Chapter

Impact of Disturbances on the Biodiversity of Ijala-Ikeren Wetland Ecosystem in Niger Delta

Michael Aigbe Uwagbae, Abdul-Rahman Dirisu, Tambeke Nornu Gbarakoro, Eman I. El Surtasi, Julia Ekenma Agwu, Martins S.O. Aisien and Johnny Rotimi

Abstract

An assessment of Ijala-Ikeren wetland in the Niger Delta of Nigeria was conducted for 9 months for biodiversity data comprising flora and specific aquatic fauna (amphibians and insects) in order to inventorise the species and ecosystem and to ascertain the effects of anthropogenic and natural disturbances on the wetland ecosystem. Five sites comprising three sites within the mangrove swamp and two ponds at the fringes of the mangrove ecosystem were sampled. Data collection methods include insect and amphibian sampling, and a few abiotic data. Empirical data on fish fauna was also obtained from fishermen. The pH value of the sampled sites in the mangrove ranged between 4.7 and 6.1, while temperature ranged from 28 to 29°C. Red mangrove species (*Rhizophora* sp.) and few species of white mangrove (*Avicennia* sp.) were dominant plants. Only three insect species from three families were encountered and thirteen species of amphibians from three families were only encountered in ponds at the fringes of the wetland. Amphibians had the highest value of species richness index (d) (2.75) and diversity index (H′) (2.08). The acidic pH values maybe attributed to the influx of effluent from the Warri refinery about 2.5 km away and the low insect diversity is due to the salinity.

Keywords: amphibian, biodiversity, environmental factor, insect, mangrove wetland, Niger Delta

1. Introduction

Nigeria has the largest mangrove forest in Africa and the third largest contiguous mangrove forest in the world. The mangrove region is widest on the sides of the Niger Delta, 35–45 km and narrows towards the centre to a width of 15 km except for the channel of the Brass River, which has extensive mangroves far upstream [1].

The mangrove forests of Nigeria comprise principally only three families and six species as follows: Family, *Rhizophoraceae* (the red mangrove): *Rhizophora racemosa*, *R. harrisonii* and *R. mangle.* Of these *R. racemosa* is the most abundant covering about 90% of the mangrove forest. *Avicenniaceae* (white mangrove), *Avicennia africana* and *Combretaceae* (*Laguncularia racemosa* and *Conocarpus erectus* [1] and alike have been reported in most parts of the West African coast [2]. The Ijala-Ikeren wetland is situated in the Niger Delta region of Nigeria. The Niger Delta region of Nigeria has four main ecological zones: Coastal Barrier Islands, Mangrove swamp forests, freshwater swamp and lowland rainforest. The mangrove swamp forest among these four ecological zones is the most affected by anthropogenic influences, as it has very poor regeneration potential [3].

Anthropogenic disturbances in the Niger Delta include oil spills which has been extensive, difficult to assess and often underreported. According to [3], oil spillages in the Niger Delta most especially in the mangrove wetlands are never reported or merely branded minor without minimum post-spill containment, recovery and remediation responses. Also, the World Commission on Environment and Development (WCED) as cited by [4] had reported that the mangrove deforestation and degradation are some of the greatest factors that would cause species extinction in the Niger Delta region in the next 50 years. Consequently, it is frightening that depletion of the mangrove forest could eliminate 5–15% of species by 2020 [5]. The Niger Delta biodiversity, including the Ijala-Ikeren wetland is very important for the concomitant presence of rainforests, mangroves, and many endemic flora and fauna, which are affected by oil pollution from oil spills, usually from bunkering and pipeline vandalisation of the petroleum refinery facilities situated less than 2 km to the East of the Ijala-Ikeren Wetland as well as solid waste pollution.

Oil pollution and its attendant impact on the creek ecology and the community are highly visible in the mangrove swamps due to proximity of the communities to refinery and oil pipelines criss-crossing the environment. The Ijala-Ikeren wetland has been affected by industrial activities, and pollution and this has affected the water quality in the community, and arthropods (insects) and amphibians [6]. Reported that the physical and sanitary quality of hand-dug well waters from communities around the Warri refinery including Ijala-Ikeren wetland was found slightly acidic at 6.04 and may be attributed to emissions from gas flaring and petroleum refining activities, which is common in the area. They also stated that the water quality from the community's surface water bodies and aquatic insect indicators are believed to be gradually deteriorating.

The Ijala-Ikeren wetland is well watered all the year round although the level of water in the creeks drops to about two meters during the dry season and varies daily owing to tides. The current ecological regime in the wetland is the amount of water in creeks and creeklets. This water is determined by tidal flow of sea water from the Atlantic Ocean at high tide and fresh water from the mainland into the Ocean at low tide. The continuous mixing of fresh and sea water gives rise to the brackish nature of water in the creeks and creeklets and in the mangrove swamp. Any change in the water regime either through the stoppage of sea water flowing into the wetland or fresh water flowing into the Ocean, will certainly change the ecology of the wetland and its current composition. The potential route of off-site contaminants to the ecosystem is by Ijala-Ikeren creeks and creeklets. The discharge of water from the creeks to the mangrove ecosystem is constant and runs all through the year but quantity and volume of water available in the mangrove and creeks are unstable [7]. Higher volumes of water are available in the rainy season due to run-offs and inter-tidal nature of the Warri River especially during high tide (personal communication).

Aquatic insects play very important role in food webs, and particularly in wetlands, the larval and adult stages provide a wholesome meal to fish [7], shorebirds [8] and other creatures in the Niger Delta mangroves. They are essential elements in food webs, essentially in energy flow and nutrient cycling [9]. This food source is key to the survival strategy of some fishes, amphibians and other animals. Selected aquatic insects are predators and in consuming their watery prey they help keep the insect population stable and functioning. Many species of aquatic insects are very sensitive to pollution and other environmental hazards, thus they reflect environmental changes and as a result are often used as indicators of the effects of human activity on water system and provide information on habitat and water quality [10]. Also some aquatic insects help keep the water clear by filtering it, others support in breaking down fallen dead leaves, while yet others clear the algae, allowing the water to produce more oxygen [11, 12].

