KWAME NK RUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

KUMASI

COLLEGE OF SCIENCES

DEPARTMENT OF THEORITICAL AND APPLIED BIOLOGY

FLORA DIVESITY OF ASOKORE AND OSABENE WETLANDS IN THE NEW JUABEN MUNICIPALITY, GHANA

BY

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A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOY IN PARTIAL FULFILMENT OF THE REQIREMENTS FOR THE DEGREE

OF

MASTER OF SCIENCE

IN ENVIRONMENTAL SCIENCE

JUNE, 2015

DECLARATION

I Budu rank author of this thesis "Floral Diversity of Asokore and Osabene wetlands in the New Juaben Municipality, Ghana" do hereby declare that apart from references to past and current literature duly cited in this thesis, the entire research work presented in this thesis was done by me as a student of Institute of Distance Learning of Kwame Nkrumah University of Science and Technology. It has neither in whole nor in part been submitted for a degree elsewhere.

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DEDICATION

I dedicate this work to my wife Franklina Budu and my children Franklyn Oheneba Annor Budu, Frank Odeshe Asante Budu and Frankmina Ohenewa Anobea Budu.

ACKNOWLEDGEMENT

First and foremost, glory and honour goes to our heavenly father for his unending grace, strength, guidance and direction given me throughout this programme.

I offer my sincerest gratitude to my supervisor, Mr. J.L. Terlabie of the Theoretical and Applied Biology Department, for his support throughout my thesis work with his patience and knowledge whilst allowing me the room to work in my own way. I attribute the level of my Masters degree to his encouragement and effort and without him this thesis would not have been written. One simply could not wish for a better or friendlier supervisor. I will be an ingrate not to mention Dr. Patrick Addo Fordjour for the pieces of advice with his critical and analytical knowledge in diversity.

To Mr. Solomon Anum, Mr. Clement Tawiah Abbam, Mr. Appiah Boateng and Mr. Benjamin Farouk all of Survey Department, regional office-Eastern for their unflinching support and assistance in identification and mapping out the wet land spot on the topo map of the new Juabeng Municipality.

To Mr. and Mrs. Joseph Agyei Obeng of Akropong-Akuapem I say thank you for your support and assistance given me during the thaught course. I could never have gone through the one year period without the free accommodation you offered me. I cannot afford to leave my mates unmentioned especially Lionel Ablodeppey, Edward Kweku Eson Thompson and John Asamoah Tachie for the healthy and cooperating relationship I was privileged to enjoy. It remains my fervent prayer that each one of us finds feet in our search for life full of hope and prosperity in the next stride of endeavours.

To my entire family especially my mother Mad. Dina Anobea I say I am most grateful to you for your immense support for me in all spheres of my academic endeavours. May the good Lord watch over you to reap the fruit of whatever you have sowed.

Lastly my sincere gratitude goes to Sir Lloyd Larbi for typing and setting of the entire work.Also to Mr. Amponsah, the Senior Technician at the Herbarium of Botany Department, University of Ghana for his enormous contribution in identification and naming of the sampled plant species.

LIST OF ABBREVIATION/ ACRONYMS

ASA- American Society of Agronomy

CSSA- Crop Science Society of America

SSSA- Soil Science Society of America

EPA-Environmental Protection Agency

UNESCO-United Nations Educational, Scientific and Cultural Organization

IUCN- International Union for Conservation of Nature

WWF- World Wide Fund

IOPs- International Organisation Partners

IDRC- International Development Research Centre

FOE-Friends of the Earth

NEAP- National Environmental Action Plan

WACAF-West and Central Africa

UNIDO- United Nations Industrial Development Organization

DFID-Department for International Development

MMDAs- Metropolitans, Municipal and District Assemblies

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ABSTRACT

Ghana as a country has developed many policy frame work and strategies to manage its wetlands. But one limitation in wetland management in Ghana is that the Ghana forest and wildlife policy covers only those wetlands designated Ramsar sites with no consideration to the minor wetlands. This study generally focused on the state of nonRamsar recognized wetlands in the new Juaben Municipality with special reference to the floral diversity of such wetlands. The objectives of the research were to determine the species richness of flora in the Asokore and Osabene wetlands in with respect to species composition, species evenness and population density. Stratified sampling was used to select specific locations of 200m by 20m ($400m^2$) within the study sites to carry out the study. The tools or materials used in the study were ecological tools such as $1m^2$ quadrant, line transect and point frame were used in sampling the plant species in the determination of species richness, species composition, and abundance. The sampled plant species were identified at the herbarium of the Department of Botany at the University of Ghana using reference for regional manual of flora. The data were analyzed using chi-square and Fisher's exact test and t-test analysis where possible. Forty four (44) individual plant species belonging to twenty (20) families were sampled and identified at the two study sites each with Asokore having 31 of the species and 13 being observed at Osabene. The study has shown that there is correlation between species diversity and human interaction within the wetland since the Asokore with relative less degree of abuse was found to be more diverse than the Osabene wetland with quite higher degree of abuse.

CHAPTER ONE INTRODUCTION 1.1. BACKGROUND OF STUDY

According to Articles 1.1 and 2.1 of Ramsar Convention (1971), wetlands are areas of marsh, swamp, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt including areas of marine water, the depth of which at low tide does not exceed six metres. Under the treaty of wetland convention in 1971, wetlands were classified into three major types as Coastal or Marine; Inland; and Man-made but there were many other classification including riparian, swamps, marshes, and bogs, among others based on factors such as soil type, climatic conditions, vegetation and location (Dahl, 2000). The Wetlands of Ghana form an ecologically valuable resource providing feeding, roosting and nesting sites for thousands of migratory and resident birds; marine turtles; many species of fish; plant genetic materials for research; and a major source of income for especially poor communities (Kwei & Ofori-Adu, 2005). The wetland ecosystems are distributed over the entire country and constitute about ten percent of the country s total land surface.

More than 50 lagoons and estuaries mark Ghana's 550 km coastline (Kwei & Ofori-Adu, 2005). There are three main types of wetlands recognized in Ghana, namely Coastal/Marine, Inlands and Man-made (Anku, 2006). The water found in wetlands can be saltwater, freshwater, or brackish and technically, a wetland must meet three criteria:

It must have mostly hydric soils;

It must have standing water or saturated soil for at least part of the growing season;

It must support mostly vegetation adapted to wet soil conditions (Ghabo, 2007).

That is, there are three key elements which identify wetlands; hydrophytes, hydric soil and hydrology (Tiner, 2003).

According to Firehock & Doherty, (1995), wetlands truly are transitions between our land world and the water world that covers three fourths of the planet we depend on. There are strong links between wetlands, even far inland, and the deep water environments of lakes and oceans.

Wetlands have unique characteristics: they are generally distinguished from other water bodies or landforms based on their water level and on the types of plants that thrive within them (Weiher & Keddy, 2001). Specifically, wetlands are characterized as having a water table that stands at or near the land surface for a long enough season each year to support aquatic plants (Byers & Chmura, 2007). Wetlands are considered the most biologically diverse of all ecosystems (Mitsch, *et. al.,* 2009), plant life found in wetlands includes mangrove, water lilies, cattails, sedges, tamarack, black spruce, cypress, gum, and many others and animal life includes many different amphibians, reptiles, birds, insects, and mammals (David, 1999).

Wetlands have many benefits including erosion control, fisheries habitat, flood control, ground water recharge and discharge, natural filter, rare species habitat, recreation, source of income, wildlife habitat and education (Lokkeborg, 2011).

Modification of wetlands in any form militates against their ability to perform their function effectively (Turner, 2002). For instance human modification of the original wetlands (a common practice in the early part of this century) has destroyed the ability of wetland to modify flooding. Lack of wetlands were a significant factor in the severe flooding in the Upper Mississippi and Missouri River Basin in the summer of 1993 (Parrett *et. al.*, 1993). In 1987, a report of the World Commission on Environment and Development described protected areas including wetlands as indispensable, prerequisite for sustainable human development. Today, wetlands are known to have economic, ecological and social functions (Sutton, 1996). Turner (2002) mentioned that the ecological and social functions of wetlands give them an added economic worth over their productive value, and warned that failure to treat these functions with respect could result in seriously damaging consequences on the environment or a great loss which could cost a community a great deal to repair and offset.

1.2. STATEMENET OF THE PROBLEM

Wetlands have historically been the victim of large-scale draining efforts for real estate development or flooding for use as recreational lake. By 1993 half of the world's wetlands had been drained. Due to overpopulation in the nation’s cities, including Koforidua, the capital of the New Juaben municipality in particular, land which is one of the limiting factors in every social development has become a hot commodity. Apart from slums sprinkling up everywhere, people are building at any available space including wetlands and even silting up some streams or smaller water bodies just to put up a structure, encroachment on government land etc. Another environmentally threatening practice around the area is lumbering which does not only lead to habitat loss but also causes erosion and sediment loading in rivers and streams. Sand winning is yet another major negative impact on wetlands in the area but an even more worrying incidence is farming activities around the main water reservoir for the municipality which if not addressed in time may affect water supply to the people in the area. Acknowledgement of the benefits derived from wetland by the people, especially its ability to absorb flood water and providing habitat for wildlife will help to mitigate the abuse of wetlands in the municipality and the nation as well.

1.3. RATIONALE FOR THE STUDY

Wetlands have long been considered worthless and an impediment to development and therefore they have been abused in many ways regardless of the various benefits derived from them (Lopez & Fennessy, 2002).

The government, districts, municipal and metropolitan assemblies have various laws and regulations regarding land acquisition, ownership and usage, yet people bend around these laws to acquire and develop land in whichever way they wish, creating environmental problems in varying degree. A notable consequence of the abuse of wetlands is the flooding that happens in various parts of the country anytime it rains (Anku, 2006).The management of wetlands is therefore inevitable as flooding is no more restricted to Accra but in recent times occurring in other places as witnessed in Swedru in the Central Region (Daily graphic, June, 2010), Atiwa District in the Eastern Region and Adaklu Anfoe, Adaklu-Waya and Agotime-Kpetoe in the Volta Region (Daily graphic, July, 2011), all at alarming rate.

A topical environmental issue the whole world over in recent days is global warming or climate change. As documented by Burdick (2008), wetlands either preserve greenhouse gas, carbon dioxide in the form of carbon (peat) or absorb the gas thereby maintaining the atmosphere. Again, in the mist of erratic rainfall pattern, it is a blessing for a community that lies close to a wetland to have reliable rainfall since wetland vegetation evaporate or transpire water into the atmosphere which falls as rain in the surrounding area to help maintain stable climatic conditions. Most importantly, the New Juaben Municipality especially its capital Koforidua is a low lying area and therefore any incident of flooding will be disastrous and catastrophic. Management will also go a long way to recharge groundwater to provide quality water for the rural folk or people in general, filter run-off, enhance educational research by preserving plants and animal species, create revenue through recreation and tourism.

