UNIVERSITY OF CAPE COAST

CHARACTERIZATION AND QUANTIFICATION OF LITTER ON SELECTED BEACHES IN THE CENTRAL REGION OF GHANA: TOWARDS THE MANAGEMENT AND PROPER DISPOSAL OF SOLID WASTE

BY

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Thesis submitted to the Department of Fisheries and Aquatic Sciences, School of Biological Sciences, University of Cape Coast, in partial fulfilment of the requirements for the award of Master of Philosophy Degree in Integrated Coastal Zone Management

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of the author research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: .... Date: ....

Nunana Agbemabiese

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised by the guidelines on supervision of thesis laid down by the University of Cape Coast.

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ABSTRACT

Ghana faces challenges with managing solid waste especially plastics, these waste moves through drains, blown by the wind or are directly deposited onto beaches which end in the seas. Litter in the seas causes harm to organisms living in there which may result in deaths. This study was carried out to characterize litter on the beach, litter landed by selected fishermen and selected household litter of some household directly adjacent some beaches in the central region of Ghana, namely Anomabo, Bakano and Moree for eight months. (October 2018 to June 2018). To achieve these objectives, a 10 x 100 m belt transect was surveyed along the three beaches to assess the volume, composition, diversity and sources of the litter. Litter was also collected from landings of selected beach seiners also to assess the volume, composition, diversity and source of litter. Household litter was also collected from 20 selected households for four weeks. Households were educated on segregation of waste and were each given 2 bins, one for organic waste and another for any other waste. 32,557 litter items were collected for the beach litter, of which plastics was found to be the most dominant forming 55% of the total litter load. 5,987 floating litter items was counted from selected fishermen, similar to findings from beach litter, plastics were found to be dominant with sachets water wrappers forming greater part of the plastics forming 86% of the total litter load. Bakano beach was found to have the highest litter load for beach litter whiles Moree was found to have the highest floating litter load. For household waste, it was realized that organic waste formed a majority of the litter collected. A social survey was also conducted within the same period to ascertain the perception of beach users on the beaches for the study. Majority of people interviewed believed that Ghana's beaches were dirty and litter load continues to increase. Respondents agreed to provide bins, education and punishments as means to mitigate the current situation.

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DEDICATION

I dedicate this work to the Agbemabiese family

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CHAPTER ONE

INTRODUCTION

Background

This study was carried out to document the accumulation of litter along coastal zones, especially beaches, which are narrow strips of land that lies along the edge of an ocean, lake, or river. Materials such as sand, pebbles, rocks, and seashell cover beaches. They form an important interface between land and oceans. Beach materials may travel long distances, carried by wind, waves and tides these may carry materials from a few meters to hundreds of kilometres and deposit them on other coasts.

Anthropogenic litter on the sea surface, beaches and seafloor has significantly increased in recent decades. Initially described in the marine environment in the 1960s, marine litter is nowadays commonly observed across all oceans (Ryan, 2015). Marine debris is commonly observed everywhere in the oceans. Litter enters the seas from land-based sources, ships and other installations at sea, from point and diffuse sources, and can travel long distances before they are left behind on the beach. Marine debris is defined by the National Oceanic and Atmospheric Administration (NOAA) as any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment or the Great Lakes. These include man-made object discarded, disposed of, or abandoned that enters the coastal or marine environment. Marine debris range from common domestic material, industrial products, to lost or discarded fishing gear (NOAA, 2007) such as plastics, plastic bottles, snack wrappers, papers, parts of boats, metal pieces, tree trunks or branches and seaweed. They are found in all beaches, ocean surfaces and seafloors or even isolated islands and unpopulated coastlines(Zhou et al., 2015). Marine debris can be categorized as ocean or waterway-based and land-based sources (NOAA, 2007; Sheavly, 2007; UNEP, 2009). Land-based sources account for about 80% of the world's marine pollution and the remaining 20% is credited to ocean or waterway-based sources (GESAMP, 1991). Other items are classified as general source items because they cannot be traced to a specific or sole source (Jambeck *et al*., 2011).

Marine debris are now recognized internationally as a form of marine pollution as they constitute plastics and other synthetic materials that are discarded from various sources. Marine debris can be found in remote beaches as well as highly patronized recreational beaches throughout the world despite extensive beach clean-up efforts by volunteers and municipalities (Coe & Rogers, 1997; Jambeck *et al*., 2001; Sheavly, 2007). It has also been described as an environmental, economic, health and aesthetic problem (Sheavly, 2007; UNEP, 2009; NOAA, 2010; World Ocean Review, 2010).

Marine debris is a growing worldwide problem, due to an ever increasing global plastic production and continuing indecent disposal. This debris is not only aesthetically displeasing, it can adversely affect marine live and even pose hygienical threat to humans. Marine debris contamination affects ecosystems and the provision of ecosystem services in various ways, among which are deleterious effects on wildlife and habitat quality, economy and aesthetics and even human health and safety (UNEP, 2006). These debris may be harmful to organisms within the marine ecosystem as they clog gills, other respiratory and feeding apparatus of many organisms, many others get entangled in abandoned and discarded nets. Organisms such as sea birds, and large fishes feed on these debris; they end up in the stomach of these organisms and result in diseases and deaths. Marine debris can also cause habitat destruction by affecting water quality and causing physical damage to sensitive ecosystems. Coral reefs, sea grass beds and bottom dwelling species are very susceptible to the impacts of marine debris. Debris are also harmful to humans because many diseased fishes are fed on by humans, some metal parts are harmful and may cause injuries with others being very hazardous. Debris affect the aesthetic appeal of many beautiful beaches and leads to lose of employment, livelihood and income for many people and countries. Discarded fishing lines, ropes and plastic bags can wrap around and damage boat propellers, or get sucked into boat engines (UNEP, 2009). Medical wastes and drug paraphernalia lying on beaches can carry diseases, broken glasses and other sharp objects pose obvious dangers for barefooted beachgoers (NOAA, 2010).

Ghana has a very productive coastline spanning about 550km which is a major source of income for the country. The beaches of Ghana have been stuck with litters from both inland and marine environments. Plastics form the most dominant type of litter and especially evident at beaches after rains and during low tides posing a threat to the booming tourism industry in Ghana (Nunoo & Quayson, 2003). Other types of litter include pieces of fishing net, foam, foot wear, cloth, charcoal, wood, and husk of sugar cane and coconut (Nunoo & Quayson, 2003; Tsagbey *et al.*, 2009). There is also direct sewage disposal into the sea (Nunoo & Evans, 2007), which is harmful to organisms in the area, fishermen and consumers. Management practices that have been adopted along Ghana‘s coast include education, enforcement of appropriate policy initiatives, provision of collection, disposal and treatment infrastructure, recycling and beach clean-ups (Nunoo & Quayson, 2003).

According to Cheshire et al., 2009, marine litter investigations will generally fall into one of three basic types:

1. Beach litter surveys.
2. Benthic litter surveys, which include:

   a) Observations made by divers, submersibles or camera tows.

   b) Collection of litter via benthic trawls.
3. Floating litter surveys, which include:

   a) Observations made from ship or aerial based platforms.

   b) Collection of litter via surface trawls

Problem Statement

Over the past decade, degradation of the coastal and marine environments continued globally, and in many places even intensified. The major threats to the health, productivity, and biodiversity of the marine environment result from human activities in both coastal and inland areas. This is consistent with the case of Ghana as Obirih-Opareh, (2002) and Mariwah, (2012) recorded that Ghana is facing major challenges in managing its waste especially solid waste in the metropolitan areas, with most of the waste being domestic, industrial and construction waste. Most of which end up in drains and water ways which leads directly into the beaches and seas. Although many projects have focused on the provision of improved sanitation and hygiene education in the coastal areas, improper disposal of solid and liquid wastes remain widespread (Nunoo & Quayson, 2003).

Meanwhile, increasing plastic production and use in emerging economies will continue, and waste management infrastructure will have to be developed accordingly. Unfortunately, the properties of plastic that make it so valuable also makes its disposal problematic, such as its durability, light weight and low cost. (Impacts, 2011). Currently, it is estimated that Ghana has an average daily waste generated per capita of 0.45 kg, equating to 3.0 million tons of solid waste annually (GhIE, 2011). It is estimated that only 10% of solid waste generated is properly disposed of mainly through land fill sites but options are rapidly depleting (GhIE, 2011). In the absence of better management at source, the exponential growth of litter in the marine environment is certain to continue (Barnes, 2002). The need to develop and evaluate alternative management strategies is therefore central if we aim to limit the amount of litter entering marine systems. Current rates are likely to be substantially greater, given the prolonged timeframe for decomposition and the very small amounts of litter actually removed through beach clearances, it can be argued that the volume of marine litter in the oceans will continue to increase exponentially over the coming decades (Cheshire et al., 2009). The situation needs to be given special attention in order to prevent further damage to life.

Justification

A comprehensive data on amount of debris collected on the coast of Ghana is deficient as it is impossible to ascertain and quantify the effect of debris on the general coast of Ghana. This study emphasizes on the types, quantities and trends in the deposition of debris. Despite measures to prevent and reduce marine debris, evidence shows that the problem continues and will likely worsen (National Academy of Sciences, 2012). Some debris will continue to arrive on our shores over the course of the next decade and beyond and will thus continue to pose some degree of risk to our safety, environment and economy (NOAA, 2007; UNEP/GPA, 2006). Monitoring of quantities, types and trends in debris will help understand the source of debris and be incorporated in the management and protection of the coastal zone. Also, this will help ascertain the effectiveness of interventions made at various levels.

Study Hypotheses

The following hypotheses were established to deepen understanding on the research issues:

H0: Sampling months has no significant effect on the amount of litter obtained

H1: Sampling months has significant effect on the amount of litter obtained

H0: Sampling location has no significant effect on the amount of litter obtained

H1: Sampling location has significant effect on the amount of litter obtained.

Aim of study

The study aimed to contribute to efforts towards planning and integrated coastal management to reduce the disposal, accumulation and impacts of beach litter and litter generating activities for the sustainable utilisation and conservation of the marine and coastal environment of Cape Coast. It is further intended to provide scientifically informed lessons for addressing comparable situations along the West African Coast.

Objectives of study

The specific objectives of the study are to:

1. document the categories and quantities of debris on Anomabo, Bakano and Moree beach
2. establish the trends in the types, quantities and seasonality of debris.on Anomabo, Bakano and Moree beach
3. determine the sources and driving factors accounting for the beach litter on Anomabo, Bakano and Moree
4. assess public perceptions associated with beach litter and their effect on the marine environment.

CHAPTER TWO

LITERATURE REVIEW

This chapter reviews literature related to the study and seeks to describe the physical and ecological characteristics of beaches as well as their importance. It will also explore the use of beaches 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.

Definition of Marine Debris

Marine debris is man-made waste discarded in any water body whether it is a sea, lake or an ocean (Singh, 2011). Marine debris includes any form of persistent, manufactured or processed material discarded, disposed of or abandoned in the marine environment. It consists of items made or used by humans that enter the sea, whether deliberately or unintentionally, including transport of these materials to the ocean by rivers, drainage, sewage systems or by wind; accidentally lost, including material lost at sea in bad weather (fishing gear, cargo); or deliberately left by people on beaches and shores (UNEP, 2005; NOAA, 2007; Galgani et al., 2010a; STAP, 2011; US EPA, 2012). This definition does not include semi-solid remains of, for example, mineral and vegetable oils, paraffin and chemicals (Galgani *et al*., 2010).

History of Marine Debris

Although societies have altered natural environments since time immemorial, the magnitude, intensity, and rate of change have increased dramatically (Laist & Liffmann, 2000; Potts & Hastings, 2011). The work of

Laist & Liffmann (2000) states, *inter alia*, that nowhere is this more evident than in coastal areas, where growing populations, increased demands on natural resources, and powerful modern technologies have combined to bring about far-reaching changes in coastal and marine environments, not all of them favourable. Significant marine debris impacts can be traced to the 1940s when new synthetic materials began replacing natural fibres in the manufacture of fishing nets, line and everyday items- the low cost, light weight, and long life of new synthetic materials resulting in more items being discarded, their transport to the most remote ocean shorelines and waters, and a much longer hazard life for marine species (Laist & Liffmann, 2000). Although the roots of marine debris pollution date to the mid-1900s, its impacts on marine life were largely unrecognized until 1984 when the National Marine Fisheries Service (NMFS), at the recommendation of the Marine Mammal Commission, hosted the Workshop on the Fate and Impact of Marine Debris in Honolulu, Hawaii (Shomura & Yoshida, 1985; Laist & Liffmann, 2000). Data compiled at the workshop revealed that marine debris was affecting far more species in many more areas than previously realized (Laist & Liffmann, 2000). Its biological impacts were found to have two principal forms:

- Entanglement of animals in loops and openings of derelict line, nets, strapping bands.
- Ingestion of plastics causing damaged or blocked digestive tracks: both potentially lethal to marine life.

In addition, human safety problems caused by fouling and disabling of vessel propulsion systems were noted (Laist & Liffmann, 2000). The early days before the global recognition of beach litter or marine debris, the issues were treated with minimal importance as the impacts were seemingly localized or regional at most (IOC, 2009). The 1984 workshop spurred national and international efforts to investigate, monitor, and mitigate marine debris impacts (Laist *et. al.*, 1999 cited in Laist & Liffmann, 2000).

Sources of Marine Debris

Marine debris is a problem along shorelines, in coastal waters, estuaries, and oceans throughout the world (Cheshire *et al.*, 2009; US EPA, 2012). It is found in all sea and ocean areas of the world – not only in densely populated regions but also in remote places far away from any obvious source (UNEP, 2005; World Ocean Review, 2010). Marine debris travels over long distances with ocean currents and winds and is found everywhere in the marine and coastal environment, from the poles to the equator, from continental coastlines to small remote islands (UNEP, 2005; World Ocean Review, 2010). While there are many types of debris, it all shares a common origin - people. People‘s mishandling of waste materials and a host of other items constitutes the bulk of the marine debris problem (NOAA, 2007; NOAA, 2012). Some of the litter, often the smaller pieces, become buried and re-emerge at later times to compound the litter problem at beaches (Williams & Tudor, 2001; Nagelkerken *et. al.*, 2001; Kusui & Noda, 2003, cited in Tsagbey *et al.*, 2009). Natural events, such as tornadoes, hurricanes, floods, and tsunamis, can all generate and carry debris into the marine environment (US EPA, 2012). It is the product of poor waste management, inadequate infrastructure and a lack of public knowledge about the potential consequences of inappropriate waste disposal (UNEP, 2009). Marine debris comes from local sources as well as global contributions (Department of Environmental Conservation, 2012) and from a diverse range of land- and ocean-based sources (Derraik, 2002; Mouat *et al.*, 2010).

