UNIVERSITY OF GHANA

ASSESSMENT OF LITTER ON THE BANKS OF SOME SELECTED LAGOONS ALONG THE EASTERN COAST OF GHANA

BY

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DECLARATION

I hereby declare that this thesis is the result of my own original research produced under the supervision of Prof. Elvis Nyarko and Dr. D. Nukpezah and that no part has been published or presented for another degree in this University or elsewhere.

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ABSTRACT

Apart from contributing to the degradation of lagoons, litter on the banks of coastal lagoons reduces their aesthetic values and denies them of their functions in ecosystem conservation and sustainability – a condition that results in the disappearance of coastal lagoon. The main objective of the study is to assess the litter load on the banks of coastal lagoons (Kpeshie, Mukwei, Sakumo II, Gao and the Keta) located along the eastern coast of Ghana over a six month period (i.e. from July to December).To achieve the objective, a 50 x 100 m (5000 m^2) belt transect was surveyed along the banks of each lagoon to assess the volume, composition, diversity and sources of the litter. The most prevalent litter type identified was further examined to conclude on the appropriate management strategies. The perceptions of the public on the litter load were also evaluated. Close to 4.9 tonnes of debris was collected from the five lagoons over the six month study period. Litter abundance across the sites was observed to decrease from the west to the east in the order of Kpeshie > Mukwei > Gao > Sakumo II > Keta whereas the monthly litter abundance was also in order of July > November > October > September > August > December. Litter diversity at the study sites also followed the order of Gao > Mukwei > Kpeshie > Keta > Sakumo II. Lagoon debris was mainly from public related and land based sources. Plastic litter formed the most abundant and diverse litter type on the banks of all the lagoons. People of all ages litter when found around the lagoons but while those aged between 18 -25 years were the most culpable, those aged 35 years and above were found to be more environmentally responsible.

A multivariate cluster analysis was also conducted to further establish the relationship, associations or linkages between the occurrences of the individual types of plastic litter at the various sites in terms of their frequency and abundance based on which management strategies to address the litter accumulation problem on the banks of coastal lagoons were recommended.

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To all the above I will forever be thankful.

DEDICATION

To my children Dede Manko, Korkor Shiegblie, Jojo Akpeng and Nhyira Amissma Quarshie.

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LIST OF ACRONYMS

BPS	Black Polythene Strands
Casset	Cassette
CSWP	Crisp and Sweet
DETWP	Detergent Wrappers
FDWP	Food Wrappers
LTPWB	Locally Tied Pure Water Bags
MDS	Multiple Dimensional Scaling
NYSK	Nylon Sack
PEMKB	Pen Marker
PL Bottle	Plastic bottles
PL Cutlery	Plastic Cutlery
PL Spray	Plastic Spray
PL Top/Lid	Plastic Tops and Lid
PL Toy	Plastic Toy
PWS	Pure Water Sachet
STRIP	Polythene Strips
STRP	Strapping Bands
STRW	Straw
TOTHB	Toothbrush
TOTHP	Toothpaste
WPH	Water Pump Hose

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

A worldwide concern receiving much public discussions today has been the occurrence of earthquakes, tornados, terrorist insurgencies, plane crashes and the outbreak of diseases; but an environmental problem that is potent enough to destroy the integrity of coastal environments is our utter disregard for the worth of coastal ecosystems. Meanwhile, the survival of humans now and in the future is ultimately dependent on these ecosystems. Our disregard for the natural environment is demonstrated in our continued release of pollutants into it. This problem has plagued the natural environment since the appearance of earlier ancestors (Markham, 1994).

Globally, there are general trends of population increase in coastal regions of the world and coastal cities are the principal growth nodes (Taljaard *et al.,* 2006). For example, it has been estimated that by 2025, the coastal zone from Accra to the Niger delta could be an unbroken chain of cities with a total population of fifty million along 500 km stretch of coastlines (Hatziolos *et al.,* 1996); the coastal zone in Ghana is already the fastest growing area in terms of urbanization and industrialization (Armah et al., 1996). This trend has a direct bearing on the ecological state of coastal zones as the continued deposition of litter will be so high that in future, the marine environment could no longer contain it.

This notwithstanding, the desire by human beings to satisfy their numerous wants; and the sheer change in lifestyles contribute to the generation of complex forms of waste. With the continued deposition of these waste either directly or indirectly into the coastal

environment; the world will thus be living, working, vacationing, increasingly conglomerating along the coasts and standing on the frontline of the greatest, most unprecedented litter tide ever faced (Guern, 2010).

Ghana's 550 Km stretch of coastline holds over 90 lagoons which together with their wetlands provide priceless products and services replete with supporting fisheries, absorbing floodwaters and protecting biodiversity and serving as roosting, nesting and feeding grounds for many bird species (Entsua- Mensah *et al.*, 2000). As Coastal populations continue to grow and pressures on the environment from land and marine based anthropogenic activities increase, coastal and marine living resources and their habitats are being lost or damaged in ways that are diminishing biodiversity and aggravating poverty. The degradation of coastal ecosystem has become increasingly acute within the last 50 years. (Crossland *et al.*, 2005); but when the conservation status of marine ecosystems is improved it will have important implications on the welfare - which strongly depend on the goods and services such as food - , raw materials, natural heritage, climate regulation, the monitoring of global change, recreation, tourism, education among others they provide; (Hanley *et al.*, 2003; European Environment Agency, 2010).

Litter is defined as any item discarded by an individual and includes those items found in unacceptable locations regardless of their origin; be it those dropped by individuals or blown from trash receptacle (Schultz *et al.*, 2013). Also known as marine litter, marine debris has also been defined by the UNEP (2005) as "any persistent, manufactured or processed solid material discarded, disposed off or abandoned in the marine and coastal environment, It consists of items that have been made or used by people and deliberately

discarded into the sea or rivers or on beaches; brought indirectly to the sea with rivers, sewage, storm water or winds; accidentally lost, including material lost at sea in bad weather (fishing gear, cargo); or deliberately left by people on beaches and shores." It is one of the most pervasive, yet potentially solvable, pollution problems plaguing the world's oceans and waterways (Coe and Rogers, 1997).

Thus, litter is a collective term used to qualify any disposed item intentionally or unintentionally, from point, non point or diffused sources as well as marine or land base. Litter poses a number of important environmental, social and aesthetic problems; environmentally, litter seen anywhere is a substantial source of contamination. Misplaced plastics, styrofoam, paper, glass and many other commonly used consumer materials accumulate in the environment, posing a number of harmful environmental consequences (Schultz *et al.*, 2013).

Undeniably, all items named in the above definitions are found in the marine environment and since all coastal lagoons are essential part of most marine environments, the items also constitute lagoon litter. Marine debris or litter washing ashore also pose a threat to human health and safety as beach users can be harmed by broken glass, medical waste and syringes (Sheavly and Register 2007; Dixon and Dixon, 1981) regional economies and marine species survivorship (Derraik, 2002; Ballance *et al.*, 2000).

Many beach litter monitoring surveys have mainly projected two major sources; these are the 'marine', 'sea' or 'ocean based' sources popularly stated to comprise of litter from shipping, oil rig activities, fishing activities among others and 'land based' sources

also comprising litter from tourism, recreational activities, fly tipping, litter from local businesses and unprotected waste disposal sites as well as riverine transport of litter through inland waters (OSPAR, 2009; Sheavly and Register, 2007; Allsop *et al.*, 2006; UNEP, 2005). Thus, more litter is found in areas where the population is denser and has been mainly consumer plastic items such as bottles, shopping bags and personal hygiene products (Ocean conservancy, 2010).

Littering has also become a common phenomena causing environmental degradation. It is recognised as an anti-social behaviour that reduces societal benefits (Cialdini, 2003; Cialdini and Baumann, 1981; Reich and Robertson, 1979; Baltes and Hayward, 1976). In addition, the relative weak administrative and financial capacities of municipal authorities have also resulted in difficulties in dealing with household solid waste in cities due to their dispersed production and diverse composition (Eaton and Hilhorst, 2003). This noted challenge in dealing with municipal solid waste results in the presence of litter at almost every available space in most municipalities.

Coastal lagoons are transitional zones between land and the ocean and tend to accumulate litter in transit to the oceans. They are among the most sensitive ecosystems that are particularly subjected to direct human impacts such as overexploitation of their resources, pollution, and various forms of environmental degradation worldwide (European Environment Agency, 2000).

The presence of litter in the marine environment is a worldwide occurrence that is not exclusive of African countries. Increasing urbanisation and industrialization particularly among populations of the coastal cities have also resulted in increased solid waste to an

unprecedented level during the past two decades. Major cities such as Lagos, Port Harcort, Dakar, Saint Louis and Kaolack are continually wrestling with solid waste management issues. In Coutonou, Poto Novo, Ouidah for instance, the low capacity of the Municipal Authorities to install proper solid waste management have led to the conspicuous presence solid waste accumulation which increased from 87,000 tons in 1986 to 150,000 tons in 1992 (UNEP, 1999).

Like other developing countries, Ghana is also grappling with pollution challenges and marine debris is one of her major environmental problems (Eshun, 2011). Meanwhile a South Asian Co-operative Environment Programme report - on marine litter that focuses on the current status of marine litter in some selected Gulf of Guinea countries - has indicated that in Ghana, there are areas particularly in the Greater Accra metropolitan area, where marine debris pollution is so severe that land and aquatic ecosystems are threatened due to technological advancements and increase in industrial activities (SACEP, 2007).

The problem is further compounded by waste from domestic activities, the laxity and nonenforcement of pollution control measures. These have aggravated the discharge of solid waste from residence into open drains and the conversion of coastal wetlands areas into dumpsites. This debris eventually ends up in coastal lagoons or on their banks as well as other adjoining ecosystems.

A number of beach litter surveys conducted around the globe have aimed at better understanding of the types and distribution of marine debris (Kusui and Noda, 2003; Velander and Mocogni, 1998; Golik and Gertner, 1992). Monitoring programmes on

marine litter have also clarified the issues related to the problem by answering the questions about the types, the sources and how wide spread the problem of litter is. These surveys have also provided a framework for formulating marine debris management strategies as well as how these strategies are to be modified in situations of changing conditions (Cheshire *et al.*, 2009; Coe and Rogers, 1997).

1.2 Problem Statement

The Environmental Protection Agency of Ghana in 2006 advised the closure of some coastal lagoons which include the Korle and Fosu lagoons to all swimming and fishing activities because they were extensively polluted (Eshun, 2011). The Butuah lagoon - located in the urbanised centre of the Sekondi -Takoradi metropolis in the Western Region of Ghana- has also been added to the list of dead lagoons due to pollution (Ghana Review International, 2011). These closures raised issues of concern for the people whose livelihoods depended on those lagoons and also painted a gruesome picture for the health status of lagoons in Ghana.

The pollution of the environment with litter is a common occurrence in Ghana. It is so pervasive that most environmentalists and well-meaning Ghanaians are worried about the state of environment that the current generation will bequeath to the future generations if the incessant littering act is unchecked. The Director of the Environmental Health and Safety Unit of the Accra Meropolitan Authority has indicated that Ghana produces 13,000 tons of waste on daily bases. A performance audit report of the Auditor General on Solid waste management by the Accra Metropolitan Assembly has also indicated that the Assembly spends an average of GH₵ 6,570,000.00 annually on collection of solid waste in the Accra Metropolitan area. Whiles some environmentalists

call for the strict enforcement of Act 296 of the criminal offence act, others suggest the promulgation of a new law to prosecute people who litter and also fail to take part in national cleanup exercises. Meanwhile the littering of streets, drains, in between houses and on parks in most cities and towns continues to increase and end up in drains that empty into coastal lagoons and subsequently into the sea.

It is worth noting that coastal lagoons form an integral part of marine fisheries and provide important spawning and nursery grounds for many fish species. During the preliminary tour of lagoons for this study, it was evident that some of the lagoons were inundated with so much litter that most of them are now completely lifeless. Again a cursory comparison of the extent of pollution in coastal lagoons on regional bases also showed that most of the lagoons located at the Central and Western coast of Ghana and are adjoining heavily populated coastal cities were severely polluted than those located in the Eastern coast. The researcher therefore seeks to assess the litter load along the banks of lagoons at the Eastern Coast of Ghana.

1.3 Justification of the study

There is currently a dearth of knowledge in the assessment of litter in coastal lagoons in Ghana. Works done so far have focused on the assessment of litter on Ghana's beaches and include but not limited to "the influence of tourist pressure on beach litter and microbial quality" (Tsagbey *et al.,* 2009) and "management of litter accumulation" (Nunoo and Quayson, 2003). Few studies that have targeted coastal lagoons have also looked at the quality of water in the lagoons and also includes but not limited to "water quality characteristics at the estuary of Korle Lagoon of Ghana and the distribution of heavy metals in the Fosu Lagoon" (Eshun, 2011); Ecological baseline survey for Korle

Lagoon (Amaoh *et al.,* 1998); the degradation of the Korle Lagoon (Amuzu,1995) and the Environmental baseline studies - limnology of Sakumo II Lagoon (Biney,1995). Since the formulation of the management strategy for Ghana's coastal wetlands in 1991 and the designation of five coastal wetland areas as RAMSAR sites, the various baseline studies on these RAMSAR sites have so far also focused only on the flora, fauna, hydrology, limnology, soil and socioeconomic aspects of these sites (Tufour,1999).

1.4 Scope and limitation of the study

Considering the current patchiness of work on litter assessment on lagoons, a survey of this nature should have been much more extensive in coverage to include all coastal lagoons from the West to the East coast of Ghana and also undertaking for a much longer period of time in other to gather enough baseline data on the problem but due to the constraint of finances and time, this study only focused on five major lagoons lying along the Eastern Coast of Ghana stretching from Accra to Keta, and include lagoons such as Kpeshie, Mukwei, Sakumo II, Gao and the Keta lagoons and span over a period of six months.

1.5 Objectives of the study

The study aimed at assessing the abundance, and composition of litter loads on the banks of five coastal lagoons located along the Eastern coast of Ghana.

The specific objectives were to:

i. Assess the abundance of litter on the banks of each of the selected lagoon;
ii. Identify the dominant litter types across the various lagoons over the study period;
iii. Identify the possible sources of litter to the banks of each of the selected lagoons.
iv. Identify the possible management strategies for addressing the dominant

category of litter in coastal lagoons.

v. Evaluate the public attitudes, perceptions and management issues for litter in coastal lagoons.

1.6 Organisation of the study

The study has been divided into six chapters. Chapter one covers the background of the study, the statement of the problem, objectives of the study, research questions, the scope of the study and the organisation of the study. Chapter two reviews related literature for the study. Chapter three involved the methodology and provides a description of the sampling site, the techniques used for the study as well as the analytical tool for the data analysis. Chapter four deals with the presentation of the result on the litter and that of the interview schedule. Chapter five discusses the results from both the respondents and the litter assessment analysis. Finally chapter six draws conclusions from the main findings and proposes some recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter reviews literature related to the study and seeks to describe the physical and ecological characteristics of coastal lagoons as well as their importance. It will also explore the use of coastal lagoons as receptacles of marine debris. It will also focus on the act of littering, sources of litter in the coastal environment and the effects of litter on the marine ecosystem. Marine litter surveys in Ghana and the Legislation / Regulatory Instruments for the management of marine litter will also be reviewed.

2.1 Coastal Lagoons

A coastal lagoon is a shallow coastal water body separated from the ocean by a barrier and connected intermittently to the ocean by one or more restricted inlets (Kjerfve, 1994). Thus, coastal lagoons are shallow aquatic ecosystems that form a transition between coastal terrestrial and marine ecosystems.

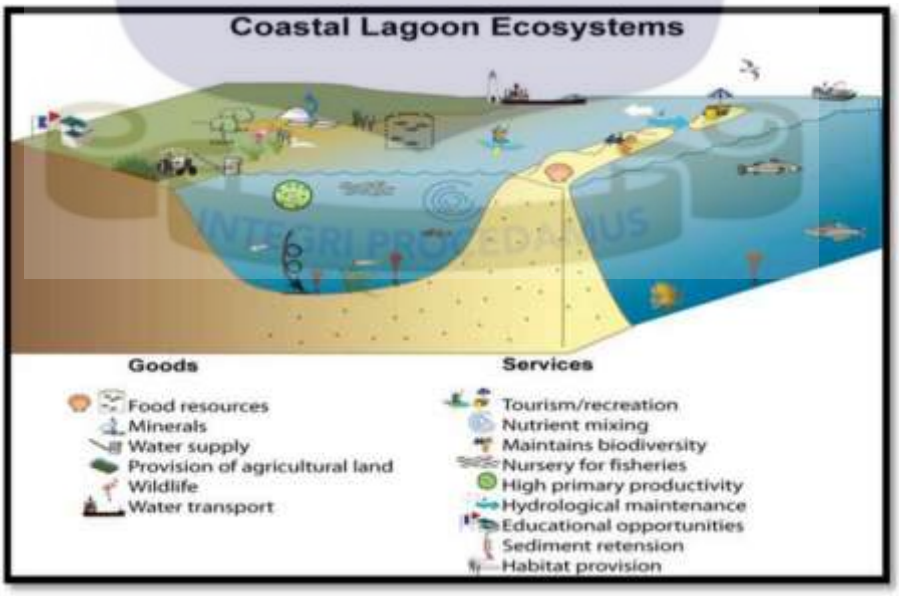


Figure 2.1: Schematic diagram of a Coastal Lagoon ecosystem.

Source: Seeram (2008) retrieved from http://epp.eurostat.ec.europa.eu

2.2 Physical characteristics of Coastal Lagoons

Coastal Lagoons are typically found along low lying coastlines that have a tidal range of less than 4m (Martin and Dominguez, 1994); globally, it constitute 13 % of the entire coastal regions and has an area ranging between less than 0.01 km^2 to more than 10,000 km^2 and typically of a depth of 5 m (Bird, 1994; Kjerfve, 1994).

Nichols and Boon (1994) have been instructive on the processes that form lagoons; according to them, coastal lagoons are formed and maintained by sediment transport processes through rivers, waves, currents, winds and tides. As the sediments are carried through these media, they accumulate in rivers and tidal deltas, on marshes and flats where there are submerged aquatic vegetation. This vegetation slows down the current. According to Bird (1994) wind and wave actions continuously erode the barriers of a Lagoon; and so lagoons need even more continuous deposition of sediment for their maintenance.

The Flushing rate of the coastal lagoon is a physical property that controls the retention time of water and its constituents within the lagoon ecosystem. Lagoons tend to have low flushing rates because of restricted exchange with the ocean. This is a contributing feature to high primary productivity and potentially high pollutant concentrations (Spaulding, 1994). Determinants of flushing rate include the size and shape of the lagoon, the level of connectivity with the ocean, tidal range, and freshwater flow (Phleger, 1981).

Kjerfve and Magill (1989) has subdivided coastal Lagoons into three major geomorphic groupings - choked lagoons, restricted lagoons or leaky lagoons based on the nature of

exchange of water between the lagoon and the open ocean. Choked lagoons are characterised by a single entrance channel. The ratio of entrance channel, cross-sectional area to the surface area of choked lagoons is usually small. They have long residence time and are dominated by hydrologic or reverine cycles. They are controlled by the wind and experience limited short term marine variability. Leaky lagoons are those that have multiple entrance channels and a relatively large ratio of entrance cross-sectional area to surface of the lagoon. They are dominated by marine influence, near oceanic salinities, strong tidal variability and occasional significant wave energy. Restricted lagoons share characteristics that lie between the choked and leaky extremes (Miththapala, 2013; Kjerfve and Magill, 1989).

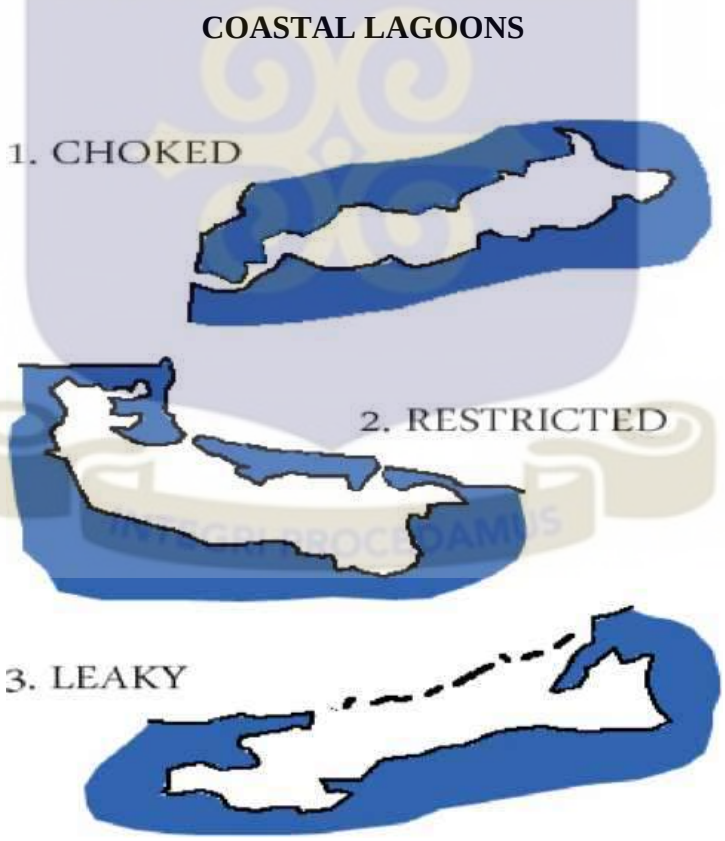


Figure 2.2: Types of Lagoons.

Source : Miththapala (2013).

2.3 Ecological characteristics of Coastal Lagoons.

Lagoons are highly productive ecosystems and contribute to the overall productivity of coastal waters by the support they give to a variety of habitats such as salt marshes, sea grasses and mangroves. They provide habitat for many fish and shell fish species (Anthony *et al.,* 2009). Sea grass beds are common features of most lagoons and can enhance the biodiversity of lagoons as they make available a physical refuge for aquatic organisms and provide them with a safe environment against predation. They also serve as nursery and feeding grounds for a variety of organisms (Harris *et al.,* 2004; Heck and Thoman, 1984).

Anthony *et al.,* (2009) have stated that the relatively low flushing rate makes coastal lagoons a favourable habitats for primary producers i.e. phytoplankton and aquatic plants and added that nutrients enter lagoons from runoff and ground water flows and through the exchanges with the ocean. Nutrient availability in coastal lagoons often limits primary productivity and can foster high rates of primary production thereby supporting high rates of secondary production compared to other aquatic ecosystems (Nixon, 1995). However, if primary production exceeds the demands of consumers, euthrophication can result (Valiela *et al.,* 1992). Excess phytoplankton and algal blooms lead to hypoxia that reduces light penetration. This condition puts a stress on marine organisms and results in die-offs; it also changes in food web interactions and community structure and finally, loss of biodiversity (National Research Council, 2000).

2.4 Importance of Marine Ecosystem

Marine ecosystems have enormous value as they are home to a tremendous diversity of marine organisms and play a critical role in nutrient and energy cycle (U.S. Congress,

Office of Technology' Assessment, 1987). Thus, they give sustenance to humanity as they store food species that are extracted through recreational and commercial means. People also hunt coastal waterfowl, harvest marine plants and use the marine ecosystem for aquaculture operations. A number of other economic activities that leverages on fishing alone include fish processing and retailing, canoe and boat building etc. marine resources also serves as an important source of pharmaceutical and consumer product; thus Coastal and marine ecosystems provide many benefits to the human society. The United Nations Environmental Programme (UNEP) contends that these benefits provided by nature to serve mankind and have been referred to as ecosystem "goods" or "services" (UNEP, 2006).

According to Beaumont *et al.,* (2007), the goods and services of a marine or coastal ecosystem are the direct and indirect benefits people derive from an ecosystem. A synthesis report on the findings of the Millennium Ecosystem Assessment prepared by the United Nations Environment Programme (UNEP) acknowledges this crucial ecosystem service provided by marine ecosystem lists them to include provisioning services such as food, water, timber, and fibre; regulating services for climate, floods, disease, wastes and water quality; cultural services such as recreational, aesthetic and spiritual benefits; and supporting services such as soil formation, photosynthesis and nutrient cycling.

It further indicates that the food provisioning services for instance refers to the extraction of marine organisms by humans for consumption purposes. Thus, the biodiversity of marine ecosystem (the flora and fauna) provide protein and forms significant proportion of human diet. Its fish catch is therefore one of the most important services provided from coastal and marine ecosystems.

The report is emphatic that with more than a billion people relying on fish as their main source of animal protein, the fisheries industry in developing countries is particularly an important source of protein. Fisheries and fish products provide direct employment to 38 million people with a further 162 million people indirectly engaged in the industry (UNEP, 2006). Again a wide variety of raw materials are provided by marine biodiversity and meant for several purposes, for example the use of seaweed for fertiliser and fishmeal for aquaculture and farming suggests that the raw materials obtained from the marine environment are important. Some Pharmaceuticals and ornamental goods such as shells are all obtained from the marine environment (Beaumont *et al.,* 2007).

Beaumont *et al.,* (2007), support the synthesis report of the UNEP in the areas of the regulatory services obtained from marine biodiversity and points out that it refers to the benefits derived from the balance and maintenance of the chemical composition of the atmosphere and oceans by the marine living organisms. This includes the regulation of climate, the prevention of disturbance in terms of flood and storm protection. It include that the removal of waste materials - pollutants- from the ecosystem through both direct or indirect activities of marine organisms and the processes of the marine ecosystem are part of the regulation services provided by the marine ecosystem. These activities bury, store and transform many waste materials through assimilation and chemical decomposition and re-composition. Estuaries, marshes and lagoons play a key role in maintaining the hydrological balance and the filtration of water pollutants (UNEP, 2006).

The cultural and amenity services include the non-material benefits people derive from marine ecosystems. They include tourism and recreation, aesthetic and spiritual services;

traditional knowledge and educational and research services (UNEP, 2006). Beaumont *et al.,* (2007) have also indicated that cultural and amenity services are those benefits from biodiversity that is of founding significance to multiple cultural identities of a community (Beaumont *et al.,* 2007; Worm *et al.,* 2006). Benefits associated with the marine biodiversity for example include religion, folklore, painting, cultural and spiritual tradition.

Globally, tourism has been deemed the world's most profitable industry and coastal tourism is one of its fastest growing sectors providing employment for many people and generating local incomes for coastal folks (UNEP, 2006). Thus, coastal states attach special relevance to marine ecosystem as it plays a role in the revenue accumulation from tourism; for instance, with its multibillion tourism industry, it has been estimated by the National Ocean Economics Program that coastal states like California records revenue in the region of US $ 46 billion as the states' ocean - dependent economy, therefore any reduction in the quality of ocean and coastal recreation could impact negatively on the state (Stevenson, 2011).

The sprawling of many resort, recreational and relaxation centres and the development of hotels and other buildings for residential purposes around lagoons in Ghana could be cited to confirm this less concrete but very well known and sort after value of lagoons. It must be said that part of the reasons why lands acquired from areas closed to lagoons are relatively more expensive than those not in close proximity to lagoons and other water bodies in Ghana could be as a result of the tacit value lagoons render to mankind. There are other supporting services obtained from the marine ecosystem; these are the provision of habitats, primary productivity, nutrient recycling and soil formation. A

large number of marine species use the coastal areas such as estuaries, mangroves and sea grasses as nurseries. Estuaries for instance are important nursery grounds for fisheries and other species as they form one of the strongest linkages between coastal, marine and freshwater ecosystems and the ecosystem services they provide (UNEP, 2006).

Some contend that lagoons form a particular type of natural capital which generates a number of values and contribute positively towards improving human well-being. Such values have been broadly divided into "use" values and "non-use" values. Whiles the "use" values consist of present and future use values, of which the present use values form the highest values generated by lagoons, the "non-use" values can be further categorised into the option, bequest and existence values (Katupotha *et al.*, 2013).The option use value originates from societal desire to leave the option of either direct or indirect use of the lagoon for the use of future generations while bequest values are derived from leaving the lagoon resources for the use of future generation whether for their direct or indirect uses. Again the value people place on the knowledge that a particular resource such as the lagoon resource is there gives them satisfaction although they may not actually use it imply the existence value.

The present use values according to Katupotha *et al.*, (2013) consist of direct use values and indirect use values. The major direct use value components are those emerging from the extractive uses of lagoons and can be associated with the provisioning values proposed by UNEP (2005). Such extractive values include the extraction of fish, shrimp, fuel wood, timber, stakes, fruits, salt, wild game, medicine; fodder for large number of cattle during dry seasons, among others.

Other values derived from lagoons include the provision of a safe place for anchorage for marine fishing crafts as well as a site for recreation including but not limited to fishing, boating and bird watching. There are also research and studies -scholarly values- ; education, location for films and cultural events, photography, scenic beauty, cultural inspiration among others all of which constitute the non extractive direct use values of coastal lagoons.

The indirect and "invisible use" values may also be derived 'onsite' or 'off site'. Whereas the onsite values include the provision of natural habitat for flora and fauna, shoreline protection, flood protection, nutrient cycling, water regulation, erosion regulation, natural hazard regulation, sediment retention and sink for waste absorption, the off-site values are those values generated due to the "inspirational" effects of lagoons and include the creation of poems, songs and books. The entire economic and social values of lagoons are presented in the model below.

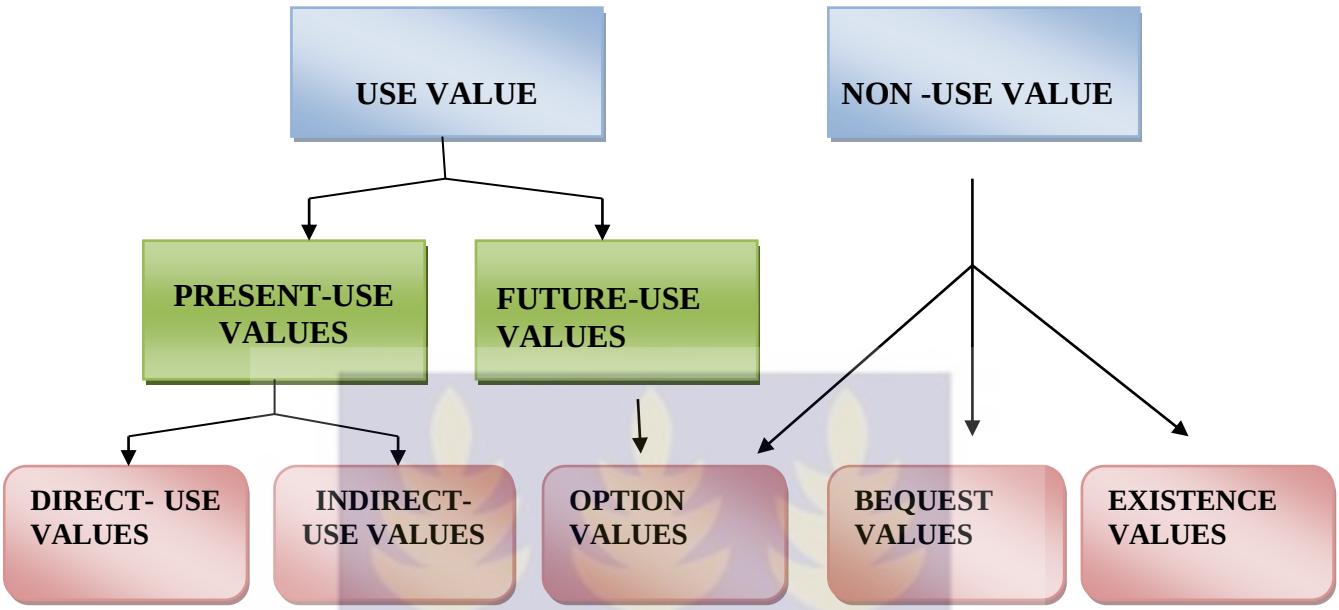


Figure 2.3: Total social and economic values of Lagoons.

Modified from Silva *et al.*, (2013).

Many of these ecosystems are deteriorating fast while others have become degraded as a result of anthropogenic factors (Richards, 1990; Goodland and Ledec, 1989). This condition is also fast stripping the marine ecosystems particularly coastal lagoons off their functions, values or services. The degradation of coastal lagoons and other marine environments has continued globally over the past decade and has been chiefly from anthropogenic sources originating from both inland and coastal areas (Taljaard *et al.*, 2006). One of the major anthropogenic factors that degrade the marine ecosystems and deny it from functioning is litter.

2.5 Coastal lagoons as receptacles of marine debris

Coastal lagoons form an integral part of the marine ecosystem; however it's now serving as a temporal containment for marine litter apart from being the conduit for the inflow of

fresh water and nutrients from inland into near shore environment of the ocean. Most lagoons are connected with river systems that feed them with inland waters however this inflow is loaded with litter mainly floatable items which have been discharged into the ocean. According to Arafat *et al.*, (2007) research reports have stated that 18 % of all litter is washed into streams which finally end up into the ocean. The US EPA (1995) has also indicated the flow of runoff water usually carrying debris such as discarded cups, plastic bags, cigarette butts, pet waste, and other litter enters into lakes, rivers, streams, lagoons and oceans.

It can be inferred from the above that litter can be generally defined as any item released into the environment through anthropogenic activities and have ecological, economical and welfare impacts on mankind.

2.6 The act of littering

The act of littering is the careless, incorrect disposal of minor amounts of waste (Hansmann and Scholz, 2003). Although the exact percentage of litter from the improper disposal behaviour by individuals is unknown, there is evidence that suggest that a large amount of litter is linked to individuals' improper disposal behaviours (MSW Consultants, 2009). Curnow *et al.*, (1997) also reviewed literature on the influence of socio-cultural factors on littering and found that males are more likely to litter than females, thus females rather than males were more likely to protect the environment and so are more environmentally conscious of littering than males (Slavin *et al.*, 2012; Al-Khatib *et al.*, 2009; Torgler *et al.*, 2008).

In an attempt to understand peoples littering behaviour, Community Change Consultants (CCC) in Australia - a firm that specialises in applying psychological principles to connect people's attitudes and their behaviour in environmental issues - conducted a study in 1997 and found a number of key findings; some of which are in agreement with the findings of Curnow *et al.*, (1997) as follows;

i. While some people simply leave litter behind, many litterers deliberately placed litter in certain locations.

ii. Many people of all ages, sex and social backgrounds litter; thus while people aged under 15 years are less likely to litter, all adults of all ages are more likely to litter; and that within the adult segment, people under 25 years were found most likely to litter when they are found in a group but those above 25 years were found most likely to litter when they are rather alone.

iii. Students and people who were not in any employment have higher than average littering rates. People with tertiary and post graduate education had lower than average littering rates.

iv. Littering will still occur whether or not litter bins are provided. The study came to this conclusion since it was observed that most littering occurred within five meters from a bin. A high proportion of such littering occurs in locations conducive for hiding or in places resembling litter bins such as in bushes or pot planters. The authors of the study noted with surprise that people go through a great deal of trouble to place their litter carefully in locations such as bushes while ignoring nearby bins; and when litter bins are even overflowing, people continue to use the same bin while another bin close by remained almost empty.

Slavin *et al.,* (2012), confirms the association between age and littering behaviour of people as they observed in a study that; younger people tend to litter more and also feel less guilty about their actions than older individuals. This trend is also supported by Cialdini *et al.,* (1990) and Arafat *et al.,* (2007).

Although people will not openly admit to littering as the act is mostly seen by many as untidy and can be harmful to human health and that of wild life (Wever, 2007), in another study, Arafat *et al.,* (2007) observed a counter- logical relationship between education and littering behaviour as they found in their survey that whereas a higher majority of their respondents with lowest educational level admitted that they never throw litter around, an equally higher percentage of the respondents with the highest education level admitted littering but only 'for absolute necessity'.

The act of littering is the most visible form of environmental degradation, though mostly ignored (Fennie, 1973), and various environmental problems pose environmental sustainability threat among which are pollution concerns (Steg and Vlek, 2009). It is a behavioural problem that dwells in psychology, so it is only discreet to explore the littering problem from littering preventive strategies (Oluyinka, 2013). Taking littering preventive actions is an aspect of Responsible Environmental Behaviour (REB) which is 'a positive behavioural attitude that hinges on the individual's different preventive actions taken by his own volition to protect the physical environment' (Tanner, 1999).

2.6.1 Drivers of littering behaviour

Brook (2012) gives factors that influence littering behaviour to include personal, social, material and habitual factors; whiles personal factors according to him refers to the extent to which an individual considers that it depends on his own volition or his personal responsibility to dispose of their litter properly as against someone else's responsibility to clean it up; the social factors are those that describe social norms that send strong signals about acceptable behaviours; such that if most people are seen littering, then the littering act becomes an acceptable norm. Brook again contends that while material factors refer to the likelihood of the characteristics of a site to provide cues for the promotion of littering behaviour, the habitual factors are those factors that can become an automated cognitive default behaviour of individuals such that littering becomes an act carried out without an elaborate reasoning (Steg and Vlek, 2009).

It can be inferred from above factors that the degree to which an attendant of a particular lagoon feels it is their personal responsibility to dispose of their litter properly than for someone else to clean up their litter after their visit, they will have a positive littering behaviour. If the act of littering around lagoons is considered a shameful act by its attendants, people will feel guilty if they littered whereas if lagoons site are always overwhelmed with litter, continuous littering by its attendants will become an acceptable norm even when they are cleaned.

2.6.2 Types of marine litter

A number of studies have identified several items of litter and have classified litter into material types as shown in Table 2.1.

Table 2.1: Materials and items found as Marine Litter

Material	Litter types
Plastics	Beverage bottles, trash bags, food wrappers, bottle caps, toys, light sticks for fishing, cigar tips, cigarette filters.
Rubber	Gloves, boots, Tyres.
Wood	Construction timber, pallets, fragments of both.
Sanitary or sewage related debris (SRD)	Tampons, condoms, human waste (Faeces), cleansing Materials / products.
Paper and cardboard	Boxes, containers, general items closer to shore.
Cloth	Clothing, furnishings, shoes.
Glass	Bottles, light bulbs.
Pottery	Fragments of plates, cups, etc.
Resin	Agricultural fertilizer pellets, pre-production resin pellets.
Metal	Beverage cans, oil drums, aerosol cans, automobile parts, scrap including household items (e.g., bikes, furniture).
Various combined materials	Lost and abandoned fishing nets (plastics, wood & metal) and computer equipment monitors (plastics, glass & metal).

(Ten Brink *et al*, 2009; Cheshire *et al.*, 2009; MCS, 2009; CEP, 2009; NOAA, 2007; Sheavly and Register, 2007; Allsopp *et al.*, 2006; UNEP, 2005).

2.6.3 Trend in litter quantities in the marine environment

Enormous actions have been taken to reduce or curb the continuous occurrence of litter in the marine environment; these efforts have partly been addressed from both international and national corridors but this notwithstanding, the trend in quantities of litter accumulating in the marine environment including water ways, estuaries and lagoons still persist in larger quantities (Derraik, 2002).

Globally, reliable estimates of the levels of marine litter are relatively rare as it is inherently complex to determine the quantities of litter that enters the entire marine environment (Mouat *et al.,* 2010; Allsop *et al.,* 2006). However, it has been estimated that an average of 13,000 and 46,000 pieces of marine litter were found per every square kilometre stretch in 2005 and 2006 respectively (UNEP 2006). Gregory (2009) has contended that over the last five to six decades the contamination and pollution of the aquatic environment by debris has been recognised as an ever-increasing phenomenon. This indicates that the ultimate desire to eliminate this environmental problem does not seem to be achievable anytime soon.

Plastics form a major constituent of litter in the coastal environment (Ryan *et al.,* 2009). According to UNEP (2005), in a 1998 survey, 89 % of the litter observed floating on the ocean surface in the North Pacific was plastic. Plastic is versatile, lightweight, flexible, resistant to moisture, strong and relatively inexpensive. These attractive features provokes our taste ravenously for plastics for the production of so many products; but it is an extremely persistent material in the environment meanwhile our consumption and further waste generation continues. This has led to the drastic change in the nature and quantity of rubbish ending up in the marine environment in the last 30 to 40 years due to the increased

use of plastics and synthetics (Allsopp *et al.*, 2006; National Association of Science, 1975). Derraik (2002) has argued that determining how much of litter is present in the ocean is challenging. Nevertheless, given the variety of ways litter can enter the marine environment and the relatively slow rate of degradation of most marine litter items particularly plastics, the amount of litter reaching the marine environment can be said to be significant. Research efforts to date indicate that the amount and variety of marine debris present in the oceans are considerable, increasing, and constitute a threat to the marine environment (Edyvane *et al.*, 2004; Lidia and Fischer, 2003).

2.7 Sources of litter in Coastal Environments

Litter in the marine environment is unsightly (Kiessling and Hamilton, 2003).) and finding measures to reduce or prevent it is a positive stride to keeping the marine environment and its ecosystem safe and healthy; the identification of the sources of these litter is not only vital to ensuring the formulation of appropriate policies to deal with it but to properly direct them to achieve the expected outcome (Ten Brink *et al.*, 2009). This notwithstanding, the Marine Conservation Society (MCS) of the United Kingdom (UK) asserts in 2009 that although some of the litter items found has been accurately identified and their sources determined with high level of confidence, identifying the sources of many of the other litter items is a complex task since litter may reach the marine environment through a number of different ways. The society categorises some litter items under sources such as public litter, fishing litter, sewage related debris, shipping litter and medical litter. Litter items that are unidentifiable or that could come from different sources are grouped as non-sourced litter as shown in Appendix 2. Public source remains the highest proportion in the marine environment, followed by fishing litter (MCS, 2009).