Amphibians have important roles within nature and their sensitivity to changing environmental conditions may help determine the health of an ecosystem. They constitute an important part of food chain and contain important pharmaceutical compounds on their skin [13]. The International Union of Conservation of Nature (IUCN) Red List of threatened species has identified amphibians as being the most threatened vertebrate group, with about 40% at risk of extinction. The extinction and decline have been variously attributed to habitat loss, pollution, climate change, wild fire and over-exploitation [14].

Recent studies have documented the incidence and severity of sediment contamination by heavy metals in mangrove ecosystems [15, 16]. Contaminants are released via industrial activities and ultimately enter aquatic ecosystems [16, 17].

Industrial effluent is a common anthropogenic impact on aquatic ecosystems including mangroves and this kind of pollution changes physical and chemical characteristics of aquatic systems, thus affecting the assemblage of aquatic fauna [17, 18].

The mangrove forests and salt marshes control the tidal wetland ecosystem dynamics and contribute to the development and condition of the tidal saline wetland ecological communities [19]. Mangrove forests and salt marshes are highly valued ecosystems; however, mangrove forests and salt marshes maintain divergent ecological communities and a different suite of goods and services [20]. Climate change, environmental stress and anthropogenic activities can cause the conversion of mangrove forest to salt marshes, with positive and negative expected and unexpected consequences (e.g., effects upon fish and wildlife populations, ecosystem resilience, nutrient cycling, and variation of texture and soil geochemistry). The physicochemical conditions and ecological implications of these mangrove forests to salt marshes conversions are poorly understood, but would likely include changes in soil, water, associated wildlife populations and supply of some ecosystem goods and services [21, 22].

The lack of publications on the biodiversity (particularly on the indicator species)—such as the insects and amphibians in Ijala-Ikeren wetlands of the Niger Delta, necessitated this study. Hence, this preliminary study was aimed at evaluating the abundance, community structure and diversity of biodiversity therein coupled with temperature, salinity and the pH levels of the ecosystem. We therefore, welcome future collaboration with available funding for a robust study.

2. Materials and methods

2.1 Study area

The study was conducted in Ijala-Ikeren wetland located within latitude 05.55°N and 05.57°N and longitude 05.68°E and 05.70°E in Warri, Delta State, Nigeria (**Figure 1**). The wetland is a brackish network of creeks and creeklets, and marshes with one or more relatively narrow connections to the sea.

The study area which covers a space of 1 km^2 was divided into 2 regions: interior region bearing three sites; site 1, 2 and 3, and edges (fringes) region bearing sites 4 and 5. Altogether, 5 sites were engaged. Site 1 is located at the position, 05.55940°N,

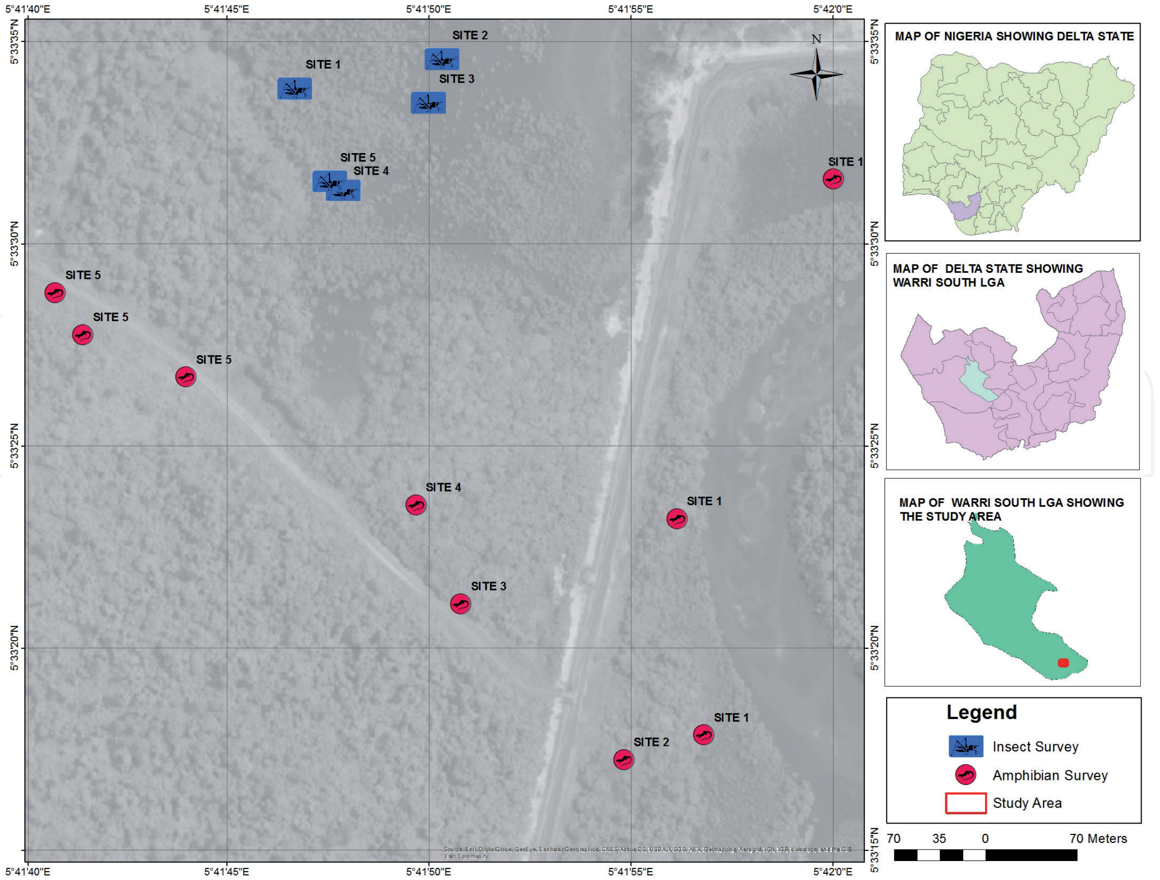

Figure 1.
Map of the study area.