Land-based sources include users of the beach, storm water-runoff, landfills, solid waste, rivers, and streams, floating structures, ill maintained garbage bins and dumps and litterbugs (NOAA, 2007; US EPA, 2012). Marine debris also comes from combined sewer overflows and storm drains. Typical debris from these sources includes medical waste, street litter and sewage. Land-based sources contribute approximately 80% of the marine debris found on our beaches and waters and the remaining 20% originating from ocean-based sources (GESAMP, 1991; NOAA, 2007; Sheavly, 2007; World Ocean Review, 2010; US EPA, 2012), although this varies between areas (Allsopp *et al.*, 2006; Mouat *et al.*, 2010).

Ocean-based sources of debris include galley waste and other trash from ships, recreational boaters and fishermen and offshore oil and gas exploration and production facilities (NOAA, 2007; Sheavly, 2007; World Ocean Review, 2010; US EPA, 2012). The sources can be categorised into four major groups (Allsopp *et al.*, 2006; Mouat *et al.*, 2010):

Tourism related litter at the coast: this includes litter left by beach goers such as food and beverage packaging, cigarettes and plastic beach toys.

Sewage-related debris: this includes water from storm drains and combined sewer overflows which discharge waste water directly into the sea or rivers during heavy rainfall. These waste waters carry with them garbage such as street litter, condoms and syringes.

Fishing related debris: this includes fishing lines and nets, fishing pots and strapping bands from bait boxes that are lost accidentally by commercial fishing boats or are deliberately dumped into the ocean. Wastes from ships and boats: this includes garbage which is accidentally or deliberately dumped overboard.

For some litter types, however, it is difficult to distinguish direct origin (beach or boat user) (Hall, 2000; MCS, 2009). Adding to this problem is the population influx along our nation's shores. More people mean more paved area and wastes generated in coastal areas. These factors; combined with the growing demand for manufactured and packaged goods, have led to an increase in non-biodegradable solid wastes in our waterways (US EPA, 2012).

Types of Marine Debris

While the definition of marine debris encompasses a very wide range of materials, most items fall into a relatively small number of material types and usage categories (STAP, 2011). Marine debris can be classified into several distinct categories. These include:

- Plastics including moulded, soft, foam, nets, ropes, buoys, monofilament line and other fisheries related equipment, smoking related items such as cigarette butts or lighters, and micro plastic particles.
- Metal including drink cans, aerosol cans, foil wrappers and disposable barbeques
- Glass including buoys, light globes, fluorescent globes and bottles.
- Processed timber including pallets, crates and particle board Paper and cardboard including cartons, cups and bags.

- Rubber including tyres, balloons and gloves
- Clothing and textiles including shoes, furnishings and towels
- Sewage related debris (SRD) including cotton bud sticks, nappies, condoms and sanitary products (Fanshawe & Everard, 2002; Allsopp *et al*., 2006; NOAA, 2007; Sheavly and Register, 2007; Cheshire *et al*., 2009; MCS, 2009; Galgani *et al*., 2010a; Mouat *et al*., 2010).

While the types and absolute quantities vary, it is clear that plastic materials represent the major constituents of this debris (Barnes *et al*., 2009; Ryan *et al*., 2009; Browne *et al*., 2011 cited in STAP, 2011a). Plastics dominate marine debris and represent a significant threat to the marine environment due to their abundance, longevity in the marine environment and their ability to travel vast distances. The trend on shorelines is echoed by data from the seabed where items of plastic debris recovered by fishermen were more abundant (>58%) than those of metal (21%) (KIMO 2008; STAP, 2011a). Other synthetic materials are similar to plastic in that they are used in a wide range of products, are often cheap to produce and lightweight and thus are common marine litter items. These include glass such as light globes, fluorescent globes and bottles; rubber including tyres, balloons and gloves; and metal including drink cans, aerosol cans, disposable foil wrappers for barbeques. These items can undergo fragmentation over long time periods and often do not completely biodegrade (OSB, 2008 cited by Potts & Hastings, 2011).

Processed timber such as pallets, crates and particle board, and paper and cardboard items such as cartons, cups and bags, also contribute to marine litter but is found in much smaller quantities than synthetic materials. This may be due to a shorter residence time in the marine environment as they are relatively quick to bio- and photo-degrade, thus their accumulative impact on the environment, society and economy may be much less (Velander & Mocogni, 1998;; Galgani *et al*., 2010 cited by Potts & Hastings, 2011).

Textiles also constitute as marine litter including clothing, shoes, and furnishings. The specific impacts of these items are unknown, but are generally considered of lesser importance than other synthetic materials (Velander & Mocogni, 1998;; Galgani *et al*., 2010 cited by Potts & Hastings, 2011).

Impacts of Marine Debris

Marine litter threatens the realisation of a shared vision for clean, healthy, safe, productive, biologically diverse marine and coastal environments, managed to meet the long-term needs of nature and people (Potts & Hastings, 2011). Debris in the marine environment gives rise to a wide range of negative environmental, social, economic and public health and safety impacts (Allsopp *et al*., 2006; Mouat *et al*., 2010). While these impacts are diverse, they are often also interrelated and frequently dependent upon one another (Ten Brink *et al*., 2009 cited in Mouat *et al*., 2010). Ghost fishing, for example, can result in harm to the environment, economic losses to fisheries and reduced opportunities for recreational fishing (Macfadyen *et al*., 2009 cited in Mouat *et al*., 2010).

Environmental Impacts

The environmental impact of marine debris is serious and multidimensional (Valavanidis & Vlachogianni, 2011). Marine debris can cause a wide variety of adverse environmental impacts to individual organisms, species and ecosystems (Mouat *et al*., 2010; Department of Environmental Conservation, 2012). Ingestion and entanglement of wildlife are among the well-known impacts of marine debris and primary threats that marine debris poses to marine wildlife (Allsopp *et al*., 2006; US EPA, 2007; Gregory 2009; Thompson *et al*., 2009 cited in Mouat *et al*., 2010; Jambeck *et al*., 2011). Each year, thousands of marine animals are caught in, strangled by or ingest various forms of debris (Allsopp *et al*., 2006; US EPA, 2007).These phenomena had been known to affect individuals of at least 267 species worldwide (Laist, 1997 cited in Allsopp *et al*., 2006; Mouat *et al*., 2010; NOAA, 2012). This includes 86% of all sea turtle species, 44% of all seabird species and 43% of all marine mammal species as well as numerous fish and crustacean species (Allsopp *et al*., 2006; Mouat *et al*., 2010). It is possible that the total number of species listed is an underestimate because most victims are likely to go undiscovered as they either sink or are eaten by predators thus making the exact extent of the problem difficult to quantify (Baird & Hooker, 2000; Derraik, 2002; Allsopp *et al*., 2006). Marine debris can also cause damage to benthic environments (Moore, 2008 cited in Mouat *et al.*, 2010). An accumulation of debris on the seabed may affect the number and type of organisms present by inhibiting gas exchange between overlying waters and the pore waters of the sediments resulting in an oxygen deficit in the sediments (Allsopp *et al.*, 2006). There is also the risk of entanglement and ingestion of marine debris by benthic organisms (Derraik, 2002) and potentially lead to the loss of ecosystem functions (Ten Brink 2009 cited in Mouat *et al.*, 2010). Entanglement is harmful to wildlife for several reasons:

- It can result in lacerations from abrasive or cutting action of attached debris that can lead to infections or loss of limbs.
- It may cause death by strangulation, choking, or suffocation.
- It can impair an animal's ability to swim, which may lead to drowning, or make it difficult for the animal to move, find food, and escape from predators (US EPA, 2007; Derraik, 2002; Allsopp *et al.*, 2006).

Ingestion

This occurs when an animal swallows marine debris. Ingestion sometimes happens accidentally, but generally animals ingest debris because it looks like food (Sheavly, 2005; Allsopp *et al.*, 2006; US EPA, 2007). The ingestion of marine debris has been reported to date in over 111 species of seabird (Allsopp *et al.*, 2006), 31 marine mammal species (Allsopp *et al.*, 2006) and 26 species of cetaceans (Derraik, 2002). The main impacts of ingestion include:

- Physical damage to the digestive tract including wounds, scarring and ulceration which can lead to infection, starvation and potentially death.
- Mechanical blockage of the digestive tract
- Reduced quality of life and reproductive capacity
- Drowning and reduced ability to avoid predators
- Reduced feeding capacity and malnutrition
- A false sense of satiation leading to general debilitation, starvation and possibly death
- Toxic chemical poisoning from contaminated plastics leading to reproductive disorders, increased risk of diseases, altered hormone levels and possibly death (Derraik, 2002; Gregory, 2009; OSPAR,

2009 cited in Mouat *et al.*, 2010; Sheavly, 2005; Allsopp *et al.*, 2006; US EPA, 2007).

Ghost fishing

Derelict fishing gear which has been lost or discarded by fishermen may continue to function as fishing apparatus on its own (Matsuoka *et al.*, 2005 cited in Allsopp *et al.*, 2006). Most fishing gear are made of synthetic materials which do not biodegrade and can continue to catch marine organisms such as fish and crustaceans and can cause their death if they cannot escape in a process known as ghost fishing (Sheavly, 2005; Allsopp *et al.*, 2006). A cycle is thus set up whereby marine organisms are captured and, in turn, these species may attract predator species which may then also become trapped (Allsopp *et al.*, 2006). The cycle continues as organisms which die and decay in the nets may subsequently attract and trap scavengers such as crustaceans (Allsopp *et al.*, 2006). The catching efficiency of ghost fishing gear is highly dependent on environmental conditions but a single net has been shown to continue fishing for decades (Mouat *et al.*, 2010).

Alien Species Introduction and Habitat Destruction

Human activities have resulted in many species being moved from their native habitats to regions where they are not native in a process called a biological invasion (Allsopp *et al.*, 2006). Natural debris floating in the oceans has always acted as means of travel for certain marine species (Lewis *et al.*, 2005; Allsopp *et al.*, 2006, Mouat *et al.*, 2010). They include volcanic pumices, floating marine algae, sea grasses, plant trunks or seeds (Aliani & Molcard, 2003; Barnes & Milner, 2005 cited in Allsopp *et al.*, 2010). However, the introduction of vast quantities of marine debris, particularly, plastics into the marine environment over the past half century has massively increased the opportunity for the dispersal of marine organisms (Allsopp *et al.*, 2006, Gregory, 2009; Mouat *et al.*, 2010).

The slow travel rates of marine debris also provide alien species with more time to adjust to changing environmental conditions (Allsopp *et al.*, 2006; Moore 2008 cited in Mouat *et al.*, 2010) and as a consequence, marine debris may be a more effective vector for the transport of alien species than ships hulls and ballast water (Allsopp *et al.*, 2006; Moore 2008 cited in Mouat *et al.*, 2010). Additionally, debris affects the water quality of aquatic habitats and also cause physical damage (Sheavly, 2005). Moved by currents and tides, ropes and nets abrade, scour, break and destroy living corals (Sheavly, 2005). Ensnared debris may also cause increased siltation and turbidity, blocking essential sunlight to, or smothering sea grass or corals (Sheavly, 2005; UNEP, 2009; Mouat *et al.*, 2010; Kershaw *et al.*, 2011; NOAA, 2011).

Social Impacts of Marine Debris

The problem of marine debris is a common problem for coastal local communities and other organisations throughout the world (KIMO, 2012). The social impacts of marine debris are rooted in the ways in which marine litter affects people‘s quality of life and includes reduced recreational opportunities, loss of aesthetic value and loss of non-use values (Cheshire *et al.*, 2009; Mouat *et al.*, 2010).

Reduced Recreational Opportunities

Many residents and visitors to coastal communities value the beach as a public amenity (JurrasicCoast, 2012). Beaches, coasts and seas are used for countless different recreational activities including swimming, diving, boating, recreational fishing and a wide variety of water sports (Mouat *et al.*, 2010).

Accumulations of marine litter can have a strong deterrent effect and discourage recreational users from visiting polluted areas (Ballance *et al.*, 2000; Sheavly and Register 2005 cited in Mouat *et al.*, 2010). The level of litter required to actively deter people from visiting certain areas is subjective depending on personal preference, purpose of activity and litter levels in surrounding areas (Mouat *et al.*, 2010). Beach users, for instance, frequently rank cleanliness as their top priority when choosing where to visit (Ballance *et al.*, 2000; ENCAMS 2005 cited in Mouat *et al.*, 2010). A pioneering South African study found that 85% of tourists and residents would not visit a beach with more than 2 debris items per meter and 97% would not go to a beach with 10 or larger items of litter per meter (Ballance *et al.*, 2000, Mouat *et al.*, 2010). Humans, animals and birds discharge billions of tons of faecal material into the environment every year. Much of this faecal material reaches water bodies either indirectly through discharge after treatment or directly by being washed off the surface by rainfall or through defecation directly into water bodies. This faecal material can carry pathogenic microbes that may pose a risk to humans exposed to contaminated surface water (WHO, 2012). Marine litter also deters other recreational users such as sailors and divers (Sheavly & Register, 2007) due to both the reduced aesthetic quality of an area and concerns about the health and safety risks posed by accumulations of marine debris (Cheshire *et al.*, 2009; Mouat *et al.*, 2010).

Loss of Aesthetic Value

Marine debris can negatively affect people's quality of life by reducing their enjoyment of the landscape and scenery (Cheshire *et al.*, 2009; Mouat *et al.*, 2010; STAP, 2011b). The loss of visual amenity can have significant effects on people 's recreational use of the marine environment, as outlined above, but it can also simply be about the loss of a previously beautiful view (Mouat *et al.*, 2010). The marine environment is often the focus of many of the creative arts including paintings, literature and films and a loss of aesthetics could also negatively affect the inspirational quality of the marine environment (Naturvårdsverket, 2009 cited in Mouat *et al.*, 2010).

Loss of Non-Use Value

Non-use value relates to the benefits generated by knowing that a particular ecosystem is maintained. There are three main categories of non-use value, which are existence value, bequest value and altruistic value, although these may overlap to some degree. Marine litter therefore threatens the non-use value derived from the ―knowledge of the existence of desirable coastal environment, the value derived from being able to bequest unimpaired resources to future generations, the altruistic benefits of preserving attractive coastal resources for other users, and the value associated with the belief that maintaining a litter-free coast and ocean is intrinsically desirable (Committee on the Effectiveness of International and National Measures to Prevent and Reduce Marine Debris and Its Impacts *et al.*, 2008 cited in Mouat *et al.*, 2010). There is, however, limited data on the overall influence marine litter has on society, and further research is needed (Cheshire *et al.*, 2009; Mouat *et al.*, 2010; Potts & Hastings, 2011).