1.4.0. RESEARCH OBJECTIVES

1.4.1 MAIN OBJECTIVE

The purpose of this study was to determine plant diversity in wetlands in the New Juaben Municipality

1.4.2 SPECIFIC OBJECTIVES

i. To determine plant species richness in the wetland areas; ii. To determine the composition of plant species in the wetland areas; iii. To determine abundance of plant species in the wetland areas;

1.5 SCOPE OF THE STUDY

The area selected for the study is New Juaben Municipality. The study was carried out on two wetland spots within the Municipality based on their location and the kind of abuse they are subjected to by humans. The research was limited to determination of species richness, composition and abundance of flora in two sites of the identified wetland sites (Asokore and Osabene wetland sites).

1.6 LIMTATION OF STUDY

The only problem encountered in the conduction of the research was people clearing portions of one of the study sites for late season cultivation of maize which disturbs the structure and composition of plants in the area.

1.7 ORGANIZATION OF WORK

This report is made up of six chapters. Chapter one begins with an introduction which consists of the background, the objectives, the problem statement, the justification, the scope of the study and the limitation of the study. Chapter two presents a review of available literature. Chapter three describes the study area and the research methodology. Chapter four presents the results and chapter five discusses the findings whiles the sixth chapter outlines the conclusions and recommendations of the study.

CHAPTER TWO LITERATURE REVIEW

2.1.0. Types of Wetlands

According to Bayers & Chmura (2007), two main scientifically based and comprehensive wetlands classification systems have been developed for the purpose of wetlands inventory and management. The first one among them was develop by

Cowardin and his co-worker for US government and the second one adopted by Conference of Wetlands. The Cowardin system generally categorizes wetlands into five main types as; Marine, Estuarine, Riverine, Lacustrine and Palustrine (Cowardin, *et. al.*, 1979). This classification is based on the hydrologic, geomorphic, chemical, vegetation and the biological factors prevailing at the area where the wetland is located (Neubauer, 2008). The Cowardin system of classification organized wetlands into hierarchy of structures and recognized deep water habitat but did not include many wetlands that have resulted from human activities (Mitsch & Gosselink, 2000). To avoid confusion, a second system was adopted at Conference of Wetland as Ramsar Sites.

2.1. Ramsar Classification of Wetlands

Approved by recommendation 4.7 and amended by resolution VI.5, the Conventions on Wetlands in 1990 adopted the Ramsar Classification System for Wetland Type which was modified in 1996 (Ramsar Convention Bureau, 1997). Three broad identified habitats were recognized as; Marine or Coastal wetlands, Inland wetlands and Man-made wetlands and subdivisions totaling 40 wetland types (Mitsch & Gosselink, 2000). **Coastal wetlands:** are mainly saltwater ecosystems that are primarily associated with flood plains of estuaries of large rivers and water causes (Neubauer, 2008). There are 11 subdivisions including: Permanent shallow marine waters less than six meters deep at low tides ; Marine sub tidal aquatic beds; Coral reefs; Marine shores; Sand shingle or pebble shores; Estuaries waters; Intertidal mud and flats; Intertidal marshes; Intertidal forested wetland; Coastal brackish or saline lagoons and Coastal fresh water lagoon.

Inland wetlands: are mainly fresh water ecosystems which occur where water from the ground, surface springs or rain cause soil to be saturated either permanently or seasonally with water (Weiher & Keddy, 2001). There are twenty forms of fresh water inland wetland types including Deltas; Permanent river, streams; Permanent freshwater lakes; Seasonal, intermittent irregular rivers; Seasonal freshwater mouth; Non - forested peat lands, Alpine wetland.

Man-made wetlands: are wetlands constructed for aquaculture, agriculture, salt exploration, water storage etc. (Neubauer, 2008). There are nine forms including Pond, Irrigated lands, Salt pan, Excavated pit, Canals, Waste water treatment area etc.

2.2.0. Benefits of Wetlands

Wetlands were long regarded as wasteland until recently that they have been recognized as important features in the landscape that provide numerous beneficial services for people, fish and wildlife. The beneficial services considered valuable to societies worldwide are the result of the inherent and unique natural characteristics of wetlands (Schuyt & Brander, 2004). The various benefits derived from wetlands have categorised into three broad areas as ecological functions, economic functions and social functions.

2.2.1. Ecological values of wetlands

Ecologically wetlands function in the hydrological and chemical cycles as well as providing extensive food webs and biodiversity support (Barbier, *et. al.,* 1997). Wetland plays an important ecological role through biogeochemical cycling, which involves the biological, physical and chemical transformation of various nutrients within the biota, soil, water and air (Murkin, *et. al.,* 2000). For instance, due to anaerobic nature of wetlands, they support microbes that function in nitrogen and sulphur cycling. Upon death and decay, the nitrogen or sulphur in plants and animals biomass is released through mineralization (Moon & Haukos, 2009). Much of this is eventually transformed into gaseous form and released into the atmosphere, where it once again becomes available to certain plants and their associated nitrogen-fixing bacteria in soil. Thus, wetlands produce the condition needed for the removal of both nitrogen and phosphorus from surface water (Kingsford, 2000). Scientists also point out that wetlands are involved in atmospheric maintenance by storing carbon within their life and preserved (peat) plant biomass instead of releasing it to the atmosphere as carbon dioxide, a greenhouse gas affecting global warming. Wetland world-wide therefore help to moderate global climatic conditions. As noticed by Burdick (2008), one ecological importance of wetlands is fish and wildlife habitat. With their diverse and abundant vegetation, wetland support many valuable species of fishes, wildlife and endangered species. For examples, coastal wetlands provide critical habitat for shell fish like clams and mussels and for migratory and nesting shore birds like sandpipers, plover. Saltmarshes are renowned duck habitat and nesting birds like osprey and herons feed on both freshwater and saltwater wetland species (Reinecke & Uihlein, 2006). Certain mammals, such as furbear and muskrat live in or near wetlands and use houses made of wetland vegetation. Studies of bogs during 1970s and 1980s resulted in the discovery that wetland harbors rare plant species, example orchids and vital endangered wildlife. Example, shore birds like the piping plover (Relyea & Jones, 2009). Another important ecological function of wetland is purification and provision of quality water. They clean water by filtering out sediment, decomposing vegetative matter converting chemicals into usable forms (Nelms, *et. al.,* 2012). They clean the water in number of ways, for example nitrogen in water is transformed into harmless nitrogen gas, and nutrients are taken up by wetlands plant, pollutant such as phosphorus, heavy metals and toxins trapped in the sediments are removed (Merino, *et. al.,* 2010). In addition to improving water quality through filtering, some wetlands maintain stream flows during dry periods, others replenish groundwater (Bridgham, *et. al.*, 2000). As documented by Mitsch and Gosselink (1993), wetlands control erosion by slowing down and stabilizing heavy runoff with their dense vegetation, stabilize coastal shoreline by the plant acting as buffer zone by dissipating waters energy and wave action generated by hurricane and tropical storm by binding the soil with their extensive root system. Wetlands function for flood protection as they lower flood peak by temporally holding water and slowing the water's velocity (USEPA.1995).

2.2.2. Economic value of wetlands

Apart from the numerous ecological benefits derived from wetlands, there are economic, commercial and monetary gains derived from wetlands. By its rich source of decomposed organic matter and continuous recharge of water, wetlands serves as vital agricultural land for cultivation of rice which is the staple diet for more than half of humanity

(Adanus,1993). Also palm from wetlands in Africa yield valuable oil for cooking and soap making (De Steven & Lowrance, 2011). In monitory terms, the filtering function capability of wetlands saved New York City alone about us $ 3-8 billion to be spent on new waste water treatment plants. The harvesting of fish and shellfish from wetlands offers job and income to people living around wetland areas (Tiner, 2003). For instance, the coastal marshes of Louisiana alone produced commercial fish and shellfish harvest amounting to 1.2 billion pounds annually which was worth $
224 million in 1991 (Schuyt & Brander, 2004). A document from the US Army Corps of Engineers indicates that wetlands worldwide support timber totaling about 55 million acres and provide life supporting plant such as cranberries, mint, blueberries and wild rice which earn foreign exchange and income to the local people (USEPA, 1995). The wetlands flood controls ability reduces likelihood of flood damages to homes, businesses and crops in agricultural areas. This flood protection results in less monetary floods damage and related insurance cost as well as protection of human health, safety and welfare (Baldassarre & Bolen, 2006). The Manomet Center for Conservation Services reported an impressive monetary gains from wetlands that enjoyments of birds generated 19000 jobs and more than $895 million in sales and income tax revenues in 1991. In addition, 3 million migratory bird hunters generated $1.3 billion in retail sales (USEPA, 1995). Also regional statistics in birding activities was great, for example, Delaware Bay shore and Cape May peninsular of New Jersey realized more than $ 40 million annually for birders. Medicine from wetland soil and plant apart from monetary gains, improves human health (Baldassarre & Bolen, 2006).

2.2.3. Social and cultural value of wetlands

Wetlands have archeological, historical, cultural, recreational and scientific values. Societies have traditionally formed along the water bodies and artifact found in wetlands provides information about those species (Merino, *et. al.*, 2010). For example, the

Coburg Peninsula (the world's first Ramsar site), traditional Aboriginal owners still conduct an active ceremonial life and undertake semi-traditional hunting and gathering in its coastal wetlands. The culture of Louisiana bayou and the Chesapeake Bay were formed as the result of their wetlands ecosystems (Schulz, 2002). In terms of recreation, wetlands everywhere provide important leisure facilities such as canoeing and fishing, shell collecting and bird watching, swimming and snorking, hunting and sailing. For people living around wetlands, they have every aspect of their culture tied to the wetland since they depend directly on the wetland for their basic need for survival. For example they depend on the wetland for food such as fish, rice and cranberries, medicinal plants for their health care, peat for fuel, poles for building materials and grasses and reeds for making basket, mats and thatch houses (Erwin & Beck, 2007). Historically, painters and writers have used wetlands as their subject matter. Today, such artists are often joined by others with cameras and camcorders. The monetary value derived from the observation and photography of wetland-dependent birds is at least $ 10 billion per year (Evans & Day, 2002). In the field of education, the aesthetic, geological, ecological and the complexity of wetland habitat makes it an ideal location for research and academic place (Erwin & Beck, 2007).

2.3.0. Flora of Wetland

Wetlands are noted to be hydric, poorly aerated and acidic and therefore only special plant species known as hydrophytes survive in wetlands (Cooke & Azous, 2000).

Hydrophytes are plants that grow in water or need a waterlogged environment. Hydrophyte are morphological adapted to wetlands by having shallow roots to facilitate survival during times of waterlogged, reproductively adapted by having seeds which need certain amount of flooding to germinate in water or dispersed by flooding and physiologically adopted by being tolerant to toxins created by anaerobic condition (Dahl, 2006). Plants of wetland areas include macrohytes, microphytes, trees and shrubs.

