forms/ habit of the macrophytes encountered was determined:

## Data Analysis

All the collected data were subjected to analysis of variance (ANOVA). Significant means were separated at the 5% level of probability using Duncan's Multiple Range Tests. Correlation analysis was used to determine relationships in physicochemical parameters.

## Results

Minimal monthly variations in physicochemical parameters existed in the three stations. Varying levels ($P>0.05$) of air and surface temperatures were observed in this study. Temperature levels were generally higher ($P<0.05$) in Station 3, Amukpe (down stream) than in Station 1, Umuaja (up stream) and Station 2, Abraka (mid stream). Water level, speed, transparency, pH and total alkalinity were significantly ($P<0.05$) different in the three stations. Station 3 had significantly ($P<0.05$) higher water level and lower speed and transparency. Water level was significantly ($P<0.05$) higher in Station 3 and with lowest speed, particularly in November, 2018. River Ethiope at Station 2 had highest ($P<0.05$) level of transparency. Station 3, Amukpe had the highest pH level while Station 1, Umuaja had the lowest level. Conductivity and total dissolved solids had insignificantly lower levels.

Levels of total dissolved solids were generally low while dissolved oxygen level were higher in Station 2, followed by Station 1 and lowest in Station 3. Total alkalinity was high during the period of study in all three stations. Nitrate concentrations obtained in this study was not significantly ($P>0.05$) different in study stations surveyed. The level of phosphorus was higher in Station 2, followed by Station 1 and then Station 3 throughout the period of study. Though the levels of magnesium followed the same trend as the levels of calcium, magnesium levels were lower than calcium levels. Monthly mean variations in physicochemical parameters are presented in Tables 1, 2 and 3. Variations in the degree of correlation were observed. There was strong positive correlation between surface and air temperature with water level throughout the period of study. Other parameters also exhibited both strong and well as positive and negative correlations.

**Table 1:** Mean (± S.E.M.) variations in physicochemical parameters across the study stations in November, 2018.

| Parameters | November, 2018 | | |
|---|---|---|---|
| | **Station 1 Umuaja** | **Station 2 Abraka** | **Station 3 Amukpe** |
| Surface Temp ($^0$C) | 27.40±0.67a | 27.47±0.00a | 28.87±0.03a |
| Ambient Temp ($^0$C) | 28.73±0.03a | 29.00±0.15a | 29.33±0.09b |
| Water Level (cm) | 31.67±7.67a | 231.67±1.67b | 883.33±17.64c |
| Speed (m/s) | 0.47±0.01b | 1.01±0.01c | 1.43±0.01a |
| Transparency (cm) | 31.67±7.31b | 231.67±1.67c | 1.43±0.23a |
| pH | 3.57±0.36a | 4.64±0.02b | 5.70±0.06c |
| Conductivity (μmhos/cm) | 0.00±0.00a | 0.00±0.00a | 1.00±0.00b |
| Dissolved Oxygen (mg/L) | 6.00±0.10b | 3.73±0.72a | 3.97±0.07a |
| Total Dissolved Solids (mg/L) | 0.10±0.00a | 0.10±0.00a | 0.10±0.00a |
| Total Alkalinity (mg/L) | 303.33±7.19a | 497.83±4.02b | 515.97±5.21b |
| Nitrate (mg/L) | 0.72±0.02a | 0.80±0.01b | 0.84±0.02b |
| Phosphorus (mg/L) | 1.16±0.12a | 0.98±0.23a | 0.66±0.06a |
| Calcium (mg/L) | 5.11±0.07a | 10.39±0.34b | 10.19±0.21b |

| | | | |
|---|---|---|---|
| Magnesium (mg/L) | 1.77±0.18a | 4.22±0.24b | 3.94±0.14b |

Means with different letters on the same rows are significantly different (P ≤ 0.05) while same letters on the same row are not significant at P>0.05.