Public Health and Safety Impacts

Marine debris impacts humans by endangering health and safety (US EPA, 2007). Marine debris presents a number of public health and safety concerns including navigational hazards (US EPA, 2007; Macfadyen *et al.*, 2009), injuries to recreational users (US EPA, 2007; Cheshire *et al.*, 2009) and the risks associated with the leaching of poisonous chemicals (Thompson *et al.*, 2009; Department of Environmental Conservation, 2012).

Navigational Hazards

Marine debris is also a significant ongoing navigational hazard for shipping (STAP, 2011a). Marine debris can present numerous different safety risks for vessels but entanglement in derelict fishing gear such as nets, ropes and lines present a key concern (Allsopp *et al.*, 2006; Mouat *et al.*, 2010). Derelict fishing gear can cause serious damage to vessels (Department of Environmental Conservation, 2012). One such incidence is when an entire Russian submarine reportedly became entangled in a discarded fishing net in 600 feet of water off the Kamchatka coast making navigation and surfacing difficult thus warranting an international rescue effort to rescue the seven-man crew (TenBruggencate, 2005; Allsopp *et al.*, 2006; Mouat *et al.*, 2010). Nets, ropes and other derelict gear entangle vessel propellers and rudders or puncture the bottom of boats resulting in costly repairs, loss of time and danger to boaters and crew especially if power is lost in a storm and the vessel cannot return to shore or steering is hampered and collision cannot be avoided (Sheavly, 2005; Allsopp *et al.*, 2006; US EPA, 2007; NOAA, 2011). In 1993, derelict fishing gear contributed to the sinking of the Korean passenger ferry M/V Seo-Hae, which resulted in the deaths of 292 of the 362 passengers (Cho, 2006). Plastic bags clogging and blocking water intakes is also a common cause of burned-out water pumps with such incidents requiring costly engine repairs (Sheavly, 2005; Allsopp *et al.,* 2006; US EPA, 2007).

Injuries to Recreational Users

Items such as broken glass, medical waste, rope and fishing line pose immediate risks to human health and safety (Sheavly, 2005; US EPA, 2007; Valavanidis & Vlachogianni, 2011). Sharp objects, such as broken glass and rusty metals may cause injuries when people step on them on the beach or ocean floor (US EPA, 2007; Cheshire *et al.*, 2009). Discarded syringes, condoms and tampon applicators can indicate more serious water quality concerns that affect human health. Swimmers, divers and snorkelers can become entangled in submerged or floating debris (Sheavly, 2005; US EPA, 2007; Mouat *et al.*, 2010; STAP, 2011a). Medical and personal hygiene debris can indicate the presence of invisible pathogenic pollutants such as streptococci, feacal coliform and other bacterial contamination (Sheavly, 2005; Sheavly, 2007). Consumption or contact with water polluted with these pathogens can result in infectious hepatitis, diarrhoea, bacillary dysentery, skin rashes and even typhoid and cholera (Sheavly, 2005; Sheavly, 2007).

Leaching of Poisonous Chemicals

Marine debris, especially plastic debris, is widely recognized as a global environmental problem (Allsopp *et al.*, 2006; NOWPAP CEARAC, 2007; Mouat *et al.*, 2010; STAP, 2011a; WDCS, 2012).In recent years there has been an increasing focus on the impacts of toxic chemicals as they relate to plastic debris (NCBI, 2012). While plastics themselves are believed to be biochemically inert in the marine environment, they can carry toxic compounds that potentially pose health risks to both wildlife and humans (Allsopp *et al.*, 2006; Mouat *et al.*, 2010). Some plastic debris acts as a source of toxic chemicals: substances that were added to the plastic during manufacturing leach from plastic debris (NOWPAP, 2007; NCBI, 2012).

Plastic debris also acts as a sink for toxic chemicals: plastic sorbs persistent, bio accumulative, and toxic substances (PBTs), such as polychlorinated biphenyls (PCBs) and dioxins, from the water or sediment and these PBTs may desorb when the plastic is ingested by any of a variety of marine species (NCBI, 2012). Current research suggests that while there is significant uncertainty and complexity in the kinetics and thermodynamics of the interaction, plastic debris appears to act as a vector transferring PBTs from the water to the food web, increasing risk throughout the marine food web, including humans (NCBI, 2012). Although it is not clear how long plastic items remain in their original form, some plastic items appear to be broken up to smaller fragments over time (Allsopp *et al.*, 2006). At sea, this process is thought to occur due to wave action, oxidation and ultraviolet light (Allsopp *et al.*, 2006). On the shore, it may break up into smaller pieces due to grinding from rocks and sand (Erickson and Burton, 2003, Allsopp *et al.*, 2006).

Economic Impacts of Marine Debris

Marine litter has a substantial direct and indirect impact upon the economy (Potts & Hastings, 2011). For several years policy makers and communities have experienced the problem of marine litter on beaches, waterways, bays and ports and the subsequent impacts on a range of economic activities (Potts & Hastings, 2011). The direct impacts are the most obvious, from local authorities responsible for clean-up activities, the loss of tourism expenditure or shifts in tourism activity, and the loss of vessel activity as a result of propeller fouling or bringing up litter in fishing nets (Potts & Hastings, 2011). Indirect impacts can also be substantial and occur from a decline in ecosystem services and the environmental quality of the coast that can cause losses in amenity and resulting losses in property values, opportunity costs and civic pride (Potts & Hastings, 2011). While economic costing of ecosystem services is considered a relatively new science, it is clear that marine and coastal litter can impact and deteriorate a range of natural functions that provide ongoing social and economic benefits (Potts & Hastings, 2011). The full economic cost of the impact of marine litter on the environment is complex because some impacts are more readily evaluated than others. For example, costs for cleaning operations or lost fishing revenue from entanglement are captured in traditional economic calculations but the economic implications of degraded ecosystem services are difficult to value (Mouat *et al.*, 2010; Potts & Hastings, 2011).

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 and found a number of key findings; some of which are

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

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 beach 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 beaches is considered a shameful act by its attendants, people will feel guilty if they littered whereas if beaches site are always overwhelmed with litter, continuous littering by its attendants will become an acceptable norm even when they are cleaned.

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, (UNEP 2006) estimated an average of 13,000 and 46,000 pieces of marine litter were found per every square kilometre stretch in 2005 and 2006 respectively. Gregory (2009) has contended that over the last 5 to 6 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 provoke 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).

Municipal Waste Management in Africa

Throughout much of the world, coastal areas are developed, overcrowded and overexploited (Hinrichsen, 1998). Coastal waters and bays are often horribly polluted with untreated (or partially treated) municipal, industrial and agricultural wastes (Rockefeller, 2008). Underlying the crisis is escalating human numbers and needs (Hinrichsen, 1998). Poor waste management practices can be a major source of litter, enabling the transportation of litter into the marine environment through a variety of pathways (wind, reverie) (Potts and Hastings, 2011). Over the last decade, all over the world and particularly in many developing countries in Africa, there has been remarkable population growth, accompanied by intense urbanization, and relative increase of industrial activities with attendant higher exploitation of cultivable land. According to Coast (2002) at the turn of the twenty-first century global population, within a space of twelve years had increased from five billion to an excess of six billion with developing countries accounting for 80 per cent of the world's population.

Coast (2002) again asserts that growth rates in Africa still exceed 2.3 per cent per year, the highest growth rate of any major region. These transformations have brought huge increase in quantities of solid waste discharged and a wide diversification of other types of pollutants (including marine litter) that reach the sea (Nunoo & Quayson, 2003). Waste includes all items that people no longer have any use for, which they either intend to get rid of or have already discarded. Many items can be considered as waste example household rubbish, sewage sludge, wastes from manufacturing activities, packaging items, discarded cars, old televisions, garden waste, old paint containers etc. Thus, all our daily activities can give rise to a large variety of different wastes arising from different sources. With such vast quantities of waste being produced, it is of vital importance that it is managed in such a way that it does not cause any harm to either human health or to the environment (EIONET, 2009). The OECD- defines waste management as collection, transport, treatment and disposal of waste, including after-care of disposal sites (EIONET, 2009). For a long time, waste management along the coast was regarded by coastal countries as a purely aesthetic problem and only coastal resorts attempted to tackle the problem by regularly cleaning debris from the beaches (World Ocean Review, 2010). According to the World Ocean Review (2010), the seas are full of garbage and the National Academy of Sciences in the USA estimates that around 6.4 million tonnes of litter enter the world‘s oceans each year. An accurate estimate of the amount of garbage in the oceans is however difficult to arrive at because, it is constantly in motion and enters the marine environment from different pathways, (World Ocean Review, 2010).

According to the United Nations Joint Group of Experts on the Scientific Aspects of Marine Pollution, land-based sources can account for up to 80 percent of the world‘s marine pollution UN-(GESAMP, 1991). The problem, according to the World Ocean Review (2010) does not only affect the coastal areas but propelled by the wind and ocean currents, travels very long distances throughout the oceans and to remote beaches and uninhabited islands. Researchers have shown that marine litter has very serious implications for humans, particularly for coastal communities with the main impacts being: risks to human health, rising costs involved in clean up exercises, low patronage by tourists, damage to ships fishery losses as well as adverse effects on near-coastal farming. Catastrophic effects on marine fauna have also been established (World Ocean Review, 2010). Hinrichsen (1998) asserts that globally, little is being done to manage the crisis of our coast yet the World Ocean Review (2010) makes the argument that fact that marine litter is a problem that must be taken seriously is only gradually being recognized.

Ghana has a long and productive coastline of about 550 km facing the Gulf of Guinea (EPA, 2012). It has been granted with exceptional environmental diversity and aesthetic beauty. The coastal zones of Ghana are very productive and represent a huge natural and economic resource for the country (Amlalo, 2007). Almost 60 per cent of all industries in Ghana are located in the coastal zone, principally in the Accra-Tema metropolitan area which covers less than 1 per cent of the total area of Ghana. This concentration of industrial activity has led to the continuous immigration of people in search of jobs from the inland and rural areas to the coastal industrial centers, a contributing factor to the waste problem (UNEP, 1999). The population of the country is estimated at 24.7million with an annual growth-rate of 2.5% (Ghana Statistical Service, 2012). Proper waste management has been a major challenge for successive governments in Ghana (Jospong Group of Companies, 2010). Mensah and Larbi (2005) assert that the key problems with solid waste disposal in Ghana principally relate to:

- Problems with indiscriminate dumping;
- Increasing difficulties with acquiring suitable disposal sites;
- Difficulties with conveyance of solid waste by road due to worsening traffic problems and the lack of alternative transport options; and
- The weak demand for composting as an option for waste treatment and disposal.

Ghana dumps most of its municipal and industrial effluents directly into coastal waters with little or no pretreatment. Raw sewage is channeled into coastal waters. In some areas, high concentrations of bacteria pose a clear threat to human health (UNEP, 1991a from Hinrichsen, 1998). Amlalo (2007) puts Ghana‘s coast and the intense coastal activities being carried out into context: *“The marine and coastal resources of Ghana exist within a very fragile ecosystem. Current development trends and pressures exerted on these resources are steadily degrading the components of this fragile ecosystem”.* Large scale rural urban migration and subsequent congestion in cities have led to major waste and environmental sanitation problems (Jospong Group of Companies, 2010). Most of the concern for waste management in Ghana is within the urban areas. Urban areas in Ghana produce a variety of waste, the predominant wastes being domestic solid waste, industrial waste and construction waste. These wastes are sent to a few dumpsites, but majority end up in drains, streams and open places and eventually into the seas at the coast (United Nations Commission on Sustainable Development, 2012). This has created a pressing sanitation problem as many towns and cities are overwhelmed with management of municipal solid and liquid wastes.

Generally, the poor state of waste management is clearly not only an engineering problem. Rapid urbanization, poor financing capacity of local authorities, low technical capacity for planning and management of solid waste, weak enforcement of environmental regulations - which allow local authorities to flout environmental regulations without any sanctions - have all contributed to compound the problem (Mensah & Larbi, 2005). The Ghanaian experience shows that within the existing socio-economic context, manual systems are appropriate. The challenge therefore is to develop and promote disposal systems that require a minimum level of mechanical equipment (Mensah & Larbi, 2005). The archaeologist Emil Walter Hairy wrote: *"whichever way one views the mounds [of waste], as garbage piles to avoid, or as symbols of a way of life, they…are the features more productive of information than any others."* (Bogner *et al.*, 2007). Without proper waste management we are not only harming the beauty and health of our environment but we are also increasing the negative effects that waste can have on our own health.

International Legislation and Conventions Concerned with the Prevention of Marine Debris

For centuries, humans have regarded the oceans as an inexhaustible source of food, a useful route of transport, and, unfortunately, a dumping ground. What's more, this dumping ground was often believed to be too vast to feel the effects of human action (Rockefeller, 2003). Coastal zones have the most nutrients of all marine ecosystems and although they only account for 10 percent of the ocean environment, they are home to over 90 percent of all marine species. Of the 13,200 known species of marine fish, almost 80 percent of them are in coastal zones (WWF Global, 2000). In coastal areas around the world, shoreline developments have destroyed the habitats and breeding grounds of several marine species (Rockefeller, 2003). While there are laws regulating the dumping of trash at sea and on shore, the global nature of marine debris, the inability to confine debris within territorial boundaries and the complexity of identifying debris sources have made effective laws difficult to develop and even harder to enforce (Sheavly, 2007). The key to controlling marine litter is to tackle it at source and this is not only consistent with the precautionary principle, but would appear to be the only management option that is economically sustainable in the longer term (Fanshawe & Everard, 2002). A wide range of international agreements and legislation both directly and indirectly address the problem of marine litter. Several pieces of legislation are specifically designed to reduce marine litter and prevent the discharge of waste into the marine environment but many of the existing agreements take a broader approach and outline fundamental principles for the sustainable use and conservation of the oceans (Mouat *et al.*, 2010). The key pieces of international legislation are briefly outlined below.

United Nations Convention on the Law of the Sea (UNCLOS), 1982

UNCLOS is designed to comprehensively govern the management of marine resources and their conservation for future generations. Provisions of the Convention include territorial sea limits, conservation and management of living marine resources, protection of the marine environment, economic and commercial activities, marine scientific research and a binding procedure for the settlement of disputes relating to the oceans. The protection and preservation of the marine environment is addressed by Part XII of the Convention (Articles 192 - 237) which outlines basic obligations to prevent, reduce and control pollution from land-based sources; pollution from sea-bed activities subject to national jurisdiction; pollution from activities in the Area; pollution by dumping; pollution from vessels; and pollution from or through the atmosphere. Marine litter was specifically addressed in November 2005 as part of UN General Assembly Resolution A/RES/60/30– Oceans and the Law of the sea, which states: *"…The General Assembly, 65. Notes the lack of information and data on marine debris and encourages relevant national and international organisations to undertake further studies on the extent and nature of the problem, also encourages States to develop partnerships with industry and civil society to raise awareness of the extent of the impact of marine litter on the health and productivity of the marine environment and consequent economic loss; 66. Urges States to integrate the issue of marine debris within national strategies dealing with waste management in the coastal zone, ports and maritime industries, including recycling, reuse,* *reduction and disposal, and to encourage the development of appropriate economic incentives to address this issue including the development of cost recovery systems that provide an incentive to use port reception facilities and discourage ships from discharging marine debris at sea, and encourages States to cooperate regionally and sub regionally to develop and implement joint prevention and recovery programmes for marine debris;…"* (Mouat *et al.*, 2010).