2.4.0 Human Impact on Wetland Status and Vegetation

Humans' activities and disturbance over the years have led to loss of wetlands and affected the value and function of wetlands (Tiner, 2003). The impacts on wetland can be direct or indirect; direct impacts result from activities or disturbance occurring within the wetland. Some common direct impacts include, removal of vegetation, building construction, road and bridge construction, changes in water levels and drainage pattern (Mensing, *et. al.*, 1998). Indirect impacts result from disturbance occurring in areas outside the wetland such as upland or waterway. Common indirect impacts include influx of surface water and sediments, loss of recharge area or change in local drainage pattern (Tiner, 2003). Major human activities or disturbances that affect wetland vegetation or the entire wetland include:

2.4.1. Agriculture

Agriculture historically has been a major factor in freshwater and estuarine wetland loss (Naiman & Rodgers, 1997). As stated by Altinsacli & Griffiths (2001), established effects of agriculture on wetlands include: direct loss of wetlands due to drainage and conversion to agricultural land; indirect loss of wetland areas due to water withdrawal from rivers and streams for irrigation; loss of seasonal wetlands due to change in hydrologic cycle from water storage; loss of wetland functions due to salinization, sediment deposition, erosion, eutrophication and pollution from the use of pesticides and other chemicals. Excessive amount of fertilizer and animal waste reaching wetlands in runoff from agricultural areas can cause eutrophication leading to algal bloom which in long term reduces the composition of submerged plants (Mitsch & Gosselink, 1993). The physical disturbance of wetlands during dry season by tillage and compaction can increase the dominance of invasive non-native species as well as destroy viable seed bank. Kingsford (2000), indicates that developing countries tend to have scarce water resources and relatively larger agricultural demand; and as such will have greater water extractions, which in turn can have greater impacts on associated wetland, for instance, in eastern South Africa, approximately 50% of wetlands have been lost or degraded, most commonly a modification by commercial or subsistence agriculture (Sutton, 1996).

Upon the evaluation of wetland function and wetland values of Ramsar sites in Greece. Lemly, *et. al.,* (2000), concluded that irrigation was the most decisive activity that negatively influenced all functions and values of wetlands, followed by cropland expansion and overgrazing.

2.4.2. Mining

Mining in any form has long-tern effect on wetland values and functions, water quantity and quality and on aquatic life (Jones, *et. al.,* 2009). As observed by Mitsch & Gosselink (1993), phosphate mining has resulted in the loss of acres of wetlands in central Florida. The acidity and the high metal concentrations alter the biotic community, composition and can result in mortality (Rendig & Taylor, 1989). When wetland soils are exposed due to mining or destruction of their vegetation, sulphides in the original soils are converted into sulphuric acid leading to acidification (Naiman & Rodgers, 1997). According to the United State Environmental Protection Agency (USEPA, 1995), peat mining does not only remove peat but also requires clearing of vegetation, drainage of the wetland and creation of roads for equipment to harvest the peat. These activities destroy the portion of wetland selected for the mining operation. In Ghana, inland wetlands are the worse victims of mining activities as surface mining causes deforestation, resulting in increased surface runoff and sediment load in water; notable ones are the devastating effect on river Ankobra, Offin and Birim (Ntiamoah-Baidu & Gordon, 1991). Report from Kingsford (2000), indicates that active and abandoned mine sites in South Africa introduces high level of acidity and heavy metals into wetland environment through runoff and direct drainage of acid into water bodies which does not only alter the biotic community composition but results in mortality of aquatic life.

2.4.3. Urbanization

Urbanization is a major cause of impairment of wetlands (USEPA, 1995), since urbanization results in direct loss of wetland acreage as well as degradation of wetlands. Degradation is due to changes in water quality, quantity and flow rate; increase in pollutant inputs and changes in species composition as a result of introduction of nonnative species and disturbances (Firehock & Doherty, 1995). Anku (2006), in a report says the rapid convention of wetland and agricultural land for housing development and excessive urban sprawl result in annual flooding of housing and destruction of life. Another problem associated with urbanization is creation of impervious surfaces dues to roads, building and parking lots construction (O'Connell & Nyman, 2010). Impervious surfaces prevent rainfall from percolating into the soil, rainfall and snowmelt carry sediments, organic matter, pet wastes, pesticides and fertilizing from lawn gardens and golf course, fossil fuels, road salt and debris into urban streams and wetlands (Mitsch & Gosselink, 2000).

2.4.4. Dredging and water diversion

Diversion of water through canals and channelization changes the hydrology of wetlands and increase the speed with which water flows into and through wetlands (Gopal, 2003). As a result of channelization, patterns of sedimentation are altered and wetland functions and values that depend on the normal slow flow of water through a wetland can be affected, (Grace & King 2000). As indicated by Poiani & Johnson (1989), channelization contributes to turbidity to affect smaller aquatic vegetation and causes change in submerged vegetation cover and species composition. Severe turbidity shifts plant community structure towards floating and emergent species and away from submerged species (Pollock & Kennard, 1998). Diversion may lead to dehydration of wetland which subsequently decreases the species richness of obligate hydrophyte (Vivian-Smith, 1997). According to Wilson and Keddy (1991), inundation may increase or decrease the exposure of plants to competitors and herbivores and cause a shift in the location of plants community in wetlands. Interruption of water corridors between wetlands by diversion can hinder the spread of seeds of some wetland plants eg, *Carex species* (Budelsky & Galatowsitch, 2000). Dehydration has variable effect on plants community richness. In California subalpine wetland, species diversity within *Carex rostrata, Scirpus acutus and Nuphar* sp. communities was highest during dry years whereas biomass was lowest then. (Cooke & Azous, 2000). In Alaskan riparian wetland, sites with intermediate flooding were the most species-rich, whereas those with no flooding or low flood frequency were species poor (Toner & Keddy, 1997).

2.4.5. Grazing

Most wetlands have recovery capacity from herbivory but overgrazing has destructive effect on wetland vegetation, soil structure and water quality, (Allen & Feddema, 1996). Kingsford (2000) upon the assessment of South African wetlands indicated that disturbance of vegetation and soil by cattle movement in the wetlands where surface water flows can leads to gully erosion and the subsequent loss of wetland. A study in some Louisiana wetlands found herbivory and fire individually affecting the structure and the composition of plants community and indicated *Spartina paters* to be less resilient to herbivory (Clary, 1995, Tiner, 2003). Urea and manure from grazing livestock can result in high nutrient input which leads to eutrophication of water (Turner, 2002). A study of Manitoba delta marsh by Squires & van der Valk, (1992) shows that overgrazing of riparian area by livestock reduces streamside vegetation, preventing runoff filtration, increasing stream temperatures and eliminating food and cover for fish and wildlife. It can also leads to stream bank destabilization and erosion causing downstream sedimentation (Homyack & Haas, 2009). Overgrazing according to Kirkman & Sharitz, (1994) harms wetland through soil compaction, lower seed germination rate and stream bank destabilization. To Newman (1991), excessive herbivory from dear population may have caused *Chaemecyperis thyoides* to be replaced by *Acer rubrum* in swamps of New Jersey

Pine Barrens. Herbivory by nutria (*Myocastor coypus*) limited regeneration of bald cypress stand and short-term grazing of riparian vegetation after more than 30 years of cattle exclusion stimulated growth of herbaceous vegetation (Pezeshki, *et. al.,* 1996).

2.4.6. Road and Bridge Construction

Road when poorly placed and designed can increase fluvial sediment loads smothering aquatic biota and modifying wetland and stream geometry, as well as creating an influx of heavy metals and other toxicants adsorbed on the sediment particles (Gopal, 2003). Daoust & Childers (1999), explained that road and bridge construction activities disrupt habitat community, driving out more sensitive interior species and providing habitat for headier opportunistic and non- native species. Dahl (2006), writes that burrow pits that are adjacent to wetland can degrade water quality through sedimentation and increase turbidity in wetland, thus greatly affects the diversity of submerged plant species. Roads and tracts construction and usage does not only lead to soil compaction but generate dust great enough to cover leaves of nearby vegetation leading to low foliage gaseous exchange (impairing photosynthetic rate of plant), (Ehrenfeld & Schneider,1993). McDermott, *et. al.,* (2009) stated that rock salt used for deicing roads can damage or kill vegetation and aquatic life. The herbicide, soil stabilizers, dust palliative used along road ways and loads of hydrocarbons can damage wetlands plants and the chemicals may concentrate in aquatic life or cause mortality.

2.4.7. Pollution

Although wetlands are capable of absorbing pollutants from surface water, there is a limit to their capacity to do so. The primary pollutants causing wetlands degrading are sediments, fertilizers, humus sewage, animal waste, road salts particles, heavy metals and hydrocarbons, (Keddy, 2000).There are two main sources of pollutants into wetland as point source such as municipal industrial sites and non-point sources such as agricultural land and urban runoff, add materials to groundwater and surface water which upset balance of wetland water chemistry (Ewing, 1996). The USEPA (1995) report indicated that wetland can be adversely affected by pollutants released from boats and marines, including hydrocarbons, heavy metals, and toxic chemicals from paints, cleaners and solvents. Dumping of waste from fresh fish cleaning and discharging of human waste materials can increase the nutrients and agricultural matter in wetlands leading to eutrophication (Mitsch & Jorgensen, 2004). Landfills also contribute diversely to wetland pollution as sludge and waste water treatment plant effluents rich in nitrogen and phosphorus can lead to algal bloom in estuaries (Farmer, 1990). Also, leachates from solid landfills often have high biological oxygen demand (BOD), and ammonium, iron, manganese in concentrations that are toxic to plant and animal life (Firehock & Doherty, 1995). Dittman & Neely, (1990) observed that saline water discharges, hydrocarbon contamination and radionuclide accumulation from oil and gases production can significantly degrade coastal wetlands and plants do suffocate when oil blocks the stomata. Again, nitrous oxide, sulfurous oxide, heavy metal, volatilized pesticides, hydrocarbons and radionuclide released into the atmosphere by industrial, agricultural activities and from vehicles enter wetland through wet and dry atmospheric deposition and can adversely affect aquatic organisms (Christensen *et. al.*, 1996).

2.5.0. Threat to Wetlands in Ghana and Management Efforts

The wetlands in Ghana form an ecological valuable resource providing feeding, roosting and nesting sites for thousands of migratory and resident birds, marine turtles, many species of fish, plant genetic materials for research and major source of income for especially poor communities from agriculture activities, salt mining and other economic activities (Kwei & Ofori-Adu, 2005), but the same people that the wetlands serve pose major threat to them. Though many efforts through policy formulation and legislation have been put in place to halt the threats but lack of education, community involving and lack of political will to enforce existing policies seem to thwart managerial efforts.