**Table 2:** Mean (± S.E.M.) variations in physicochemical parameters across the study sites in December, 2018

| Parameters | December, 2018 | | |
|---|---|---|---|
| | **Station 1 Umuaja** | **Station 2 Abraka** | **Station 3 Amukpe** |
| Surface Temp ($^0$C) | 27.53±0.03a | 27.53±0.03a | 27.53±0.03a |
| Ambient Temp ($^0$C) | 27.73±0.15b | 27.73±0.15b | 27.73±0.15b |
| Water Level (cm) | 28.53±1.28a | 28.53±1.28a | 28.53±1.28a |
| Speed (m/s) | 0.47±0.15a | 0.47±0.15a | 0.47±0.15a |
| Transparency (cm) | 28.53±1.28b | 28.53±1.28b | 28.53±1.28b |
| pH | 3.70±0.06a | 3.70±0.06a | 3.70±0.06a |
| Conductivity (µmhos/cm) | 0.00±0.00a | 0.00±0.00a | 0.00±0.00a |
| Dissolved Oxygen (mg/L) | 8.03±0.06b | 8.03±0.06b | 8.03±0.06b |
| Total Dissolved Solids (mg/L) | 0.10±0.00a | 0.10±0.00a | 0.10±0.00a |
| Total Alkalinity (mg/L) | 358.37±2.61a | 358.37±2.61a | 358.37±2.61a |
| Nitrate (mg/L) | 0.74±0.01a | 0.74±0.01a | 0.74±0.01a |
| Phosphorus (mg/L) | 1.01±0.78a | 1.01±0.78a | 1.01±0.78a |
| Calcium (mg/L) | 5.21±0.18a | 5.21±0.18a | 5.21±0.18a |
| Magnesium (mg/L) | 1.62±0.06a | 1.62±0.06a | 1.62±0.06a |

Means with different letters on the same rows are significantly different (P ≤ 0.05) while same letters on the same row are not significant at P>0.05.

**Table 3:** Mean (± S.E.M.) variations in physicochemical parameters across the study sites in January, 2019.

| Parameters | January, 2019 | | |
|---|---|---|---|
| | **Station 1 Umuaja** | **Station 2 Abraka** | **Station 3 Amukpe** |
| Surface Temp ($^0$C) | 29.03±0.09b | 29.03±0.09b | 29.03±0.09b |
| Ambient Temp ($^0$C) | 30.23±0.15a | 30.23±0.15a | 30.23±0.15a |
| Water Level (cm) | 44.67±1.45a | 44.67±1.45a | 44.67±1.45a |
| Speed (m/s) | 0.26±0.02a | 0.26±0.02a | 0.26±0.02a |
| Transparency (cm) | 44.67±1.46b | 44.67±1.46b | 44.67±1.46b |
| pH | 4.60±0.06a | 4.60±0.06a | 4.60±0.06a |
| Conductivity (µmhos/cm) | 1.00±0.00b | 1.00±0.00b | 1.00±0.00b |
| Dissolved Oxygen (mg/L) | 6.20±0.06a | 6.20±0.06a | 6.20±0.06a |
| Total Dissolved Solids (mg/L) | 0.10±0.00a | 0.10±0.00a | 0.10±0.00a |
| Total Alkalinity (mg/L) | 307.03±2.61a | 307.03±2.61a | 307.03±2.61a |
| Nitrate (mg/L) | 0.79±0.01a | 0.79±0.01a | 0.79±0.01a |
| Phosphorus (mg/L) | 1.12±0.78a | 1.12±0.78a | 1.12±0.78a |
| Calcium (mg/L) | 5.22±0.18a | 5.22±0.18a | 5.22±0.18a |
| Magnesium (mg/L) | 2.03±0.06a | 2.03±0.06a | 2.03±0.06a |

Means with different letters on the same rows are significantly different (P ≤ 0.05) while same letters on the same row are not significant at P>0.05.

The soil properties are presented in Table 4. The results show no significant differences (P>0.05) observed in temperature, pH, bulk density and particle size of soils at Umuaja, Abraka and Amukpe stations. However, with respect to electrical conductivity, Umuaja and Abraka with (0.11a) were significantly lower (P<0.05) from Amukpe (0.33a) while % moisture was significantly different (P<0.05) in the three stations.

