STUDIES ON THE ECOLOGY AND CONTROL OF*TYPHA* SPECIES IN HADEJIA-NGURU WETLANDS, NIGERIA

BY

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PhD./SCIE/00067/2006-07

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July, 2015

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A DISSERTATION SUBMITTED TO THE POST GRADUATE SCHOOL AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (Ph.D) IN BOTANY

DEPARTMENT OF BIOLOGICAL SCIENCES, FACULTY OF SCIENCE, AHMADU BELLO UNIVERSITY, ZARIA.

July, 2015

DECLARATION

I declare that this thesistitled**"Studies on the Ecology and Control of *Typha* species in Hadejia-Nguru Wetlands, Nigeria"**is my personal work in the Department of Biological Sciences. Ahmadu Bello University, Zaria under the supervision of Prof**.** M.L Balarabe, Prof.A.U. Khan and Prof. A. K. Adamu.This work has not been presented in any form for another qualification at any other university or institute.Informationderived from othersourceshavebeen duly acknowledged in the text and list of references provided.

YAKUBU ABDULLAHI BIRNIN-YAURI _______________ _______________

Signature **Date**

CERTIFICATION

This Dissertation entitled **"STUDIES ON THE ECOLOGY AND CONTROL OF *TYPHA* SPECIES IN HADEJIA NGURU WETLANDS, NIGERIA".**By Yakubu Birnin-Yauri ABDULLAHImeets the regulations governing the award of the degree of Doctor of Philosophy (PhD) in Botany of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This research work is dedicated to my parentsAlhaji Abdullahi Suleman andLate Safiya Salihu

ACKNOWLEDGEMENT

I wish to express my sincere appreciation to the chairman of my supervising team Prof. M. L. Balarabe for accepting to supervise me and for his untiring efforts in encouraging me to finish this work. I am highly indebted to my other supervisors Prof.A.U.Khan and Prof. A. K. Adamu (Dean Faculty of Science and (Head of Biological Sciences Department) for their encouragement and motivation for me to finish the work. I shall forever remain grateful for their encouragement, patience and sincerity with this work.

I sincerely appreciate the efforts of Prof. S.P. Bako, Dr Aminu Raji (FormerExecutive Director of NIFFR), Dr. A.N. Okaeme (The Executive Director of NIFFR), Dr. S. I. Ovie, Dr.Mbagwu, Dr. N.O Bankole, Dr. J. Biodun, and late Dr. Femi Daddy (May his gentle soul rest in perfect peace) for criticizing my work and offering suggestions to improve the work.

Dr. D. B. Dangora, Dr D. M.Shehu M. Alassan Rara for their advice and assistance. I wish to thank Mrs Dele Amoa, Dr. Ibio Malam, Zulkifilu Abdullahi,   M. Musa Abdullahi, M.Sule M. Abdullahi, M.Yusuf Abdullahi, Mr. Elijah Aina, Mr Stephen Owotunse, M. Sani Pandogari M., Mansur Hassan and Hadejia Nguru Wetlands Project, who assisted in the actualization of this work. I am grateful to my parents M.Abdullahi Sule and late Safiya Salihu (May her soul rest in perfect peace) who encouraged and assisted me in many ways.

Lastly; I thank my wife Hajiya Aishat Hassan and children; Idris, Fatima, Khadijat, Zainab, Mohammed Sani and Safiya for their encouragement, support and understanding especially under difficult conditions.

ABSTRACT

Aspects of ecology and managementof*Typha* species in Hadejia-Nguru wetland were studied for a period of twenty-four months between January 2010 to December 2011.The aim was to identify the residentspecies of *Typha*, physico-chemical parameters, soil and sediment associatedwith proliferationof*Typha*species, profer Management solutions to Hadejia-Nguru wetlands community. The Hadejia Nguru wetland has an area of about 58,100 hectares of which35,000 hectareswere infested by *Typha* species.*Typha* proliferationcauses a number of ecological problems which includetransformation of aquatic environments into terrestrial ones, interference with various methods of catching fish,blockade of river channels and impeding navigation.Generallytheybecame a nuisance by affecting social and economic well-being of the people who ultimately depend on the wetlands for their livelihoods**.** It also alters the biodiversity of aquatic ecosystems as well as a reduction in light penetration within the aquatic system.The study involved dividing the wetlands into three segment Upper, Middle and Lower courses.*Typha* species, water,soil and sediment samples, were collected in these segmentsand impact of *Typha* species on fish catch and distribution was evaluated by dividing each segment into two, *Typha* un-infested and *Typha* infested area. For the biological control; each segment was divided into four each containing 2000 species of *Typha* interplant with 50kg, 25kg, 10kg and without *Phragmites karka* respectively. Manual control each segment was divided into six as cutting *Typha* 15 cm, 10cm, 5cm below and15cm, 10cm 5cm above water. For physical control each segment was divided into four using single black tarpaulin, double, triple and without black tarpaulin.*Typha latifolia* and *Typha angustifolia*accounted for 64-70% and 30% of the *Typha* species of the wetlands respectively. The physico-chemical parameters of water and sediment of the wetlands showed significant variations, in water PO_4-P, NO_3-N and Mg;ranging from 3.5-13.5 mg/l, 3-13mg/l and 1-10mg/l respectively. The sediment values showed that phosphate-phosphorus rangedfrom 6.5-16mg/kg, Nitrate-nitrogen 6-14mg/kg and Organic matters concentration 4-12mg/kg.The further result indicated that, water PO_4-P, NO_3-N and Mg concentration favour the growth and proliferation of *Typha.* A similar trend was exhibited by sediment Phosphate-Phosphorus, Nitrate-Nitrogen and organic matter concentration.

The concentrationof water PO_4-P, NO_3-N, Mg and sedimentPO_4-P, NO_3-N, and Organic matter along the three segments showed that the upper course had greater, concentration than the middle and that of the middle is greater than the lower course. The same trend was observed in the distribution of *Typha latifolia* and *Typha angustifolia*. The result ofimpact on fish catch and distribution showed that open water has the highest number and weight of fish caught than *Typha* infested area, ranging between83,167 to 173,026kgand 14,402 to 59,355kg respectively. The control of *Typha* proliferation involved biological, manual and physicaltechniques. The use of *Phragmites karka* for Biological control reduced*Typha*species proliferation by 25%, Manual cutting at 15cm below water level accounted for 95% of total control. The use of shade with black tarpaulin reduced*Typha* proliferation by 54%. The best control method was that of cutting at 15cm below the water surface**.**The findings recommended that,farmers should be sensitized on appropriate farming system particularly the involving the use of manure instead of inorganic fertilizer and the best time to control *Typha,* when theirdensity is low which is at the peak of the wet season.

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ABBREVIATIONS

Abbreviation	Descriptive name
APIS	Aquatic Plant Information System
BOD	Biological Oxygen Demand
CPOM	Coarse Particulate Organic Matter
FPOM	Fine Particulate Organic Matter
DO	Dissolved oxygen
DOC	Dissolved Organic Carbon
DOM	Dissolved Organic Matter
HNW	Hadejia Nguru Wetlands
HJKYB	Hadejia- jam ‘are Komadugu-Yobe Basin
KYB	Komadugu-Yobe sub Basin
NO_3-N	Nitrate- nitrogen
OC	Organic carbon
OM	Organic matter
PO_4-P	Phosphate- Phosphorus
POM	Particulate organic matter
POC	Particulate Organic carbon
TOC	Total Organic Carbon
TDA	Trans Boundary Diagnostic Analysis

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Mitsch and Gosselink (1986) defined wetlands as lands that are transiting between terrestrial and aquatic ecosystems where the water table is usually at or near the surface, or the land is covered by shallow water (Prasad *et al.,* 2002).The importance of wetlands is increasingly receiving attention as they contribute to a healthy environment in many ways. This comprises a vast complexity of direct and indirect uses (Acharya, 1998), which include: (1) water retention during dry periods, thus keeping the water table high and relatively stable; (2) flood mitigation and (3) trapping of suspended solids and attached nutrients, thus, streams flowing into lakes by way of wetland areas will transport fewer suspended solids and nutrients to the lakes than if they flow directly into the lakes (Prasad *et al*., 2002).Removal of such wetland systems because of urbanization or other factors typically affects wetland water quality (Barbier, 2002).

Additionally, wetlands are important areas for wildlife, because they provide resting and stop-over places, as well refuges for migrating and resident animals (Lameed, 2011). As with any natural habitat, wetlands are important in supporting species diversity. Other values include the use of the wetlands for domestic and agro-industrial water supply (Ibrahim and Chiroma, 1998), harvesting of wetland bio-resources, such as, fish and plants, and the function of wetlands in groundwater recharge and discharge (Yahaya *et al.,* 2010).

The Hadejia-Nguru wetlands are on the list of Ramsar wetlands of international importance**,** meaning 58,100 ha in sizeand are designated asRamsar Site**.**The wetlands are important for water birds, both as breedingground and water for birds. The estimated water bird population varies between 200,000 and 325,000with about 377 bird species seen in the wetlands, including occasional sightings of the near-threatened pallid harrierandgreat snipe species (Sanusi and Daura, 2006).

North east of Nigeria in the early 60’s and 70’s hadserious problem of drought, andin order to ameliorate the problem, water scheme was intensified upstream. This led to the construction of Tiga Dam, and subsequently emergence of aquatic weeds, especially *Typha* species, a nuisance affecting social and economic well-being of the people who ultimately depend on the wetlands. Some of the problems associated with *Typha* weeds include blockage of river channels, though also provides breeding and nesting site for Quelea birds (Sanusi and Daura, 2007).Hadejia Nguru Wetlands (HNWs) is located in the Sahel zone of north-eastern Nigeria. The area is a floodplain wetland comprising of permanent water bodies and seasonally flooded areas. About 40% of the wetlands remain wet throughout the year, resulting in mats of *Typha* (now extensive: over 200ha, compared to 550ha in 1999) (Sanusi and Daura, 2007).

The prevalence of *Typha* species was identified first in the Lake Chad Basin, as one of the seven priority regional environmental concerns in the basin Trans-boundary Diagnostic Analysis (TDA) (Sanusi and Daura, 2007). Others are variability of the hydrological regime and fresh water availability, water pollution, decrease viability of biological resources, loss and modification of ecosystem, and sedimentation in rivers and water bodies. However, the problem is mostly seen in the Komadougou-Yobe sub Basin (KYB), Chari Logone sub system and the lake itself. In the KYB sub-system, there are two prominent invasive species, *Typha* species and Quelea birds. In the Chari-Logone system it is water hyacinth while the lake has been invaded by *Typha* species.*Typha* is a species of water loving plants that can, under favourable conditions (i.e. in shallow permanently inundated areas) proliferate and become difficult to control making it an invasive species. Under such conditions it out-competes almost all other plants.

In Hadejia-Nguru wetland in particular and other parts of Hadejia-Jama'are-Komadugu-Yobe Basin (HJKYB) in general, the invasion of *Typha* specieshas for the past years constituted one of the most alarming threats to the economy and ecology of the area. In recent years, river channels, lakes and fadamas in the wetlands have been taken over by *Typha*along with many hectares of farmlands and potential grazing lands. On the Marma Channel and Nguru Lake (a section of Hadejia-Nguru wetlands) for an example, where *Typha* invasion is more severe, over 35,000 hectares of potential farming and grazing lands have been taken over by the *Typha* species. Conversely, it has also contributed to the desiccation of Burum Gana Channel, where about 60% of dry season irrigation farms have been hindered. In addition, *Typha* provides a harbor for large flocks of Quelea birds (another invasive bird species in the basin),which is a cereal crops pest (Sanusi and Daura, 2007).

The major environmental impact of weed infestation is the blockage, and in some instances even diversion of channels. This has led to parallel incidences of channel desiccation and inundation in the HNWs, the net consequences of which have been loss of livelihoods, poverty and resources use conflicts (Lameed,2011).

1.2Statement of Research Problem

Typha speciesproliferation causes anumber of ecological problems in Nigeria with similar cases reported in Malaysia,andEgypt. Theseincludes blockage of river channels and impending navigation, fishing and secondary succession**.** *Typha* specieshas become a nuisance affecting social and economic well-being of the people thatdepend on the wetland for their livelihoods.It also alters the biodiversity of aquatic ecosystems as well as a reduction in light penetration within the aquatic system. In 2002 the National Institute for Freshwater Fisheries Research (NIFFR) revealed that, this plant was responsible for the above problems in Hadejia, Nguruwetland. Other problems associated with*Typha* includes interference with various methods of catching fish and competing with rice in paddy system,*Typha* speciesserve as host to the vectors of cholera, bilharzia (schistosomiasis,), malaria and dysentery (WHO, 2011). It also serves as a shelter to Quelea birds, which feed on the grains (Agricultural Research, 2010).*Typha* decreases incomes and hence, increases poverty level of communities around the wetlands. *Typha* speciesalso cause conflicts among farmers and blockade of channels for irrigation.so far little have been done about the control measures. Farmers burn thesurface of *Typha* species during dry season, with no impact on the rhizomes, which later sprout the shoot. These necessitate the urgent need to proffer solution in the control and management of *Typha* speciesin Hadejia Nguru wetland Nigeria.

1.3 Justification of the Study

The importance of Hadejia Nguru Wetland to the socio-economic well-being of inhabitants of the area cannot be over emphasized. This research among other things provides information on proliferation of *Typha*species, the physio-chemical parameters, soil, sediment responsible for the proliferation of *Typha* species and its impact on fish catch and distribution. *Typha* speciesproliferation could degradeand deteriorate water quality resulting in reduce dissolved oxygen concentration level, and consequently impose stress on the survival of aquatic animals(Thompson, 2010). Thus, there is need to also investigate the physico-chemical parameters of the wetlands.

Therefore, this study becomes essential since over 5 million people in Hadejia-Nguru wetland, depend on this wetland for source of livelihood, and also being an important internationally recognized ecological site. This study will provide useful results and experience necessary for management of *Typha* species proliferation.

1.4 Aim and Objectives of the Study

The aim of the study was to investigate the diversity and impact of *Typha*species in Hadejia-Nguru Wetland and proffer management optimism for sustainable ecology, with the following specific objectives:

1. To identify the species of *Typha* resident in Hadejia-Nguru Wetlands and their relativeabundancemonthly for the period of two years.
2. To determine the monthly physico-chemical parameters associated with *Typha* species proliferationfor the period of two years.
3. To evaluate the soil, nutrients status and characteristics that supports the growth of *Typha* species,monthly for the period of two years.
4. To determine the impact of *Typha* specieson fish catch and distribution, monthly for the period of two years
5. Todetermine the bestmanagement practice for Hadejia Nguru wetland community.

1.5 Hypotheses (Null)

1. There are no different species of *Typha* resident in Hadejia Nguru wetland.
2. There are no relationships between physico-chemical parameters and *Typha*speciesproliferation.
3. There is no significant difference among seasonal variation, soil characteristic, nutrientsand soil structure that supports the performance of *Typha* species in the area.
4. There is no significant effect on the impact of *Typha* species infestation on fish catch and distribution.

5. There is no significant difference among the various management practices on control of *Typha* species.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Description and Ecology of *Typha* species.

Typha, from the Greek truth (*Typhe*) "bulrush, or Canadian term or generally called "cattail" are among common of all aquatic plants. They are often a nuisance but also perform an important function in keeping a lake healthy by filtering the runoffs.In West Africa,*Typha angustifolia*, *Typha latifolia*, *Typha gluca*,*Typha australis* and *Typha elephantine* are common (Smith, 2004). In Nigeria, Daddy(2006) reported *Typha australis* in Tatabu flood plain, while NIFFR (2005) reported *Typha latifolia* in Asa Lake.

Typhalatifolia forms a dense monoculture when there is a wetland disturbance. They can reach up to 2 or 3 metres in height and grow prolifically from thick underground rhizomes, forming dense rhizome mats and litter which have an impact on species diversity by alteration of habitat. Dense *Typha latifolia* growth and litter may reduce the opportunity for other plants to establish or survive.

The plant is a weed with densely packed tiny flowers;a male flower ison top cluster and female flower is at bottom cluster (USEPA, 2007). The stem can be more than one foot long with leaves strap-like and stiff, rounded on back, flat and D shaped. Leaves are straight at the bottom half but twisted and spiral at the top,thick and pale grayfish-green in colour especially during May and June with tiny and tufted nutlet fruit(USEPA, 2007). USEPA (2007) reported that cattail can be distinguished by the following; "male flowers are brown, minute, >1.3cm long, thickly clustered, anthers 1-3mm long. Female flowers are tiny, 2-3mm long when in flower, 10-15mm long when in fruit. Female fruiting spike are pale green when flowering, drying to brownish, later blackish brown or reddish brown in fruit. The seed are minute and numerous.

2.2 Taxonomy

*Typha*species belong to Kingdom Plantae, Division Magnoliophyta, the Angiosperms (flowering plants), Family Typhaceae, Class Liliopsida, (the Monocotyledons), Subclass Commelinidae, Order Typhales, the cattails, Genus *Typha*. There are several species, *T. angustata (*Bory and Chaub), *T. angustifolia*, *(*Schum and Thonn., *T. capensis* (Rohrb) N E.Br, .*T. domingensis pers*., *T. elephantine* Roxb., *T. laxmannii* (*Lepech.*), *T. orientalis* (C. presl), *T. davidiana* (Kronf.)Hand-mazz., *T. latifolia* L,*T minima* (Funck exHoppe), *T. shuttleworthii* (Kock and sond.).

2.3 Occurrenceof *Typha* Species

Typha species are found in**c**oastlands, estuarine habitats, lakes, riparian zones, water courses, Wetlands,geographical range.Native range: Alaska, Continental US, Hawai (Smith, 2004). Africa (Algeria; Morocco; Ethiopia; Kenya; Tanzania; Uganda and Nigeria); Asia-temperate (Afghanistan; Iran; Israel; Jordan; Lebanon; Syria; Turkey; Armenia; Azerbaijan; Georgia; Russian Federation - Ciscaucasia, Dagestan; Russian Federation; Kazakhstan; Kyrgyzstan; Turkmenistan; Uzbekistan; Mongolia; China and Japan); Asia - tropical (Pakistan); Europe (Denmark; Finland; Ireland; Norway; Sweden; United Kingdom; Austria; Belgium; Czechoslovakia; Germany; Hungary; Netherlands; Poland; Switzerland; Belarus; Estonia; Latvia; Lithuania; Moldova; Russian Federation - European part; Ukraine; Albania; Bulgaria; Greece; Italy; Romania; ex-Yugoslavia; France; Portugal; Spain), Northern America (Canada, USA); Southern America (Guatemala; Mexico; Brazil; Argentina; Paraguay) (Smith, 2009).

Known introduced range: Naturalised in Australia, present in New Zealand, South America and the Caribbean (Smith, 2009).

Typha plant grows where soil remains wet, saturated or flooded in most of the growing season in shallow freshwater and occurs in slightly blackish marshes. It prefers soil with high amounts of organic matter, and also grows on fine texture mineral soils with a wide gradient of substrate types. Wet pure sand, peat, clay and loamy soils have been documented under *Typha* stand. Seed germination can be 100 percent in slightly flooded conditions (Smith, 2004). *Typha latifolia* seeds are tolerant to salt (NaCL) concentrations in the substrate when compared to *Typha angustifolia*seeds. However, seed of both species, when soaked in salt solution, would germinate after being returned to non-saline conditions (McMillan, 2007). *Typha angustifolia*, seeds showed no significant germination response when sprouted along a moisture gradient, which ranged from 5cm below substrate to 10cm above (Keddy and Ellis, 2000). Other studies have confirmed that water is required at a depth of 2.54cm for germination. Sifton (2009) showed that light and low oxygen tension affected germination of broad-leaved cattail. The seed of *Typha* species when mature usually fall directly into water. However, the number of days it require to stay in water before germination is not properly known but it has been suggested by Smith (2004) that for proper storage, seed of aquatic plants should be kept in water.Vander Valk and Davis (2006) suggested that the germination of *Typha* seeds or growth could be inhibited by an allelopathic interaction caused by *Typha* litter or any allelopathic plant within the environment. Seed longevity and dormancy may be affected by soil moisture temperature and soil atmosphere (Morinage, 2006).

*Typha latifolia*rapidly colonizes exposed wet mineral soils, as it produces an extremely high number of windand water dispersed seeds (Smith, 2004). It reproduces by seed and vegetatively by rhizomes. Vegetative reproduction occurs through an extensive rhizomes system and is responsible for the maintenance and expansion of existing stands. Sexual reproduction is *via* seed dispersal and seedling establishment is responsible for invasion of new areas.*Typha* grows rapidly from seeds in favourable substrates. *Typha* colonies are commonly maintained by vegetative reproduction. A perennial root stock is the major organ responsible for reproduction (Apfelbaum, 2005). Net annual of *Typha* production has usually been estimated as the maximum standing crop (shoot biomass) values for a good site is between 1000 and 1700 g/m (d.w.) (Gustafson, 2006). *Typha*production mostly exceeds the average standing crop yields for maize and sorghum.*Typha* species seed may be transported by wind, water, mud on the feet of birds and livestock, or by humans and machinery. Up to 95% of all seed produced is viable (Smith, 2009).

Shoot density report (numbers of stems per square meter) range from 28/m^2 (Lieffers, 2003). *Typha* can produce 20,000-700,000 fruits per inflorescence (Prunster, 2003; Marsh, 2003; Yeo, 2009). The total biomass in the *Typha* is caused by higher concentration of Carbon, Nitrogen and Phosphorus. A possible explanation for this could come from a study by Denny (2008), which found that *Typha latifolia* contain internal gas spaces with elevated carbon concentrations causing carbohydrate formation and subsequently growth to be higher than in most terrestrial C3 plants. This may be partially responsible for the higher production of *Typha*in wetlands.

2.4 Usesof *Typha*Species

Typha is used for thatching of roof, or woven into mats, chairs and hats; it is a source of fibres for rayon and a crude, greenish brown paper; torches and tinder.Its pollen is used in making fireworks; stuffing pillows, insulation, crude floatation devices, wound dressing, and lining for diapers (Bray and Kurtz, 2014).*Typha latifolia* stands provide important food cover for wildlife and birds. They establish habitats for waterfowl and are especially valuable in attracting nesting red-winged blackbird. Muskrats use the foliage to construct their lodges, which in turn provide resting and nesting sites for water birds (Smith, 2004).

Many parts of this plant are edible by human. Smith (2004) stated that the "native Americans used the leaves and stems as food. Rhizomes are dried and ground into flour or eaten as cooked vegetables; the pollen is used in baking (Bray and Kurtz, 2014). Young stems are eaten raw or cooked; and immature fruiting spikes are roasted". The rootstocks and rhizomes are important source of food when other food is scarce (Bray and Kurtz, 2014).

2.5 Physico-chemical Properties of WetlandsEcosystem

The quality of any given water body is governed by its physical, chemical and biological factors, all of which interact with one another and greatly influence its productivity (Adams *et al*., 2009). The interactions of these factors (physical, chemical and biological)with their catchments are influenced by atmospheric deposition, evapotranspiration and land use, all of which are strongly affected by climate (Stennis, 2013). Climate change in combination with human induced eutrophication of lakes via nutrient loading through agriculture, industry, sewage release, and soil erosion can lead to adverse consequences for ecosystem functioning and services. As a consequence of such anthropogenic nutrient enrichment, wetlands may experience large proliferation of *Typha* species, algal blooms, oxygen deletion, decreased biodiversity, and massive fish kill (Schultz, 2006; Moss, 2008).

Wetlands have different characteristics. The most common feature of all wetlands is that the water table (the groundwater level) is very near to the soil surface or shallow water covers the surface for at least part of the year. The main characteristics of a wetland are determined by the combination of salinity of the water in wetland, the soil type, plants and animals living in the wetland. High variability of these conditions and different needs distinguish among different types of wetlands, and so far, there is no single wetlands classification system that would account for the manifold aspects of this specific ecosystem type. However, the two major types of classification of wetlands are based on traditional concept of a wetland, and the second is based on scientific grounds.

2.6 Physico-chemical parameters and T*ypha* species Distribution

2.6.1 Temperature

Typha speciestolerate wide range of temperatures as low as -34°C and conditions where bodies of water are frozen from September to May (Grace and Harrison, 2006). At the other extreme, *Typha* species population can persist in warm desert habitats such as Arizona sites, which receive rainfall of less than 100 mm (Mcvea and Boy, 2009). *Typha* species can also survive in warm climates with high levels of humidity and plentiful rainfall, such as the Everglades region in southern Florida.Greathead, (2010)reported that temperature do not influence *Typha* species density.

2.6.2 Turbidity

The distribution of macrophytes within the Condamine Balonne River in the Murray Darling catchments, found that submerged species were not present where turbidity was greater than 20-30 NTU. In another study by Blanch (2011) higher water turbidity does not affect growth and performance of *Typha* species.

2.6.3 Conductivity

High concentrations of organic materialsincrease theconductivity of shallow water bodies which usually results in higher potential fish yield conductivity as high as 380.63µscm^{-1} is indicative of eutrophication of lakes in tropical regions (Dillon *et al.*,1990). The relationship of conductivity to ionized matter concentrations varies with both the quality and quantity of the ions present (Sanjer and Sharma, 1995b). Sifton (2009) revealedthat*Typha* speciesperformedwellunderdifferent conductivity concentrations. Lower or higher conductivity do not affect *Typha* species density;the rhizome is able to utilized low and high conductivities.