and 05.69630°E. The substratum here was covered with an admixture of black muddy and clayey sediment with an average depth of 0.2 m. Tidal flow was low and was at a low transparency. Vegetation here includes *Rhizophora racemosa*, *Rhizophora harrisonii* and *Rhizophora mangle*. This site is situated immediately after edges. Meanwhile, site 2 has the same substratum coverage and depth with site 1. The vegetation cover included thick stands of *Rhizophora racemosa*, *Rhizophora harrisonii* and *Avicennia africana*. The site is located at 05.44960°N and 05.69731°E. This site was very close to the oil pipelines. The last site in interior region; site 3, had the same substratum coverage and depth with sites 1 and 2. The vegetation cover were; *R. racemosa*, *R. harrisonii* and *Nymphaea lotus* (Water lily). The site is located at 05.55930°N and 05.69722°E. On the other hand, the two study sites representing the edges (fringes) region were sites 4 and 5. Site 4—the substratum was clayey with an average depth of 1.2 m, stagnant water with high infestation of invasive species such as water hyacinth (*Eichhornia crassipes*) most importantly. While at site 5—the substratum was clayey too with an average depth of <1 m. Stagnant water and some grasses occurred at this site. It was located at 05.55876°N and 05.69654°E. These sites (1–5) were selected on the strength of the tide and vegetation cover.

2.2 Environmental condition

Physicochemical parameters such as air temperature, water temperature, and pH were determined in situ. Temperatures were measured using the 0–100°C mercury in glass thermometer (Kurison Model—59). The pH was determined in situ using digital pH meter (consort 121, Belgium) adopted from [23]. While, salinity was determined in the laboratory by using HACHCO150 Model for total dissolved solid/conductivity/salinity meter.

2.3 Vegetation cover

A description of the vegetation cover in and around the wetland was undertaken. Diversity of species of mangroves was recorded from the two studied regions. We used a [24] sampling technique for rapid assessment of the mangal vegetation of the brackish ecosystem in the study area by walking around at low tide. This involved a reconnaissance survey of the study stations of the Ijala-Ikeren mangrove ecosystem where a systematic sampling along the directed transects was applied to conduct the flora survey of the study sites.

2.4 Insect sampling

Insect sampling was conducted in the dry season (October 2013—February, 2014) and in the wet season (March–June, 2014). It was a 9 month study. Collection of samples was carried out through the use of sweep and kicks nets, and hand collection. Access to the mangrove interiors was through Falcorp Mangrove Park. Hand collections were made from wetland (mangrove) plants and from ant hive (**Figure 2**). The sieve-like dip net was used to collect aquatic insects from a distance on the mangroves while small aquatic nets were used to collect specimens in the aquatic plant (*Nymphaea lotus* and Water lily) while in water. Specimens collected were placed in vials containing 70% ethanol solution (C_2H_6O).

Kick sampling method modified after [23] was used to collect aquatic insect larvae (macro-invertebrates) for 3 min. We used 1 min to conduct searches before disturbing the water column and placing the net against the direction of the current for actual sampling. This method was also used to collect insects from water surface, from boulders, logs of wood and plants (**Figure 3**). All the collected specimens were identified using keys of [25–27]. The identified specimens were counted and placed into vials of 70% ethanol (C_2H_6O) which were well labelled indicating the location and date of collection.

2.5 Amphibian fauna

Sampling for amphibian was conducted using the Visual Acoustic Encounter Survey (VAES) method (i.e. listening to amphibians call and tracing the calls) at night and the anurans were captured by handpicking. The method was used along the trunk road (edges) traversing the area and in the interiors wetland (mangrove swamp) through the access to Falcorp Mangrove Park. Collection at the park was both during the day and at night.

2.6 Fish study

We used empirical method to ascertain the occurrences and diversity of fish species within Ijala-Ikeren wetland from the local fishermen at a few fish landings therein. A few fish species were equally sighted, observed and noted in-situ.

2.7 Statistical analysis of data

Overall diversity of soil insect was expressed as species richness, abundance, evenness and Simpson diversity index. Species richness and diversity patterns are a fundamental point for any scientific act in conservation biology [28]. Species richness represents the simplicity of describing communities at different scales and its broadly understood meaning. The complementary picture of overall diversity pattern of any community was documented by information about the abundance of

Figure 2.
An ant hive hanging on a mangrove plant in Ijala-Ikeren mangrove swamp where insect collection was made.

Figure 3.
Insect collection from under woods, logs and fallen leaves in Ijala-Ikeren mangrove.

species, the evenness of communities across the sampling region or the dominant species. Abundance is the kind of diversity measures that has inclusively been considered as equivalent to biodiversity per se [29] and referred to the sum of individuals in area. However, Simpson diversity index (D) is nearly the most tractable and statistically useful calculation [30]:

$$\lambda = \sum pi^2, D = 1 - \lambda \tag{1}$$

Where D is Simpson diversity index, λ is an index of dominance. p_i is the proportion of the community occupied by the ith species.

All parameters of diversity were calculated with PAST (version. 1.92) software running on Windows® XP, [31].

3. Results

3.1 Environmental condition

The mean values of physical parameters were recorded at the study sites. Air temperature ranged between 29 and 29.50°C in the mangroves (interior) and 30°C at the fringes (edges), while water temperature was between 28.50 and 29°C in the interior and 28–29°C at the edges (**Table 1**). On the other hand, the measured pH values ranged between 4.8 and 4.9 in the interior and 5.3–6.1 at the edges, and salinity values were between 1.50 and 1.70 ppm (**Table 1**).