In spite of the litter source categorisation by MCS above, other literature on the sources of litter found in the marine environment as popularly acclaimed in many beach litter monitoring surveys have mainly projected two major sources; these are the 'marine', 'sea' or 'ocean based' sources popularly stated to comprise of litter from shipping, oil rig activities, fishing activities among others and 'land based' sources also comprising litter from tourism, recreational activities, fly-tipping, litter from local businesses and unprotected waste disposal sites as well as riverine transport of litter through inland waters (OSPAR, 2009; SACEP, 2007; Sheavly and Register, 2007; Allsop *et al.,* 2006).

2.7.1 Land-based sources

Allsop *et al.,* (2006) further explain that land based sources include storm water discharges, combined sewer overflows, littering, solid waste disposal, landfills and industrial activities and give details as below;

i. Storm water discharges comprise runoff water generated during heavy rain. They contend that when it rains storm drains collects and are directly discharged into nearby rivers, streams or ocean. Rubbish from streets can be washed into storm drains and then discharged straight into the ocean or to streams / rivers (and coastal lagoons) which in turn empty into the ocean (US EPA 2002). In most cases since Lagoons serves as the interface between this inland storm water and the ocean, it mainly receives this debris for a little while before their final destination into the sea during high tide when the sandy barrier is broken (Barnes *et al.,* 2009).

ii. Combined sewers normally carry sewage and storm water in periods of heavy rains when the waste water treatment facilities that the sewers are directed towards can no longer handle the sewage and the storm water. This results in

overflows which is then directly discharged into nearby rivers and finally into the ocean. The waste can include rubbish such as condoms, tampons applicators, syringes and other street litter.

iii. Beachgoers also carelessly leave their litter on the beaches after their recreation in much the same way as the more regular beach attendants such as fisher folks do after their fishing expedition and subsequent trade. Litter from such activities includes items such as food packaging, beverage containers, cigarette butts and plastic beach toys.

Landfills located in coastal environments or near rivers also contribute to the deposition of debris in coastal environment. Run-off from such landfills finds its way into the marine environment and leaves the litter it carries there. Nollkaemper (1994) has opined for example that in the USA many estuaries have been contaminated by garbage from nearby solid waste sites. Silva *et al.,* (2013) have also noticed that wetlands have been used as "sinks" (waste lands) for the release of wastes in urbanised areas. A similar situation can be seen in Ghana where some waste dump sites in coastal municipalities are located just within the vicinities of lagoons, beaches or estuaries as shown in the figure below.

Plate 2.1: Domestic refuse dump on the shore of the Densu Lagoon.
Photo credit: Quarshie J.T (2014)

The composition of litter classified above as 'land based' by OSPAR (2009); Sheavly and Register (2007); Allsop *et al.,* (2006) are in consonance with those constituting 'public related' sources by MCS, (2009). Public related sources of litter into the marine environment can therefore be considered as litter from land-based sources.

2.7.2 Sea-based sources

Sea-based litter originates from commercial fishing vessels; merchant, military, and research vessels; recreational boats, ferries and cruise ships; and offshore oil and gas platforms and associated supply vessels (Sheavly and Register, 2007; UNEP, 2005). In spite of Annex V of the International Convention for the prevention of Pollution from ships (MAPOL 73/78) that regulates the dumping of garbage from vessels into the sea, some litter still enter the sea through poor waste management practices and illegal waste disposal practices from galleys; others are from accidental loss or system failures. Commercial and recreational fishermen create marine litter when they discard ship generated waste overboard or fail to retrieve nets, ropes, trawl floats and other fishing gear (Ten Brink *et al.,* 2009).

All types of boat and ships and offshore industrial platforms are potential sources of marine debris and may originate from accidental loss, indiscriminate littering or illegal disposal. Allsop *et al.,* (2006) categorises the ocean based sources of litter to include Commercial fishing; Recreational Boaters; Merchant, Military and Research vessels and offshore oil and Gas platforms and Explorations as explained below.

According to a Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP), marine litter originates from numerous sources with approximately 80% of litter entering the marine environment from land-based sources and the remaining 20% originating from ocean-based sources (Guern, 2010).

2.8 The effects of litter on the marine ecosystem

Litter poses a number of important environmental, social and aesthetic problems; environmentally, litter seen anywhere is a substantial source of contamination. Misplaced plastics, styrofoam, paper, glass and many other commonly used consumer materials accumulate in the environment, posing a number of harmful environmental consequences (Schultz *et al.*, 2013).

Marine debris is a global problem affecting all major water bodies on the planet (Ten Brink *et al.,* 2009). Their effects in the coastal environment are variable; marine litter kills, injures and cause pain and suffering; each year, it entails great economic cost and losses to people and communities around the world (UNEP, 2005). According to the Caspian Environmental Programme, marine litter can pose a serious threat to the ecological lifecycle of pristine habitats as it affects fisheries, aquaculture, benthic communities, coral reefs and sea grasses. It damages human health and have a negative

influence on recreation, leisure, navigation, power generation and desalination plants. It also affects agricultural and cattle's grazing exploits in coastal areas and reduces the aesthetic characteristics of the coastal areas (CEP, 2009; Arafat *et al.,* 2007).

Entanglement and ingestion are the primary kinds of direct damage marine debris cause to wildlife. It smothers sea beds and causes disturbance to habitats during mechanical beach cleaning exercises (UNEP, 2005). It serves as a medium for the introduction and accumulation of toxic substances in the marine environment and brings about environmental changes resulting from the transfer of invasive species which were hitherto not native to the marine ecosystem (Allsop *et al.,* 2006; UNEP, 2005). Entanglement, ingestion and ghost fishing are the other effects of litter in the marine environment.

2.8.1 Entanglement

Entanglement of marine wildlife - seabirds, sea turtles, dolphin's in nets, fishing lines, ropes and other debris- is particularly disturbing. It poses significant risk to marine animals.

The major effects of entanglement include;

i. Exhaustion that results in drowning;
ii. Lacerations from the abrasive or cutting action by attached debris; this leads to infections and loss of limbs of marine organisms.
iii. Impairment of mobility to a point where marine animals can no longer catch food or avoid predators.
iv. Death caused by strangulation of suffocation. (US EPA, 2007; Allsop *et al.,* 2006; Derraik, 2002).

Focusing on plastic litter in Chilika lagoon, Singh *et al.* (2013) have reported that entanglement incidences also occurs in lagoons as according to them the connection of the Chilika lagoon with the Bay of Bengal located close to the Olive Ridley serves as an important nesting ground for sea turtles and that during the migration and stay periods of the turtles in the coastal waters they are often entangled in nets and die due to drowning.

2.8.2 Ingestion

Ingestion of marine litter mainly plastic items occurs in marine bird species, leatherback turtles and other marine animals; these accidental ingestions of plastic litter by wildlife can have devastating impacts on ecologically sensitive (McCauly and Bjorndal, 1999). Although such items can be accidentally ingested, it is thought that ingestion of marine debris occurs mainly because these animals confuse debris for food and directly target and consume them. In some instances the debris may pass through the gut without harming the animal, but in other cases it can become lodged in their throats or digestive tracts (US EPA 2012).

Plate 2.2: Plastic litter in the remains of a dead bird.

Source: Guern Lytle (2010).

In addition, debris can accumulate in the gut and give a false sense of fullness, causing the animal to stop eating and slowly starve to death (Sheavly, 2005). Ingestion of sharp objects can damage the gut of marine animals and may result in infection, pain or death (Allsop *et al.*, 2006). Singh *et al.*, (2013) have indicated that in their migration from the Chilika Lagoon into the Bay of Bengal sea turtles also ingest plastic litter that enters the coastal waters often leading to death of the turtles. Indeed, there are significant proportion of marine animals with documented reports of ingestion and entanglement as tabulated by Laist (1997) and presented in table 2.2 below.

Table 2.2: Number and percentage of marine species worldwide with documented marine debris entanglement and ingestion records by species group.

Species Group	Total number of species worldwide	Number and percentage of species with entanglement records.	Number and percentage of species with ingestion records
Sea turtles	7	6 (86%)	6 (86%)
Seabirds	312	51 (16%)	111 (36%)
Penguins	16	6 (38%)	1 (6%)
Grebes	19	2 (10%)	0
Albatrosses, petrels, shearwaters	99	10 (10%)	62 (63%)
Pelicans, boobies, gannets, cormorants, frigatebirds, tropicbirds	51	11 (22%)	8 (16%)
Shorebirds, skuas, gulls, terns, auks	122	22 (18%)	40 (33%)
Other birds	-	5	0
Marine mammals	115	32 (28%)	26 (23%)
Baleen whales	10	6 (6%)	2(20%)
Toothed whales	65	5 (8%)	21 (32%)
Fur seal lion	14	11 (79%)	1 (7%)
True seals	19	8 (42%)	1 (5%)
Manatees and dugongs	4	1 (25%)	1 (25%)
Sea otter	1	1 (100%)	0
Fish	-	34	33
Crustaceans	-	8	0
Squid	-	0	1
Species Total	136	136	177

Source: Laist, (1997). (-) no record.

2.8.3 Ghost fishing

Derelict fishing gear including traps, pots and nets can continue to fish for long periods of time after it had been abandoned in the marine environment - a situation referred to as "ghost fishing". The catching efficiency of ghost fishing is highly dependent on the environmental conditions but a single net has been shown to continue fishing for decades (Mouat *et al.,* 2010). Allsop *et al.,* (2006) have explained this environmental condition in relation to where in the ocean the fishing gear is lost or abandoned. They emphasis that it is nets lost in calm waters near oceanic convergence zones that will continue to fish for decades but those lost in areas of larges swell and storm activity may rapidly tear apart and get destroyed.

The indiscriminate nature of ghost fishing means that this affects a diverse range of species including seabirds, seals and crustaceans as well as commercially important and non - target fish species (Macfadyen *et al.,* 2009). Indeed, ghost nets have been described as perpetual "killing machines" that never stops fishing (Sheavly, 2005). Discarded and lost fishing nets also continue to trap and catch fishes and other valuable species in wetlands. In the Chilika Lagoon, instances of fish and shellfish trappings in damaged and discarded nets have been reported (Singh *et al.,* 2013). Ghost fishing also referred to as abandoned, lost or otherwise discarded fishing gear (ALDFG) impacts on the viability of the already stressed fisheries worldwide (Sheavly, 2005). Thus, it undermines fisheries management and threatens marine life (STAP, 2011; OSPAR, 2009).

2.8.4 Loss of Aesthetic Value/Reduction of opportunities for recreation.

Many recreational activities such as swimming, diving, boating, recreational fishing and a wide variety of water sports are done on beaches, coasts and seas. The accumulation of

marine litter can have a strong deterrent effect and discourage recreational users from visiting polluted areas (Sheavly and Register, 2007). The selection of a particular location for a recreational activity depends on the personal preferences of the organizers, the purpose of activity and the litter load of the surrounding area (Mouat *et al.*, 2010).

2.8.5 Introduction of alien species

Biological invasion has mostly resulted due to the introduction of litter. Litter floating in the ocean not only serves as a convenient means of transport for certain marine species but also greatly increase the opportunity for the dispersal of marine organisms. The invasive barnacle species *Elminius modestus* was found on plastics on the shoreline of the Shetland Islands (Barnes and Milner, 2005). Again in the North Sea, modifications of the coastline and increased levels of marine litter may provide more favourable habitats for the settlement of the benthic life stages of jellyfish. The litter travels slowly and so gives the alien species more time to adjust to the changing environmental conditions (Mouat *et al.*, 2010; Allsop *et al.*, 2006). Thus marine debris poses as a more effective vector for the transport of alien species.

2.8.6 Navigational hazards

Derelict fishing gear does not only harm marine life, it also poses substantial damage to vessels and the shipping industry. Marine debris can present numerous safety risks for vessels as a result of entanglement of the propellers of vessels by discarded fishing gear such as nets, ropes and lines (Mouat *et al.*, 2010; Allsop *et al.*, 2006).

2.8.7 Injuries.

Discarded syringes, broken glasses, medical waste mainly contained in glass wares or rusty metal containers may cause injuries to users of the marine environment if they accidentally step on them (Cheshire *et al.,* 2009). Condoms and tampon applicators and the contents of medical containers can also cause significant water quality concerns that affect the health of swimmers, divers and other users of the marine environment (Mouat *et al.*, 2010).

2.8.8 Repellant to migratory birds

Marine litter can also pose significant threat to the perching of migratory birds. Both resident and migratory birds usually depend on the benthic organisms of coastal lagoons and lakes for their food. Marine litter chiefly made of plastic could affect the bird populations of wetlands. Carrier bags hanging on the mangrove tree branches produce a peculiar sound when the wind blows and this disturbs the foraging of migratory and resident birds in Pichavaram Mangrove area (Singh *et al.*, 2013)..

2.9 Marine Litter surveys in Ghana

Litter surveys so far conducted on the marine environment in Ghana include those done by Nunoo & Quayson (2003), which looked at marine litter on two beaches (Sakumono and Centre for national culture (CNC) beaches) in Accra as well as that carried out by Tsagbey *et al.,* (2009) which also focused on the La pleasure and Korle Gonno beaches also in Accra.

Whereas the first study investigated marine litter accumulation of those two beaches over a two months period (between April and May) and focused on assessing the types and

quantities of litter to determine the rate of accumulation, the second concentrated on comparing the litter accumulation on the selected beaches over a two-week festive period (between December, 26, 2006 and January, 9, 2007) and investigated the degree to which human pressure at the two beaches, which serve different social communities, contributes to beach degradation.

Nunoo & Quayson (2003) found that 7 of the 22 individual items identified belonged to the world's famous 'dirty dozen' and that though the litter load at both beaches were high but changed weekly, the litter load at the CNC were higher than those counted at the Sakumono beach whereas Tsagbey *et al.*, (2009) also found that six of the thirty two litter items identified were part of the list of the world's dirty dozen and that there were significant variation in the litter load between the festive and non-festive seasons only at the Korle beach, due to the high patronage of the beach during the festive season while at the La pleasure beach, the variation was not significant between seasons as the beach serves as a popular social centre for the community and the many hotels surrounded it. Both studies revealed again that plastics dominated the overall litter collected.

A more recent study that assessed marine litter and water quality along the Accra - Tema coastline over a period of sixteen weeks focused on four beaches and also found among other things that nine of the fifty one litter items identified to belong to the worlds 'dirty dozen' list and also confirmed the dominance of plastic litter on the beaches along the Accra Tema coastline of Ghana (Himans, 2013).

In contrast to beach litter assessments conducted in Ghana no work has been carried out on the assessment of litter on the banks of lagoons along the coastline of Ghana.

Meanwhile, lagoons serve as integral part of the coastal environment and the holding capacity for runoff carrying debris from unmanaged refuse dumpsites and poorly managed solid wastes from municipalities across Ghana.

2.10 Legislation / Regulatory Instruments on the management of marine litter

The management of litter in marine environment has necessitated the formulation of both legal and technical measures worldwide. It has involved multiple stakeholders in many different countries of the world and has become an issue of discussion in many international conferences on environmental sustainability. Parties to these conferences have been encouraged to formulate local legislative instruments to address the problems of environmental pollution in their respective countries.

The deleterious effects of marine litter have attracted the attention of all well meaning naturalists particularly various environmentalist groups. The growing concerns for the conservation of the marine environment and its ecosystems have resulted in a number of measures both international and national. These measures aimed at prohibiting the disposal of litter at sea or on land where it can easily enter the ocean.

The Global Initiative on Marine Litter created by UNEP's Regional Seas Programme and the Coordinating Office for the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA) in 2003 for instance is intended for the management of the marine debris problem through partnerships, cooperative arrangements and joint activities (Butterworth *et al.*, 2012).

2.10.1 UNCLOS

The legal framework that addresses marine debris is provided by the United Nations Convention on the law of the Sea (UNCLOS) which entered into force in 1994 and called for the protection of the entire marine environment from all sources and types of marine pollution including litter in the marine environment.

Aside the Global Initiative Programmes by the UNEP, there are multiple global legal instruments as well as voluntary agreement also aimed at managing and preventing the litter problem both on land and at Sea. UNCLOS does not directly address the issue of terrestrial waste reduction except for article 207 which calls on states to pass National legislation to combat pollution from rivers estuaries, lagoons and pipelines. UNCLOS comprises 320 articles and 9 annexes; it addresses issues of delimitation, environmental control, marine scientific research, economic and commercial activities and the transfer of technology and the settlement of disputes relating to the ocean.

The part of the convention that protects and preserves the marine environment and so relevant to the litter in the marine environment including lagoons is captured in part XII in articles 192-237. These articles relates to the basic obligation on state to prevent reduce and control pollution from land based sources, including pollution from sea-bed activities subject to specific national jurisdiction, pollution from activities in the special area; pollution from dumping from vessels as well as pollution from atmospheric sources.

2.10.2 MARPOL 73/78.

Another piece of legislation that controls and prevents pollution and litter that enters the marine environment from ocean-based sources is the International Convention for the

Prevention of Pollution from Ships 1973; it was modified by the protocol of 1978, and so has been generally known as MARPOL 73/78. It has six annexes and covers different types of pollution as illustrated in table 2.3.

Table 2.3:Types of pollution covered by the annexes of MARPOL 73/78

ANNEX	SPECIFIC TYPE OF POLLUTION DEALT WITH BY THE ANNEX
ANNEX I	Oil
ANNEX II	Noxious substances in bulk
ANNEX III	Harmful substances in packaged form.
ANNEX IV	Sewage
ANNEX V	Garbage (that may become marine litter)
ANNEX VI	Air pollution from ships.

Source: Ball (1999).

Although annex V is optional, it has been ratified by 116 countries and is one that deals with the different types of garbage and specifies the distances from land where the disposal of garbage may occur. Under annex V as with other annexes certain sea areas are designated as special areas where the disposal of these annex V waste is much stricter than other areas falling outside of the special areas zones. The disposal of all plastics is prohibited throughout the world's oceans.

The convention obliges States to ensure the provision of adequate Port Reception Facilities in their Ports and Harbours for the management of all ship generated wastes that cannot be disposed of at sea (UNEP, 2005).

2.10.3 Agenda 21

Another comprehensive plan for global, national and local action by Organizations of theUnited Nations conference on environment and Development (UNCED) is the Agenda 21.Chapter 17 of the Agenda deals with the protection of the oceans, all kinds of seas andcoastal areas and the protection of their living resources while its chapter 18 deals with the management of freshwater bodies including lakes, lagoons and rivers. Chapter 21 also deals specifically with solid waste including all domestic refuse and non-hazardous waste such as commercial and institutional wastes, street sweepings and construction debris.

2.10.4 The Johannesburg Plan of Implementation

The Johannesburg Plan of Implementation is another international agreement adopted at the World Summit on Sustainable Development to address the prevention and minimisation of waste and the maximisation of reuse, recycling and use of environmentally friendly alternative materials in production so as to reduce the adverse effects of litter in the environment and to improve resource efficiency. Paragraph 33 addresses the pollution of the marine environment from shipping.

2.10.5 Current measures used for managing litter.

Globally, the major means of managing litter in the marine environment has been through retrieval methods. This is evident in the numerous beach cleanup programmes such as "keep America Beautiful (KAB)", "Keep Australia Beautiful (KAB)", " The big beach watch" organised regularly in the respective countries worldwide (OSPAR, 2009). The Korean government has invested in the retrieval programme and research projects as well as the revision of the marine environmental management act as a response to the marine litter problem (Hong *et al.*, 2014).

Ghana has also adopted retrieval of litter in major cities and the coastal environment through her monthly cleanup exercises dubbed the National Sanitation Day (NSD) backed by Zoom lion and Zoil companies who have been chiefly responsible for managing waste in the country. These removal programs and technical approaches have achieved some significant results in managing marine litter pollution.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter describes specific methods and procedures used in assessing the litter on the banks of some lagoons along the eastern coast of Ghana. It focuses on the description of the study area, the research approach and data collection techniques. It also describes the research design for the survey, the population and sampling techniques, data collection and analysis technique as well as statistical tools for data analysis.

3.1 Study Area

Ghana is a coastal state in the Western part of Africa and has a total surface area of 239,460 km. It is boarded to the North by Burkina Faso, the South by the Gulf of Guinea, the East by Togo and the West by Cote d'Ivoire.

UNEP (1999) has estimated that the coastline of Ghana stretches 550 km along the Gulf of Guinea from the East to the West. Ghana's EEZ - 200 nautical mile limit - comprises the coastal and marine zones as well as landward limits of coastline constituting over 50 lagoons, creeks, swamps, wetlands and their intervening rivers. Some of these lagoons are very small and are less than 1 km^2 of surface area while others are as large as 50 km^2 to 250 km^2 (UNEP, 1999).

This study was conducted in five lagoons located along the eastern coast of Ghana stretching from the Greater Accra Region to the Volta Region. Four of the sampling sites are located in the Greater Accra Region while one is located in the Volta Region. The four Lagoons located in the Greater Accra Region include the Kpeshie, Mukwei, Sakumo II

and the Gao while the one in the Volta region is the Kedzi part of the Keta Lagoon complex. The lagoons and sampling sites are shown in Figure 3.1.

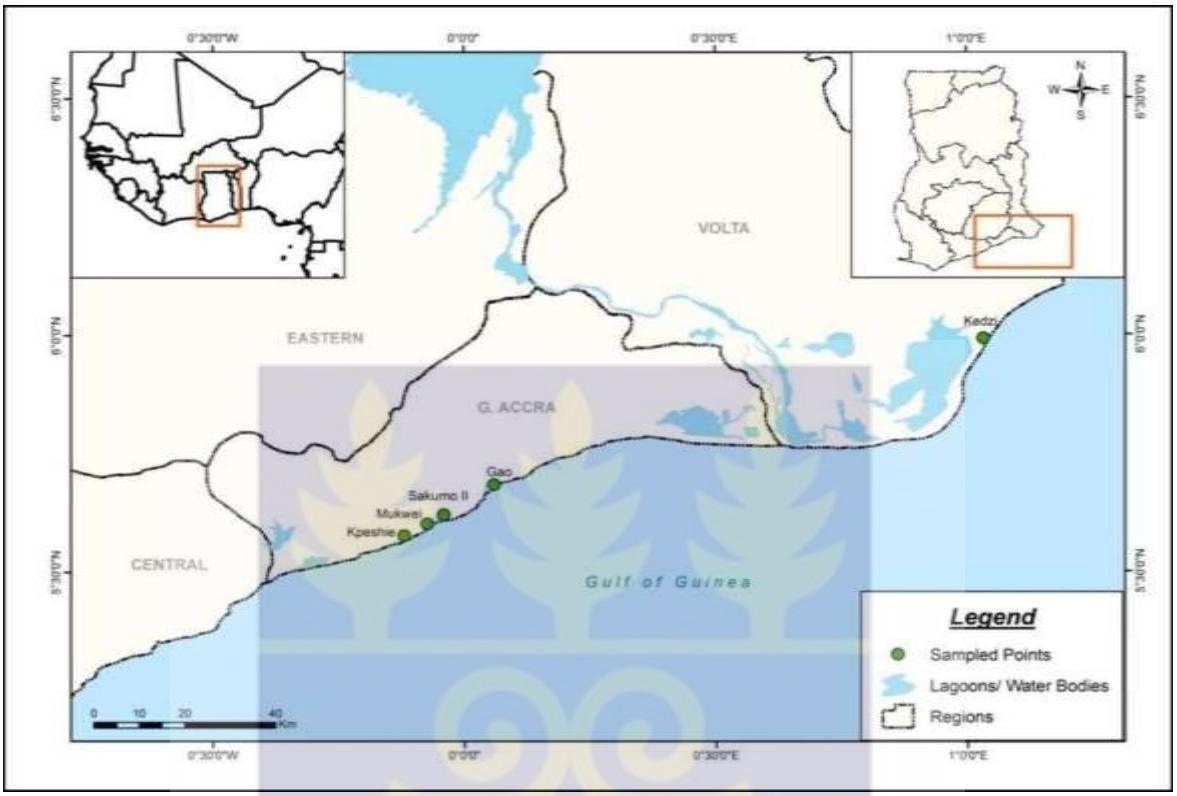


Figure 3.1: Map of study area showing sampling sites

The lagoons were selected based on their socio economic and ecological importance. All the lagoons are major fishing sites and a number of fishermen depend on them for fishing. They also serve as nursing grounds for fishes (Entsua-Mensah *et al.*, 2000).

The Sakumo II and the Keta lagoons, for instance, are designated as RAMSAR sites due to their ecological importance. The criteria used for selection of the lagoons were based on their easy accessibility, the availability of a minimum shoreline length of 100 m (Lippiatt *et al.*, 2013; Cheshire *et al.*, 2009) as well as their connection with the Sea. The following is a description of the five lagoons studied.

3.1.1 Kpeshie Lagoon

The Kpeshie Lagoon is located in the La Dade - Kotopong municipal Authority of theGreater Accra Region of Ghana. The district has an estimated population of 183,528 (Ghana Statistical Service, 2010) and well known for its fishery activities. It serves as a nursing ground for both marine and freshwater fisheries (Mensah, 1979). However, over the years the sources of freshwater flow into it from the Burma Camp and areas around Madina to its north as well as the Military Academy and Tsublewuto area to its East have been choked. The water sources from areas around the La Trade-fair Centre, the La Palm and La Beach Hotels have also been choked with refuse thereby reducing the inflow to the barest minimum.

Not only do the dwellers within the Kpeshie community discharge their domestic waste and effluent into the drains that empty into the lagoon, they have also threatened the real existence of the lagoon by directly filling the northern periphery with refuse on which they later put structures such as kiosks and even houses for rentals. The Lagoon therefore belongs to the "choked Lagoon" classification by Kjerfve and Magill (1989).

3.1.2 Mukwei Lagoon

The Mukwei Lagoon is a relatively small lagoon located within the Ledzokuku Krowor municipality in the Greater Accra Region. The district has an estimated population of 227,932 (Ghana Statistical Service, 2010). The Lagoon receives two main sources of freshwater from the Sakumono Estate to the east and Nungua township near the Regional Maritime University on the western side. The Lagoon is also connected to the sea by a narrow strip which opens up significantly during high tides and receives a lot of saline water from the sea. This, therefore occasionally increases both the surface area and depth

of the Lagoon. The fringes of the Lagoon are covered by mangroves that promote land accretion (Miththapala, 2013).

The contiguous beach on the left side of the Lagoon, popularly known as 'Mighty beach', serves as a recreational site for beachgoers as they normally recline during festive occasions and holidays. Due to its remoteness (to the main township of the Ledzokuku Krowor municipality), it also serves as spiritual grounds for worshippers. Fishing activities in the lagoon and the near shore are restricted to cast net and hook and line respectively. According to the classification by Kjerfve and Magill (1989), the Mukwei Lagoon can conveniently be categorised under the choked classification.

3.1.3 Sakumo II Lagoon

The Sakumo II Lagoon is one of the biggest lagoons located in the Tema Metropolis of the Greater Accra Region of Ghana the district has an estimated population of 292,773 (Ghana Statistical Service, 2010), it is situated between the Tema Township and Sakumono Estate. It is an "open lagoon" with a wide flood plain and fresh water marshes. During the dry season, it covers an area of about 1 km^2, however in the wet season; the entire flood plain may be so inundated that its surface area may increase significantly to about 10 km^2. It is reported to house about thirteen (13) fish species belonging to thirteen (13) genera and eight (8) families with *Sarotherodon melanotheron* (Black-Chin tilapia) constituting about 97 % of the fish population (Klake *et al.,* 2012). As a characteristic of wetlands, the lagoon is silted thereby reducing the water volume to minimum levels with the soft substrate (mud) forming its bulk volume.

The Sakumo II Lagoon is separated from the sea by an eroding sand bar on which the Accra-Tema coastal road is built. This lagoon belongs to the closed classification by Kjerfve and Magill (1989) as it opens into the sea through a culvert beneath the road which acts as an artificial conduit point. It is one of five RAMSAR sites located in Ghana and has been home to many bird species that groom and roost in the marshes. The catchment area of the flood plains is drained by a number of streams which flow into the brackish water of the lagoon.

Four principal sub-drainage basins have been identified in the area. The major ones are the Mamahuma-Onukpawohe on the western side and the Dzorwulu-Gbagbla-Ankonu on the northern side. The drainages from the Tema General Hospital and Tema Community 3 constitute minor drainages that flow into the lagoon on the eastern side.

3.1.4 The Gao Lagoon

The Gao lagoon on the other hand is located in the Kpone Katamanso municipal Authority with an estimated population of 109,864(Ghana Statistical Service, 2010). It is relatively bigger than the Mukwei lagoon and lies between the Tema New-Township and Kpone townships. It is also an open lagoon and by observation, it is highly influenced by tidal regimes. It receives freshwater inflow from the Tema Free zone port at its northern part and storm flood water from the eastern side along the West African Gas Pipeline exit as well as the area around the Volta Aluminium Company (VALCO).

The riparian vegetation along the entire periphery of the lagoon (except the sand bar between the sea and the lagoon) are also dominated by mangroves. The sand bar between the sea and the lagoon which is bridged at the western corner to the sea serves as sandy

beach for beach attendants in and around the Kpone community. A popular example is the 'Paradise Beach'. The southern part of the lagoon is shallow and entirely exposed during low tides while the northern part is relatively deep and remains inundated at all times.

3.1.5 Keta Lagoon complex

The Keta Lagoon complex which is the biggest lagoon in the West African sub-region is designated as a RAMSAR site. The Kedzi portion of the lagoon which is located at the eastern corner of the Ketu-South District of the Volta Region and has an estimated population of 160,756 was the sampling site (Ghana Statistical Service, 2010). The lagoon has no direct connection with the sea and is relatively deeper at the Kedzi end due to the dredging of the lagoon for both beach nourishment and the construction of an artificial island during the Keta Sea Defence project. There is an all year round fishing activity in the lagoon and different fishing gears and methods are deployed. Notable among the fishing gears are bottle traps (Tekali) employed by women and cast net, gill net, drag net and rope fishing which are used by the indigenes (Entsua-Mensah *et al.*, 2000).

3.2 Research approach

Both quantitative and qualitative approaches were used to achieve the objectives of the study. Quantitative assessment of litter was carried out using the protocols of OSPAR (2007) and MCS (2009). The protocols have been extremely used in national Beach Watch and monitory programmes.

Litter was manually collected from a 5000 m^2 transect (i.e. 50 m x 100 m) demarcated at the banks of each lagoon and extended to cover both the low and high water marks up to

the tip (of the vegetative cover where possible) of each of the selected lagoons as shown in plate 3 below.

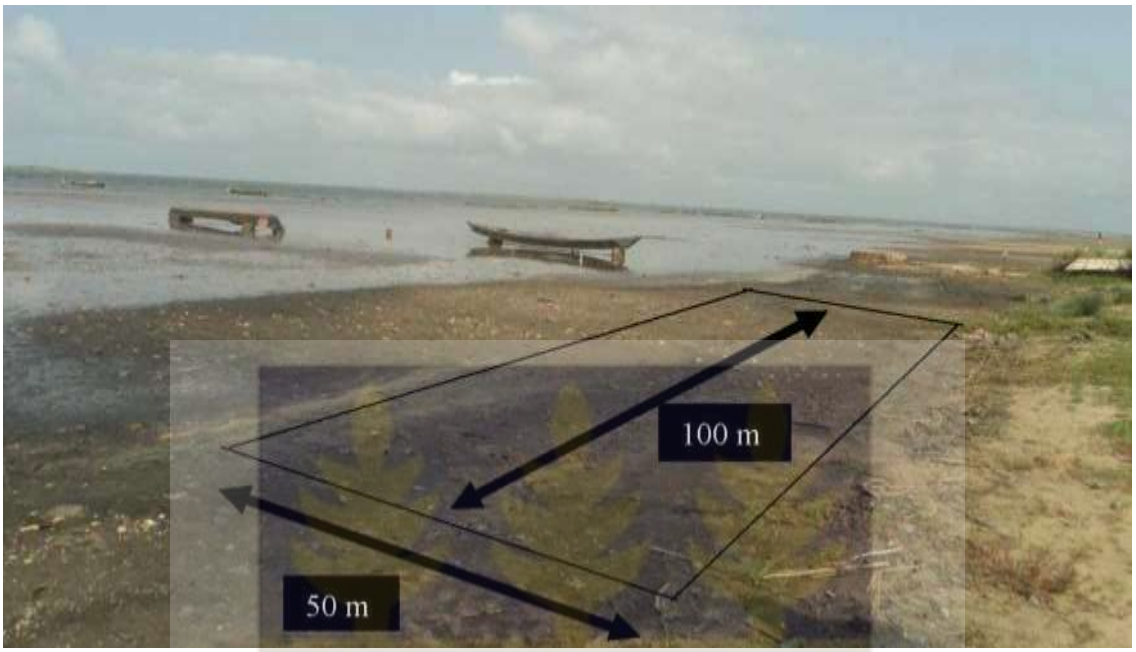


Plate 3.1: Schematic representation of the 5000 m^2 transect at the Kedzi sampling site.
Photo Credit: Quarshie J.T (2014).

3.3 Mode of litter collection

An average of 5 of the volunteers lined up at the 50m side of the transect with approximately 2 metre intervals between them and then slowly walked parallel to the lagoon water mark from that end the other end; in the process, they collect every litter on their course. The team then repeats the walking and collection pattern in a reversed direction to cover the other half of the 50 m transect. Natural debris such as algae and shells were however not included in the data gathering. All the debris collected was taken to a distance from the sample site for the rest of the team to sort, count and weigh them. The results recorded on a data sheet (Appendix 2) on-site for analysis. To avoid the possibility of double counting on subsequent visits, this team of volunteers burnt all collected litter after the counting and weighing. The litter collection pattern is illustrated with the Figure 3.2 below.

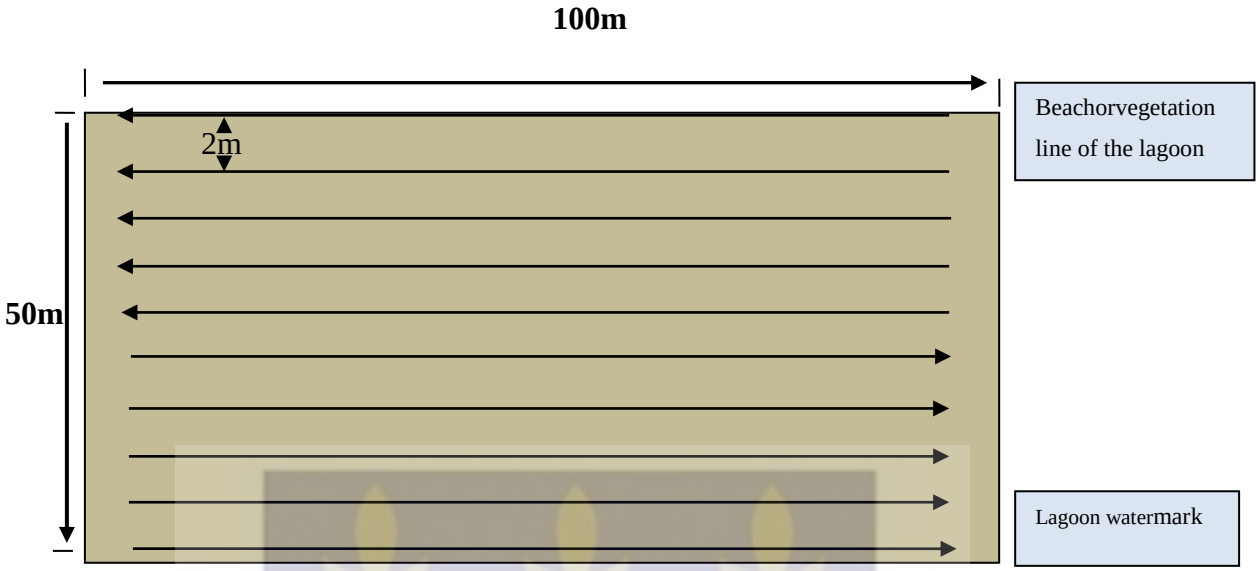


Figure 3.2: Walking pattern for the collection of litter on the bank of a lagoon. Modified after Sheavly (2007).

3.3.1 Instruments used in sampling lagoon litter.

The instruments used for the collection of data for the study included the following:

i. Electronic balance: There were two types of weighing instruments for weighing the litter. Heavier litter were weighed with spring balance that can read more than 5000 grams whiles lighter ones were weighed with the electronic beam balance that weighed less than 500 grams.

ii. Global Positioning System (GPS): This was used to take the coordinates of sampling site for the preparation of the map of the study area. It was also useful in assisting in locating the exact sampling site during subsequent visits. The sizes of thesampling units were also measured accurately with the GPS (Cheshire *et al.*, 2009).

iii. Measuring tape: This was used to check the dimensions of the rectangular transect from which the litter were to be collected to ensure that it is of the accurate dimension of 5000 m^2 as indicated in Plate 3.1 above.

iv. Digital camera: This was used to take images of the sampling units and used as a complement of the GPS in relocating the sample units at subsequent visits. The camera was also used to take some images for the illustrations in the main work.

3.3.2 Materials used in sampling lagoon litter.

i. Pair of rubber gloves: These were worn by volunteers for the picking of the litter within the transect. It was to protect the volunteers from pathogens.

ii. Polythene bags: These were supplied to each volunteer for carrying the collected litter to the sorting site.

iii. Nose masks: This was also provided to protect the volunteers from the stench around the lagoon.

iv. Data record sheet (Appendix 2) and pens: This aided in the recording of the counts and weight of the litter.

3.4 Research Design for the social survey

Qualitatively, the study was descriptive in nature and adopted descriptive research design to collect data. As Gay (1992) puts it; this design involves the collection of data to answer questions pertaining to the status of a topic under study and determines the way things are. Thus the design assisted in describing the perceptions of the public on the issue of litter accumulation in the lagoons. Polit and Hungler (1995) have also maintained that descriptive surveys aim at investigating the full nature of the phenomenon under study thus describing, observing and documenting aspects of a situation as it naturally occurs. It also seeks to explain people's perceptions, attitudes and behaviour based on data gathered at a point in time.

The descriptive survey design was therefore considered the most suitable research design for the social survey.

3.5 Target population and Sampling Technique

All users of the respective lagoons formed the target population of the study. Different People have different uses for the lagoons; whereas some people use them as places of worship, others use them for recreation, fishing, or trading and for relaxation purposes. Irrespective of the use a particular individual may have for a particular lagoon, it was expected that few people will be found around the lagoon to be interviewed at any moment.

The researcher therefore purposively selected four respondents from each of the five lagoons for each visit. Over the six month sampling period, this technique yielded a total of 120 respondents as the sampled size for the social survey. This enabled the researcher to gather adequate and relevant data for analysis. This sample size ultimately allowed generalizable conclusions to be drawn and inferences made from the data acquired.

3.6 Data collection instruments for social survey

A questionnaire (Appendix 1) was used to collect information from the respondents. This instrument aided the researcher to solicit information related to the issue of litter in the lagoons by asking both targeted and probing questions.

The schedule had spaces for recording relevant information and other salient points. The instrument was divided into two sections. Section A consisted of questions that sought answers concerning some aspects of the socio-demographic characteristics of respondents that have direct link to the litter issue in the respective lagoons. Section B was subdivided into three parts with each part soliciting for answers concerning their perceptions about the problem of litter in the respective lagoons.

Part I of this section consisted of seven questions (i.e questions 7 to 13) that bothered on the respondents beliefs about the presence of litter in the respective lagoons. It asked of the extent to which the particular lagoon was important to the respondent; the specific activity the respondents use the lagoons for; how frequent they visited it as well as their agreement or otherwise of some fundamental issues related to the lagoons. It specifically asked for the opinion of the respondents about the state of litter in the respective lagoons and about the rate of change in the litter load over time. Their views on the sources of the litter in the lagoons were also explored. The respondents were also asked to suggest some reasons why they think other people put litter in the lagoons.

Part II of the schedule also comprised seven questions that concerned the views of the respondents on their own actions and the effect those actions may have on the lagoons. It bothered on the type of litter they generate when they are around the lagoons and the disposal attitude for those litter.

Part III explored their views on the management regimes deployed of litter at the respective lagoons and their own efforts towards its management. It also sought to find out from the respondents whether they have suffered any kind of problem associated with the litter in the lagoons.

All in all, the entire questions were developed around the objective and the research question that sought to assess the public perception of the presence of the litter in the Coastal lagoons.

3.7 Data Processing and Analysis

The shore litter classification techniques by OSPAR (2009) was used to classify the litter collected into eight major categories such as plastics, metallic, fabric, paper, glass, plant materials, polystyrene and ropes/net and others. The data was also grouped under three broad categories such as 'diversity' (which refers to the respective types or kinds), 'abundance' (which referred to the quantity of each major category counted) and corresponding 'weights' (Tsagbey *et al.*, 2009; UNEP 2005; Coe & Rogers 1997).