2.6.4 pH (Hydrogen ions)

The pH of water determines the solubility (amount that can be dissolved) in water and biological availability-(amount that can be utilized by aquatic life) of chemical constituents such as phosphorus, nitrogen, carbon, and heavy metals (lead, copper, cadmium etc.). The level of pH whether low or high may also determine whether it can be used by aquatic organisms.In the case of heavy metals, the degree to which they are soluble determines their toxicity; metals tend to be more toxic at lower pH because they are more soluble (Moore, 1989).

In wetlands, lake and pond, the water's pH is affected by its age and the chemicals discharged by communities and industries. Most lakes are basic (alkaline) when they are first formed and become more acidic with time due to the build-up of organic materials. As organic substances decay, carbon dioxide forms and combines with water to produce a weak acid called carbonic acid and this lower water pH (EPA, 2013). When acidic water comes into contact with certain chemicals and metals, they often make them more toxic than normal water (Bruton, 2005).

Goodman (2002) reported that*Typha latifolia*is tolerant to wide ranges of (lower and higher) pH. However,Hollis *et al*.,(2003) made a similar observationof *Typha latifolia*where growth was sustained at pH 3.5, 5.0, 6.5 or 7.0 and with $NH_4^+NO_3$ as the sole N-source. In addition, the effects of pH and nutrient sources on H^+ extrusion and Adenine nucleotide contents were examined. *Typha latifolia* was able to grow with both nutrients source at near neutral pH levels, but the plant had higher relative growth rates, higher tissue concentrations of the major nutrientswhen grown on $NH4^+$.Growth almost completely stopped at pH 3.5, irrespective of nutrients source, probably as a consequence of pH effects on plasma membrane integrity.

2.6.5 Dissolved Oxygen (DO)

Oxygen levels can be reduced through over fertilization of plants by run-off from farm fields containing phosphate and nitrates (the ingredients in fertilizer). Under these conditions, the number and size of water plants increase a greater deal, then if the weather becomes cloudy for several days, respiring plants will use much of the available DO, andwhen these plants die they become food for bacteria, which in turn multiply and use large amount of oxygen (Beeton, 2002). The solubility of oxygen in water increases with decreasing water temperature and *Typha* species proliferation (Dillon *et al*., 1990). Prakash *et al.* (1994) reported that optimum dissolved oxygen level in natural water bodies ranged between 4 to 6mg/l, this level could rise up to 10mg/l in mid dry season (January to February) during harmattan when surface water temperature is minimal due to influence of the north east trade wind.Smith (2004) reported higher concentration of oxygen in *Typha* species infested area than non-infested area because *Typha* species released oxygen during photosynthetic activities.

2.6.6 Biological Oxygen Demand (BOD)

Biological oxygen demand is the measured amount of oxygen required by acclimated micro-organisms to biologically degrade the organic matter in water (Henry and Heinke, 2005). Biological oxygen demand is the most important parameter in water pollution, as measure of organic pollution, as a basis for estimating the oxygen needed for biological processes, and as an indicator of process performance (EPA, 1986).Green (2013) reported that low BOD affectmicroorganism, which play vital roles in decomposition of organic matter utilized by

Typha species. If there is low BOD the decomposition will be slow and *Typha* species density will alsobe low.

2.6.7 Water Nitrate-nitrogen

In freshwater, nitrates and ammonia are dietary requirements for planktons causing nitrogen concentrations to be lower at the surface than in the deep (Cox, 1991). He also added that at increasing nitrogen concentrations in surface layers, plankton production increase, leading to algea blooms, which may occur mostly in lentic waters.Vander and Davis (2006) observed that an increased in water nitrate-nitrogen, causes increase in the density of *Typha domingensis* and increase in rhizome and tillering of *Typha latifolia.*

2.6.8 Water Phosphate-Phosphorus

Phosphorus is a multivalent non-metal of the nitrogen group. It is found in nature in severalallotropic forms and is an essential element for the life of an organism (Raiswell, 2011). In natural world, phosphorus is never encountered in its pure form, but only as phosphates, which consist of phosphorus atom bonded to four oxygen atoms. This can exist as negativelycharge phosphate ions(PO_4^{3}), which occur in minerals, or as organophosphates in which there are organic molecules attached to one, two or three oxygen atoms (Bruton, 2005).

Phosphate will stimulate the growth of *Typha* species, which become invasive (Manson, 2002). If an excess of phosphate enters the water ways, algae and *Typha* species will grow rapidly, choke up the water ways and use up large amount of oxygen, giving rise to condition known as eutrophication or over-fertilization of receiving waters. These rapid growths of aquatic vegetation lead to overcrowding, and eventually death of plants. As it decays it uses up oxygen. This process in turn causes death of aquatic life because of the lowering of dissolved oxygen levels (Bruton,1985; Cox, 1991).

2.6.9 Water Magnesium

This element is found naturally in seawater, which is about 1300ppm, and the most common cation found in oceans after sodium. Freshwater contains approximately 4ppm of magnesium (Stennis, 2013). Magnesium and other earth metals are responsible for water hardness, therefore water containing large amounts of alkali earth ions is calledhard water, and water containing low amounts of these ions is called soft water (Boyd, 1979). Large amount of minerals contain magnesium, for example, dolomite, and magnesium carbonate. Magnesium is washed from rocks and subsequently ends up in water (Rowe *et al*., 2002).

Magnesium is also a dietary requirement for all organisms, it is also the central atom of the chlorophyll molecule, and is therefore a requirement for plant photosynthesis. Smith (2009) reported that magnesium increased the density of *Typha australis* and rhizome formation.

2.7 Sediment Phosphate-Phosphorus

Heilman (2007) reported that, *Typha* species, growth and biomass allocation patterns are influenced by sediment phosphate-phosphorus.Campbell(2002) observed that, shoot: root ratio was higher for *Typha angustifolia*,particularly when grown at a high phosphorus-phosphate concentration.

2.7.1 Sediment Nitrate-Nitrogen

Shuwen Li*etal*. (2010)observed growth of *Typha*to be generally enhanced by increasing in sediment Nitrate-Nitrogen availability Significant interactions betweenorganic sedimentswere detected for leaf elongation. *Typha domingensis* plants growth was increased by 35% at nitrate-nitrogen levels of 10, 80 and 500 µg P L^{-1}.

2.7.2 Sediment organic matter content.

Additionsoforganicmattertosedimentcausedgreatchangesinthechemistryofthe interstitialwater. Changesweregreatestduringthefirst2weeksanddiminishedlater,variedwithbot hthetypeoforganicmatteraddedand speciesexamined.Growthonsedimentwithorganicmatteradditionwas inhibitedrelativetothecontrolinmostcases.Inhibitionwasgreatestwithadditionsoffarm yard manure,andpineorganicmatterand leastwith*Myriophyllum*andoak.Growthofthe*Typha* specieswasgenerallygreaterandwaslessinhibitedbyorganicmatteradditionsthanthatofthesubmer gedspecies.Growthoftheemergentspecieswasstimulatedbytheadditionof*Myriophyllum*organic matter.Variationsinthecompositionofbottomsedimentsmaystronglyinfluencethegrowthand distributionof *Typha latifolia* (Smith,2009).Theprincipalinfluenceofsediment organic matter uponthedistributionofrootedaquaticplantsmaybeduetoitsphysicaltextureratherthantoitschemic alcomposition.The possibleimportanceoftextureindeterminingplantrooting successandresistancetoerosioninparticularconditionsofwaterflowcannot,however, bedismissed. However growthofsomeaquaticplantsmaybesignificantly retardedonvery organicsediments.

2.8 Impact of *Typha* Species on Fish Catch and Distribution

Inrecentyears,therehavebeensomeeffortstounderstand theinteractionsresponsiblefor differences inmacrophytescommunitiesatdifferentlevelsof nutrientavailability.Aquaticplantsservemanyecosystemfunctionsincludingprimaryproduction,stabilizingsediments,maintainingwaterclarityandprovidinghabitatforzooplankton,macroinvertebrates andnumerousfishspecies.Aquaticmacrophytes,whenpresentinlargequantitieshavethepowerof modifyingthecomposition, abundanceanddistributionofotherorganismsinawaterbody.Abubakar*et al*.(2012)reported that, the impact of emergent macrophytes on fish catch in Nguru Lake, the portion of lake infested with themacrophytesparticularly *Typha* species led to poor fish yieldwhen compared with non-infested areas.

2.9Management of *Typha* species.

Most *Typha* control efforts have been made by wildlife managers interested in waterfowl production. Some methods would not be considered for use in designated nature reserves or natural areas. These applications may be considered for adjacent lands or for areas that are being restored and could be helpful to natural area land stewards. This method includes chemical, physical control, burning by fire, shading and water level modification. Biological control of cattail has not been documented.

2.9.1 Flooding

Sale and Wetzel (2003) investigated the growth and metabolism of *Typha* and discovered that internal aerenchyma cells in the stems of the plants form an oxygen-diffusion pathway that allows rhizomes to receive oxygen from the atmosphere and thus survive anaerobic conditions in the sediment. When aerial shoots die, they remain standing, allowing the pathway to remain functional. Oxygen diffuses through dead leaf tissue to rhizomes until the dead tissue decays in late winter or spring, or until young shoots emerge above the water in the spring to provide a new pathway. If the pathway is disrupted, anaerobic respiration begins, producing ethanol. *Typha* plants have not developed defenses against ethanol, so extended anaerobic periods can lead to extensive tissue breakdown or death. Flooding techniques are therefore, aimed at blocking the diffusion pathway that leads to the death of the entire plant.

Several studies have used this strategy to determine flooding depths that would create openings in dense *Typha* stands. Flooding occurred as a result of using water control structures to manipulate water levels. Smith (2004) found that flooding to a depth of 45 cm killed *Typha* less than one year old, and that flooding at 45-50 cm did not kill second year growth but prevented vegetative spreading. Depths of 64 cm were sufficient to kill *T. latifolia*, but did not harm *T. angustifolia*. Other studies, which include Grace and Wetzel (2002), reported that *T. angustifolia* could be controlled when flooded to depths greater than 100 cm for at least one year. These studies show that flooding can be effective when sufficient depths are reached. In some instances, however, mature *Typha* stands, which have formed dense-rooted mats may float to the surface and continue to grow (Apfelbaum, 2004).

2.9.2 Drainage

Nelson and Dietz (2006) found that 100% kill of *T. latifolia* could be obtained by draining a site for two years. Mallik and Wein (2007), however, reported significant increases in *Typha* cover after draining a site for one year, andthree years respectively, possibly due to the stimulation of tillering. Several studies showed that draining in conjunction with another treatment could produce effective control. Mallik and Wein (2007) reported that draining followed by multiple summer burnings was effective in decreasing *Typha* dominance and increasing species diversity, achieving a state which remained for three years after the treatment. Nelson and Dietz (2006) showed that cultivation after drainage could produce complete kill, though cultivation was slow and required the marsh to be out of production for one year to sufficiently dry the soil prior to treatment.

2.9.3 Mowing

Nelson and Dietz (2006) reported that mowing during the growing season was inefficient and slow due to limitations associated with using heavy machinery on soft substrates. Bell (2000) found that mowing in the winter over ice followed by flooding for the duration of the growing season reduce *Typha* stand by 89%. Other studies (Sale and Wetzel 2003; Apfelbaum, 2004;Nelson and Dietz 2006; Weller 2010) showed that two or three mowing treatments made during the growing season followed by submergence could result in up to 100% control, depending on whether or not all cut stems were submerged after flooding.

2.9.4 Biological Control

Biological control is using an organism to control an organism it can be plant to plant or animal to animal or otherwise. *Typha* control through indirect manipulation ofmuskrat populations is a natural, efficient.mukratpopulations can be encouraged to control *Typha* species. Several native insects, such as *Arzama* spp. (boring-moth larva) have been reported to cause serious damage or to entirely eliminate dense *Typha* stands. Their use as a biological control method has not been investigated. (Aleksiuk, 2004).

Manipulation numbers of muskratresults; to exponential population growth of muskrat andserious vegetation “eat-outs” (Bell, 2000).

2.9.5 Chemical Control of *Typha* species

For designated reserves or natural areas, especially where system-oriented stewardships are used, chemical applications may not be appropriate. This is particularly true because cattail is an element of certain natural communities. The use of chemicals to control an overabundance of cattail has been documented. Spraying Dalpan at 8.8-35.3 kg/acre (4-16 lb/acre) produced 74 to 97 percent reductions in cattails ten months after a mowed area was sprayed(Nelson and

Dietz, 2006). Control was most effective when treated areas could be flooded 10-15 cm (4-5 inches) or deeper. Dalpan spray achieved varied success, but the greatest control occurred where cattail stems were cut below water depths regardless of the quantity of herbicide used. Poorest results were attained in areas with shallow fluctuating water levels.

Spraying mature cattails rather than re-growth after cutting gave better results. Weller (2005) reported similar results using Amitrol, Rodopan, and Doupon herbicides. Theseherbicides were effective in creating and maintaining openings for at least three years after spraying. The areas were quickly invaded by peripheral cattail. High doses of MCPA or 2 4D in diesel oil (2.2-4.5 kg per acre) were effective if applied during flowering. Dalpan (9 kg/acre) and Amino-triazole (91-136 kg /acre) were also effective and economical for cattail control. Use of Erbon (18.14 kg/acre) gave good control results in Montana. Herbicide applications were found necessary for up to three years in some areas.However,chemical application may not be appropriate because most of the riverine populace in Africa have river as their primary source of drinking water and thiscan cause lethal or accumulative effect.

2.9.6 Physical Control of *Typha* species

Mechanical cutting of cattails followed by submergence of all cattail stems yield good results in control of cattail. Up to 100 percent of cattail control was measured for two growing seasons after treatment. No visible cattail re-growth occurred in one year and cattail rhizomes were found dead. The highest cattail control of any method tested was achieved by two clippings followed by stem submergence to at least 7.5cm (3 inches) (Nelson and Dietz, 2006).Control was best if plants are cut before emergent of the flower. Lower cutting cattail and re-flooding with at least 8 cm (3.1 inches) of standing water over plant stems was effective. Clipping cattails too early in the growing season (for example in May) stimulated their growth and resulted in a 25 percent increase in stem counts the following year, with an eventual decline to preclip levels. August clipping controlled up to 80 percent of cattail only, if followed by submergence. It was important to remove all dead and live cattail stems to achieve this control. Cutting shoots below the water surface in one growing season before flower production reduced cattail stands (Birnin Yauri *et al*., 2004; Weller, 2010,Weller, 2005).). Investigated cattail control by injuring developing rhizomes and shoots

Crushing and re-flooding showed that cattails injured after June, had poor recoveries. Success of crushing depended on the load used, number of times an area was crushed, and standing water depths after treatments.Spring and early summer treatments generally create favorable seedbeds for cattail that required a fall crushing to control seedlings. Crushing involve pulling fifty-five (55) gallon water filled in drums behind a tractor. Deeper water areas showed highest control (up to 100 percent) while re-growth occurred in shallow area.

2.9.7 *Typha*species Exposed toFire

Fire was found to provide little or no *Typha*control (Nelson and Dietz, 2006). Fire that destroyed cattail roots offered control; However, most fires only burn above-ground biomass and did little to control cattail. Drying in readiness for burning was effective cattail control, when done for two years in Arid Utah. Water level draw down, burning, and re-flooding to 20-35 cm (8-18 inches) water depth or deeper can control cattail. Fire was found to be useful for cattail litter clean up and assisted access for mowing or hand clipping (Nelson and Dietz 2006; Weller. 2010).

2.9.8 Shading Method of controlling *Typha* species

Black polyethylene traps were used to cover cattails in an attempt to control it (Nelson and Dietz, 2006). Actively growing cattail tips were killed, when completely covered for at least sixty days. Greatest control was achieved in July when food resources of cattail were presumed to be lowest (Linde *et al*.2006). Problems with holding traps down and their degradation could be found by this technique.

2.9.9 Water Level Modification

Two years of 65 cm (26 inches) deep flooding was required before established cattail began to die. Open water conditions were created at Messissipi Marsh. *Typha* initially survived flooding from 1973-77 and became the dominant emergent plant. A light green colour, noticeably narrower leaves, and absence of fruiting heads indicated stress in 1996. Cattail stem densities declined from 57 percent with all emergent plants dead in 1977. Horicon Marsh flooded to a depth of 40 cm (16 inches) showed declines in emergent and aquatic plants but *Typha*required two years before it declined.

Mature *T. latifolia* and seedlings less than one year old were killed by water depth of 63.5 cm (25 inches) and 45 cm (18 inches) or more, respectively. *Typha angustifolia*was unaffected by this degree of flooding. *Typha latifolia* establishment was prevented when water levels were maintained at 1.2 m (47 inches) or deeper.Quantities of water (2-3 m of water/acre/year), their establishment may serve to exacerbate water level instability and further contribute to be disruptive influences supporting increased in *Typha*. Flooding must account for evapo-transpiration losses of water to maintain a level effective in cattail control. Integratedcontrol techniques by burning fire, flooding, and physical removal are most appropriate. For example, there is no report on fire as a control measure by or destroying*Typha* rhizomes and the effects on other vegetation, either plants or seed banks. Implementation of a regular burning program would gradually reduce *Typha* vigour and mineralize substrates. This could promote re-growth by seed bank plants of invading species.

Periodic burning will not instantly control cattails, but may reduce their overall vigour. In conjunction with the restoration of a naturally dynamic water level and quality, use of fire may help to promote maintenance of the natural quality of a site. The effects of flooding seem to support a recovery dominated by those plants represented in the soil seed bank. At Horicon Marsh, after three years of flooding cattail was eliminated, this was followed by drawdown. Seeds of soft stem bulrush, cattail, nut grass, canary grass, sedges, and blue vervain germinated. The viable seeds present in newly exposed soils largely determine plant species that appeared during recovery in the few available studies.

The effectiveness of *Typha*control by mechanical means was more a function of the relationship between water depth and height at which cattails were cut than the methodology that was used. Method that reduce*Typha* stature, followed by flooding to cover the cattail stems, offered reliable cattail control within several growing seasons. Chemical methods have also worked but should be less desirable. The potential for the use of fire should be determined in each research since substrates need to be dried to affect *Typha* rhizomes. If fire is prescribed during a drawdown followed by re-flooding, it could eliminate standing *Typha* stems and reduce the need for clipping. Hand clipping was as effective, in conjunction with flooding, as any cattail control method. This may be the most desirable *Typha* control method in nature(Yeo, 2009).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 The Study Site and Background to the Research Location

Hadejia-Nguru wetlands (HNW), which is located in north-eastern Nigeria, occupies an area of approximately 58,l00 ha and is situated between latitudes 12°40′N and 13°60′N and longitudes 10°20′E and 11°00′E (figure 1). The Hadejia-Nguru wetlands (HNW), Hadejia-Nguru is surrounded by a flood plain made up of a network of channels and pools producing a complete pattern of permanently and seasonally flooded land and dry land (Hollis *et al*., 2003).

3.2 Field Methods

3.2.1 Sampling stations:

Based on the results of the preliminary study the wetlands where divided into three segments on thebasis of Topography of the wetlandsystemland, use human settlement andfishing activities (figure 2). Thesampling stations were:

Upper course -Punjamu is located at the entry to the wetland where water drains from Marma channel between coordinates N12 49′ 16.1′ and E l0 24′ 21.5′. It has an altitude of 343m with a lot of human activities and higher concentration of aquatic macrophytes, especially *Typha* species as a result of higher concentration of water, soil and sediment nutrients.

Middle course-Badun is located close to Dabar Magini settlement, between coordinates N12 50′ 27.9′ and El0 24′ 08.1′ with an altitude of 334m. A lot of fishing and agricultural activities take place there. In addition, the people of this settlement are engaged in the exploration and refining of potash.

Lower course- There is less human activity in this areaand there are few *Typha* species resident, located between coordinates N12 49′ 40.7′ and El0 24′ 21.1′ with an altitude of 341m above sea level.

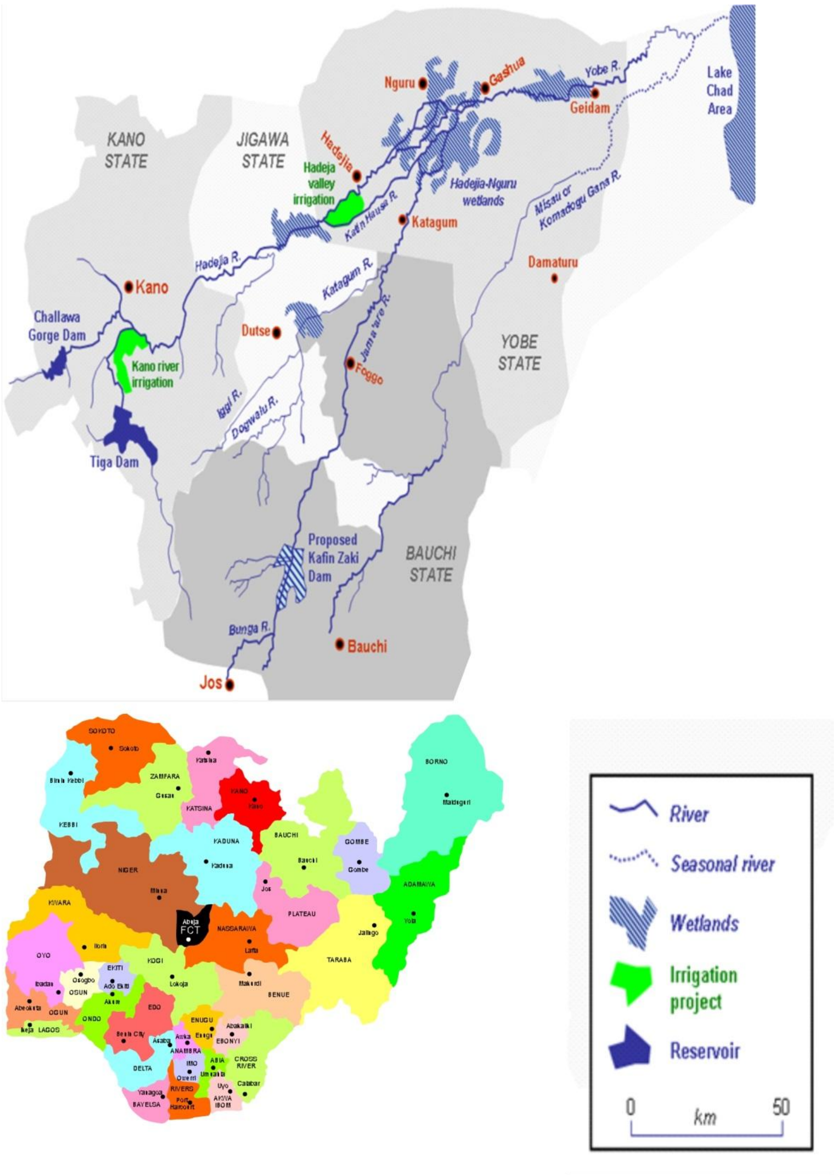

Figure: 3.1: Map of Nigeria showing Hadejia-Nguru Wetlands

Source: Modified From Administrative Map of Nigeria

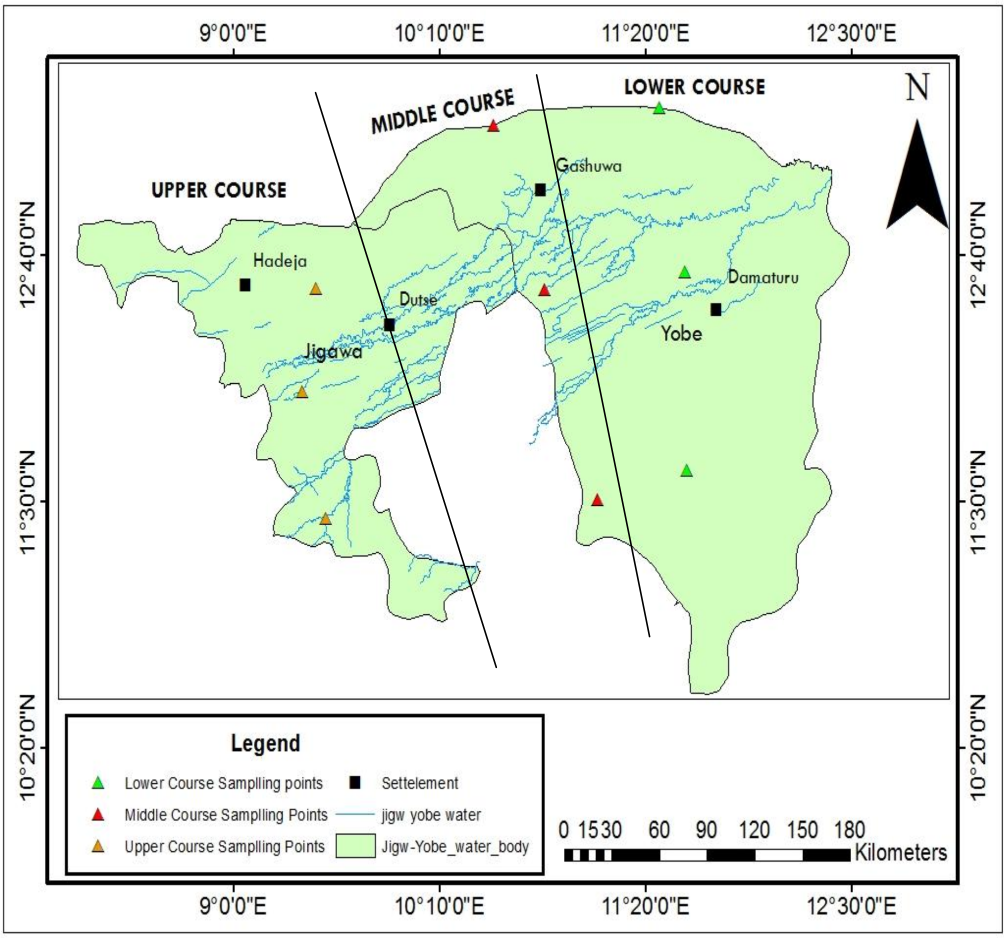

Figure 3.2: Map of Study Area Showing the Sampling Points and Locations

Source: Modified From Administrative Map of Nigeria

3.3 Identification of *Typha* species resident in Hadejia-Nguru Wetlands

Sampling of plants in the study area were made and species of *Typha* identified using Aquatic plant information system (1996) (Table 3.1).