International Convention for the Prevention of Marine Pollution from Ships, 1973, As Modified by the Protocol of 1978 Relating Thereto (MARPOL 73/78) Annex V

The MARPOL Convention is the key international agreement to prevent pollution of the marine environment by ships and has six annexes concentrating on different types of pollution, as shown in Table 1:

Table 1: Pollution types covered by MARPOL Annexes I-VI

Annex	Specific Type of Pollution Dealt With By The Annex
Annex i	Oil and oily wastes
Annex ii	Noxious liquid 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

Annex I (Oil) and Annex II (Chemicals) are compulsory but the other annexes are voluntary (Fanshawe and Everard, 2002; UNEP, 2005; Mouat *et al.*, 2010). MARPOL Annex V regulates the types and quantities of garbage that ships may discharge into the sea and specifies the distances from land and manner in which they may be disposed of (UNEP, 2005a; Mouat *et al.*, 2010). For the purposes of Annex V, garbage includes ―all kinds of food, domestic and operating waste, excluding fresh fish, generated during the normal operation of the vessel and liable to be disposed of continuously or periodically (IMO, 2002; Mouat *et al.*, 2010). Under these regulations, the disposal of plastic anywhere into the sea is strictly prohibited and the discharge of other wastes is severely restricted in coastal waters and ―Special Areas‖. The North Sea and adjacent areas are designated ―Special Areas‖ under MARPOL Annex V and in accordance with these regulations, discharges of garbage, except food waste, into the sea are strictly prohibited. As of March 2010, 140 states had ratified MARPOL Annex V and these regulations now cover 97.5% of the world‘s shipping tonnage (IMO, 2010). The International Maritime Organisation (IMO) is currently reviewing MARPOL Annex V, in consultation with relevant stakeholders, to assess and improve its effectiveness in addressing ocean-based sources of marine litter (Mouat *et al.*, 2010).

International Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, 1972, and 1996 Protocol Relating Thereto

The London Convention aims to promote the effective management of all sources of marine pollution and prevent the dumping of wastes and other matter at sea. It operates using a ―black- and grey-list approach‖ whereby dumping of all blacklist items is strictly prohibited; dumping of grey-list materials requires a special permission and is subject to strict control; and the dumping of all other items is allowed with a general permit (UNEP, 2005; Mouat *et al.*, 2010).

The black list are the contaminants most likely to cause great harm to living resources, marine life and human health due to their hazardous characteristics. These hazardous characteristics include not only toxicity, but the propensity to bio-accumulate and bio-magnify in the human food chain (Kimball, 2005). Grey list items refers to wastes containing significant amounts of arsenic, beryllium, chromium, copper, lead, nickel, vanadium, zinc, organosilicon compounds, cyanides, fluorides, pesticides and their by-products not covered in Annex I (UNEP, 2005; Mouat *et al.*, 2010). Annex I of the London Convention explicitly prohibits signatories from dumping persistent plastics and other non-biodegradable materials into the sea from ships and other man-made structures (UNEP, 2005; Mouat *et al.*, 2010). Agreed in 1996, the London Protocol aims to modernize the Convention and will eventually replace it. The Protocols' objective is to protect the marine environment from all sources of pollution and therefore all dumping is prohibited under the Protocol with the exception of possibly acceptable wastes on the ―reverse list. States can be a Party to either the London Convention 1972, or the 1996 Protocol, or both (UNEP, 2005; Mouat *et al.*, 2010). The following international agreements are also important for the protection of the marine environment and the prevention of marine litter.

Agenda 21: The United Nations Programme of Action from Rio and the Johannesburg Plan of Implementation. Agenda 21 is a comprehensive plan of action to be taken globally, nationally and locally by organizations of the

United Nations System, Governments, and Major Groups in every area in which human impacts on the environment (UNEP, 2005).

Convention on Biological Diversity 1992, with the Jakarta Mandate on the Conservation on and Sustainable Use of Marine and Coastal Biological Diversity 1995 (UNEP, 2005; Mouat *et al.*, 2010). The convention underlines the need for co-operation among parties in respect of areas beyond national jurisdiction for the conservation and sustainable use of biodiversity, either directly or through competent international organizations (Kimball, 2005).

Limitations to International Legislation and Conventions

A major limitation within the frameworks of international binding agreements is their poor acknowledgement of the approximately 80% of marine plastic debris that originates terrestrially (Simon and Schulte, 2017, Vince and Hardesty, 2016). For example, UNCLOS (1982) only goes as far as requesting that states control terrestrial pollution through domestic governance (Gold et al., 2014, UNEP, 2014). Additionally, regional agreements that do control for terrestrially sourced plastic, such as the Helsinki Convention (1992), are threatened by migrating marine plastic debris from beyond their area of control. The GPA and the Honolulu Strategy are promising new non-binding developments, as they do incorporate land-sourced plastic into their frameworks (UNEP, 2017, UNEP, 2012). Furthermore, the GPA approaches marine plastic debris management from a collaborative, integrated perspective; it brings together multiple stakeholders; states, NGOs, and corporate sector. This is distinctive from other examples of international law, which fail to acknowledge the governance potential of corporate sector involvement. Indeed, soft law approaches to managing marine debris are currently far more extensive and better developed than their hard law equivalents (Vince and Hardesty, 2016). However, soft law approaches alone will struggle to bring about the level of change required to overcome marine plastic pollution, because of their voluntary nature. In its current state, international law will not solve the marine plastic debris problem (Simon and Schulte, 2017, Gold et al., 2014). There is substantial debate on whether the problems of the world's oceans need more regulatory framework, or need more effective implementation of existing regulations (Houghton, 2014, Gold et al., 2014).

As marine plastic debris has become a global priority, the answer may be a combination of the two. A new binding treaty focusing on marine plastic debris may be required to match the scale of the risk posed (Simon and Schulte, 2017, Vince and Hardesty, 2016); such a treaty would combine the various aspects of marine plastic debris currently covered in international agreements into a comprehensive, integrated instrument. Furthermore, a new treaty should take this ripe opportunity to include non-state actors into its functioning, especially the often ignored corporate sector, which has the direct ability to produce more sustainable products (Landon-lane, 2018). Marine plastic debris policy development should not be limited to the international level, on the contrary, its relationship to national policy should be to provide consistent guidelines for domestic marine plastic debris policy development. Additionally, integrated, holistic policy includes as many actors as possible, both state and nonstate. Therefore, with careful designing, such policy is more likely to succeed (Vince and Hardesty, 2016). Policy integration can be achieved using governance institutions that is, organisations that are created with the explicit purpose effecting governance, but, importantly, requires the near total support of all participants (Vince, 2015). Therefore, to implement effective, integrated marine plastic debris policies on an ocean commons scale, almost every state must be supportive of the proposed policies – a formidable goal.

Ghana's National Strategy and Programme Support Elements

Ghana is of the opinion that the effective implementation and coordination, locally and regionally, of the activities involved in the various programmes listed below will ensure sustainable environmental conditions in our marine and coastal ecosystems (UNEP, 1999). Meanwhile the following measures have been taken in Ghana (UNEP 1999):

- An Environmental Protection Agency (EPA) was established in 1994 and vested with the appropriate authority for environmental matters: to co-manage, protect and enhance the country's environment, as well as seek common solutions to global environmental problems.
- A National Environmental Action Plan (NEAP) has been produced: The National Environmental Policy was adopted to provide the broad framework for the implementation of the action plan and to ensure sound management of resources over a ten-year period, from 1991-2000. The NEAP endorsed a preventive approach to environmental management and emphasizes a need to promote socioeconomic development within the context of acceptable environmental standards. It sought to reconcile economic planning and environmental resource development with the view to achieving sustainable national development.

- All relevant national technical institutions have been identified and associated with the NEAP:
- The Ghana Environmental Resource Management Programme (GERMP) has been planned to help the Government implement the NEAP;
- Ghana is signatory to various international conventions related to the problems of sustainable development and regional and international cooperation in matters of the environment;
- In response to UNCED (1992) and Agenda 21 Ghana is involved in the following:

  i) ICAM (Integrated Coastal Area Management Programme). The programme is designed to assist countries in their efforts to build marine scientific and technological capabilities as a follow up to Chapter 17 of Agenda 21, and to Chapter IV of the Mauritius Strategy.

  ii) International Geosphere Biosphere Programme (IGBP). IGBP was launched in 1987 to coordinate international research on global-scale and regional-scale interactions between Earth's biological, chemical and physical processes and their interactions with human systems.

  iii) Land and Ocean Interactions in the Coastal Zone (LOICZ). LOICZ is working to support sustainability and adaptation to global change in the coastal zone

  iv) The Gulf of Guinea Large Marine Ecosystem Regional Project. The Project aimed to increase fish harvests to meet human nutritional needs and earn foreign exchange, to control the encroachment of coastal zone and to restore mangroves and sea grass beds.

v) The Lower Volta Mangrove Project (LVMP) of Ghana. This project is aimed at reversing the decline of coastal wetlands vegetation through reforestation of degraded wetland catchments, awareness creation, capacity building and improvement in the livelihoods of surrounding communities.

vi) The Western and Central Africa (WACAF) programme of the Regional Seas Programme of UNEP. WACAF focuses on projects on contingency planning, pollution, coastal erosion, environmental impact assessment, environmental legislation and marine mammals.

vii) The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities. This was adopted by the international community in 1995 and ―aims at preventing the degradation of the marine environment from land-based activities by facilitating the realization of the duty of States to preserve and protect the marine environment‖. It is unique in that it is the only global initiative directly addressing the connectivity between terrestrial, freshwater, coastal and marine ecosystems (UNEP, 1999).

Monitoring Marine Debris

Marine debris monitoring, as defined by UNEP and IOC, is the repeated surveys of beaches, sea bed and/or surface waters to determine litter quantities such that information can be compared with baseline data to evaluate whether changes occur through time and / or in response to management arrangements. Several different means through which this can be done are available, although some basic principles need to be adhered to (Cheshire *et al.*, 2009). It is estimated that about 6.4 million tons of marine litter are disposed in the oceans and seas each year (UNEP, 2005; World Ocean Review, 2010). According to other estimates and calculations, some 8 million items of marine litter are dumped in oceans and seas every day, approximately 5 million of which (solid waste) are thrown overboard or lost from ships. Furthermore, it has been estimated that over 13,000 pieces of plastic litter are floating on every square kilometre of ocean today (UNEP, 2005).

Despite efforts made nationally, regionally nationally and internationally, there are indications that the marine litter problem keeps growing. As long as the input of non-degradable or slowly degradable litter into the marine environment keeps increasing, their destructive impact on the ocean and coastal environment will increase likewise (UNEP, 2005). Deficiencies in the implementation and enforcement of existing international, regional, national regulations and standards that could improve the situation, combined with a lack of awareness among main stakeholders and the general public, are other major reasons why the marine litter problem not only remains but keeps increasing worldwide (UNEP, 2005). Marine litter is part of the broader problem of waste management. Solid waste management is becoming a major public health and environmental concern in many countries, where generally a lack of appropriate systems for the management of waste, from its source to its final disposal or processing exists (UNEP, 2005). By enhancing our capacity to undertake longer term, broad scale monitoring programs we will be able to undertake meaningful comparisons of marine debris loads at different locations and data acquired will allow us to better identify sources of debris, leading to targeted control, education and behaviour modification strategies. (Cheshire & Westphalen, 2007; Sheavly, 2007).

Beach Litter Surveys in Ghana

Beach litter survey is the structured set of procedures to provide a quantitative assessment of the amount of litter in a given location (Cheshire *et al.*, 2009). In Ghana, a survey of marine litter on two beaches in Accra was carried out between April - May, 2000 by Nunoo & Quayson(2003). The study investigated Sakumono and Centre for National Culture (CNC) beaches in Accra for the types and quantities of litter and their rate of accumulation. A similar study was carried out by Tsagbey *et al*. (2009) at the La Pleasure and Korle Gonno beaches also in Accra during a 3-week festive period (December, 26, 2005 – January, 9, 2006) and a 3-week non-festive period (January 23, 2006 – February 6, 2006). 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).

Compared to global initiatives undertaken the world over, very little work concerning the issue of solid waste and beach litter in Ghana has been carried out. Although pollution is moderate in the West and Central African (WACAF) region, the threats it poses are more serious in coastal hotspots associated with the larger coastal cities (UNEP, 1999). In spite of the various sectoral national monitoring and assessment efforts, coastal area and marine data and information provide limited transboundary and integrated regional information upon which management actions and political decisions can be based at regional level negotiations (IGCC/GCLME, 2010). They are also invariably not designed to assess long-term trends and potential threats of cumulative impacts of human activities and until recently most laboratories in the region had no standardised methodologies and techniques for sampling, analysis and interpretation of data (IGCC/ GCLME, 2010). Waste characterization data specific to African cities is generally not available, though some regional evaluations have been made (Palczynski, 2002). Solid waste and marine debris for the Gulf of Guinea region is estimated at 3.8 million tonnes/year of mainly non-hazardous waste Scheren *et al.* (2002). The Abidjan Convention for Co-operation in the Protection, Management and Development of the Marine and Coastal Environment of the West and Central African (WACAF) region was born out of the need to undertake regional and common approaches to the prevention, reduction and combating of pollution in the marine environment, the coastal areas and related inland waters of western Africa(IGCC/ GCLME, 2010) through the development of a set of environmental indicators for use in macroeconomic and sector planning and policymaking (Palczynski, 2002).

A key challenge in developing guidelines for the assessment of marine litter is to identify the major processes that control the entry and / or removal of litter from the oceans and also the transformations that occur during the lifecycle of any given litter item (e.g. when floating litter sinks to become benthic litter or is cast onto a beach to become beach cast litter) (Cheshire *et al.*, 2009). It is the assertion of Cheshire *et al.* (2009) that:

- For as long as the input processes (discard) exceed the removal processes (collection and decomposition) then the amount of litter will increase through time resulting in more litter in the oceans and on the beaches.