DOI: http://dx.doi.org/10.5772/intechopen.82604

3.2 Vegetation cover

The study also included the description of the vegetation in and around the wetland. It showed that the mangrove swamp in Ijala-Ikeren wetland is covered by three species of *Rhizophora* (red mangrove): *Rhizophora racemosa*, *R. harrisonii* and *R. mangle*. (**Table 2**). Other flora species found were *Avicennia africana* (white mangrove), *Eichhornia crassipes* (water hyacinth) which occurred on the fringes of mangrove swamp floating in the pond and *Pandanus candelabrum* (**Table 2**).

3.3 Insect composition and diversity

The sampled insects were identified into three orders: Hemiptera, Hymenoptera and Diptera. As shown in **Table 3**, *Aquarius remigis*, *Formica* sp. and *Chironomus* sp. were the identified species. Of these three species, only the order Hemiptera (Family: Gerridae) *Aquarius remigis* (Water strider) (adult)

Parameter	Site 1 (Ijala-Ikeren mangrove)	Site 2 (Ijala-Ikeren mangrove)	Site 3 (Ijala-Ikeren mangrove)	Site 4 (pond infested with water hyacinth at the fringe of mangrove)	Site 5 (backhouse pond close to the boundary of the mangrove swamp)
Air temperature (°C)	28.00	29.00	29.50	30.00	30.00
Water temperature (°C)	29.00	29.00	28.50	28.00	29.00
pH	4.8	4.7	4.9	5.3	6.1
Salinity (ppm)	1.55	1.50	1.70	1.70	1.58

Table 1.
Mean values of physical parameters of sampled sites in Ijala-Ikeren mangrove swamp and fringes.

S/N	Common name	Scientific name	Habitat	Uses
1	Red mangrove	*Rhizophora racemosa*	Mangrove swamps	Fuel wood, timber
2	Red mangrove	*Rhizophora harrisonii*	Mangrove swamps	Fuel wood, timber
3	Red mangrove	*Rhizophora mangle*	Mangrove swamps	Fuel wood, timber
4	White mangrove	*Avicennia africana*	Mangrove swamps	Fuel wood, timber
5	Screw pine	*Pandanus candelabrum*	Mangrove swamps	—
6	Water hyacinth	*Eichhornia crassipes*	Fringes of mangrove swamp Floating in ponds	—

Table 2.
List of identified flora in Ijala-Ikeren mangrove swamp and fringes.

Order	Family	Species	Site 1 (Ijala-Ikeren mangrove)	Site 2 (Ijala-Ikeren mangrove)	Site 3 (Ijala-Ikeren mangrove)	Site 4 (pond infested with Water hyacinth at the fringe of mangrove)	Site 5 (backhouse pond close to the boundary of the mangrove swamp)
Hemiptera	Gerridae	*Aquarius remigis*	5	8	9	—	—
Hymenoptera	Formicidae	*Formica* sp	25	45	37	—	—
Diptera	Chironomidae	*Chironomus* sp.	—	—	—	17	25
Total no. of taxa			2	2	2	1	1
Total abundance			30	53	46	17	17
Margalef's index (d)			0.29	0.25	0.26		
Shannon diversity index (H′)			0.45	0.42	0.49		
Evenness (E′)			0.65	0.61	0.71		

Table 3.
Biodiversity index (ecological diversity), abundance and distribution of insect species encountered in Ijala-Ikeren mangrove swamp and fringes.

was found in the wetland. Meanwhile, *Formica* sp. (Hymenoptera: Formicidae) were handpicked from hives hanging from mangrove plants using forceps. No significant difference was detected among insect species ($F_{(2,14)} = 1.5$, $P < 0.3$) in their abundance. The most specious abundant was *Formica* sp. (62.6%) followed by the dipteran species; *Chironomus* sp. (24.6%) in total catch of insect individuals (171 individuals).

Spatially, the three study sites in the interior (mangrove swamp) represented the highest percentage (75.5%) of species abundance, where *Aquarius remigis* and *Formica* sp. were the only identified species there. Meanwhile, the other abundance percentage (24.5%) was recorded at the edges (fringes) in the ponds (other two sites) in relating to the abundance of one species; *Chironomus* sp.

As shown in **Table 3**, the study sites at the mangrove swamp were the richest area with species number (2 species), site 1 had the greatest value in Margalef's species richness index (d) and diversity of species out of these sites. On the other hand, site 2 had the least value of both indices.

3.4 Amphibian composition and diversity

A total of ninety-one (91) individual amphibians were collected in this study. Thirteen amphibian species belonging to three different families were identified: Bufonidae, Hyperoliidae and Ranidae. All these species were collected from the edges (fringes) of the mangrove swamp (**Table 4**).

Family	Species	Abundance	Family abundance %
Bufonidae	*Amietophrynus maculatus*	3	3.30%
Hyperoliidae	*Afrixalus dorsalis*	23	60.40%
	Afrixalus fulvoguttatus	2	
	Afrixalus sp.?	1	
	Hyperolius concolor	13	
	Hyperolius fusciventris burtoni	2	
	Hyperolius guttulatus	1	
	Hyperolius sp. 1	12	
	Hyperolius sp. 2	1	
Ranidae	*Hoplobatrachus occipitalis*	6	36.3
	Ptychadena bibroni	4	
	Ptychadena oxyrhynchus	9	
	Ptychadena pumilio	1	
Total no. of taxa		13	
Total abundance		91	
Margalef's index (d)		2.75	
Shannon diversity index (H′)		2.08	
Evenness (E′)		0.08	

*The 'E' which was very manifest in the unidentified Hyperolid (Hyperolius sp 1), Hyperolius occidentalis and Afrixalus dorsalis (***Figure A1***). These could be cryptic colourations to enable them escape detection by predators in their exposed habitats.*

Table 4.
Abundance and distribution of amphibian fauna encountered in Ijala-Ikeren mangrove swamp and fringes.