**Table 4:** Variations in soil parameters in the study area

| Water Parameters | Umuaja | Abraka | Amukpe |
|---|---|---|---|
| Temperature | 28.7a | 29.4a | 29.39a |
| pH | 6.95a | 6.67a | 6.86a |
| Conductivity | 0.11a | 0.11a | 0.33b |
| % moisture | 16.59c | 20.65b | 26.55a |
| Bulk density | 2.02a | 1.93a | 1.69a |
| Particle size | 0.20a | 0.20a | 0.20a |

Means with different letters on the same rows are significantly different (P ≤ 0.05) while same letters on the same row are not significant at P>0.05.

Results obtained from this study recorded twenty six (26) taxa of macrophytic species from River Ethiope exhibiting four major habits: embankment (3), emergent (9), submerged (7) and floating (7) (Table 5). This indicates that from the three sites of study, emergent species with 34.62% had the highest number and diversity of macrophytic vegetation followed by 26.90% floating and submerged and 11.54% of embankment (Table 6). The study also showed that in Abraka 22 macrophytes were encountered, 11 in Amukpe and 5 in Umuaja (Abraka > Amukpe > Umuaja) (Table 6). A total of 15 families were identified; with Poaceae (4) and Nymphaeaceae (3), having the highest abundance with (+++), Cyperacea, Ruppiaceae, Ranunculacea, Menyanthaceae and Pontederiaceae having (2) as sparse abundance (++) while Amaranthaceae, Convolvulaceae, Nephrolepidaceae, Lamariopsidaceae, Zonteraceae, Hydrocharitacea , Araceae and Onagraceae had rare abundance (+) (Table 7).

**Table 5:** Diversity of macrophytes and their life form in River Ethiope, Delta State, Nigeria

| S/N | Macrophytes | Common Name | Family Name | Habit/Life Form |
|---|---|---|---|---|
| 1 | *Alternanthera sessilis* | Sessile joy weed | Amaranthaceae | Embankment |
| 2 | *Ipomoea aquatica* | Water spinach | Convolvulaceae | Emergent |
| 3 | *Leersia virginica* | white cutgrass | Poaceae | Embankment |
| 4 | *Nephrolepis biserrata* | Gant sword fern | Nephrolepidaceae | Embankment |
| 5 | *Nephrolepis exaltata* | Sword fern/Boston fern | Lamariopsidaceae | Emergent |
| 6 | *Cyperus esculentus* | Chufa flatsedge | Cyperaceae | Emergent |
| 7 | *Cyperus rotundus* | Nut grass | Cyperaceae | Emergent |
| 8 | *Nymphaea tetragona* | Pygmy water lily | Nymphaeaceae | Floating |
| 9 | *Zostra marina* | Eelgrass | Zonteraceae | Submerged |
| 10 | *Ruppia maritima* | Widgeon grass | Ruppiaceae | Submerged |
| 11 | *Ruppia cirrhosa (Pentagna)* | Spiral dutch grass | Ruppiacceae | Submerged |
| 12 | *Ranunculus fluitans* | River water crow foot | Ranunculaceae | Submerged |
| 13 | *Ranunculus penitatus* | pond water crow foot | Ranunculaceae | Submerged |
| 14 | *Vossia cuspidate* | Hippo grass | Poaceae | Submerged |
| 15 | *Echinochloa stagnina* | Burgu grass | Poaceae | Emergent |
| 16 | *Elodea canadensis* | Water weed | Hydrocharitaceae | Submerged |
| 17 | *Phragmite karka* | Common reed | Poaceae | Emergent |
| 18 | *Nymphoides indica* | Banana plant | Menyanthaceae | Floating |
| 19 | *Nymphoides aquatic* | Banana lily | Menyanthaceae | Floating |
| 20 | *Nymphaea lotus* | Water lily | Nympheaceae | Floating |
| 21 | *Nymphaea alba* | White water lily | Nympheaceae | Floating |

| | | | | |
|---|---|---|---|---|
| 22 | *Pistia stratiotus* | Water lettuce | Araceae | Floating |
| 23 | *Eichhornia crassipes* | Water hyacinth | Pontederiaceae | Free floating |
| 24 | *Ludwiga stolonifera* | The water primrose | Onagraceae | Emergent |
| 25 | *Ludwiga peploides* | Floating primrose willow | Onagraceae | Emergent |
| 26 | *Eichhornia natans* | Eichhornia | Pontederiaceae | Emergent |

Field survey (2018/2019)