3.4 Percentage occurrence of *Typha* species

The percentage occurrence of each *Typha* species was determined using line transects method.The *Typha* species were recorded in each five meters from the shoreline to the open water. The following formula was used to calculate the percentages occurrence of each species of *Typha*according toTitus(2003). Density is a measurement of population size per unit area, i.e., population size divided by total land area. Abundance refers to the relative representation of a species in a particular ecosystem.

$$\text{Percentage of species (\%)} = \frac{\text{The area covered by each species}}{\text{Whole Total area of the habitat}} \times 100$$

3.5 Determination of *Typha* species density

The density of *Typha* species were determined following the procedure as described bySmith (2009) as follows 50m by 50m infested by *Typha* species was demarcated in each of the sampling sites.The number of each species in 2500m^2 were recorded and related with each physico-chemicals parameters of water, sediment and soil nutrients for a period of two years.

3.6 Collection of water samples

Water samples were collected with a Van Dorn Water Sampler, which was lowered into the water with a graduated rope at higher water level in the wetlands. Temperature, Transparency, electrical conductivity and pH where measured at the samplings stations The water was transferred into clean sample bottles before transporting to the NIFFR hydrobiology laboratory for analysis.

Table 3.1: Morphological features for identifying *Typha*species

Parameter	*T. latifolia*	*T. angustifolia*	*T. xgluca*	*T.dominigensis*
Appearance	Coarse stout	Slender	Either	Slender
Leaves x -section	Flat	Convex on back	Convex on back	Convex on back
Width of leaves in mm	8-15	5	6-12	6-12
sheaths	Tapering	Auriculate	Auriculate	Tapering
Length between femaleand male	Non	5-12cm	0-4cm	0.7-4.5cm
Pith colour at base	White	White	Yellow buff	White
Female flower bract	None	Dark brown blunt	Non rarely like ang. and dom.	Light brown Ovate and apiculate

APIS, (1996)

3.7 Determination of Physical Characteristics of Water

3.7.1 Determination of Temperature

Both air and water temperature were determined with a mercury thermometer calibrated to the nearest 1^{o}C. Air temperatures were taken by holding the thermometer above the water for 5 minutes until it stabilized. Water temperature was determined by lowering the thermometer into the water in an inclined position at 10cm for 5 minutes to allow for equilibrium before recording.

3.7.2 Determination of Transparency

Transparency was measured directly in the field using a secchi disc as described by APHA, (2005)A secchi-disc of 25cm in diameter was used to determine the transparency, by lowering the secchi-disc with measuring tape into the water until it disappeared from view, the measurement of which was recorded as P_1. The secchi-disc was then pulled out and the depth of reappearance was measured and recorded as P_2, the transparency was calculated using the following formula: Transparency = P_1+P_2/2.

3.7.3 Electrical Conductivity(EC)

Electrical conductivity of the soil samples were measured with a soil water ratio of 1-2 (w/v) using HANNA digital Electrical Conductivity (EC) meter, (HI98129 model). The electrical conductivity meter was first calibrated using 0.1M KCI. Ten grams (10g) of 2mm sieved air-dried soil samples were weighed into 100ml plastic containers and 20ml of distilled de-ionized water was added. The mixtures were then stirred for 30mins.Later the soil suspensions were allowed to stand for 30mins undisturbed. The electrode of the EC meter was then inserted into the settled suspension. The EC of the soil samples were measured.Electrical Conductivity was measured in micro-ohms/cm (µs/cm).

3.8 Determination of Chemical characteristics of Water

3.8.1 Determination of pH

The surface water was collected in plastic bottles from each sampling station, pH was determined with 3015 model pH metre at 25^{o}C. The pH metre was standardised with buffer solution at pH 4.0, 7.0 and 9.0 and the electrode was dipped into the water sample and reading was taken and recorded.

3.8.2 Dissolved Oxygen (DO)

Dissolve oxygen was determined by the modified Winkler's method (APHA,2005) Water was collected from the marked sampling sites in 250ml.Amber sampling bottles and filled up to the brim. 2ml, standard Manganous sulphate solution and 2ml, alkaline-iodide solution were added on the spot and the content was shaken for 10 second. 2ml concentrated Sulphuric acid (H_2SO_4) was added to the sample and the stopper replaced immediately, to avoid air being trapped.The bottle was shaken again for few seconds till the precipitation dissolved. Samples were then transported to the NIFFR hydrobiology laboratory in an icebox.

The prepared solution was titrated with sodium thiosulphate 0.2000N, until the sample changed from yellow to colourless. The number of digits was read from the counter window, and value was multiplied by 0.1 to determine the concentration of dissolved in mg/l.(APHA, 2005).
DO was also taken using D.O meter HI9142.

3.8.3 Biological Oxygen Demand (BOD)

After the initial dissolved oxygen (DO) of the water sample was determined by the modified Winkler's method above) water sample was incubated in 250ml BOD bottles at 20^{o}C for five days. On the 5th day, determination of DO wascarried out on the incubated water sample again BOD_5 (mg/L or mgL-1) was calculated as DO_1-DO_5 (mg/L).

Where,

DO_1= Dissolved oxygen concentration prior to incubation

DO_5= Dissolved oxygen concentration after 5days incubation (APHA, 2005) crosschecking using DO meter HI9142 for comparison

3.8.4 Water Phosphorus

Total phosphorus in water was determined according to the method described by APHA (2005). The sulphuric acid-nitric acid digestion method was used to convert all chemical aspects of phosphorus to phosphates. 50ml of water sample was pipetted into a microkjedhl flask and 1ml of concentrated. H_2S0_4 and 5 ml of concentrated. HNO_3 were added. The mixture was digested to a volume of 1ml of clear solution. The solution was cooled and 20ml of distilled water was added. After neutralizing with NaOH, the solution was made up to 100 ml with distilled water.50 ml of the treated sample was pipetted into a volumetric flask and 8.0 ml of the combined reagent was added. After thorough mixing, the solution was allowed to stand for between 10-30 minutes for the blue colour to develop. The absorbance of the sample was then measured on 634 UV-visible spectrophotometer, at 880 nm using a reagent blank as the reference solution. Total phosphorus content was estimated by extrapolation from a calibration curve preparedusing standard concentrations of phosphate-phosphorus.

3.8.5Water Nitrate-Nitrogen

Phenoldisulphonic acid method was used as described by Mackereth (1978) and(APHA, 2005)

Fifty (50ml) was measured into khjeIdahI flask, 0.3g of magnesium oxide was added, 0.4g was also added, the flask was attached to the distillation machine, and then distils of the sample was collected. The distillate appeared green in colour. Then the distillate was titrated with standard acid, and green to pink colour was observed, the titre value was recorded from the burette for calculation of Nitrate-Nitrogen as indicated below:

$$N = \frac{\text{Titre value x 100}}{\text{Mills of aliquot (50ml)}}$$

The result was recorded as concentration of Nitrate in mg/l

3.8.6 Water Magnesium and Calcium

Twenty(20ml)was measure into conical flask, 5ml of buffer solution was added, 3 drops for each of the following reagents, were also added, Potassium cynide, Potassium perocynide, Hydroxylamine, hydrochloride, Triethanolamine and Eriocrome black T indicator. The solution turned purple, and was then titrated against EDTA 0.01M.

The endpoint turned a permanent blue colour, and the titre value was recorded and Magnesium ion was determined using the formula:

$$Mg+Ca = \frac{\text{Titre value x 0.01}}{\text{Mills of aliquot}} \text{ x 1000}$$

What was obtained was equal to Ca + Mg. Therefore, the amount of Ca was subtracted from this value to give that of Magnesium.

3.9 Sediment Determination

3.9.1 Sediment pH

Ten 10gsof dried sediment wasweighed added into 10mls of distilled water in a beaker. The mixture was stirred with a glass rod for 30 minutes, after which it was allowed to stand for 30 minutes undisturbed. The pH was determined and recorded(Udo and Ogunwale, 1986).

3.9.2 Electric Conductivity (EC)

Ten (10g) of dried sediment wasweighed added into a beaker, with 50mls of distilled water andwhich E C was determined by dipping the electrode ofthe conductivity meter in the sample recorded EC in µs/cm (Udo and Ogunwale, 1986).

3.9.3Sediment Nitrate-Nitrogen

Two(2g) of the dried sedimentweighedadded into khjeldahI flask, the catalyst was added with 20ml concentrated Sulphuric acid. Digestion was carried on the digestion chamber in fume cupboard for one hour.

The content was allowed to cool, and distilled water was added to dilute the digested sample to 50ml volume. Distillation was carried out by measuring 10ml of the digested sample into macro khjeldahI flask and 30ml of distilled water were added. Then 20ml of 40% NaOH was added, and then the attached flask was placed on distillation machine. Boric acid indicator was placed under the condenser. Then titrated against 0.01 molar H_2S0_4. The mixture turned from green to pink, and the titre value was recorded for calculating the amount of Nitrogen in the sample using the formula:

N = titre value x 0.01 molar x 0.014 x 50 x 1000/weight of sediment x mills of aliquot. The concentration was calculated as nitrate-nitrogen in g/kg.

3.9.4 Sediment Calcium Ion Exchange Capacity (C.E.C.)

Five (5g) of the sediment was weighted transferred into conical flask, containing 20ml of ammonium acetate solution, this was saturated overnight. The mixture was filtered using funnel and filter paper, and the filtrate collected in a conical flask. 30mls of ammonium acetate solution was also added to wash the residue of the sediment in the flask which was then filtered with paper and funnel.The filtrate solution was used to determine Na, K, Ca and Mg.Na and K was determined on a flame photometer. While Ca and Mg was determined by the Atomic Absorption spectrophotometer (AAA).

3.9.5 Sediment Phosphate-Phosphorus

Two(2gs) of sediment wasweighedtransferred into a conical flask, 7ml of phosphorus extraction solution was added, shaken for 30 minute using mechanical shaker.The mixture was filtered and the filtrate collected. Therefore 2mls of the filtrate was added into 50mls volumetric flask, 2mls of ammonium molybdate wasadded, with 30-40mls of distilled water, 1ml of fresh diluted stannous chloride and distilled water were added to 50mls mark. The colour intensity was taken from the spectrophotometer at 660 wave lengths; the reading was taken and used to calculate the concentration of phosphorus as follows:

$$P = \frac{\text{Reading x conversion factor (0.61) x dilution factor (25)}}{\text{Atomic weight of phosphorus}}$$

The value was recorded as Phosphorus in g/kg

3.9.6 Sediment Total Organic matter content(TOC)

The method described by Agbeti **(**1995)was used to measureTOC.1g of finely ground sediment sample was added into a250ml conical flask. This was followed by the addition of 10ml 17N $K_2 Cr_2 O_7$ and concentrated H_2SO_4,which was allowed to cool for 30 minutes. The suspension was filtered with Whatman filter paper N01).1- 5 drops of Ferroin indicator was added followed by titration with 0.4N $(NH_4)_2\ SO_4.6H_20$ until it changes from dark green colour to red end point. The TOC was calculated by means of the following formula:

Total organic matter content (TOC) (g) = $\frac{\text{meg of } Cr_2O_7 \text{ meqfe-}NH_4.\ SO_4 x4}{\text{Wt. of sample}}$

3.9.7 Sediment particles size distribution and textural Classification

The determination of particle size was done using the hydrometer method (Bouycos, 1951)Fifty grams (50g) of 2mm sieved soil sample was transferred into a 250ml plastic beaker. Fifty millilitres (50ml) of 6% H_2O_2 was added and coveredwith glassand placed on water bath till the organic matter was oxidized (indicated by the presence of effervescence).The beaker was removed and allowed to cool. The contents were transferred into a dispersing cup containing 400ml of distilled water. Calgon solution of 100ml was added, and then stirred with a glass rod for 10min.The suspension was transferred into a setting cylinder, filling it up to the 1 litre mark. The mouth of the cylinder was then closed with a rubber stopper and the cylinder was then shaken vigorously, for 1min. Then the cylinder was placed on a table and first reading was recorded after four minutes. The temperature of the suspension wasalso taken and recorded. The suspension was allowed to settle undisturbed. Hydrometer was inserted again into suspension two hours after the initial shaking was stopped, and the reading was recorded for the second time.

The calculation of the sand, silt and clay composition was done as well as determination of the texture of the soil sample using textural triangle. To obtain the sand, silt and clay composition (%) following formula was used:

% Silt= d-g/ax100

% Clay= g/ax100

$$\% Sand = 100 - (\%Silt + \%Clay)$$

Where; d= corrected hydrometer reading at 4mins

g= corrected hydrometer reading at 2hours observation

a=weight of the soil sample (g)

Textural classification of the soil samples was done using the soil texture triangle as described by Verma and Agarwal (2007) based on the relative percentage composition of clay, silt and sand in the samples.

3.10 Soil chemical Determination

3.10.1 Soil Phosphate-phosphorus

Five (5gs) of dry soil wasweighedtransferred into tube with stopper, 35cm3 was added (with pipette) of the extraction solution. The container was shaking for 1minute and filter the suspension into a dry bottle. The solution back through the filter.

Ten(10cm^3) of the filtrate was transferred to a dry 100cm^3 beaker, and 25 cm^3 of ammonium molybdate reagent, and 5cm^3 stannous chloride dilute solution and mixed

After 10 minutes, the colour development at 890 nm on a spectronic 20, the absorption was read.

3.10.2 Soil Nitrate-Nitrogen

Soil chemical was determined as described by Gee and Bauder (1986).

One (1g) of 100 mesh soil was weighted in 500ml KhjeldahI flask. 4 drops of water was allowed to stand for about 30 minutes 5gs ofKhjeldahI catalyst mixture was added and concentrated sulphuric acid. Digestion was carried on the digestion chamber under fume cupboard for one hour.

The content was allowed to cool, then distilled water was added to dilute digested sample to 50ml.Distillation was carried by measuring 10ml of the digested sample into macro KhjeldahI flask and 30ml of distilled water were added. Then 20ml of 40% NaOH were added, and then the attached flask was placed on distillation machine. Boric acid indicator was placed under the condenser. The sample was then heated to distillate, which was then titrated against 0.01 molar H_2S0_4, the mixture turned from green to pink, and the titre value was recorded for calculating the amount of Nitrogen in the sample using the formula below:

N = titre value x 0.01 molar x 0.014 x 50 x 1000/Weight of sediment x mills of aliquot.

The concentration was calculated as nitrate-nitrogen in g/kg.

3.10.3 Soil organic Carbon and Organic matter Determination

The determination of organic carbon (OC) was done using the method of Walkley and Black (1934) adopted by IITA (1979).One gram (1g) of the soil sample was weighed in triplicates into 250ml conical flask 10ml of 0.02moldm^{-3} potassium dichromate was pipetted into each flask and was swirled gently to disperse the soil followed by addition of 20ml concentrated H_2SO_4. The flask was swirled gently until soil and reagents were thoroughly mixed. The mixture was then allowed to stand for 30mins on a glass plate, 200ml distilled water was added followed by the addition of 1ml ferroin indicator, later stirred and then titrated with 0.25moldm^{-3} ammonium ferrous sulphate. Blank titration was carried out similarly but without soil sample to determine organic carbon (OC) and organic matter (OM) the formula below was used:

% OC= (Blank titre-Actual tittre) X 0.3xf/weight of air-dried soil sample

Where f = correction factor=1.33M= concentration ferrous ammonium sulphate

% OM in soil= %) OC X 1.729

3.10.4 Soil calcium, magnesium

Five (5) grams of soil was weighed and transferred into conical flask, containing 20ml of ammonium acetate solution, this was saturated overnight. The mixture was filtered using funnel and filter paper, and the filtrate was collected in a conical flask. 30mls of ammonium acetate solution was also added to wash the residue of the sediment in the flask, which was then filtered with paper and funnel.The filtrate solution was used to determine Na, K, Ca and Mg.

3.11 Impact of *Typha* specieson fish catch and distribution in Hadejia-Nguru wetland

The Hadejia Nguru wetland was divided into three sampling sites and each sampling site (A and B). A is un-infestedarea while B was *Typha* infested area. Experimental gillnets mesh sizes of 1; 1.5; 2; 2.5; 3; 3.5; 4; 5; 7; were set in the evening and checked early in the morning, once in each month for the period of two years Fish caught was measured using weighing and spring balance of various sizes. Fish species were identified using manual by Olaonsebikan and Raji (2004) .The Dissolved Oxygen (DO) Biological Oxygen Demand (BOD) and the number of fish species caught, inthe three sampling sites,recorded.

3.12 Management Methods

3.12.1 Biological control of*Typha* species using *Phragmites karka*at different weight.(As observed in the field by Birnin –Yauri, (2009). A plot infested by *Typha* species was marked A, B, C, and D. In each sampling station containing two thousand (2000) per 2500$m^2$of *Typha* species were selected randomly for the experiment; Sample A= was interplanted with 50kg of *Phragmites karka.*Sample B=was interplanted with 25kg of *Phragmites karka.* Sample C= was interplanted with 10kg of *Phragmites karka.* Sample D=The *Typha* species were free from

*Phragmites karka*and served as control experiments. The mortality rate of *Typha latifolia* and *Typha angustifolia* were recorded monthly for a period of two years.

3.12.2 Manual Control

Manual control was carried out as described by (Nelson and Dietz, 2006). A 2500m^2plot infested with *Typha* species were replicated 3 times A, B, C, and D each containing two thousand stands of *Typha* species plantwere selected randomly in each sampling point. A= *Typha*plantsshoot cut 5cm below the water and submerged for the period of two years B= shoot cut 10cm below the water and submerged. C=shoot cut 15cm below the water and submerged; D= shoot cut 5cm,10cm and 15cm, above the water as control experiments. The number of dead plants and regrowth were recorded in the three stations within sampling site, for the period of two years.

3.12.3 Physical Control Using Shading

Physical control control was carried out as described by(Linde *et al*.,2006). (50m by 50m plot infected by *Typha* species were replicated three times A,B,C, and D. each was counted and contained two thousands of *Typha* species for the experiment 100m by 100m of Black tarpaulin were used to cover 50m by 50m plot infested with *Typha* species containing two thousand *Typha* species and was marked A, B, C, and D in each sampling site. A= the black tarpaulin that was single; B= the black tarpaulin was doubled; C= the black tarpaulin was tripled; D= without black tarpaulin to serve as control experiment.Data of*Typha* species mortality rate was recorded in the three sites within sampling station, for the period of two years.

3.13 Statistical Analysis

The data collected were subjected to Analysis of Variance (ANOVA) using statistical Package for Social Sciences (SPSS).The data for physico-chemical parameters, soil nutrients and sediment nutrients were subjected to Principal Components Analysis.

Analysis of variance (ANOVA) was used to test the significant difference between *Typha latifolia*, and *Typha angustifolia*. Numbersand weightof fish caught,in two different locations that is *Typha* un-infested (site A) and*Typha* infested Area (site B). The test between 50kg of *Phragmites karka*. (A)25kgof *Phragmites karka* (B)10kg of *Phragmites karka* (C) Free from*Phragmites karka*as control(D),in terms of effect of difference weight of*Phragmites karka.*The significance difference between 5cm below the water levels (A) 10cmbelow the water levels(B) 15cmbelow the water levels(C) 5cm, 10cm, 15cm above the water levels as control (D) in terms of re-growth rate.

Duncan′s Multiple Range Test was used to separate the means of the data collected.Pearson's product moment correlation coefficient was used to determine the relationships inthe physico-chemical propertiesof sediment, soil nutrients and *Typha* species. T-test was used to determine if there is significant difference between the two years measured environmental and biotic variables.The level of significance was set at ($P<0.05$).

CHAPTER FOUR

4.0 RESULTS

4.1 *Typha*species residentin Hadejia-Nguru Wetland.

The species of *Typha* identified in Hadejia-Nguru wetland for the period of two years were *Typha latifolia* and *Typha angustifolia*with 65-70 and 30-35 percentage occurrence respectivelyas shown in figure(4.1 and 4.2.) The result showed that the population of *Typha latifolia* washigherwhen compared to *Typha angustifolia.*The simple way to differentiate the two species of *Typha* is the inflorescence.In *Typha angustifolia,*the male and female reproductive structures are separate in the inflorescence*Typha latifolia*has no separation in the inflorescence male and female reproductive structures(Appendices Iand II). *Typha latifolia* has narrow-leaves, while *Typha angustifolia* has broad-leaves as showed in (Appendices III and IV).There was significant difference between *Typha latifolia* and *Typha angustifolia*in abundance (Table 4.1). Interaction between *Typha latifolia* and *Typha angustifolia*showed significant difference betweensMonth and Sample, Month and location, Sample and Location> However there is nosignificant difference betweens location and Season and Month x Sample (P<0.05)

4.2 *Typha* species density

The density of two species of *Typha*ranged as follows-*Typha latifolia*, then *Typhaangustifolia*.The range of *Typha latifolia*,andT*ypha angustifolia* density were 40 to 100,20to 60 stand per $9m^2$, respectively, (Figure 4.1).

4.3 Principal ComponentsAnalysis

The results of principal component analysis showed six variables thatwere found to beresponsible for the proliferation of *Typha latifolia* and *Typha angustifolia* in Hadejia-Nguru wetlands. These were water Phosphate-phosphorus, Nitrate-nitrogen, Magnesium and Sediment Phosphate-Phosphorus, Nitrate- Nitrogen and organic matters(Table 4.2).