2.5.1. Threats to Wetlands

Existing literature reveals that in Ghana, urbanization, high population growth, fuel wood gathering, salt and sand winning are among the major factors threating mangrove and wetland ecosystems along the coast (Anku, 2006). These threats include rapid conversion of wetlands for housing development, rapid development of slums, mining, land and soil degradation, sanitation and water pollution (Anku, 2006). As noticed by Ntiamoah-Baidu and Gordon (1991), mangroves and other forested coast areas act as wind breaks and help to mitigate the impact of coastal storm surges but a greater part of the eastern shoreline of Ghana especially at Keta and Ada is vulnerable to storm surge and seriously erosion due to the lack of such natural protective wetlands systems. Wetlands as tourist sites generates direct revenue to the government, but the revenue generated from these sites are waning due to poor sanitary condition (Yankson & Kendel, 2001). The Songor Ramsar site is the second largest in the country amongst the Dansu delta, Mumi lagoon, Anlo-Keta lagoon and Sakumo lagoon but a look around the Songor Ramsar site will pose a sight of development of houses. The vegetation in and around the site has been destroyed, and part of the lagoon has been filled with solid waste which had led to the frequent flood and storm attack over the few years on the communities along the site (Kwei & Ofori Adu, 2005). Also a review of the state of the Sakumo wetland indicates that the communities do fish and farm on the wetlands especially during the drought season and cut off the mangrove and other trees found along the fringes and in the wetland for fuel wood (EPA-Ghana, 2008). These activities have led to conversion of the wetland into farms, pollution of water bodies, uncontrolled bush burning, unapproved resource extractive method and persecution of wildlife species. Inland wetlands in Ghana also have their peculiar loss of biodiversity through wood carving activities, illegal and unsustainable logging practices, slash and bush farming and poaching or bush-meat hunting (Wuver & Attuquayefio, 2006), driving out wildlife through habitat loss (Ntiamoah-Baidu, 1998). Previously lesser threat which is now of national concern is surface mining which has major impact on inland wetlands vegetation and hydrology through vegetation removal, erosion, sedimentation and loss of water bodies (EPA-Ghana, 2008). Some notable water bodies affected are Birim river, River Pra and Ankobra.

2.5.2. Wetland Management Effort in Ghana

Internationally, the most important wetland protection measure was the Conservation on wetlands of international importance treaty signed by approximately 160 nations in Ramsar, Iran, adopted in 1971 which pledged protection of 200 wetlands of international importance, but relies on individual countries like Ghana to protect these sites, (King, et. al., 2006).

The awareness and management of wetlands in Ghana became intensive in 1992, with financial support from IDRC, FOE where Ghana undertook a study of wetland management to satisfy NEAP requirements. The study sought to identify and provide management plans for the rehabilitation and conservation of wetlands in Ghana (Kwei & Ofori-Adu, 2005). A review by Trevallin commissioned in 1994 by the Government of Ghana, examined how integrated policy had been designed and implemented within the national development plans. The Wetlands Policy of Ghana in 1999 recognizes that wetlands are important commodity of natural resources and aims at ensuring their wise use for the benefit of the country and its people, present and future with the objectives of promoting sound management and sustainable utilization; maintaining the ecological and life support functions of wetlands and ensuring that the people of Ghana are aware of the importance of wetlands and commit to their conservation (Anku, 2006). Other policies, which have been enacted into laws that have implications for wetland usage include: Fisheries Law, Environmental Policy, Wildlife and Forestry, and the Land Policy.

Ghana has also ratified a number of international agreements and participates in regional programs (WACAF) with the view to supporting her coastal and marine resources example Ramsar Convention in 1988. National institutions have been set up to regulate and generally manage wetlands, example Environmental Protection Agency (EPA) ,District , Municipal and Metropolitan Assemblies, Ministry of Food and Agriculture,
Forestry Department, Council for Scientific and Industrial Research (CSIR) as well as NGO's (Kwei & Ofori-Adu, 2005). More so, Ghana has undertaken a number of projects and programs which have had bearing on wetlands. These include; Korle Lagoon Ecological Restoration Project; survey of urban birds in the Accra metropolis as a tool for urban development and planning; the Large Marine Ecosystem of Gulf of Guinea Program funded by Global Environment Facility and administered through UNIDO, which aims at assisting several West African States to manage their coastal resources sustainably; the Lower Volta Mangrove Project (LVMP) funded by DFID investigated in detail the problems related to excessive exploitation of mangroves. (Wuver & Attuquayefio, 2006). Most wetlands and their resources have been protected and regulated in the past through varied traditional practices, depending on the beliefs of the traditional area that claims ownership. These traditional practices involve customary laws or taboos, which determine rights to land and resource use. They include the enforcement of sanctions for violation by the responsible authority. Many wetlands have cultural heritage value, Sakumo lagoon, for instance is regarded as the abode of "gods" (Anku, 2006). They are therefore revered and protected through various traditional practices aimed at maintaining and preserving the land.

2.6.0. State of Wetlands in the New Juaben Municipality

According to the Baseline Profile of New Juaben Municipality (2010), a document prepared after the 2010 population census, the vegetation of the Municipality is characterized with tall trees, evergreen undergrowth and rich in economic trees including *Chlorohora excelsa* (Odum), *Ceiba pentandra* (Onyina), *Antaris africana* (Kyenkyen), *and Triplochinton scleroxylon* (Wawa), but an observation of the vegetation in the area today indicates a sharp contradiction because the vegetation cover is dominated with herbaceous plants, shrubs interspersed with few trees.

Although there were no documents at New Juaben Municipal Assembly, the Regional Statistical Department or the Regional Land Commission on the state of wetlands in the Municipality, personal observation indicates a decline in the size, species composition and vegetation cover of the wetlands. The decline is as a result of estate development, road construction and farming activities (Plate1). Also most of the wetlands in the Municipality are now acting as sinks for domestic waste (sewage) since most of the constructed drains are connected to the wetlands. This act pollutes the water bodies and subsequently kills aquatic plants and animals.

Plate 1: Wetland sites disturbed by farming and real estate development

CHAPTER THREE METHODOLOGY 3.1 PROFILE OF STUDY AREA

New Juaben Municipality is one of the twenty one (21) districts in Eastern Region located along the Accra-Kumasi rail way line. It has a total land area of 110 square kilometres and has fifty-two (52) communities starting from Mile 50 and ends at Suhyen, a distance of about 25km.The total population of New Juaben Municipality is 147,155 as at 2010 projection by the 2000 population census. The Municipality is distributed into four clusters, which are Koforidua, Ada, Effiduase, Oyoko and Adweso with Koforidua being the district capital and doubles as the regional capital. The Municipality shares boundaries with four other (4) districts in Eastern Region; Akuapem North to the south,

East Akim to the north, Yilo Krobo to the east and Suhum Krobua Coaltar to the west.

The main trunk road has been tarred with good road network within the Municipality. The Municipality falls within the semi-deciduous rain forest climatic zone with a bimodal rainy season of between 1200mm and 1700mm reaching its maximum during the two peak periods of May/June and September/October. The vegetation is characterized by tall trees with evergreen undergrowth and rich in economic trees including *Chlorohora excelsa* (Odum), *Ceiba pentandra* (Onyina), *Antaris africana* (Kyenkyen), *and Triplochinton scleroxylon* (Wawa). Existing tourist attractions are the water falls, parks, historic places, cultural heritage and supporting facilities such as hotels and parks.

Notable among these are the Kentenkiren Water fall, Akwadum-Mpaem Forest, Akyekyeso Crocodile Sanctuary, Obuotabiri Mountains and Bird View at Srodai, and the Koforidua Park. Majority of the populace are engaged in trading especially food crops.

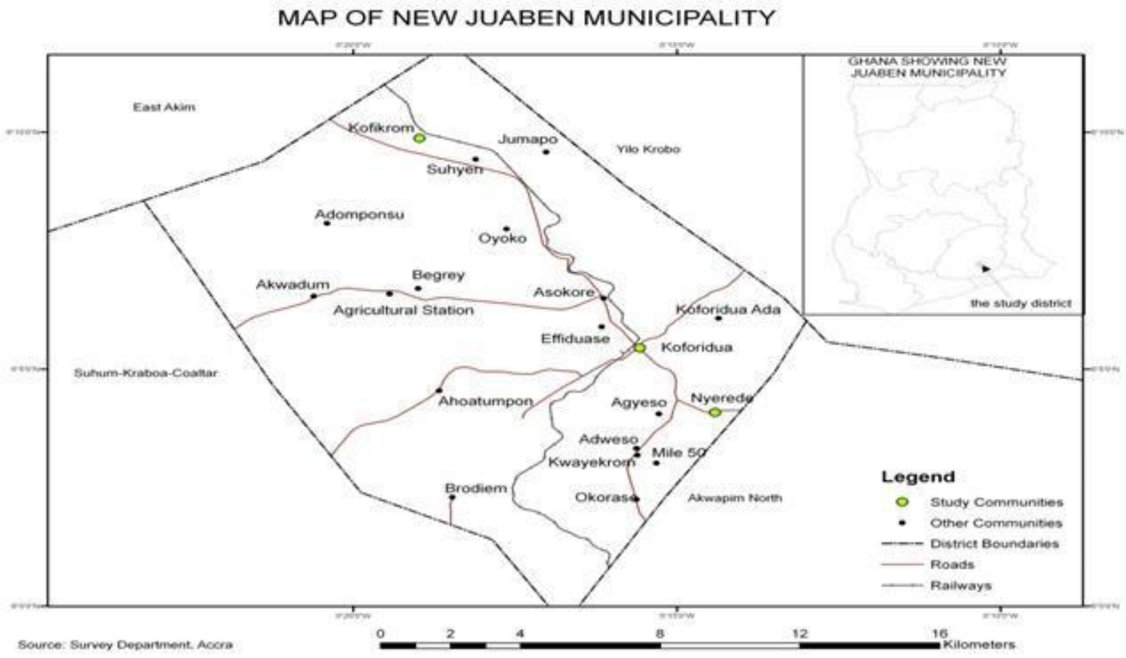

Fig 1: The map of New Juaben Municipality

3.2 SITE SELECTION

Though the various wetland sites within the New Juaben Municipality have been impacted by humans, the degree and nature of impact differs from wetland to wetland depending on its location. Two different sites (Asokore and Osborne sites) both located near and within human habitation were chosen for the study. While the Asokore site was located near flowing stream (Riverine wetland) and at relative elevated area, the Osabene site was located in a marshy area

(Marshy wetland) and at a relative low lying area. The main human impacts at Asokore site are farming activity and waste disposal but the human impacts at Osabene site are domestic sewage (waste water) and drainage discharges.

Stratified sampling method was used to select the specific areas within the study sites. Because of the vast and long stretch nature of the study areas, the areas were first divided into sub units, twelve [12] sub units of 200m×20m each at Asokore and seven sub units of 200m×20m each at Osabene. They were numbered 1 to 12 and 1 to 7 respectively on pieces of papers and carefully folded. A paper each from the two sites was randomly selected, plot number 9 from Asokore and plot number 4 from Osabene were chosen.