- Given that decomposition is slow (particularly for some of the persistent and more toxic plastic forms of litter) then this will never be a solution to the marine litter problem. In some cases, material engineering may provide alternative materials that decompose more rapidly; increased rates of decomposition would then result in a reduction in the size of the litter pool.
- The key point of control in the system is through the management of discard behaviours. If we can reduce inputs, we have some chance of managing the downstream environmental consequences. Consequently, litter assessments need to be planned to ensure that they sit within and across the context of a broader regional management framework and are delivered consistent with the defined protocols.

Types of Shoreline Surveys

There are two main types of shoreline surveys: accumulation and standing-stock surveys. Accumulation studies provide information on the rate of deposition (flux) of debris on to the shoreline. These studies are more suited to areas that have beach cleanups, as debris is removed from the entire length of shoreline during each site visit. This type of survey is more labour-intensive and is used to determine the rate of debris deposition (number of items per unit area, per unit time). Accumulation studies can also provide information about debris type and weight. These surveys cannot be used to measure the density of debris on the shoreline because removal of debris biases the amount of debris present during subsequent surveys (Opfer *et al.*, 2012).

Standing-stock studies provide information on the amount and types of debris on the shoreline. Debris within discrete transects at the shoreline site is tallied during standing stock surveys. This is a quick assessment of the total load of debris and is used to determine the density (number of items per unit area) of debris present. Debris density reflects the long-term balance between debris inputs and removal and is important to understanding the overall impact of debris (Opfer *et al.*, 2012).

Beach Selection

Selection of beaches for marine litter surveys should follow the approach detailed in the NMDMP (which are similar to the OSPAR and AMDS criteria; Sheavly, 2007; OSPAR, 2007; Cheshire & Westphalen, 2007 cited in Cheshire *et al.*, 2009), although the need for sandy beaches should be relaxed such that gravel beaches can also be included. The basic beach selection criteria should therefore include:

- Beach length of at least 500 meters
- Low to moderate slope (15-45°)
- Composed of sand to small gravel
- Clear, direct access to the sea (not blocked by breakwaters or jetties)
- Accessible to volunteer's year round
- Does not receive any routine municipal or community cleaning during the study; and site would not impact any endangered or protected species such as sea turtles, sea/shorebirds, marine mammals or sensitive beach vegetation (Sheavly, 2007).

These characteristics should be met where possible, but can be modified (Opfer *et al.*, 2012). Beach surveys vary widely in the length of beach surveyed and a minimum length of 100 m is required for any significant survey, although beaches with small amounts of litter can be longer (Cheshire *et al.*, 2009).

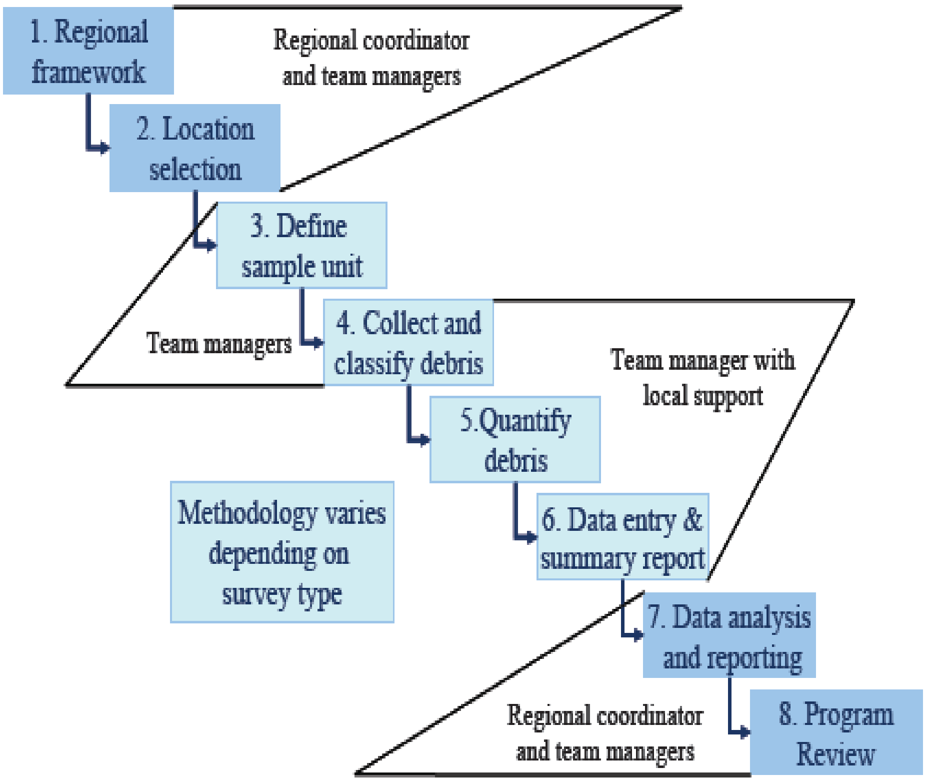

Figure 1: Steps in developing a marine litter assessment strategy (Source: Cheshire et al., 2009)

Challenges with Litter Assessment

The primary approach to controlling marine debris is to reduce the rate of input, largely through a variety of educational, behavioural and enforcement strategies, all of which require solid information on the sources of marine debris (Cheshire & Westphalen, 2007). Beach surveys are a primary tool for measuring debris loads in marine systems and also provide an invaluable mechanism for education and building community understanding (Cheshire & Westphalen, 2007; IOC, 2009). However, the identification of debris sources and the associated development and/or verification of management objectives are hampered by a lack of consistency in beach survey design and debris characterisation. As such, there is limited capacity to compare and contrast between surveys and therefore to develop our understanding about the spatial and temporal scales of variability in the amount of debris on beaches or adjacent oceans (Cheshire & Westphalen, 2007).

CHAPTER THREE

MATERIALS AND METHODS

This chapter describes specific methods and procedures used in assessing the litter on the beaches of selected towns in the central region 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 data collection and analysis technique as well as statistical tools for data analysis.

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 exclusive economic zone - 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 (UNEP, 1999).

This study was conducted along three beaches located along the central coast of Ghana. The criteria used for selection of the beaches 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.

Central region of Ghana is characterized by a diversity of coastal landforms and environments including sand spits, quartz-rich sand beaches, dunes, cliffs and rocky shore platforms, lagoons and estuaries. The study was carried out at three adjoining communities with sandy beaches in the central region; Moree Beach (5° 8'13.01"N 1°11'42.40"W) and Bakano beach (5° 6'7.40"N 1°15'8.19"W) and Anomabo beach (5°10'25.86"N 1° 7'7.51"W). Cape Coast, the regional capital experiences high temperatures throughout the year with the warmest months being February and March, just before the main rainy season, while the coolest months are between June and August. The climate is defined by a rainy season from April to mid-November and dry season December to March. Cape Coast is a densely populated area with 169,894 inhabitants, is one of the six metropolitan areas in the country and records quite a lot of visitors as a result of its beaches (Ghana Statistical Service, 2013). The major economic activities in the region are fishing, small scale farming and retailing. Maximum high tide recorded in the tide tables for Cape Coast which is of 1.8 m and a minimum height of -0.1 m

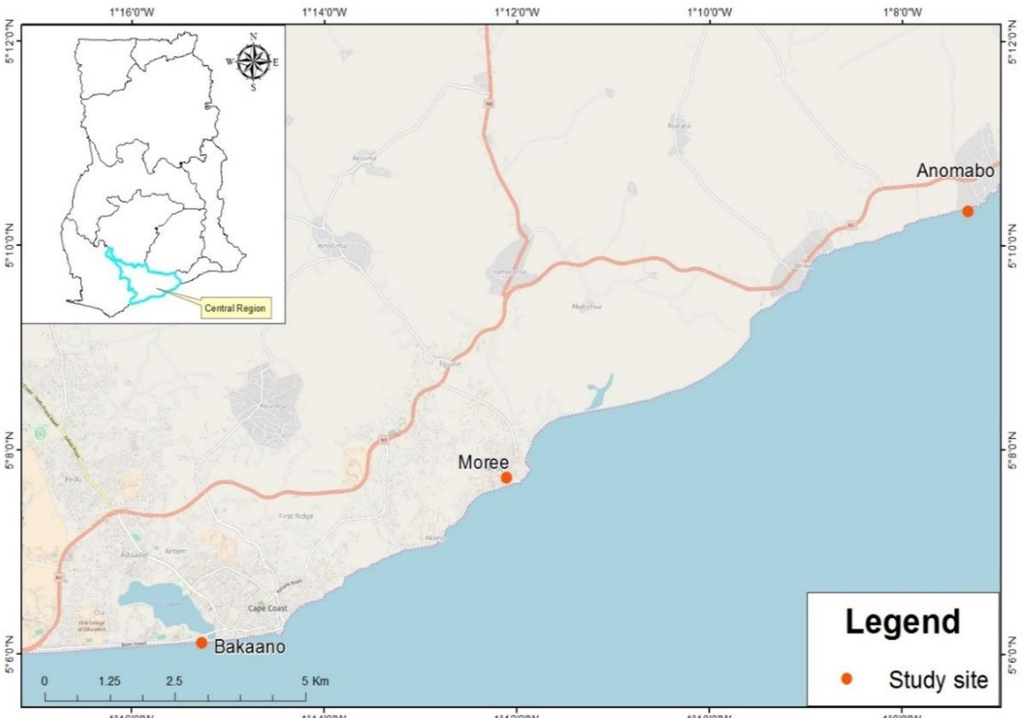

Figure 2: Map of study area showing the 3 study sites: Bakano, Moree and Anomabo in the Centrral Region of Ghana

Data Collection

The study was done mainly with the use of primary data, via the collection of both qualitative and quantitative data. Primary data was collected from the field through beach surveys, semi structured questionnaire interviews and field observations. Quantitative assessment of litter was carried out using the protocols of OSPAR (2007) and MCS (2009).

Beach Survey

Litter collection was done on all three beaches namely Anomabo beach, Moree Beach and Bakano beach, with one sampling site each. At each beach location data was collected on the depositional environment and proximity to litter sources, including;

- Prevailing wind (from meteorological data)
- Beach curvature
- Total beach length
- Nearest river – name, distance, direction and whether or not it inputs directly to the beach
- Nearest town – name, distance and direction
- Estimated number of person visits
- Main beach usage (i.e. recreational – swimming and sunbathing, fishing, boat access or remote)
- Beach slope should be measured at the start and end point of each transect
- The shape of the beach profile should be described at transect start and end points and
- Access (vehicular, pedestrian and/or boat only)

Selection of Sampling Unit

A belt transect, representing a sampling area of 1000 m^2 (10m × 100m) was demarcated at each beach between the low tide mark and the zone of emergent vegetation, dunes, road or other anthropogenic structures such as seawalls. This was done using a surveyor's measuring wheel and markers to ensure length accuracy, photographs and GPS locations for each transect and survey site was also taken, noting unique features and landmarks that would identify the site's location to ensure repeatability in successive surveys. The markers were placed at the beginning and end points of the 10 m × 100 m transect for each study site. To evaluate the composition and abundance of beach litter, all the visible pieces of debris (number of items) found on each belt transect was identified and recorded *in situ*.

Mode of Litter Collection

Litter was collected weekly, at each sampling site making four each month. An average of 3 to 4 of volunteers lined up at the 50m side of the transect with approximately 15 metre intervals between them and then slowly walked perpendicular to the beach 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 sorting, counting and weighing. The results recorded on a data sheet on-site for analysis. To avoid the possibility of double counting on subsequent visits, the team of volunteers sent debris collected to the dump site after collection, counting and weighing. The litter collection pattern is illustrated with the .

To ensure that the entire transect was be covered, a perpendicular walking pattern suggested by Opfer *et al*. (2012) was employed (Figure. 3). The surveyor stands facing the water edge and walks from starting point of the belt transect collecting debris from both the left and right sides at about one-meter intervals until the entire belt transect is covered.

This procedure was carried out weekly at the same location for each beach. Litter was scored in one of ten categories, according to its composition as seen in (UNEP, 2009):

- **Cloth**: Clothing, shoes, hats & towels
- **Glass**: ceramics and pottery
- **Foam:** (including sponge and packaging/insulation foam)
- **Hard plastics:** (anything that has been moulded) e.g.: forks, knifes, spoons, bottle caps & lids.
- **Soft plastics**
- **Metals:** aluminium drink cans, foil wrappers, wire, wire mesh
- **Rubber**: Balloons, balls, Inner-tubes and rubber sheet.
- **Paper and cardboard**: including newspapers, magazines, cardboard boxes.
- **Wood**: Ice-cream sticks, chip forks, chopsticks, matches & fireworks
- **Other** (this group is not necessarily based on composition)

The litter items were counted and weighed using an electronic scale and the hand scales. Litter was further categorised as either originating from the ocean or having a land-based source based on the classification by Barr (2000).

Table 2: Showing sources of litter

Source of Litter	Litter Types
Land-Based	plastic bottles, straws (plastic), black plastic bags, used condoms, caps/lids, glass bottles, pure water sachet, aluminium foil, umbrellas, paper, used sanitary towels, balloons, metal cans, cigarette packaging/ wrappers etc.
Ocean/Waterway-Based	fishing net, rope, strapping bands, incandescent bulb, seaweed
General	nails, cardboard pieces, glass pieces, metal pieces, plastic containers, styrofoam pieces, pieces of foam, bones, car tyres.

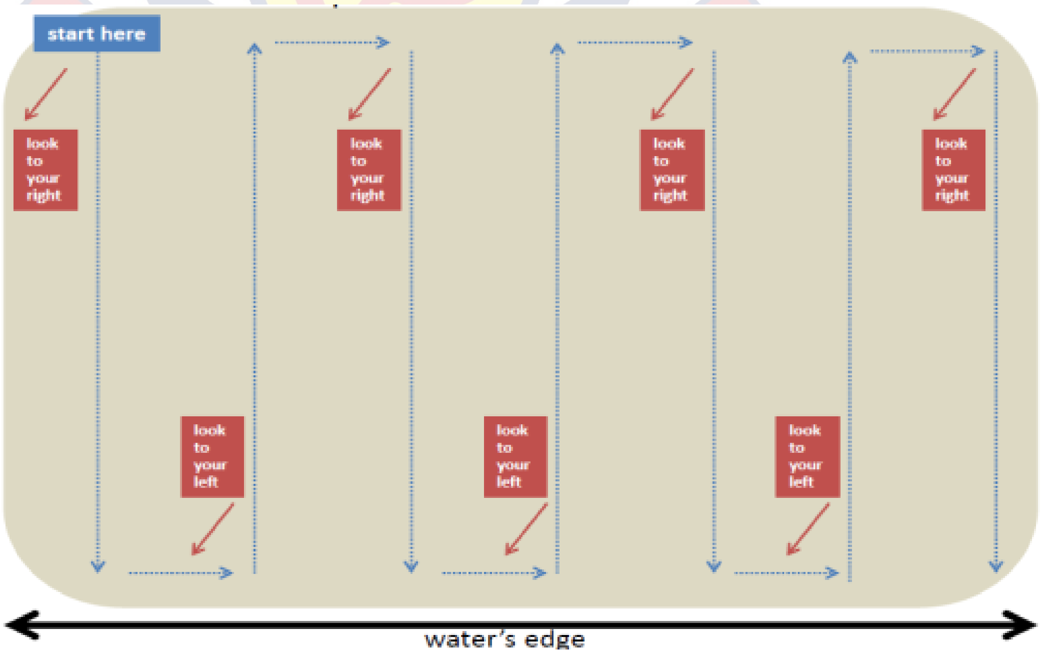

Figure 3: Walking pattern employed in collecting debris within transect (Source: Opfer et al., 2012)

Floating Litter

Litter collection was done on all three beaches namely Moree Beach and Bakano beach, and Anomabo beach. All sites are relatively closed and assumed to be influenced by similar climate and oceanographic events.