S/N	Common name	Scientific name
1.	Trunkfish	*Gymnarchus niloticus*
2.	African Bonny Tongue	*Heterotis niloticus*
3.	Characin	*Alestes macrolepidotus*
4.	Moonfish	*Cuherinus cuherinus*
5.	Cyprinit-African Carp	*Labeo* spp.
6.	—	*Eutropius niloticus*
7.	Catfish	*Bagrus bayad*
8.	Silver Catfish	*Chrysichthys nigrodigitatus*
9.	Catfish	*Auchenoglanis occidentalis*
10.	Electric Fish	*Malapterurus electricus*
11.	Niger Perch	*Lates niloticus*
12.	Tilapia	*Tilapia galilaea*
13.	Tilania	*Tilapia aurea*
14.	Tilapia	*Tilapia zilli*
15.	Snakehead	*Channa obscura*
16.	—	*Hemichromis* spp.
17.	Clarias	*Clarias* spp.
18.	—	*Hemichromis fasciatus*
19.	Elephant Snout Fish	*Mormyrus macrophthalmus*
20.	—	*Polypterus senegalus*

Table 5.
Indicative checklist of the fishes found in Ijala-Ikeren wetland.

Hyperoliidae was the most abundant one among the identified species (eight taxa) with an abundance of fifty-five individuals species. One feature of this group was the tendency to present different morphs (colour shade, pigmentation and design). Among this group, the dominant species was *Afrixalus dorsalis* (family: Hyperoliidae). The rare species were *Hyperolius guttulatus* and *Ptychadena pumilio*, *Hyperolius* sp. 2 and *Afrixalus* sp. About 30.8% of the identified species were grass frogs belonging to the family *Ranidae*, the genus *Ptychadena* had the dominant number of species (3 species); *Ptychadena bibroni*, *P. Oxyrhynchus* and *P. Pumilio* (**Table 4**). Meanwhile, only one species; *Amietophrynus maculatus*, was identified belonging to the family Bufonidae.

3.5 Fish fauna diversity

A checklist of the fish species is presented in **Table 5**. Catfish and Tilapia were the dominant species in the entire study area. A total of twenty representative species were recorded throughout.

4. Discussion

The study of vegetation in Ijala-Ikeren wetland clarified the richness of mangrove species, which is covered by about 95% Rhizophora species (red mangrove) and *Avicennia africana* (white mangrove) with 5% other species, mostly *Pandamus candelabrum* and *Eichhornia crassipes*. This vegetation community richness of biotic community is more present and stable [32]. The complete absence of Ephemeroptera, Diptera, Odonata, Coleoptera, Trichoptera and Arachnida especially mesofauna were observed which may be due to the brackish water predominantly. A significant change was also detected in the environmental condition with particular reference to pH value, which was estimated at between 6.3 in 2009 and decreased to 4.8 on the average (acidic value). This may be attributed to the absence of the above listed arthropod orders especially as insects cannot tolerate the slightest change in salinity values beyond the fresh water concentration. This same scenario could be playing out for the amphibians, as none were recorded or encountered in the wetland (within the mangroves). This phenomenon has certainly explained the very low occurrence of species diversity of insects and amphibians populations and occurrences in the wetland ecosystems. This is particular for insects, as no aquatic insect larvae were encountered or collected during the survey period. Similarly, no amphibian eggs/tadpoles or adult forms were encountered inside the mangrove habitats of Ijala-Ikeren wetland.

The acidity of water was explained by [6] who investigated the impact of refinery effluents around Warri Refinery and Petrochemical Company (WRPC) on surface waters of the creeks and soil qualities of host communities within and around Ijala-Ikeren wetland, and concluded the change in water pH to be 6.3, while the soil pH was 6.8 in Ijala-Ikeren wetland. This inference may be related to the discharge of these effluents from Warri Refinery and Petrochemical Company (WRPC) into Warri River which feeds the Ijala waters and also crude oil and its fraction seepages from numerous loading and off-loading jetties within the river which finds its way into the creeks in the Ijala-Ikeren wetland. They further stated that the Warri River is open to flooding which carries various contaminants. Contrary to our findings in water pH, the sediments studies conducted elsewhere in the Mexican pacific and Thailand, recorded alkaline pH values ranging from 6.91 to 7.83 [18, 22].

Secondly, the discovery of illegal toxic waste dumpsites belonging to WRPC within these wetlands (pers. comm.) could increase the pollutant load of the study area. In turn, the highest concentration of calcium and salinity level was reported at the surface water within the wetland as reported by [6] though we did not analyse for calcium and heavy metals in this study. Also, heavy metals in varying concentrations and reasonable quantity from refinery effluents that resulted from Nigeria's crude oil could be one of the contributing factors to the acidic pH values. Especially, the metallic components in crude oil which are in the form of metalloporphyrin chelates, transition metal complexes, organometallic compounds, carbonyl acid salts of polar functional groups and colloidal minerals while other inorganic constituents of crude oil are sulphur, nitrogen, and oxygen [33].

Spatially, the study sites at the mangrove swamp was the richest habitat in terms of species number of insects, site 1 had the greatest value in Margalef's species richness index (d) and diversity of species out of these sites. This result may relate to increasing the renewal of water during high tide as a common phenomenon in the area which could give rise to runoffs of debris from land into the mangrove. On the other hand, site 2 had the least value of both indices. As expected, this study site was characterised by its proximity to oil pipelines which over time had ruptured severely due to vandalisation and outlet that leads into the creeks.

Among the sampled insects, the presence of *Chironomus* sp. and *Aquarius remigis* at low salinity (<2 ppm) and acidic pH of surface water were detected. *Chironomus* sp. (Dipteran-Chironomidae) is tolerant of polluted water and an indicator of poor water quality with reduced oxygen concentration, and unhealthy ecosystem [34, 35]. Therefore, this is a clear indication of the effect of the effluent on the biotic components of the water ecosystem.

Many amphibian species and their eggs are unable to tolerate and thrive in the brackish/salty environments of the mangrove (interior). One species, *H. occipitalis* was however an exception; this frog was encountered in several stagnant pools of water along the earth road leading to the wetland. Some individuals of this frog were sighted in a backhouse pond (edge) sharing boundary with the Ijala-Ikeren mangrove wetland.