Lagoon debris was also classified according to their sources as established by Marine Conservation Science (MCS's) survey format. In this format litter items were categorised according to their likely litter sources or as un-sourced in situations where they could not be clearly identified according to MCS procedure (Appendix 2). The source categorisation includes beach visitor litter, fishing, Sewage Related Debris (SRD), shipping, medical and non-source.

Results of the litter assessment obtained from the field were analysed using Microsoft Excel 2010 and Minitab 15.

Primer 6 was also used to conduct Cluster analysis on the plastic types identified from each sample site. Euclidean distance was used to generate the dendrogram and non-metric Multi-dimensional Scaling (MDS) to group the plastics litter into clusters. The purpose of this was to detect the special similarity for the groups of plastic types in relationship to abundance, occurrence and diversity across sites. For convenience interpretation of the result a 9.3 Euclidean distance of resemblance was chosen as a base mark.

Data for the social survey was also analysed with the Predictive Analytical Software (PAS).

CHAPTER FOUR

RESULTS

4.0 Introduction

This chapter presents data collected from the field for the assessment of litter on the banks of the lagoons. The presentation is in accordance with research objectives and questions. The thematic areas covered in this chapter includes data on the general monthly trend in litter distribution, the abundance of litter types, the variation of litter accumulation, the trend in litter diversity, analysis of plastic litter as the most dominant litter, multivariate cluster analysis of plastic litter groups, the similarity of plastic litter accumulation across sites and the analysis of the perception of respondents for the survey.

4.1 General monthly trend in litter distribution across sites

4.1.1 Kpeshie Lagoon

The total litter collected along the banks of the Kpeshie Lagoon varied widely between 22,167 and 1,634 in July and August respectively. The litter represent a total of eight litter categories according to OSPAR (2009) classification. The unclassified items were grouped under the "others" category. Plastic litter was the most predominant litter collected across the six months sampling period and registered as high as 20,255 (93.5 %) in July; 5,234 (42.8 %) in October; 3,816 (57.3 %) in November; 3,718 (61 %) in December, 3,438 (82.2 %) in September and lastly 1,235 (62.5 %) in August as indicated in "A" to "F" of Figure 4.1. Polystyrene litter category, however, represented the second most dominant solid waste collected and it recorded values ranging between 271 (13.7 %) in August and 5,073 (41.5 %) in October.

Processed wood (plant materials) category of litter was the third dominant litter observed and recorded values varying between 485 (11.1 %) in November and 67 (3.4 %) in August and. The next category of litter observed at the Kpeshie lagoon was the fabric. It represented between 502 (2.3 %) in July and 78 (1.6 %) of the total litter September and. Glass and metal were the fifth and sixth highest debris collected respectively. Glass items for instance recorded values ranging between 330 and 165 in September and July respectively while metallic objects also ranged between 280 and 55 again in September and August respectively. Paper, rope/net and litter categorised as "others" occurred in insignificant quantities except in August, September and December where they recorded a little over 20 (Figure 4.1 A to F).

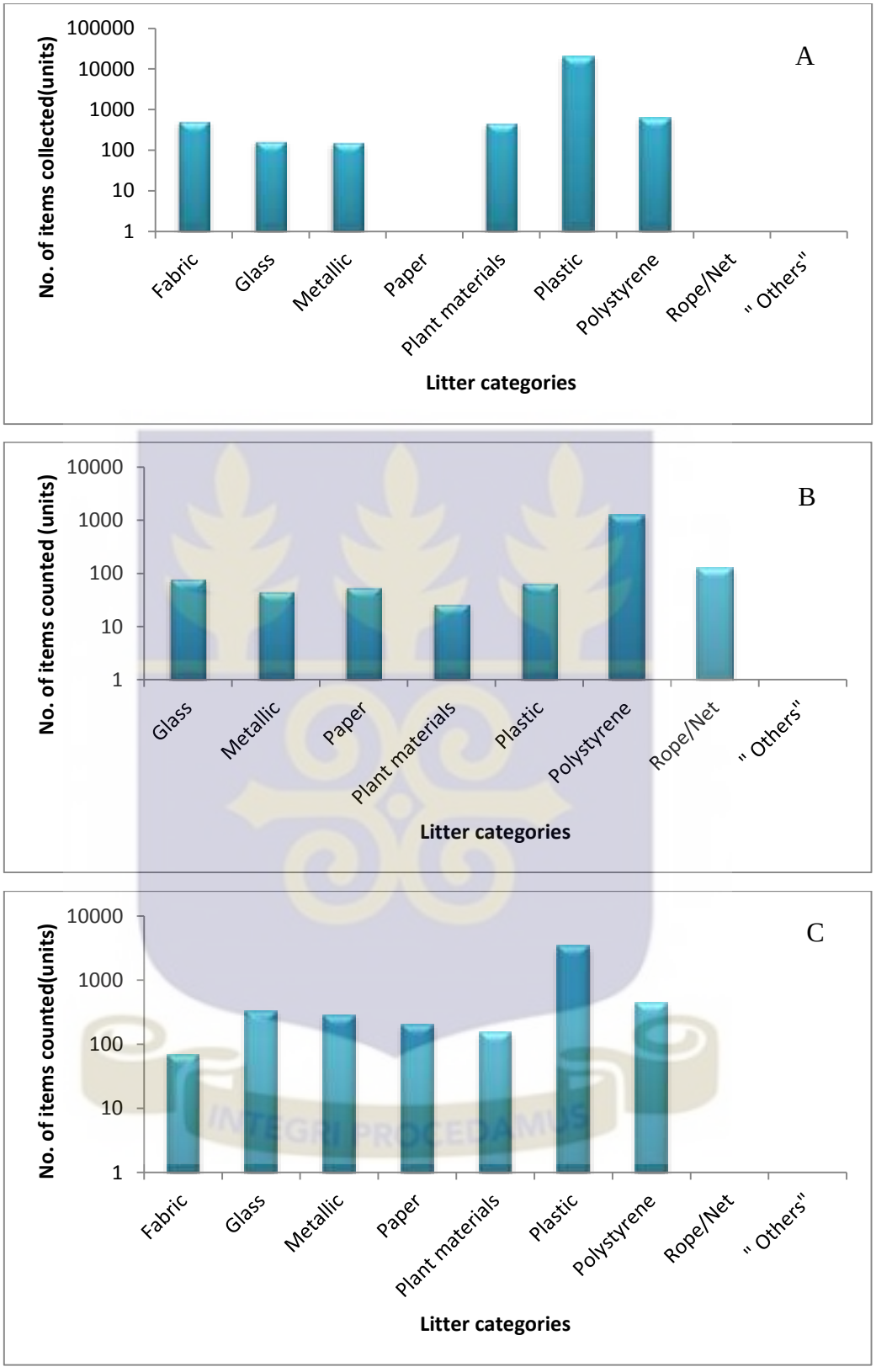
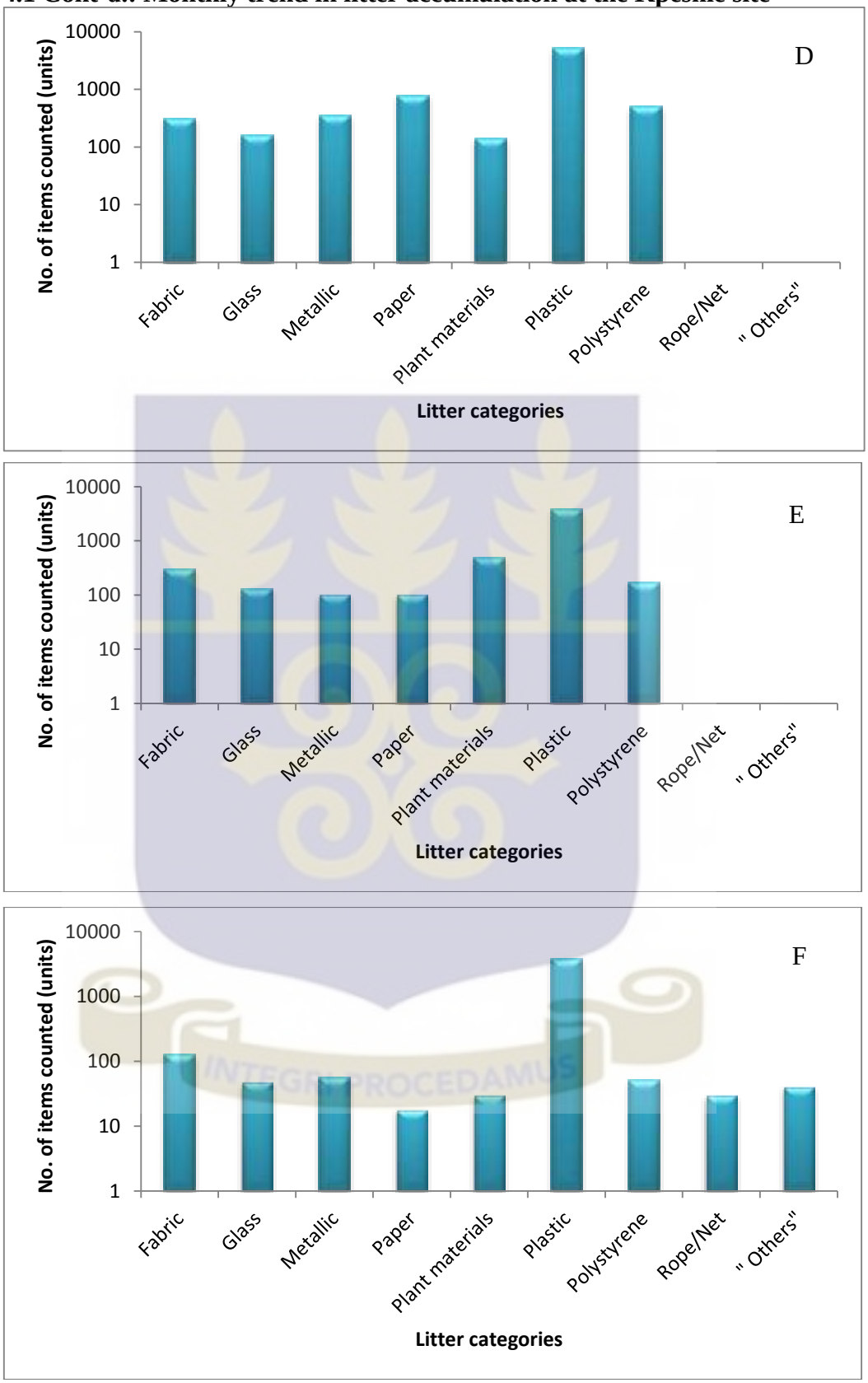


Figure 4.1: Monthly trend in litter accumulation at the Kpeshie site

(A) July, (B) August, (C) September.
Source: Field work, 2014.

Figure 4.1 Cont'd.: Monthly trend in litter accumulation at the Kpeshie site



(D) October (E) November and (F) December

Source: Field work, 2014.

4.1.2 Mukwei lagoon

Monthly litter abundance at the Mukwei lagoon also ranged between 1,381 in December and 5,524 in September. Again, the total litter observed represents eight identified litter categories according to OSPAR (2009) classification with the unclassified items group under the "others" category. Again plastic litter category was the most prevalent litter recognized and registered in all the sampling months. The count of plastics were 3,264 (79.4 %) in July, 2,860 (84.8 %) in August, 3,340 (60.4 %) in September, 1,790 (63.7 %) in October, 840 (48.2 %) in November and 1,200 (86.2 %) in December as shown in "A" to "E" of Figure 4.2. It was also observed again that polystyrene litter category formed the second highest litter collected and recorded values between 48 (2.5 %) in November and 975 (49.9 %) in September.

Processed wood (plant materials) litter category was also the third dominant litter counted at Mukwei lagoon and recorded values varying between 4 (0.3 %) in December and 431 (7.8 %) in September. Likewise, fabric litter category again was the fourth dominant litter recorded and represented between 60 (4.3 %) in December and 296 (5.4 %) in September as shown in "A" to "F" of Figure 4.1. Similarly glass and metal litter categories were the fifth and sixth most abundance debris observed respectively, glass objects for instance recorded values ranging between 26 (3.5 %) and 255 (34.5 %) in December and November respectively whereas metallic objects recorded also ranged between 11(0.3 %) and 245 (14.1 %) in December and November respectively. Paper litter, ropes/net and litter constituting the "others" category was detected in minimal counts of the overall litter counted in all the sites as shown in Figure 4.2 A to F.

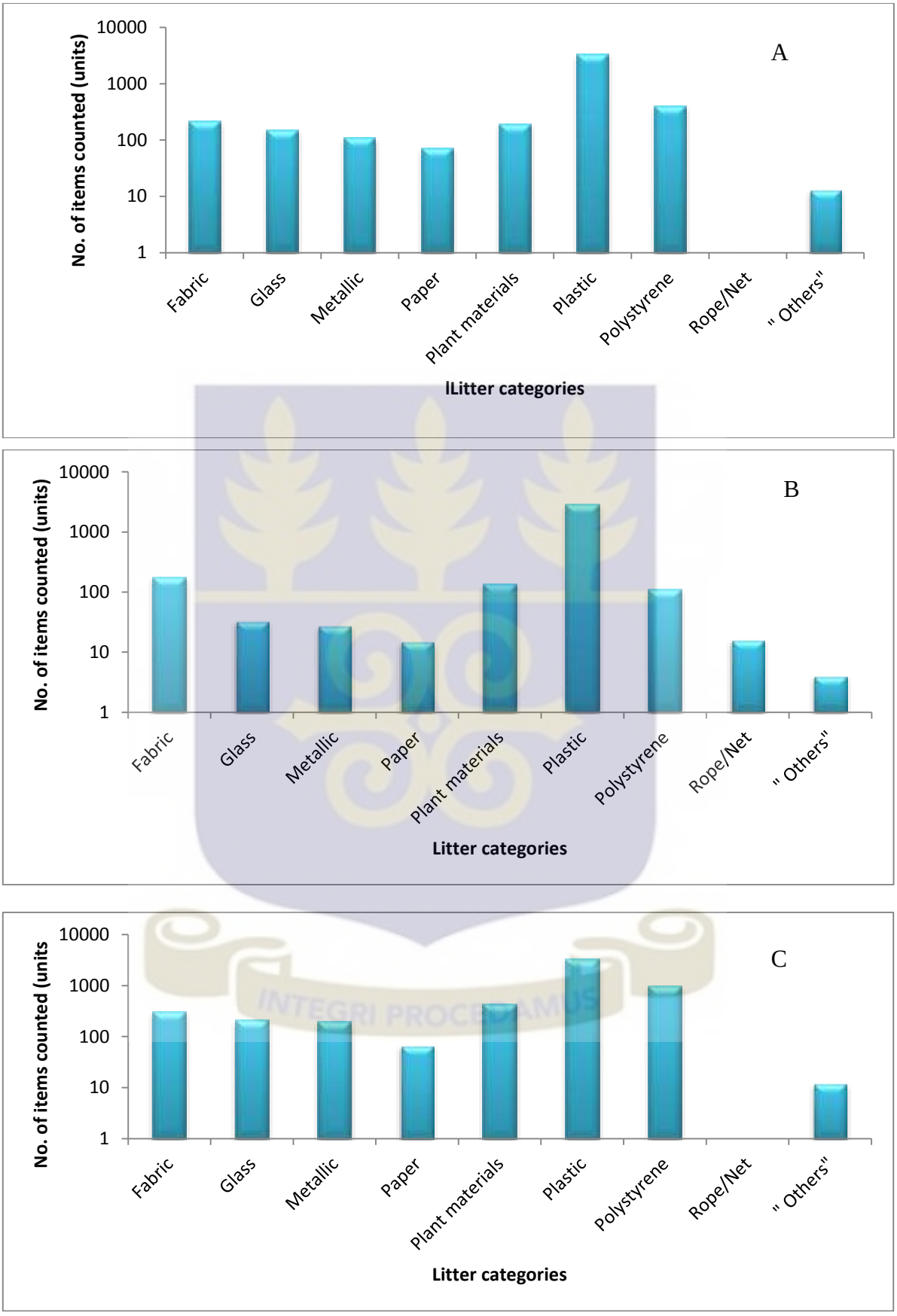
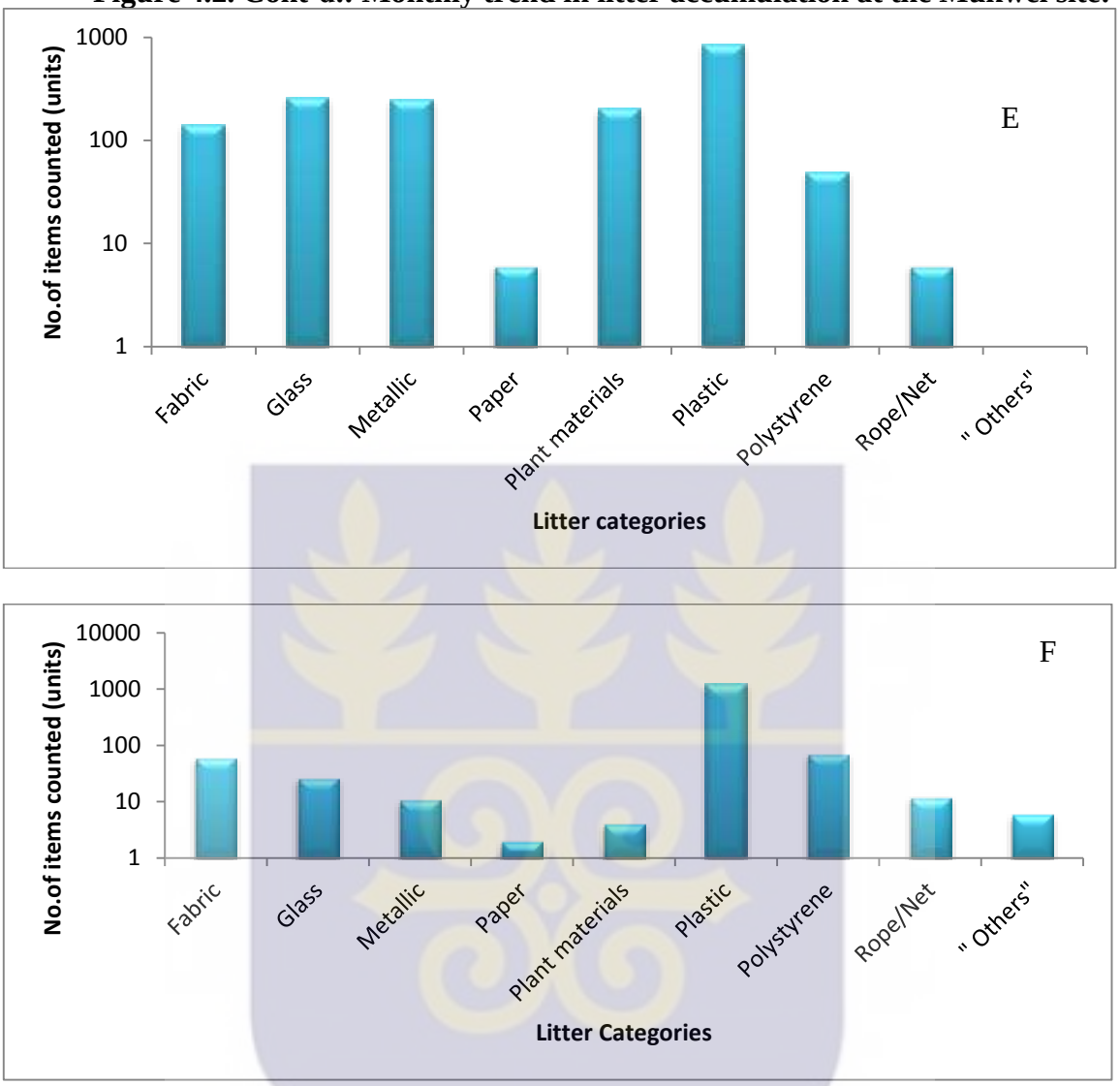


Figure 4.2: Monthly trend in litter accumulation at the Mukwei site: (A) July, (B) August, (C) September
Source: Field work, 2014.

Figure 4.2. Cont'd.: Monthly trend in litter accumulation at the Mukwei site:



(D) October (E) November and (F) December
Source: Field work, 2014.

4.1.3 Sakumo II lagoon

The total monthly litter collected at the bank of the Sakumo II lagoon ranged from 339 in August to 3,718 in November. As already indicated, sampling was not possible in October due to the flood incidence that made access to the sample site impossible. The sampling site was totally submerged under the flood water and all the litter were either carried away or submerged. Of all the nine categories of litter collected, plastic litter registered the most dominant litter category. The highest record of plastics 1,540 (77 %) occurred in September while the least was 260 (67.5 %) of in August. Thus plastic debris again formed

more than 60 % of the total litter recorded during most of the six months sampling period. Plastics litter counted in July, December, November and August for instance were 1,415 (71.7 %), 581 (66.5 %), 580 (16.6%) and 260 (76.7 %) respectively shown in Figure 4.3 'A' to 'F'. Fabric litter category was the second most dominant solid waste observed at the Sakumo II lagoon as compared to polystyrene category. The fabric litter recorded a maximum of 2,838 (76.3 %) in November and a minimum of 21 (6.2 %) in August while Polystyrene litter category was now the third highest litter observed and recorded 259 (13.1 %) in July and 8 (0.9 %) in December.

Metallic litter category was the fourth dominant and was only 11 in August and 100 in December. Processed wood (plant materials) litter category was next dominant solid waste observed and recorded values between 6 in August and 77 in July. The remaining litter categories such as the "others" group and glass recorded negligible values of the total litter counted as shown in "A" to "F" in Figure 4.3 below.

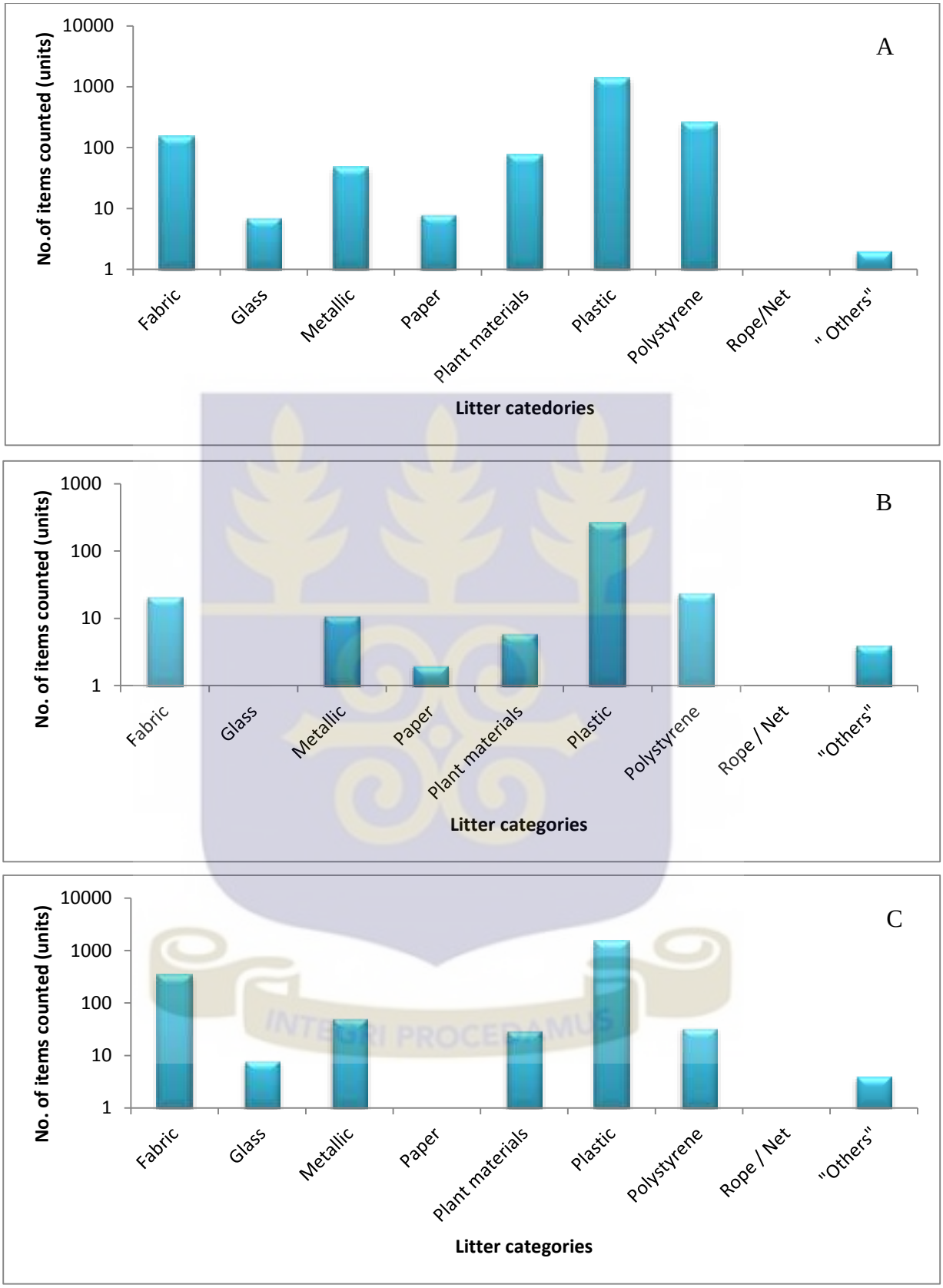
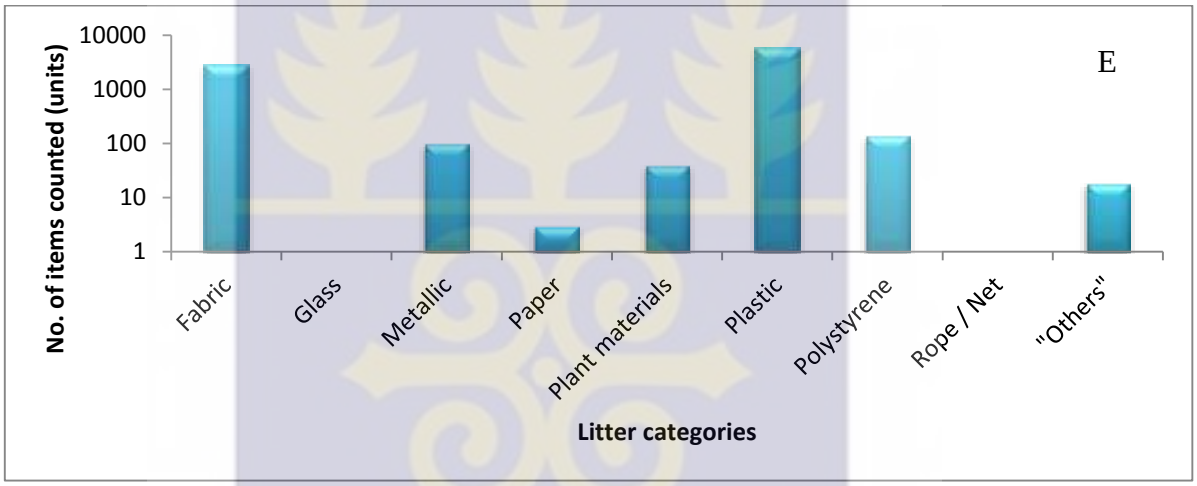
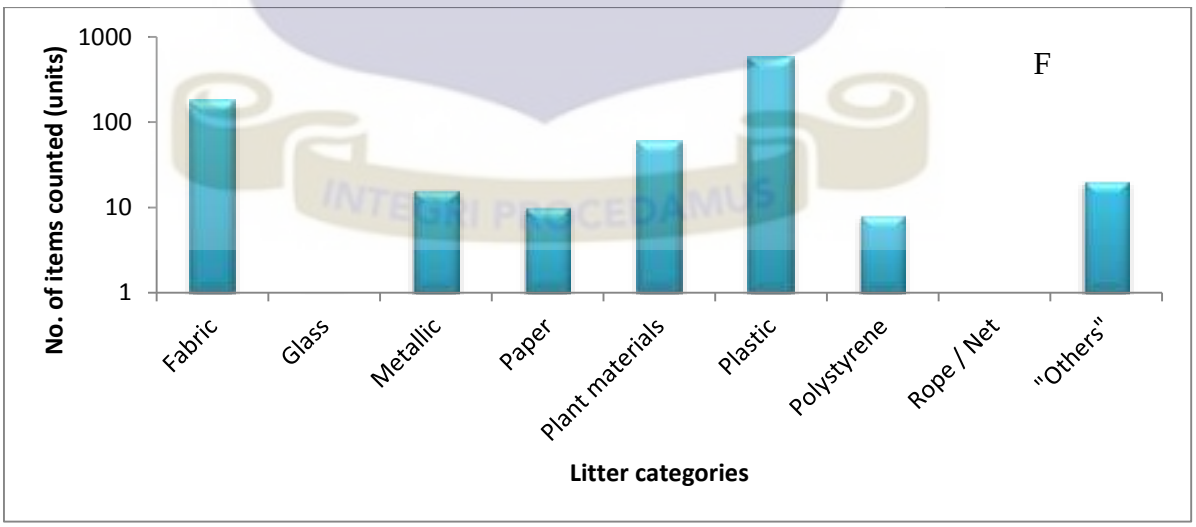


Figure 4.3: Monthly trend in litter accumulation at the Sakumo II Lagoon site (A) July, (B) August, (C) September
Source: Field work, 2014.

Figure 4.3 Cont'd.: Monthly trend in litter accumulation at the Sakumo II Lagoon site

D





(D) October, (E) November, (F) December
Source: Field work, 2014.

4.1.4 Gao lagoon

Of the overall litter collected from the bank of the Gao lagoon (ranging from a high of 5,415 in July and a low of 1,383 in October), plastic debris was again the most predominant litter type and formed close to 4,100 (76.7 %) in July, 2,900 (74.7 %) in August, 1000 (68.5 %) in September, 800 (57.4 %) in October, 2,100 (76.1 %) in November and 1,010 (67.6 %) in December. Polystyrene litter was the second highest litter recognized and recorded the least litter count of about 60 in October and the maximum of 990 in August as indicated in "A" to "F" of Figure 4.4 below.

Fabric litter was the third highest debris collected and ranged between 82 (5.8 %) in September and 704 (13.0 %) in July (Figure 4.4, 'C' & 'F'). Process wood (plant materials) litter category was also the third dominant litter counted at the Gao lagoon site and recorded values varying between 11 in December and 169 in September. The next highest litter category was metallic items followed by paper and litter constituting the "others" categories forming the fifth and sixth highest debris observed respectively. Rope/nets and glass litter categories were the least litter counted as shown in "A" to "F" of Figure 4.4.

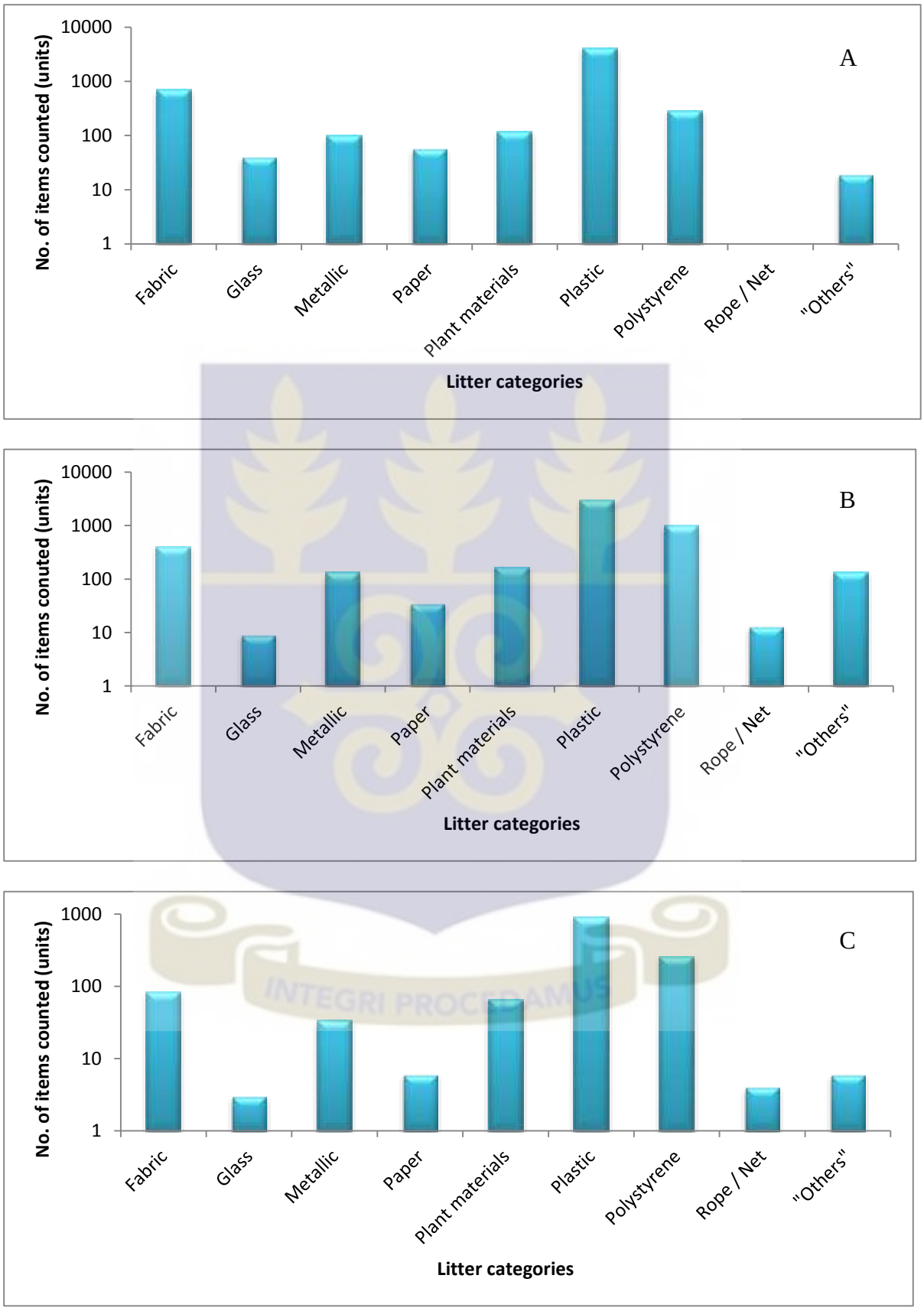
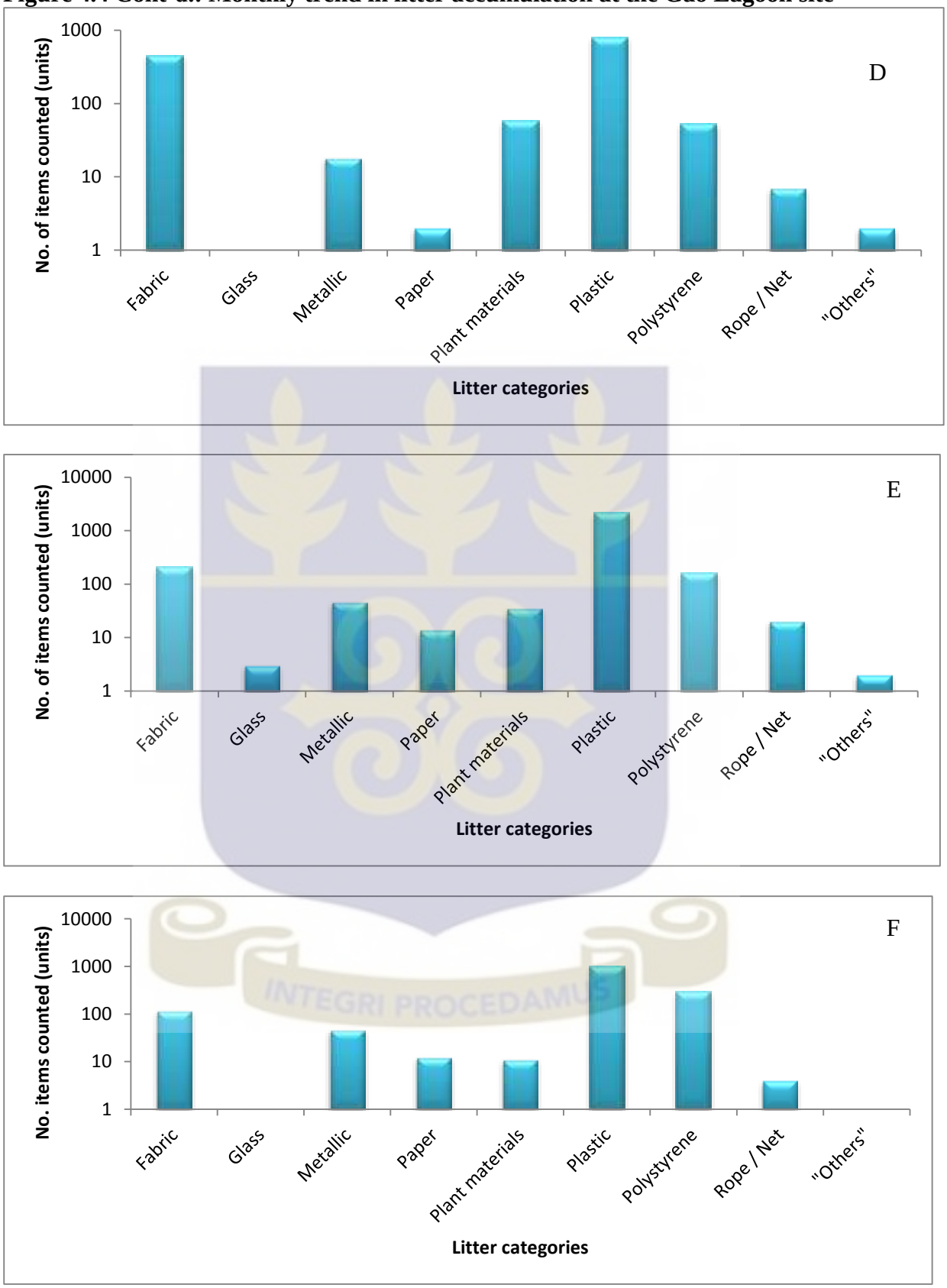


Figure 4.4: Monthly trend in litter accumulation at the Gao Lagoon site (A) July, (B) August, (C) September
Source: Field work, 2014.

Figure 4.4 Cont'd.: Monthly trend in litter accumulation at the Gao Lagoon site



(D) October (E) November and (F) December
Source: Field work, 2014.

4.1.5 Keta lagoon

The total monthly litter collected from the banks of the Kedzi portion of the Keta lagoon ranged between 610 and 1,572 in September and July respectively. The entire litter collected was dominated again by the plastic litter category and represented the most prevalent litter observed monthly. It formed a highest of 1,407 (89.5 %) in July and almost 800 (86.3 %), 700 (89.6 %), 600 (82.6%) and 520 (84.9 %) in August, October, November and September respectively with the least of a little over 400 (75.2 %) in December as shown in "A" to "F" in Figure 4.4. Glass litter category was the second highest litter counted at the Keta lagoon and ranged between 8 pieces in August and 68 pieces in December (Figure 4.4 'B' & 'E'). Rope/nets litter category was the third dominant debris registered followed by Process wood (plant materials), fabric and Polystyrene litter category. Paper, metallic objects and litter forming the "others" categories were quite few and accounted for less than 50 each of the total litter counted (Figure 4.4).