For this survey, litter was collected from landings of fishermen (beach seiners) after their fishing expedition. This was collected, as beach seiners fish in areas directly adjacent their beaches. Fishing gear and skill of fishers will be kept consistent as far as possible throughout the study period by sampling from same net and crew. When catch is landed, the total catch was estimated with the number of bowls acquired and weighed and compared with litter acquired from the trip. To evaluate the composition and abundance of marine litter, all the visible pieces of debris (number of items) found in the landed catch was identified *in situ* and recorded. Litter was scored in one of ten categories, according to its composition as seen in beach survey above.

House Hold Survey

This survey was conducted in communities that are located directly adjacent selected beaches. These communities are mainly made up of households as the main economic activity in the area is fishing. In total, 60 sample households was selected for the study, with 20 households from each community. Households was selected using the stratified random sampling technique for the total number of households in the area. This was done by sub dividing the total households according to their nearness to the beach. Household were then randomly selected from each sub group. Randomly selected households from the study location was visited to inform occupants about the survey and to receive feedback on their willingness to participate in the study. The selected households were educated on waste sorting and separation using designed flyers and personal contacts.

According to Brunner and Ernst (1986) there are three methods for determining the composition of urban solid waste streams. They are i) waste product analysis, ii) market product analysis and iii) direct sampling analysis.

The method chosen for this study included direct sampling analysis of solid waste from specific sources, labour-intensive manual process of sorting, classifying and weighing all items in each sampling unit and a detailed recording of the data.

Each of the waste samples from the source of generation were emptied on a black polythene sheet laid on a bare floor for sorting, the collected wastes were dumped together and mixed thoroughly and a representative sample was taken to comprise the composite sample (Soncuya and Viloria, 1992).

The total wet weight of each waste category was determined and expressed in kilogram and the percentage of each constituent was calculated. The whole process of sorting and weighing was carried out seven times a week for three weeks.

Initial sorting of the waste was carried out by members of the households and further sorting after waste is collected. Two bins (of different colours) supplied to each household for the sorting and separation, to organic wastes and all other waste. The organic waste bin was labelled ‘‘Biodegradables except paper” which included food or kitchen waste, leaves, tree branches, and agricultural waste) while the ‘‘Other wastes” comprised plastics, papers, wood, textiles, metals, glass, rubber, leather and any waste which could not be classified. Further sorting was done bi-weekly for a consistent period of four weeks.

The sorted wastes was weighed using a hand scale and a top Pan. Counting of litter items was also be done manually. Fine particles was sieved from the waste to help ease the sorting and also reduce the fractions which could otherwise be identified as inert. The wastes sorted by households was further be segregated into 23 various sub-fractions and analysed by their weight, number as well as the percentage composition as described by Pichtel (2005) and ASTM D5231-92 (2008);

- **Organics** – a. food waste, b. yard waste (grass trimmings), c. wood, d. animal droppings
- **Paper** – a. cardboards, b. newsprints, c. office papers, d. tissue papers
- **Plastics** – a. polyethylene terephthalate (PET), b. high density polyethylene (HDPE), c. Polyvinyl chloride (PVC), d. Low density polyethylene (LDPE), e. Polypropylene (PP), f. Polystyrene (PS), g. other plastics
- **Metals** – a. scrap b. cans/tins
- **Glass** – a. coloured b. plain
- **Rubber and leather**
- **Textiles**
- **Inert** (sand, fine organics, ash).
- **Miscellaneous** (construction waste, batteries, paints, any other waste fraction not fit in the categories)

Materials Used in Sampling Beach Litter

- 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.
- Polythene bags: These were supplied to each volunteer for carrying the collected litter to the sorting site.
- Nose masks: This was also provided to protect the volunteers from the stench around the beach.
- Data record sheet (Appendix 2) and pens: This aided in the recording of the counts and weight of the litter.
- Plastic sheet – to spread waste over it for sorting, once collected and labelled from sampling site Gloves – for field volunteers to handle waste
- Nose masks – to protect workers from respiratory infections

Determination of the Generation of Mean Solid Waste

There are two known methods to determine the per capita generation rate of solid waste for a study area. They are;

1) Determining the number, sizes and volumes of solid waste collection systems
2) House-to-house, weight analysis methods and the weight and numbers of the two was used for this study. This approach allowed for high accuracy as it clearly indicates the source and area of waste and the number of generators.

Interview

The interviews was conducted at all three beach locations: Anomabo beach, Moree Beach and Bakano beach, over the whole period. This was to ascertain the perception of beach users as to source of litter and where it is perceived to ends up. Also, interview sought to find out the impacts of the litter from the people and if they understand the possible impacts of beach litter and how it can be managed and mitigated. The survey questionnaire designed for the respondents to complete comprised close-ended and open-ended questions, multiple choice, and multi-method questions.

Some local stakeholders who have experience and knowledge of the beaches under study and who could provide technical details and also strategic information on the possible means of managing and eradicating litter was also be interviewed.

All users of the respective beaches formed the target population of the study. Different people have different uses for the beaches; 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 beach.

The researcher therefore purposively selected four respondents from each of the three beaches s for each visit. Over the eight-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.

Stakeholders Survey

The views of some organisations and stakeholders were also sought using questionnaire- interviews to obtain first hand description of their opinion and understanding of the subject. Also, the interview was set out to find out feasible solutions from the various organizations. The interview was designed and oriented to local stakeholders who had experience and knowledge of the beaches under study and who could provide technical details and also more strategic information. Assembly members of the various communities under study, staff of zoomlion and some fisheries personals were identified.

Data 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. Litter was also group according to their likely source, Barr (2010) land based, sea based and other. Debris densities along the beaches was estimated by calculating the mean density of litter per area for each beach according to the material they are made of, function and their origin. These values was expressed in terms of numbers of items per meter squared**.** The percentage that each potential category contributed to the total debris was then be estimated for each beach and day. Results of the litter assessment obtained from the field were analysed using Microsoft Excel 2016.

Two-way ANOVA was also run on litter collected all three-study location and for the eight months period.

Data for the social survey was also analysed with the Statistical Package for the Social Sciences (SPSS), where logistic regression and descriptive analysis was run

CHAPTER FOUR

RESULTS

This Chapter presents data collected from the field for the assessment of litter on the beaches and households. The presentation is in accordance with research objectives and questions. The thematic areas covered in this chapter includes data on the general monthly trends 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 and the analysis of the perception of respondents involved in the survey.

Beach Litter Survey

A total of 32,640 items of beach litter was collected from the Bakano, Moree and Anomabo beaches over eight months (November to June). With Bakano recording the highest number of items amounting to 12,243 followed by Anomabo recording 10, 684 and Moree recording the lowest 9,713. The calculated mean number of weekly litter accumulation in a transect during the period was 303 ±76.67 at Moree beach. Anomabo beach, however, had a mean count of weekly litter accumulated in the transect area to be 333.9 ±73.9 and the calculated mean count of weekly litter accumulation in transect was 382.6 ±88.9 on Bakano beach. This is shown is Table 3. After a two-way ANOVA done between the location and time (months) form the independent variable and amount of marine waste items (dependent variable) the p-value (<2e-16) suggests acceptance of (H1). Therefore, if means are not same then the occurrence of waste items depends on the location. That sampling location has significant effect on the amount of litter obtained. A p-value of 0.011 also indicates a rejection of (Ho) that is sampling months has significant effect on the amount of litter obtained.

Table 3: Summary of beach debris (counts) and mean counts for the selected study beaches of the central Region of Ghana

Location	Total litter count	Weekly litter count
Bakano	12243	382.59
Anomabo	10684	333.88
Moree	9713	303.53

A total of 41 different debris items with 7 of them included in the world's famous 'dirty dozen' were identified. Plastic materials were found to be the most common debris type in all the study sites with an average composition of 55%, followed by paper composing 16%. Land based marine debris were the dominant debris types collected and waterway/ocean-based debris accounted for the least amount of debris types sampled over the duration of the study.

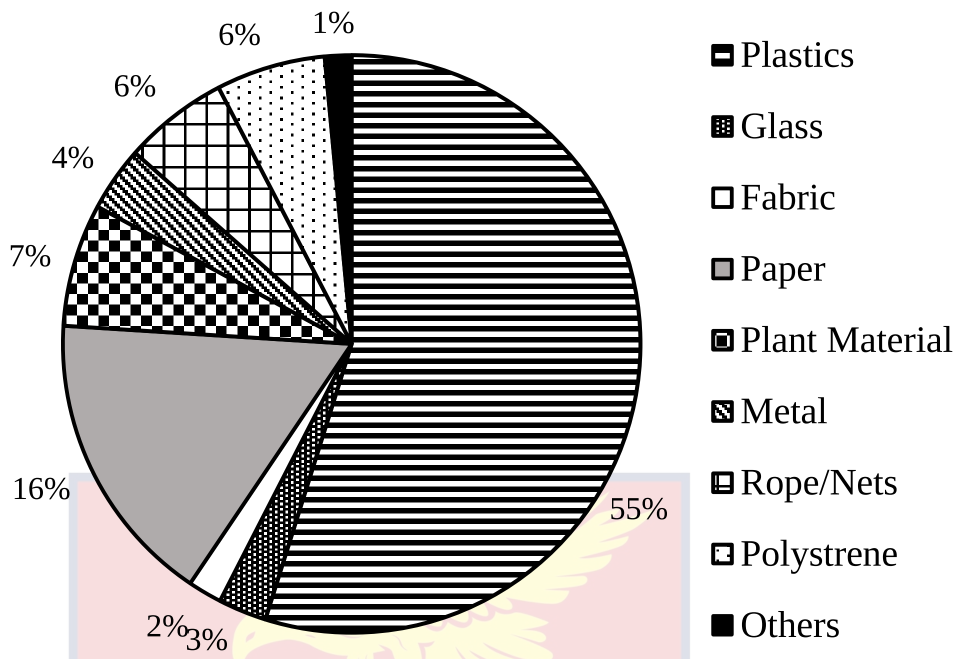

Figure 4: Total beach litter composition for selected study beaches of the central Region of Ghana

Sources of litter on the beaches

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 eight-month period were mainly from the public related sources (PRS) or were found to be mainly land based. Ninety percent (90%) represented litter from land-based sources whiles 8% of the total litter collected from the beaches represented ocean based sources as shown in Figure 5.

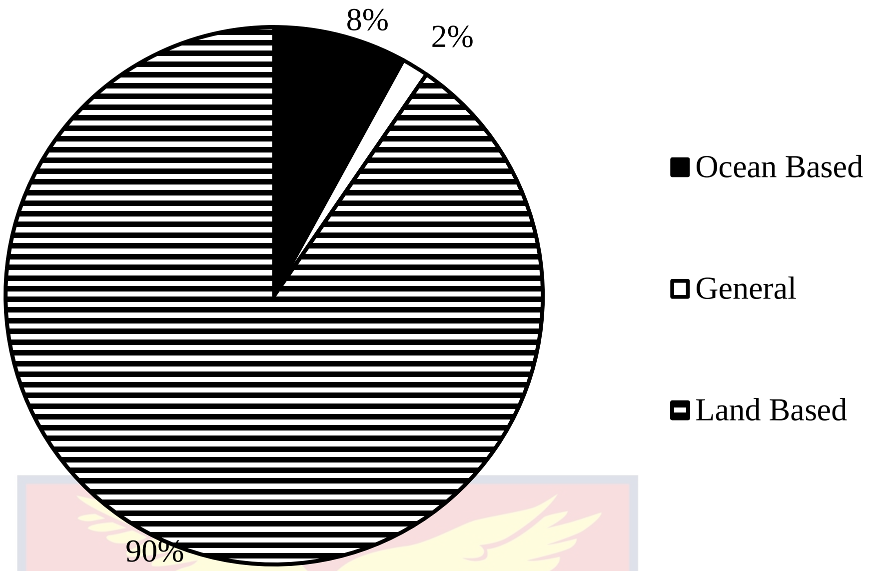

Figure 5: Sources of beach litter from the three study sites

General monthly trend in beach litter distribution across selected study beaches of the central Region of Ghana

Moree

The total litter collected along the beach of the Moree varied widely between 1,799 and 899 in December and May respectively. The litter represents a total of eight litter categories according to OSPAR (2009) classification. The unclassified items were grouped under the "others" category. Plastic litter was the dominant litter collected across the eight months sampling period and registered as 5,914 (62%). With metals representing the lowest 209 (1%), as represented in Figure 6 and 9.