**Table 6:** Diversity of macrophytes in Umuaja, Abraka and Amukpe along River Ethiope, Delta State, Nigeria

| **Macrophytes** | | **Study Stations** | | |
|---|---|---|---|---|
| **S/N** | | **Umuaja** | **Abraka** | **Amukpe** |
| 1 | *Alternanthera sessilis* | + | | + |
| 2 | *Ipomoea aquatica* | + | + | + |
| 3 | *Leersia virginica* | + | | + |
| 4 | *Nephrolepis biserrata* | | + | |
| 5 | *Nephrolepis exaltata* | | | |
| 6 | *Cyperus esculentus* | | + | |
| 7 | *Cyperus rotundus* | | + | + |
| 8 | *Nymphaea tetragona* | | + | + |
| 9 | *Zostra marina* | | + | |
| 10 | *Ruppia maritima* | | + | + |
| 11 | *Ruppia cirrhosa (Pentagna)* | | + | |
| 12 | *Ranunculus fluitans* | | + | |
| 13 | *Ranunculus penltratus* | + | + | |
| 14 | *Vossia cuspidate* | | + | |
| 15 | *Echinochloa stagnina* | | + | |
| 16 | *Elodea canadensis* | | + | |
| 17 | *Phragmite karka* | | + | |
| 18 | *Nymphoides indica* | | + | + |
| 19 | *Nymphoireldes aquatic* | | + | + |
| 20 | *Nymphaea lotus* | | + | + |
| 21 | *Nymphaea alba* | | + | + |
| 22 | *Pistia stratiotus* | | + | |
| 23 | *Eichhornia crassipes* | | | + |
| 24 | *Ludwiga stolonifera* | + | + | |
| 25 | *Ludwiga peploides* | | + | |
| 26 | *Eichhornia natans* | | + | |

Field survey (2018/2019)

**Table 7:** The relative abundance of macrophytic species/ families

| S/N | Family | Number of species | Abundance |
|---|---|---|---|
| 1 | Amaranthaceae | 1 | + |
| 2 | Convolvulaceae | 1 | + |
| 3 | Nephrolepidaceae | 1 | + |
| 4 | Lamariopsidaceae | 1 | + |
| 5 | Cyperaceae | 2 | ++ |
| 6 | Nymphaeaceae | 3 | +++ |
| 7 | Zonteraceae | 1 | + |
| 8 | Ruppiaceae | 2 | ++ |
| 9 | Ranunculacea | 2 | ++ |
| 10 | Poaceae | 4 | +++ |
| 11 | Hydrocharitaceae | 1 | + |
| 12 | Menyanthaceae | 2 | ++ |
| 13 | Araceae | 1 | + |
| 14 | Pontederiaceae | 2 | ++ |
| 15 | Onagraceae | 2 | ++ |
| | **Total** | **26** | |

**Key**

+ = present/ rare abundance

++ = sparse abundance

+++ = more abundance

## Discussion

Variations in physicochemical parameters were observed during the study. Temperature varied throughout the period of study. Folland. *et al.,* (2018) reported irregularities in global mean surface temperatures. The higher air and surface temperatures observed in Station 3 may be due to the fact that Stations 3 is more urban with a few industries unlike the other stations which are located in villages. Yue and Xi, (2013) noted that thermal environment had an effect of urban water. Air temperatures were in most cases higher than the surface water temperatures. Harvey. *et al.,* (2011) observed that air temperatures have an effect on surface water temperatures. Temperature is one of the controlling factors, which alter the functions of the aquatic ecosystem, and it impacts the growth and circulation of flora and fauna (Jalal and Sanalkumar, 2012; Tank and Chippa, 2013). Station 3 with larger volume of water had a reduced flow and low transparency probably due to heavier loads as it approaches the point of deposition into a bigger water body.