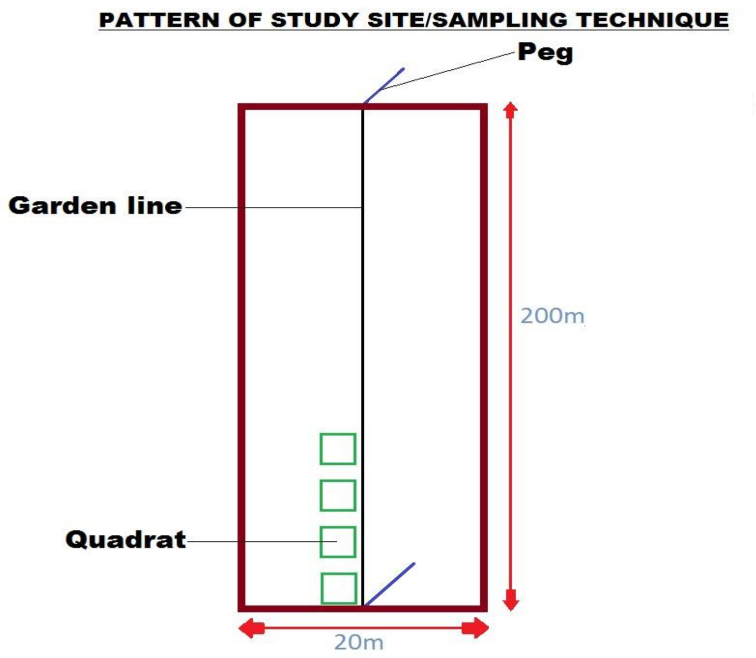

Fig.2: Pattern of the study area showing sampling technique

3.3.0 SAMPLING OF PLANT SPECIES

3.3.1 Sampling for determination of abundance and population density

Plant species were sampled using line transects. A spot on the chosen site of 200m×20m was selected randomly by standing at a corner and casting a coloured ball without looking onto the plot. At the spot where the coloured ball landed a garden line was pegged at both ends stretching along the length of the plot (Fig.2). A $1m^2$ quadrat was placed along the line at 2m intervals. All the plants species captured within the quadrat were counted (Plate 2) and recorded, the few shrub and tree species encountered were directly counted.

Plate 2: Student counting plant species within quadrat

In all, the quadrat was thrown sixty-seven times and the number of each plant species counted was recorded as in Table B-1 in the appendix.

3.3.2 Identification of sampled plant species

A collection of the sampled plant species were taken to the herbarium at the Botany Department of University of Ghana, Legon for identification with the assistance of the Senior Technician (Plate 3) using reference of regional manual on flora (Hawthorne & Jongkind, 2006).

Plate 3: Student at Legon herbarium with Senior Technician to identify sampled plants species

3.4.0 DATA ANALYSIS

3.4.1 Species composition

Difference in plant species composition between the two wetland areas was determined by SØrensen's similarity index (S) given as follows: S = 2c/ (a+b)

Where a = number of species in one habitat b = number of species in the other habitat c = number of species common to both habitats

3.5 STATISTICAL ANALYSIS

Continuous data were presented as mean ± standard deviation and were compared using t-test analysis whereas discrete data were presented as percentages and proportions and were compared using chi-square and Fishers exact test analysis where possible. All analyses were performed using Graph Pad Prism for windows version 6.0. All statistical analyses were considered significant if $P < 0.05$.

CHAPTER FOUR RESULTS

4.1 Species richness in the wetlands

A total of forty four (44) species were identified in the two wetlands (Table 1). These belonged to thirty five (35) genera and twenty (20) families. The total number of species recorded in Asokore wetland was 31 and that of the Osabene wetland was 13.

4.2 Species composition

A total of 22 unique species were identified in the Asokore wetland and 4 unique species were identified in Osabene wetland (Table 1). Sørensen's similarity index of composition between the Asokore and Osabene wetlands was 0.364.

4.3 Abundance of individual plant species within the sites

The abundance of species such as *Coix* sp. (587), *Cyclosorus sp. (611)*, *Centrocema* sp. (470), *Luffa* sp.(229), *Ipomea* sp. (401), were significantly higher at Asokore ($P < 0.00001$) compared to Osabene wetland (Table 1) , while species such as *Panicum maximum*,(372) *Pennisetum sp.* (497) *Cyperus rotundus* (261), *Floscopa* sp. (189) and
Justicia sp. (211)) recorded significantly high abundance at Osabene area than the Asokore site ($P < 0.00001$). Between the two sites, *Cyclosorus sp. (611), was the most abundant with Blighia* sp. (4) recording the least abundance (Table 1).

Table 1 Abundance of individual plant species in the study sites

	Total	Asokore	Osabene

Flora type	7549(100%)	4510(59.7%)	3039(40.3%)	P value
Urticaceae				
Laportea ovaliafolia (Schumach & Thonn)	51(0.7)	51(1.1)	-	<0.0001
Laportea aestuan (Linn Chew)	21(0.3)	21(0.5)	-	0.0004
Gramineae				
Dacyloctunium aegytetium (Beauv, P)	87(1.2)	87(1.9)	-	<0.0001
Echinochloa pyramidalis (Clayton, W.D)	144(1.9)	144(3.2)	-	<0.0001
Seteria longiseta (Beauv, P)	855(11.3)	427(9.5)	428(14.1)	<0.0001
Panicum maximum (Webster, R.D)	372(4.9)	-	372(12.2)	<0.0001
Pennisetum purpureum (Schumach & Spreng)	497(6.6)	-	497(16.4)	<0.0001
Penicum laxum (Rank, L)	248(3.3)	95(2.1)	153(5.0)	<0.0001
Ciox lacryma-jobi (Soreng, R.J)	835(11.1)	587(13.0)	248(8.2)	<0.0001
Cyperaceae				
Torulynium odoratum (Tucker, C)	316(4.2)	129(2.9)	187(6.2)	<0.0001
Cyperus rotundus (Yazdanparast, R)	421(5.6)	160(3.5)	261(8.6)	<0.0001
Cyperus mariscus alternifolia (Lun-Kai Dai)	154(2.0)	154(3.4)`	-	<0.0001
Compositeae				
Meranthera scandens (Schumarh & Thonn)	379(5.0)	163(3.6)	216(7.1)	<0.0001
Eclipta prostrate (Hyekyuang Yang)	125(1.7)	125(2.8)	-	<0.0001
Ageratum conyziodes (David, S.C)	49(0.6)	49(1.1)	-	<0.0001
Aspilia africana (Ainslie, R.J)	91(1.2)	91(2.0)	-	<0.0001
Synedrella nodiflora (Blanco, F.M)	33(0.4)	33(0.7)	-	<0.0001

Table 1 cont'd. Abundance of plant species in the study sites

	Total	Asokore	Osabene	
Flora type	7549(100%)	4510(59.7%)	3039(40.3%)	P value
Araceae				
Colocasia esculenta (Ivancic Anton)	72(1.0)	72(1.6)	-	<0.0001
Xanthosoma sagittifoliam (Weisse K.)	81(1.1)	81(1.8)	-	<0.0001

Acanthaceae				
Justicia flava (Powell, J.W)	285(3.8)	74(1.6)	211(6.9	<0.0001
Amaranthus speciosa (Rory Smith)	136(1.8)	74(1.6)	63(2.1)	0.1799
Thelyptericeae				
Cyclosorus striatus **(**Micheal Hassler)	611(8.1)	611(13.5)	-	<0.0001
Talinaceae				
Talinum trangularis (Udoh, E.J)	112(1.5)	-	112(3.7)	<0.0001
Solanaceae				
Physalis micrantha (Bearts & Lehmann)	34(0.5)	34(0.8)	-	<0.0001
Papilianaceae				
Centrocema plumieri (Sousa, A.C.B)	147(1.9)	147(3.3)	-	<0.0001
Onagraceae				
Ludwigia leptocarpa (Andres H)	68(0.9)	68(1.5)	-	<0.0001
Verbenaceae				
Gmelina arborea (Menz, D.K)	7(0.1)	7(0.2)	-	0.0742
Cucurbitaceae				
Luffa aegyptiaca (Miller)	229(3.0)	229(5.1)	-	<0.0001

Table 1 cont'd. Abundance of plant species in the study sites

	Total	Asokore	Osabene	
Flora type	7549(100%)	4510(59.7%)	3039(40.3%)	P value
Convolvulaceae				
Ipomea batatas (Brian Swale)	401(5.3)	401(8.9)	-	<0.0001
Amaratheceae				

Alternanthera nodiflora (Lebot V.)	136(1.8)	136(3.0)	-	<0.0001
Sapindaceae				
Blighia sapida(Koenig, D.K)	4(0.1)	4(0.1)	-	0.2578
Euphorbiaceae				
Alchornea cordifolia (Nmeregini, A)	11(0.1)	11(0.2)	-	0.0158
Commeliceae				
Floscopa rivularis (Clarke, C.B.)	368(4.9)	179(4.0)	189(6.2)	<0.0001
Cannaceae				
Canna indica (Vera Kratochvil)	67(0.9)	67(1.5)	-	<0.0001
Asteraceae				
Tridax procumbems (Muscle, J.S.)	102(1.4)	-	102(3.4)	<0.0001

4.4 Abundance of families at the study sites

Twenty families were observed in the two study areas (Table 2). Three families namely Compositeae, Gramineae and Cyperaceae were most abundance in the entire study areas. They formed 61% of individual plants in the area (Table 2). Compositeae, Gramineae and Thelyptericeae constituted the most abundant families in Asokore and Gramineae and Cyperaceae were the most abundant families in Osabene. Among the twenty (20) families, 5 families were found in both sites but 13 of them were exclusive to Asokore and 2 were exclusive to Osabene (Table 2).

Table 2: Abundance of different families of flora stratified by the locality

Family	Total 7549(100%)	Asokore 4510(59.7%)	Osabene 3039(40.3%)	P value
Compositeae	677(9.0)	461(10.2)	216(7.1)	< 0.0001
Acanthaceae	421(5.6)	147(3.3)	274(9.0)	< 0.0001

Solanaceae	34(0.5)	34(0.8)	-	< 0.0001
Cannaceae	67(0.9)	67(1.5)	-	< 0.0001
Convolvulaceae	401(5.3)	401(8.9)	-	< 0.0001
Cucurbitaceae	229(3.0)	229(5.1)	-	< 0.0001
Urticaceae	72(1.0)	72(1.6)	-	< 0.0001
Papilionaceae	147(1.9)	147(3.3)	-	< 0.0001
Gramineae	3038(40.2)	1340(29.7)	1698(55.9)	< 0.0001
Araceae	153(2.0)	153(3.4)	-	< 0.0001
Amaratheceae	136(1.8)	136(3.0)	-	< 0.0001
Thelyptericeae	611(8.1)	611(13.5)	-	< 0.0001
Cyperaceae	891(11.8)	443(9.8)	448(14.7)	< 0.0001
Onagraceae	68(0.9)	68(1.5)	-	< 0.0001
Commeliceae	368(4.9)	179(4.0)	189(6.2)	< 0.0001
Verbenaceae	7(0.1)	7(0.2)	-	0.0742
Sapindaceae	4(0.1)	4(0.1)	-	0.2578
Euphorbiaceae	11(0.1)	11(0.2)	-	0.0158
Asteraceae	102(1.4)	-	102(3.4)	< 0.0001
Talinaceae	112(1.5)	-	112(3.7)	< 0.0001

CHAPTER FIVE DISCUSSION

5.1 Species richness in the wetlands

The representation by fewer taxa at Osabene (13 species) compared to the Asokore site (31 species) could result from acidification. Due to the location of the Osabene site just close to a major road and not being too far from a filling station, residue of fossil fuel such as petrol and diesel carried by surface runoff to the site create acidity of the area impacting plant by limiting the availability of some inorganic nutrient. The acidic conditions promote the conversion of nitrates into ammonium salt (Reddy *et.al*, 2005), this favoured the richness of grasses but affected that of woody species (Table 1) since the grasses can utilize nitrogen in the form of ammonia.