So, the presence of *Aquarius remigis* and amphibian species; *Hoplobatrachus occipitalis,* at pH value of 4.1–4.9 indicates that the two species are indicator species of high acidic pH value. Those species whose presence occurred in acidic water bodies are tolerant of such environment and could be good candidate for monitoring changes in pH values in aquatic ecosystem especially brackish water including mangrove swamps. In accordance with the record of [36] these species of frog were found in some Nigerian waters at lower pH value which ranged from 4.1 to 4.2.

The presence of the insect (*Chironomus* sp.) and amphibians (*Hyperolius concolor*, *H. burtoni*, *H. guttulatus* and two unidentified *Hyperolius* species of *Afrixalus dorsalis*, *A. fulvovitattus* and *Afrixalus* sp.) are indicators of high levels of contamination of water from petroleum refinery effluents, however, we did not analyse the content of the effluent. They are indicators of acidic water of pH value between 5.3 and 6.1. In addition, the absence of aquatic insects in the adjacent mangrove swamps within Ijala-Ikeren wetlands tells us of the high level of contamination trends in the mangrove and creeks/creeklets in the area which may have generally affected the density of fish catch (outside overfishing, and using the wrong fishing gears) in the area which is a major source of livelihood for the host communities (personal communication). This invariably has affected the income of the people and also their protein intake. Despite the diversity of fish fauna (20 individual species), the fishermen remarked that the population of fish per catch is fast dwindling a situation they attributed to human induced factor rather than natural. [23] asserted that fish and crustaceans species are well supported in an alkaline pH value of water greater than 7. Furthermore, the absence of amphibians in the mangrove equally raises concern as amphibians have important roles to play within nature and their sensitivity to changing environmental conditions may help determine the health of an ecosystem.

Species richness measures the number of different kinds of species present in a particular area. Margalef's Species Richness index (d) values range from 1 to 5 where the higher index indicates the greater diversity (**Table 3**). Shannon diversity index (H′) takes into account the number of species and the evenness of the species. Diversity (H′) values less than 1.0 are considered very low; between 1.0 and 3.0 have moderate diversity, while any value greater than 3.0 signifies high diversity and ecosystem stability (i.e. similar to a pristine ecosystem). Evenness (E′) refers to how evenly each species is represented in a given ecosystem. Equitability assumes a value between 0 and 1 with 1 being complete evenness.

The abundance was very evident in the order Hymenopteran (*Formica* sp.) (Appendix, **Figure A2**). These could be adduced to the fact that most arboreal ants are at least partially herbivorous—feeding on extra-floral nectaries, food bodies, pollen, epiphylls, and sap. They are also cryptic herbivores that feed on hemipteran honeydew [21, 37, 38].

5. Conclusion/recommendation

Oil pollution from oil spills usually from illegal bunkering and pipeline vandalisation of the petroleum refinery facilities situated less than 2 km to the East of the wetland, and solid waste pollution are the major threats to this unique wetland. The Ijala-Ikeren wetland ecosystem has been affected by industrial activities and pollution, and these have affected the insect species and the amphibians. Based on the findings of this study, it has been established that the wetland ecosystem is highly stressed from contaminants with records of high acidic pH values which has resulted in the absence of aquatic insects and reduced fishes. The study pointed out that over 5 years (between 2009 and 2014) drastic changes in pH values occurred in the wetlands, as it reduced from 6.3 in 2009 to 4.8 in 2014. This could deteriorate more to a very precarious situation in the next 5 years if the pollution source is still left unattended to.

The study has shown that amphibian population in Ijala-Ikeren wetland appeared not to be under threat or extinction in spite of their absence at the mangroves; as thirteen (13) species were encountered with some equally having preference for acidic ponds. The results also showed that degradation of the wetland is on-going and it will be recommended that wetland conservation should be encouraged to forestall further loss of biodiversity. In doing this, adequate channels to set up a national awareness campaign among coastal and marine communities in the Niger Delta in conserving wetlands be identified. This becomes necessary as there are over nine (9) enacted national legislation/Acts for the protection of wetlands but their enforcement has been very weak. So government needs to mobilise in order to save our wetlands.

Government and non-governmental agencies should encourage studies on the inventory of aquatic insect species of water bodies in the host communities around the refinery to determine the health and pollution status of the aquatic ecosystem via funding.

Acknowledgements

The funding for this research was provided by the Duke University Marine Laboratory/Oak Foundation Mini-Grant for marine conservation project to the first author (MAU). We are very much grateful to Duke University Marine Lab at Beaufort, NC USA. Thanks to Mr. Henry Erikowa, managing director of Falcorp Mangrove Park, Ijala-Ikeren in Warri for providing logistics for the team during the study. Special thanks also go to Messrs. Abiloye Erikowa and Festus Arijode for their various field assistance.

Conflict of interest

The authors have not declared any conflict of interests.