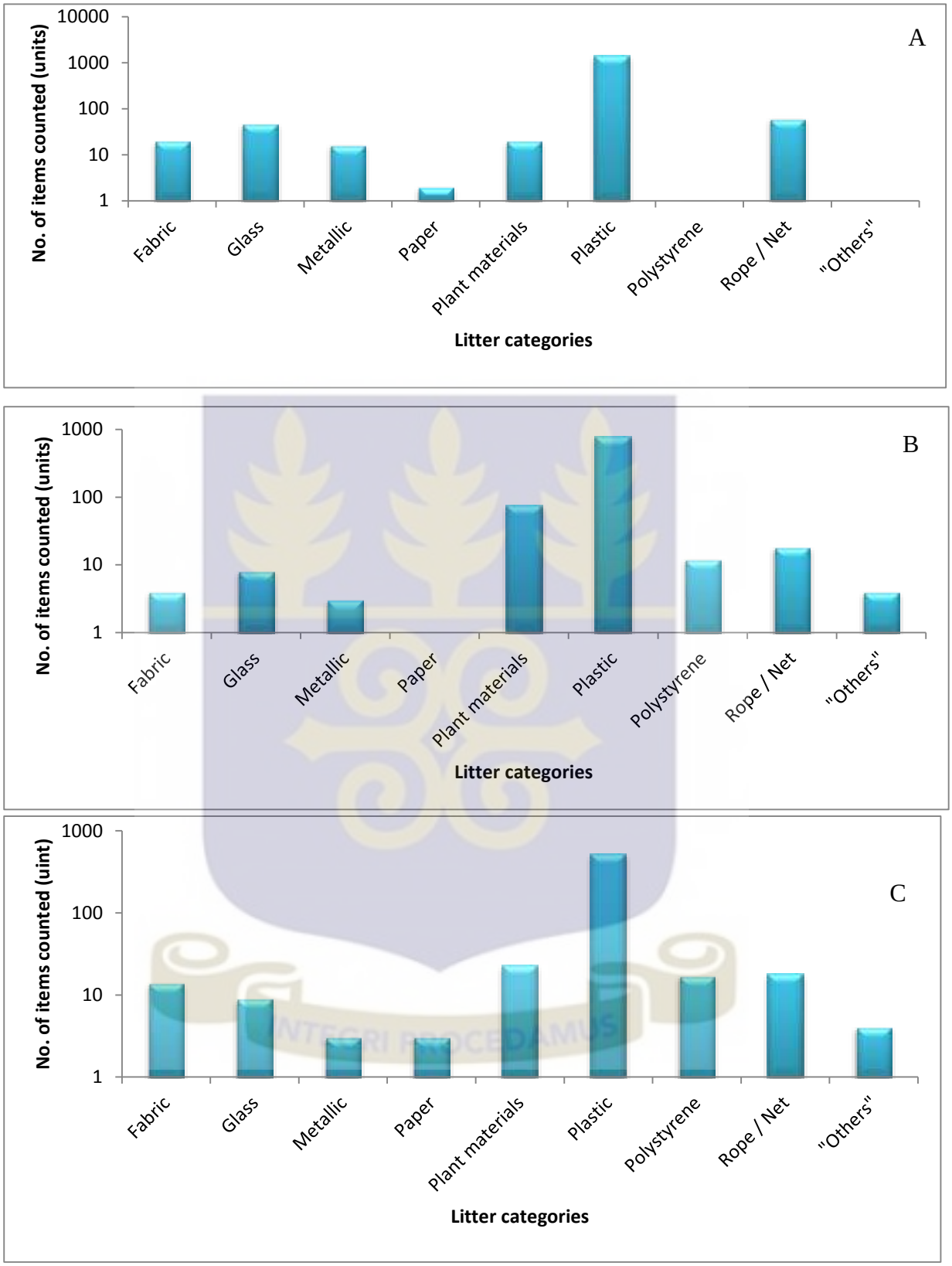
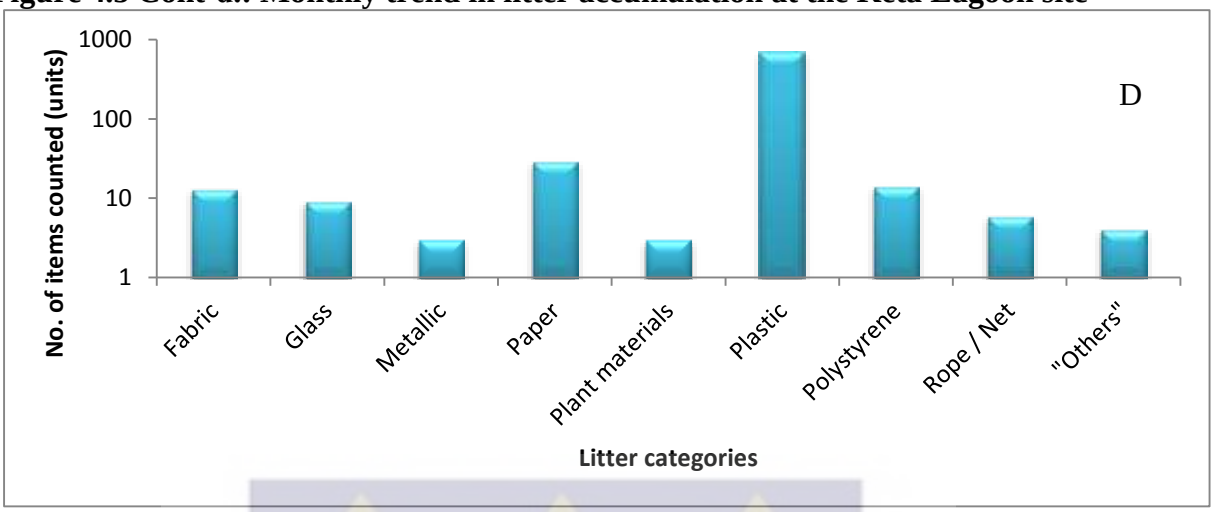
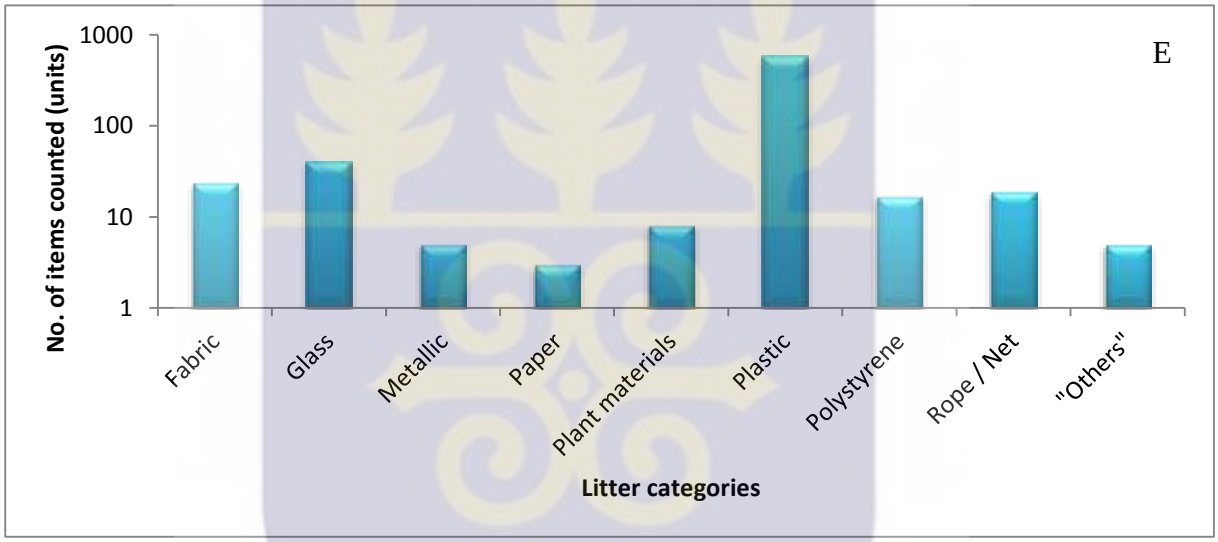


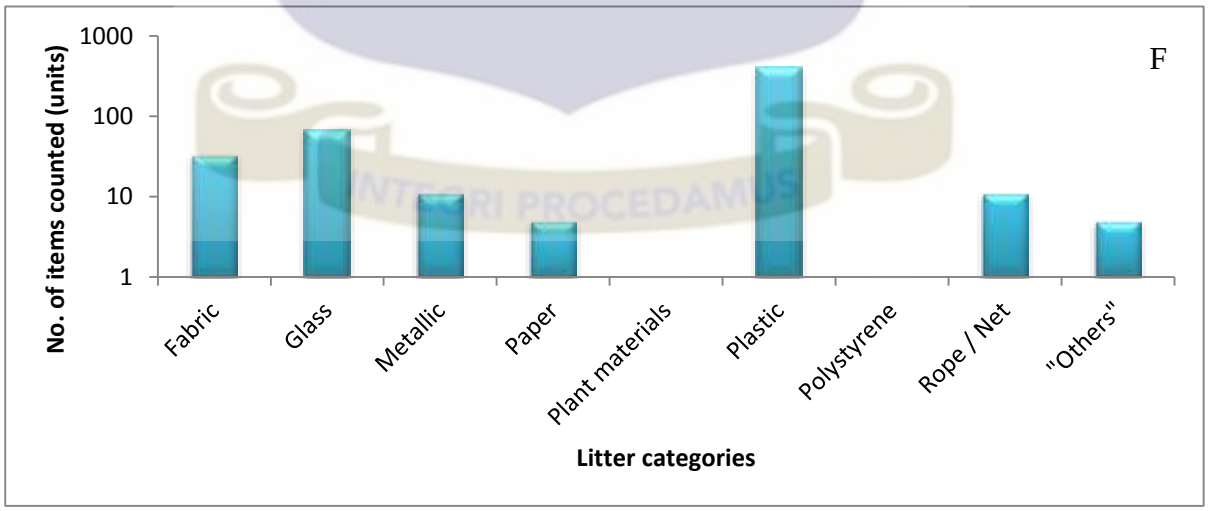
Figure 4.5: Monthly trend in litter accumulation at the Keta Lagoon site

(A) July, (B) August, (C) September
Source: Field work, 2014.

Figure 4.5 Cont'd.: Monthly trend in litter accumulation at the Keta Lagoon site







(D) October (E) November and (F) December
Source: Field work, 2014.

4.2 Abundance of litter types across sites

Other significantly dominant litter categories in most of the sites apart from plastics included fabrics (which constituted cloth pieces, underwear, hats and foot wears), glass litter several of which were broken alcoholic bottles, perfumes bottles and specimen bottles for laboratory investigations. There were few other bottles which were used to store medicines. Metallic objects were also quite significant in most of the sites and included aluminium can drink containers, tomato paste containers as well as other containers for fish and milk. Aerosol cans were also observed among the metallic litter categories. Paper debris was mostly mutilated cartons, pieces of news papers and cigarette boxes and were also quite many at few sites. A detail account of the litter categories observed across the five sites during the sampling period is discussed and demonstrated as below.

4.2.1 Fabrics

The highest count of fabric litter occurred at the Sakumo II lagoon followed by the Gao, Kpeshie and Mukwei lagoon. The least was however recorded on the banks of the Keta lagoon. The most abundant fabric litter recorded at the Sakumo II lagoon was in November and the least in July and December. There were however significant count of fabric in September. The Gao lagoon site recorded the next highest count of fabric litter after Sakumo II but was rather dominant in July and least in September. While the abundance of fabric was almost similar in August and October, there was a significant reduction in November and December on the bank of the Gao lagoon. The quantity of fabric counted at the Kpeshie lagoon formed the third highest and followed almost similar deposition rate as that of Gao; for instance, it was again highest in July and least in September with August, October and November recording almost similar abundance after which it decreased in December. At the Mukwei lagoon site, fabric items were highest in

September and least in December, there was however similar deposition rate in July, August and November but there was a significant decrease in October as shown in Figure 4.6 below.

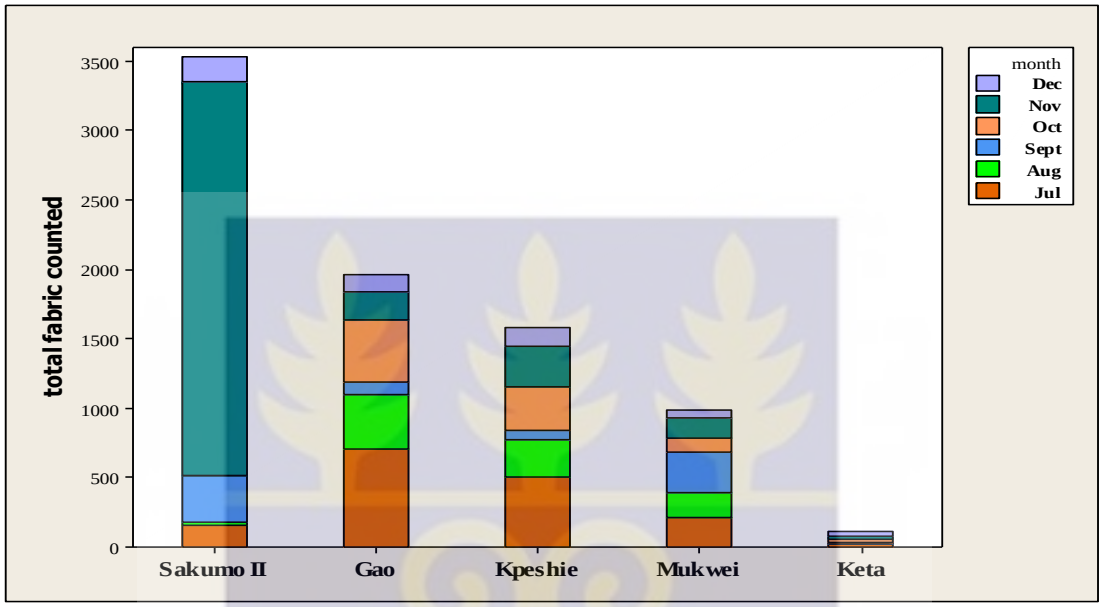


Figure 4.6: Monthly abundance of fabric litter across sites

Source: Field work, 2014.

4.2.2 Glass

The highest glass litter was recorded at the Mukwei lagoon followed by Kpeshie, Keta and Gao. Sakumo II lagoon however recorded the least glass litter accumulation over the sampling period. The highest glass deposition occurred in November and September with July, August and December registering similar quantities while October recorded the second highest glass litter. Glass litter recorded at the Kpeshie lagoon was highest in July but decreased significantly in August and September but had a substantial rise in October and November. It subsequently declined again in December. At the Keta lagoon, glass litter deposition was highest in December with July and November recording the next highest but similar quantities. There was however few quantities of glass in September

while August and October recorded the least but similar quantities. Gao lagoon registered the next highest litter deposition with Sakumo II lagoon recording the least glass litter. Of the least quantity of glass collected on the bank of the Gao lagoon, August recorded the highest while at the Sakumo II lagoon, July recorded the highest as shown in Figure 4.7.

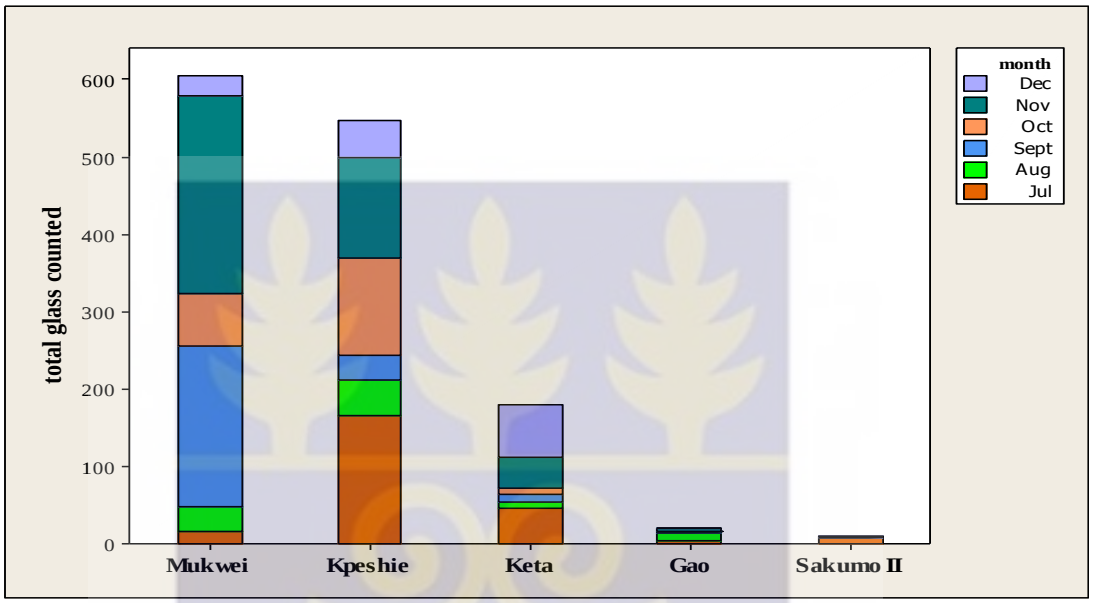


Figure 4.7: Monthly abundance of glass litter across sites
Source: Field work, 2014.

4.2.3 Metal

The highest metallic litter collected occurred at the Mukwei lagoon site. It however assumed a steady decline at the Kpeshie, Gao, Sakumo II and finally the Keta lagoons respectively. The highest count of metallic debris recorded at the Mukwei lagoon was in November whereas the least occurred in July and December respectively. September recorded the second dominant metallic debris but reduced significantly in October and further in July. At the Kpeshie lagoon July registered the highest metallic debris followed by November. Whiles August and December recorded the next highest but similar quantities of metallic objects, September and October recorded the least metallic litter deposition respectively. At the Gao lagoon, the highest metallic litter recorded occurred in August whiles the least was in October. Similar quantities of metallic litter were deposited

as the Gao lagoon site in November and December but was less in July and more fewer in September. Of the overall metallic litter recorded at the Sakumo II lagoon, November recorded the highest followed by July and September with December and August recording the least. There were fewer metallic objects observed at the Keta lagoon during the entire sampling period as compared with the other sites, however July and December registered some noticeable quantities as shown in Figure 4.8.

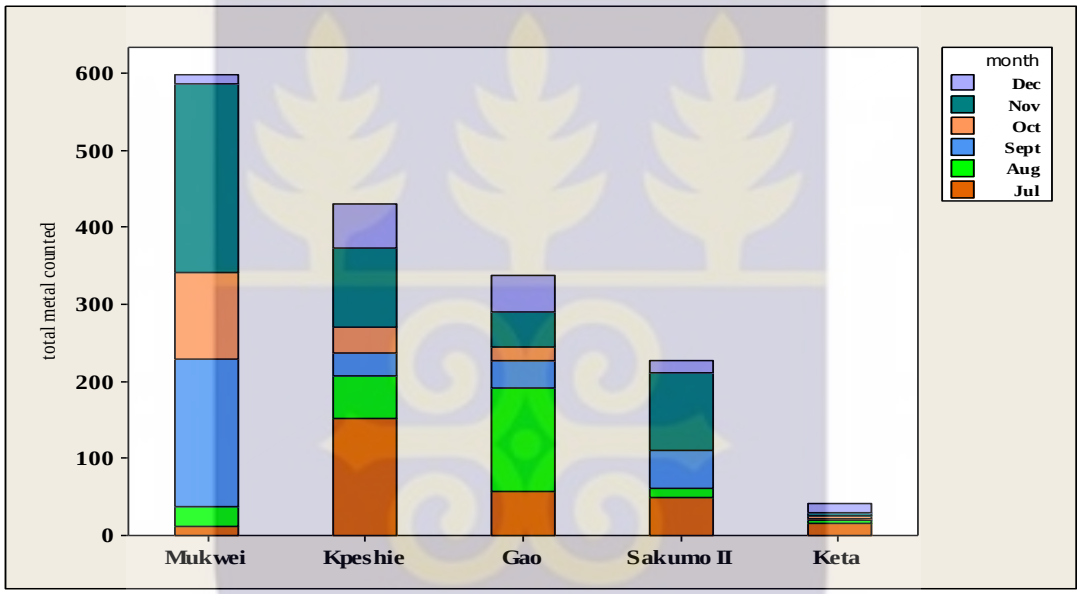


Figure 4.8: Monthly abundance of metallic litter across sites

Source: Field work, 2014.

4.2.4 Paper litter

Generally, paper debris was the second least litter collected from all the sites after rope/net category. Kpeshie lagoon recorded the highest paper litter whiles Mukwei and Gao recorded similar quantities respectively and represented the next highest paper litter. Paper debris was clearly absent at the Kpeshie site in July but highest in November followed by October and August and least in September and December. At the Mukwei lagoon, the highest paper litter occurred in September followed by October whereas the least was in

December and November. There were few paper debris recorded in July but it increased slightly in August as shown in Figure 4.9 below.

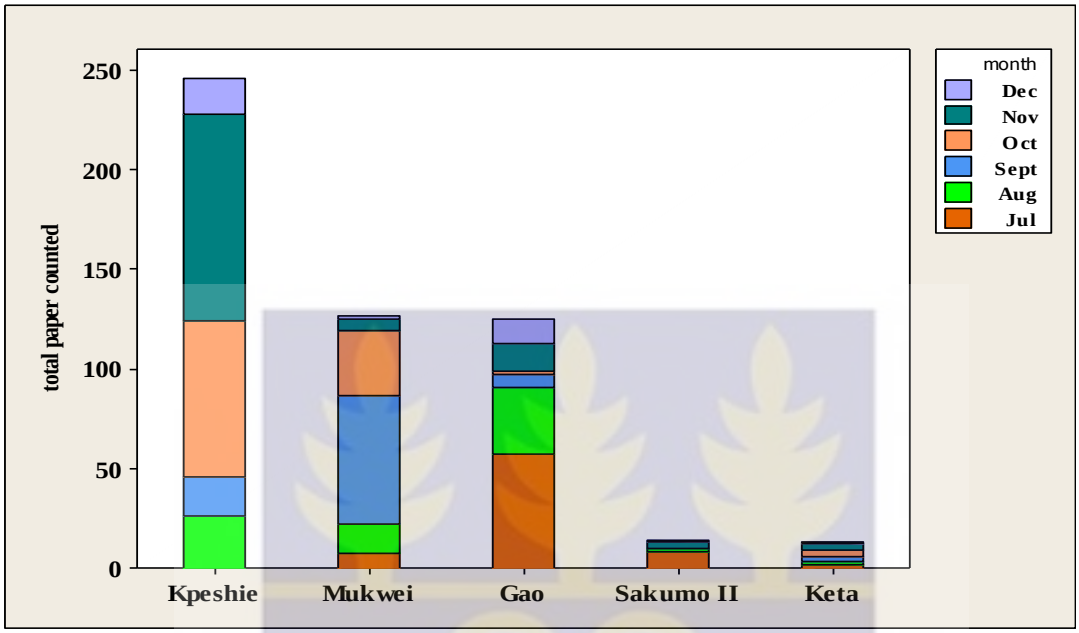


Figure 4.9: Monthly abundance of Paper litter across sites

Source: Field work, 2014.

4.2.5 Processed wood

Kpeshie lagoon again recorded the highest processed wood follow by Mukwei, Gao, Sakumo II and finally Keta. The accumulation of processed wood was quite significant in July at the Kpeshie lagoon site but declined significantly in August. It then increased slightly in September and further attained the highest in October. It then declined steadily in November and December. The processed wood debris accumulation patterns on the bank of the Mukwei lagoon was also quite significant in July but also declined slightly in August and increased significantly to attain the highest in September. It then declined again in October and then further in November. There was much fewer processed wood litter accumulation in July at the Gao and Sakumo II lagoons as compared to that of Mukwei and the Kpeshie sites. It also increased in August and then had similar decline in

the rest if the months. There were similar accumulation pattern of processed wood debris on the banks of Sakumo II and the Keta lagoons as shown in of the Figure 4.10 below.

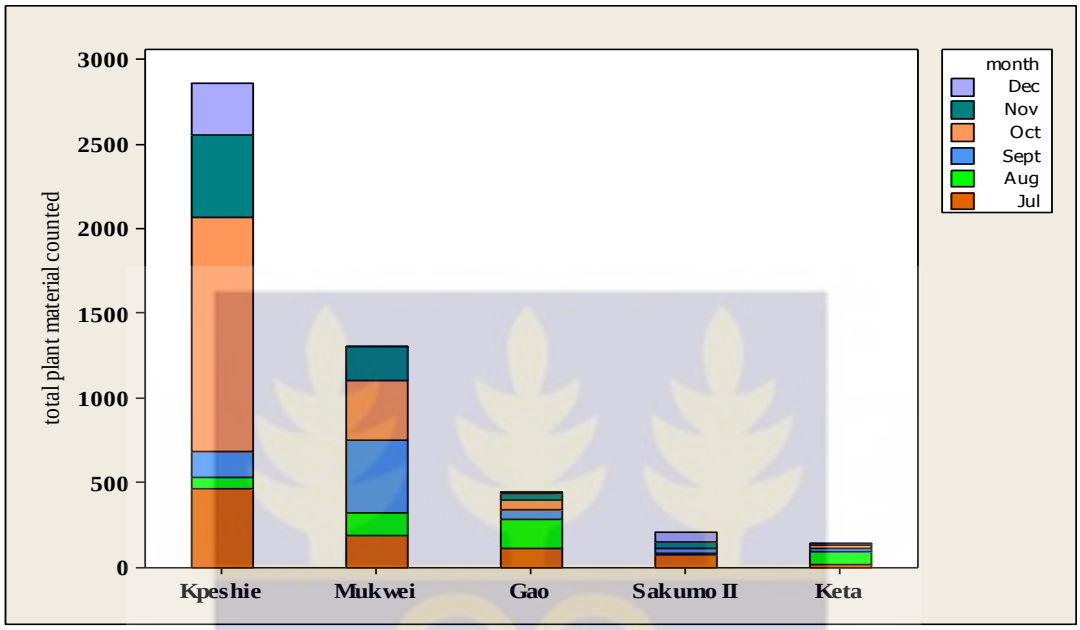


Figure 4.10: Monthly abundance of processed wood across sites

Source: Field work, 2014.

4.2.6 Plastic litter

Generally monthly accumulation of plastic litter was higher in all the sites than other types of litter as their accumulation quantities were mostly in thousands (Figure 4.11). Kpeshie lagoon site again recorded the highest plastic litter followed by the Sakumo II lagoon and then by Mukwei, Gao and Keta. At the Kpeshie site, the total plastics litter were outstandingly high in July but declined significantly to attain the least in August; it then followed an increasing trend in September and October and reduced slightly again in November before reducing further in December. Plastic litter accumulation was similar in July and September at the Sakumo II lagoon site but least in August and December.

The highest plastic debris accumulation on the bank of the Sakumo II lagoon site was observed in November. There were almost similar accumulation pattern of plastic litter in

July, August and September at the Mukwei lagoon site but followed a steady decline from October through to November and then in December when it recorded the least plastic litter accumulation. There was also a general decreasing trend in plastic litter accumulation from July to September and October at the Gao lagoon but increased significantly in November before further reducing in December. At the Keta lagoon, apart from July which recorded quite significant plastic debris, the accumulation pattern for the rest of the months was similar with December recording the least (Figure 4.11).

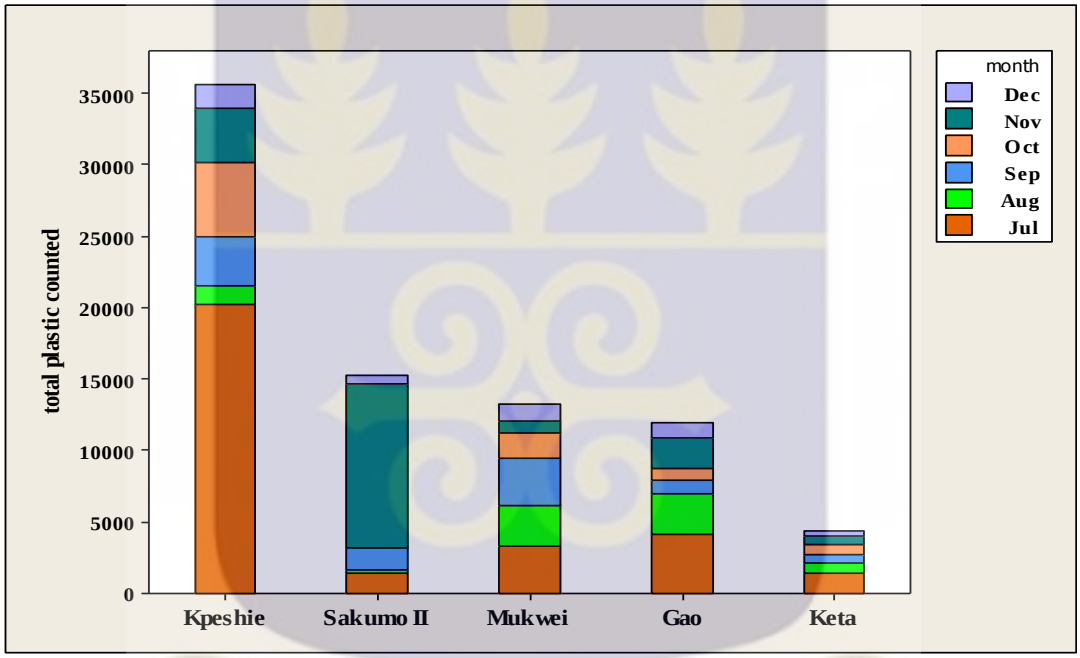


Figure 4.11: Monthly abundance of plastic litter across sites

Source: Field work, 2014.

4.2.7 Polystyrene debris

The second most dominant litter recorded for the study after plastics was polystyrene debris. Again Kpeshi recorded the highest polystyrene litter deposition with Mukwei recording about three times lower count followed by Gao then by Sakumo II lagoon. The Keta lagoon again recorded the least accumulation of polystyrene debris. At Kpeshie, October recorded the highest total polystyrene count whereas August recorded the least. The second highest polystyrene accumulation was in November but decreased

substantially in December with September recording similar accumulation as that of December. At Mukwei, whereas September recorded the highest polystyrene litter August and November recorded the least while July and October recorded similar quantities. There was very negligible record of polystyrene materials in October at the Gao lagoon even though the accumulation pattern was similar in July, September, November and December. The least polystyrene was however recorded in August. At the Sakumo II lagoon, polystyrene materials were only observed in July and November. The count of Polystyrene litter was negligible at the Keta lagoon (Figure 4.12).

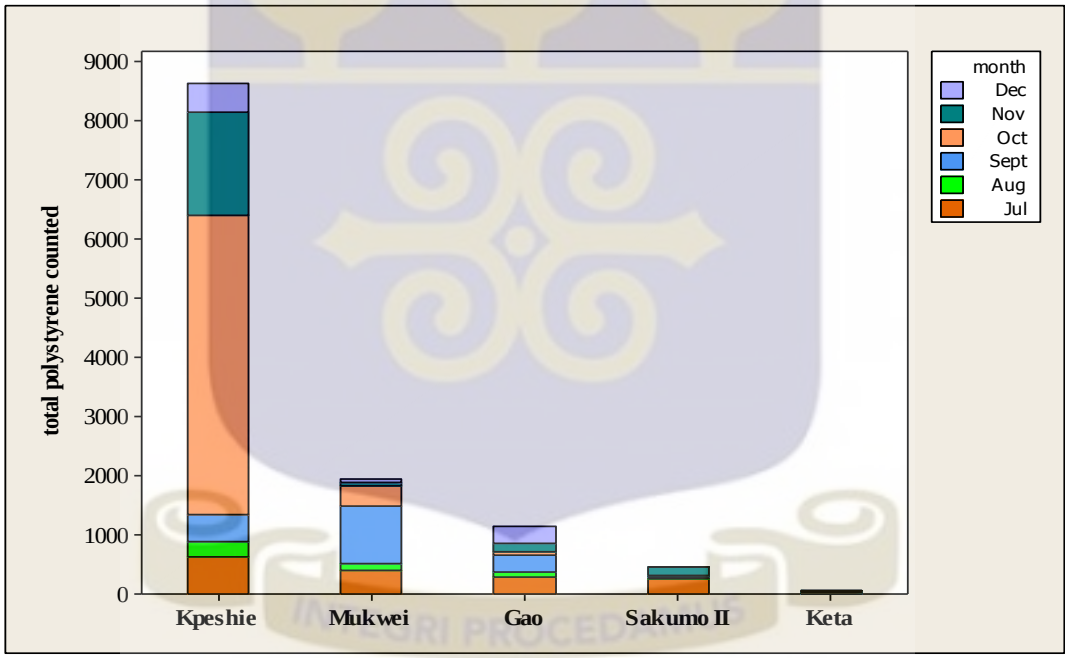


Figure 4.12: Monthly abundance of polystyrene litter across sites

Source: Field work, 2014.

4.2.8 Rope/Net

Rope / net was the lowest counted during the survey but was prevalent at the Keta lagoon site where there was a steady increase in its accumulation in July and August but reduced slightly in September and increased significantly in October where it recorded the highest.

The second highest rope/net recorded was in November while the least was in December. The next dominant ropes/nets were observed at the Gao lagoon site which recorded the highest in November and least in July. Interestingly there was no record of rope/net debris at the Sakumo II lagoon site whereas the Mukwei lagoon recorded the third highest accumulation of rope / net. At the Mukwei site, July recorded the least count of ropes/net but increased significantly in August. It then reduced substantially in November and increased again in December. Few rope/net debris were recorded in December at the Kpeshie lagoon site (Figure 4.13).

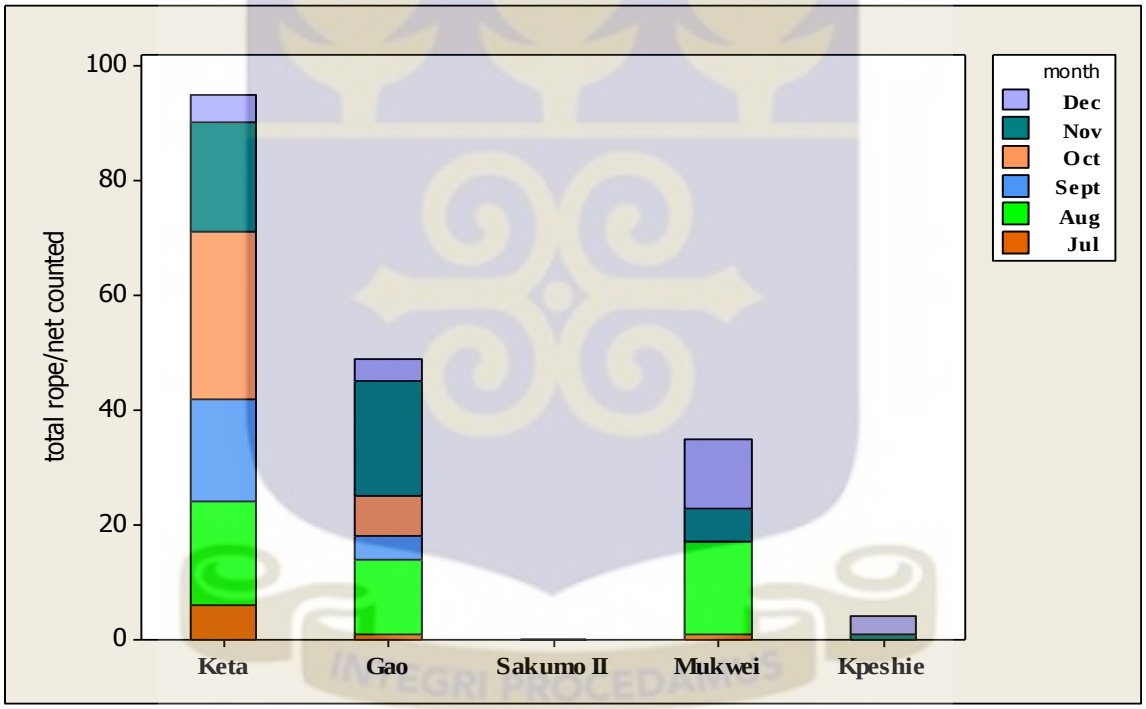


Figure 4.13: Monthly abundance of ropes/net litter across sites

Source: Field work, 2014.

4.2.9 "Others"

Like many of the identifiable litter types discussed above the litter type categorised as "others" which included different litter types normally intertwined by a rope or a strand of fabric to form one unit assumed a sharp decreasing trend from Gao through to Kpeshie as

shown in Figure 4.14. At the Gao lagoon where higher quantities of this type of debris were observed, there were very few recorded in July, but in August there was an outstandingly high quantities recorded. It then decreased in September and assumed negligible quantities for the rest of the months. At the Sakumo II lagoon, litter constituting the others category was very low in July, August and September but increased significantly in October and December. At the Mukwei lagoon site the quantities of this litter type was almost equal in both July and September and least in August and December however, the accumulation pattern was similar in all the months at the banks of the Keta lagoon while Kpeshie lagoon recorded the least only in December as shown in Figure 4.14.

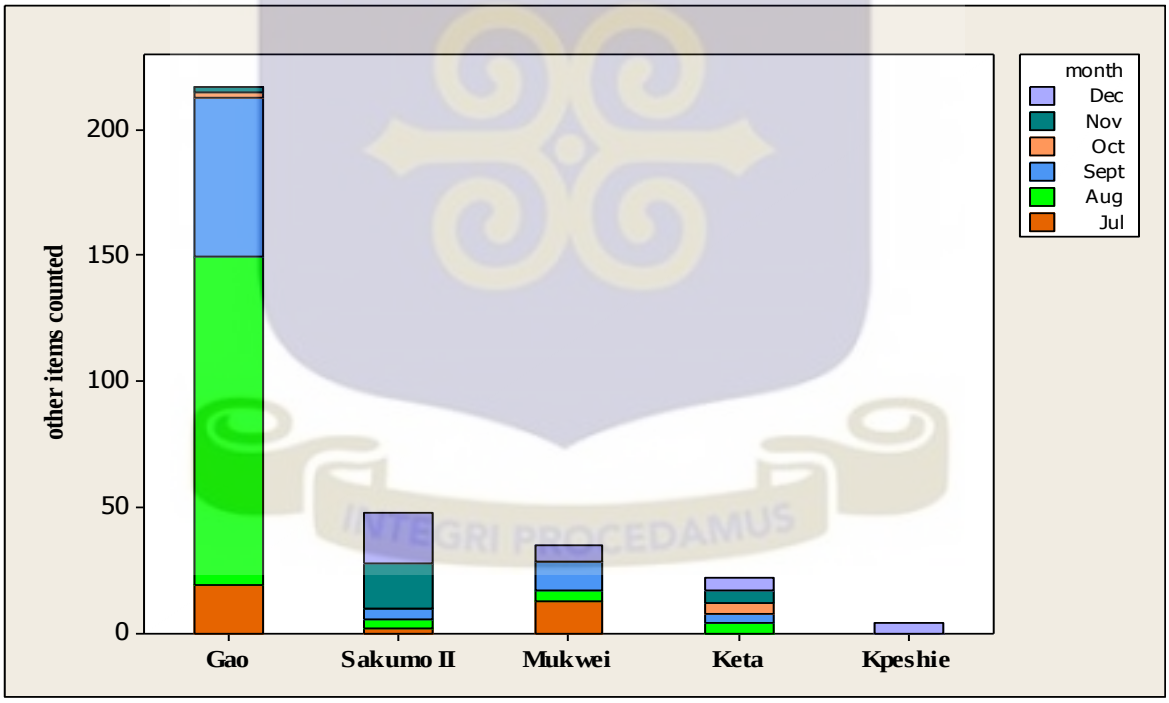


Figure 4.14: Monthly abundance of litter in the "Others" category across sites
Source: Field work, 2014.

4.3 Variation of litter accumulation across sites

A Two-way analysis of variance (ANOVA) showed no significant differences ($p = 0.44$) in rate of monthly litter accumulation across sites. However, the mean litter deposition per metre squared across sites showed a consistent decrease in litter accumulation towards the eastern coast with the Kpeshie site recording higher values of 1.6 ± 1.5 items / m^2 followed by Mukwei lagoon (0.7 ± 0.3 items / m^2) then by Sakumo II (0.6 ± 0.7 items / m^2), Gao lagoon (0.5 ± 0.3 items / m^2) and finally the Keta lagoon (0.2 ± 0.1 items / m^2.) as shown in Table 4.1.

Table 4.1: Mean monthly litter deposition per meter square across sites

Lagoons	Kpeshie	Mukwei	Sakumo	Gao	Keta
Mean litter /m2	1.6 ±1.5	0.7± 0.3	0.6 ± 0.7	0.5 ± 0.3	0.2 ± 0.1

Source: Field work, 2014.

4.4 Trend in litter diversity across sites

The total litter collected was composed of one thousand and forty three (1,043) individual litter types classified under the nine categories as classified by types according to OSPAR (2009). The diversity of litter across sites was almost similar as shown in Table 4.2. The relative percentage litter diversity per site ranged from 14.6 - 24.7 % and the trend was in order of Gao > Mukwei > Kpeshie > Keta > Sakumo II whereas the relative percentage litter diversity across month also ranged from 14.4 -19.2 % and in the order of August > December > July > November > October > September. Analysis of variance (ANOVA) show no significant difference ($p = 0.5$) between litter diversity across month. However, there was significant differences ($p = 0.03$) between litter diversity across site (Table 4.2).

Plastic litter types dominated the entire litter diversities across all the sampling sites and formed close to 50 % (Table 4.2). Fabric materials were generally the second highest litter type followed by plant materials, polystyrene and metallic objects; litter constituting the 'others' group formed the sixth highest diverse litter across all the sites with paper, glass and finally rope/nets constituting the less diverse categories of litter across sites as indicated in Table 4.2 below.

Litter diversity at each sites also showed similar trend as that of the diversity across months as discussed above. However, there were few differences; for instance from the mean litter types across sites it can be observed that whereas fabric debris were the second highest litter type, plant materials formed the third whiles polystyrene, metallic objects and litter categorised as others formed the fourth, fifth and sixth most diverse litter types. Paper, glass objects and ropes and nets the least diverse (Table 4.3).

Table 4.2: Diversity of litter within sampling sites and across months

Months	July	August	September	October	November	December	TOTAL PER SITE	% PER SITE
Kpeshie	22	24	33	40	39	42	**200**	**19.2**
Mukwei	44	56	31	40	31	41	**243**	**23.3**
Sakumo	41	36	18		30	27	**152**	**14.6**
Gao	42	55	34	46	40	41	**258**	**24.7**
Keta	30	29	34	34	32	31	**190**	**18.2**
TOTAL PER MONTH	**179**	**200**	**150**	**160**	**172**	**182**	**1043**	
% PER MONTH	**17.2**	**19.2**	**14.4**	**15.3**	**16.5**	**17.4**		

Source: Field work, 2014.

Table 4.3: Mean Litter type across site

Sites	Kpeshie	Mukwei	Sakumo II	Gao	Keta	
Group			Mean % Diversity			TOTAL
Fabric	12.6	14.9	14.9	15.8	10.5	68.7
Glass	5.7	3.6	3.6	2.8	3.2	18.9
Metallic	6.9	6.0	6.0	4.2	5.4	28.5
Paper	2.9	5.3	5.3	3.2	3.2	19.9
Plant material	13.4	11.8	11.8	11.2	13.1	61.3
Plastic	48.0	47.3	47.3	49.7	44.7	237
Polystyrene	10.4	9.2	9.2	7.5	4.2	40.5
Rope/nets	-	-	-	3.2	11.6	14.8
Others	2.6	5.8	5.8	3.6	5.0	22.8

Source: Field work, 2014.