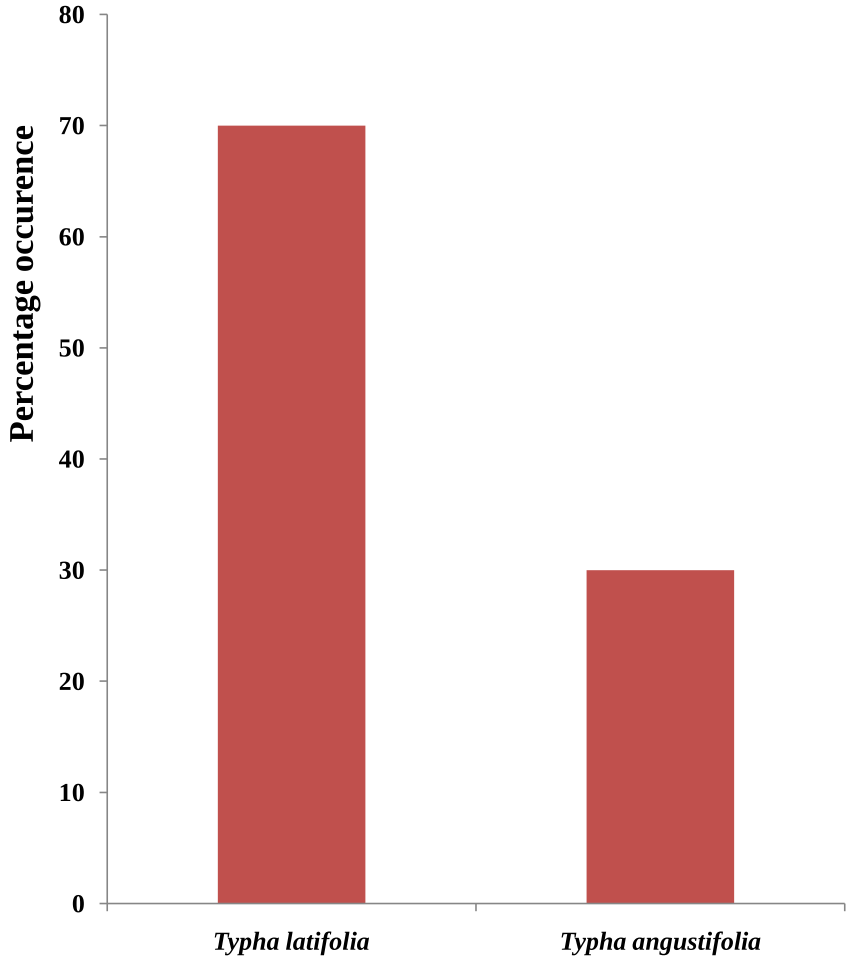

Figure 4.1:The percentage occurrence of *Typha latifolia* and *Typha angustifolia* resident in Hadejia Nguru Wetland during dry season 2010 and 2011

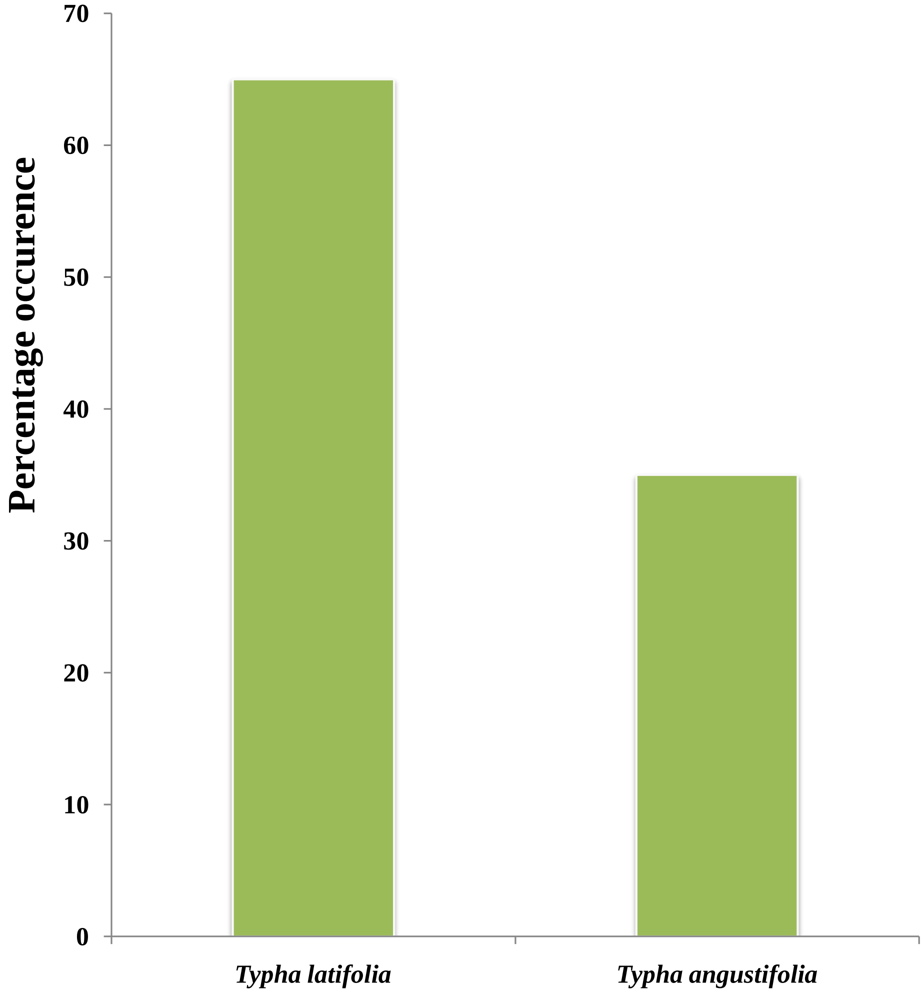

Figure 4.2: The percentage occurrence of *Typha latifolia* and *Typha angustifolia* existing in Hadejia Nguru Wetland during wet season 2010and 2011

Table 4.1: Analysis of variance between *Typha latifolia* and *Typha angustifolia* density in the study area for the period of two years (2010 and 2011)

Source of variation	**DF**	***Typha latifolia***	***Typha angustifolia***
TL (Treatment)	116	0.001*	0.003*
Month	11	0.004*	0.004*
Sample	2	0.002*	0.003*
Location	2	0.021*	0.025*
Season	1	0 .008*	0.042*
Month sample	22	0.001*	0.372
Month location	22	0.0278*	0.001*
Sample location	4	0.0421*	0.042*
Location season	2	0.043*	0.367
Month sample location	44	0.012*	0.234
Sample location season	6	0.021*	0.041*
Error	207		

* Significant; at ($P<0.05$).

Table 4.2: Principal Component analysisof chemical characteristics sediment and water from Hadejia- Nguru wetlands 2010 and 2011.

Variables	Extraction	Main factors Extracted
Phosphorus water	0.999065	Water Phosphorus
Nitrogen Water	0.999065	Water Nitrate
Magnesium	0.998774	Water Magnesium
Sediment phosphate-phosphorus	0.998233	Sediment phosphate-Phosphorus
Sediment nitrate nitrogen	0.997911	Sediment nitrate nitrogen
Sediment organic	0.996365	Sediment organic matter

4.4 Relationship between some Physical and Physico-chemical parameters, and *Typha* species density

Physical parameters such as air temperaturetransparency and electrical conductivity (EC) were showed by principalcomponent analysis to have nocorrelation with proliferation of *Typha* species in Hadejia Nguru wetland. Air temperature ranges between 21-35^{o}C, 0.4-1.9 m, and 166- 375 (μs/l)respectively. Also chemical parameters such as pH. Dissolved oxygen (DO) and Biological oxygen demand (BOD) rangedbetween 7.0-8.8,0.9-8.84 mg/l 4.11-15.00 mg/l respectively. (Tables 4.3 and 4.4).

Most aquatic plants can do well relative to higher or lower transparency, temperature, electrical conductivity, pH. Dissolved oxygen (DO) and Biological oxygen demand (BOD).Similar trend was observed with soil texture and nutrients concentration (Appendix xix) these could be associated with leaching of soil minerals to sediment. The factors that influence *Typha* species proliferation must be observed directly from the root or those that affect photosynthesis activities.

Table 4.3: The average Physico –chemical parameters extracted out by Principal Component Analysis in Hadejia Nguru wetland) in the 2010.

Month	Water Temp.°C	Air Temp. (°C)	pH	Transparency (m)	DO2 mg/l	BOD mg/l	Conductivity (µs/l)
Jan. 10	16	21	7.8	1.8	9.24	10.05	328
Feb. 10	18	24	7.8	0.7	4.83	14.41	297
Mar. 10	17	24	7.7	0.9	3.15	9.53	285
Apri. 10	20	27	8.1	1.9	2.24	8.65	289
May 10	25	35	7.5	1.8	8.84	12.71	261
Jun. 10	21	33	7.6	1.7	1.55	11.46	302
Jul. 10	20	30	6.9	1.0	1.92	10.88	268
Aug. 10	15	21	7.0	0.4	0.91	7.53	260
Sept. 10	16	22	7.3	0.9	5.82	14.91	266
Oct. 10	22	26	7.8	1.4	2.64	8.72	268
Nov. 10	21	25	8.0	1.5	3.11	7.99	370
Dec. 10	18	24	7.4	1.7	3.15	4.11	375

Table 4.4: The average Physico –chemical parameters extracted out by Principal Component Analysis in Hadejia Nguru wetland) in the year 2011.

Month	**Water Temp. (°C)**	**Air Temp. (°C)**	**pH**	**Transparency (M)**	**DO2 mg/l**	**BOD mg/l**	**Conductivity (µs/l)**
Jan. 11	15	21	7.8	1.8	9.24	8.05	308
Feb. 1120		25	7.9	0.7	4.83	14.25	297
Mar. 11	19	22	7.7	0.9	3.15	9.52	185
Apr. 11 22		28	8.1	1.9	2.24	14.23	280
May. 11	25	35	7.5	1.8	8.82	15.00	266
Jun. 11	23	32	7.5	1.7	1.55	1.46	302
Jul. 11	20	30	6.5	1.0	1.92	9.89	268
Aug. 11	15	22	7.0	0.4	0.91	10.54	260
Sept. 11	14	22	7.3	0.9	5.82	9.92	166
Oct. 11 17		27	7.8	1.5	2.64	8.73	265
Nov. 11	21	25	8.0	1.6	3.11	9.89	276
Dec. 11	19	24	7.5	1.7	3.15	12.12	275

4.5 Relationship between water Phosphate- Phosphorus and *Typha*species density

Phosphate-Phosphorus is essential to the growth of organisms and can be the nutrient that limits the primary productivity of water. The results of phosphate -phosphorus concentration of Hadejia-Nguru wetlands is presented in Figure 4.3. The range of Phosphate-Phosphorus concentration was 3.5mg/l to 13.5mg/l.The range of *Typha latifolia* and T*ypha angustifolia* densities were 60 to 100 stand per $9m^2$, 40 to 65 stand per $9m^2$respectively.The high value of water Phosphate- Phosphorus was obtained, during extremes dry season (April-May), while lower values were obtained in wet season(July- August). The populationof *Typha latifolia* and *Typha angustifolia* follow the same pattern with Phosphate -Phosphorus concentration. The result showed significant difference between months, samplings station, location and season. Similarly, Month and Sample, Month and Location, Sample and Location, location and Season and month x sample x location, and season years and seasons interaction with *Typha latifolia*density were also significant.However,no significant difference was observed between the season and *Typha angustifolia*density. Significant correlation was established at ($P<0.05$) between *Typha latifolia*, T*ypha angustifolia* densities and Phosphate-Phosphorus concentration. (Tables 4.5, 4.6, 4.7 and 4.11).

4.6 Relationship between water Nitrate- nitrogen concentration and *Typha* species density

Nitrate -Nitrogen is the second most abundant nutrient element and like carbon, exists in a wide range of organic forms. Nitrogen is one of the important nutrients for T*ypha* species growth in the aquatic environment. Figure 4.4 show the results of water nitrate- nitrogen concentration and *Typha latifolia* - *Typha angustifolia* density in Hadejia-Nguru wetlands.The concentration of Nitrate-nitrogen in water ranges from 3mg/l to 13mg/l. *Typha latifolia*, and

Typha angustifolia density were 60 to 100 stands per $9m^2$ and 40 to 65 stands per $9m^2$respectively.The High value of water Nitrate-Nitrogen (NO_3^-N) was obtained, during extreme dry season (April-May), while lower values were obtained inwet season (July-August).

Typha latifolia and *Typha angustifolia* follow the same pattern with nitrate-nitrogen concentration. The result showed significant difference at ($P<0.05$) betweenmonths, samplings station, location and season. Similarly month and sample, month and location, sample and location, location and season and month x sample x location, and season years and seasons interaction with *Typha latifolia* density were also significant. Concentration with *Typha latifolia* and *Typha angustifolia* densityalso showeda significant correlationat($P<0.05$) between *Typha latifolia*,T*ypha angustifolia* densitiesand Nitrate- Nitrogen concentrations (Tables 4.5, 4.6, 4.7 and 4.11)

4.7 Relationship between water Magnesium concentration and*Typha* speciesdensity

The result for water Magnesium concentration in the water of Hadejia-Nguru wetlands is presented in Figure.4.5.The concentration range between 1mg/l to 10mg/l *Typha latifolia* and*Typhaangustifolia* density were 60 to 100 stands per $9m^2$and 40 to 65 stands per $9m^2$,respectively. The high value of water magnesium (Mg^{4-}) was obtained during extreme dry season (April-May),while lower values were obtained in the rainy season(July- August). However, *Typha latifolia* and *Typha angustifolia* density followed similar trend of fluctuation.The result showed significant difference at ($P< 0.05$) betweenmonths, samplings station, location and season. Similarly month and sample, month and location, sample and location, location and season and month x sample x location, and season years and seasons interaction with *Typha latifolia* density were also significant. Except month x sample x location,which showed no significant difference between magnesium concentration with *Typha latifolia* density. It also showed a significant correlation at ($P<0.05$) between *Typha latifolia*,T*ypha angustifolia* densities and magnesium concentration it also showed non-significant difference between Sample, Month sample location (Tables 4.5, 4.6, 4.7 and 4.11).

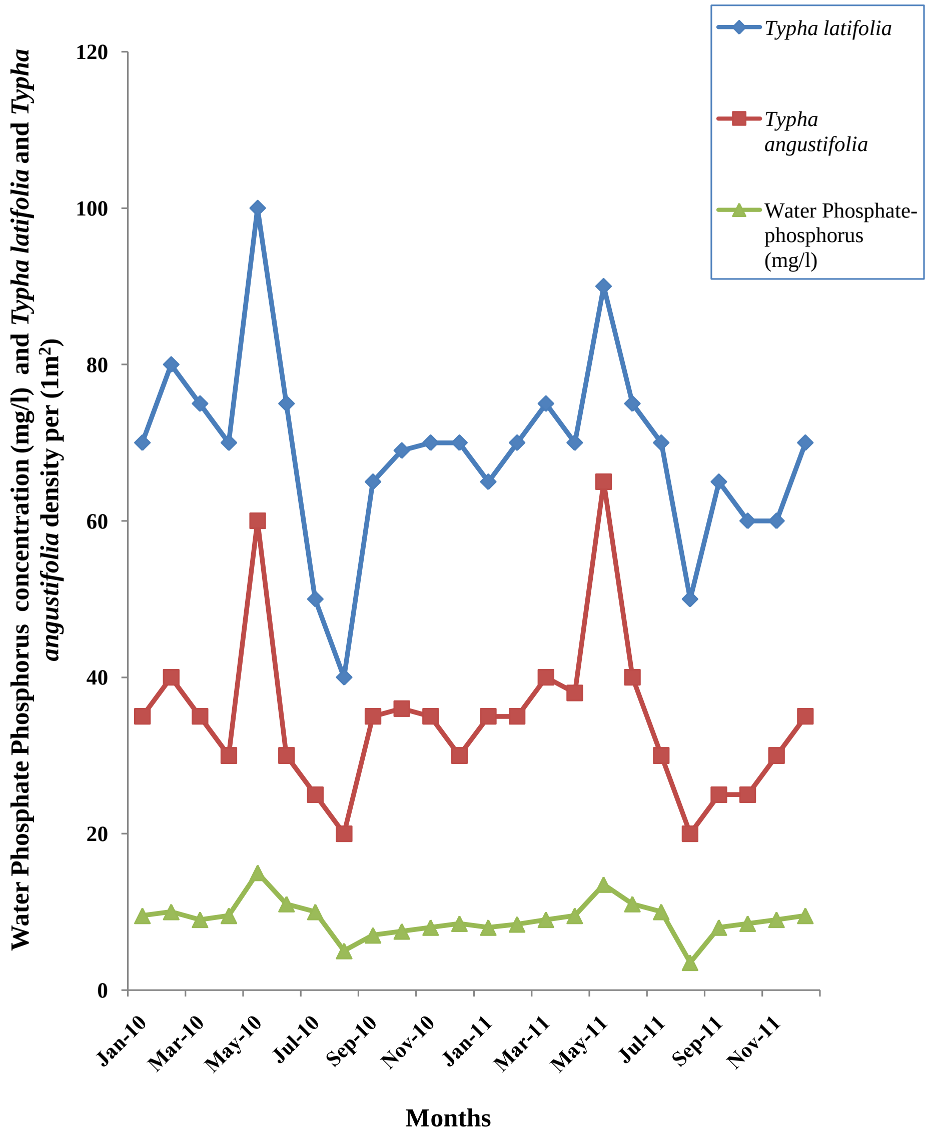

Figure 4.3: Monthly variation between water Phosphate- Phosphorus concentration and *Typha* speciesdensity in Hadejia-Nguru wetland in the 2010 and 2011.

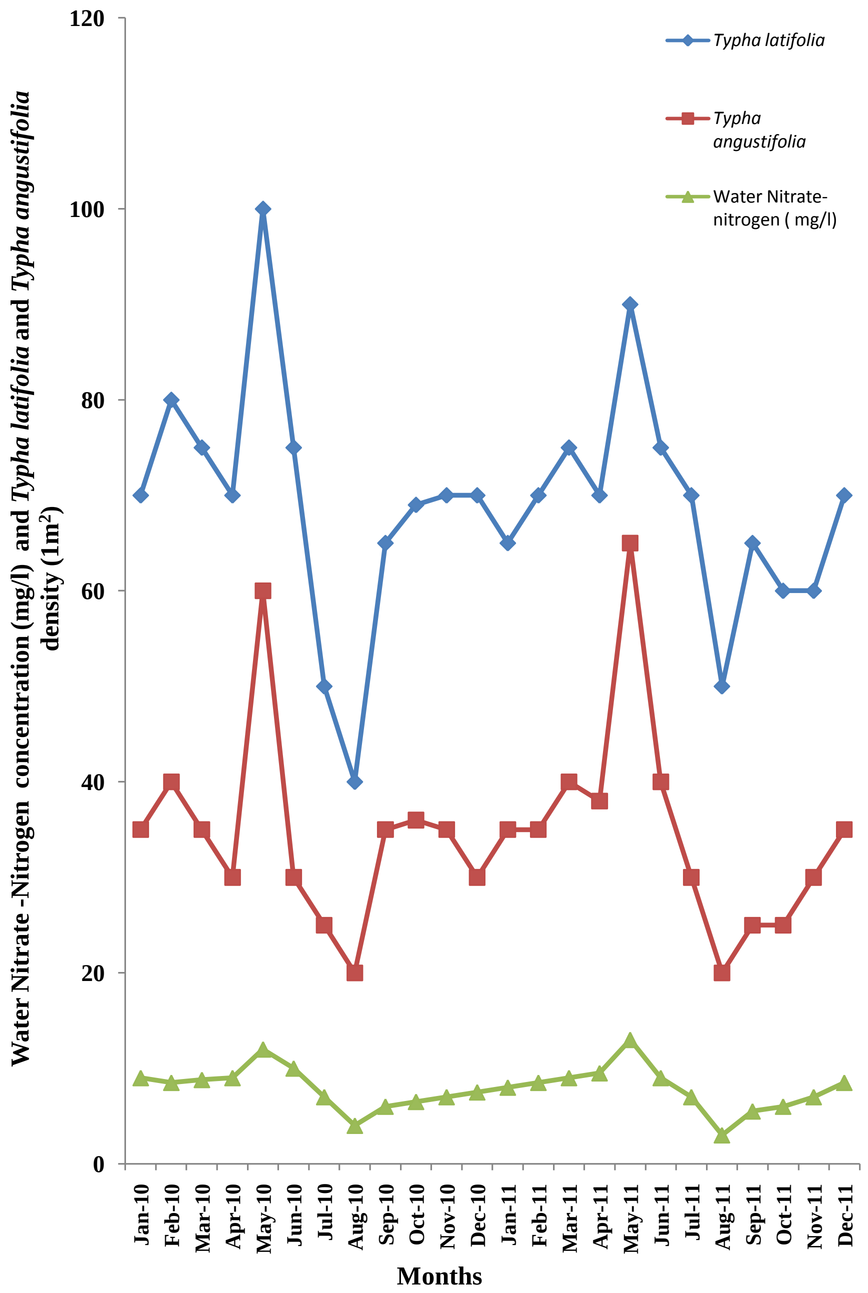

Figure: 4.4: Monthly variation between water Nitrate-Nitrogen concentration and *Typha* speciesdensity in Hadejia-Nguru wetland in the year 2010 and 2011

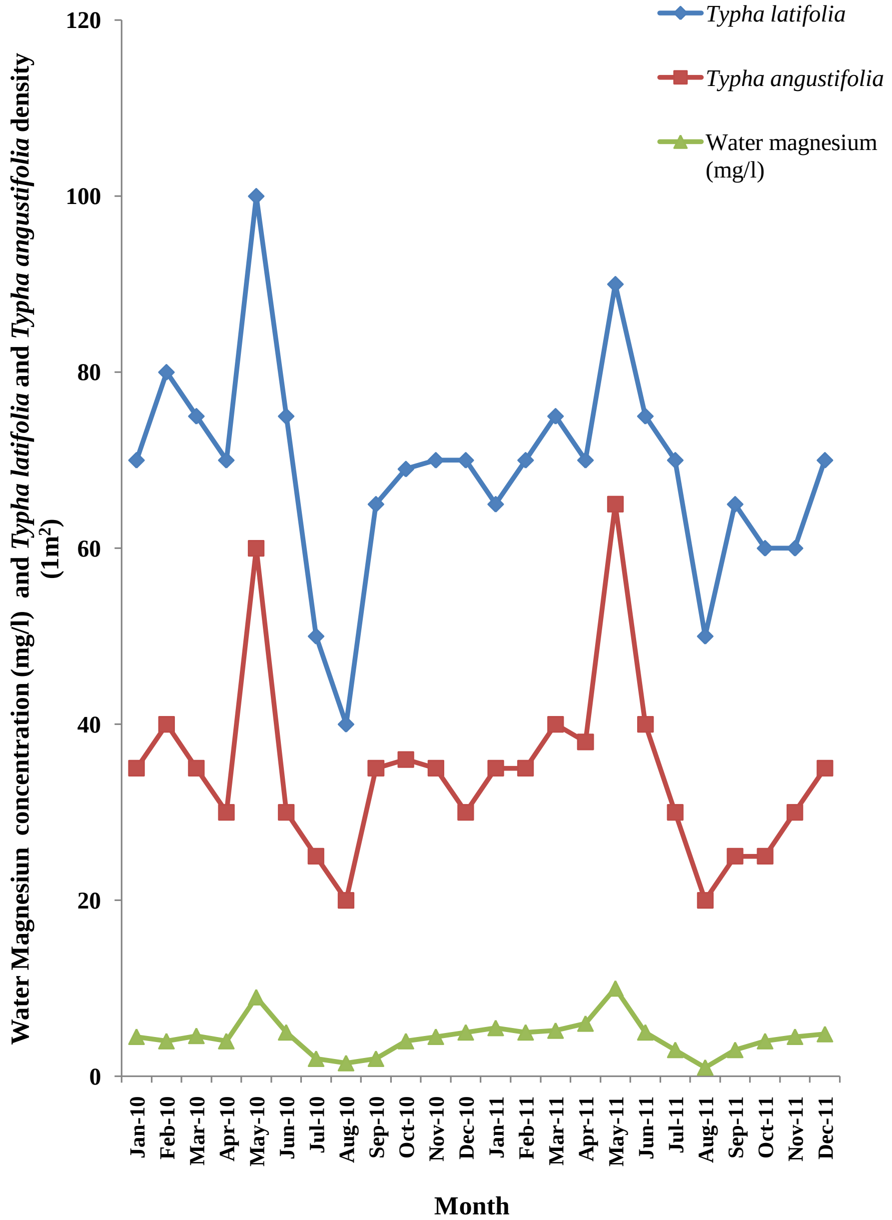

Figure 4.5: Monthly variation between water Magnesium concentration and *Typha* species density in Hadejia-Nguru wetland (2010 and 2011)

Table 4.5 Analysis of varianceof*Typha latifolia* with respect to physico-chemical parameters for period of two years (2010 and 2011)

Source of variation	DF	Water (PO_4-P mg/l)	Water (NO_3-N mg/l)	Water (magnesium mg/l)
TL (Treatment)	116	0.024*	0.035*	0.036*
Month	11	0.036*	0.031*	0.042*
Sample	22	0.034*	0.330	0.012*
Location	2	0.032*	0.004*	0.008*
Season	1	0.020*	0.003*	0.011*
Month* sample	22	0.003*	0.032*	0.048*
Month* location	22	0.021*	0.002*	0.034*
Sample* location	4	0.002*	0.033*	0.026*
Location* season	2	0.040*	0.002*	0.002*
Month *sample *location	44	0.002*	0.002*	0.760
Sample location season	6	0.003*	0.043*	0.243
Error	207			

*Significant; at ($P<0.05$).

TL= ***Typha latifolia***

Table 4.6: Analysis of variance of *Typha angustifolia* with respect to physico-chemical parameters concentration for period of two years (2010 and 2011)

Source of variation	**DF**	**Water (PO_4-Pmg/l)**	**Water (NO_3-Nmg/l)**	**Water (Magnesiummg/l)**
TA (Treatment)	116	0.434	0.020*	0.031*
Month	11	0.436	0.011*	0.002*
Sample	22	0.012*	0.312	0.001*
Location	2	0.021*	0.004*	0.004*
Season	1	0.351	0.003*	0.002*
Month* sample	22	0.028*	0.214	0.037*
Month* location	22	0.002*	0.003*	0.003*
Sample* location	4	0.027*	0.003*	0.0185
Location* season	2	0.030*	0.003*	0.013*
Month *sample *location	44	1.33	0.004*	0.019*
Sample location season	6	0.004*	0.013*	0.001*
Error	207			

*significant at ($P<0.05$)

TA= ***Typha angustifolia***

Table 4.7: Mean valuesseasonal variation of surface water chemical concentrations and *Typha* species density with respect to season and year in Hadejia-Nguru wetlands.

Season/ Years	***Typha latifolia* density per 1m^2**	***Typha angustifolia* density per 1m^2.**	**Water phosphate phosphorus (mg/l)**	**Water Nitrate nitrogen (mg/l)**	**Water magnesium (mg/l)**
Seasons					
Wet year	65.53^b	35.06^b	3.00^b	2.00^b	3.62^b
Dry	80.53^a	40.49^a	7.00^a	4.00^a	5.20^a
Years					
2010	75.91^b	50.59^b	9.13^b	5.92^b	4.56^b
2011	88.29^a	57.82^a	11.94^a	6.01^a	6.35^a

Means with the same letters across columns are not significantly different (P<0.05)

4.8 Relationship between sedimentphosphate- phosphorus concentration and*Typha* speciesdensity.

The result of soil sediment phosphate-phosphorus concentration of Hadejia-Nguru wetlands is presented in figure 4.6. The sediment Phosphate- Phosphorus concentration ranged from 6.5 to 16mg/kg. The range of *Typha latifolia* and *Typha angustifolia* densities was between 60 to 100 stands 40 to 65 stands,respectively. Higher sediment Phosphate-Phosphorus ($PO_{4-}P$) concentration was obtained during dry season (April- May) while lower concentration was obtained at the peak of wet season (July-August).*Typha latifolia*,and *Typha angustifolia* follow the same pattern of fluctuation.