A high pH was observed in Station 3 and this could be due to the higher organic matter load. Jalal and Sanalkumar, (2013) noted that pH controls the acidic or basic physiognomies and is a crucial property of any aquatic ecosystem since all the biochemical functions and retention of physicochemical attributes of the water are greatly depending on pH of the surrounding environments. Edema, (2011) reported that the environment has some impacts in the bodies of fresh water in Delta State. According to Chambers. *et al.,* (2012), the chemical constituent of water can have an effect on the pH of water. The level of pH could also be affected by respiratory and photosynthetic activities of aquatic organisms in the river (Zaprudnova and Kamshilov, 2010). Conductivity levels are a reflection of the volume of metal elements and chloride ions in the water column. The low level of conductivity observed could be credited to low level of elements in the water. Oyem. *et al.,* (2014) and Perlman, (2014) noted that electrical conductivity is a measure of elements in dissolution in the water column. Total dissolved solids obtained in this study were lower than levels gotten by Eze and Ogbaran, (2010), which might be a reflection of low effluent discharges into the water body. The levels of dissolved oxygen obtained were slightly lower than levels obtained in the same river (Nwabueze, 2015). Station 3 had the lowest level of dissolved oxygen probably due high amount of suspended matter as evidenced by the low level of transparency obtained. Dissolved oxygen is an important water quality parameter to maintain because of its significant regulatory biological and physicochemical role in water bodies (Kotadiya and Acharya, 2014).

High levels of total alkalinity were observed in the three stations. According to Bhavnagar and Devi, (2013), optimum alkalinity for fish productivity is between 25 to 100 mg/L. Though values obtained in this study were above this range, the values are suitable for fish survival. Levels of phosphorus were also generally low and comparable to levels obtained for the same river in earlier studies (Nwabueze, 2015). Şahin. *et al.,* (2012) reported that phosphorus is gradually releases from sediments infractions. Though the levels of calcium and magnesium obtained in this study were low, levels were within the typical range of 4 - 100mg/L in freshwater bodies as reported by Fella. *et al.,* (2013). Varying degrees of strong and weak positive and negative correlations of physicochemical parameters existed. Values other than within these ranges show no correlation as was observed for total dissolved solids and conductivity during the study which had negligible levels. Ponce, (2014) reported that the levels of total dissolved solids are related to electrical conductivity since conductivity is based on the total dissolved solids in the water body.

The luxuriance, diversity and abundant growth of macrophytes in Abraka and Amukpe show that the soil quality is suitable for them as they are middle and downstream respectively when compared with rare abundance at the upstream observed at Umuaja. Most of the soil nutrients could have been washed away to the other locations with the flow. The role of macrophytes vegetation in aquatic systems cannot be underemphasized. Agbogidi, (2005) established that macrophytes serve as food source, diversity habitats for invertebrates, primary production, uptake of nutrients, accumulation of detritus level, as aerators as well as providing cover, release nutrients to the aquatic systems. The presence of these aquatics corroborates earlier findings of Agbogidi, (2014) on Onah Lake, Asaba, Delta State and Uneke and Okereke, (2015) on Ebonyi River, South eastern Nigeria. It could also serve as the tourist centre because of the natured beauty of the water. The water is very clear and has been compared to any processed bottle water but for some of the anthropogenetic activities affecting it (Okumagba and Ozabor, 2014). Although, Agbogidi and Olele, (2009) maintained that excessive population of aquatic macrophytes in water bodies contribute to the depletion of aquatic nutrients, Agbogidi, (2014) also posited that aquatic macrophytes have a lot of industrial, agricultural and economic uses when efficiently exploited because they are essential ecosystem services that can be sustainably managed for better life (Agbogidi, 2019).

## Conclusion

This study has shown that minimal monthly variations in physicochemical parameters existed in the study stations. Significant differences were observed in water level, speed and transparency in the three study stations along River Ethiope. This study is useful for the continued assessment and monitoring of the physicochemical properties of River Ethiope as it affects life of organisms in the river. This study concludes that River Ethiope is a biodiversity hot spot and provides information on the macrophytic vegetation, their diversities, ecological value as well as proffer ways these macrophytes can be adequately harnessed for use in Delta State in particular and Nigeria in general as some may constitute weeds and interfere with the operations of inland and commercial fishery operations.

## Acknowledgements

We are grateful to the Tetfund Committee, Delta State, Nigeria for sponsoring the research and Mr. Igwe Zelibe for his assistance in data collection.