4.5 Analysis of plastic litter as the most dominant litter across all the study sites.

4.5.1 Kpeshie lagoon

A total of twenty seven (27) plastic types were recorded in the Kpeshie lagoon. Plastic bottles were the most dominant debris collected and represented close to 26,000 of the overall plastics litter counted. The highest quantity (17,000) was recorded in July and the least in August. October recorded the second highest plastic bottles whiles September and the other months recorded the same rate of accumulation (Figure 4.15). Pure water sachet (PWS) debris was the second highest plastic type recorded and formed close to 4,000 of total plastics collected. Again July recorded the highest PWS whiles September recorded the least with no observation in August; however the accumulation pattern of the PWS were almost the same in October, November and December (Figure 4.15).

Crisp/sweet wrappers were the third highest plastic types and accounted for about 1,500 of the total plastic litter collected. Crisp/sweet wrappers were encountered throughout the sampling period with September and October recording the same rate of accumulation while the other months recorded the least but consistent rate of deposition. Locally tired

pure water (LTPW) and disposable cups were the next highest plastic type and recorded almost the same abundance.

The rate of accumulation of disposable cups was regular however that of the LTPW was inconsistent. Other plastics debris such as black poly strands, top/lids, food wrappers and alcoholic drink sachet were approximately 1000 each of the total plastics counted. However their rate of accumulation varied. Alcoholic drink sachet and lip/tops for instance were encountered throughout the period with the same rate of accumulation patterns while black poly strands and food wrappers were only registered in July and August and sparely encountered in the other months. All the other plastic litter types occurred in small quantities and were not encountered throughout the study periods.

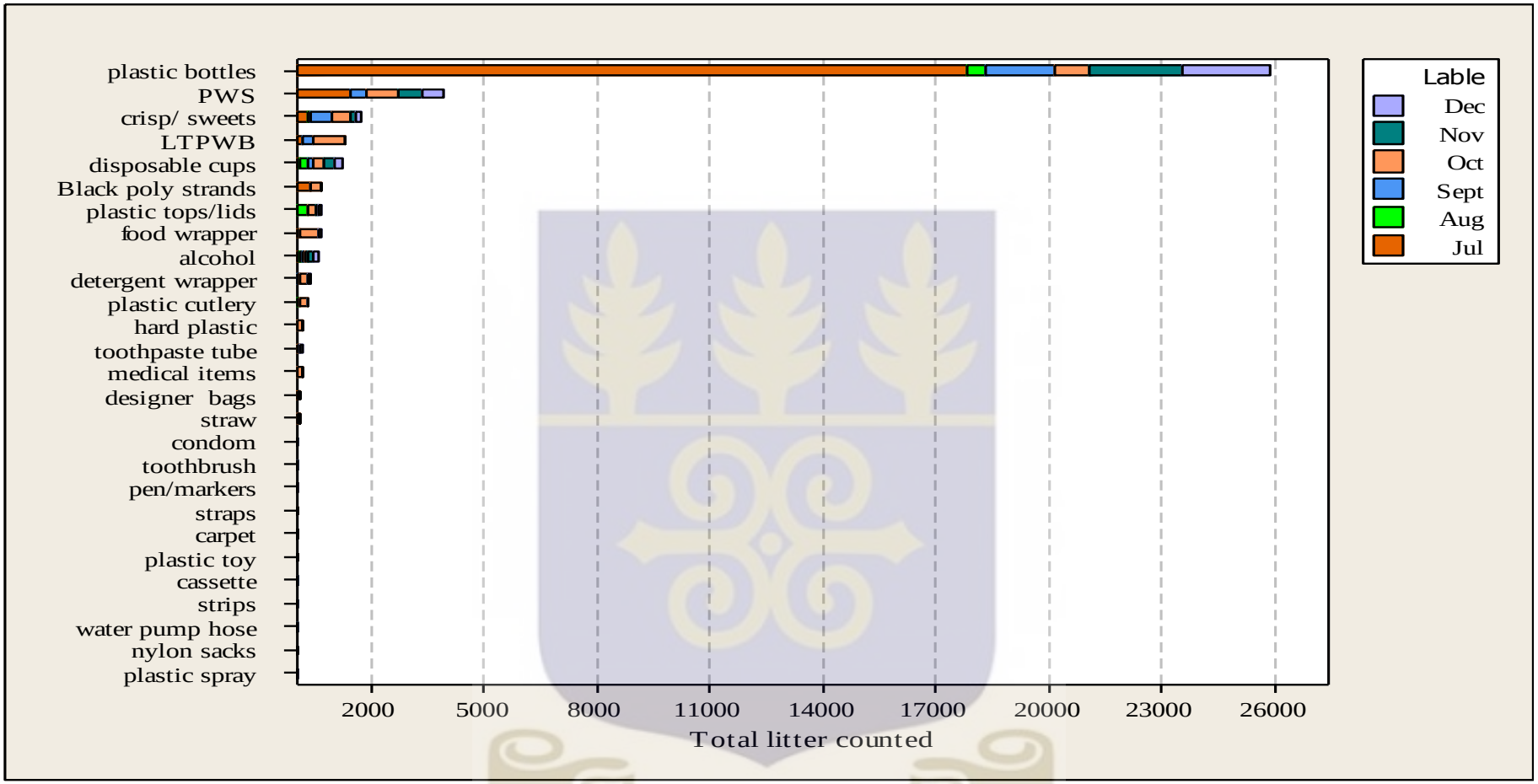


Figure 4.15: Plastic litter distribution on the banks of the Kpeshie lagoon

Source: Field work, 2014

4.5.2 Mukwei lagoon

Mukwei sampling site recorded twenty nine individual types of plastic litter over the study period; however pure water sachet (PWS) were the most abundant plastic debris encountered throughout the months (Figure 4.16). Plastic bottles were the second highest plastic debris collected and formed the highest plastic abundance in September. The abundance of black poly strands and crisp/sweet wrappers (CSWP) were approximately the same but the rate of deposition varied across the months. Disposable cups and locally tied polythene bags (LTPWB) formed the fourth and the fifth highest plastic litter recorded respectively. Plastic top/lids, hard plastics and designer bags were the sixth to seventh plastic debris collected at the Mukwei lagoon respectively and were closed to 500 each of the overall count within the study period. There was also an exponential decrease in plastic debris abundance for litter types such as the straws (STRW), plastic containers and tooth paste (TOTHP), alcohol wrappers, plastic cutlery, food wrappers (FDWP), detergent wrappers (DETWP) and tooth pastes tube (TOTHB). The abundance of other plastic debris such as medical items up to cassette was very insignificant (Figure 4.16). Generally, the rate of plastic debris deposition decreased in November and December respectively.

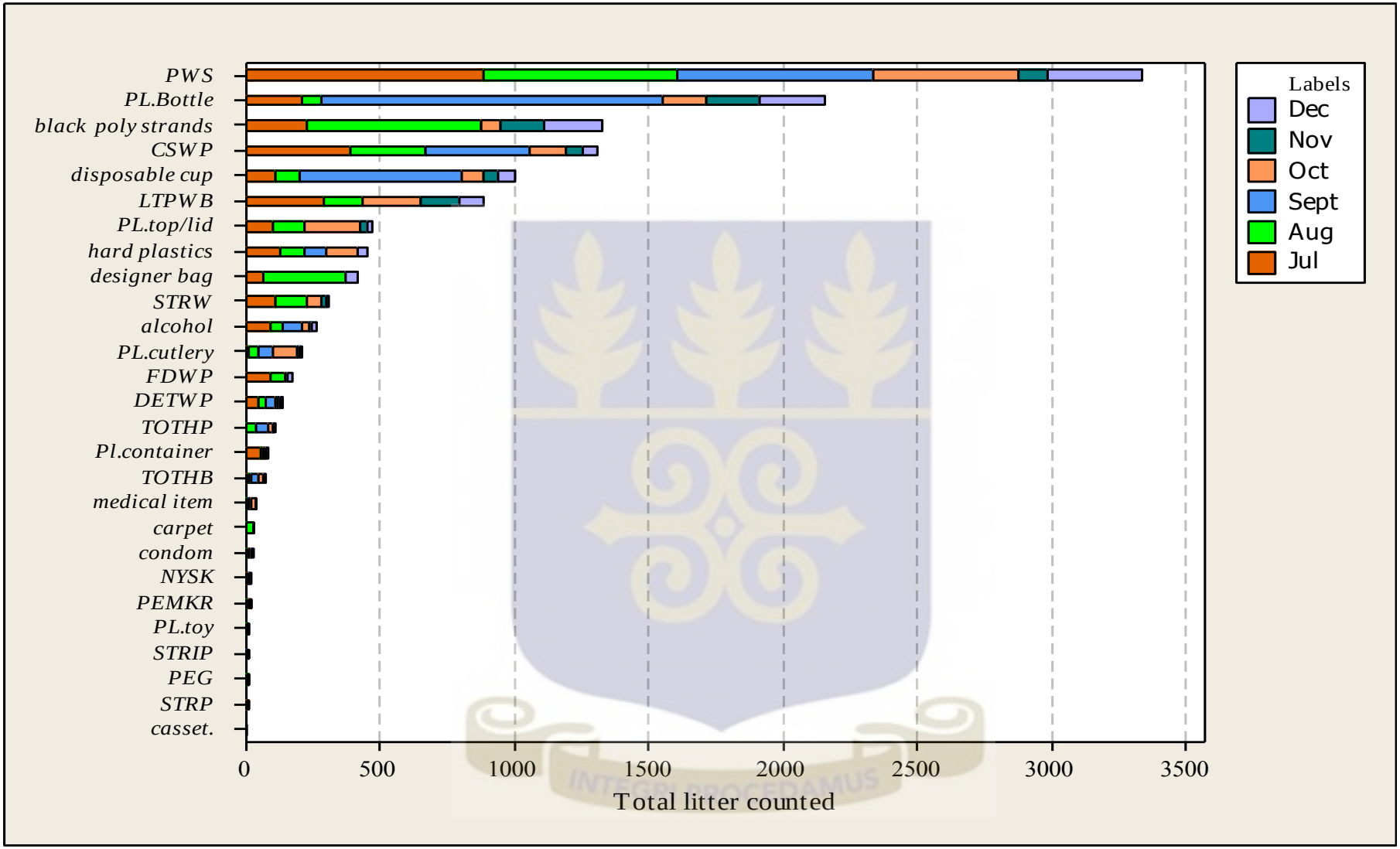


Figure 4.16: Plastic litter distribution on the banks of the Mukwei lagoon.

Source: Field work, 2014.

4.5.3 Sakumo II lagoon

Thirty (30) plastic litter types were registered at Sakumo II lagoon with plastic bottles forming the most prevalent plastic debris accounting for close to 14,500 of the total plastic collected. As much as about 11,400 bottles were collected in November alone with the least of 39 in August however no data was collected in October. The rate of accumulation was only similar in July and September and erratic in the rest of the months. The second highest debris was PWS and accounted for about 260 of the total plastic litter types recorded. The rate of accumulation of PWS was consistent across the sampling period.

Black polythene strands were the third plastic litter type recorded in Sakumo II lagoon and represented close to 140 of the total plastic debris collected. The total litter counted for the other plastic types were quite low and ranged from designer bags recording about 29 to as little as 1 for shaving sticks as shown in Figure 4.17. The accumulation patterns of the plastic litter at the bank of the Sakumo II were widely varied both in space and time. The outstanding dominance of the plastic bottles litter may possibly be scoured unto the banks of the lagoons from the sea during high tide as the lagoon has no direct recreational activities from which the plastic bottles may have been generated.

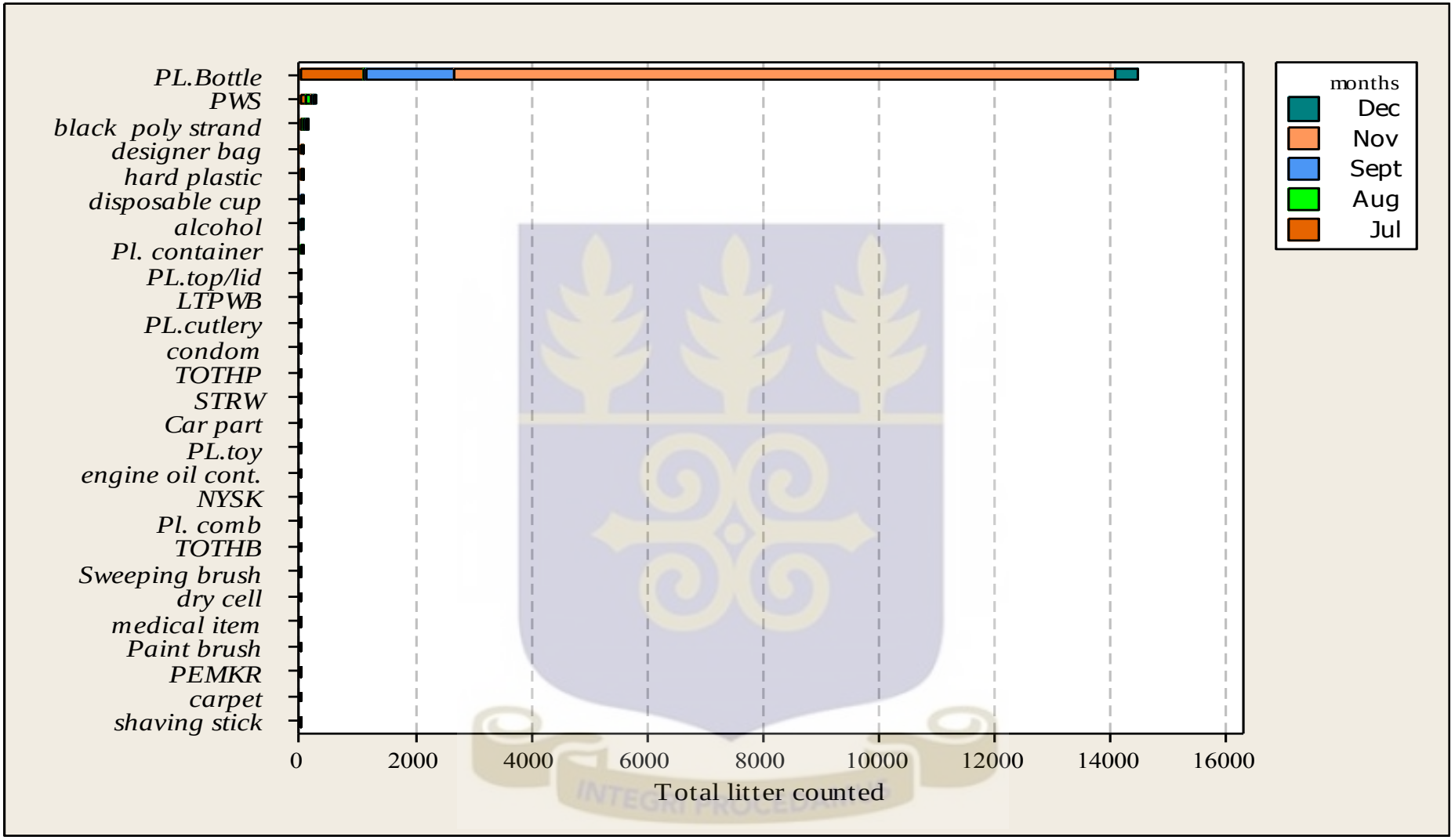


Figure 4.17: Plastic litter distribution on the banks of the Sakumo II lagoon.
Source: Field work, 2014.

4.5.4. Gao lagoon

A total of twenty five (25) types of plastic debris were registered at the Gao lagoon. Plastic bottles were the most dominant plastic debris collected and represented about 5,500 of the total plastic counted. Again July recorded the highest accumulation rate of plastic bottles whiles the rate of accumulation in August and November was similar (1000/month) followed by September and November recording close to 500 bottles per month each and lastly December as shown in **Figure 4.18**. Pure water sachet (PWS) and black poly strands were the next highest plastic litter types recording little over 900 each of the total litter counted.

The rate of accumulation of PWS was highest in November and least in October. However the accumulation rate in July and August were similar while that of September and December were also within a close range (Figure 4.18). The accumulation rate of black poly strands in July and August were similar (350 count/month) to the least in November however no black poly strands were recorded in September. Disposable cups and plastic cutlery were the fifth plastic types recorded forming a little over 600 each of the total litter counted.

The rate of accumulation of disposable cups were consistent (146 - 177 count/month) with the least in August and December (67-77 count/month) respectively. The rate of plastic cutlery accumulation was erratic. However, July recorded the highest rate and the least in November (Figure 4.18). Designer bags were the sixth highest plastic types and accounted for about 540 of the total plastic debris counted. Again the rate of accumulation was erratic with August registering the highest rate of accumulation. Crisp/sweet, alcoholic and hard plastics were the next highest plastic type and represent approximately 400 respectively each of the total plastic litter counted. Straw (STRW), food wrappers (FDWP) and locally tired pure water bags (LTPWB) recorded close to 300 each of the total plastic debris counted. All the other plastic types observed formed less than 125 each of the total plastic counted and the rate of accumulation was not consistent throughout the sampling period (Figure 4.18).

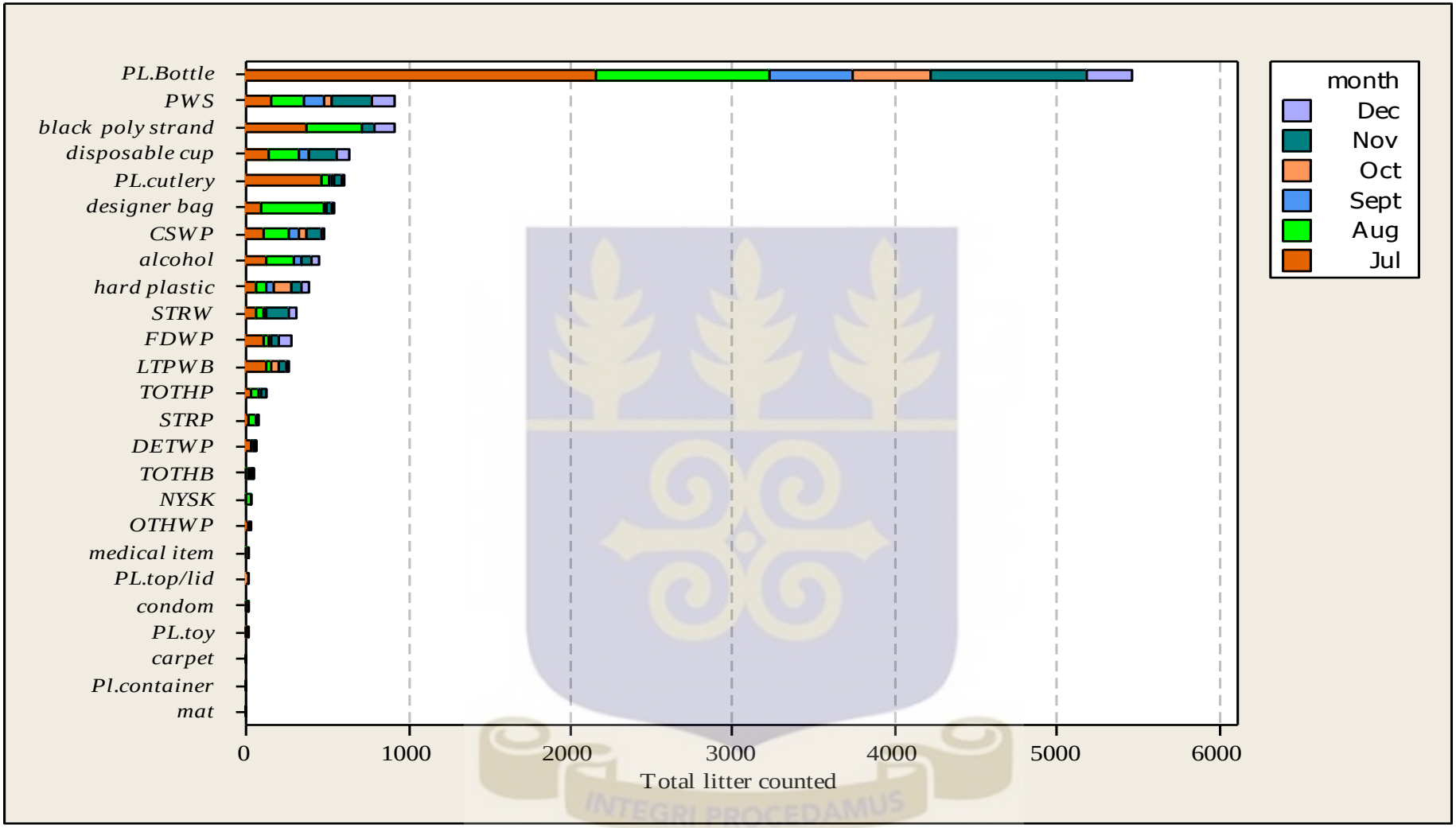


Figure 4.18: Plastic litter distribution on the banks of the Gao lagoon.

Source: Field work, 2014.

4.5.5. Keta lagoon

A total of twenty (20) plastics types were recorded at the Kedzi section of the Keta lagoon complex. Pure water sachet (PWS) was the most dominant plastic debris collected and represented close to 1,400 of the total litter counted. The highest rate of accumulation was observed in July while other months recorded similar accumulation patterns (Figure 4.19).

Black polythene strands was the next dominant plastic litter type recording about 1,200 with approximately equal rate of litter deposition across the month. Locally tied pure water bags (LTPWB) were the next highest type of plastic debris collected. They formed close to 1,000 of the total litter counted and their rate of accumulation was also similar except that of August when it formed almost 160 of the total litter counted. Designer bags were fourth dominant plastic litter types recorded. They formed a little over 300 of the total litter counted but their rate of accumulation was inconsistent. Plastic tops/lids were the fifth plastic types registered and constituted about 115 of the total plastic debris counted.

Hard plastic and alcoholic beverage sachet were the next highest plastic litter types. Their rate of accumulation was almost the same with exception of July while alcoholic sachet recorded the highest accumulation rate of 36 sachets each per month. Crisp/sweets and food wrappers were the eighth and ninth plastic types respectively and recording close to 80 of the total litter counted. Plastic bottles were also observed throughout the period but recorded low accumulation rates across the entire sampling period as shown in Figure 4.19. Other plastic litter types recorded values below 10 and were not persistent throughout the study period.

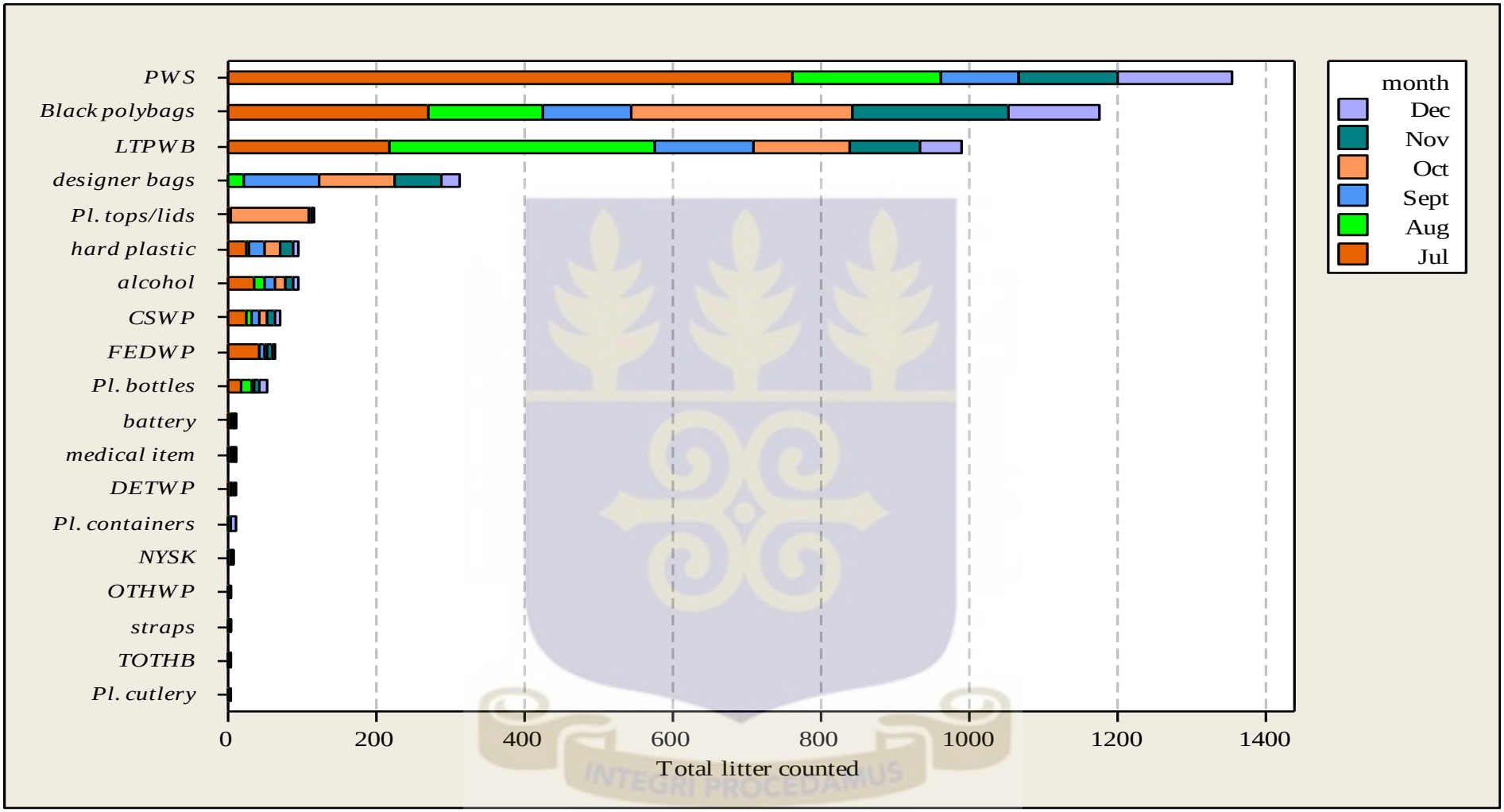


Figure 4.19: Plastic litter distribution on the banks of the Keta lagoon.

Source: Field work, 2014.

4.6 Multivariate cluster analysis of plastic litter groups at the various sites.

A multivariate cluster analysis is a statistical technique used in analysing large data with more than one variable (Bam *et al*, 2011). Plastics have been found to be the most predominant litter type accumulated at all the sampling site for this study. In order to further establish the relationship between the occurrences of the various plastic types, a multivariate cluster analysis was needed. In this study, the technique was therefore used to establish the associations or linkages between the occurrences of the individual types of plastic litter at the various sites in terms of their frequency and abundance as discussed below.

4.6.1 Kpeshie lagoon

Three clusters (A-C) were generated indicating relatively high level of independency of each group. Cluster 'A' for instance formed the dominant litter composition (88 %) and comprised plastic bottles (Pl. Bottles), pure water sachets (PWS), alcoholic beverage wrappers (ALCO), disposable cup (DPCs) and sweet and crisp wrappers (CSWP). However there were significant differences ($p < 0.05$) between these items. Thus whereas alcoholic beverage wrappers, sweet/crisp and DPCs were grouped as one sub-cluster, PWS constituted another sub-cluster while plastic bottles also formed the third sub-cluster. Cluster 'B' constitutes the most diverse but less abundance plastic debris while cluster 'C' comprises of less diverse plastic types which are significantly different (Figure 4.20).

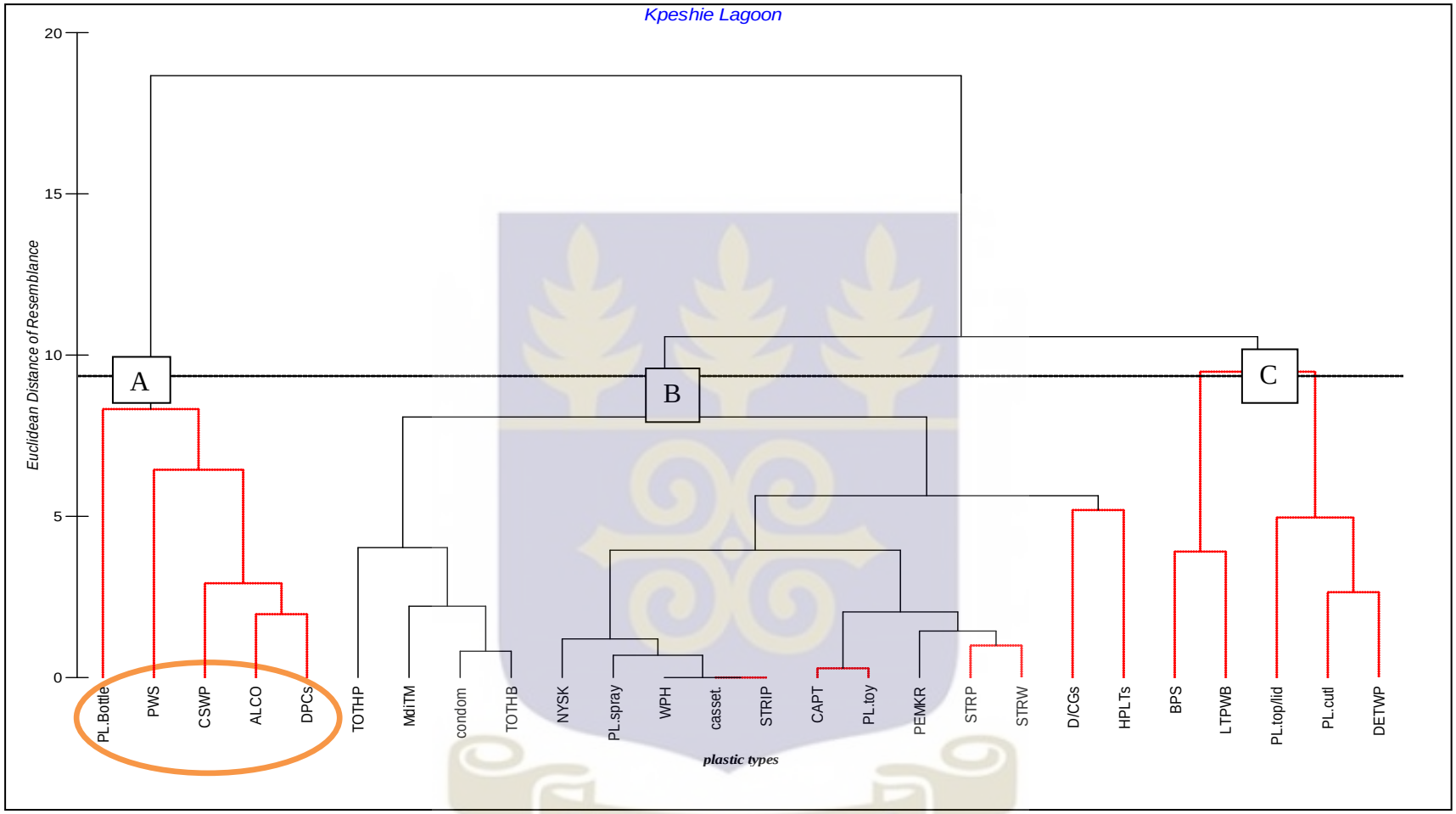


Figure 4.20: Cluster similarity of litter on the bank of Kpeshie lagoon
Source: Field work, 2014.
Nylon sack- NYSK, Plastic spray – PL spray, WPH – Water pump hose, casset – Cassette, STRIP – polythene strips, LTPWB – Locally tied pure water bags, PL toy – plastic, PEMKB- Pen marker, STRW-Straw, STRP – strapping bands, TOTHP- Toothpaste, TOTHB – Toothbrush, PL Bottle – Plastic Bottles, PWS – Pure water sachet, CSWP - crisp and sweet, PL top/lid – plastic tops and lids, PL cutlery – Plastic cutlery, DETWP – Detergent wrappers, FDWP – Food wrappers, BPS - Black Polythene Strands.
Note: Applicable to Figures 4.21, 4.22, 4.23, 4.24as well

4.6.2 Mukwei lagoon.

Again, there were three major clusters of the plastic litter types (A-C) observed at the Mukwei lagoon. Cluster 'A' which constitutes the most dominant plastic litter types was further grouped into two sub-clusters as shown in Figure 4.21. PWS, Pl. bottles, CSWP and DPCs group occurred throughout the data collection period; BPS, LTPWB, Pl. top/lids and STRW also formed the second highly frequent litter items observed. Cluster 'B' mainly constitutes items that are homogenous in terms of the frequency of their occurrences and abundance while 'C' is made of up of items that are significantly different. Cluster 'C' items are further grouped into three sub-groups, the third sub-group comprising ALCO, HPLTs, DETWP and Pl. cutl formed the intermediate group between the first and second main groups. The second group (MdiTEM, TOTHP and TOTHB) are not frequently observed and also registered low values of abundance (Figure 4.21).

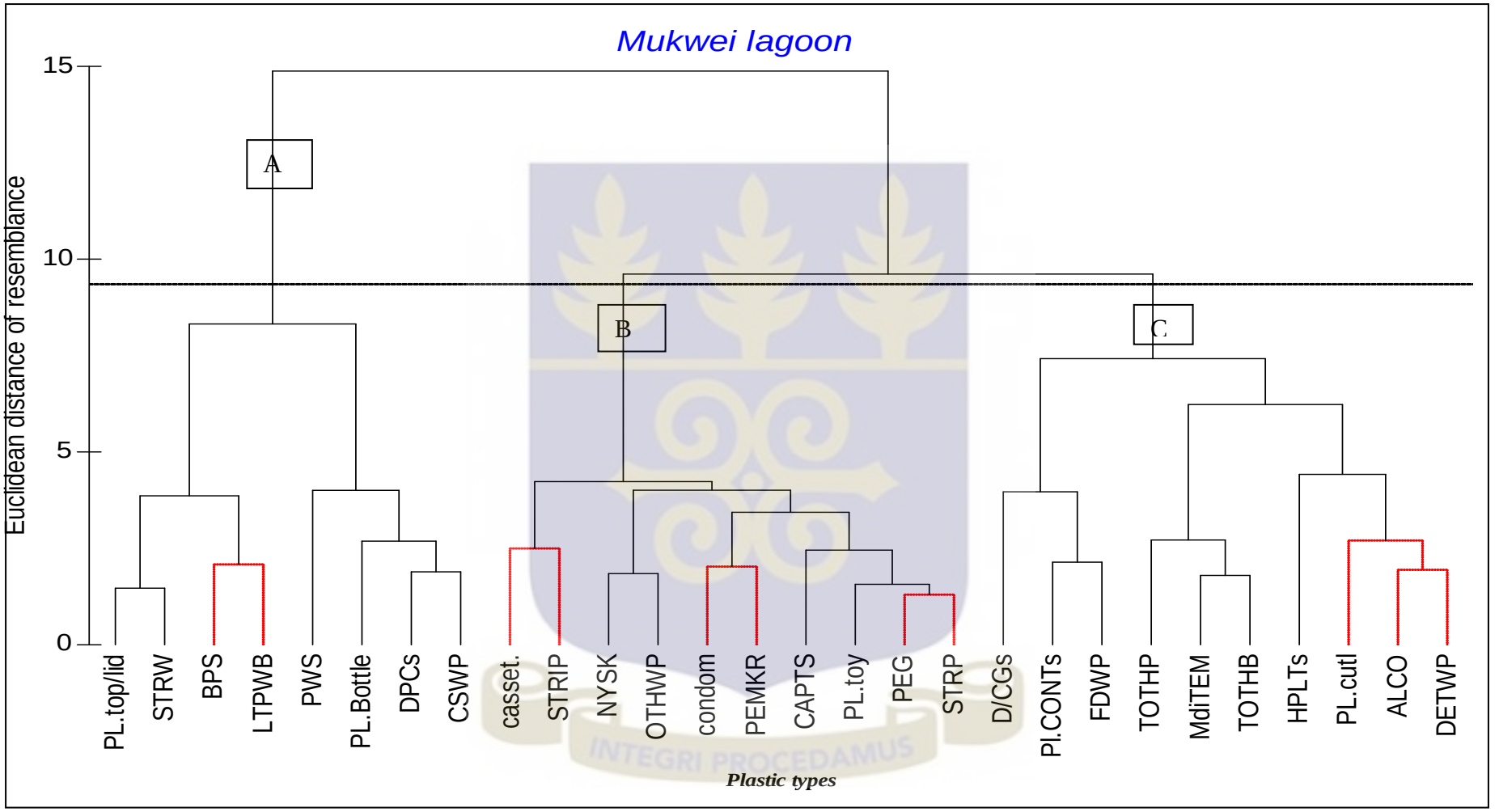


Figure 4.21: Cluster similarity of plastic litter on the bank of Mukwei lagoon.

Source: Field work, 2014.

4.6.3 Sakumo II lagoon.

Plastic litter collected over the six month sampling period at the Sakumo II lagoon were grouped nto two main clusters (B and C) with an isolated cluster 'A' (Figure 4.22).

Cluster 'A' is made up of only plastic bottles of different types and formed about 94 % of the entire plastic litter collected. Cluster 'B' constitute the most diverse but less abundant plastic litter type and is further divided into five (5) sub - clusters at about 2.5 Euclidean distance of resemblance (Figure 4.22). Cluster 'C' is made up of items such as PWS, BPS, D/CGs, HPLTs, DPCs and CSWP that are relatively abundance than items in Cluster 'B' but far lower than that of 'A'.

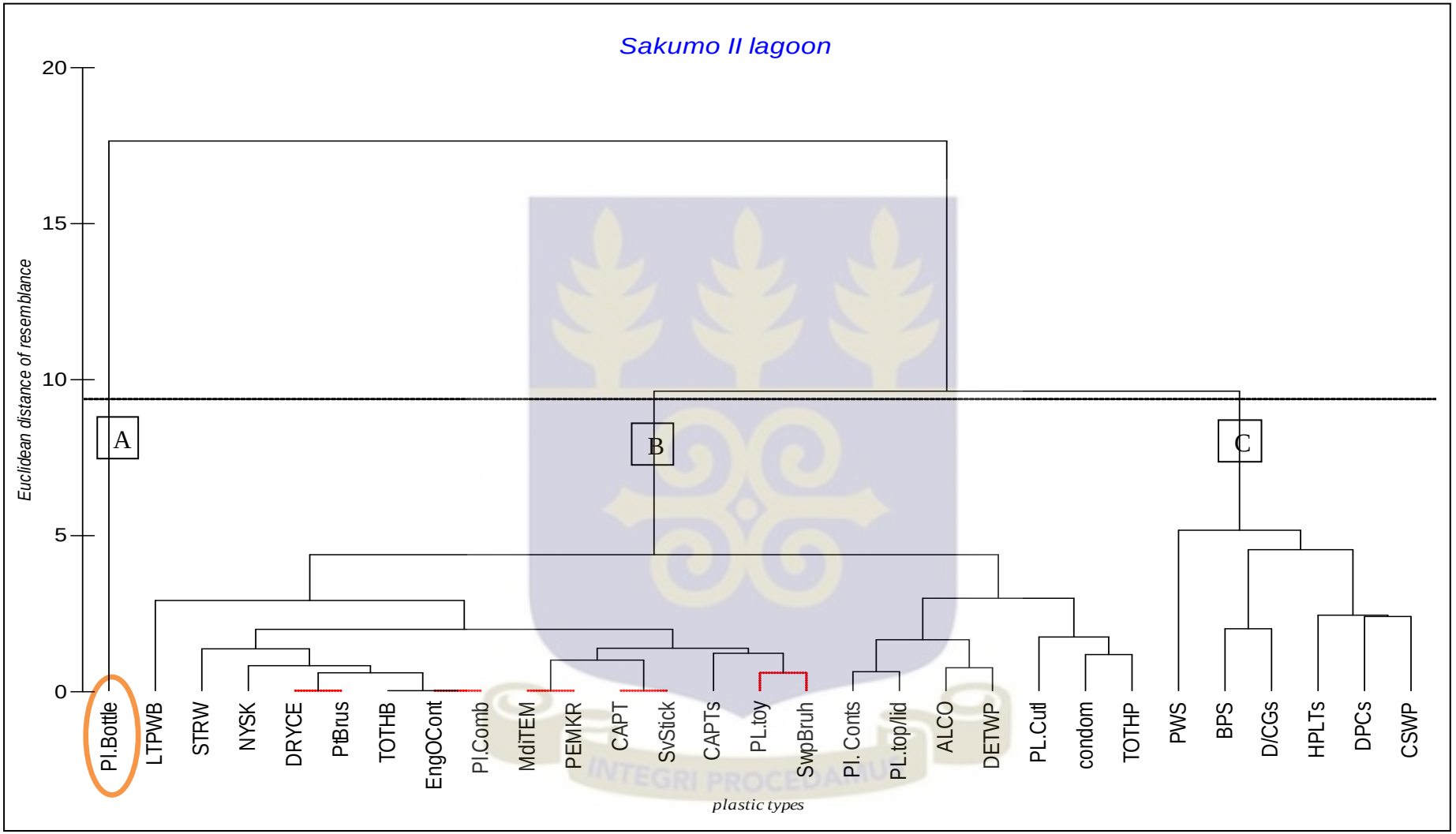


Figure 4.22: Cluster similarity of plastic litter on the bank of Sakumo II lagoon.