Species richness is also affected by enrichment resulting from livestock waste, waste water, urban runoff and fossil fuel burning. In this study, it was observed that most houses surrounding the Osabene site have directed their drainage system towards the wetland (Plate 1) apart from the constructed drains which empty their content into the wetland. Nutrient enhancement as mentioned by Galatowitsch & van der Valk (1996) can increase or decrease the species richness within the wetlands depending on the initial species mix, nutrient loading rate and season. The enrichment seemed to have decreased the species richness of Osabene but that of Asokore comparatively appreciated.

5. 2 Species composition

Three floral forms were recorded during the study; herbs, shrubs, and trees with the composition of shrubs being 3.20%, trees 6.50% compared to the herbaceous plants of 90.30% (Table 1), which virtually dominated the study. Sorensen's similarity index of composition between the two found to 0.364 indicates a significant difference in composition between the wetlands. The lower composition of the woody plants; shrubs and trees species was due to human intervention since most of these species were constantly harvested for fuel. *Alchornea cordifolia* for instance is known to be widespread in secondary forest and riverine forest, in DR. Congo, the shrub is reported to improve soil fertility by restoring calcium levels in acid soil (McClanhan & Young, 1998). However, it had a low composition in this study because of regular harvesting for fire wood. The significant composition of herbaceous plant species distributed among families like Gramineae and Cyperaceae which dominated the study, especially at the Osabene site compared to woody plants was the result of vegetation removal through herbivory or grazing. Due to the presence of grass species such as *Panicum laxum* and *Panicum* *maximum*, the Osabene site is prone to grazing by cattle. The presence of cattle at the site may disturb the germination of woody plants to the advantages of herbaceous ones. This statement can be supported by the observation made by Popolizio *et. al.*, (1994), that short-term grazing of riparian vegetation after more than 30 years of cattle exclusion stimulated growth of herbaceous vegetation. Also, the poor composition of woody plants was caused by soil tillage (Plate 1), especially Asokore since tillage treatment disrupts rhizome of perennial plants and facilitates germination of annuals and invasive species.

5.3 Abundance of individual plant species within the families

Wetland is considered to be one of the most diverse ecosystems comprising all life forms (Mitsch *et al*., 2009). This statement remains absolutely so when wetland is devoid of negative human interference, but the wetland may lose some if not all the life forms existing in it so long as humans impact negatively on the wetland. For instance, Anku (2006) has stated that wetlands in Ghana are threatened by human factors such as urbanization, high population growth and fuel wood gathering. Report by O'Neil & Yeakley (2000) indicated that plant species richness was generally less in urbanized areas than in riparian forested streamside corridors of Portland, Oregon. Apart from the significant difference in the abundance between individual species in the two sites, it can also be realized that some families were significantly represented than others. One of the major cause of the disparity in the representation or distribution of individual plant species within the families in each site is shading. Canopy cover has severe effect on undergrowth vegetation and typically shifts plant community structure towards emergent species (McClanhan & Young, 1998). For instance, in both sites, species like *Panicum laxum* and *Coix lacryma-jobi* occurred in clusters and closely packed forming a dense cover and thus preventing short stemmed plants from growing or establishing where these two species occurred. An observation made at Asokore site was that the occurrence of creeping species such as *Ipomea batatas*, *Luffa aegyptiaca* and *Centrocema plumieri* formed a dense cover shading out and hence limiting the abundance of species such as *Laportea* sp., *Synedrella* sp., *Physalis* sp. and others. At Osabene, an interesting observation made was that the area was seen to be made of plants occurring in clusters depending on height. While some portions were made of bunch of tall species like P. *maximum*, P. *laxum*, *Pennisetum purpureum* and Coix sp., other portions were made of bunch of short and smaller plants like *Cyperus rotundus*, *Tridax* sp., *Amaranthus* sp., *Talinum* sp., *Floscopa* sp. etc but group of short plants scarcely occurred among the tall ones. This indicates that shade formed by the tall species had effect on the short stemmed species.

One major abuse suffered by the Osabene wetland is that it has been turned into sink for domestic waste and constructed drainage. Due to its nature as flat marshy wetland, the water hardly flows, therefore the quantity of soluble salt in the untreated water collected by this site may affect the growth and composition of plant species. To Rendig and Taylor (1989), high concentration of soluble salt in water from irrigation return water, storm water and domestic uses are lethal to plants and sub-lethal level may impair growth, and Allen & Feddema (1996) confirmed this by saying salinity concentration of as little as 3 ppt resulted in substantial stress in several Southeastern Montana wetland trees (e.g. *Nyssa aquatica*).

Interestingly species that occurred in both sites such as *Seteria longiseta*, *Panicum laxum*, Torulynium, *Cyperus rotundus*, *Meranthera scandens*, *Justicia flava* and *Floscopa rivularis* registered a higher abundance at Osabene than Asokore except for *Coix lacryma-jobi* whose abundance was higher in Asokore than Osabene. This occurrence could have been to the fact the competition for space and light was less at Osabene than it was happening at Asokore.

5.4 Abundance of families at the study sites

The nature and degree of human disturbance at the wetland sites appear to have affected the abundance of flora families between the two sites rather than the wetland type. Thus, out of twenty families observed at the two sites 18 of them were recorded at Asokore which is a riverine wetland and only 7 of them were found at Osabene which is marshy wetland. The disparity in abundance of families between two sites could be attributed to human stressors such as contaminant toxicity, sedimentation (burial) and acidification. Contaminant toxicity emerge from pesticide application, urban runoff, water treatment system and fossil fuel combustion which affect plant metabolic pathway, enzymatic reaction and growth (Jones *et al*., 2009). The Osabene site has a relatively lower elevation than the Asokore site and also located near major trunk road. For its location it serve as receiving point for runoff from both constructed drainage and natural gullies, residue of fossil fuel washed from the road and waste water from domestic sewage system. These sources of contaminants may lead to bioaccumulation of metals such as lead, copper, zinc and aluminium in plants affecting their species composition. For instance, a study conducted at Montana reveals that upland soils with high levels of arsenic and other metals from smelting emissions had reduced cover and vertical diversity of plants, lower specie richness and increased dominance of weedy species (Galatowitsch & van der Valk, 1995). In Colorado riparian, conifers and *Populus* sp. died when exposed to high levels of iron and manganese (Brison, 1993).

Another possible cause for the lower abundance of families at the Osabene site compared to the Asokore site might have been sedimentation. Because of the lower elevation of the Osabene site it receives huge amount of sediments through erosion and runoff from drains. These sediments completely or partially bury the shoot of some plants but burial of leaves has direct effect on light needed for photosynthesis and restricting foliar gas exchange (Ewing, 1996), hence the significant low abundance or non-existence of families comprising creeping plant or short-stemmed species such as Solanaceae, Convolvulaceae, Cucurbitaceae, Papilionaceae, Urticaceae and Onagraceae at Osabene.

CHAPTER SIX CONCLUSIONS AND RECOMMENDATIONS 6.1 CONCLUSIONS

This study was designed to ascertain the flora diversity of wetlands in the Municipality with special reference to Asokore and Osabene wetland sites. The conclusions drawn after the study are as follows:

i. The more disturbed wetland had lower plant species richness than the less disturbed wetland.

ii. Plant species composition between the two types of wetlands was very low (S = 0.364). iii. The less disturbed wetland had more unique plant species than the more disturbed wetland

6.2 RECOMMENDATION

1. At the regional and district levels, municipal authorities should have severe restrictions on industries polluting wetlands, as well as for the control of domestic waste-discharge into such waters.

2. The MMDAs should create special division within their outfit to be responsible for overseeing sustainable management of wetlands and coordinate, control and harmonize policies that affect the status of wetlands.

3. Community awareness and participation needs to be made central in the management of wetland since the livelihood of some members of the community depends directly on wetlands and therefore degradation of these wetlands affects sustenance of such people.

4. The Ghana forests and wildlife policy covers only those wetlands designated Ramsar sites. This limited policy endangers the other wetlands of local importance and there should be therefore by-laws at the district level to protect the local wetlands.

5. Wetlands conservation in Ghana is mainly based on traditional beliefs, taboos and norms, which are undocumented but handed down orally from one generation to the next. Because of social and economic transformation, traditional conservation practices have been unable to halt the long-term degradation of wetland resources. There should be therefore well established policies and institutions to help conserve wetlands.

6. Each wetland is unique, both in terms of economic factors and in terms of environmental factors. A good wetlands policy must be designed and agreed to by the various actors and interest groups responsible for their development and should integrate environmental, social and economic factors.

7. The ministries of Food and Agriculture, Land and Forestry, Environment, and Science and Technology have no clear defined wetland policies, the National Development Planning Commission should be responsible for a separate wetlands-development policy.

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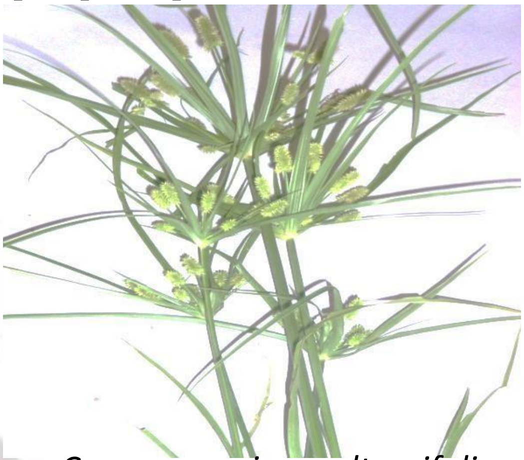
APPENDICES

APPENDIX A: Identified sampled plant species

Coix lacryma-jobi

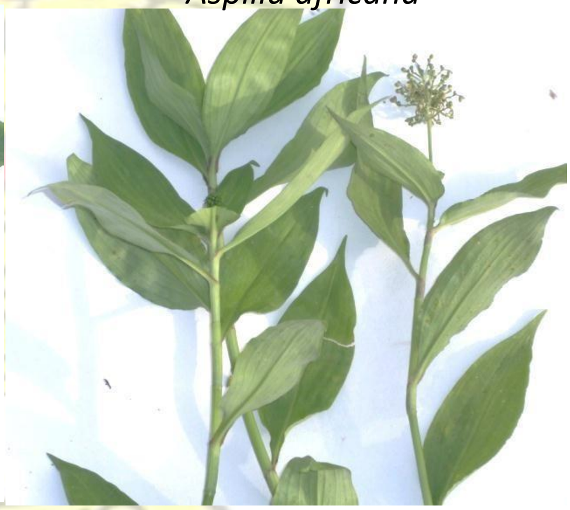


Cyperus mariscus alternifolius

Synedrella nodiflora

Aspilia africana

Colocasia esculenta



Floscopa rivularis

Plate A-1 sample plant species contd.

Plate A-1 sampled plant species contd.