The result also showed that,the concentration of sediment Phosphate-Phosphorus was significant at ($P<0.05$) in all the treatments that is, months, samplings station, location and season. Similarly month and sample, month and location, sample and location, location and season and month x sample x location, and season years and seasons interaction with *Typha latifolia and Typha angustifolia* density were also significant.It also showed a significant correlation between *Typha latifolia,* T*ypha angustifolia* densities and sediment Phosphate-phosphorus concentration.(Tables4.8, 4.9, 4.10 and 4.11).

4.9 Relationship between sedimentNitrate-Nitrogen concentration and *Typha*species density.

The range of concentration of sediment Nitrate- Nitrogen was between6 to14mg/kg. The rangeof *Typha latifolia* and *Typha angustifolia* densities was between 60 to 100 stand 40 to 65 stand per 9m^{3}respectively.Sediment nitrate- nitrogen was higher during extreme dry season (April-May) and lower in (July-August) population of *Typha latifolia* and *Typha angustifolia* followed a similar pattern, as concentration increased the density also increased. The analysed data showedthe concentration of sediment Nitrate- Nitrogen for all the treatments months, samplings station, Location and season. Similarly, month and sample, month and location, sample and location, location and season and month x sample x location, and season years and seasons interaction with*Typha latifolia and Typha angustifolia* density were also significant.It also showed a significant correlation between *Typha latifolia*,T*ypha angustifolia* densities and sediment Nitrate- Nitrogen concentration(Tables4.8, 4.9, 4.10 and 4.11).

4.10 Relationship between sediment organic matter concentration and *Typha*species density

Organic matter contentis the second most abundant nutrient element and like carbon, exists in a wide range of organic forms. It is one of the important nutrients required by *Typha* species in the formation of rhizome. Figures4.8 show the organic matter concentration in Hadejia-Nguru wetland. The range of organic matter concentration was between 4 to 12mg/kg. The ranges of *Typha latifolia* andT*ypha angustifolia* density ranges from 40 to 100 and 20 to 65 stand per $9m^2$, respectively.

Organic matter concentration decreased as the wet season progressed. The highest organic matter concentration was observed at the peak of dry season (April -May). *Typha latifolia* and T*ypha angustifolia* density followed the same pattern of fluctuations. The result showedthe concentration of sediment organic matter for all the treatments, samplings station, location and season were significant. Similarly, month and sample, month and location, sample and location, location and season and month x sample x location, and season years and seasons interaction with *Typha latifolia and Typha angustifolia* density were also significant. Except in treatment and months It also showed a significant correlation at ($P<0.05$) between *Typha latifolia,* T*ypha angustifolia* densities and sediment organic matter concentration*.* (Tables4.8, 4.9, 4.10 and 4.11)

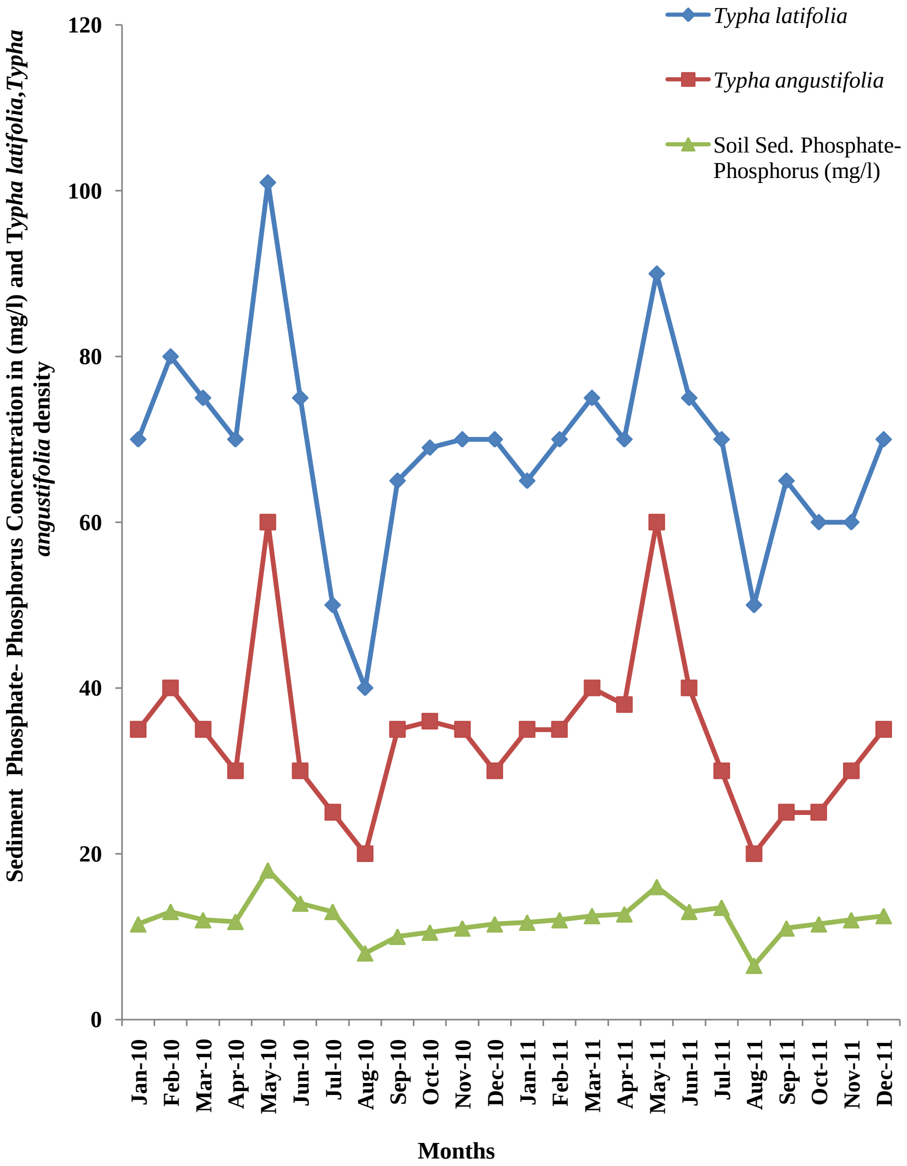

Figure 4.6 Monthly variation between sediment Phosphate- Phosphorus concentration *Typha* speciesdensity in Hadejia-Nguru wetland (2010 and 2011)

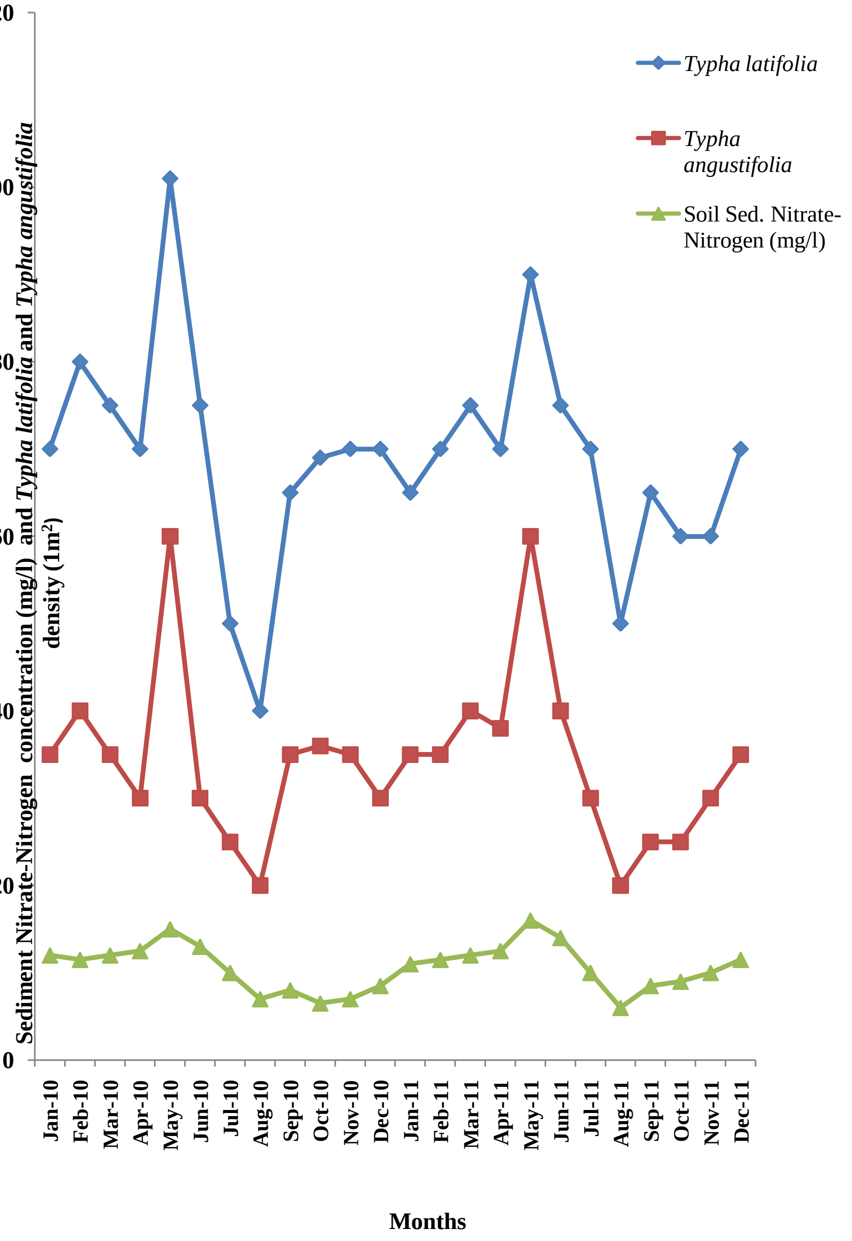

Figure 4.7: Monthly variation between sediment. Nitrate Nitrogen concentration and *Typha* species density in Hadejia-Nguru wetland (2010 and 2011)

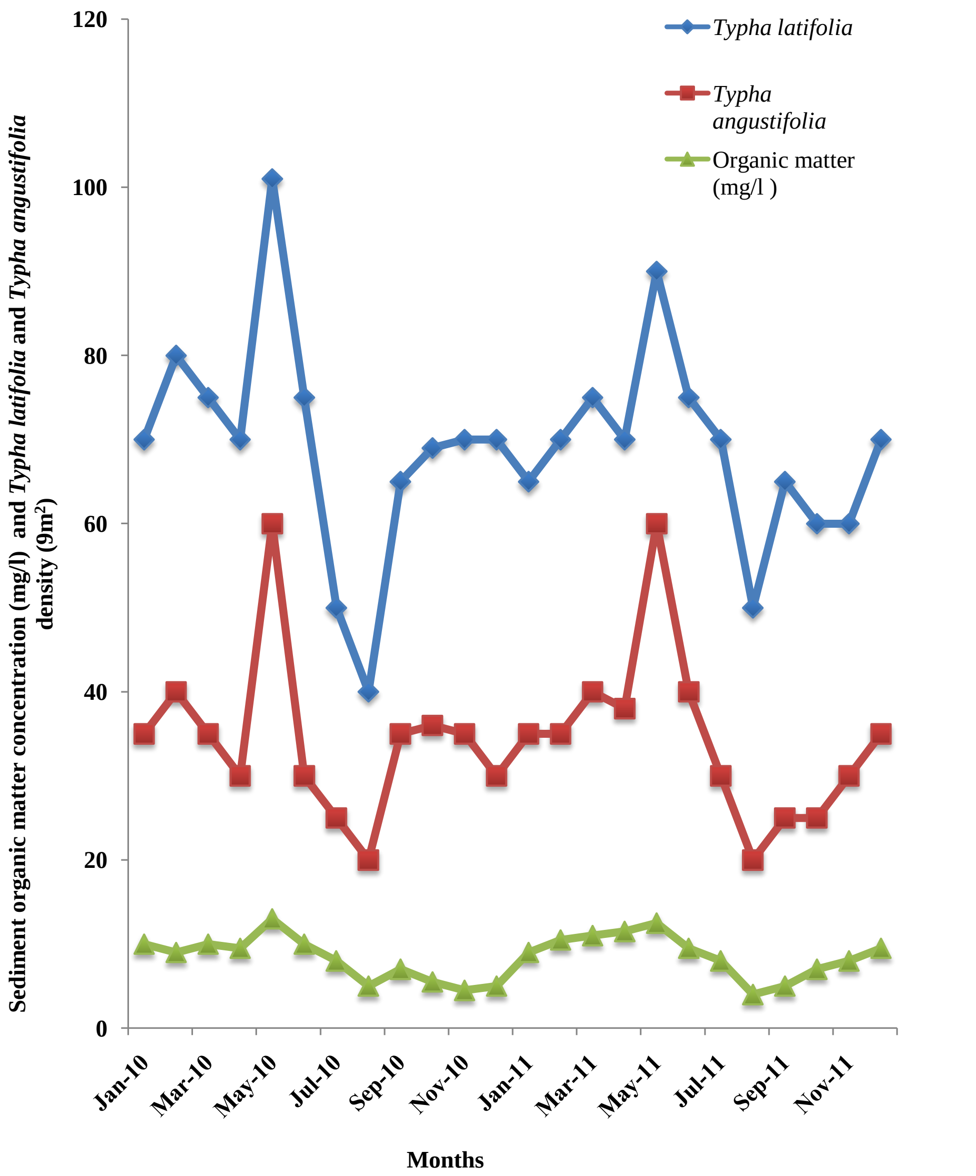

Figure 4.8: Monthly variation between sediment organic matter concentration and *Typha* species density in Hadejia-Nguru wetland (2010 and 2011)

Table 4.8: Analysis of variance with respect to Sediment Nutrients concentration (mg/kg)for period of two years (2010 and 2011)

Source of variation	DF	Sediment (PO_4-P) (g/kg)	Sediment (NO_3-N)(g/kg)	Sediment org. matter (g/kg)
TL (Treatment)	116	0.034*	0.025 *	0.236
Month	11	0.436	0.0131*	0.000*
Sample	22	0.012*	0.0251*	0.011*
Location	2	0.021*	0.040*	0.388
Season	1	0.031*	0.028*	0.000*
Month* sample	22	0.027*	0.003*	0.238
Month* location	22	0.015*	0.032*	0.000*
Sample* location	4	0.027*	0.028*	0.226
Location* season	2	0.030*	0.028*	0.000*
Month *sample *location	44	0.033*	0.023*	0.025*
Sample location season	6	0.024*	0.012*	0.030*
Error	207			

*Significant

TL= *Typha latifolia*

Table 4.9: Analysis of variance of *Typha angustifolia* with respect to sediment Nutrients concentration for period of two years (2010 and 2011)

Source of variation	**DF**	**Sediment (PO_4-P) (mg/l)**	**Sediment (NO_3-N) (g/kg)**	**(Sediment org.Matter) (g/kg)**
TA (Treatment)	116	0.334	0.031*	0.003*
Month	11	0.036*	0.023*	0.000*
Sample	22	0.001**	0.050*	0.001*
Location	2	0.003*	0.040*	0.041*
Season	1	0.031*	0.019*	0.000*
Month* sample	22	0.035*	0.001*	0.038*
Month* location	22	0.023*	0.042*	0.001*
Sample* location	4	0.027*	0.031*	0.046*
Location* season	2	0. 002*	0.032*	0.000*
Month*sample *location	44	0.023*	0.003*	0.001*
Sample location season	6	0.034*	0.015*	0.034*
Error	207			

*Significant

TA= *Typha angustifolia*

Table 4.10: Mean values (g/kg) for some sediment PO_4-P, NO_3-N and Organic matter between seasons and years in Hadejia-Nguru wetland

Season/ Years	***Typha latifolia* density per 1m²**	***Typha angustifolia* density. per 1m²**	**Sediment phosphate-phosphorus (g/kg)**	**Sediment Nitrate-nitrogen (g/kg)**	**Sediment organic matter content (%)**
Seasons					
Wet years	70.53[b]	30.06[b]	4.10[b]	2.50[b]	5.62[b]
Dry Years	95.53[a]	45.49[a]	7.50[a]	4.50[a]	8.80[a]
2010	80.01[b]	60.09[b]	13.23[b]	8.52[b]	7.56[b]
2011	90.09[a]	65.02[a]	15.94[a]	10.02[a]	8.05[a]

Means with the same letters across columns are not significantly different at ($P<0.05$)

Table: 4.11: Correlation between *Typha latifol*ia, *Typha angustifolia* and physico-chemical parameters and soil nutrients

Variables	**TL**	**TA**	**Water (PO_4P) mg/l**	**Water (NO_3N) mg/l**	**Water (mg^4) mg/l**	**Sediment (PO_4P) g/kg**	**Sediment (NO_3N) g/kg**	**Sediment Org. matter g/kg**
TL	1.000							
TA	0.0031	1.000						
Water (PO_4P)	0.032*	0.002*	1.000					
Water (NO_3N)	0.0234*	0.0203*	0.010*	1.000				
Water (Mg^4)	0.0245*	0.0140*	0.0412*	0.0101*	1.000			
Sed. (PO_4P)	0.0341*	0.0234*	0.0341*	0.0162*	0.0301*	1.000		
Sed. (NO_3N)	0.0001*	0.0210*	0.0323*	0.0231*	0.0134*	0.0231*	1.000	
Sed. Organic matter	0.0020*	0.3102*	0.023**	0.102**	0.0010**	0.2312**	0.2103**	1.000

*Significant at P<0.05; **Significant at P<0.01

Key-
TL= ***Typha latifolia***
TA= ***Typha angustifolia***
Sed. = Sediment

4.11 Variation in water PO_4-P, NO_3-N and Mg in different sampling stations

Chemical concentration, vary among the sampling stations (Figure 4.9). There was a higher concentration in upper course followed by middle course and lower course. Water Phosphate-Phosphorus, Nitrate-Nitrogen and Magnesium concentration ranged from 13 to 20 mg/lin the upper course, 12 to 16mg/l in middle course and 5.5 to 12mg/l, in lower course. *Typha latifolia* and *Typha angustifolia* density followed the same pattern of decreasingorder from upper to lower courses.The ranges of *Typha latifolia*and*Typha angustifolia* density 60 to 95, and 30 to 55 per $9m^2$stand, respectively. There was significant difference betweenwater PO_4-P, NO_3-N and Mg concentration with *Typha latifolia* and *Typha angustifolia* densities. Densities of these aquatic plants increased with increase in concentration of chemical (Table 4.12 and 4.13).

4.12 Variation in Sediment PO_4-P, NO_3-N and organic matter in difference samplings stations.

Chemical concentration, vary among the sampling stations (Figure 4.10). There were higher concentrations in the upper course followed by the middle course and lower course. Sediment Phosphate- Phosphorus, Nitrate-Nitrogen and organic matter concentration ranged from 23 to 35 mg/kg in the upper course, 16 to 22mg/kg, in middle course and13 to 20mg/kg, in lower course. *Typha latifolia* and *Typha angustifolia* density followed the same pattern of decrease order from upper to lower course.The ranges of *Typha latifolia*, T*ypha* and *angustifolia* density were 60 to 100, 30 to 55 per $9m^2$ stand, respectively. There was significant difference at ($p<0.05$) betweenwater PO_4-P, NO_3-N and organic matter concentration with *Typha latifolia*,*Typha angustifolia* densities of aquatic plant increased with increase in concentration of chemical **(**Table 4.12 and 4.13).

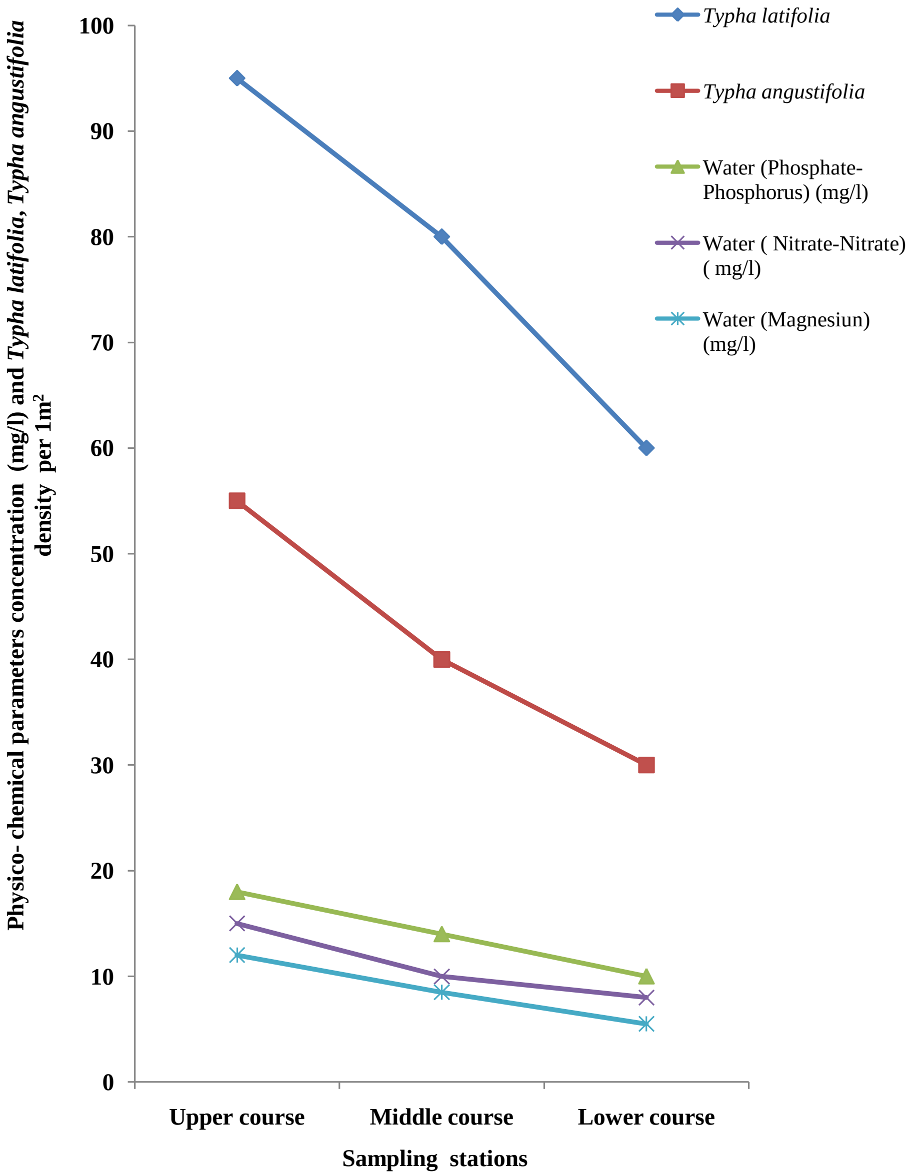

Figure 4.9: Variation betweensurface waterPO_4-P, NO_3-N and Mg concentrations indifferent sampling stations and *Typha* speciesdensityin Hadejia-Nguru wetland.