Source: Field work, 2014.

4.6.4 Gao lagoon

Euclidean distance applied at 9.33 resemblance level grouped the plastic litter collected at the Goa lagoon into two clusters (A and B) as shown in Figure 4.23. Cluster 'A' constitute the most diverse but less abundant and less frequent items which is further grouped into four sub-clusters with a few significant differences as shown in Figure 4.23 below. Cluster 'B' is however made up of the dominant plastic litter items and consisted of such as Pl. bottles, PWS, CSWP, DPCs, BPS, LTPWB, ALCO, HPLTs, FDWP, D/CGs, Pl. cutl and condoms as in Figure 4.23 below. Cluster 'B' is also further divided into five sub-clusters with plastic bottles forming a sub-cluster that is largely separated from the other sub-clusters. PWS, CSWP and DPCS sub-clusters shows significant difference while the rest are homogenous except HPLTs and FDWP sub-cluster (Figure 4.23).

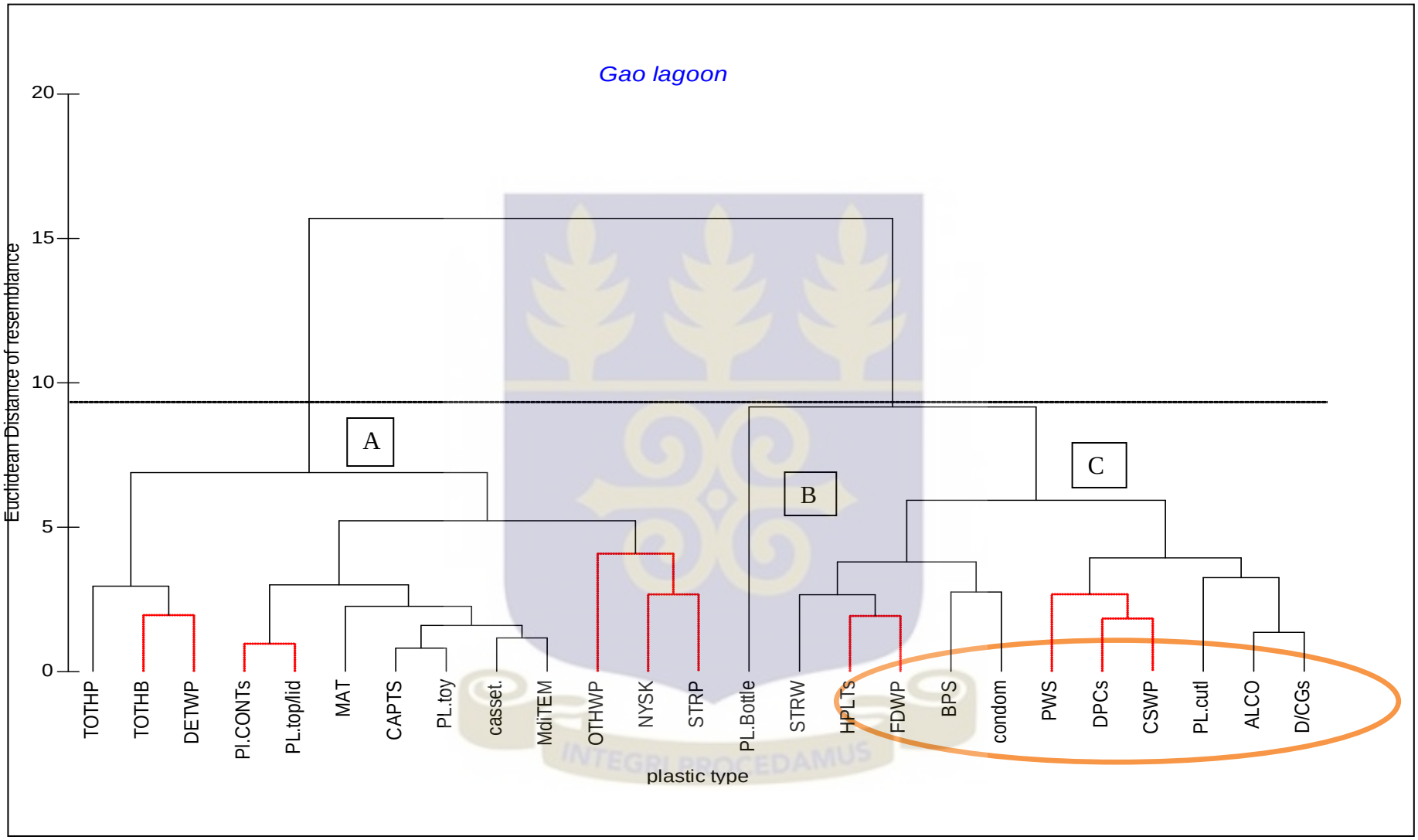


Figure 4.23: Cluster similarity of plastic litter on the bank of Gao lagoon.

Source: Field work, 2014.

4.6.5 Keta lagoon.

The plastic litter types are grouped into two main clusters (A and B) respectively (Figure 4.24) Cluster 'A' consists of less abundant and less frequently occurring plastic debris and is further divided into four sub-clusters. On the other hand cluster 'B' is made up of relatively high abundant plastic litter types constituting LTPWS, BPS and PWS which more frequently occurring on the banks of the Keta lagoon.

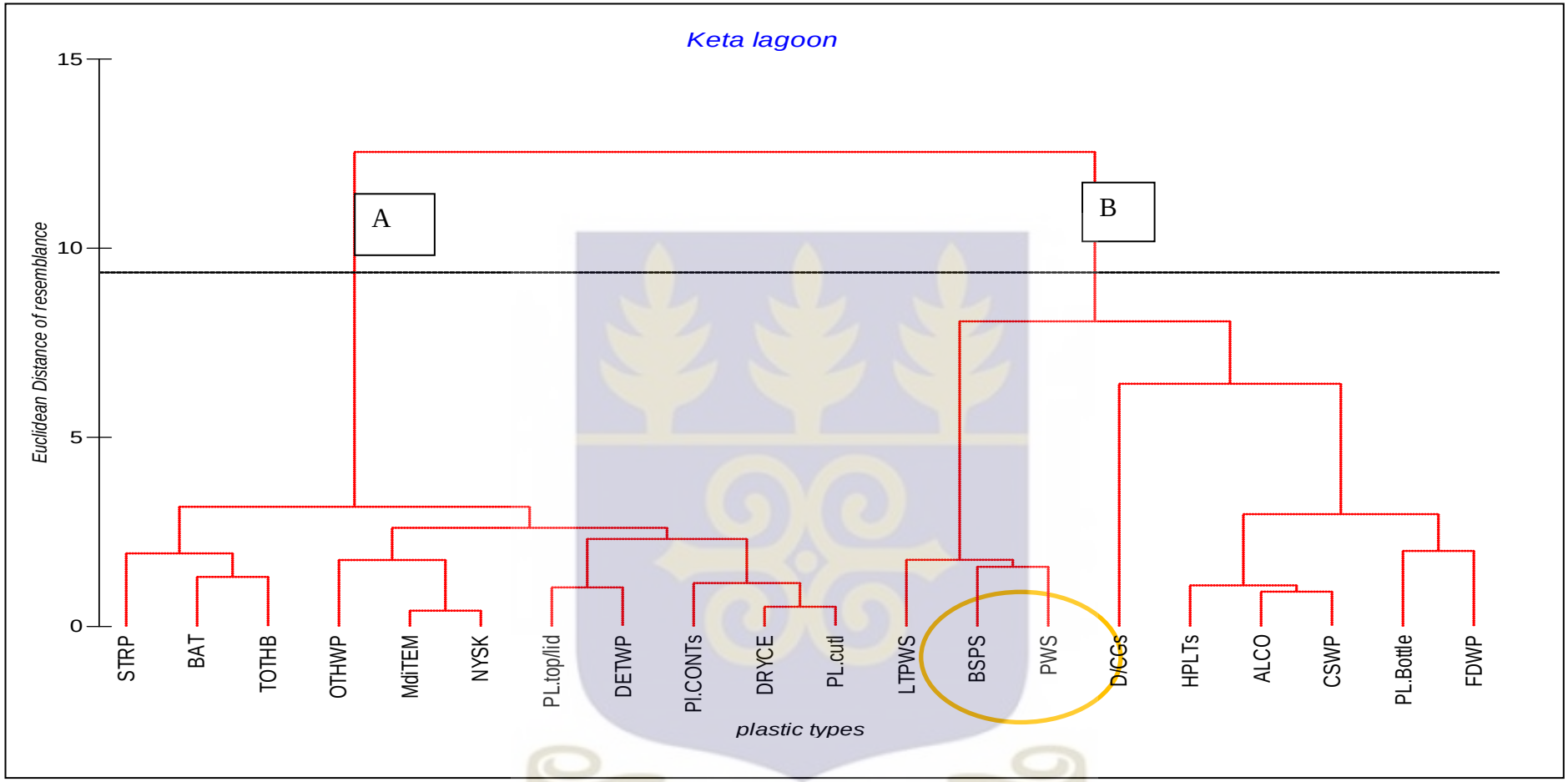


Figure 4.24: Cluster similarity of plastic litter on the bank of Keta lagoon

Source: Field work, 2014.

4.7 Similarity of Plastic litter accumulation across site

MDS analysis of total plastic litter types across all the five sampling sites shows that apart from Gao which is isolated and shows dissimilarity among the other two lagoons studied Kpeshie and Mukwei are closely associated. Sakumo II and Keta are also closely associated as shown in Figure 4.25. Kpeshie and Mukwei are clustered together because they recorded the most abundant plastic litter and form the most polluted with plastics; however, of the two lagoons Kpeshie recorded more plastic debris. In terms of diversity, Mukwei rather recorded higher diversity of plastics while Kpeshie shows low plastic diversity.

Sakumo II and the Keta lagoons are less impacted with plastic litter since they recorded lower abundances of plastics compared with the first cluster (Kpeshie and Mukwei) however of the two lagoons, plastic litter collected from the Keta were more diverse than those collected from Sakumo II lagoon.

Although the plastic litter load at on the bank of Gao lagoon was lesser than those of Kpeshie and Mukwei but more than that of Sakumo II and Keta, it recorded the lagoon with the most diverse plastic litter types.

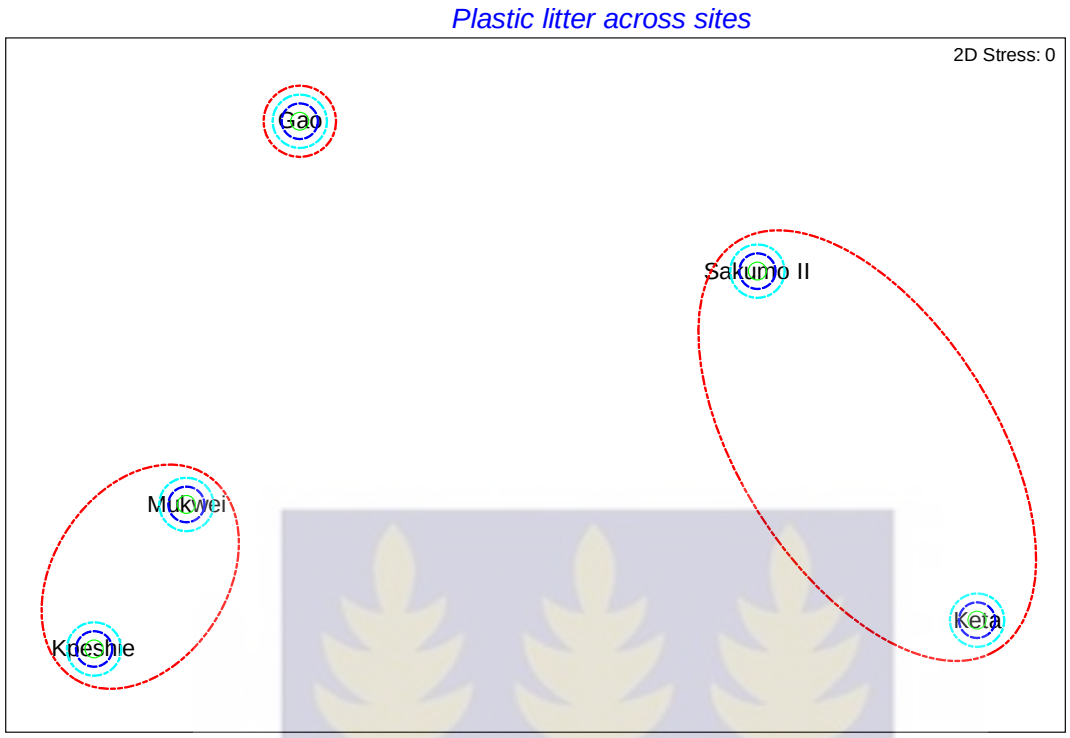


Figure 4.25: MDS cluster of plastic litter across sampling sites

Source: Field work, 2014.

4.8 Sources of litter on the banks of the lagoons.

The accumulation of litter in the marine environment has been generally found to be from marine or land based sources (OSPAR, 2009; SACEP, 2007; Sheavly and Register, 2007; Allsop *et al.*, 2006). Most of the litter constituting the land based sources are similar to those proposed by MCS (2009) as public related sources. The entire litter collected for this study across all the sampling sites over the six month period were mainly from the Public Related Sources (PRS) or were found to be mainly land based. Litter collected from the Kpeshie sampling site for example were mainly from PRS and ranged from a high of 98.1 % in July to 88.7 % in December ('A' of Appendix 6). Similar observations were made about litter collected from all the other sites but with varied percentages of the identified sources. At the Mukwei sampling site, higher proportions of litter ranging from 95.0 % collected in December and 87 % collected in November were from PRS while between 11.2 % collected in October and 3.3 % collected in August were found to be non-

sourced with approximately less than 2.1 % each constituting litter from other sources identified as Sewage Related Debris (SRD'S), Medical Waste Debris (MWD), Shipping and Fishing Sources ('B' of Appendix 6).

The Sakumo II lagoon sampling site also recorded high percentages between 99.4 % in November and 92.0 % in December all from PRS with insignificant percentages from the other sources identified as non-sourced, SRD and MWD ('C' of Appendix 6). At the Gao sampling site, litter collected were also mainly from PRS and ranged between 96.6 % recorded in November and 82.0 % recorded in December. Litter from NS also ranged between 17.0 % in December and 1.4 % in July whiles that constituting SRD also ranged from a high of 1.9 % in July and 0.2 % each in September and October respectively. The rest of the litter were obtained from the other sources identified as MWD, Shipping and Fishing Sources formed insignificant proportions of the entire litter collected over the sampling period ('D' of Appendix 6).

At the Keta lagoon site, higher proportions of litter recorded were again from PRS and ranged from 98.7 % collected in July and 88.1 % collected in September while between 8.3 % collected in August and 1.2 % collected in November were found to be non-sourced. Less than 2.0 % of the litter collected during each month were found to be SRD and MDW, however in October 3.7 % of the litter recorded were shipping related while 4.3 % of the sampling in November were from fishing related sources as shown in ('E' of Appendix 6).

4.9 Socio-demographic characteristics of respondents

To ascertain the possible human contribution of the debris along the banks of the lagoons, an interview schedule (Appendix 1) were administered and analysed as described in the sections below.

4.9.1 Background characteristics of respondents

All One hundred and twenty (120) people who were requested to participate in the survey readily accepted to participate; the response rate was therefore 100 %. The demographic data of the respondents is presented in Table 4.4 below.

Majority (50 %) of the respondents were within the ages between 18 and 25 years old. Few respondents forming about 4.1 % were older than 66 years. However, respondents aged 26 – 40 years and 41 – 65 years formed approximately 46 %. In terms of gender, the male respondents numbered 64 and formed the highest percentage (53.3 %) than females who numbered 56 (46.7 %). Results on the educational attainment of the respondents showed that 25 % of the respondents numbering 30 were illiterates; the next highest number of respondents numbering 28 (23.3 %) were SHS or Technical and Vocational training School leavers; followed by 27 (22.5 %) respondents who had attained the Primary level. 9 respondents who had attained tertiary level of education were equal in number as holders of adult Literacy certificates and formed 7.5 % each respectively.

Fifty five percent of the respondents were engaged in the fishing trade while approximately 26 % were traders who were trading their wares to the fishermen around the lagoons. Only about 10 % of the respondents were farmers while 9 % others were not employed (Table 4.4).

All in all, of the overall respondents who indicated their willingness to participate in the study, the youth within the age range 18 and 26 years where more than the old people between 66 years and above. Male respondents were more than the female respondents; again, respondents who were illiterate were more than those who had attained tertiary level education. Respondents who have attained some form of adult literacy status were also in the minority. In sum majority of the

respondent for the study were local residents within the area where the respective lagoons were located and had attained basic education while very few had attained tertiary education as demonstrated in *Table 4.4.*

Table 4.4: Summary of background characteristics of respondents.

Statement	Frequency	Percentage	Cumulative frequency
The age distribution of the respondents			
18-25 years	60	50.0	50.0
26-40 years	28	23.3	73.3
41- 65 years	27	22.5	95.9
66 and above	5	4.1	100.0
Total	**120**	**100.0**	**100.0**
Gender distribution of the respondents			
Male	64	53.3	53.3
Female	56	46.7	100.0
Total	**120**	**100.0**	**100.0**
Distribution of Educational attainment of respondents			
Illiterate	30	25.0	25.0
Adult literacy	9	7.5	32.5
Primary	27	22.5	55.0
JHS/Middle School	17	14.2	69.2
SHS/TECH/Vocational	28	23.3	92.5
Graduate	9	7.5	100.0
Total	**120**	**100.0**	**100.0**

Source: Field work, 2014.

4.10 Respondents perceptions on the littering of the lagoons

4.10.1 Respondents' perceptions of the Importance of lagoons and littering.

Respondents were asked to share their opinions on how important the lagoons were to them; their responses showed that lagoons were important to an overwhelming majority of the respondents (97 %) only 4 respondents (3 %) indicated that the lagoons are not important. In sum almost all of the respondents (116) indicated that the lagoons were of some significance to them while only 4 indicated that it was of no relevance at all (Figure 4.26).

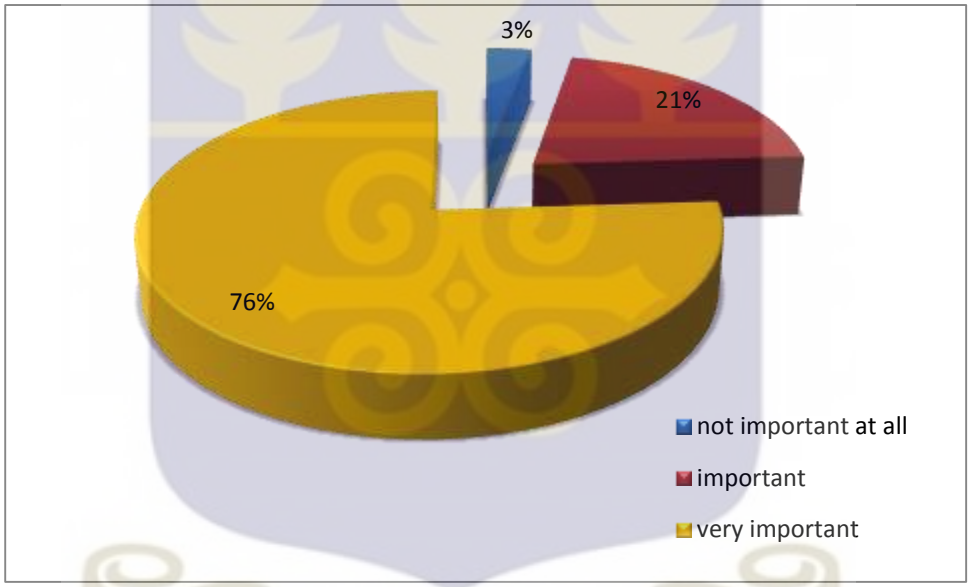


Figure 4.26: Respondents indication of how important the lagoon is to them.
Source: Field work, 2014.

4.10.2 Respondents' use of the lagoons

Almost all the respondents had some form of use for the lagoons in their respective localities. Majority of the respondents (71 %) use the lagoon as a place for fishing, while about 15 % use it for recreation purposes, 7.5 % and 5 % rather use it as a site for relaxation. One respondent did not answer (Figure 4.27).

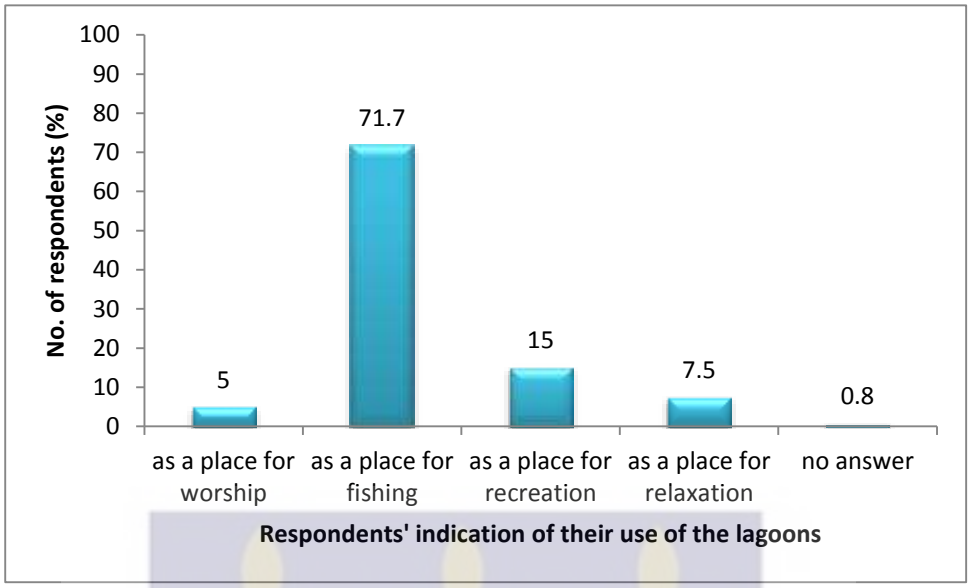


Figure 4.27: Respondents' use of lagoons.

Source: Field work, 2014.

4.10.3 Threats to the lagoons

On the issue of whether they agreed that the quality of the water in the respective lagoons was good, an overwhelming majority of respondents (84.2 %) showed their utmost disagreement; an equally high percentage of the respondents (70 %) agreed that there were litter in the lagoons indicating that they were fully aware that the litter on the banks of the lagoon indeed has a link to the quality of the water in the lagoons. Still more than half of the respondents (66.7 %) agreed that waste water is discharged into the lagoons but 20.8 % others disagreed and 12.5 % were undecided and claimed they have not witnessed the act before. Interestingly, a high percentage of the respondents (83.3 %) confirmed that there is direct defecation and disposal of human excreta into the lagoons; this is an indication that the act is pervasive along. Few respondents forming about 13 % disagreed and 4 % others were undecided on the issue.

Concerning the issue of whether the lagoons were used as dumping sites, again majority of the respondents (71) forming 59.2 % agreed while 22 others (18.3 %) disagreed to the statement; as

many as 27 other respondents forming 22.5 % were undecided. More than half of the respondents (55 %) indicated that they could smell an unbearable scent around the lagoon but 28.2 % others disagreed; 16.7 % were undecided on the issue.

While almost half of the respondents (59) representing 49.2 % agreed that the litter found on the banks of the lagoons were from the sea whiles 40 others forming 33.3 % disagreed but 21 (17.5 %) were undecided on the issue (Figure 4.28).

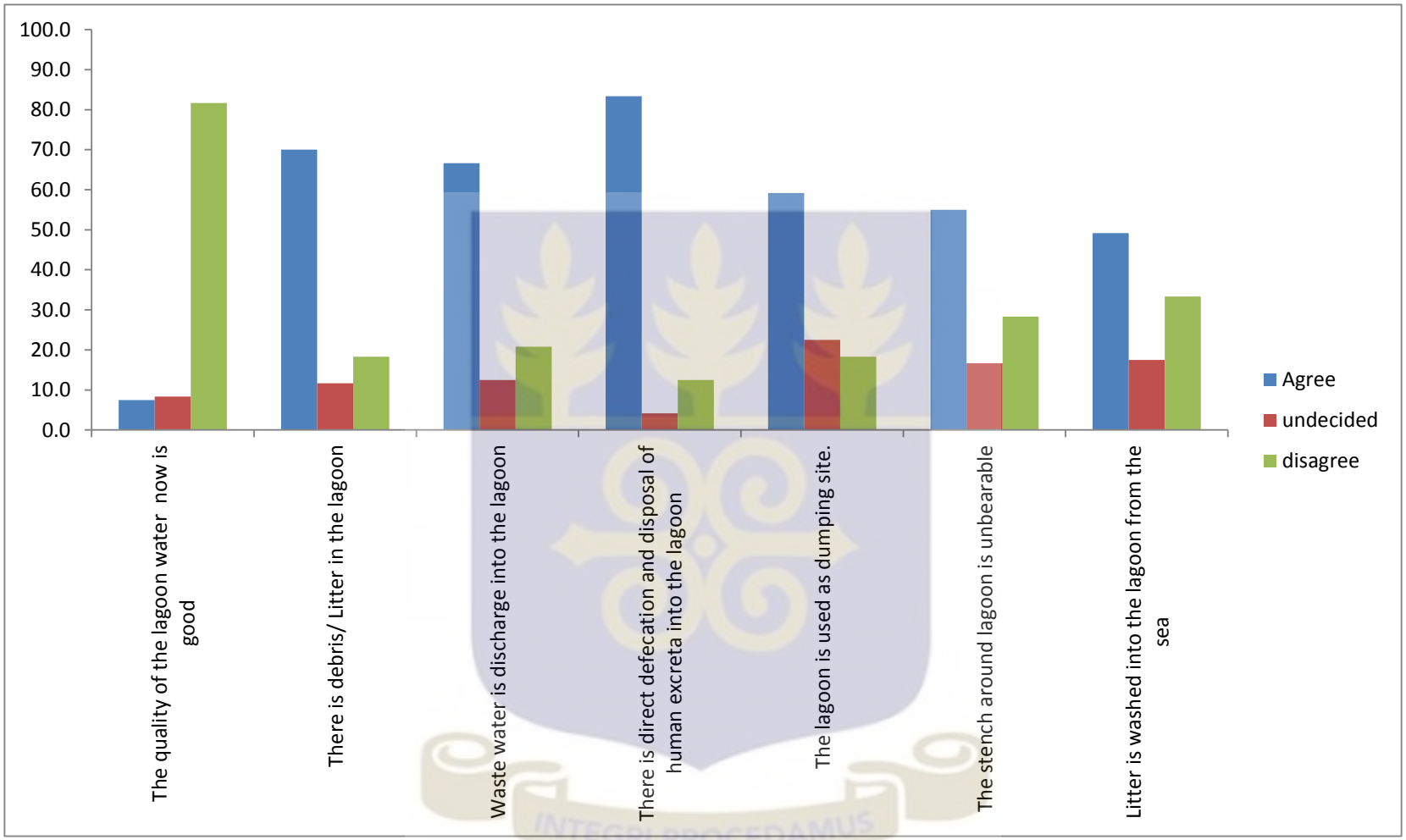


Figure 4.28: Respondents perceptions on the issues that threaten the lagoons.

Source: Field work, 2014.

4.10.4 The state of litter in the lagoons

On the whole majority of the respondents have a fair idea of the various conditions that threaten the life of the lagoons and could tell the state of most of the lagoons. More than half of the respondents (56 %) were of the view that the lagoons were moderately littered while 46 % indicated that they were heavily littered. Only 2 % of the respondents said that the lagoons were not littered at all (Figure 4.29). The respondents' general perceptions on the litter load on the banks of the lagoons therefore show that majority of the respondents (66.7 %) have noticed that overtime the load of litter on the banks of the lagoons has been increasing, 25 % of the respondents also indicated that the volume of the litter are rather decreasing. Only 8.3 % were of the view that the litter load they see currently have not changed over time (Figure 4.30).

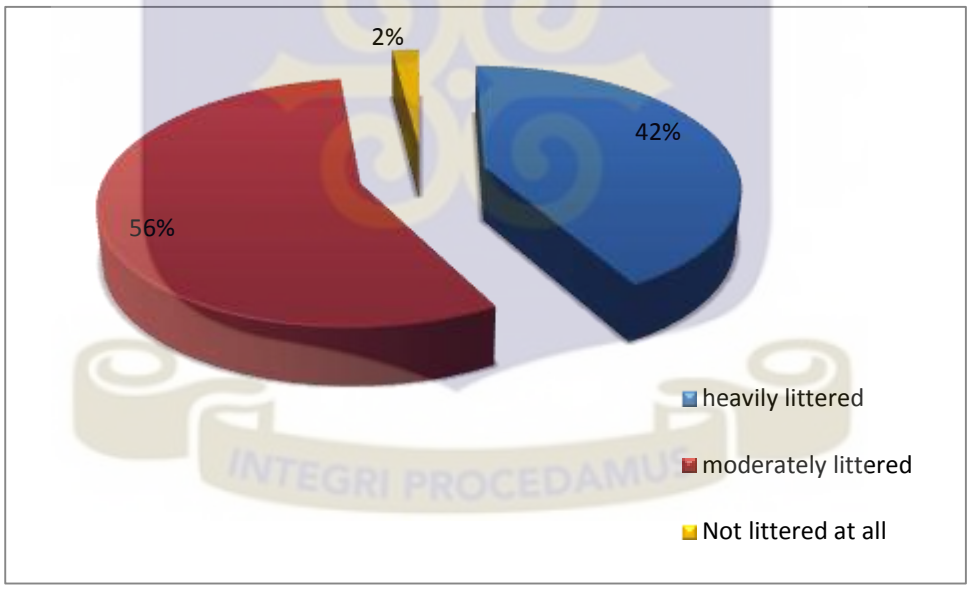


Figure 4.29: The Respondents' perception on the state of litter in the lagoons
Source: Field work, 2014.

The general perceptions of the respondents show that over time the litter load of the lagoon was increasing.

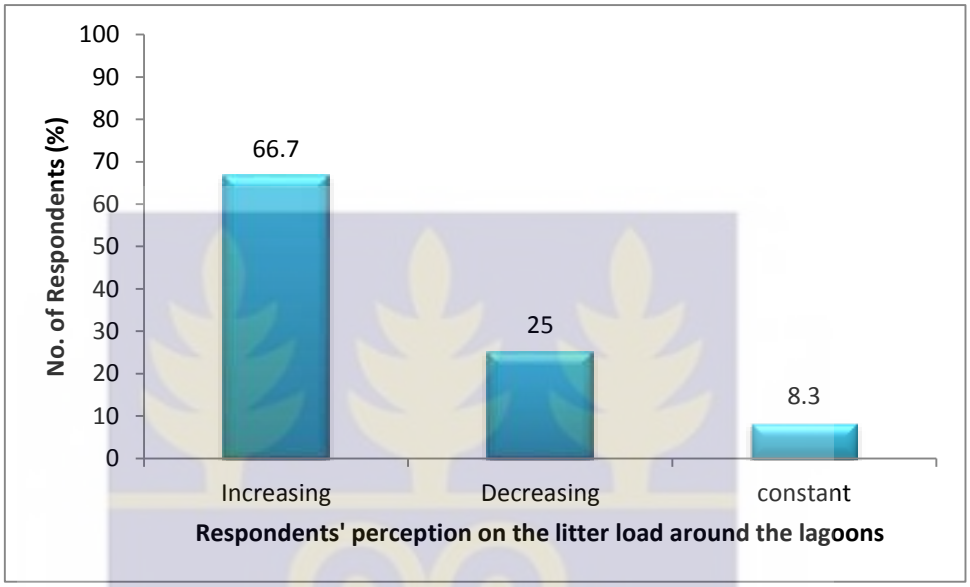


Figure 4.30: Respondents' perception of the litter load on the banks of the lagoons
Source: Field work, 2014.

4.10.5 Respondents' opinions on the sources of litter on the banks of the lagoons

Respondents were requested to rank on a scale of 3 their opinion of the source of the litter on the banks of the lagoons. They were to use 1 for the most probable source and 3 for the least probable source. An analysis of their responses shows that whereas almost half of the respondents (45 %) claim that litter was brought on the banks of the lagoons by inland waters, 36 other respondents representing 30 % indicated that they were deposited there by people who use the lagoons for recreational activities. Few respondents (13.3 %) said that the litter were deposited by visitors to the lagoons. Again very few other respondents (7.5 %) were of the view that litter were there because people use the lagoons as dumpsites for their refuse. Only

4.2 % of the respondents showed that the lagoon receives the litter dumped into the sea by the people on board the vessels and also wash them unto its banks during its high tide (Figure 4.31).

It could be inferred from the results that all the respondents agree that the debris on the banks of the lagoons were deposited there through one source or the other and that human activities were responsible for the presence of the litter on the banks of the lagoons.

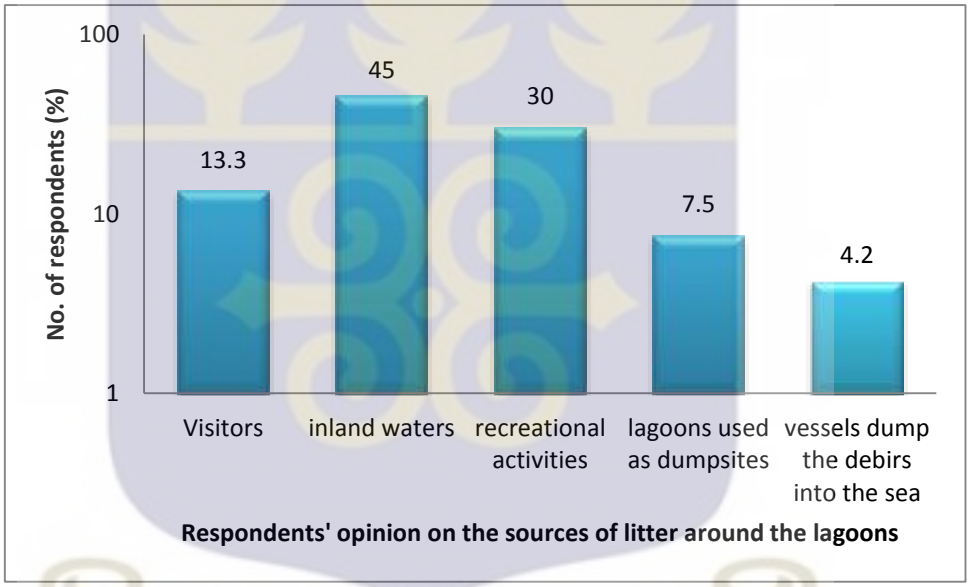


Figure 4.31: Respondents' opinions on the sources of litter on the banks of the lagoon.
Source: Field work, 2014.

4.10.6 Drivers of the deposition of litter on the banks of the lagoons.

On the issue of why respondents leave their litter they generate around the lagoons, whereas 38 % of the respondents were of the veiw that people dropped their litter around the lagoons because of their ignorance about the importance of the lagoons, an equally high percentage of other respondents (37 %) explianed that people act that way because of the lack of waste bins

around the lagoons but 25 % of the respondents also said that litter is dropped on the banks of the lagoons because people perceive lagoons as wastelands (Figure 4.32).

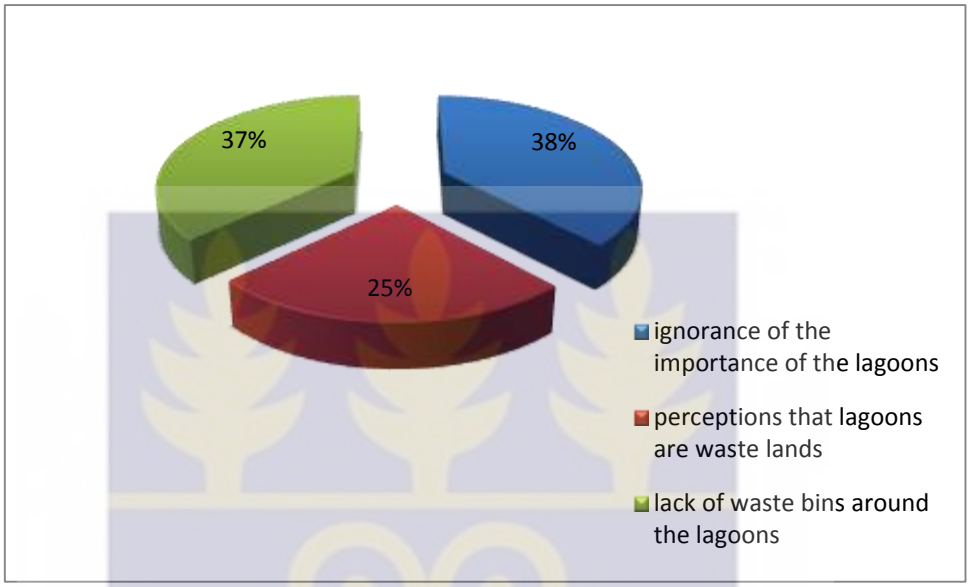


Figure 4.32: Repondents' perception on why people leave litter in the lagoons
Source: Field work, 2014.

4.10.7 Perceptions on people's contribution of litter on the banks of the lagoons

On the whole, respondents perceive that visitors contribute significantly to the accumulation of litter on the banks of the lagoons since only 16 % indicated that they see visitors carrying their litter away while as many as 64.2 % indicated that visitors just leave their litter around the lagoons and 18 % others said the visitors throw the litter in the bushes nearby the lagoons. Only 2 % of the respondents said the visitors burn the litter they generate around the lagoons.

Interestingly, 70 % said of the respondents said they have never tried to advice the visitors against their actions, only about 36 respondents forming 30 % said they have ever adviced the

visitors to the lagoons on their littering attitudes. Of the 70 % who have never adviced the visitors on their actions, majority (49) representing 70 % explianed that they would not attempt to advise them for fear of being insulted, 18 others representing 25 % said they just do not have the courage to do so whereas 3 (5 %) others explianed that advising them would not be necessary since the visitors will still litter anyway (Table 4.5).

Table 4.5: Respondents' perceptions on people's contribution to the deposition of litter on the banks of the lagoons.

Statement	Frequency	Percentage	Cumulative frequency
Do you see visitors drinking water during their visit			
Yes	108	90.00	90.00
No	12	10.00	100.00
Total	**120**	**100.0**	**100.00**
Where do the visitors leave their litter			
The leave them around the lagoon	77	64.20	64.20
The carry them away	19	15.80	80.00
The burn them	2	1.70	81.70
The throw them away in the bushes	22	18.30	100.00
Total	**120**	**100.00**	**100.00**
Have ever tried to advice someone littering around			
No	64	70.00	53.30
Yes	56	30.00	100.00
Total	**120**	**100.00**	**100.00**
What prevent you from advising someone littering around the lagoon			
I will receive insults in returns	49	70.00	70.00
I don't have the courage to advice that person	18	25.70	95.70
The person will still litter if I do	3	4.30	100.00
Total	**70**	**100.00**	**100.00**

Source: Field work, 2014.

4.10.8 Respondents' own contribution towards the accumulation of litter on the banks of the lagoons.

Almost all respondents (82 %) also consume food and or beverage when they are around the lagoons only 18 % indicated that they do not consume anything when they are around the lagoons; but all 92 % apart from 10 respondents representing 8.3 % drink water when they visit the lagoons.

Interestingly, a little over 50 % of the respondents (52 %) also leave their own litter they generate on the banks of the lagoons just as they indicated for the case of the visitors. 21 % said they carry their litter home while 4 % others burn their litter. As much as 27 respondents (23 %) also said they throw their litter into the bushes (Table 4.6).

On the whole the respondents admit that their actions to a large extent also contribute to the accumulation of litter on the banks of the lagoons

Table 4.6: Respondents' contribution on the deposition of litter on the banks of the lagoons.

Statement	Frequency	Percentage	Cumulative frequency
Do you consume food and or beverage when you are around the lagoon?			
Yes	98	82.00	82.00
No	22	18.00	100.00
Total	**120**	**100.00**	**100.00**
Do you drink water during your visit to the lagoon?			
Yes	110	92.00	92.20
No	10	8.00	100.00
Total	**120**	**100.00**	**100.00**
Where do you leave the litter you have generated around the lagoon?			
Leave directly around the lagoon	62	51.67	51.67
Carry it home	26	21.67	73.34
I burn them	5	4.16	77.50
Throw them away in the bushes	27	22.50	100.00
Total	**120**	**100.00**	**100.00**

Source: Field work, 2014.

4.10.9 Respondents' opinion on the effects of litter accumulation on the banks of the lagoons.

More than half of the respondents (59 %) have had a cut before while using the lagoon, 42 other respondents forming 35 % have had a disease while the 7 others (approximately 6 %) feel some form of discomfort using the lagoon due to the litter accumulated at the banks of the lagoons (Figure 4.33).