**References**


1. Agbogidi, O.M. "The role of macrophytes in aquatic systems: a botanical review." *Nigerian Journal of Science and Environment* 4 (2005): 1-9.
2. Agbogidi, O. M. "A survey of macrophytic vegetation of Onah lake, Asaba Delta State." *Nigeria Jorunal of Science and Environment* 13.1 (2014): 75 – 80.
3. Agbogidi, O.M. "Ecosystem services and management for better life." *80th in the series of inaugural lectures of the Delta State University, Abraka* (2019): 97.
4. Agbogidi, O.M. and Olele, N.F. "Effects of excessive populations of aquatic macrophytes in water bodies." *Journal of Sustainable Tropical Agricultural Research* 31 (2009):82-88.
5. APHA. "Standard method for the examination of water and waste water, 21st Edition." *American Public Health Association* (2005): 62-68.
6. Bako, S. P. and Oniye, S. J. "Macrophyte community development and its implication for fisheries in Maigana fish farm, Kaduna state, Nigeria." *Journal of Aquatic Sciences* 19.2 (2004): 85-94.
7. Bamidele, J.F. and Agbogidi, O.M. "Aquatic macrophytes and their potential uses." *The Nigerian Field* 66 (2002):139-147.
8. Banner, A. and Mackenzie, W. H. "The ecology of wetland ecosystems." (2000). https://:www.for.gov.bc.ca/hfd/pubs/docs/en/en45.pdf
9. Bhatnagar, A. and Pooja, D. "Water quality guidelines for the management of pond fish culture." *International journal of environmental sciences* 3.6 (2013): 1980– 1993.
10. Chambers, P., Paresh, L., Murphy, K.J. and Thomaz, S.M. "Global diversity of aquatic macrophytes in freshwater." *Hydrobiologia* 595 (2007): 9 - 26.
11. Chambers, D., R. Moran, and L. Trasky. "Chapter 5: Potential Effects of the Pebble Mine on Salmon." *Bristol Bay's Wild Salmon Ecosystems and the Pebble Mine. Portland, OR: Wild Salmon Center and Trout Unlimted. http://www. wildsalmoncenter. org/pdf/PM-Ch5. pdf* (2012).
12. Collins, A. L. and Walling, D. E. "Sources of fine sediment recovered from the channel bed of lowland groundwater-fed catchments in the UK." *Geomorphology* 88.1-2 (2007): 120-138.
13. Edema, N. E. "Impacts of environment on some aquatic brackish and fresh water bodies in Delta State, Nigeria." *Nigerian Journal of Science and Environment* 10.1-2(2011):270-275.
14. Eze, J. and k. Ogbaran. "Freshwater biodiversity conservation: recent progress and future challenges." *Journal of the North American Benthological Society* 29.1 (2010): 344-358.
15. Fella, H. C. Mohamed, B. E, Fatouma, B. and Mohamed, S. H. "Preliminary study on physico-chemical parameters and phytoplankton of Chiffa River (Blida, Algeria)." *Department of Biology and Chemistry, University of Saad Darla, BP270, Route de Soumaa, Blida, Algeria. Journal of Ecosystems* 13 (2013): 9-15.
16. Folland, C.K., Olivier, B., Andrew, C. and David, E. P. "Causes of irregularities in trends of global mean surface temperature since the late 19th century." *Science advances* 4.6 (2018): eaao5297.
17. Harvey, R., Leonard, L., Ali, K. and Renee, P. "The influence of air temperature on water temperature and the concentration of dissolved oxygen in Newfoundland Rivers." *Canadian Water Resources Journal* 36.2 (2011): 171-192.
18. Iloba, K. I. "Rotifers of River Ethiope in Delta State, Nigeria." *International Journal of Fisheries and Aquatic Studies* 5.2(2017): 74-79.
19. Jalal, F.N. and Sanalkumar, M.G. "Hydrology and water quality assessment of Achencovil river in relation to pilgrimage season." *International Journal of Scientific and Research Publications* 2.12 (2012): 1-5.
20. Jalal, F.N. and Sanalkumar, M.G. "Water quality assessment of Pampa river in relation to pilgrimage season." *Int. J. Res. Chem. Environ* 3.1 (2013): 341-347.
21. Kotadiya, N. G. and Acharya, C. A. "An assessment of lake water quality index of