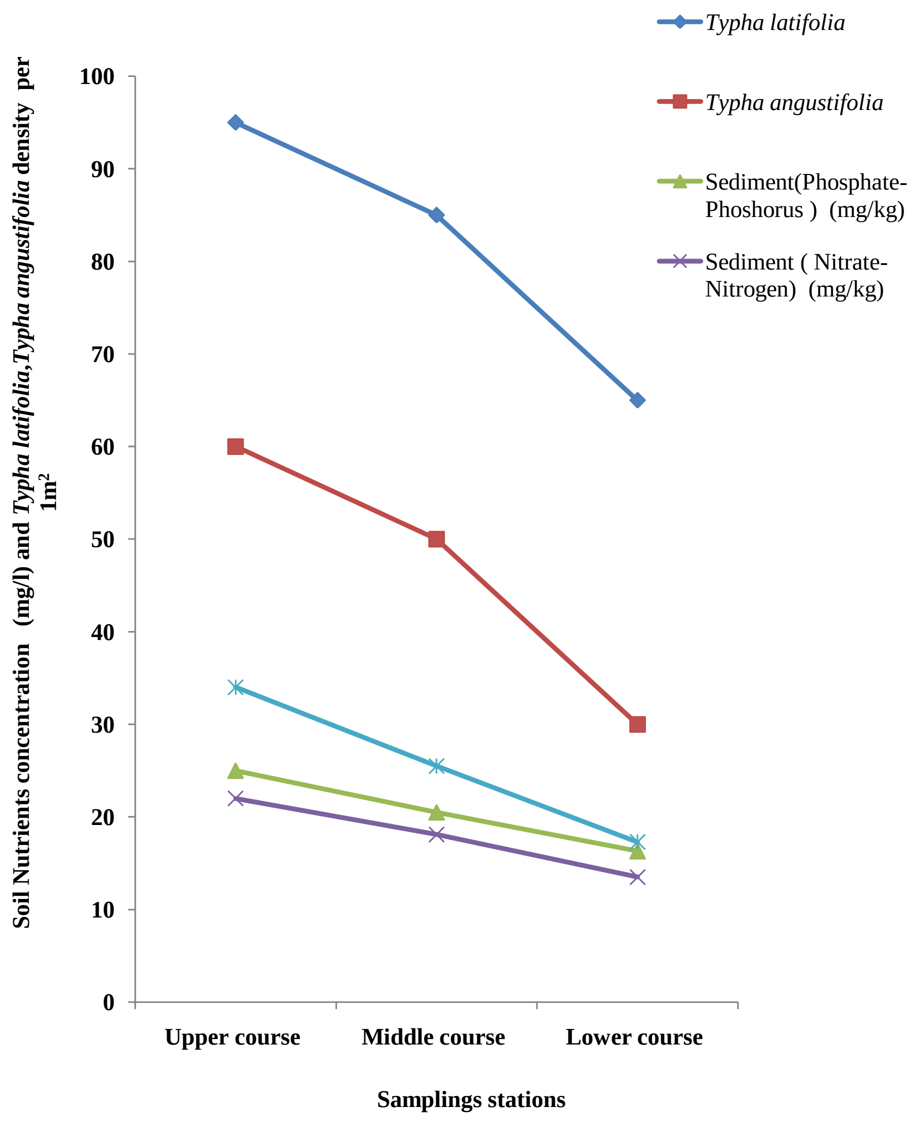

Figure 4.10: Variation between Sediment PO_4-P, NO_3-N and sediment organic matterin different samplingstations and *Typha species*densityin Hadejia-Nguru wetlands

Table 4.12: Mean values of chemical parameters of surface waterin sampling sites and *Typha latifolia,Typha angustifolia* densityin Hadejia-Nguru wetlands

Sample	***Typha latifolia* density per 9m²**	***Typha angustifolia* density per 9m²**	**Water (PO_4-P) (mg/l)**	**Water (NO_3-N) (mg/l)**	**Water mg^{2+} (mg/l)**
Upper course	74.620[a]	27.953[a]	1.494[a]	0.702[a]	0.598[a]
Middle course	73.722[b]	25.521[b]	1.362[b]	0.601[b]	0.384[b]
Lower course	71.435[c]	23.721[c]	0.800[c]	0.502[c]	0.280[c]

Means with the same letters across columns are not significantly different at (P<0.05)
a>b>c

Table 4.13: Mean values ofsedimentnutrients in samplingsites and*Typha latifolia*, *Typha angustifolia* densityin Hadejia-Nguru wetlands

Samples	***Typha latifolia* density per 9m^2**	***Typha angustifolia* density per 9m^2**	**Sediment (PO_4-P) (g/kg)**	**Sediment (NO_3-N) (g/kg)**	**Sediment Organic matter (%)**
Upper course	74.620^a	27.953^a	3.494^a	2.002^a	2.008^a
Middle course	73.722^b	25.521^b	2.262^b	1.201^b	1.840^b
Lower course	71.435^c	23.721^c	1.100^c	0.702^c	0.600^c

Means with the same letters across columns are not significantly different at (P<0.05)
a >b>c

4.13 Impact of *Typha* specieson fish catch and distribution in Hadejia-Nguru wetland (2010 and 2011).

The results showed the average, water, air temperature dissolved oxygen (DO), Biological oxygen demand (BOD) number and weight of fish caught monthly for period of two years in A (un-infested area) ranged between 795 to1.948, 83,167.9 to 173,026.8Kg and B (*Typha*species infested area) 150 to 600, 14,402 to59,355 in Hadejia-Nguru wetlands are presented (tables4.14 and 4.15).The number and weight of fish species decreased in 2011.Twenty three different families and sixty-two fish species were caught in A (open water area) in 2010, while in 2011 twenty two families and fifty six species were caught. This indicated that one family and eight species were lost in 2011 (Appendix xix and xx), due to the increase in *Typha* species infestation. The result was subjected to statistical analysis for both 2010 and 2011, which showed significant difference between the months. There wassignificant difference between (DO) and (BOD) in un-infested and infested area. However there was no significant difference between (January, February and March), (May and June) (August and September), (November and December) in air temperature. Similar trend was exhibited by the number and weight of fish caught in two sites in both two years. (Tables 4.14 and 4.15).The weights and number of fish caught in A (*Typha* un-infested area) and B (*Typha* species infested area) also between seasons and years there was significant difference (Table 4.16).

4.14 Management Methods

4.14.1: Biological control using different *Phragmites karka* weight in Hadejia-Nguru Wetlands is presented in figure 4.11. The first five months showed little changes. However,there was a gradual decreased in T*ypha* speciesdensity with increasing inweight of *Phragmites karka* 50kg is greater than, 25kg, which is greater than 10kg. The decrease were as follows 2000-0 (August 2011), 2000-1400 (December 2011) and 2000-1800(December 2011) respectively while April and May had highest density.The control experiment, which was free from*Phragmites karka* continued to increase each month as shown in figure 4.11.The best control was achieved from June-August, and this may be associated with low concentration of physico-chemical parameters and sediment nutrients. The experiment also showed that the higher the weight of *Phragmites karka* the more effective the control as indicated in (Appendices v, vi, vii and viii).The data analyzed showed that there were significant difference between all the treatments, years and seasons. However, no significant difference between the control experiment (Tables 4.17 and 4.18).

4.14.2 Manual control of *Typha latifolia* and *Typha angustifolia* using Cutting

The results of manual control obtained indicated that, the *Typha* speciescut at 5cm,10cm and 15cm below the water showed no more re-growth in the months of February, April and June respectively (figure 4.12)and (Appendices ix and x). It further showed that, the lower the cut below the water the better the control of *Typha* species. While*Typha* speciescut at 5cm, 10cm and 15cm above the water, (which served as control experiment)continued to increase in density. These also showed steady re-growth rate (Appendices xi and xii).

The analysed result shows that, there were significant differences at ($P<0.05$) between all the cutting levels, years and seasons (Tables 4.19 and 4.20). However, there was no significant difference between the cutting levels above the water.

4.14.3 Physical control of *Typha latifolia* and *Typha angustifolia* using Shading

The results of impact of shade on *Typha* species is presented in figure 4.13.The obtained result indicated that, when triple black tarpaulin was used,*Typha* specieslasted only for four months and the doubled tarpaulin lasted for eight months and single lasted 13 months. The effectiveness of the shade depended on the impact of shading by the black tarpaulin cover. It was observed that, the control experiment continued to increase(Appendices,xiii, xiv, xv and

xvi) with the single,double and triple black tarpaulin and control after two months. The data also revealed that using black tarpaulin to control *Typha* species can also be applied to other nuisance aquatic macrophytes. The data analysed showed that, there were significant differencesbetween single, double, triple, year and seasons (Tables4.21 and 4. 22). The mean values of different methods of controlling *Typha latifolia* and *Typha angustifolia* were compared. Cutting below the water showed the highest mortality of *Typha*followed by shading with black tapaulin and biological method using *phragramites karka*respectively(Table 4.23)

Table: 4. 14 The average (DO), (BOD) Air temperature, Number and weight of fish caught in two locations A (Un-infested) and B (*Typha* species infested area) in Hadejia-Nguru wetland 2010

Month	*FAMILY NAME*	*SPECIES*	Area A Number	Weight (Kg)	DO (A) mg/l	BOD (A) Mg/l	Area B Number	Weight Kg	DO (B)9mg/l	BOD (B) mg/l
Jan.10	*DASYTIDAE* *PROTOPTERIDAE* *POLYPTERIDAE*	*Dasyatisgarouaensis* *Protopterusannectens* *Polypterusansorgii* *Polypterusbichirbichir* Polypterus (e) endicheri *Polypterus(s) senegalus* *Erpetoiochthys Calabaricus*	842	86,187	5.9	*15*	162	17,400	4.4	14..5
Feb.10	*CLUPEIDAE*	*Odaxothrissamento* *Pellonulavorax*	1,227	127, 200	6.8	*15.5*	225	39,460	4.5	14.1
	OSTEOGLOSIDAE *PANTODONTIDAE*	*Heterotisniloticus*								

		Pantodonbuchholzi								
	MORMYRIDAE									
		Mormyrusrume								
		Mormyrus tapirus								
		Hippopotamyrus psittacus								
		Mormyropsanguilloides								
		Campylomyrustamandua								
Mar. 10	*GYMNARCHIDAE*	*Marcuseninussyprinoides*	1,051	134,809	7.5	*15.1*	250	30,047	5.0	14.0
		Marcuseninussenegalensis								
	CROM ERIDAE	*Gytmnorchusniloticus*								
	HEPSETIDAE									
		Cromeianilotica								
	CHARACIDAE	*Hepsetusodoe*								
		Hydrocynusbrevis								
		Hydrocynusvittatus								
		Hydrocynusforskalii								
		Alestes dentex								
		Brycinusleuciscus								
		Micralestes elongates								
April 10	*DISTICHODONTI-DAE*	*Phagoloricatus*	111	170,142	6.8	*15.8*	200	37,057	4.2	13.5
May 10	*CITHARINIDAE*	*Distichodusengyce*	1,150	154,929	6.2	*15.3*	310	40,015	4.0	14.2

		phajus *Citharidiumansorgii* *Citharinuslatus* *Citharinuscitharinus*								
Jun. 10	*CYPRINIDAE* Icthyboridae	*Chelaethiopsbibie* *Labeocoubie* *Labeosenegalensis* *Barbusbynnioccidentalis*	1,948	140,147	6.8	*15.4*	400	34,500	4.0	14.2
Jul.10	*BAGRIDAE*	*Bagrusdocmak* *Bagrusfilamentosus* *Bagrusbajad* *Claroteslaticeps* *Chrysichthysaluluensis* *Chrysichthysauratus* *Chrysichthysnigrodigitatus* *Auchenoglanisbiscutatus*	1,334	133,026	7.0	*16.0*	361	23,633	4.1	14.6
Aug. 10	*SCHILBEIDAE*	*Parailia pellucid* *Schilbeintermedius* *Schilbemystus*	1,025	127,315	9.0	*15.8*	467	25,236	4.2	14.8

Sept .10	*CLARIIDAE* *MALAPTERURIDAE*	*Gymnallabestypus* *Heterobranchusisopterus* *Clariasgariepinus* *Clariasanguillaris* *Clariasjaensis* *Clariasmacromystax* *Malapterurus electricus* *Malapterurusminjiriya*	1,063	119,773	8.4	*15.0*	474	35,910	4.7	14.6
Oct. 10	*CHANNIDAE* MOCHOKIDA*E*	*Parachanna africana* *Parachannaobscura* *Chiloglanisbenuensis* *Synodontisresupinatus* *Synodontisbudgetti* *Synodontisclarias* *Synodontisomias* *Synodontisrobbianus*	1,070	114,473	7.4	*15.9*	392	48,137	4.6	14.7

		Synodontisnigrita *Synodontisschitt*								
Nov. 10	*CHANNIDAE* *CENTROPODAE*	*Parachanna african* *Parachannaobscura* *Latesniloticus* *Chromidatilapia guntheri* *Tilapia dageti* *Tilapia zilli* *Tilapia guineensis*	1,047	115,656	8.2	16.1	402	53,338	4.3	14.3
Dec. 10	*CHANNIDAE* *CENTROPOMIDAE*	*Parachanna african* *Parachannaobscura* *Latesniloticus* *Chromidotilapia guntheri* *Tilapia dageti* *Tilapia zilli* *Tilapia guineensis*	1,000	118,256	8.1	16.1	402	59,335	4.3	14.3

Table: 4. 15 Table: 4. 14 The average (DO), (BOD) Air temperature, Number and weight of fish caught in two locations A (Un-infested) and B (*Typha* species infested area) in Hadejia-Nguru wetland 2011

	FAMILY NAME	SPECIES	**Area A Number**	**Weight (Kg)**	**DO (A) mg/l**	BOD (A) Mg/l	**Area B Number**	**Weight(Kg)**	**DO (B)9mg/l**	**BOD (B) mg/l**
Jan 11	*PROTOPTERIDAE* *POLYPTERIDAE*	*Protopterusannectens* *Polypterusansorgii* *Polypterusbichir* *Polypterus endltcheri* *Erpetoiochthyscalabaricus*	800	83,167	6.0	*15.4*	1 27	14,402	4.2	14.5
Feb.11	*CLUPEIDAE* *OSTEOGLOSSIDAE* *PANTODONTIDAE* *MORMYRIDAE*	*Odoxothrissamento* *Heterotisniloticus* *Pantodonbuchholzi* *Mormyrusrume* *Mormyrustapirus* *Hippopotamyruspsittacus* *Campylomyrustamandua*	1,100	117,199	5.9	*16.1*	600	31,465	5.0	14.2

		- *Marcuseninussypri noides*								
Mar 11	*GYMNARCHIDAE CROM ERIDAE HEPSETIDAE CHARACIDAE*	*Gytmnorchusniloti cus Cromeianilotica Hepsetidaeodoe Hydrocynusbrevis Hydrocynusvittatu s Hydrocynusforskal ii Alestesdentex Brycinusleuciscus Micralestes elongates*	1,022	121,799	6.7	*15.3*	250	30,047	4.6	14.4
April 11	*DISTICHODONTIDAE*	*Phagoloricatus Distichodusengyce phajus*	111	170,142	6.9	*15.5*	150	32, 067	4.7	14.4
May 11	*CITHARINIDAE*	*Citharidiumansorg ii Citharinuslatus Citharinuscitharin us Chelaethiopsbibie Labeocoubie*	1,150	134,929	7.2	*15.3*	300	40,000	4.3	14.9
Jun. 11	*CYPRINIDAE*	*Chelaethiopsbibie Barbusoccidentalis*	1,338	121,472	8.7	*15.6*	403	25,510	4.3	14.6

Jul .11	*BAGRIDAE*	*Bagrusdocmak Bagrusfilamentosus Bagrusbajad Chrysichthys aluluensis Auchenoglanisbiscutatus*	1,334	173,026.8	8.4	*15.4*	355	43,643	4.1	14.8
Aug. 11	*SCHILBEIDAE*	*Parailia pellucid Schilbeintermedius Schilbemystus*	795	11,305	7.8	*15.6*	450	42,365	4.0	14.6
Sept. 11	*CLARIIDAE*	*Gymnallabestypus Heterobranchusisopterus Clariasgariepinus Clariasanguillaris Clariasmacromystax*	953	109,763	6.9	*15.4*	479	57,914	4.2	14.8
Oct. 11	*MALAPTERURIDAE*	*Malapterurus electricus Malapterurus minjiriya*	1,030	142,463	5.0	*15.4*	370	38,147	4.6	14.5
	MOCHOKIDAE	*Chiloglanis benuensis Synodontis*								

		resupinatus *Synodontis budgetti*								
Nov. 11	*CHANNIDAE* *CENTROPMIDAE*	*Parachanna africana* *Parachannaobscura* *Latesniloticus* *Chromidotilapia gunther* *Tilapia dageti* *Tilapia zillii*	1,000	111,646	6.8	*15.5*	450	41,348	5.0	14.2
Dec. 11	*ANABANTIDAE*	*Clenopomanebulosum* *Ctenopomamurei* *Ctenopomapaetherici*	1,043	102,346	7.5	*15.4*	430	48,233	4.9	15.0

Comment [h1]:

Table 4.16: Mean values per ($1m^2$) of fish caught in *Typha* species free and *Typha*infested area between the seasons and years in Hadejia-Nguru wetlands

Source of variation	Mean values
(A) *Typha* unifested area	85.998[a]
(B) *Typha* infested area	60.880[b]
Seasons	
Dry (A) *Typha*unifested area	90.324[a]
Dry (B) *Typha* infested areas	40.562[b]
Wet (A)*Typha* Unifested area	50.231[a]
Wet (B)*Typha* infested areas	30.126[b]
Years	
2010 (A)*Typha*unifested area	85.761[a]
2010 (B) *Typha* infested areas	55.264[b]
2011 (A) *Typha*unifested area	70.452[a]
2011 (B) *Typha* infested areas	42.642[b]

Means with the same letters across column are not significantly different at ($P<0.05$)

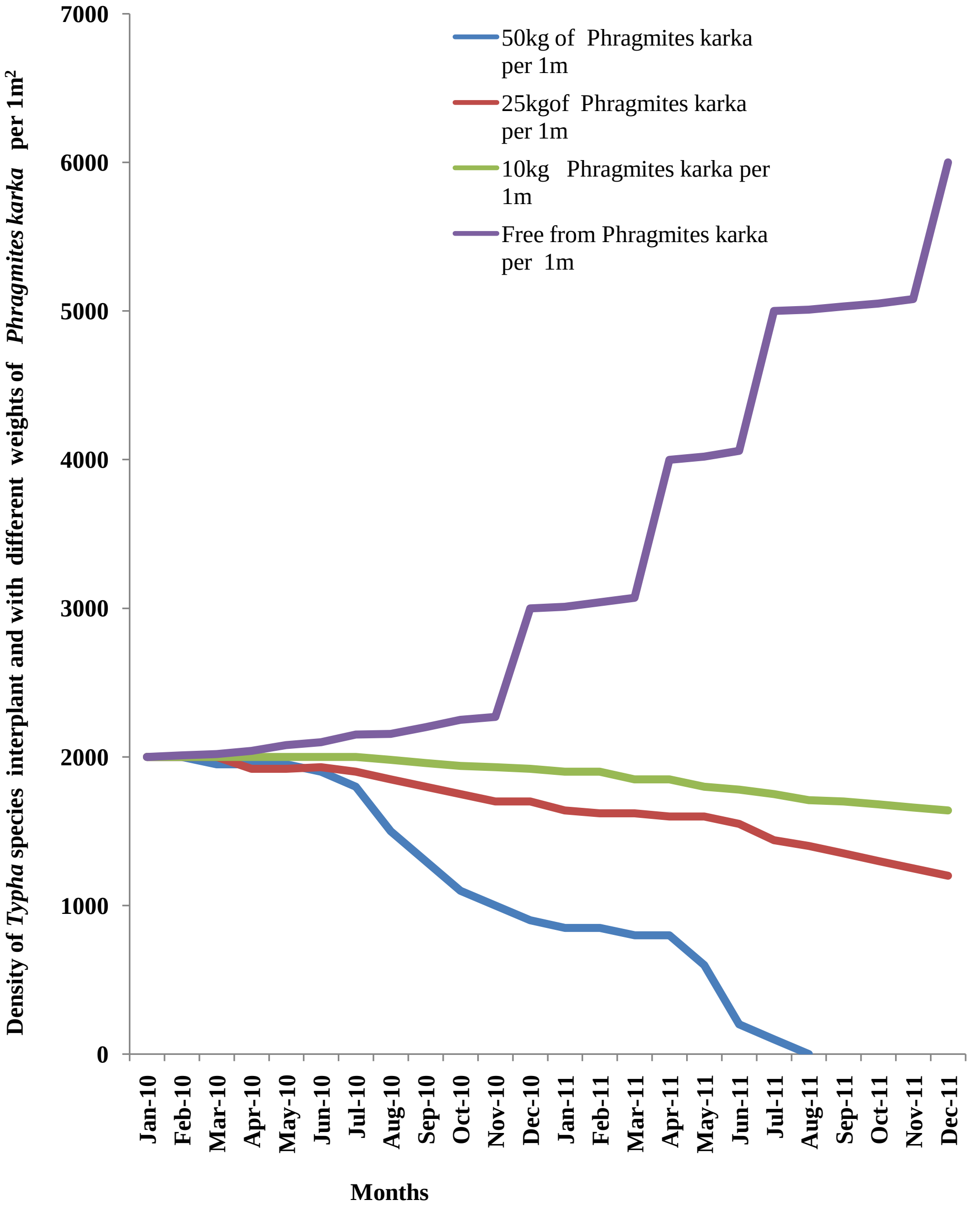

Figure 4.11: Monthly variation between different *Phagramites karka* weight and *Typha latifolia* and *Typha angustifolia*in Hadejia-Nguru, wetland (2010 and 2011)

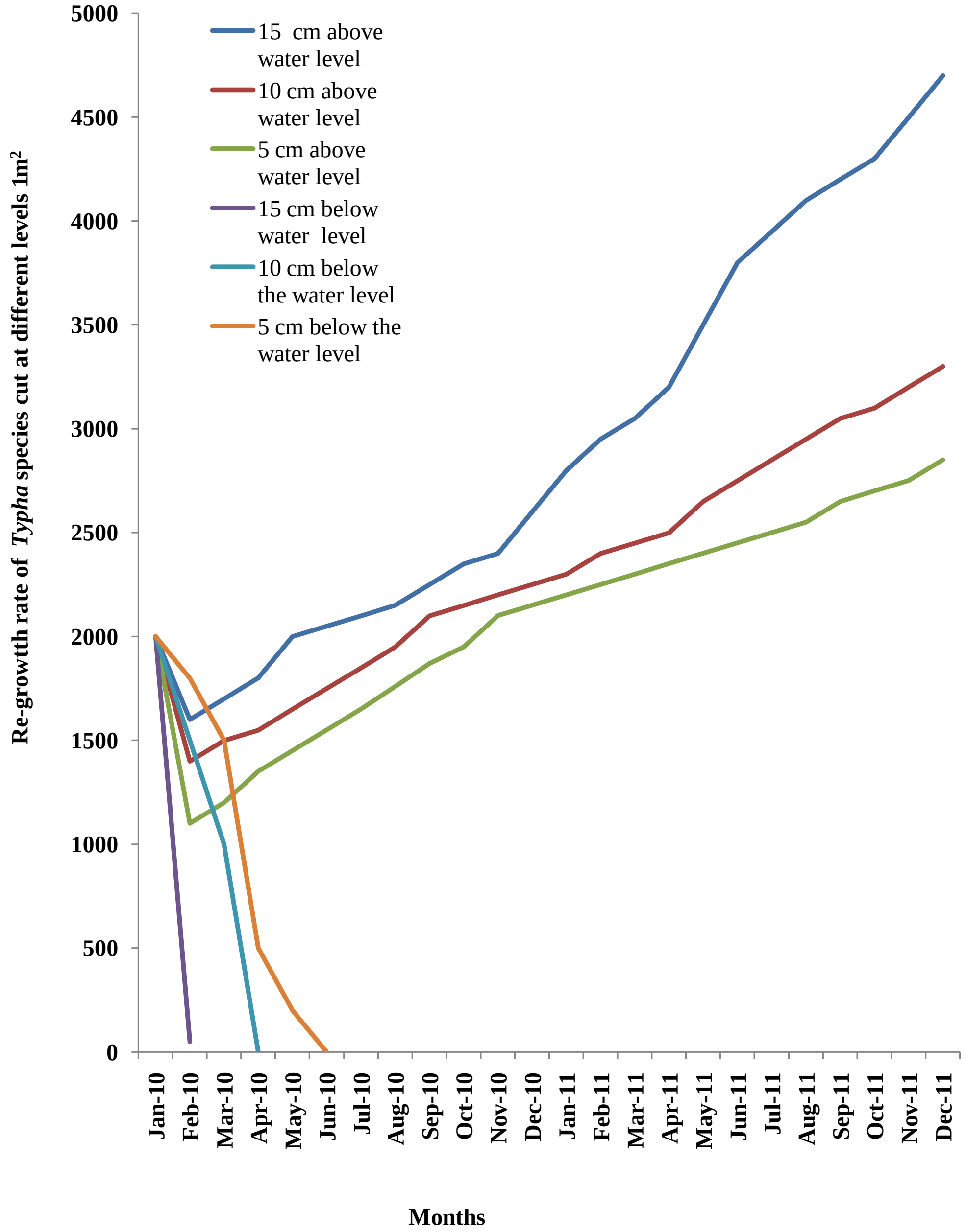

Figure 4.12: Monthly variation between different re-growth rate of*Typha latifolia* and *Typha angustifolia* cut atdifference levelsin Hadejia-Nguru wetlands in the year 2010 and 2011

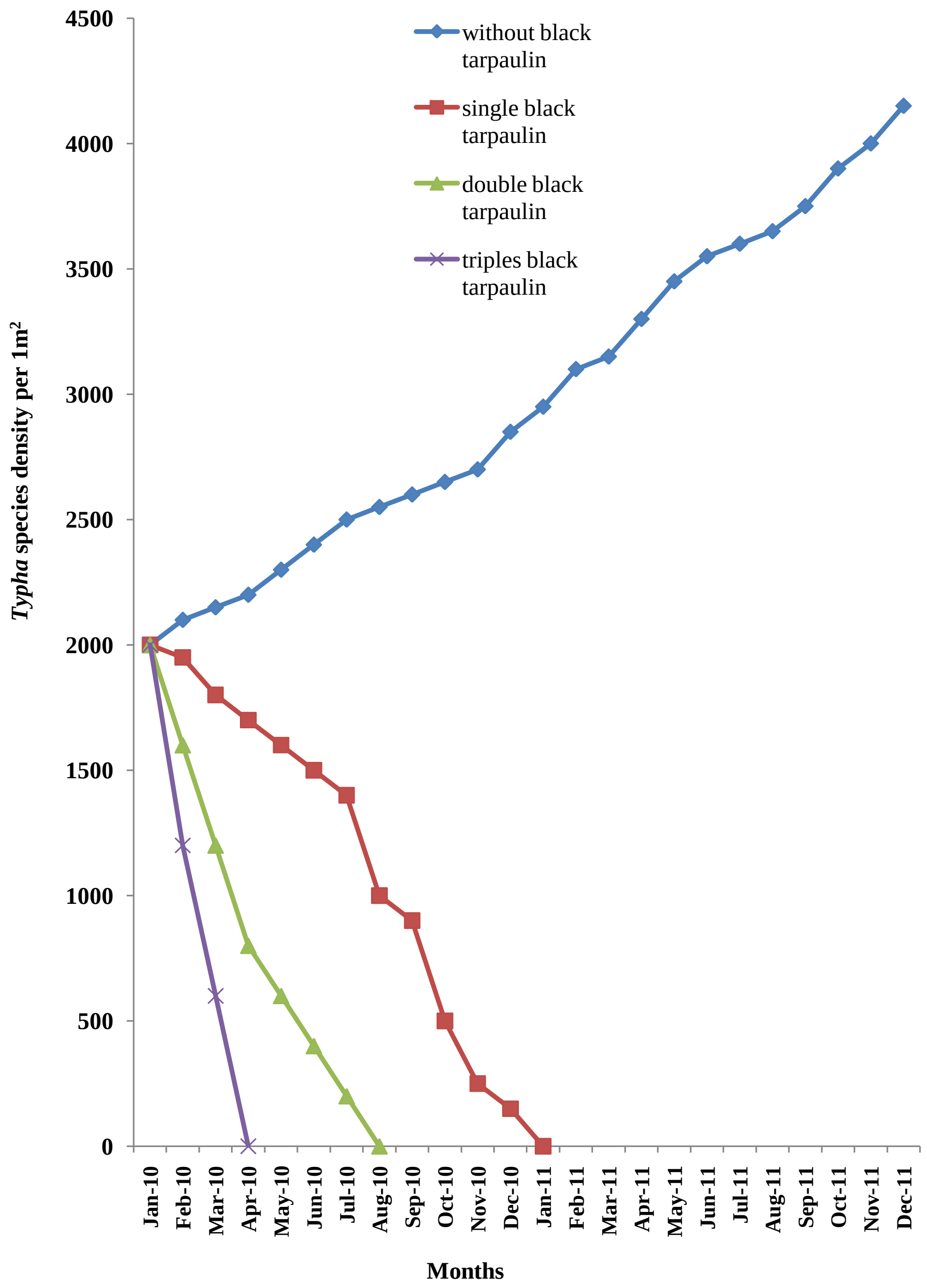

Figure 4.13: Monthly variation between different numbers of black tarpaulin number and *Typha latifolia*, *Typha angustifolia* densityinHadejia-Nguru wetland in the year 2010 and 2011.