Centrocema plumier

Meranthera scandens

Amaranthus speciosa

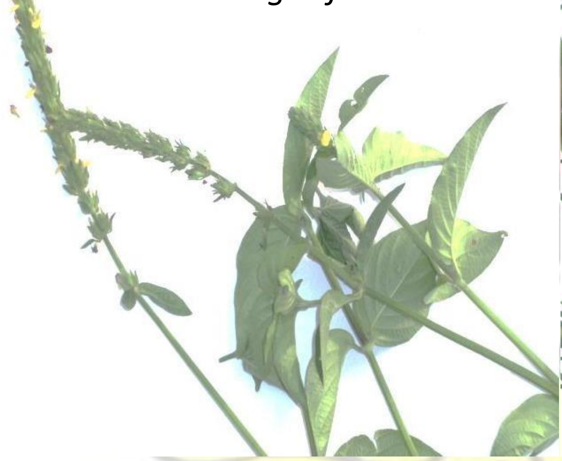
Ipomea batatas

Dacyloctunium aegytetium

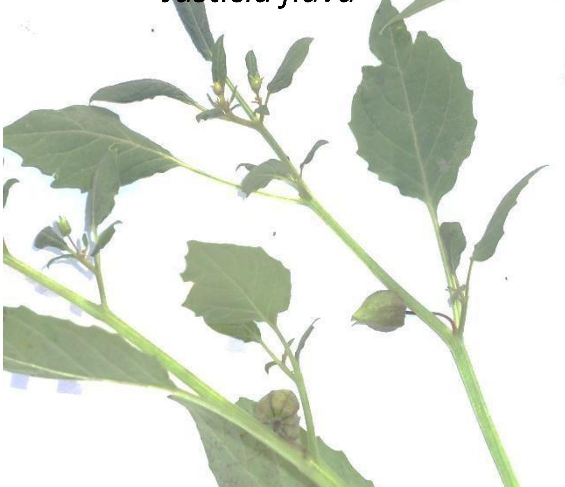
Torulynium odoratum

Plate A-1 sampled plant species contd.

Xanthosoma sagittifoliam *Canna indica*



Justicia flava *Seteria longiseta*



Physalis micrantha *Ageratum conyzoides*

Plate A-1 sampled plant species contd.

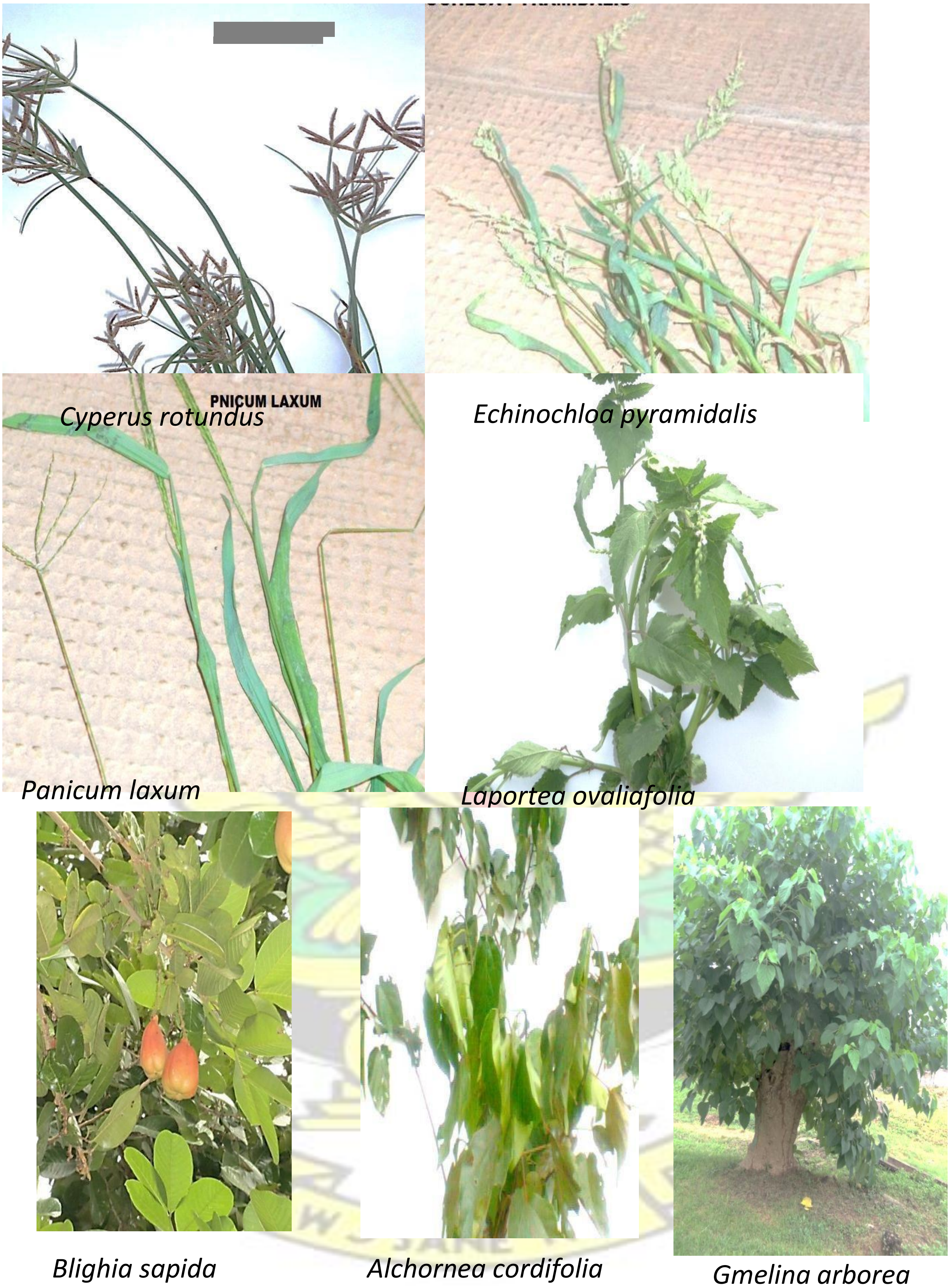


Plate A-1 sampled plant species contd.

APPENDIX B: determination of Species composition (species diversity) for plant species.

Table B-1: Species count for all plant species from throw 1 to 67 (T=each quadrat thrown)

SPECIES	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}
Cynedralla nodiflora	4	2	-	1	3	-	-	-	-	-	-	1
Justicia flava	3	1	4	2	1	-	-	2	1	4	5.5	1
Amaranthus speciosa	-	-	-	-	-	-	-	-	-	-	-	-
Ageratum conyzoides	-	4	2	1	3	4	2.5	5	3.5	-	-	-
Physalis micrantha	-	-	-	-	-	-	-	-	-	-	-	-
Canna indica	-	-	-	-	-	-	-	-	-	-	-	-
Ipomea batatas	6	3	9	11	17	13	4	5	6.6	8	9	7.5
Lufa aegyptiaca	-	-	-	-	-	2	4	8	3	4	7	9
Laportea aestuan	-	-	-	-	-	-	-	-	-	-	-	-
Centrocema plumieri	-	-	-	3	8	4	-	-	-	3	4	6
Coix lacryma-jobi	-	-	3	1	4	6	8	-	-	-	-	4
Colocasia esculenta	-	-	2	-	5	1.5	-	-	-	-	-	2
Laportea ovaliafolia	-	-	-	-	-	-	-	-	-	3	-	-
Aspilia africana	2	-	-	3	4	2	-	-	-	-	3	4
Meranthera scandens	3	4	6	2	4	3.5	4	4.5	2	6	7.5	5
Eclipta prostrata	-	-	-	-	-	-	-	-	-	-	-	-
Xanthosoma sagittifoliam	-	-	-	-	-	-	-	-	-	-	-	-
Alternanthera nodiflora	-	-	-	-	-	-	-	-	-	-	-	-
Cyclosorus striatus	11.5	14	9	6	9	17	21	4	15	16	21	20
Torulynium odoratum	-	-	-	-	-	-	-	-	8	14	12	9
Echinochloa pyramidalis	-	-	-	-	-	-	-	-	-	-	-	7
Ludwigia leptocarpa	-	-	-	-	-	-	-	-	-	-	-	-
Panicum laxum	-	-	-	-	-	-	-	-	-	-	-	-
Cyperus rotundus	-	-	-	-	-	-	-	-	16	7	11	4
Cyperus mariscus alternifolia	-	8	6	4	2	-	-	-	-	-	-	-
Dacyloctunium aegytetium	3	7	7	9	6.5	-	-	-	-	-	-	-
Floscopa rivularis	-	-	-	-	-	-	-	-	-	-	-	7
Seteria longiseta	-	-	-	-	-	-	10	4	7	9	14	1.5

SPECIES	T_{13}	T_{14}	T_{15}	T_{16}	T_{17}	T_{18}	T_{19}	T_{20}	T_{21}	T_{22}	T_{23}	T_{24}
Cynedralla nodiflora	-	-	-	-	-	2	-	-	-	-	-	1
Justicia flava	2	-	-	-	-	-	-	-	-	1	2	4.5
Amaranthus speciosa	-	-	-	-	-	-	-	-	-	1	3	-

Ageratum conyzoides	-	-	-	-	-	-	-	-	-	-	-	-
Physalis micrantha	-	-	-	-	-	-	-	-	-	-	-	-
Canna indica	-	6	4	2	11	-	-		-	-	-	-
Ipomea batatas	8	12	11.5	6	7	9	3	4	6	8	9	10.5
Lufa aegyptiaca	5	6	9	4	-	-	-	-	-	-	4	2
Laportea aestuan	-	-	-	-	-	-	-	-	-	-	-	-
Centrocema plumier	2	4	3	8	14	2	3	4	8	5	6	-
Coix lacryma-jobi	6	8	14	7	6	8	4	7	6	-	-	2
Colocasia esculenta	3	4.5	5	7.5	-	-	-	-	-	-	-	-
Laportea ovaliafolia	1	-	-	-	2	-	-	-	-	-	-	-
Aspilia africana	2	-	-	-	2	4	0	2	-	-	-	-
Meranthera scandens	5	4	4	-	-	-	3	7	8	4	3	6
Eclipta prostrate	-	-	-	-	-	-	3	1	2	3	-	4
Xanthosoma sagittifoliam	-	-	-	-	-	2	3	2	-	-	-	-
Alternanthera nodiflora	-	-	-	-	-	-	-	-	-	-	-	-
Cyclosorus striatus	13	17	18	12	11	9.5	6	8	9	4	2	4
Torulynium odoratum	7	10.5	4	6	8	2	-	-	-	-	-	-
Echinochloa pyramidalis	11	8	10	3.5	4	8	5.5	8.5	7	4	2	5
Ludwigia leptocarpa	-	-	-	-	-	-	-	-	-	-	-	-
Panicum laxum	-	-	-	-	-	-	-	-	-	-	-	-
Cyperus rotundus	12	14	2	3	4	-	-	-	-	-	-	-
Cyperus mariscus alternifolia	-	-	-	-	-	-	-	-	-	-	-	-
Dacyloctunium aegytetium	-	-	-	-	-	-	-	-	-	-	-	-
Floscopa rivularis	11	4	6	7.5	9	4	2.5	5	7	4	6	2
Seteria longiseta	8	6	4.5	-	2.5	11	-	-	10	9	10	12