Manipu Lake of district Ahmedabad, Gujarat." *Int J Sci Res* 3.4 (2014): 448-450.
22. Nwabueze, A. A. "Plankton abundance and diversity in relation to Seasonal variations in physico-chemical parameters of River Ethiope, Nigeria." *Journal of Agriculture and Food Environment* 2.3(2015):89-101.
23. Ojianwuna, C. C. and Amusan, B. O. "A survey of butterfly fauna in the sacred grove of Umuaja Forest, Southern Nigeria." *Ethiopian Journal of Environmental Studies and Management* 12(2019): 158 – 166.
24. Okumagba, P. O. and F. Ozabor. "The Effects of Socio-Economic Activities on River Ethiope." *Journal of Sustainable Society* 3.1 (2014): 1-6.
25. Oyem, H. H., Oyem, I. M. and D. Ezeweali. "Temperature, pH, electrical conductivity, total dissolved solids and chemical oxygen demand of groundwater in Boji-BojiAgbor/Owa area and immediate suburbs." *Research Journal of Environmental Sciences* 8.8 (2014): 444.
26. Perlman, H. "Electrical conductivity and water. *In*: The USGS Water Science School." *http://ga.water.usgs.gov/edu/electrical-conductivity.html* (2014).
27. Ponce, V. M. "Total dissolved solids (TDS) based on electrical conductivity (EC)." *Online Salinity Calculator. Retrieved from http://ponce. sdsu. edu/onlinesalinity. php* (2014).
28. Rameshkumar, S., Kalidoss, R., S. Aanand. and R. Rajaram. "Influence of physico-chemical water quality on aquatic macrophyte diversity in seasonal wetlands." *Applied Water Science* 9.1 (2019): 1-8.
29. Şahin, Y., Ahmet, D. and Feyyaz, K. "Phosphorus fractions and its potential release in the sediments of Koycegiz Lake, Turkey." *Lakes Reserv. Ponds* 6.2 (2012): 139-153.
30. Schuyler, A. "Classification of life forms and growth forms of aquatic macrophytes." *Bartonia* 50 (1984): 8-11.
31. Sondergaard, M., Liselotte, S. J., Torben, L. L., TORBEN, B. J., Lone, L. and Erik, J. "Submerged macrophytes as indicators of the ecological quality of lakes." *Freshwater Biology* 55.4 (2010): 893-908.
32. Tank, S. K. and Chippa, R.C. "Analysis of water quality of Halena block in Bharatpur area." *International Journal of Scientific and Research Publications* 3.3 (2013):1–6.
33. Uedeme-Naa, B., Gabriel, U. U. and Akinrotimi, O. A. "The relationship between aquatic macrophytes and water quality in Nta-Wogba Stream, Port Harcourt, Nigeria." *Continental Journal of Fisheries and Aquatic Science* 5.2 (2011): 6 - 16.
34. Uneke, B.I. and H. Udennafor. "Aquatic macrophytes diversity and physic-chemistry of Asu River, south-eastern Nigeria: implication for aquatic ecosystem management." *American Association for Science and Technology* 4.1(2017): 1 – 6.
35. Yue, W. and Lihua, X. "Thermal environment effect of urban water landscape." *Shengtai Xuebao/Acta Ecologica Sinica* 33.6 (2013): 1852-1859.
36. Zaprudnova, R. A. and Kamshilov, I. M. "Buffer and respiratory properties and ion surrounding of hemoglobin of the sterlet Acipenser ruthenus." *Journal of Evolutionary Biochemistry and Physiology* 46.3 (2010): 242–244.
37. Zelnik, I., Mateja, P. and Alenka, G. "Environmental Conditions and Macrophytes of Karst Ponds." *Polish Journal of Environmental Studies* 21.6 (2012): 1911 – 1920.

**Source of support:** Nil;

**Conflict of interest:** The author declare that they have no competing interest.

**Cite this article as:**

Agbogidi, O. M., Nwabueze, A.A., Edema, N. E, Erhenhi, A.H and Obi-Iyeke, E.G. "Diversity and Life Forms of Aquatic Macrophytes in Relation to Physicochemical Parameters of River Ethiope in Delta State, Nigeria." *Annals of Plant Sciences*.11.04 (2022): pp. 5040-5050.