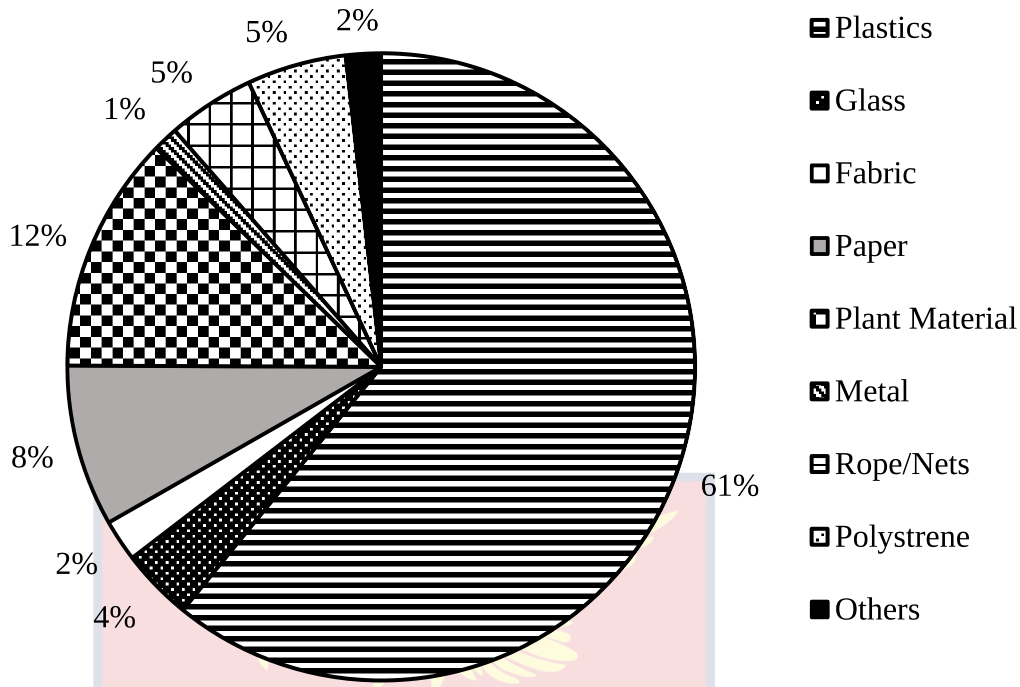

Figure 6: Total beach litter composition at Moree over the study period

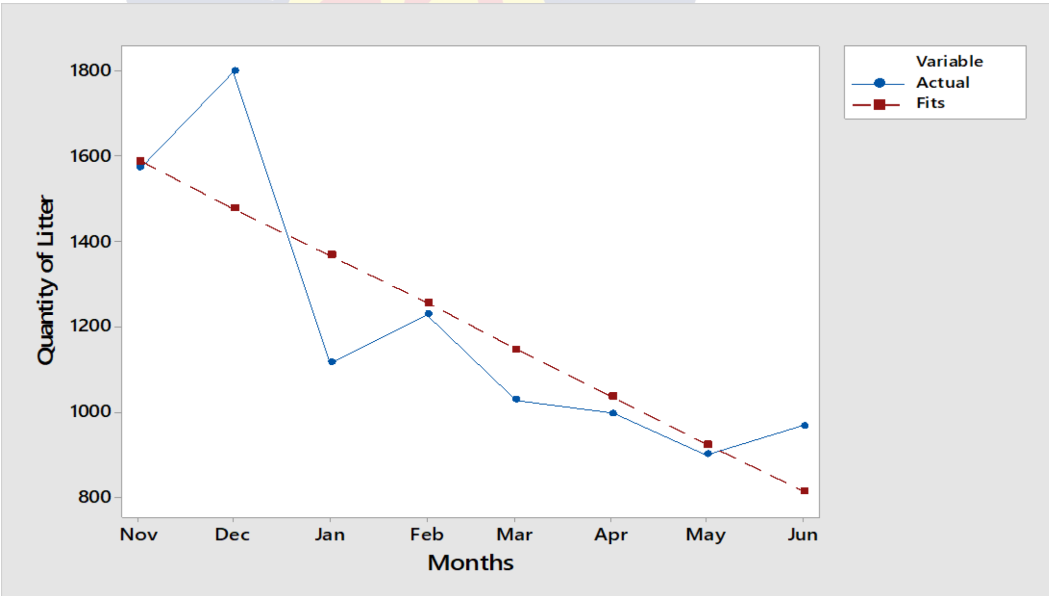

Figure 7 Monthly beach litter variations at Moree across the sampling period

Anomabo

Monthly litter abundance at the Anomabo beach also ranged between 1,086 in April and 1,913 in December. Again, the total litter observed represents eight identified litter categories according to OSPAR (2009) classification with the unclassified items group under the "others" category representing 112 items. Again, plastic litter category was the most prevalent litter recognized and registered in all the sampling months. The count of plastics was 5225 (49%) with others forming the least (1%) of the litter counted. Figure 7.

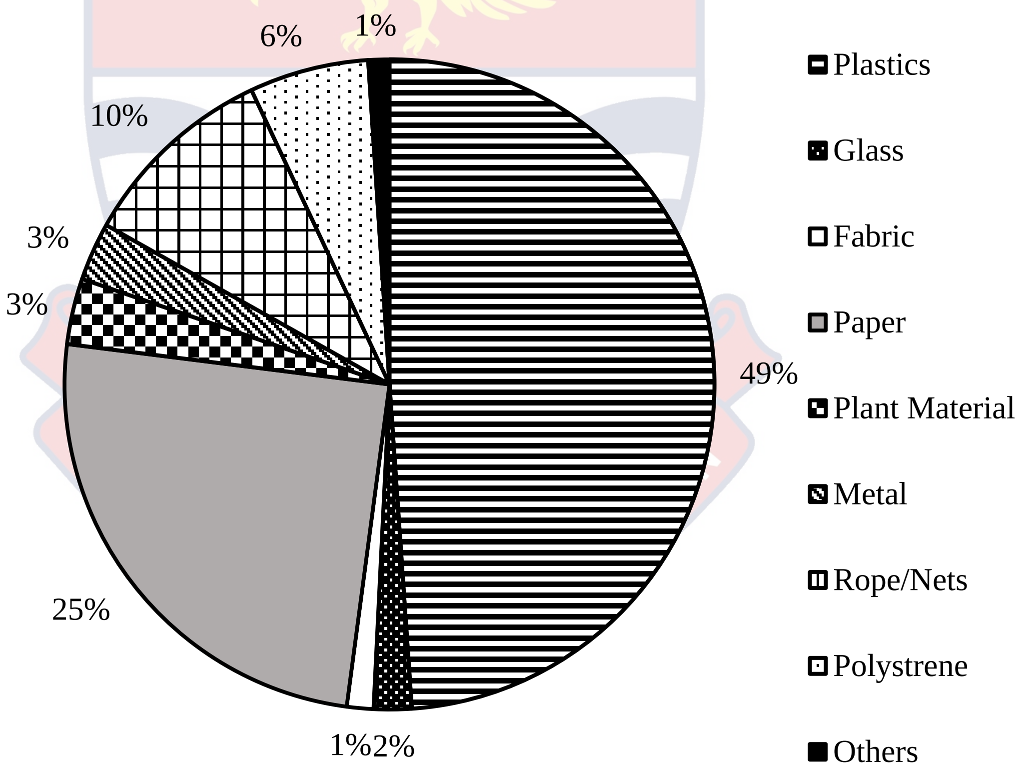

Figure 8: Total beach litter composition at Anomabo over the study period

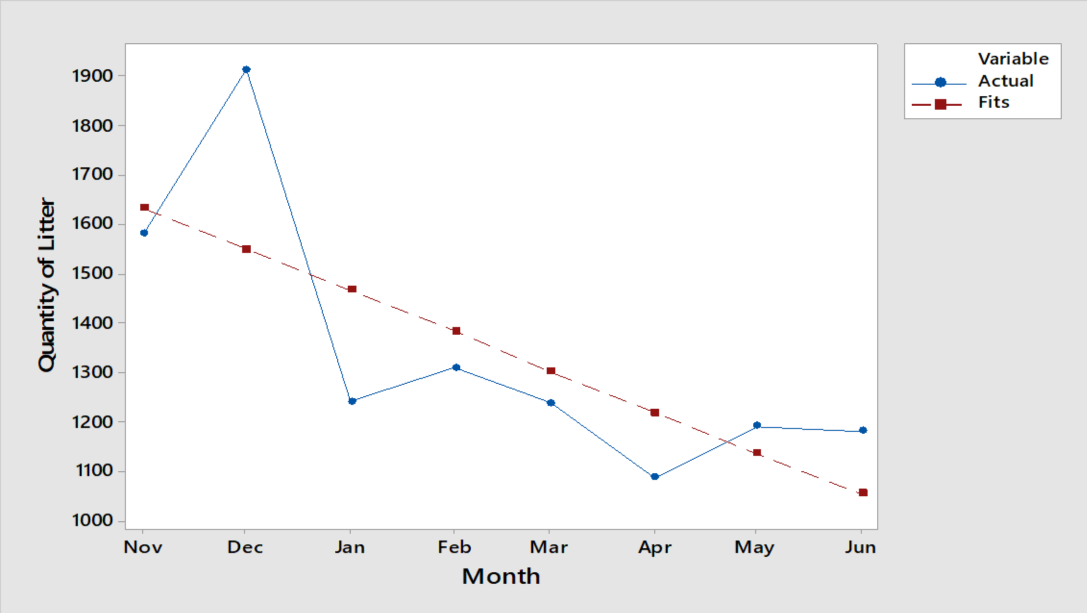

Figure 9 Monthly beach litter variations at Anomabo across the sampling period

Bakano

Of the overall litter collected from the Bakano beach, June recorded the lowest 1105 with the highest being December which recorded 1862 items. Bakano was the most littered beach among the three beaches, plastic debris was again the most dominant litter type and formed close to 6804 (56%) with the lowest being others representing 2% of the total litter. This is shown in Figure 8 and 9 below.

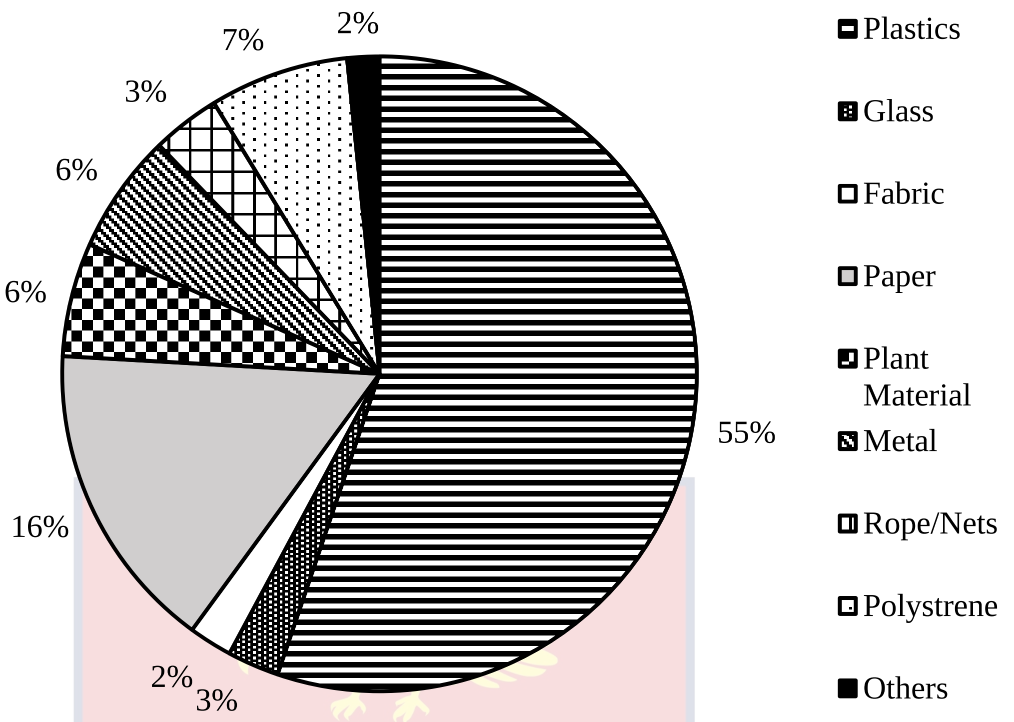

Figure 11: Total beach litter composition at Bakano over the study period

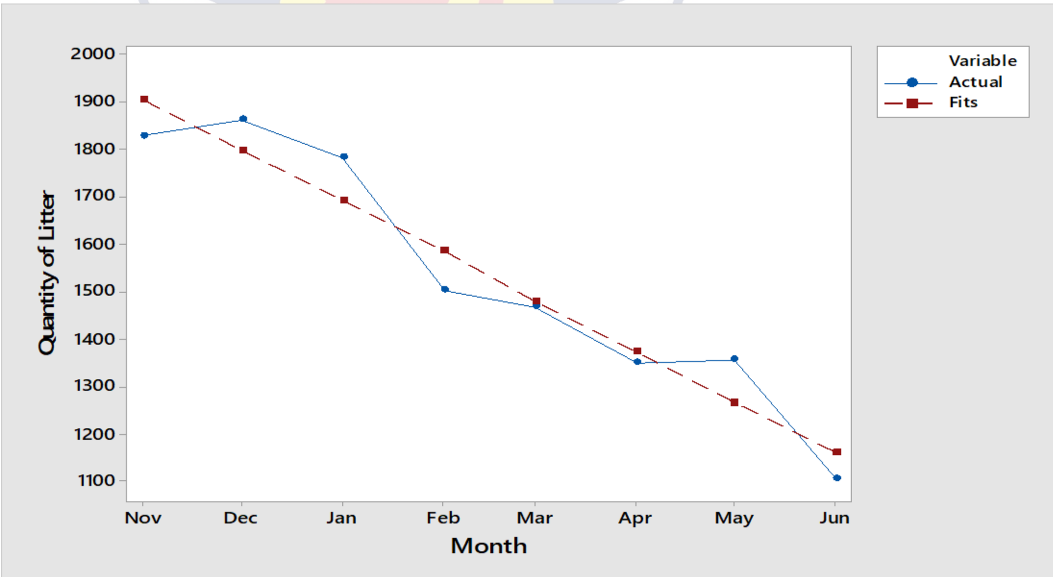

Figure 10 Monthly beach litter variations at Bakano across the sampling period

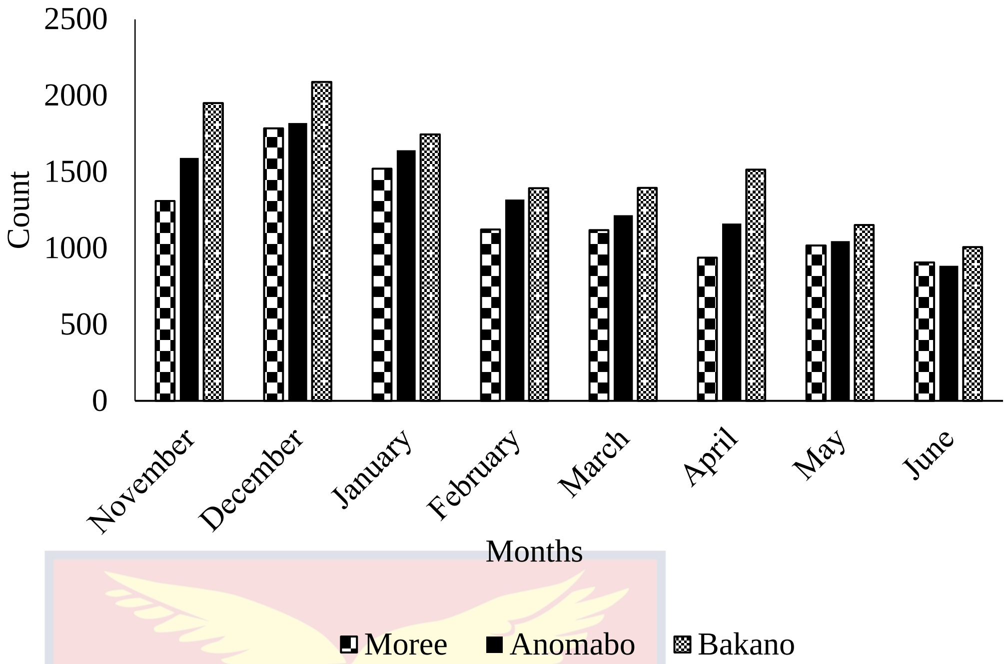

Figure 12: Monthly beach litter variations across sampling period at for all three study sites