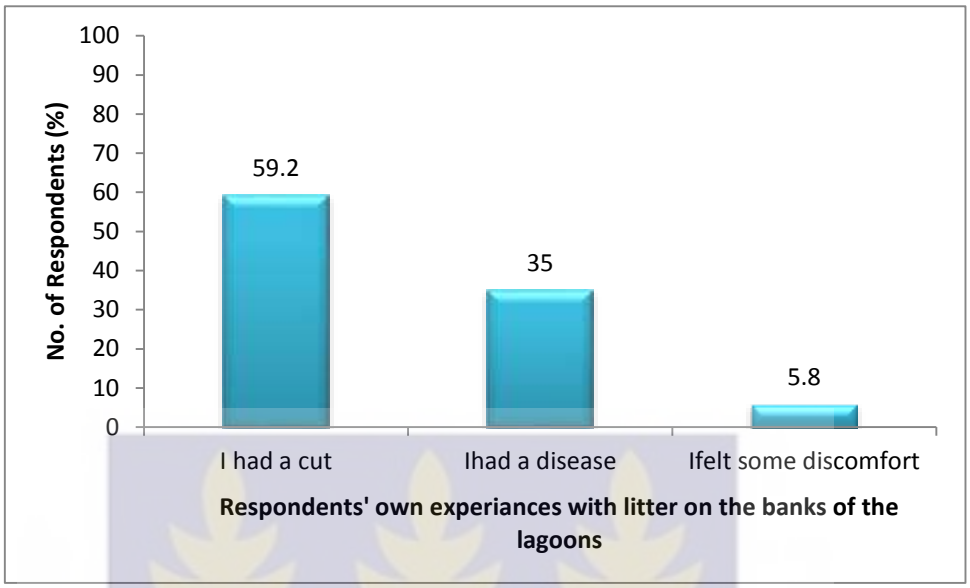


Figure 4.33: Respondents' experience with litter on the banks of the lagoons.

Source: Field work, 2014.

4.11 Management of litter on the banks of the lagoons

4.11.1 Respondents' view on the management of litter on the banks of the lagoons

Concerning the extent to which litter on the banks of the lagoons were cleaned as many as 80 respondents (67 %) indicated that they had never experienced any form of cleanup activities organised to extend to the banks of the lagoons before; only 40 of them (33 %) indicated that the communities around the lagoons organise cleanup activities to clean the litter on the banks of the lagoons (Figure 4.34). When asked to indicate the frequency with which these cleanup activities were done, 2 respondents of the forty representing 5 % did indicate that cleanups were done weekly; 2 others (5 %) also said the cleanup exercises were done monthly. A number of respondents forming 20 % of the group also said it was done quarterly whereas 57 % noted that the cleanups were organised annually and 13 % others declined to answer (Figure 4.35).

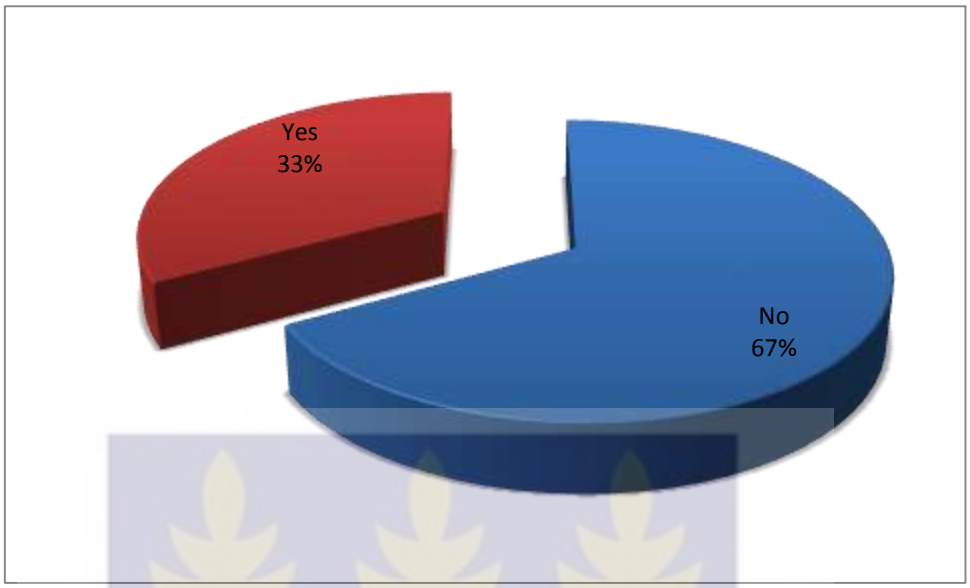


Figure 4.34: Respondents' perceptions on cleanup exercises round the lagoons

Source: Field work, 2014.

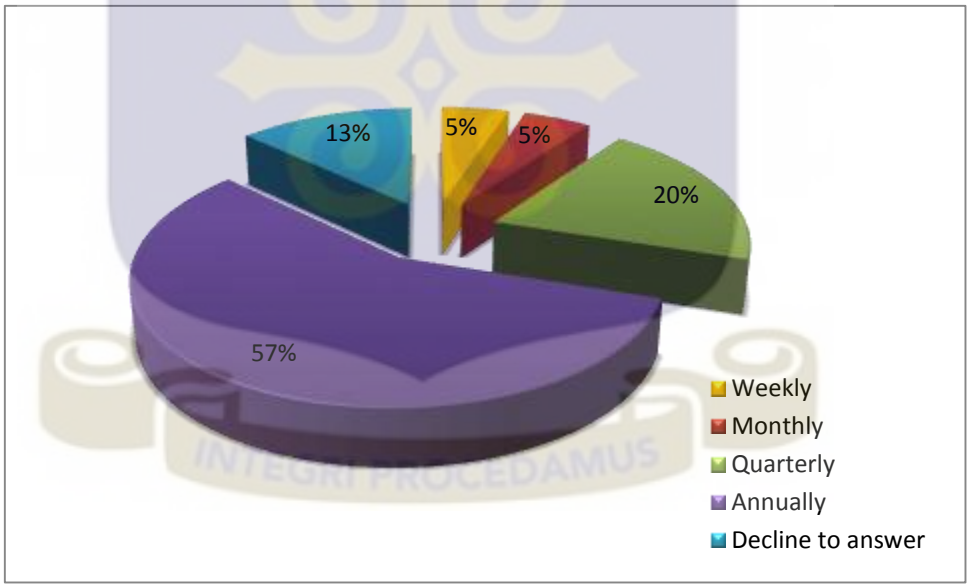


Figure 4.35: Respondents' perception on the frequency of cleanup exercises around the lagoons.

Source: Field work, 2014.

4.11.2 Respondents' willingness to participate in clean-up activities on the banks of the lagoons.

To assess the extent to which respondents who have witnessed some clean-up around the lagoons showed environmentally responsible behaviour and willingness to assist in cleaning up the litter, respondents who had indicated that they had not witnessed any such activities clean-up activities were asked whether they would get involved in clean-up activities should it be organised. Almost all 80 respondents (75 %) said they would take part. Only 16 % said they would not participate and 9 % other however refused to answer the question (Figure 4.36).

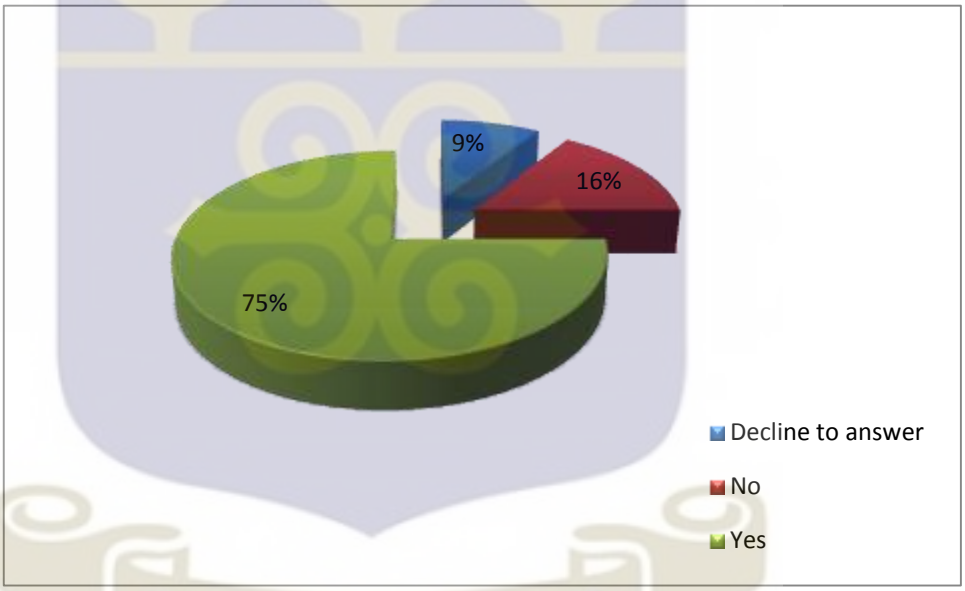


Figure 4.36: Respondent's participation in cleanup activities around the lagoons. Source: Field work, 2014.

4.11.3 Solution to the littering problem

Majority of the respondents (51 %) suggested that the provision of waste bins at vantage points around the lagoon will help solve the litter problem, 26 others representing 22 % rather suggested that some form of punitive measures should be instituted to deter users of the

lagoons from littering; but 33 others (27 %) were of the view that educating users of the lagoons will help to solve the littering problem (Figure 4.37). Meanwhile, majority of the respondents (59 %) indicated that the communities within which the lagoons are located should be responsible for the management of the litter on its banks. Others (30 %) rather suggest that the government through her district assemblies should be responsible for the management of the litter along the banks of the lagoons. Only 13 respondents representing about 11 % think that the polluters of the lagoons should be responsible for their own litter (Figure 4.38).

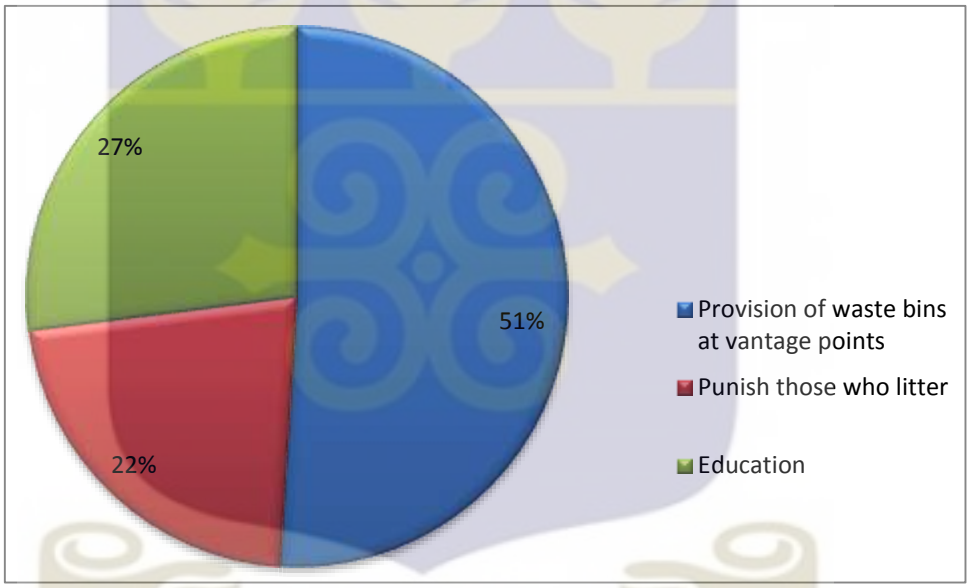


Figure 4.37: Respondents' opinion on how the littering problem could be solved.
Source: Field work, 2014.

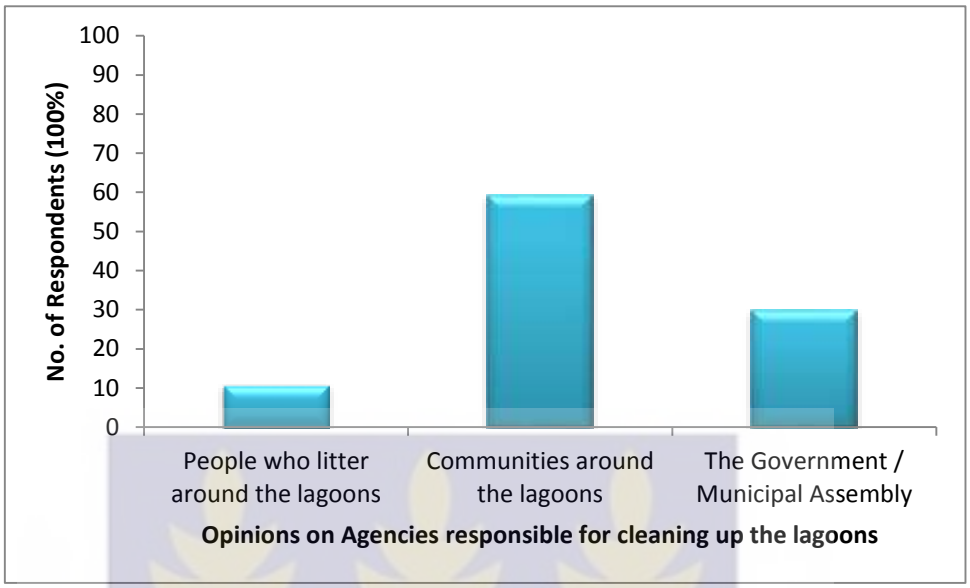


Figure 4.38: Respondents' view on who is responsible for cleaning up the litter in lagoons
Source: Field work, 2014.

4.12 Cross tabulations of selected responses and littering behaviours

4.12.1 Importance of lagoons and disposal practices

One would have expected that majority of the respondent who have indicated that the lagoons were important to them would demonstrate environmentally responsible behaviour by not littering around the lagoons but a crosstab of the respondents' opinion on how important the lagoons are to them and their own disposal practices reveal that only 3 respondents of this group carry their litter home whereas as many as 9 others just throw their litter away in the bushes around 13 of the 25 respondents who said that the lagoons were very important to them leave the litter they generate when they are around the lagoons directly on the banks of the lagoons..

Again, as many as 47 of the 91 respondents who indicated that the lagoons were important to them also leave their litter directly on the banks of the lagoon while an equally high number of the same group (16) also just throw their litter into the bushes around. Only 5 respondents said they burn their litter while 23 of them indicated that they took their generated litter home. As expected, half of the respondents (2) who said that lagoons were not all that important left their litter directly around the lagoon whiles the other 2 also threw their litter away in the bushes around.

All in all, it is interesting to note that as many as 60 respondents who had indicated that lagoons were of some importance to them rather disposed of their generated litter directly into the lagoons and 25 others also just threw them into the bushes around the lagoon. Only 26 respondents out of as many as 116 who had shown that lagoons were of some significance to them carried their debris home for proper disposal while only 5 of them burnt them (Table 4.7).

Table 4.7: Crosstab between how important lagoon is to the respondents and their own disposal practices.

Important	Their disposal practices				
	Leave it directly into the lagoon	Carry it home	Burn them	Throw them away in the bush	Total
Very important	13	3	0	9	25
Important	47	23	5	16	91
Not important	2	0	0	2	4
Total	62	26	5	27	120

Source: Field work, 2014.

4.12.2 Age and disposal practices

From the cross tabulation (Table 4.7.) of the age of the relationship between the age of the respondents and their own littering behaviour, it is observed that out of the majority (60) of respondents the age range 18-25 as many as 43 are not environmentally responsible enough since 24 of them leave their litter on the banks of the lagoons while 19 others throw their litter away into the bushes. Only 14 of them take the generated litter home for proper disposal whereas 3 others burn them.

The above picture is quite similar to the other respondents who are within ages 26-40. For this age bracket, it is observed that more than 50 % of them (18) also left the litter they generated when around the lagoon directly into the lagoon and 5 other just throw them away in the bushes. Only 5 respondents took their litter home for proper disposal. Again an equally high number of respondents (16) within the ages 41- 65 also indicated that they left their litter around the lagoons; 3 of them threw their litter into the bushes around while 2 burnt them. Result from the responses also showed that six other respondents demonstrate environmentally responsible behaviour by carrying their debris home. It is also interesting to note that only 1 out of the 5 respondents aged 66 and above took the generated litter home while the rest (4) also deposited their debris around the lagoon.

All in all, it can be concluded that almost all the respondents of varied age ranges are not environmentally conscious enough as an overwhelming majority (74 %) of the entire respondents (89) either leave debris around the lagoons or just threw them into the bushes around the lagoon. Only about 26 % (31) demonstrate some form of environmentally

responsible behaviour by restraining themselves from littering around and depositing debris into the lagoons (Table 4.8).

Table 4.8: Relationship between age of respondents and their disposal practices

Age	Their disposal practices				
	Leave it directly into the lagoon	Carry it home	Burn them	Throw them away in the bush	Total
18-25	24	14	3	19	60
26-40	18	5	0	5	28
41-65	16	6	2	3	27
66 and above	4	1	0	0	5
Total	62	26	5	27	120

Source: Field work, 2014.

4.12.3 Gender and disposal practices

A cross tabulation of the gender of respondents and their disposal practices as in table 4.9 show that, of the overall male respondents (64), 36 and 19 leave their litter on the banks of the and the bushes around respectively. Whereas only 5 of the male respondents take their litter home for proper disposal, 21 of the female respondents take their litter home for better management. Again, out of the 56 female counterparts, while 26 leave litter around the lagoon, 8 of them also throw them away into the bushes around.

In sum, while 34 female respondents forming approximately 61 % demonstrate environmentally irresponsible behaviour or disposal practices as many as approximately 86 % of the males demonstrate that they are environmentally unconscious by their littering attitude. This fact is also confirmed by the greater number of female who will take their debris home as opposed to a very insignificant number of male who will act similarly (Table 4.9).

Table 4.9: Relationship between gender of the respondents and their disposal practices

Gender	Their disposal practices				
	Leave it directly into the lagoon	Carry it home	Burn them	Throw them away in the bush	Total
Male	36	5	4	19	64
Female	26	21	1	8	56
Total	62	26	5	27	120

Source: Field work, 2014.

4.12.4 Educational attainment and disposal practices.

A cross tabulation of the educational attainment of respondents and their disposal practices reveal the following. Firstly out of the 30 illiterates respondents, whereas 3 throw their debris away into the bushes around, a significant percentage of this group (90 %) numbering 27, just leave their litter on the banks of the lagoons. Second, majority (56 %) of those with some form of adult literacy also leave their litter around the lagoons while only 1 of them carries it home. Two respondents of this category burn their litter and one other rather throw it into the bushes around. Third, as many as 14 (52 %) out of the 27 primary school educational leavers would throw their litter into the bushes around while 11 others representing approximately 41 % would rather leave their debris around the lagoons; only 2 respondents in this segment would carry their litter home for proper disposal. Next, majority of the 17 JHS leavers constituting 65 % said they normally leave their litter around the lagoon, 4 others throw them away into the bushes around the lagoon.

Only 2 of them carried their litter home. Forth, it is interesting to note that 50 % of the SHS respondents would all take their litter home for better disposal while 8 and 5 would leave their

litter around the lagoon and throw them away in the bush respectively. Finally, of the 9 graduate respondents none of them throw litter away around the lagoon or into the bushes around but approximately 78 % (7) will all carry their litter home for a better disposal while the rest forming about 22% (2) will rather burn them.

All in all it can be inferred from the above that all (100 %) the illiterate respondents (30) who use the lagoon for one purpose or the other would leave their litter either directly around the lagoons or throw them away in bush around it; but quite a significant proportion of the other respondents (34 %) who have attained some form of educational qualification would either carry the litter home or burn them even though an equally higher percentage of these respondents numbering 60 (approximately 66 %) also throw litter around or into the bushes around the lagoons (Table 4.10) .

Table 4.10Relationship between respondents' educational attainment and their disposal practices.

	Their disposal practices				
Education	Leave it directly into the lagoon	Carry it home	Burn them	Throw them away in the bush	Total
Illiterate	27	0	0	3	30
Adult	5	1	2	1	9
Primary	11	2	0	14	27
JHS	11	2	0	4	17
SHS	8	14	1	5	28
Graduate	0	7	2	0	9
Total	62	26	5	27	120

Source: Field work, 2014.

CHAPTER FIVE

DISCUSSION

5.0 Spatial and temporal variation in litter accumulation

The collection of close to five tonnes of litter from the banks of only five lagoons over a 6 months period is not only an indication that the rate of accumulation of litter - on the entire coast of Ghana from the west to the east -is on an increasing trend but also that, solid waste pollution is a major environmental problem that is continually plaguing coastal lagoons and gradually bringing them to a state of disrepair. Thus the continuous deposition of litter on the banks of coastal lagoons may lead to the collapse of their functional unit in Ghana if the situation continues unchecked. The enormous debris registered is also in agreement with Gregory (2009) that, litter in estuaries and lagoons persist in larger quantities.

Like other beach litter surveys (Corbin and Singh, 1993; Golik and Gertner, 1992), this study also confirms the dominance of plastic litter in all sites surveyed. The results show that plastic debris was the most prevalent litter type across time and space as reported in studies conducted by STAP, 2011, Tsagbey *et al.*, 2009, Ryan *et al.*, 2009 and Nunoo & Quayson, 2003. For example at the Kpeshie lagoon, like all the other sites, plastic litter dominated in terms of abundance and diversity. The consistent dominance of the Plastics over the six months data collection period and across the entire sampling sites confirms the dominant use of plastic materials in many of life activities particularly for wrapping purposes and as receptacles for drinking water (Allsopp *et al.*, 2006).

Fabric litter deposition along the banks of the lagoons could only be associated with direct deposition by beach attendants or indirectly by wave and current action where entanglement by vegetation is not anticipated. Naturally, most fabric items easily sink to the bottom of the water and so their accumulation on the banks of the lagoons could only be by wave or fast moving currents. Metallic and glass debris deposition could also be direct or carried by swift current from adjoining areas since they are prone to sink if they collect the lagoon water. Paper and process wood litter may have also been deposited along the banks of the lagoon through flood storms and waves.

The result from the study shows that the Kpeshie lagoon also recorded the highest load of polystyrene, paper and process wood. It also recorded the second highest load of glass and metal debris indicating that it is the highly impacted among the other four lagoons and so could undergo the highest negative effects of the presence of litter in lagoons should the accumulation processes continues. The pervasiveness of high litter load on the bank of the Kpeshie lagoon again suggests that it might be receiving the litter from regular sources such as from the dump sites located close the lagoon. Comparatively, this lagoon seems to be the only one among the other four that is exposed to numerous dump sites within its periphery and also receive regular recreational activities. It is therefore not surprising that it is receives the highest litter and has the litter diversity.

Mukwei lagoon registered the highest glass and metal debris and the second highest load of polystyrene, process wood and paper debris. This signifies that it is the second highly polluted lagoon. The possible source of these litter types could also be due to unmanaged dumpsites

nearby. The occurrence of such litter items as glass objects on the banks of the Mukwei and the Keta lagoons and metallic objects on the banks of Mukwei, Sakumo II and the Gao lagoons is a cause for concern as these debris could cause lacerations and pose danger and hazards to fishers and other users of the lagoon when they accidentally step on them.

Majority of the glass materials found at the Mukwei site for instance, were mainly containers for liquor and fruit juices that have been carelessly left while those found at the Keta lagoon were predominantly broken schnapps bottles which have been used as an indigenous fishing gear by the fisher folks in the area(Entsua-Mensah *et al.,* 2000). It could also be hypothesised that the dominance of this particular glass litter type (Schnapps) could be either remnants from worship activities around the lagoon or the direct deposition by communities living around the lagoon.

The analysis of the results from the social survey confirms that the occurrence of glass and metallic litter around the lagoons could render the lagoons unsafe to users as more than 50 % of the respondents interviewed confirmed that they have had cuts from such debris when using the lagoon resource. 35 % others also showed that they have discomforts using the lagoon when it has debris all around it. This observation resonates with the opinions expressed by Sheavly and Register (2007) and Dixon and Dixon (1981).

Again the occurrence of other litter categories such as fabric items, processed wood, polystyrene in almost all the lagoons pose significant threat to biodiversity as they can cause smothering of benthic organisms and injury to users of the lagoon (UNEP, 2005). The Gao

lagoon for instance recorded the second highest count of fabric, rope/nets and the third highest metallic objects, paper, process wood and polystyrene and so designates it as the third most polluted lagoon among the study sites.

Sakumo II lagoon recorded the highest fabric litter, the second highest plastic bottles litter and could be considered as the fourth most polluted lagoon. Fabric and plastic litter could be from inland sources or from the sea. The Plastic bottles in particular may have been deposited on the several beaches dotted along the stretch of coastline from Mukwei to Tema where recreational activities are regular. The tidal action of the sea then transports these unto the bank of the lagoon.

5.1 Litter abundance and diversity across site

The sources of litter load on the banks of the lagoons could be site specific and most probably anthropogenic. This is shown in the trend of litter abundance, diversity, types and rate of accumulation at each of the sites studied. The decreasing trend in litter abundance from the West to East with Kpeshie lagoon being the most polluted lagoon as compared to the other lagoons is as a result of its closeness to the La pleasure Beach Resort, La Royal Palm Resort, the Accra Trade Fair Centre and the La community. The possibility of these resorts centres and the community contributing to the chunk of the litter into the Kpeshie lagoon is very high since there is lax in the enforcement of regulations to control littering and domestic and industrial waste disposal. These wastes are either dumped at dumpsite or burnt at the nearest disposal sites within the vicinities where they are generated.

The high litter load and diversity in the Mukwei lagoon could also be due to the litter inflow from the Sakumono Estate, Nungua Township as well as Regional Maritime University and possible beach attendance at the Mighty Beach.

The higher litter diversity observed on the bank of the Gao lagoon as compared to the other lagoons is possibly due to the activities of ships at the anchorage off the Tema Port as well as the proximity of the lagoon to the Tema New Town. It is also likely to be from the activities of beach attendants at the Paradise Beach which is just adjacent to the lagoon. Litter from these probable sources are diverse and are being washed ashore unto the banks of the lagoon due to east ward flow of the sea current as well as the tangential movement of wave and tide to shore.

On the other hand the low diversity of litter load in the Kpeshie and Sakumo II lagoons could be from a unilateral source of the litter which is coming from the resorts along the banks and the shores of the lagoons and the sea respectively. The low litter load on the bank of the Keta lagoon at the Kedzi portion (the farthest study site) could be attributed to low popularity and patronage of the few resort centres around the lagoon thus apart from being the site with the lowest population and hence, its designation as the least polluted of all the lagoons, the few litter load at this site is most likely from poor domestic wastes disposal practices of the communities resident as close as just about five meters away from the banks of the lagoon or might probably be from the activities of fisher folks spend most of the time around the lagoon.

The similarity in the monthly rate of accumulation of litter on the banks of each of the lagoons studied is an indication that the possible sources of the litter around the lagoons are quite

similar on monthly basis but varies from one lagoon to the other due to the differences in recreational activities and the social gatherings organised during holidays at the beaches where most of the lagoons are located (Nunoo & Quayson, 2003; Golik and Gertner, 1992).

It is expected that urban dwellers for example would be more environmentally conscious than their rural counterparts due to the differences in the educational advancement in these areas; this expectation was however not evident in this study as high litter abundance were observed on the banks of lagoons closer to the urban centres as compared to less litter abundance on the banks of lagoons near rural areas; this observation only confirms the fact that population differences is a major factor influencing the accumulation of litter on the banks of lagoons rather than education (Tsagbey *et al*., 2009).

5.2 Plastic litter Distribution

The most dominant and prevailing plastic litter observed at all the sampling sites and throughout the period were plastic bottles, pure water sachets, black polythene strands, locally tied pure water sachets, crisp/sweet wrappers and other wrappers for alcohol, detergents and food. The bottles were identified as containers mainly for water, juice and liquor which are associated with camping activities by Christian and other traditional worshippers, holiday makers and fishers. There were however few plastic bottles which had been used to store medicines. This observation suggests that each lagoon is being used as a direct sink for litter(Silva *et al.*, 2013).

At the Kpeshie site, the most dominant plastic litter types were plastic bottles, pure water sachets (PWS), crisp and sweet wrappers (CSWP), locally tied pure water bags (LTPWB), disposable cups (DCS), Black polythene strands (BPS), plastic tops and lids (pl. top/lids), food wrappers (FDWP) and alcoholic wrappers (ALCO) and formed about 500 items / 5000 m^2. These items certainly come from points such as from resorts centres and beach attendant. Only a few of such litter as locally tied pure water bag (LTPWB), food wrapper (FDWP) and black poly strands (BPS) might emanate from non-point sources such as the many dumpsites sited indiscriminately dotted around the periphery of the lagoons. These could be considered as high priority litters for any management plan.

The dominant plastic debris observed along the bank of Mukwei lagoon is also mainly composed of PWS, plastic bottles, BPS, CSWP, DPCs and LTPWB. The origin of these types of plastic litter could be several; it could be hypothesised that the abundance of the PWS is particularly due to the high patronage of water in sachet bags by low income earners who depend on it as their main source of drinking water. There are also quite a significant number of plastic bottles mainly identified as Voltic, Bellaqua, Special ice and other bottles for storing water. There were also some bottles which were quiet difficult to identify what they may have contained though it is most probable that they were used to store alcoholic beverages. It could also be conveniently hypothesised that the predominance of these bottles could be attributed to their high patronage of commodities they store by the rich in the society.

At Sakumo II lagoons, plastic bottles, PWS and BPS were the dominant plastic litter items. Again the plastic bottles are likely to come from the beach resorts dotted along the Tema

Beach Road while PWS and BPS are most likely to from the activities of beach attendant, food vendors and fishermen within the periphery of the lagoon.

At the Gao lagoon site the most prevailing plastic litter types were plastic bottles, PWS, BPS, DPCs, pl. cutlery, ALCO, HPLTS, STRW, FDWP and LTPWB. The source of the plastic bottle, DPCS, STRW and hard plastics (HPLST) litters into the Gao lagoon could be directed as ships that are at the anchorage off the Tema Port. The community within the Tema New Town are mainly fisher folks and are mostly low - income earners who probably could not afford to patronise water in plastic bottles as their source of portable water. PWS and ALCO, BPS, LTPWB and HPLTS could be as a result of fishers and probable beach attendant. The rest could be due to dumpsites which might be located near Tema New Town.

At the Keta lagoon the dominant plastic litter items were PWS, BPS and PTPWB. The possible sources of these debris types could be from the trading activities by traders who trade their wares to the fisher folks or could possibly come from dumpsites that are located on the bank of the lagoon and along its periphery. This is in agreement with the analysis of the results from the social survey. It was revealing to note that the respondents themselves were found culpable of this unfortunate environmental irresponsibility when majority of them (74 %) indicated that they themselves also throw their litter around the lagoons and into the bushes. These individuals are obviously environmentally unconscious of the impact of the plastic bottles they litter on the ecosystem of the surrounding water bodies.

5.3 Sources of litter

Public related sources consistently dominated the quantities of litter collected at all the study sites and throughout the study period. Though litter from the public source was the most dominant across the study sites, in terms of quantities, the Kpeshie lagoon recorded the highest public litter followed by Mukwei, Sakumo II, Gao and Keta. This is an indication of poor public attitudes towards environmental sanity in these areas. The study also confirms the prevalence of land based litter sources unto the banks of the lagoons (MCS, 2009; Nollkaemper, 1994).

The non - enforcement of by laws on the disposal of solid waste and littering could the main reason for the indiscriminate dumping of such waste anywhere and unto the banks of the lagoons. This trend in public litter around the lagoons could also be due to frequent recreational activities organised around the vicinities of some of the lagoons. Other litter sources such as sewage related debris (SRD), medical waste, fishing and shipping as well as non – source litter accounted for an infinitesimal proportion of the entire litter collected during the survey and might originate from diffuse sources.

5.4 Possible management plans for plastic litter in the lagoons

Analysis based on Euclidean distance of 9.33 grouped the plastic litter types either into two or three broad clusters across the study sites. The most abundant and the less abundant litter types were clearly separated out for easy identification and recognition. This implies that the probability of finding these items together is high. It further implies that the management mechanism that could be used to manage the plastic litter types could be directed at specific target group or cluster in order to effectively manage the plastic litter pollution on the banks of

the lagoons. It is therefore possible to categorise the management of plastic litter into two broad groups however specific priorities could be assigned to each management plan. For example at the Kpeshie lagoon, the clustering of litter under cluster 'A' indicates that the occurrence of plastic bottles is associated with PWS, SCWP, ALCO and DPCS. However MDS plot shows that the occurrence of plastic bottles is significantly different from the other plastic litter types.

The occurrence of PWS was also different from the cluster consisting CSWP, ALCO and DPCS group even though they were grouped as one cluster. Again the clustering of items such as LTPWB and BPS together with plastic cutlery, DETWP and plastic lid/tops is a clear indication that these plastic items are associated together. Again within the same cluster TOTHP, MEDITEM, condom and TOTHB are also grouped separately. This is an indication that all the plastic types found in each sub-groups are highly correlated and that there is a high probability of finding them together.

The association of the plastic litter types also suggest that the occurrence of CSWP, ALCO and DPSCS are likely to be due to recreational activities at the beach but PWS and plastic bottles is a combined activities of both recreational and beach resorts. For priority measures four management plans is possible to address the plastic litter generated by beach attendants and resorts operator these plans should focus on addressing the issue of better was management at the source of the generation, thus the beach resort operators should be encouraged to adopt the method of segregating the waste for recycling rather than allowing these litter to be washed unto the banks of the lagoons. Thus, the current management of sweeping and gathering all

litter items adopted by the metropolitan assemblies may not be effective in dealing with the litter load on the banks of the lagoons if the source of the problem is not solved.

Mukwei lagoon registered the most diverse plastic litter types however there was no significant differences in their abundance; this implies that the source of litter can be attributed to non-point sources and so managing a specific litter type will most likely be difficult and unsuccessful in yielding better result. However, since PWS, CSWP, PL. bottles and DPCS well as plastic top/lids and STRW are clustered together separately as the most abundant high priority could be assigned items in this cluster by identifying their respective sources for effective management. At the Sakumo II lagoon for instance, the major management plan could be the focus on the plastic bottles since it formed the most outstanding plastic litter type that accumulate at the bank of the lagoon. Another priority measure can now be focused on the other plastic litter types. For complete solution to the plastic litter problem on the banks of the lagoon the respective perceived sources could be targeted and solutions found at the source of their generation.

Gao lagoon registered the second highest plastic litter diversity with much significant difference between litter abundance during the months. The euclidean distance analysis and again grouped the plastic litter into two broad categories. The most abundant litter types were grouped under three sub-clusters indicating that for specific management strategy, plastic bottles should be managed alone, PWS, DPCS, CSWP, D/CGS, ALCO and PL.CUTL should also be handled separately while BPS, condom, STRW, FEDWP and HPLTS also be treated differently.

Plastic litter diversity was high at the Keta lagoon site with significant differences between their abundance the grouping of these litter types into two broad clusters implied that separate management strategies could be given to LTPWS, BPS and PWS alone and another specifically made for HPLTS, ALCO, CSWP, PL. bottles.

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APPENDICES

APPENDIX 1

UNIVERSITY OF GHANA

Institute for Environment and Sanitation Studies

QUESTIONNAIRE

Dear Respondent,

This survey aims at collecting the views on people's perceptions on lagoon litter to determine the social drivers of coastal lagoon litter and requires your responses on the few questions below. The questionnaire is structured in two sections, SECTION A which entails the Demographic Data and SECTION B which borders on the actual lagoon survey and subdivided into three parts as below.

Lagoon Survey: PART I: Respondents` beliefs about the littering of Coastal lagoons;

PART II: Respondents` views on whether their actions have any effect

on Coastal lagoons along the Eastern Coast of Ghana; and

PART III: Respondents` view on the management of litter in the lagoons.

The survey will be carried out along lagoons in the Eastern Coast of Ghana and your supply of responses to the questions is estimated to take approximately 20 mins of your time.

Please be assured that all your answers are anonymous and will be treated with the utmost confidentiality. Kindly answer the questions as objectively and honestly as possible.

Thank you very much for your cooperation.

Will you like to take part in this survey? YES [ ] NO [ ], if YES, go to Question Section A.

Section A: Demographic Data

1. Please tick the age category you belong to

a) 18-25 [ ] b) 26-40 [ ] c) 41-65 [ ] d) 66 and above [ ]

2. Gender a) Male [ ] b) Female [ ]

3. What is your highest Educational Level Attained?

i. Illiterate [ ]
ii. Adult literacy [ ]
iii. Primary [ ]
iv. JHS/ Middle School [ ]
v. SHS/TECH/Vocational [ ]
vi. Graduate [ ]
vii. Post graduate []
viii. Choose to decline to answer [ ]

4. Please tick in the boxes below the following as applicable to you; I am

a. A local resident in this area [ ]
b. A Ghanaian tourist in this area [ ]
c. An international tourist to this area. [ ]

5. Where do you live?

a. Just close by [ ]
b. 1 Kilometer away [ ]
c. 2 Kilometers away [ ]
d. More than 2 Kilometers away. [ ]

6. What is your primary occupation?

a. Trader [ ] b. Fisherman [ ] c. Farmer [ ] d. Not employed [ ]

e. Others, specify …….

Section B:Lagoon survey Data.

PART I: Respondents` beliefs about the littering of Coastal lagoons

7. How important is the lagoon to you?

a. Important [ ] b. Very important [ ] c. Not important at all [ ]

8. How do you use the lagoon / what do you do with the lagoon?

a. A place for worship [ ] e. For washing [ ]
b. A place of convenience [ ] f. For irrigation [ ]

c. A place for fishing [ ] g. For recreation. [ ]

d. A place for relaxation [ ]

h. Others, specify …….

9. How often do you visit this lagoon?

Very frequently [ ] Frequently [ ] Occasionally [ ] Rarely [ ]

10. Indicate the extent of your agreement to the following concerns about lagoons using the scale of 1-5. (***Circles 1to indicate your least agreement and 5, your strong agreement).***

Lagoon issue					
The quality of the lagoon water is good.	[1]	[2]	[3]	[4]	[5]
There are Debris/ Litter in the lagoon.	[1]	[2]	[3]	[4]	[5]
There are flies and insects around the lagoon.	[1]	[2]	[3]	[4]	[5]
The sprawl of settlement/development around the lagoons is good.	[1]	[2]	[3]	[4]	[5]
Waste water is discharged into the lagoon into lagoon.	[1]	[2]	[3]	[4]	[5]
There is direct defecation and disposal of human excreta into the lagoon	[1]	[2]	[3]	[4]	[5]
The lagoon is used as a dump site.	[1]	[2]	[3]	[4]	[5]
The stench around the lagoon is unbearable.	[1]	[2]	[3]	[4]	[5]
The mangroves in the lagoon are harvested.	[1]	[2]	[3]	[4]	[5]
Litter is washed into the lagoon from the sea.	[1]	[2]	[3]	[4]	[5]

11. What in your opinion is the state of litter in this lagoon?

a. heavily littered [ ] b. moderately littered [ ] c. not littered at all. [ ]

i. ***If you ticked options (a) or (b),*** what is your assessment of litter load in the lagoon?

a. Increasing [ ] b. Decreasing[ ] c. Remaining constant[ ] d.Very negligible.[ ] e. No idea[ ]

12. What in your opinion are the sources of litter into lagoons? (***Please tick at least three sources)***

Source	Rank Using only 1, 2 and 3. (*Use 1 for the most probable source and three for the least probable source.*)
Direct deposition of litter by visitors into the lagoon.	[ ]
Debris is brought into the lagoon by inland waters.	[ ]
Recreational activities along the coast/closer to the lagoon.	[ ]
The use of wetlands as refuse dump.	[ ]
Debris are dumped into the sea by vessels and washed ashore.	[ ]
Coastal communities dump their domestic waste into the lagoons.	[ ]

Others, specify……

13. Why do you think people will drop litter into the lagoon or around it?

a. Ignorance of the value/importance of the lagoon to the ecosystem. [ ]

b. Perception that lagoons and their related wet lands are waste lands. [ ]

c. Lack of waste bins around the lagoon [ ]

d. Do not know [ ]

e. Others, specify……

PART II: Respondents` views on whether their actions have any effect on Coastal lagoons

14. Do you usually consume food and/or beverage when you are around the lagoon?

YES [ ] NO [ ]

i. ***If you answered YES,*** In what container do you consume the food or beverage you bring to the lagoon? ***Otherwise move to QUES 15***.

a. in a plate brought from home [ ]

b. in a disposable plate [ ]

c. in a take away container [ ]

d. in a picnic pack [ ]

e. others , specify ……

15. Do you drink water during your visit to the lagoon?

YES [ ] NO [ ]

i. ***If you answered YES,*** Which type of water do you normally drink? ***otherwise move to 18***

a. plastic bottled water (Voltic) [ ]

b. Sachet water [ ]

c. in a gallon [ ]

d. locally/hand tied water [ ]

e. others, specify .....

16. ***If you answered YES to question 14 and/or 15***, what do you usually do with the litter you generate at around the lagoon? Tick only one answer; ***otherwise move to QUES 17.***

a. Leave directly around the lagoon [ ]

b. Carry it home [ ]

c. I burn them [ ]

d. Throw them away in the bushes [ ]

e. Other,specify.....

17. Have you at least once left litter in the lagoon?

YES [ ] NO [ ]***If you answered YES, did you feel guilty?***

i. YES, I felt guilty [ ]

ii. NO, I did not feel guilty [ ]

18. Do you see people bringing food and /or beverage around?

YES [ ] NO [ ]

i. ***If you answered YES***, in what container do they consume their food and / or beverage they bring to the lagoon? ***Otherwise move to QUES 19.***

a. in a plate brought from their homes [ ]

b. in a disposable plates [ ]

c. in a take away containers [ ]

d. in a picnic pack [ ]

e. others , specify .....