Table 4.17: Mean valuesof difference *Phragmites karka* andmortality rate per ($1m^2$) of *Typha latifolia* and *Typha angustifolia* interplaned with different *Phragmites karka*weightin Hadejia Nguru Wetlands

Treatments	**Mean value of mortality rate of *Typha latifolia*, *Typha angustifolia***
50kg of *Phragmites karka*	55.342[a]
25kg of *Phragmites karka*	33.653[b]
10kg of *Phragmites karka*	25.672[c]
Free from phragmites *karka*	10.324[d]

Means with the same letters across columns are not significantly different at $P<0.05$

Table 4.18: Mean valuesof different*Phragmites karka*and mortality rate per ($1m^2$) of *Typha latifolia* and *Typha angustifolia* interplaned with different *Phragmites karka*weightwith respect to years and seasons in Hadejia Nguru Wetland.

Source of variation	**50kg of*Phragmites karka***	**25kg of *Phragmites karka***	**10kg of *Phragmites karka***	**Free from *Phragramites karka***
Year				
2010	90.232[b]	53.127[b]	20.653[b]	345.230[a]
2011	120.620[a]	75.230[a]	32,234[a]	345.231[a]
Seasons				
Dry	50.342[b]	42.103[b]	25.120[b]	246.781[a]
Wet	75..531[a]	55.107[a]	35.708[a]	246.781[a]

Means with the same letters across columns are not significantly different at P<0.05

Table 4.19: Mean valuesof different cutting levels of *Typha latifolia* and *Typha angustifolia* and re-growth rateper ($1m^2$) in Hadejia Nguru Wetlands

Treatments	**Mean value re-growth rate of *Typha latifolia, Typha angustifolia* ($1m^2$)**
15 cm above the water	95.342[a]
10cm above the water	80.321[b]
5cm above the water	72.461[c]
5cm below the water	55.672[d]
10cm below the water	33.653[e]
15 cm below the water	15.342[f]

Means with the same letters across columns are not significantly different at $P<0.05$

Table 4.20: Mean values of different cutting levels of *Typha latifolia* and *Typha angustifolia* re-growth rate per ($1m^2$)with respect to years and seasons in Hadejia-Nguru wetlands

Source of variation	**15 cm above the water**	**10 cm above the water**	**5cm above water**	**15 cm below the water**	**10cm below the water**	**5cm below the water**
Year						
2010	98.673[a]	65.342[a]	50.876[a]	20.365[a]	35.642[a]	45.678[a]
2011	98.672[a]	65.456[a]	50.798[a]	10.123[b]	30.750[b]	40.320[b]
Seasons						
Dry	98.654[a]	65.342[a]	50.860[a]	15.645[a]	33.123[a]	35.105[a]
Wet	98.653[a]	65.453[a]	50.873[a]	6.532[b]	25.432[b]	30.000[b]

Means with the same letters across columns are not significantly different at ($P<0.05$)

Table 4.21: Mean values of differenceblack tarpaulinnumber and mortality rate per ($1m^2$) of *Typha latifolia* and *Typha angustifolia* covered with black tarpaulinin Hadejia Nguru Wetlands

Treatments	Mean value of mortality rate of *Typha latifolia*, *Typha angustifolia*per($1m^2$)
Triples black tarpaulin	80.342^{a}
Double black tarpaulin	40.653^{b}
Single black tarpaulin	21.672^{c}
Without black tarpaulin	8.324^{d}

Means with the same letters across columns are not significantly different at P<0.05

Table 4.22: Mean values of different number black tarpaulinand *Typhalatifolia Typha angustifolia* mortality rate per ($1m^2$) with respect to years and seasons in Hadejia-Nguru wetland

Source of variation	Without black tarpaulin	Single black tarpaulin	Double black tarpaulin	Triples black tarpaulin
Year				
2010	70.451[a]	63.000[a]	60.345[a]	45.306[a]
2011	70.443[a]	52.125[b]	50.325[b]	35.202[b]
seasons				
Dry	69.532[a]	58.324[a]	35.307[a]	35.812[a]
Wet	68.453a	45.453b	25.209b	20.254[b]

Means with the same letters across columns are not significantly different at P<0.05

Table 4.23: Comparism of mean values of different peak level of mortality rateper ($1m^2$) of*Typha latifolia* and *Typha angustifolia* with different methods of controllingin Hadejia-Nguru wetland

Methods	Mean value of mortality rate of *Typha latifolia*, *Typha angustifolia*
Manual control (Cutting below the water levels)	95.653[a]
Mechanical control (Shading using black tarpaulin)	54.753[b]
Biological control using (*Phragmites karka*)	25.765[c]

Means with the same lettersacross columns are not significantly different at ($P<0.05$)

CHAPTER FIVE

5.0 DISCUSSION

5.1 *Typha* species resident in Hadejia-Nguru Wetland

Two species of *Typh*a were identified during the two years of studies using aquatic plant information system.These were *Typha latifolia* and *Typha angustifolia*with the levels of infestation at 65%-70% and 30%-35%, respectively.This is contrary tothe findings of Wetzel (2003) that reported *Typha angustifolia*is not common inWest Africa wetlands. The range of their densities were60 to 100 and 40 to 60 stands per $9m^2$, respectively. *Typha latifolia* has higher density than *Typha angustifolia*, whichmight be as a result of seasonal variation resultant from the flood (flood fluctuation). This is in line with the findings of Smith (2004) that *Typha latifolia* tolerated wide range of tropical conditions than *Typha angustifolia.* However, during higher flood *Typha angustifolia* tended to increase slightly in density. This might be associated with the fact that it tolerated higher flood levels. The significant difference between *Typha latifolia* and *Typha angustifolia*could be associated with environmental factors. Similar observation was reported by Wilcox (2006) in New Delhi Lake where Phosphate-Phosphorus increased as result of irrigation activities enhacing*Typha latifolia* density, causing eliminate almost all other aquatic macrophytes.

Initial *Typha* species community developedthrough various modes of succession or colonizationfrom surrounding water, and other morphological attributes; which permitted water or wind dispersal or direct transportation by water fowls. Alteration of the environment due to seasonal and periodic changes could also influence changes in *Typha* species (Chiroma *et al*., 2005). The variation of *Typha latifolia* and *Typha angustifolia* distribution, composition and abundance in Hadejia Nguru wetlands could also be attributed to such factors, as the construction of Tiga dam upstream which altered the environmental conditions.

Wetzel (2003) reported aquatic macrophytes infestation being favoured by alteration of the environment factors. The complex relationship relates to the ecosystem components through the succession pattern via components of the biotic and abiotic factors.These inter-linked factors involve cycling of materials from non-living abiotic factors throughproducers, consumers and decomposers. Smith (2009) established a close relationship between nutrient cycle on one hand and *Typha* species structure on the other hand. He found that, increase in water nutrients and sediment nutrients increased*Typha* species density.

Water chemistry and *Typha* species were influenced mainly by climatic regime, rainfall patterns, extent of usage, and human activities. The extent of human activities on the basis of locations, catchment characteristics, water volume fluctuations, which vary from time to time as a result of seasonal variations, could have accounted for the major water chemistry and *Typha latifolia*,*Typha angustifolia* differences in densities in Hadejia Nguru wetland. Smith (2009) reported similar variation in water chemistry that influenced*Typha latifolia* and *Typha diminigensis* densities.

The Hadejia Nguruwetland water levels fluctuated throughout the seasons with maximum volume during the wet season.It exhibited highest variation, especially during the dry season when the water level diminishes to about one third of its maximum volume. The entire littoral area, which was otherwise covered during the wet season period, became exposed as the dry season progressesed. The overall change in water chemistry could be associated with increased anthropogenic activities, such as increased water usage, through intensive irrigation around the surrounding wetlands, block making, washing and concentration of livestock population. Also the vegetation of the exposed littoral area increased as the draw-down progressed.The rate of livestock droppings from grazing activity of livestock and their urine also increases. All these exposed areas eventually submerged as the wet season commences resulting into a build up organic matter. These could be due to differences in the individual characteristics of the Hadejia Nguru wetlands in response to the seasonal variation of waterphysico-chemical characteristics, thereby influencing *Typha latifolia*,and *Typha angustifolia* densities.Hillman(2012) reported periodic filling, gradual drying sometimes and dehydration resulted in wide ranges of physical and chemical conditions of aquatic ecosystems.

Morphology of Hadejia Nguru wetland basin has an important influence on physical, chemical and biological factors that might collectively determine the attributed of wetlands (Singh *et al*., 2006). Due to ecological and the use of characterization of wetland,*Typha* species react in different ways to changes occurring in their drainage basins over a long period of time.Stone (2001) reported significant changes in the ecological relationships with *Typha* species. Gradual drying out and shrinking of the Hadejia Nguru wetland surface area, increased *Typha latifolia* and *Typha angustifolia* proliferation. The establishment of *Typha latifolia* and *Typha angustifolia*in Hadejia Nguru wetland could also be due to their individual adaptation patterns, survival, life history patterns and generation line. The extent and nature of irregular and extreme ecological conditions of the Sudan savannah especially climatic variations through wind action could also have a resultant effect in modifying the wetland ecosystem (Smith, 2004).

The distribution of *Typha latifolia* and *Typha angustifolia* were higher in upper, middle and lowercourses, in Hadejia Nguru wetlands. These could be attributed to the fact that, human activities in Hadejia Nguru wetland is mostly taking place in upper and middle portion while virtually very little activities take place in the lower course. The nature and distribution of

Typha species was probably influenced by the concentration of water nutrients and sediment nutrients. This is shown by the differences with respect to high density of *Typha* species.Changes in accumulation of organic matter and stability of the ecosystem could also influence the composition of *Typha* species, which is seen in the relatively higher population density of species in upper and middle courses. The major physico-chemical parameters of the wetland could be linked to the extent and size of the catchment areas, soil characteristics, topography and vegetation covers. Due to its larger catchment size and population, the intensity and rate of human activities could have be suggested to a strong influence on Hadejia Nguru wetland. This activities, including irrigation, fishing, and farming within littoral edges and the catchment areas might have accounted for higher proliferation of *Typha* species in Hadejia Nguru wetland.

5.2 Surface water, PO_4-P, NO_3-N and Mg concentrations

High transparency, conductivity turbidity in Hadejia Nguru wetlands did not affect Typha *latifolia* and *Typha angustifolia* density. Thiscould beattributed tonon-response of *Typha* species to some physico-chemical parameters. Similar observation was made by Singh *et al*., (2006). Transparency and turbidity did not influence *Typha* species density, which could be associated with ability of *Typha* species totolerant varying climaticconditionsandenvironmental changes.Thisissometimes considered as an invasivenativein aquaticcommunities, and averyfastgrowingplant (MurkinandWard, 2014)

Typha latifolia and *Typha angustifolia* density in Hadejia Nguru wetlands is not influenced by higher or low pH, which may be attributed to the ability of *Typha* species rhizome reduced higher pH concentration. This in line with the findings of Singh *et al*., (2006) that *Typha* species could tolerant wide range of pH. This is because, the rhizome has ability to reduce higher pH to lower level. However this is contrary to the findings of Balarabe (2001) who reported that lower pH led to relatively lower aquatic macrophytes density.

Concerning Dissolved oxygen (DO)plant do not require oxygen they even give out oxygen during photosynthetic activities Plants generally release oxygen in the atmosphere, therefore area with dense *Typha* species have abundant oxygen. Smith (2009) reported more abundance of oxygen in area of high*Typha domingesis* growth when compared to the area without *Typha domingensis.*

Biological Oxygen Demand (BOD) affects*Typha latifolia* and *Typha angustifolia* density indirectly. BOD was needed during the decomposition of organic matter by microorganism. This in line with the findings of Smith (2009) that *Typha latifolia* density was slightly affected by low BOD due toslow decomposition of organic matter.

The water chemistry of Hadejia-Nguru wetland is influenced by the extent of human activities on the basis of catchment characteristics.Water volume fluctuations, which could vary from time to time as a result of seasonal variation accounted for the major limnological differences between *Typha latifolia* and *Typha angustifolia* densities. Torres-Orozeo *et al*., (1996) reported that, variation in lakes New Delhi Indian might have been caused by the influence of environmental factors.The water level of Hadejia-Nguru wetland fluctuated throughout the bothseasons, with maximum volume during the wet season. The wetland exhibited higher variation especially during the dry season when the water level reduced drastically(NIFFR, 2002).

Human activities, particularly livestock grazing, watering, irrigation within the expanded catchment and littoral areas of Hadejia-Nguru wetland could have accounted for the profound influence of Nitrate-Nitrogen (NO_3-N), Phosphate-Phosphorus (PO_4-P) and organic matter concentrations. This could be observed to be related to the higher deposition of faecal matter throughout the periphery of wetland. Under the influence of edaphic factors particularly during flood times and organic pollution, Nitrate-Nitrogen (NO_3-N) contents might be expected to increase significantly (Stone, 2001). The amount of nitrate in solution at a given time is determined by metabolic processes in the water body through deposition and decomposition. (Smith, 2004). Continuous mixing and re-suspension of sediment particles might increase nutrient cycling and its release in water, which influenced*Typha latifolia* and *Typha angustifolia* density Deny, (2008) andHabibah *et al.*,(2012) reported, the effectof transparency and electrical conductivityonthegrowthof *Typha dominingsis* and *Typha latifolia*studiedunder higher and low transparency and electrical conductivity.This revealedno significant relationship between *Typha dominingsis*, and *Typha latifolia*. This is in line with these studies.

The concentration of Phosphorus was generally higher at upper course. This might be connected TO the agricultural activities taking place around the site, where both irrigation and rain fed farming is done. The concentration of Phosphate-Phosphorus showed a similar trend at the entire sites, where Phosphorus level increased as the dry season progresses. At the end of dry season (April-May) the concentration was highest. *Typha latifolia* and *Typha angustifolia* recordedhighest densitiesduringthis period.This could be attributed toPhosphate-Phosphorus required by the two species in all stages of growth. This supports the findingsof Smith (2004) whoreported thatPhosphate-Phosphorus is required during rhizome phloem and xylemformation, as well as flowering.

Water n

Nitrate-Nitrogen is the second most abundant nutrient element and like carbon, exists in a wide range of organic forms. Nitrogen is one of the important nutrients for T*ypha* species growth in the aquatic environment.The amount of Nitrate-Nitrogen during the study period in the entire sampling sites followed a similar pattern, where concentration increased as the dry season progressed. The highest concentration was observed immediately after the wet season (April-May). The highest concentration wasobtained inthe upper course. Thismight be associated with run-off water and agriculture activities, which explain the reason for higher density of *Typha latifo*lia and *Typha angustifolia* at this site. The analysed resultshowed that, there is significant difference between Nitrate-Nitrogen concentration and *Typha latifo*lia,*Typha angustifolia*.

Magnesium showed significant correlation with abundance of *Typha latifolia* and *Typha angustifolia.* High values of water Magnesium (Mg^{2+}) were obtained, during extremes dry season (April-May) with lower values obtained in wet season (July- August).

Typha latifolia andTypha angustifolia follow the same pattern of fluctuations. These differences in fluctuations in water chemistry might be attributed to increase and decrease in water volume as a result of seasonal variation (wet and dry season). Hillman (2012) made similar observation that periodic filling and gradual drying often cause complete dehydration, resulting to wide ranges in physical and chemical conditions of aquatic ecosystems. The analysed result showed that, there was significant difference at ($P<0.05$) between water Magnesium concentration and *Typha latifo*lia, *Typha angustifolia* except withinmonth, and sample location.

5.3 Sediment PO4-P, NO_3-N, organic matter concentrationand *Typha latifolia, Typha angustifolia* density

High dry season mean value of Phosphate-Phosphorus (PO_4-P) occurred during extreme dry season(April-May), while lower values were obtained between (July-August). The resultfurther showed that, there was significant difference between Sediment Phosphate-Phosphorus concentration and *Typha latifo*lia,*Typha angustifolia*. This could be attributed to the concentration of the surface run-offs, which brought in plant materialsand debris that later decayed and released nutrients to the soil during the dry season. Similar observation by Green (2013) showed both sediment Phosphate-Phosphorus, beinghighly soluble in water,which did not bind to the soil thus, have high migratory potential through soil when water volumes decrease to form high concentrations.

Sediment Nitrate-Nitrogen is the second most abundant nutrient element and like carbon, exists in a wide range of organic forms of soil nitrate. Nitrogen is an important nutrient for *Typha* species growth in the aquatic environment. The mean value of Nitrate-Nitrogen (NO_3-N) was obtained, during extremehighdry season (April-May).The lower values were obtainedwithin (July to August). Both*Typha*sppfollow the same pattern of fluctuation.These may be attributed to the species response to increase in Nitrate- Nitrogen. This confirmedthe findings of Birnin- yauri *etal*.,(2004) that increase in Nitrate-nitrogen increases*Typha australis*density.

Organic matter concentration is the second most abundant nutrient element and like carbon, exists in a wide range of organic forms. The highest concentration of sedimentorganic matter content during the study period in Hadejia-Nguruwetlands was obtained during extreme dry season (April-May). The lowest concentrationwas obtained during the peak of wet season (July- August). The growth of both *Typha latifolia* and *Typha angustifolia* followed the same pattern of fluctuations with organic matter content.The analysed resultshowed that, there was significant difference between Sediment Organic matter concentrations.These may be associated with fact that all the debris from run-off end in sediment.Similar findings by Green (2013) showed that both soil and water organic matter concentration were highly soluble in water, did not bind to the soil,and have high migration potential through the soil and when water volume decrease it forms high concentration in sediment as reported earlier.The distribution of *Typha latifolia* and *Typha angustifolia* were higher in the upper course, this was followed by middle course and the lower course. Theexposed littoral zone was covered with water along with the emergent macrophytes, which attracted livestock grazing, during the dry season. It often resultant in theaccumulated droppings along the edges of the fringing vegetation and the intensity increased as the draw-down progressed. The resultant effects caused accumulation of organic matter. Balarabe (2001) reported similar observation in Dumbi and Kwangila ponds with higher *Typha* species around the littoral edges of the ponds, especially during the dry season. Organic carbon in the Kwangila over that of Dumbi was attributed to intense agricultural activitiesand deposits of faecal materials.All these factors might have accounted for the higher density of *Typha latifolia* and *Typha angustifolia* in theupper and middle courses, throughout the study period. At lower course the water level fluctuation was minimal. The nature and extent of human activities was minimal with little or no farmland within the lower course and absence of vegetation except few *Typhalatifolia* at the western littoral edges.

5.4 Impact of *Typha* specieson fish catch and distribution in Hadejia-Nguru wetlands

The number and weight of fish caught in(un-infested area) was higher than that of (*Typha* infested). This may be attributed to migration offish species from *Typha* infested to un-infested. The migration could be as result oflow dissolve oxygen (DO), high Biological oxygen demand (BOD), high temperature and transparency in*Typha* species infested area.This is in line with the findings of Smith (2004) who showed that four families and twenty-two species of fish were completely lost or emigrated as result of *Typhaaustralis* infestation in Delhi Lake,India. Water level fluctuation and temperature variations may influence fish distribution. Higher density found during the dry season,supported the findings of Scheffer*etal*.,(2003) who reported areductionin water volume increases fish catch in Sudan Lake.Similarly, seasonal or yearly variation in composition and abundance may be attributed to favourable conditions in certain areas of the wetlands. Daddy(2003) also reported low catched in macrophytes infested areas of Tatabu floodplain in Niger state.

5.5 Management of *Typhalatifolia* and *Typha angustifolia*

Three methods were used in controlling *Typha* speciesduring two years study period, namely Biological control using *Phragmites karka* at different weight, manual control using cutting at different water levels and physical control using shading at different tarpaulin numbers.

5.5.1 Biological Control

Biological controlwas employed using different weight of *Phgramites karka* in sampling site. The first observation was made after five months. The number of tillers leaves and inflorescence reduced in each treatment but nothing is noted in control experiment, This is in line with Smith (2004) who reported that the first effect of any control on plant was noted from the leaves. It was also observed that, the higher the weight of*Phragmites karka* the more effective the control. These could be attributed to the allopath substance that *Phragmites karka*has in the root. Thoughbiological control is slow and gradual, sometimes it takes several years to manifest but its lasting effect is sure. Biological control though gradual is considered as the "only cost effective, permanent and environmentally friendly method Greathead and Root, 2010 confirmed that, monitoring biological control agents takes several years before their impact could be documented. However, notable successes in Argentina, Australia India, and USA using *Neochetina bruchi* had been reported(Harley 2000). Water hyacinth had been brought under control using biological control in a number of countries including the Nile River systems in Sudan. In Nigeria biological control was used in Kainji Dam using *Eichhornia bruch* and *Neochetina bruchi*, which reduced the proliferation of water hyacinth by 30% (Daddy, 2006).The interesting thing with these findings is that, *Phragmites karka* could be effectively used as fodder for the animals.

5.5.2 Manual control

Manual control using cutting at different levels:The cutting were employed in two different levels below and above the water levels, and the results showed tht cutting below the water gradually die after 3-5months,while *Typha* species cut above the water showed gradual re-growth. It was observed that, the lower the cutting below the water the more effectiveandthe higher the cutting the more the re-growth rate. This may be attributed to the fact thatlower cutting below the water levels kill the rhizome of *Typha* species. Shootscutting of *Typha* species below the water surface in one growing season before flower production reduce *Typha australis* stand (Weller 2010; Birnin Yauri *et al*., 2004).

5.5.3 Physical control

Black tarpaulin wasused in different numbers.The results obtained indicated that, the higher the numberof black tarpaulin the more effective the control and the lower the numberthe lesseffective the result.This is attributed to *Typha* species that was prevented from photosynthetic activities. Could also be as result of the heat generated by the black tarpaulin. The higher result wasobtained during (July-August) when food resources of *Typha* species were presumed to be lowest.This is in line with Nelson and Dietz (2006) findings, which showed that actively growing *Typha* species tips were killed when completely covered for at least sixty days. However, it was observed that, great success was achieved when food resources of *Typha* species were presumed to be lowest,that isduring the peak of wet season when there was high dilution of the nutrients.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 SUMMARY

Typha latifolia and *Typha angustifolia*composition of Hadejia Nguru wetlandwas formed as aresult of water scheme upstream, which led to the Construction of Tiga dam between 1988 to 1992. *Typha latifolia* is highly invasive than *Typha angustifolia* in Hadejia Nguru wetland. Water temperature, pH, Turbidity DO and BOD did not have any strong influence on proliferation of *Typha* species in Hadejia Nguru wetland and as a result exhibited a non-significant relationship.

The fluctuation of*Typha* species in Hadejia Nguru wetland was as result of increased and decreased water surfaceof PO4-P, NO^3-N, Mg and sediment PO_4-P, NO^3-N, and organic matter contentdue to seasonal variations(dry season and wet season). The high proliferation of *Typha* species in upper, middle, lower course in ascending order wasdue to the human activities.

The number and weight of fish caught in (A) *Typha* un-infested area is higher than (B) *Typha* species infested area. Lower dissolved oxygen (DO) and Biological oxygen demand in *Typha* infested area could explain the reason for lower catches in *Typha* species infested area.