SPECIES	T_{25}	T_{26}	T_{27}	T_{28}	T_{29}	T_{30}	T_{31}	T_{32}	T_{33}	T_{34}	T_{35}	T_{36}
Cynedralla nodiflora	-	-	-	-	-	-	-	-	-	-	-	-
Justicia flava	-	-	-	-	-	-	-	-	-	3	2	1
Amaranthus speciosa	-	-	-	4	2	3	4	-	-	-	6	2
Ageratum conyzoides	-	-	-	-	2	-	-	-	3	2	1	-

Physalis micrantha	-	-	-	-	-	-	-	-	-	1	3	4
Canna indica	-	-	-	-	-	-	-	-	-	7	9.5	3
Ipomea batatas	2	9	7	2	-	4	11	3	4	7	9.5	7
Lufa aegyptiaca	7	6	6	15	6	9	8	14	7	3	5	11
Laportea aestuan	-	-	-	-	-	-	-	-	-	-	-	-
Centrocema plumier	-	-	-	-	-	-	-	-	-	-	-	-
Coix lacryma-jobi	6	15	17	8	16	17	21	3	7	9	13	16
Colocasia esculenta	-	-	-	-	-	-	-	3	4	-	-	-
Laportea ovaliafolia	2	3	4	2	-	-	-	-	-	-	-	-
Aspilia africana	2	7	-	-	-	-	-	3	4	7	-	-
Meranthera scandens	-	-	-	-	-	3	6	4	2.5	4	6	-
Eclipta prostrate	4	2	-	-	-	-	-	-	-	-	-	-
Xanthosoma sagittifoliam	-	-	-	-	-	-	-	-	4	8	7	4
Alternanthera nodiflora	-	-	-	-	-	-	-	-	-	8	6	2
Cyclosorus striatus	9	3	7	9	14	21	24	14	12.5	9	16	16
Torulynium odoratum	-	-	--	-	-	-	-	-	-	-	-	-
Echinochloa pyramidalis	6.5	4	5	-	-	-	-	-	-	-	-	-
Ludwigia leptocarpa	-	-	-	-	-	-	-	-	-	-	-	-
Panicum laxum	-	-	-	-	-	-	-	-	-	-	-	-
Cyperus rotundus	-	-	-	-	-	-	-	-	-	-	-	-
Cyperus mariscus alternifolia	-	-	-	-	-	-	-	-	-	4	6	9
Dacyloctunium aegytetium	-	-	-	-	-	-	-	-	-	-	2	8.5
Floscopa rivularis	3	8	5	2	3.5	5	2	7	2	6	4	11
Seteria longiseta	15	7	4	3	9	3.5	11	7.5	11	10	4	7

SPECIES	T_{37}	T_{38}	T_{39}	T_{40}	T_{41}	T_{42}	T_{43}	T_{44}	T_{45}	T_{46}	T_{47}	T_{48}
Cynedralla nodiflora	2	1	-	-	-	-	-	-	-	-	2	1
Justicia flava	6	2.5	1	-	-	-	-	-	-	2	4	3
Amaranthus speciosa	4	3	1	-	-	-	-	2	2	3.5	1	-
Ageratum conyzoides	-	-	-	-	2	1	-	-	4	1	1	3
Physalis micrantha	2	1	-	-	3	4	0.5	2	1	-	-	-
Canna indica	5	-	-	-	-	-	-	-	--	-	-	-
Ipomea batatas	4.5	3	2	7	9	6	8	4	6	7	14	13
Lufa aegyptiaca	2	-	-	-	-	-	-	-	-	-	-	-
Laportea aestuan	-	-	-	-	-	-	4	2	1	-	-	-
Centrocema plumier	-	7	8	-	-	-	7	3	2	4	6	11

Coix lacryma-jobi	18	15	13	10	14	-	-	14	3	4	3	7
Colocasia esculenta	-	-	-	-	2	4	6	2	1	-	-	-
Laportea ovaliafolia	-	-	-	-	-	-	2	1	4	-	-	-
Aspilia africana	-	-	-	7	2	3	4	-	-	-	-	-
Meranthera scandens	-	-	-	-	-	-	-	-	4	3	3	4
Eclipta prostrata	-	2	5	11	4	9	7	5	4	7	4	3
Xanthosoma sagittifoliam	5	-	-	-	-	-	-	-	-	4	7	6
Alternanthera nodiflora	6.5	9	-	15	13	17	4	12	6	11	9	4
Cyclosorus striatus	3	9	3	14	14	2	11	14	2	5	-	-
Torulynium odoratum	-	-	-	-	-	-	-	6	7	10	15	7
Echinochloa pyramidalis	-	-	4	3	7	3	9	2.5	5	4	7.5	-
Ludwigia leptocarpa	-	-	8	6	8	11	4	1	4	6	14	1
Panicum laxum	-	-	-	-	-	-	-	-	-	-	-	-
Cyperus rotundus	-	-	-	-	-	-	-	-	-	8	12	18
Cyperus mariscus alternifolia	11	-	-	-	-	-	-	-	7	9	13	19
Dacyloctunium aegytetium	6.5	9	4	3.5	-	-	-	-	-	-	-	-
Floscopa rivularis	8	5	1.5	3	5.5	-	-	-	4	3	2	-
Seteria longiseta	9.5	16	8	9	3	4	4	8	14	18	14	11.5

SPECIES	T_{49}	T_{50}	T_{51}	T_{52}	T_{53}	T_{54}	T_{55}	T_{56}	T_{57}	T_{58}	T_{59}	T_{60}
Cynedralla nodiflora	-	-	2	1	3	1	-	-	-	-	-	-
Justicia flava	-	1	-	-	2	4	1	-	--	-	-	-
Amaranthus speciosa	-	-	3	4	6.5	-	1	2	3	4	6	-
Ageratum conyzoides	-	--	-	1	0.5	-	-	-	1	0.5	-	-
Physalis micrantha	4	2	-	1	-	-	-	-	3	-	-	-
Canna indica	-	-	-	4.5	7	-	-	2	6	-	-	-
Ipomea batatas	13	14	12.5	7	5	6	2	4	-	-	-	-
Lufa aegyptiaca	-	-	6	4	3	11	7	16	4	9	2	1
Laportea aestuan	-	2	3	4	2	-	-	-	-	-	-	2
Centrocema plumier	2	4	0	2	1	3	-	-	-	-	-	-
Coix lacryma-jobi	2	7	9.5	10	12	16	9	17.5	14	11	12	9
Colocasia esculenta	-	2	-	-	-	-	2	4	3	-	-	-
Laportea ovaliafolia	-	-	-	-	-	-	2	1	4	-	-	-
Aspilia africana	-	-	-	7	2	3	4	-	-	-	-	-
Meranthera scandens	5	6	4	2	4	-	-	-	-	-	-	-
Eclipta prostrate	6	8	9	13	2	6	-	-	-	2	3	-

Xanthosoma sagittifoliam	8	-	-	-	-	-	-	-	-	-	-	-
Alternanthera nodiflora	2.5	5.5	6	-	-	-	-	-	-	-	-	-
Cyclosorus striatus	-	4	7	8	11	4	2	7.5	11	12	1.5	7
Torulynium odoratum	3	-	-	-	-	-	-	-	-	-	-	-
Echinochloa pyramidalis	-	-	-	-	-	-	-	-	-	-	-	-
Ludwigia leptocarpa	5	-	-	-	-	-	-	-	-	-	-	-
Panicum laxum	-	2	4	5.5	8	6	3	6	4	2	10	7
Cyperus rotundus	12	16	7	14	-	-	-	-	-	-	-	-
Cyperus mariscus alternifolia	11	7	3	7	8	4	7.5	4	3.5	-	-	-
Dacyloctunium aegytetium	-	-	-	-	-	-	-	-	-	-	-	-
Floscopa rivularis	-	-	-	-	-	-	-	-	-	-	-	-
Seteria longiseta	9	-	-	-	-	-	-	-	-	-	-	4

SPECIES	T_{61}	T_{62}	T_{63}	T_{64}	T_{65}	T_{66}	T_{67}
Cynedralla nodiflora	-	-	-	1	2	-	-
Justicia flava	2	5	-	-	-	-	-
Amaranthus speciosa	-	-	-	2	-	-	-
Ageratum conyzoides	1	-	-	-	-	-	-
Physalis micrantha	-	-	-	-	-	-	-
Canna indica	-	-	-	-	-	-	-
Ipomea batatas	-	2	5	-	-	-	-
Lufa aegyptiaca	-	-	-	4.5	2	-	-
Laportea aestuan	1	-	-	-	-	-	-
Centrocema plumier	-	-	-	-	-	-	-
Coix lacryma-jobi	14	12	14	16	20	18	21
Colocasia esculenta	-	-	2	1	4	1	-
Laportea ovaliafolia	1	-	-	-	-	-	-
Aspilia africana	-	2	1.5	-	-	-	-
Meranthera scandens	-	2	5	-	-	-	-
Eclipta prostrate	-	-	-	-	-	-	-
Xanthosoma sagittifoliam	-	4	7	4	6	-	-
Alternanthera nodiflora	-	-	-	-	-	-	-
Cyclosorus striatus	7	14	2	8	2	7	2
Torulynium odoratum	-	-	-	-	-	-	-
Echinochloa pyramidalis	-	-	-	-	-	-	-
Ludwigia leptocarpa	-	-	-	-	-	-	-
Panicum laxum	7	9	8	4	2.5	7	3
Cyperus rotundus	-	-	-	-	-	-	-
Cyperus mariscus alternifolia	-	-	-	-	-	-	-
Dacyloctunium aegytetium	-	-	8	2	8	6	3.5
Floscopa rivularis	-	-	-	2	4	-	-
Seteria longiseta	4	13	7.5	3	14	13	16

APPENDIX C: The population density of the various plant species and detail computation of Shannon diversity index

Table C-1 the population density of all the plant species within 67m^{2}area

SPECIES	**POPULATION DENSITY (INDIVIDUAL/UNIT AREA)**
Synedrella nodiflora	0.5
Justicia flava	1.1
Amaranthus speciosa	1.1
Ageratum conyzoides	0.7
Physalis micrantha	0.5
Canna indica	1.0
Ipomea batatas	6.0
Luffa aegyptiaca	3.4
Laportea aestuan	0.3
Centrocema plumieri	2.2
Coix lacryma-jobi	8.8
Colocasia esculenta	1.1
Laportea ovaliafolia	0.8
Aspilia africana	1.4
Meranthera scandens	2.4
Eclipta prostrata	1.9
Xanthosoma sagittifoliam	1.2
Alternanthera nodiflora	2.0
Cyclosorus striatus	9.1
Torulynium odoratum	1.9
Echinochloa pyramidalis	2.1
Ludwigia leptocarpa	1.0
Panicum laxum	1.4
Cyperus rotundus	2.4
Cyperus mariscus alternifolius	2.3

Dacyloctunium aegytetium	1.3
Floscopa rivularis	2.7
Seteria longiseta	6.4
Gmelina arborea	0.1
Blighia sapida	0.1
Alchornea cordifolia	0.2