19. Do you see people drinking water during their visit to the lagoon?

YES [ ] NO [ ]

i. ***If you answered YES***, Which type of water do you see them normally drinking? ***otherwise move to QUES 20.***

a. plastic bottled water (Voltic) [ ]

b. Sachet water [ ]

c. in a gallon [ ]

d. locally/hand tied water [ ]

e. others, specify ……

ii. Where do they leave their litter?

a. they leave them around lagoon [ ]

b. they carry them home [ ]

c. they burn them [ ]

d. they throw them away in the bushes [ ]

e. Others, specify……

20. Have you ever seen anybody littering around the lagoon before?

YES [ ] NO [ ],***if you answered NO move to 21.***

i. If you answered YES, did you advice the person against his action?

YES [ ] NO [ ]

ii. If you answered NO, why could you not be able to advice the person

a. I will receive insults in return [ ]

b. I do not have the courage to advice the person [ ]

c. The person will still litter if I did [ ]

d. Others specify ……..

21. Have you suffered any kind of problem associated with litter while you were around the lagoon?

Yes [ ] No [ ]

i. ***If you answered yes***, what happened?

I had a cut [ ] I had a disease [ ] I felt some discomfort [ ]

Others specify, ……

Part III: Respondents` view on the management of litter in the lagoons.

22. Does the community around the lagoon organise any cleanup activity that extends to the lagoon? YES [ ] NO [ ]***If you answered NO, please move to question 22.***

i. How often is the cleanup organised

Weekly [ ] Monthly [ ] Quarterly [ ] Annually [ ]

ii. Do you actively involve yourself in such cleanup activities? YES [ ] NO [ ], ***If you answered YES move to 23,***If NO Why don't you get involved? 23. Will you actively get involved in such cleanup activities around the lagoon when it is organised? YES [ ] NO [ ],

If NO, why?.....

24.What do you think will stop people from littering around the lagoon or the beach?

Provision of waste bins at vantage points around the lagoon and the beaches [ ]

Punishing those who litter. [ ]

Provision of some education to users of the beach and lagoon about Littering [ ]

Others, specify …….

25.What in your opinion is the main problem that the littering of the lagoon can cause?

Impact on human health and safety [ ]

Impact on aquatic life. [ ]

Lagoon becomes unattractive [ ]

Unsure [ ]

Others specify ……

26. Who do you think is responsible for cleaning the lagoon?

a. The people who litter the lagoon [ ]

b. The communities around the lagoon [ ]

c. The government / municipal authority [ ]

d. others specify ……

Thank you for participating in my survey.

APPENDIX 2

DATA SHEET

Area of study: …….. ***Name of lagoon***:…….		
Date:		
ITEMS	*COUNTS*	*WEIGHT*
beverage paper packs		
black poly bags		
bulb pieces		
charcoal		
clothes pieces		
coconut husk		
condoms		
corn comb		
deodorant plastic containers		
designer bags		
disposable cups		
fishing floats pieces		
fishing nets		
foam		
glass bottles		
hard plastics		
industrial transparent poly bags		
locally tie pure water		
mango seed		
metallic cans		
nylon sacks		
paper		
plastic bottles		
plastic containers		
plastic cutlery		
plastic lids/tops/cup		
pure water bottles		
pure water sachet		
ropes		
rubber carpet		
sanitary pads/diapers		
shaving sticks		
shoe		
Simcard holders		
straw		
ITEMS	*COUNTS*	*WEIGHT*

stripes		
Styrofoam		
synthetic hair		
take away packs		
toothbrush		
toothpaste containers		
twines		
unidentified intertwined material		
wood		
wrappers (alcoholic)		
wrappers (detergent)		
wrappers (food)		
wrappers (sweet)		

APPENDIX 3

CATEGORISATION OF LITTER TYPES ACCORDING TO THEIR LIKELY SOURCE.

Source	Litter types
Public Litter	4/6 pack yokes, plastic bags (including supermarket), plastic drinks bottles, cleaning bottles, plastic food containers, plastic toiletries bottles, plastic caps / lids, cigarette lighters / tobacco pouches, combs / hair brushes / sunglasses, crisp / sweet / lolly / sandwich wrappers, cutlery / trays / straws / cups, pens, plastic shoes / sandals, shotgun cartridges, toys / party poppers / fireworks / dummies, polystyrene fast food containers / cups, balloons / balloon string, clothing / shoes / beach towels, disposable barbecues, metal bottle caps, metal drink cans, foil wrappers, household batteries, animal faeces in bags, animal faeces not in bags, paper bags, cartons / tetrapaks (e.g. juice), cigarette packets, cigarette stubs, paper cups, newspapers / magazines, corks, ice lolly sticks / chip forks, glass bottles, glass pieces.
Fishing	Fish boxes, fishing line, fishing net and net pieces <50cm, fishing net and net pieces > 50cm, floats (fishing buoys) / reels, plastic lobster / crab pots and tops, rope / cord / string, polystyrene buoys, polystyrene fish boxes, rubber boots, heavy duty gloves, tyres with holes / rope, fishing weights / hooks / lures, metal lobster / crab pots and tops, wood lobster / crab pots and tops.
SRD	Condoms, cotton bud sticks, nappies, tampon applicators / tampons, toilet fresheners, towels / panty liners / plastic backing strips, wet wipes, other sanitary items.

Appendix 3 Cont.: Categorisation of litter types according to their likely source

Shipping	Plastic cleaner bottles, foreign plastic bottles, plastic oil bottles, industrial packaging / crates / sheeting, mesh bags (e.g. vegetable), strapping bands, aerosol cans, metal food cans, oil drums, milk cartons / tetra packs, pallets / crates, light bulbs / tubes.
	Traffic cones, tyres without holes / wheels, cloth furnishings, car parts / car batteries, scrap metal / appliances / paint tins, pottery / ceramic
Medical	Inhalers, plasters, syringes, other medical items.
Non-Sourced	Plastic pieces <2.5cm, plastic pieces >2.5cm, other plastics, fibre glass, foam / sponge / insulation, polystyrene packaging, polystyrene pieces <50cm, other polystyrene items, light weight gloves, rubber pieces <50cm, other rubber items, cloth pieces, sacking, other cloth items, wire / wire mesh / metal pieces, other metal items, cardboard, other paper items, paint brushes, wood pieces (not twigs), other wood items.

MCS Beachwatch (2009).

APPENDIX 4

OVERALL LITTER COUNT AND THEIR RESPECTIVE WEIGHT ACROSS SAMPLING SITE OVER THE SAMPLING PERIOD.

Months / Sample sites		July		August		September		October		November		December	
		Count	Weight	Count	Weight	Count	Weight	Count	Weight	Count	Weight	Count	Weight
Kpeshi	Total litter	21665	1403350.4	1976	22229.5	4114	111538.1	12,237	246961.6	6656	250184	6529	247044.6
	item/m	216.7	14033.5	19.8	222.3	41.1	1115.4	122.4	2469.6	66.6	2501.8	65.3	2470.4
Mukwei	Total litter	4112	164691.4	3373	60341.1	5516	244914.5	2808	133243	1738	78146.4	1381	56329.32
	Item/m	41.1	1646.9	33.7	603.4	55.2	2449.1	28.1	1332.4	17.3	781.5	13.8	563.3
Sakumo II	Total litter	1973	256835.3	329	8474.2	1991	106857	-	-	145	818288	865	108729.2
	Item/m	19.7	2568.4	3.3	84.7	19.9	1068.6	-	-	146.4	8182.9	8.7	1087.3
Goa	Total litter	5339	402695.8	3895	157300.7	1477	59553.6	1383	52508.1	2624	121848.3	1496	49598.6
	Item/m	53.4	4027	39.0	1573	14.8	595.5	13.8	525.1	26.2	1218.5	15	496

Appendix 4 (count.)

Overall litter count and their respective weight across sampling site over the sampling period.

Kedzi	Total litter	1518	63296.9	906	22785	611	26474	778	21618	695	20351.6	544	20253.8
	Item/m	15.2	633	9.1	22.79	6.1	264.7	7.8	216.2	7.0	203.5	5.4	202.5

APPENDIX 5

OVERALL LITTER COUNT ACROSS SAMPLING SITE OVER THE SAMPLING PERIOD.

TOTAL LITTER COUNTED AT THE KPESHIE SAMPLING SITE

LITTER CATEGORIES	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Fabric	502	78	68	312	294	126
Glass	165	46	330	159	130	48
Metallic	153	55	280	350	103	59
Paper		26	200	780	104	18
Plant materials	468	67	153	138	485	30
Plastic	202 55	1433	343	523	382	168
Polystyrene	624	127	442	507	172	51
Rope / Net					10	30
"Others"					1	40

TOTAL LITTER COUNTED AT THE MUKWEI SAMPLING SITE

LITTER CATEGORIES	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Fabric	215	172	300	107	141	60
Glass	150	33	207	69	255	26
Metallic	110	27	194	112	245	11
Paper	70	15	65	32	6	2
Plant materials	190	135	431	344	200	4
Plastic	2643	2860	3334	1789	837	1190
Polystyrene	963	110	975	355	48	70
Rope / Net	1	16			6	12
"Others"	13	4	12			6

TOTAL LITTER COUNTED AT THE SAKUMO II SAMPLING SITE

LITTER CATEGORIES	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Fabric	155	21	340		2838	178
Glass	7	1	8			1
Metallic	48	11	50		100	16
Paper	8	2			3	10
Plant materials	77	6	29		39	60
Plastic	1415	260	1531		5787	581
Polystyrene	259	24	33		140	8
Rope / Net						
"Others"	2	4	4		18	20

TOTAL LITTER COUNTED AT THE GAO SAMPLING SITE

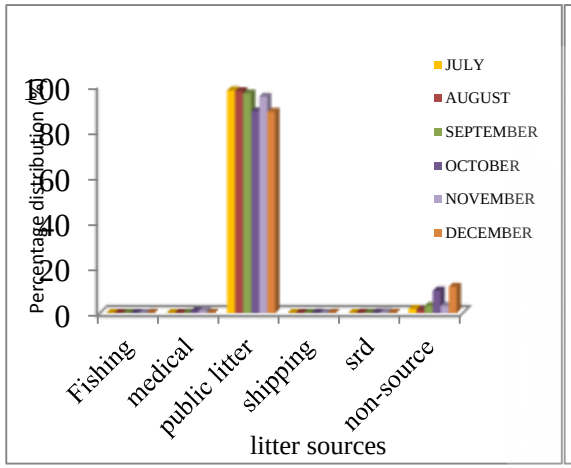
LITTER CATEGORIES	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Fabric	704	399	82	449	205	118
Glass	40	9	3		3	1
Metallic	99	134	34	18	46	46
Paper	57	34	6	2	14	12
Plant materials	117	165	65	58	35	11
Plastic	4093	2911	912	794	2139	1011
Polystyrene	285	990	256	53	159	293
Rope / Net	1	13	4	7	20	4
"Others"	19	131	6	2	2	

TOTAL LITTER COUNTED AT THE KETA SAMPLING SITE

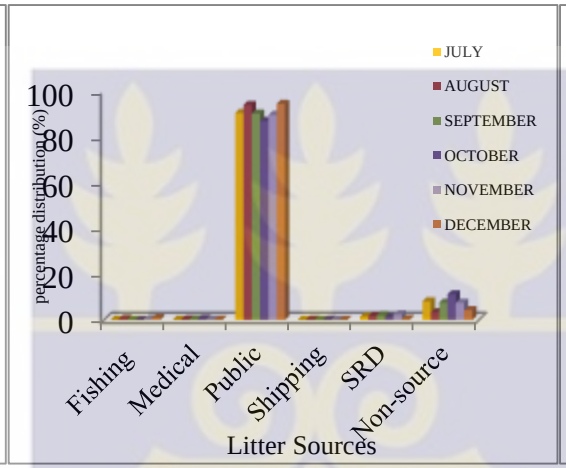
LITTER CATEGORIES	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Fabric	20	4	14	13	24	33
Glass	46	8	9	9	40	68
Metallic	16	3	3	3	5	11
Paper	2	1	3	29	3	5
Plant materials	20	74	23	3	8	1
Plastic	407	782	519	697	574	409
Polystyrene	1	12	17	14	17	1
Rope / Net	60	18	18	6	19	11
"Others"		4	4	4	5	5

APPENDIX 6

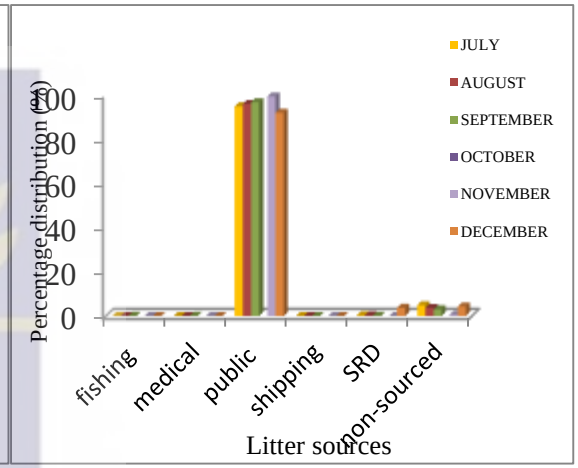
SOURCES OF LITTER



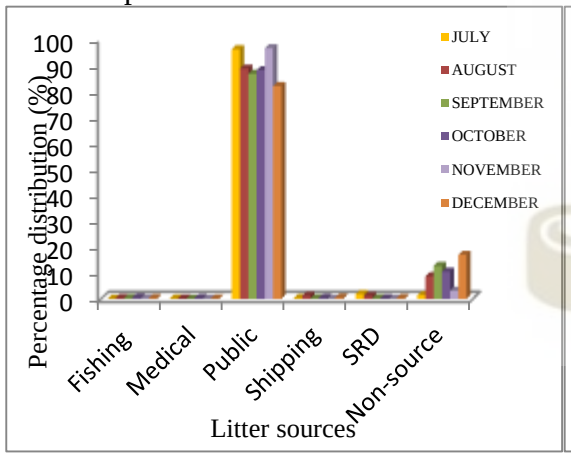
A. Kpeshie



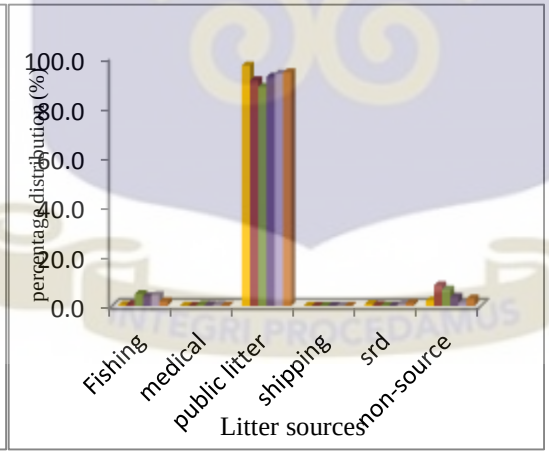
B. Mukwei



C. SakumoII



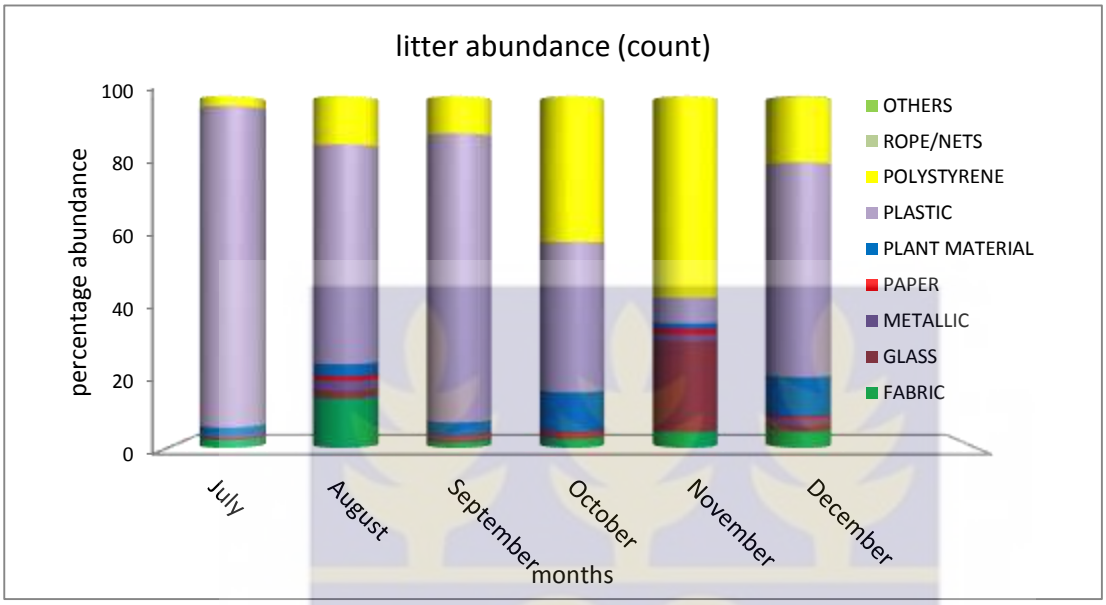
D. Gao



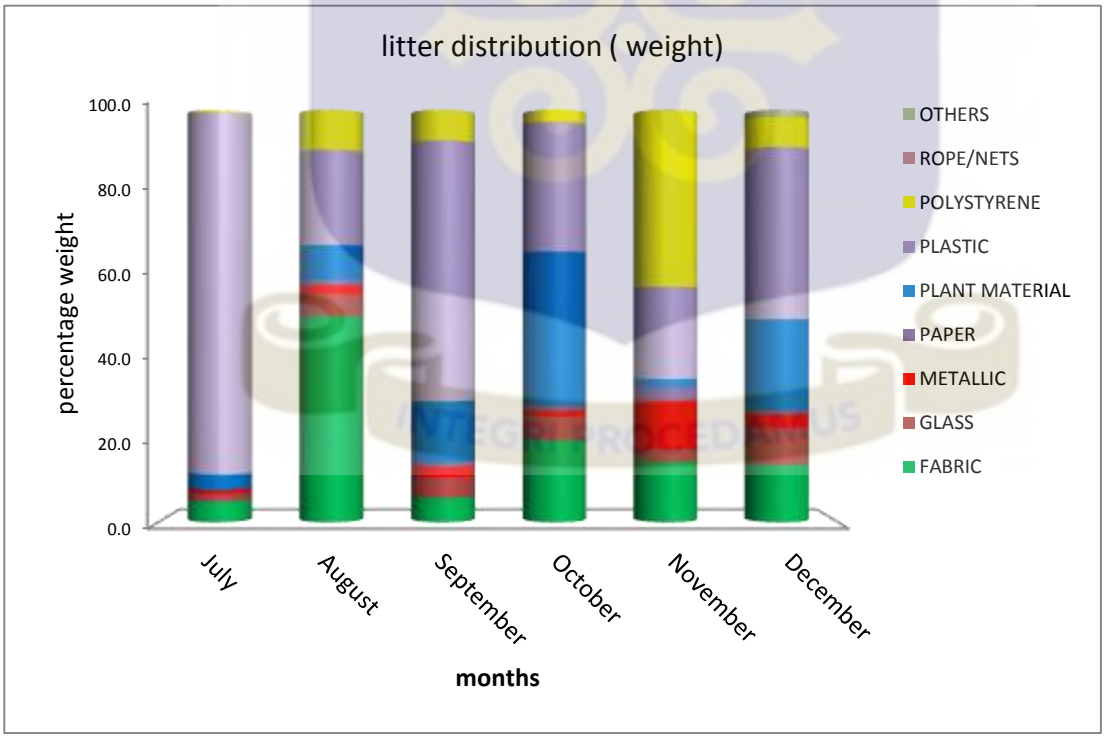
E. Keta

APPENDIX 7

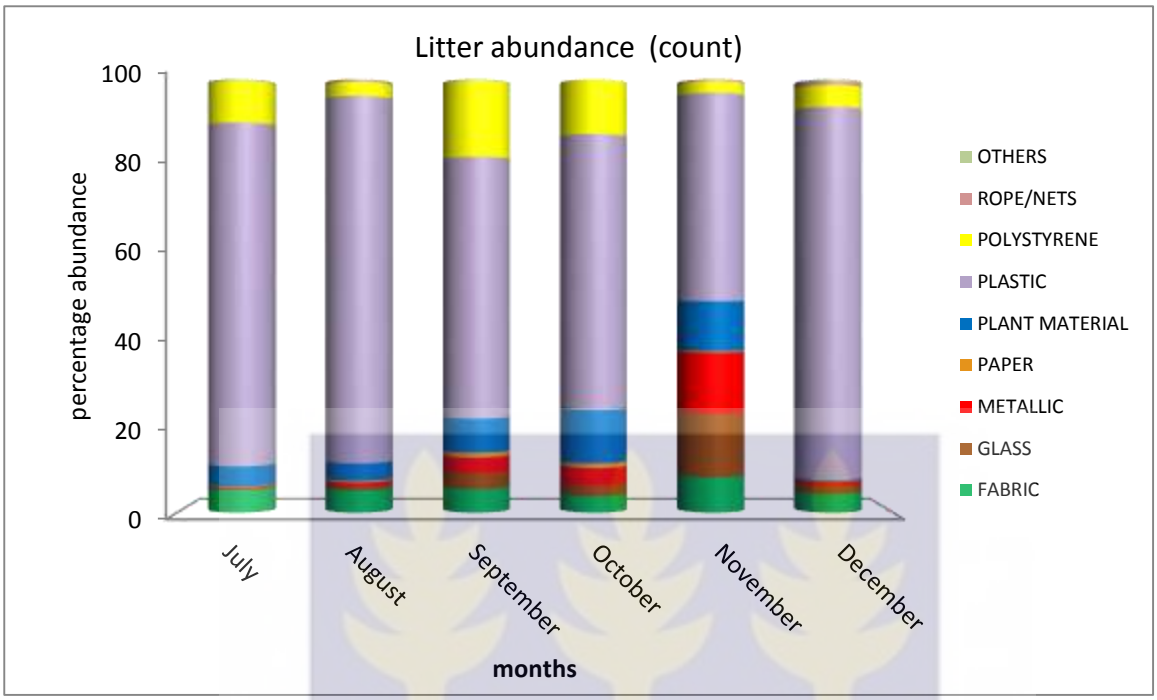
PERCENTAGE ABUNDANCE AND WEIGHT OF LITTER ACROSS SITES



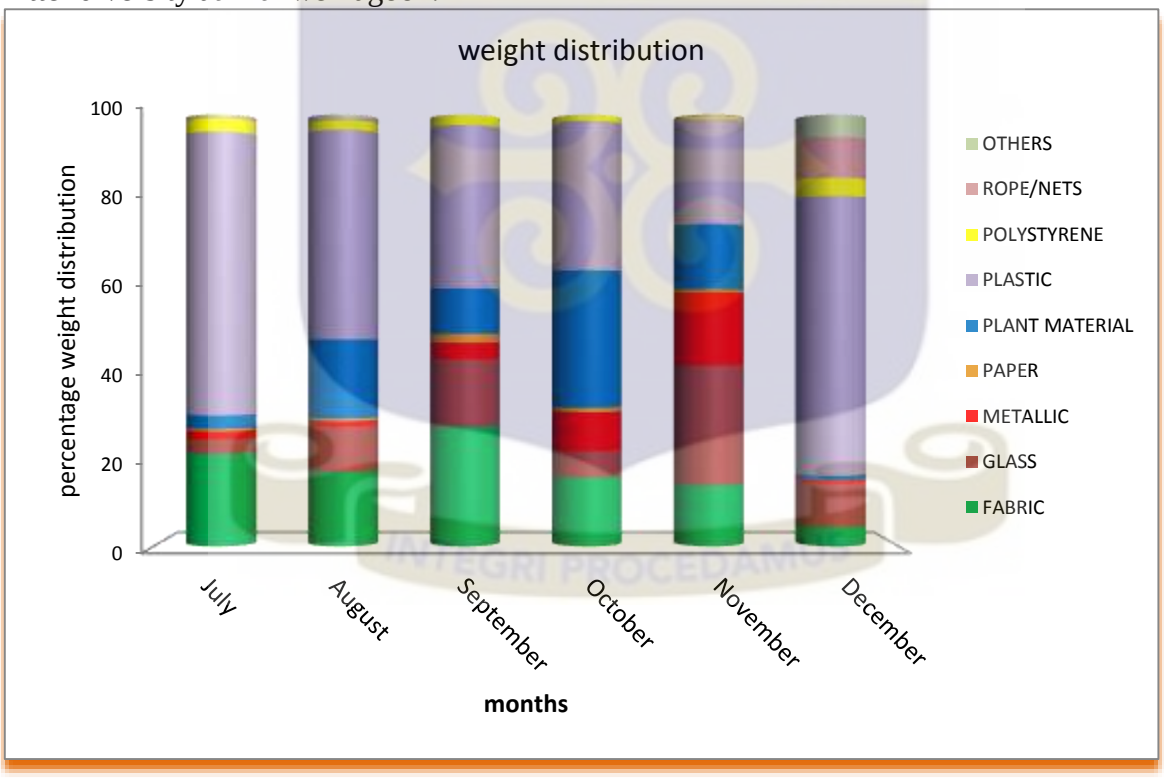
Percent Percentage abundance of litter age abundance of litter at Kpeshie lagoon



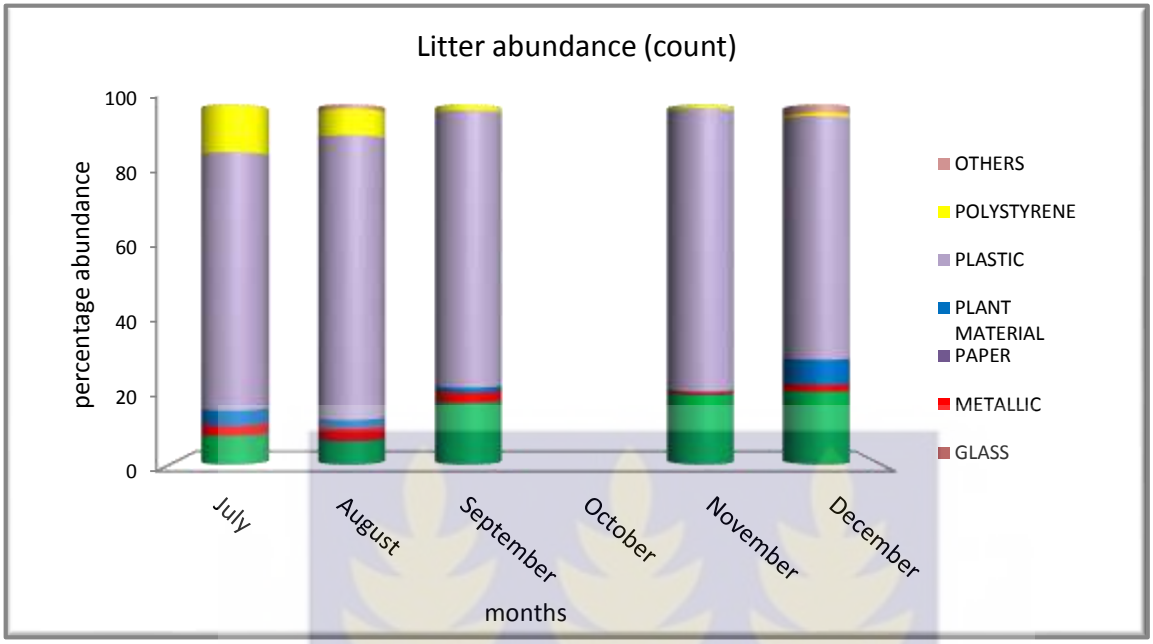
Weight distribution of litter at Kpeshie lagoon.



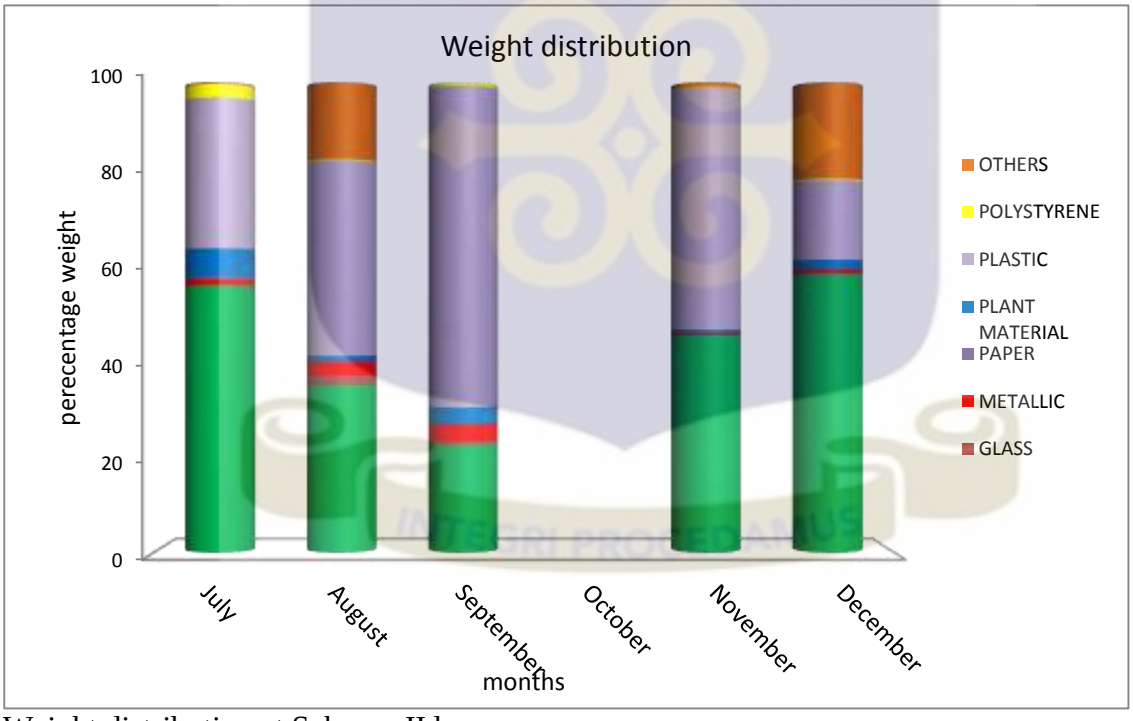
Litter diversity at Mukwei lagoon.



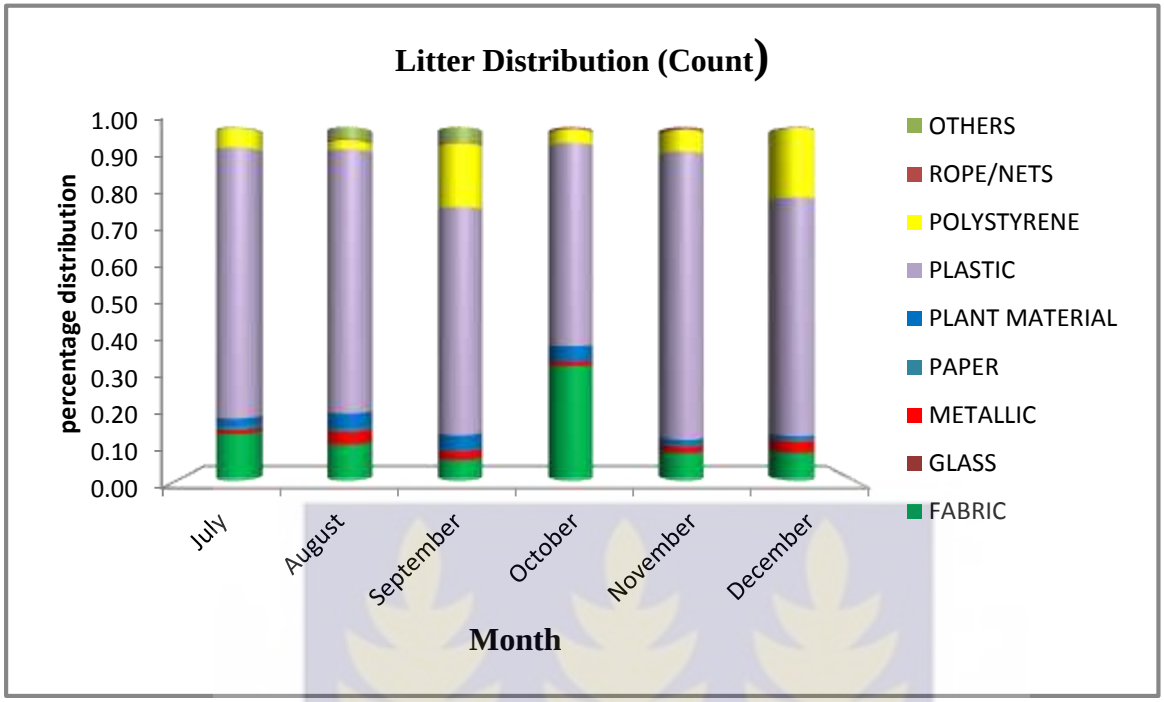
Weight distribution of litter at Mukwei lagoon.



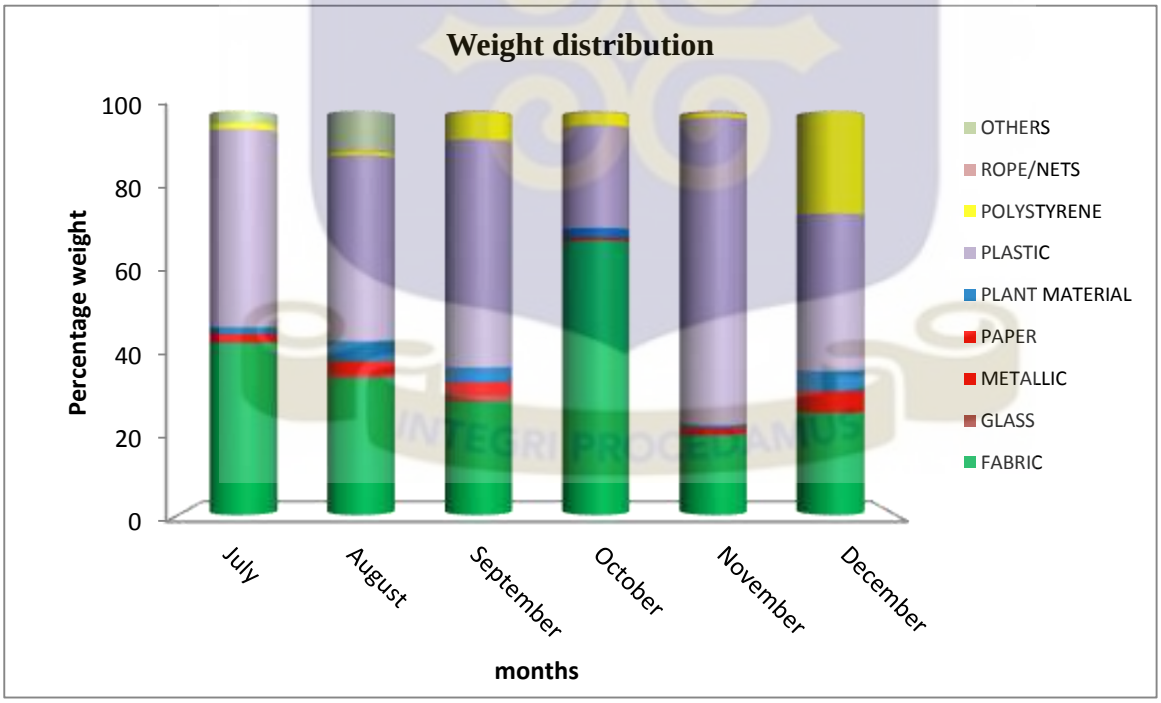
Litter distribution at Sakumo II lagoon.



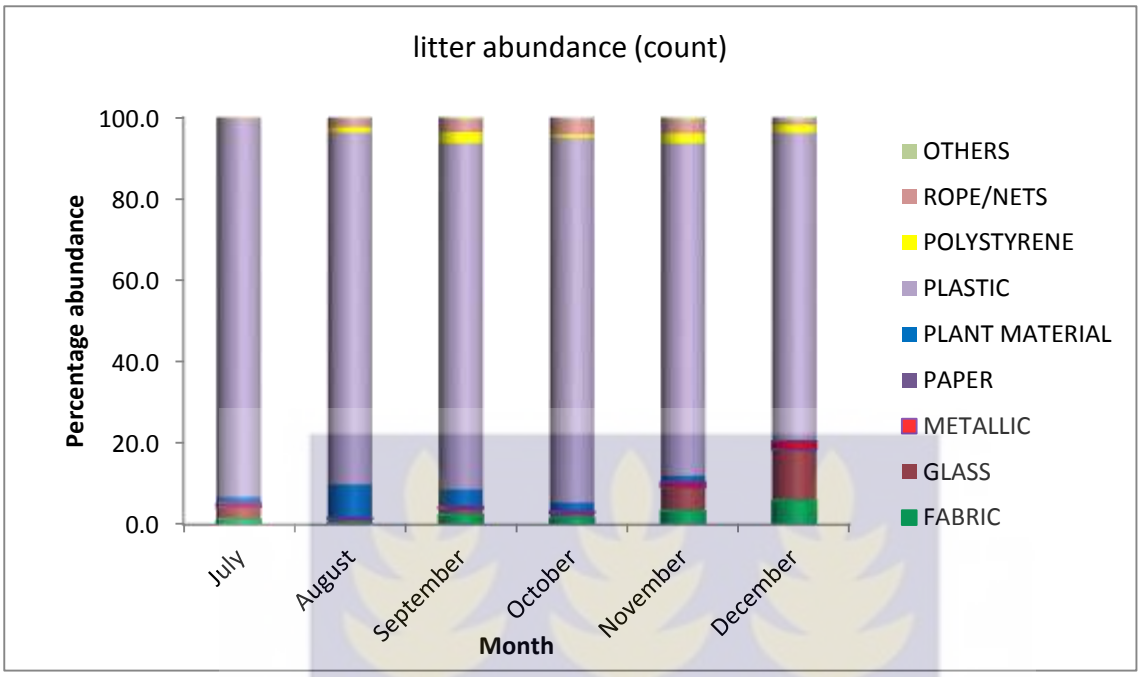
Weight distribution at Sakumo II lagoon



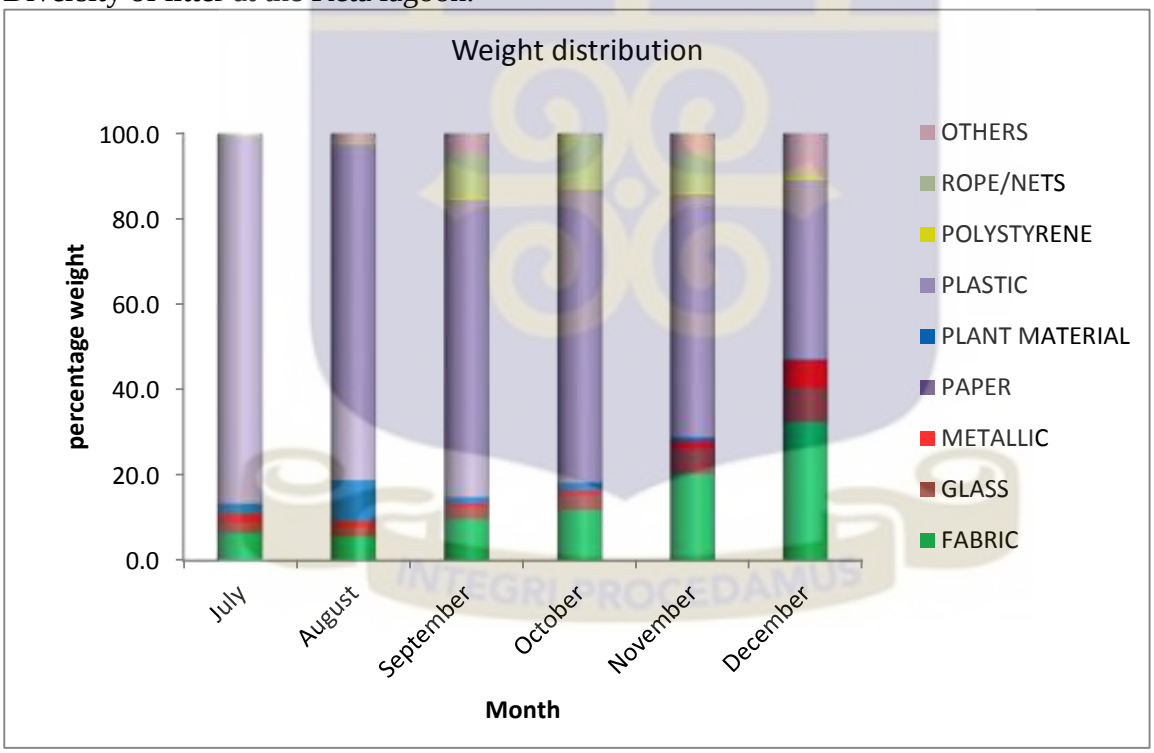
Litter distribution at the Gao Lagoon



Weight distribution of litter at the Gao Lagoon



Diversity of litter at the Keta lagoon.



Weight distributed of litter at the Keta lagoon.