A. Appendixes

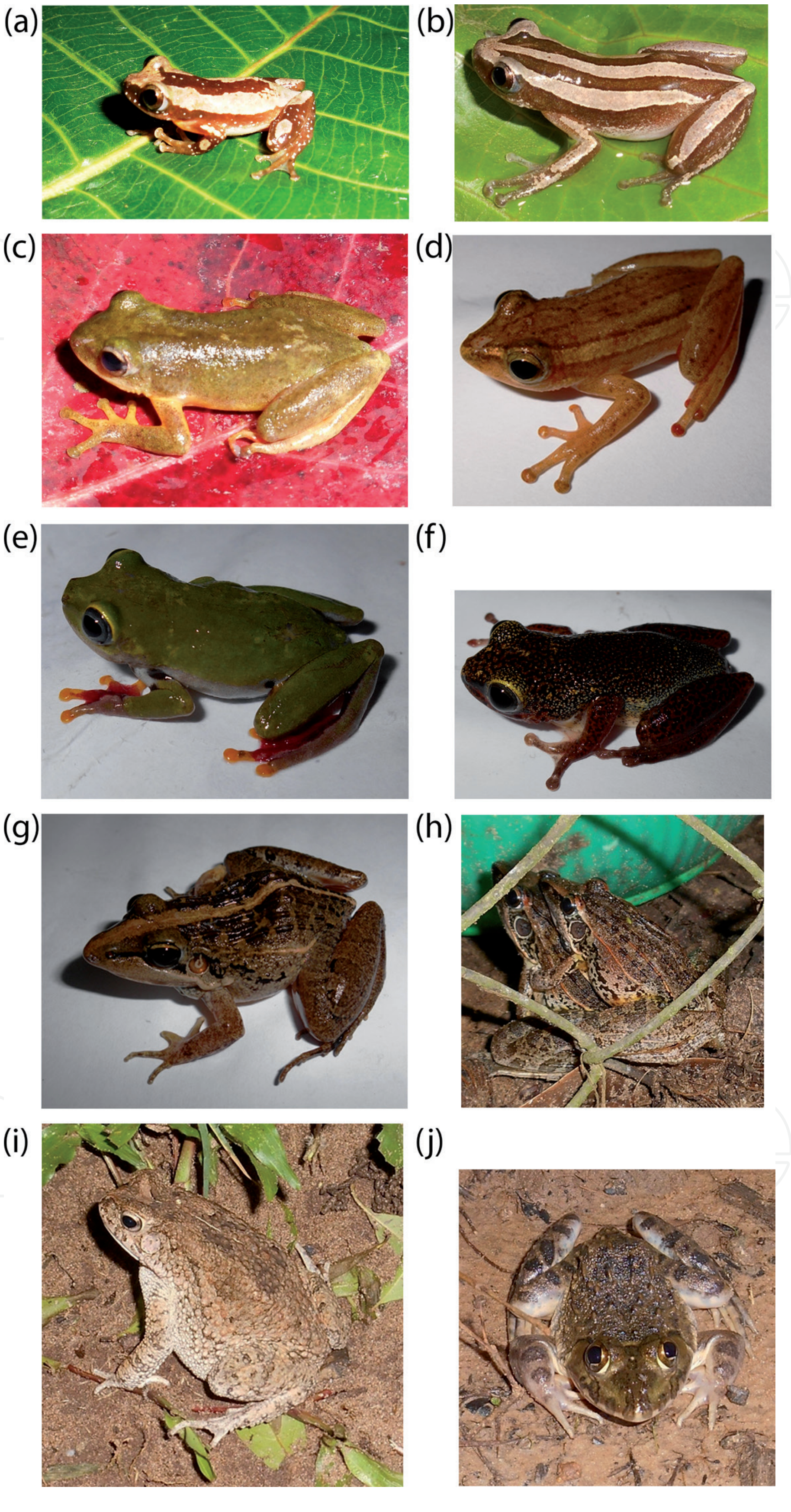

Figure A1.
(A–J) Anurans species encountered at Ijala-Ikeren community. (A) Afrixalus dorsalis; (B) Afrixalus fulvoguttatus; (C) Hyperolius concolor (phase C); (D) H. concolor (phase B); (E) Hyperolius fusciventris burtoni; (F) Hyperolius guttulatus; (G) Ptychadena bibroni; (H) Ptychadena oxyrhynchus; (I) Amietophrynus maculatus; (J) Hoplobatrachus occipitalis.

DOI: http://dx.doi.org/10.5772/intechopen.82604

(k)
(l)
(m)

Figure A2.
(K–M) Insect species encountered at Ijala-Ikeren community. (K) Aquarius remigis; (L) Formica sp; (M) Chironomus sp.

Author details

Michael Aigbe Uwagbae[1,2*], Abdul-Rahman Dirisu[1], Tambeke Nornu Gbarakoro[3], Eman I. El Surtasi[4], Julia Ekenma Agwu[5], Martins S.O. Aisien[1] and Johnny Rotimi[1]

1 Department of Animal and Environmental Biology, University of Benin, Benin City, Nigeria

2 Wetlands International, Port Harcourt, Nigeria

3 Department of Animal and Environmental Biology, University of Port Harcourt, Port Harcourt, Nigeria

4 Department of Zoology, Faculty of Science, Damietta University, Egypt

5 Department of Zoology and Environmental Biology, Faculty of Biological Sciences, University of Nigeria, Nsukka, Nigeria

*Address all correspondence to: mikeuwagbae@gmail.com

References

[1] Abere SA, Ekeke BA. The Nigerian mangrove and wildlife. In: Proceedings of the 1st International Technology, Education and Environment Conference. Human Resource Management Academic Research Society; 2011. pp. 824-834

[2] Longonje SN, Raffaelli D. Feeding ecology of mangrove crabs in Cameroon. Applied Ecology and Environmental Research. 2014;**12**(4):959-973. DOI: 10.15666/aeer/1204_959973

[3] Zabbey N. Impact of livelihoods in Nigeria. In: Paper Presented at the Conference on Petroleum and Pollution—How Does That Impact Human Rights? 27th April, 2009. Kulturhuset, Stockholm, Sweden: Amnesty International, Forum Syd and Friends of the Earth; 2009

[4] Bisong FE. Natural Resource Use and Conservation Systems for Sustainable Rural Development. Calabar: Baaj International; 2001. p. 55

[5] WRI. World Resources. New York: Basic Books; 1986. p. 348

[6] Nduka JK, Orisakwe OE. Effect of effluents from Warri refinery petrochemical company WRPC on water and soil qualities of "contiguous host" and "impacted on communities" of Delta state, Nigeria. The Open Environmental Pollution & Toxicology Journal. 2009;**1**:11-17

[7] Sustainable Livelihoods and Biodiversity Study (SLBP). Ajaetan/Ijala-Ikenren communities Ecological Survey Report. Wetlands International-Africa; 2013. pp. 1-78

[8] Nagelkerken I, Blaber SJM, Bouillon S, Green P, Haywood M, Kirton LG, et al. The habitat function of mangroves for terrestrial and marine fauna: A review. Aquatic Botany. 2008;**89**:155-185