6.2 CONCLUSIONS

Two species of *Typha* were identified inHadejia-Nguru Wetlands these are *Typha latifolia* and *Typha angustifolia*,both accounted for 65- 70% and 30- 35% occurrencerespectively. Water PO4-p, NO_3-N , Magnesium and sediment PO4-p, NO_3-N,organic matter were found to be responsible for the proliferation of *Typha* species in the Hadejia Nguru wetlands.

Typhalatifolia and *Typha angustifolia* reduced thedensity, distribution and hencefish catch in Hadejia Nguru wetlands, becausethe *Typha* un-infested area has more abundance by number and weight of fish caught than the infested area.

The study revealed that the best management method for the control of *Typha* species in Hadejia Nguru wetlands is to cut the *Typha* below the water surface at 15cm depth.

6.3 RECOMMENDATIONS

1. The studies recommended the farmers should avoid using *Typha*speciescotton- seed as a mattress and pillows so as to reduce the seed dispersal.
2. The studies recommended that the farmers should settheir traps for fishing in *Typha* species un-infested.
3. Higherconcentration of nutrients may be associated with inorganic fertilizer, application by the farmers during wet and dry season farming activities washed into the wetlands area. Therefore there is the need to enlighten the farmers on how and when to apply the inorganic fertilizer. This would reduce the proliferation of *Typha* species.
4. The studies recommended that the best time to control *Typha latifolia* and *Typha angustifolia* is when the density is low, which happen to be at the peak of wet season.Farmers should be enlightened onthis too.
5. The studies recommended that the best management method for Hadejia Nguru Wetlands communities is physicalcontrol that isby cutting the *Typha* species at 15 cm depth below the water level, equallyfarmers within the basin should be enlightened on this too.

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APPENDIX I*Typha latifolia* inflorescence

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APPENDIX II*Typha angustifolia* inflorescenc

APPENDIX III *Typha latifolia* (narrow - leaved)

APPENDIX IV*Typha angustifolia* (broad leaves)

APPENDIX V Nine month after interplanting *Typha* specieswith 10kg of *Phragmites karka* as biological control**.**

APPENDIX VI Nine months after interplanting *Typha* species with 25kg *Phragmites karka* as biological control.

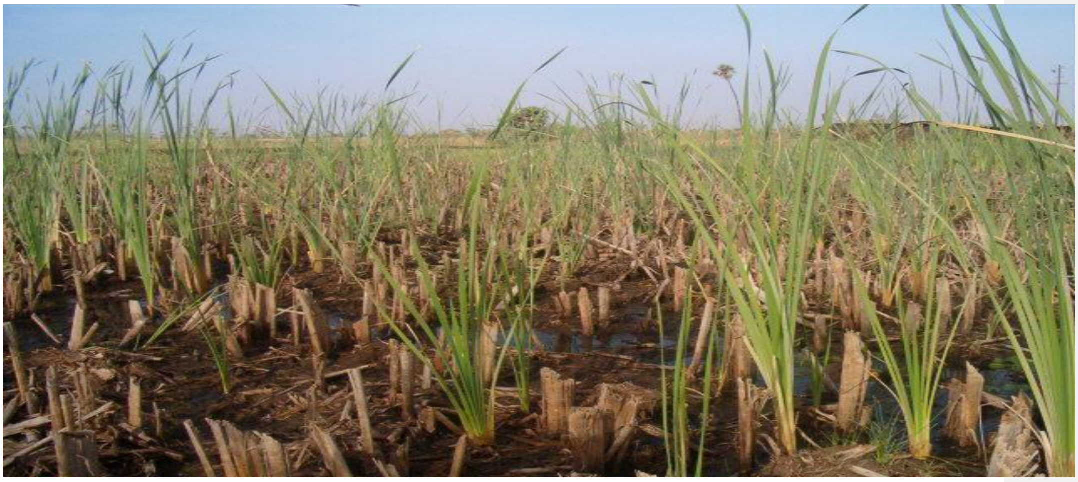
APPENDIX VII Nine month after interplanting *Typha* specieswith 50kg of *Phragmites karka* as biological control**.**

APPENDIX VIII Nine month after designing the experiment, the *Typha*species without *Phragmites karka* as control.

APPENDIX IX Re-growth rate of *Typha latifolia* and *Typhaangustifolia* cut at 15cm, below the water

APPENDIX X Re-growth rates of *Typha latifolia* and *angustifolia* cut at 10cm, below the water.

APPENDIX XI Re-growth rates of *Typha latifolia* and *angustifolia* cut at 15cm, above the water.



APPENDIX XII Re-growth rates of *Typha latifolia* and *angustifolia* cut at 10 cm, above the water.

APPENDIX XIII Two months after covering *Typha* species with single black Tarpaulin

APPENDIX XIV Two months after covering *Typha* species with double black Tarpaulin.

APPENDIX XV Two months after covering *Typha* species with triple black Tarpaulin.

APPENDIX XVI Two months after *Typha* species without black Tarpaulin as a control experiment.

APPENDIX XVII Checklist of Aquatic Macrophytes of Hadejia-Nguru wetland with botanical name, family and Hausa name**.**

Botanical Name	**Family**	**Hausa Name**
Nymphaea lotu	*Nymhaeaceae*	Bado
Cyperus articulatus	*Cyperaceae*	Aya aya rafi
Mimosa pigra	*Mimosaceae*	Kar daji
Ipomoea aquatica	*convolvulaceae*	Dakali kwadi
Typha latifolia	*Typhaceae*	Kachala
Typha angustifolia	*Typhaceae*	Kachala Shala
Leersia hexandra	*Poaceae*	Hakin doki
Polygonum spp	*Polygonaceae*	Lema kada
Pistia stratiotes	*Araceae*	Bado rafi
Commelina spp	*Commelinceae*	Balasa fadama
Azolla Africana	*Azollaceae*	Yauni market
Najasspp	*Najadaceae*	Alade Rafi
Vossia spp.	*Poaceae*	Hakin Giwa
Eichinochloa stagnina	*poaceae*	Burugu
Ludwigia erecta	*onagraceae*	Haki rafi
Ludwigia decurrena	*onagraceae*	Areyafu fatake
Echinochlao pyramidaliis	*poaceae*	Burugu
Leptochloa spp	*poaceae*	Gyasuwa rafi
Oryza longioslaminatt	*poaceae*	Shikafa akwadi
Eichhornia crassipes	*poaceae*	Kainuwa Kamaru

APPENDIX XVIII The concentration of physico-chemical parameters and soil sediment nutrients in Hadejia Nguru wetlands in the year 2010 and 2011**.**

Months	Water PO_4-P	Water NO_3-N	Water Mg^4	Soil sed. PO_4-P.	Soil Sed. NO_3-N	Org m
Mg/l	Mg/l	Mg/l	Mg/kg	Mg/kg	Mg/kg	
Jan.10	4.99	4.60	3.50	8.30	8.00	7.54.
Feb.10	6.62	5.32	4.50	8.45	8.20	7.85
Mar.10	7.60	6.32	5.22	9.00	8.44	8.00
April.	9.80	7.34	6.99	9.50	8.95	8.12
May 10	13.50	13.00	10.00	16.5	14.00	11.5
Jun 10.	12.30	11.00	9.40	12.70	12.00	10.45
July.10	9.43	8.43	8.00	10.34	10.00	9.45
Aug. 10	3.50	3.00	1.5	6.5	6.00	5.60
Sept.10	3.55	3.20	2.00	6.54	6.20	5.78
Oct. 10	3.60	3.45	3.00	6.78	6.50	6.00
Nov. 10	4.00	3.55	3.20	7.00	6.75	6.25
Dec. 10	4.60	4.33	3.75	7.30	7.00	6.45
Jan. 11	5.35	5.00	4.23	7.55	7.20	6.85
Feb. 11	6.00	5.55	4.65	8.00	7.65	7.12
Mar 11.	6.43	6.00	5.45	8.45	8.10	7.95
April.	9.54	8.55	7.55	10.55	10.40	10.00
May 11	12.35	10.32	9.89	15.50	12.50	12.00
Jun. 11	11.01	9.00	8.43	13.52	9.00	8.21
July. 11	8.20	8.00	7.45	9.54	8.48	8.45
Aug. 11	3.60	3.00	1.00	6.00	6.32	4.00
Sept. 11	3.70	3.32	2.54	6.70	6.75	4.50
Oct. 11	3.75	3.45	3.60	7.50	7.00	5.00
Nov. 11	5.09	4.00	3.78	7.85	7.45	5.54
Dec. 11	5.34	4.50	4.75	8.00	7.85	6.00

APPENDIX XIX Hadejia Nguru wetland soil textural classification and some selected chemical properties.

Location	Clay %	Silt%	Sand%	Texture	Organic Carbon %	Soil Phosphate-phosphorus	Soil Nitrate-nitrogen	Soil Calcium	Soil pH
Upper course	26.85	53.04	20.11	Silt loam	2.46	2.9	2.10	2.82	6.60
Middle Course	26.18	53.76	26.06	Silt loam	2.13	2.70	1.56	2.16	6.70
Lower course	2.55	12.10	85.35	Sandy	1.8	1.50	0.60	2.61	7.30

APPENDIX XX

Taxonomical list ventricular names of fish caught in *Typha* un-infested area and *Typha* infested area Hadejia-Nguru wetland in year 2010.

MONTH Year 2010	FAMILY NAME	SPECIES	*ENGLISH NAME*	HAUSA	IBO NAME	YORUBA NAME	A	B
Jan.10	*DASYTIDAE*	*Dasyatis garouaensis*	*Ray*	*Kunaman ruwa*		*Alate*	+	-
	PROTOPTERIDAE	*Protopterus annectens*	*West African lungfish*	*Bodami*	*Ebii*		+	-
	POLYPTERIDAE	*Polypterus ansorgii*	*Guinea Bichir*	*Gwando*	*Akata*	*Adagba*	+	+
		Polypterus bichir bichir	*ile Bichier*		*Akata*	*Adagba*	+	+
		Polypterus bichir bichir	*Bichier*		*Akata*	*Adagba*	+	-
		Polypterus (e) endltcheri	*Red/Saddled b.*		*Akata*	*Adagba*	+	-
		Polypterus(s) senegalus	*Senegal Bichirlypterus*		*Akata*	*Adagba*	+	-
		Erpetoiochthys calabaricus	*Redfish*	*Bano*	*Korotu-Wugboru*	*Woyi/*	+	-
Feb 10	*CLUPEIDAE*	*Odaxothrissa mento*	*Fangtooth Pellonula*	*Taga rana/ worrongi*	*Ntita*	*salanpore*	+	-

		Pellonula vorax	*Pellonula*	*Taga rana/ worrongi*			+	-
	OSTEOGLOSSIDAE	*Heterotis niloticus*	*Heterotis*	*Bali*		*Aika/Afo*	+	+
	PANTODONTIDAE	*Pantodon buchholzi*	*Butterfly fish*	*Kakan kifi*		*Oloyan*	+	-
	MORMYRIDAE	*Mormyrus rume*	*Bottlenose*	*Milligi*		*Lele*	+	-
		Mormyrus tapirus	*Trunkfish*	*milligi*		*Lele*	+	+
		Hippopotamyrus psittacus		*Bakin lali*			+	+
		Campylomyrus tamandua	*Wormedjawed*	*Shindagi*		*Lele elenu kodoro*	+	-
		Marcuseninus syprinoides		*Faya*		*Afinitin*	+	-
		Marcuseninus senegalensis		*Kuma/lali*		*Afinitin*	+	-
Mar 10	*GYMNARCHIDAE*	*Gytmn orchus niloticus*	*Aba*	*Dan sarki*	*Asa/Olili*	*osan*	+	-
	CROM ERIDAE	*Crome ia nilotica*					+	+
	HEPSETIDAE	*Hepsetidae odoe*	*African pike*	*Zagundumi*	*Owuwu*	*Ijakere/Ija*	+	-
	CHARACIDAE	*Hydrocynus brevis*	*Tiger fish*	*Zawai*	*Owulueze*	*ijakere*	-	+
		Hydrocynus wvittatus	*Tiger fish*	*Zawai*	*Owulueze*	*ijakere*	-	+
		Hydrocynus forskalii	*Tiger fish*	*Zawai*	*Owulueze*	*Atoko*	-	+
		Alestes dentex	*Silversides*	*Shemani*		*Arefe*	+	-
		Brycinus leuciscus	*African tetras*	*Kawara*		*Ajarapo*	+	+
		Micralestes elongates		*Kawara*			+	-
Apr 10	*DISTICHODONTI-*	*Phago loricatus*		*Kifi tsuntsu*			+	-

	DAE							
		Distichodus engycephajus	*Grasseaters*	*Chikaki*	*Ejo*	*epele*	-	+
May 10	*CITHARINIDAE*	*Citharidium ansorgii*	*Moonfish*	*Dunka*			+	+
		Citharinus latus	*Moonfish*	*Falia*	*Azu mpete/Ifulu*	*osu*	+	-
		Citharinus citharinus	*Moonfish*	*Falia*	*Azu mpete/Ifulu*	*osu*	+	+
Jun 10	*CYPRINIDAE*	*Chelaethiops bibie*					+	+
		Labeo coubie	*Labeo*	*Barkin Dumi*			+	-
		Labeo senegalensis	*Labeo*	*Farin dumi*			+	+
		Barbus bynni occidentalis	*Niger Barb*	*Dorawa*			+	+
July 10	*BAGRIDAE*	*Bagrus docmak*	*Semutundu*	*Dinko*		*Iko*	+	-
		Bagrus filamentosus	*Silver catfish*	*Dinko*		*Iko*	+	-
		Bagrus bajad	*Bayad*	*Dinko*	*Okpo-iri/Ngafu*	*Iko*	+	-
		Clarotes laticeps	*Silver catfish*	*maigo*			+	+
		Chrysichthys aluluensis	*Silver catfish*				+	+
		Chrysichthys auratus	*Silver catfish*	*Warushe*	*Okpo isiukwu*	*iganga*	+	-
		Chrysichthys nigrodigitatus	*Bagrid catfish*	*Warushe*	*Okpo Ocha*		+	-
		Auchenoglanis biscutatus	*Catfish*	*Buro*	*Okpo-isi-nkita*	*Kankian*	+	+

Aug 10	*SCHILBEIDAE*	*Parailia pellucid*	*Glass catfish*	*maigashi*			+	-
		Schilbe intermedius	*Butterfish*	*Nalanga*		*Asan*	+	-
		Schilbe mystus	*AfricanButterfish*	*Nalanga*		*Asan*	+	-
Sept. 10	*CLARIIDAE*	*Gymnallabes typus*	*Eel catfish*				+	+
		Heterobranchus isopterus	*Catfish*		*Azu isii*	*Aso*	+	+
		Clarias gariepinus	*Sharpfootbed African catfish*	*Tarwada*	*Arira/Atuma*	*Aso*	+	+
		Clarias anguillaris	*Mudfish*	*Tarwada*	*Arira/Atuma*	*aro*	+	+
		Clarias jaensis	*Catfish*				+	-
		Clarias macromystax	*Catfish*				+	-
	MALAPTERURIDAE	*Malapterurus electricus*	*Electric catfish*	*Mijiriya*	*Elulu*	*ojiji*	+	+
		Malapterurus minjiriya	*Electric catfish*	*Mijiriya*	*Elulu*	*ojiji*	+	-
	MOCHOKIDAE	*Chiloglanis benuensis*	*Catfish*				+	+
		Synodontis resupinatus	*Squeaker*	*Kurungu*	*Okpo*	*Okokoniko*	+	-
		Synodontis budgetti	*Squeaker*	*Kurungu*	*Okpo*	*Okokoniko*	+	-
		Synodontis clarias	*Squeaker*	*Kurungu*	*Okpo*	*Okokoniko*	+	-
		Synodontis omias	*Squeaker*	*Kurungu*	*Okpo*	*Okokoniko*	+	-
		Synodontis robbianus	*Squeaker*	*Kurungu*	*Okpo*	*Okokoniko*	+	+
		Synodontis nigrita	*Squeaker*	*Kurungu*	*Okpo*	*Okokoniko*	+	+
		Synodontis schitt	*Squeaker*	*Kurungu*	*Okpo*	*Okokoniko*	+	-
Nov. 10	*CHANNIDAE*	*Parachanna african*	*Snakehead*	*Tufi*	*Azu Agwo/Efi*	*Korowo/ko*	+	-

						ro		
		Parachanna obscura		*Tufi*		*Korowo/koro*	+	+
	CENTROPMIDAE	*Lates niloticus*	*Nidgerd/Nilr prtvh*	*Giwan ruwa*	*Aja*	*Korowo/koro*	+	+
		Chromidatilapia (g) Gunther		*Kwana*		*Alaje*	+	-
		Tilapia dageti	*Tilapia*	*Gtargazaa*	*Mpupa/Ifunu*	*Epia*	+	-
		Tilapia zilli	*Red belly Tilapia*	*Gargaza*	*Mpupa/Ifunu*	*Epia/Wesafun*	+	-
		Tilapia guineensis		*Gargaza*	*Mpupa/Ifunu*	*Epia/Wesafun*	+	-
Dec 10	*ANABANTIDAE*	*Clenopoma nebulosum*					+	-
		Ctenopoma murei		*Takarasa*		*Ekiki*	+	+
		Ctenopoma patherici		*Takarasa*		*Ekiki*	+	-
		Caecomastacembelus cryptacanthus	*Spiny eels*	*Gwachaka*	*Ogbogbo*	*Doje*	+	+
	TETRAODONTIDAE	*Tetraodon pustulatus*	*Globefish/pufferfih*				+	+

APPENDIX XXI

Taxonomical list, Vernucular names of fishes caught in *Typha* un-infested area and *Typha* infested area in Hadejia-Nguru wetland in the year 2011.

MONTH Year 2011	**FAMILY NAME**	**SPECIES**	**ENGLISH NAME**	**HAUSA**	**IBO NAME**	**YORUBA NAME**	**A**	**B**
Jan 11	*PROTOPTERIDAE*	*Protopterus annectens*	*West African lungfish*	*Bodami*	*Ebii*		+	-
	POLYPTERIDAE	*Polypterus ansorgii*	*Guinea Bichir*	*Gwando*	*Akata*	*Adagba*	+	+
		Polypterus bichir	*ile Bichier*		*Akata*	*Adagba*	+	_
		Polypterus (e) endltcheri	*Red/Saddled b.*		*Akata*	*Adagba*	+	+
		Erpetoiochthys	*Redfish*	*Bano*	*Korotu-*	*Woyi/*	+	-

		calabaricus			*wugboru*			
Feb 11	*CLUPEIDAE*	*Odaxothrissa mento*	*Fangtooth Pellonula*	*Taga rana/ worrongi*	*Ntita*	*salanpore*	+	+
	OSTEOGLOSSIDAE	*Heterotis niloticus*	*Heterotis*	*Bali*		*Aika/Afo*	+	+
	PANTODONTIDAE	*Pantodon buchholzi*	*Butterfly fish*	*Kakan kifi*		*Oloyan*	+	+
	MORMYRIDAE	*Mormyrus rume*	*Bottlenose*	*Milligi*		*Lele*	+	+
		Mormyrus tapirus	*Trunkfish*	*milligi*		*Lele*	+	-
		Hippopotamyrus psittacus		*Bakin lali*			+	-
		Campylomyrus tamandua	*Wormedjawed*	*Shindagi*		*Lele elenu kodoro*	+	-
		Marcuseninus syprinoides		*Faya*		*Afinitin*	+	-
Mar 11	*GYMNARCHIDAE*	*Gytmnorchus niloticus*	*Aba*	*Dan sarki*	*Asa/Olili*	*osan*	+	-

	CROM ERIDAE	*Crome ia nilotica*					+	-
	HEPSETIDAE	*Hepsetidae odoe*	*African pike*	*Zagundumi*	*Owuwu*	*Ijakere/Ija*	+	-
	CHARACIDAE	*Hydrocynus brevis*	*Tiger fish*	*Zawai*	*Owulueze*	*ijakere*	+	-
		Hydrocynus vittatus	*Tiger fish*	*Zawai*	*Owulueze*	*ijakere*	+	+
		Hydrocynus forskalii	*Tiger fish*	*Zawai*	*Owulueze*	*Atoko*	+	+
		Alestes dentex	*Silversides*	*Shemani*		*Arefe*	+	-
		Brycinus leuciscus	*African tetras*	*Kawara*		*Ajarapo*	+	+
		Micralestes elongates		*Kawara*			+	+
Apr 11	*DISTICHODONTID AE*	*Phago loricatus*		*Kifi tsuntsu*			+	+
		Distichodus engycephajus	*Grasseaters*	*Chikaki*	*Ejo*	*epele*	+	-
May 11	*CITHARINIDAE*	*Citharidium ansorgii*	*Moonfish*	*Dunka*			+	-

		Citharinus latus	*Moonfish*	*Falia*	*Azu mpete/Ifulu*	*osu*	+	-
		Citharinus citharinus	*Moonfish*	*Falia*	*Azu mpete/Ifulu*	*osu*	+	-
Jun 11	*CYPRINIDAE*	*Chelaethiops bibie*					+	-
		Labeo coubie	*Labeo*	*Barkin Dumi*			+	+
		Labeo senegalensis	*Labeo*	*Farin dumi*			+	+
		Barbus occidentalis	*Niger Barb*	*Dorawa*			+	+
July 11	*BAGRIDAE*	*Bagrus docmak*	*Semutundu*	*Dinko*		*Iko*	+	-
		Bagrus filamentosus	*Silver catfish*	*Dinko*		*Iko*	+	+
		Bagrus bajad	*Bayad*	*Dinko*	*Okpo-kiri/Ngafu*	*Iko*	+	+

		Chrysichthys aluluensis	*Silver catfish*				+	+
		Chrysichthys auratus	*Silver catfish*	*Warushe*	*Okpo isiukwu*	*iganga*	+	-
		Chrysichthys nigrodigitatus	*Bagrid catfish*	*Warushe*	*Okpo Ocha*		+	-
		Auchenoglanis biscutatus	*Catfish*	*Buro*	*Okpo-isi-nkita*	*Kankian*	+	-
Aug 11	*SCHILBEIDAE*	*Parailia pellucid*	*Glass catfish*	*maigashi*			+	-
		Schilbe intermedius	*Butterfish*	*Nalanga*		*Asan*	+	-
		Schilbe mystus	*AfricanButterfish*	*Nalanga*		*Asan*	+	+
Sept. 11	*CLARIIDAE*	*Gymnallabes typus*	*Eel catfish*				+	-
		Heterobranchus isopterus	*Catfish*		*Azu isii*	*Aso*	+	-
		Clarias gariepinus	*Sharpfootbed African*	*Tarwada*	*Arira/Atuma*	*Aso*	+	+

			catfish					
		Clarias anguillaris	*Mudfish*	*Tarwada*	*Arira/Atuma*	*aro*	+	+
		Clarias macromystax	*Catfish*				+	-
Oct.11	*MALAPTERURIDAE*	*Malapterurus electricus*	*Electric catfish*	*Mijiriya*	*Elulu*	*ojiji*	+	-
		Malapterurus minjiriya	*Electric catfish*	*Mijiriya*	*Elulu*	*ojiji*	+	-
	MOCHOKIDAE	*Chiloglanis benuensis*	*Catfish*				+	+
		Synodontis resupinatus	*Squeaker*	*Kurungu*	*Okpo*	*Okokoniko*	+	-
		Synodontis budgetti	*Squeaker*	*Kurungu*	*Okpo*	*Okokoniko*	+	+
		Synodontis clarias	*Squeaker*	*Kurungu*	*Okpo*	*Okokoniko*	+	+
		Synodontis robbianus	*Squeaker*	*Kurungu*	*Okpo*	*Okokoniko*	+	-
		Synodontis nigrita	*Squeaker*	*Kurungu*	*Okpo*	*Okokoniko*	+	-

		Synodontis schitt	*Squeaker*	*Kurungu*	*Okpo*	*Okokoniko*	+	+
Nov. 11	*CHANNIDAE*	*Parachanna african*	*Snakehead*	*Tufi*	*Azu Agwo/Efi*	*Korowo/koro*	+	-
		Parachanna obscura		*Tufi*		*Korowo/koro*	+	-
	CENTROPMIDAE	*Lates niloticus*	*Nidgerd/Nilr prtvh*	*Giwan ruwa*	*Aja*	*Korowo/koro*	+	+
		Chromidatilapia (g) gunther		*Kwana*		*Alaje*	+	+
		Tilapia dageti	*Tilapia*	*Gtargazaa*	*Mpupa/Ifunu*	*Epia*	+	-
		Tilapia zilli	*Red belly Tilapia*	*Gargaza*	*Mpupa/Ifunu*	*Epia/Wesafun*	+	+

Dec 11	*ANABANTIDAE*	*Clenopoma nebulosum*					+	-
		Ctenopoma murei		*Takarasa*		*Ekiki*	+	-
		Ctenopoma patherici		*Takarasa*		*Ekiki*	+	-
		Caecomastacembelus cryptacanthus	*Spiny eels*	*Gwachaka*	*Ogbogbo*	*Doje*	+	+
	TETRAODONTIDA E	*Tetraodon pustulatus*	*Globefish/ Pufferfish*				+	+