[9] Wallace JB, Webster JR. The role of macroinvertebrates in stream ecosystem function. Annual Review of Entomology. 1996;**41**:45-19

[10] Woodcock TS, Huryn A. The response of macroinvertebrate production to a pollution gradient in a headwater stream. Freshwater Biology. 2007;**52**(1):77-196

[11] Whiles MR, Wallace JB. Leaf litter decomposition and macroinvertebrate communities in headwater streams draining pine and hardwood catchment. Hydrobiologia. 1997;**351**(1-3):107-119

[12] Suter GW, Cormiery SM. Why care about aquatic insects: Uses, benefits, and services. Integrated Environmental Assessment and Management. 2014;**11**(2):188-194

[13] Hocking DJ, Babbitt KJ. Amphibian contributions to ecosystem services. Herpetological Conservation and Biology. 2014;**9**(1):1-17

[14] IUCN. The IUCN Red List of Threatened Species. Version 2016-2. Available from: http://www.iucnredlist.org [Accessed: 04 September 2016]

[15] Anouti FA. Bioaccumulation of heavy metals within mangrove ecosystems. Journal of Biodiversity and Endangered Species. 2014;**2**(2):1-2

[16] Ratheesh Kumar CS, Joseph MM, Gireesh Kumar TR, Renjith KR, Manju MN, Chandramohanakumar N. Spatial variability and contamination of heavy metals in the inter-tidal systems of a tropical environment. International Journal of Environmental Research. 2010;**4**(4):691-700

[17] Maiti SK, Chowdhury A. Effects of anthropogenic pollution on mangrove biodiversity: A review. Journal of Environmental Protection. 2013;**4**(12):428-1434

[18] Kaewtubtim P, Meeinkuirt W, Seepom S, Pichtel J. Heavy metal phytoremediation potential of plant species in a mangrove ecosystem in Pattani Bay, Thailand. Applied Ecology and Environmental Research. 2016;**14**(1):367-382. DOI: 10.15666/aeer/1401_367382

[19] Alongi DM. The Energetics of Mangrove Forests. New York: Springer; 2009

[20] Barbier EB, Hacker SD, Kennedy C, Koch EW, Stier AC, Silliman BR. The value of estuarine and coastal ecosystem services. Ecological Monographs. 2011;**81**(2):169-193

[21] Osland MJ, Enwright N, Day RH, Doyle TW. Winter climate change and coastal wetland foundation species: Salt marshes vs. mangrove forests in the southeastern United States. Global Change Biology. 2013;**19**:1482-1494

[22] Gutiérrez JCS, Ponce-Palafox JT, Pineda-Jaimes NB, Arenasfuentes V, Arredondo-Figueroa JL, Cifuentes-Lemus JL. Comparison of the mangrove soil with different levels of disturbance in tropical Agua Brava Lagoon, Mexican Pacific. Applied Ecology and Environmental Research. 2016;**14**(4):45-57. DOI: 10.15666/aeer/1404_045057

[23] Olomukoro JO, Dirisu AR. Macroinvertebrate community and pollution tolerance index in Edion and Omodo Rivers in derived Savannah wetlands in southern Nigeria. Jordan Journal of Biological Sciences. 2014;**7**(1):19-24

[24] Braun-Blanquet J. Pflanzensoziologie, Grundzüge der Vegetationskunde. 3rd ed. Berlin: Springer Verlag, Wien; 1964. p. 865

[25] Merritt RW, Cummins KW, Berg MB. An Introduction to the Aquatic Insect of North America. 4th ed. 2008. p. 1158

[26] Abowei JFN, Ukoroije MBR. The identification, types, taxonomic orders, biodiversity and importance of aquatic insects. British Journal of Pharmacology and Toxicology. 2012;**3**(5):218-229

[27] Umar DM, Harding JS, Winterbourn MJ. Freshwater Invertebrates of the Mambilla Plateau, Nigeria. 1st ed. 2013. pp. 10-68

[28] Blüthgen N, Gebauer G, Fiedler K. Disentangling a rainforest food web using stable isotopes: Dietary diversity in a species-rich ant community. Oecologia. 2003;**37**:426-435

[29] Peet RK. The measurement of species diversity. Annual Review of Ecology and Systematics. 2003;**5**(1):285-307

[30] Lande R. Statistics and partitioning of species diversity, and similarity among multiple communities. Oikos. 1996;**76**:5-13

[31] Hammer Ø, Harper DAT, Ryan PD. PAST: Paleontological statistics software package for education and data analysis. Palaeontologia Electronica. 2001;**4**(1):9

[32] Mackie GL. Applied Aquatic Ecosystem Concepts. University of Guelph Custom Course back. Iowa, USA: Kendall Hunt Publishing Company; 2004. p. 724

[33] Achi SS, Shide EG. Analysis of trace metals by wet ashing and spectrophotometric techniques of crude oil samples. Journal of Chemical Society of Nigeria. 2004;**29**(11):11-24

[34] M'Erimba CM, Mathooko JM, Karanja HT, Mbaka JG. Monitoring water and habitat quality in six rivers draining the Mt. Kenya and Aberdare catchments using macroinvertebrates and qualitative habitat scoring. Egerton Journal of Science and Technology. 2014;**14**:81-104

[35] Dirisu AR, Olomukoro JO. Investigation of water quality of two rivers in Agbede wetlands in southern Nigeria. Global NEST Journal. 2015;**17**(3):451-462

[36] Taiwo IE, Amaeze NH, Adie PI, Adetoro OO. Heavy metal bioaccumulation and biomarkers of oxidative stress in the wild African tiger frog, *Hoplobatrachus occipitalis*. African Journal of Environmental Science and Technology. 2014;**8**(1):6-15

[37] Davidson DW, Cook SC, Snelling RR, Chua TH. Explaining the abundance of ants in lowland tropical rainforest canopies. Science. 2003;**300**:969-972

[38] Hunt JH. Cryptic herbivores of the rainforest canopy. Science. 2003;**300**:916