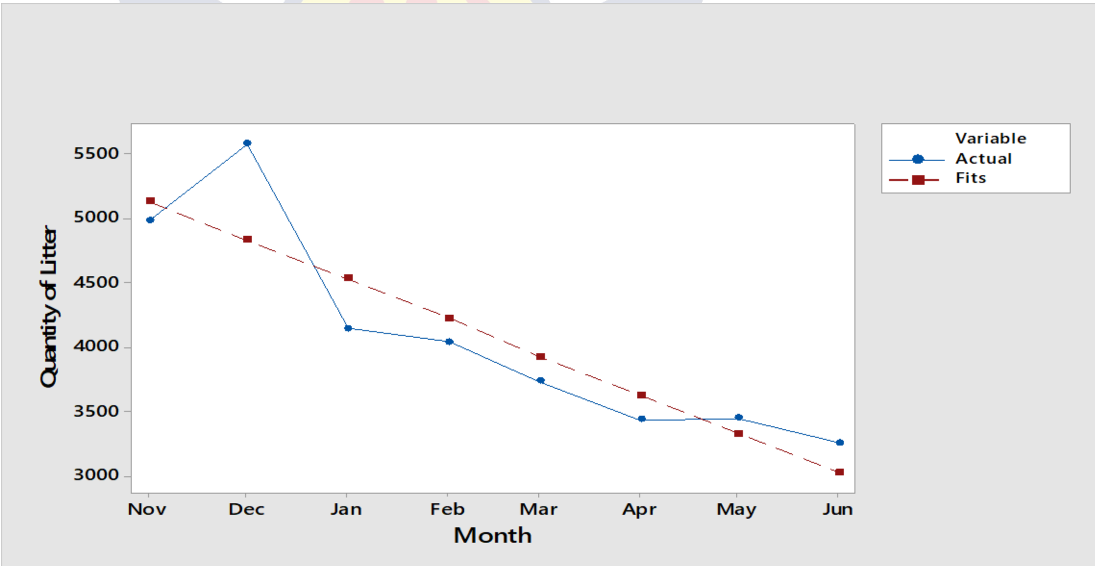

Figure 13 Monthly beach litter variations and best fits across sampling period at for all three study sites

Table 4: Information on models produced that may be used to monitor the behaviour of these series for years to come for beach litter.

		Accuracy Measures			Monthly Forecasts			
Locations	**Equations**	**MAPE**	**MAD**	**MSD**	**Jul**	**Aug**	**Sep**	**Oct**
Moree	Yt = 1699 - 110.7×t	9.7	118.7	25852.0	703	592	482	371
Anomabo	Yt = 1714 - 82.7×t	9.9	136.7	29085.3	970	887	804	722
Bakaano	Yt = 2010.4 - 106.4×t	4.0	61.4	4574.9	1053	946	840	734
Combined	Yt = 5424 - 299.8×t	6.0	274.0	113078.0	648	625	603	581

Table 4 presents information on the models or equations that may be used to monitor the behaviour of these series for years to come. It provides results of the equations or models, the accuracy measures (Mean Absolute Percentage Error-MAPE; Mean Absolute Deviation-MAD; Mean Standard Deviation-MSD) of the models as well as monthly forecasts of the series for the next four months. Inverse relationships were observed in all the models

Human excreta found on study sites

Human excreta (faeces) were also found on all three beaches. A total of 194 different patches of faeces was recorded throughout the study. Anomabo recorded the highest number (77), followed by Moree (61) and Bakano (56). The highest count of human excreta was counted in the first month which is November and the lowest in March as shown in Figure 10. A mean of 2.02 ±0.5 was encountered within the $100m^2$ transect weekly.

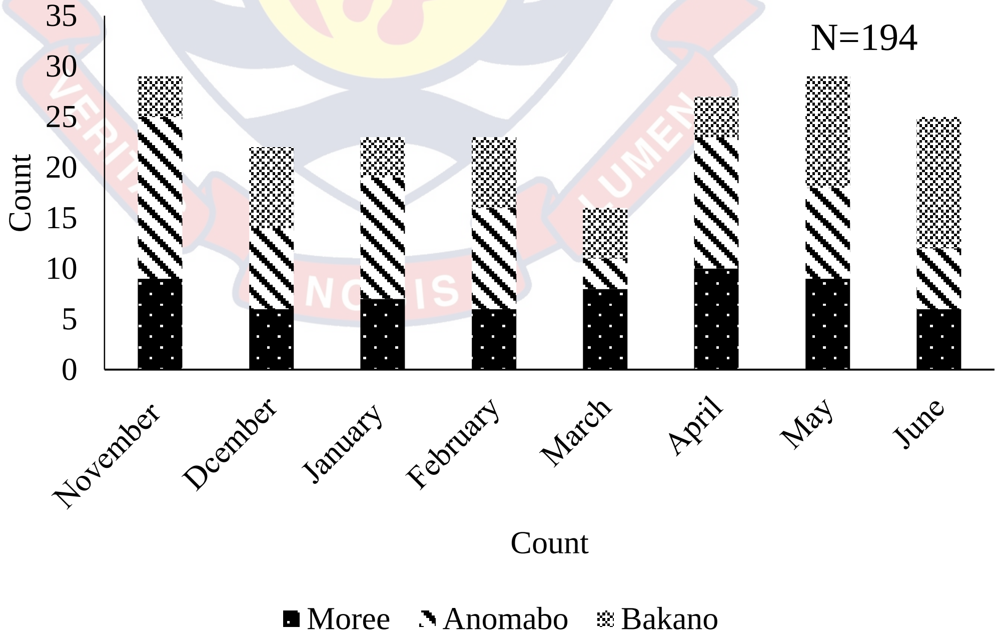

Figure 14: Total human excreta count in selected study beaches of the central Region of Ghana over 8 months the period

Floating Litter Survey

A total of 5,987 items of marine debris were collected from the Bakano, Moree and Anomabo beaches over eight months. With Bakano recording the highest number of items 2407 followed by Moree recording 1885 and Anomabo the lowest of 1705items. A total of 19 debris items with 6 of them included in the world's famous 'dirty dozen were identified. Plastic materials were found to be the most common debris type at all study sites with an average composition of 85.67% with the least being glass occupying less than 1% (Table 4, Figure 11). After a two-way ANOVA done between the location and density of floating waste items the p-value ($<2e-16$) suggests rejection of the Ho. Therefore, if means are not same then the occurrence of waste items depends on the location. After checking for the linear regression model, the p-value suggest suggests rejection of the Ho, meaning that the waste increase with months. The R^2 value of 93.85% shows how significant the model fits the data.

Table 5: Summary of floating litter (counts) and mean weekly counts for the selected study beaches of the central Region of Ghana

Location	Total litter	Average Weekly Litter
Bakano	2407	75.21
Anomabo	1705	53.28
Moree	1885	58.91

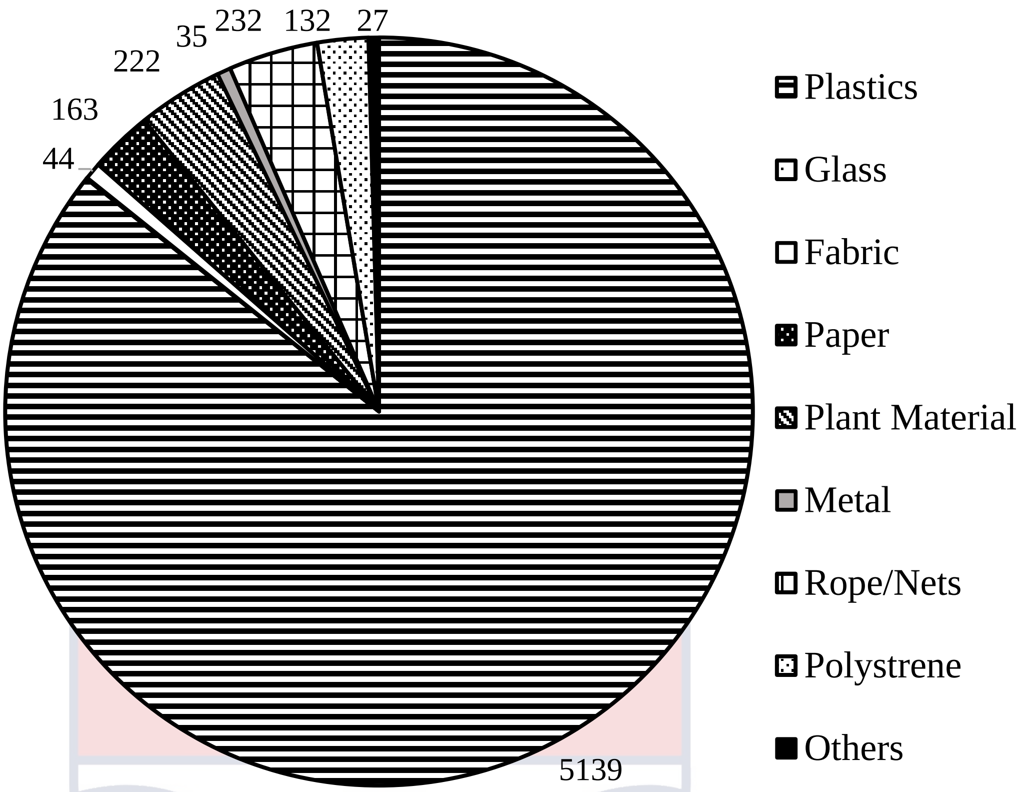

Figure 15: Total floating litter composition for all study sites

General monthly trend in floating litter distribution across sites

Moree

The total litter collected within the water column of the Moree varied between 261 and 124 in December and April 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 dominant litter collected across the eight months sampling period and registered as 1463 (78%). With metal representing the lowest and it recorded less than 1% of the total litter, no glass was found in the litter item as represented in Figure 12 and 15.

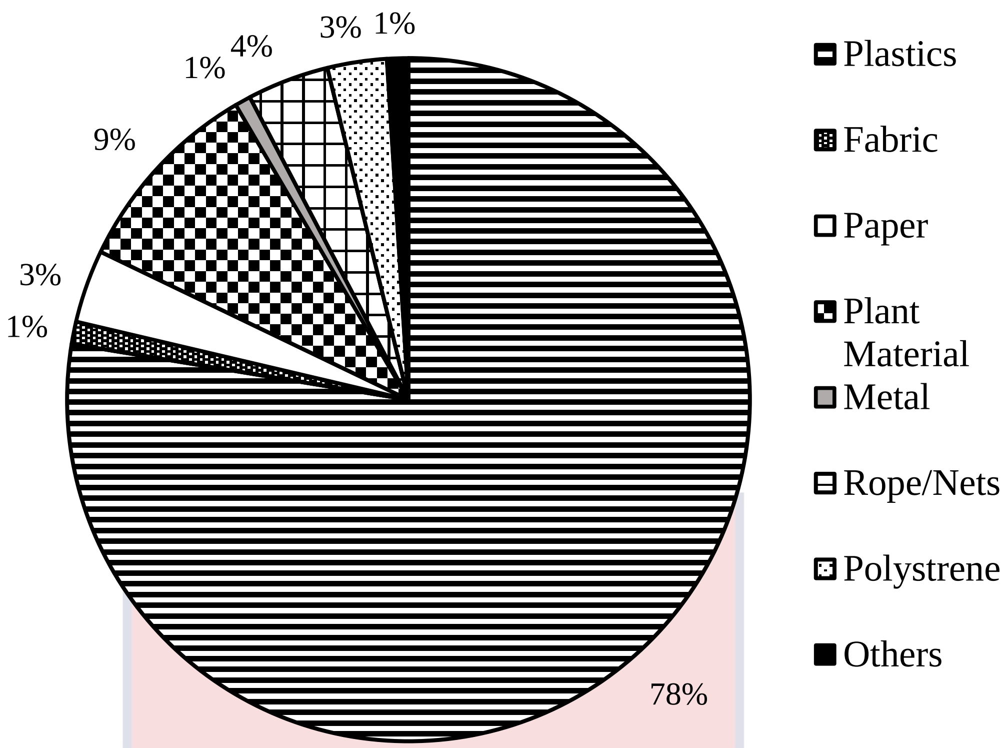

Figure 16: Total floating litter composition at Moree over the study period

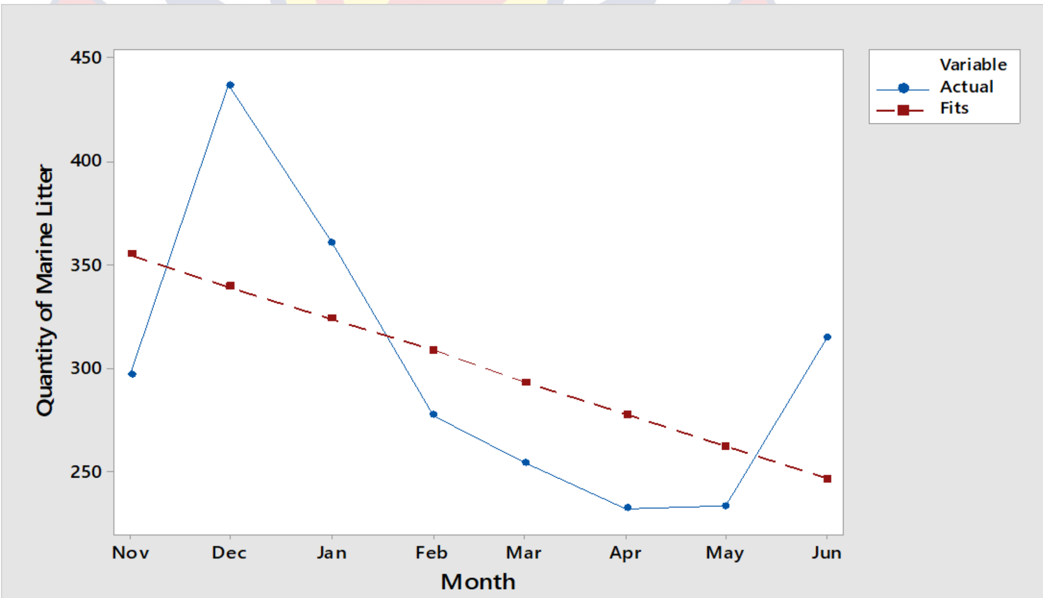

Figure 17 Monthly floating litter variations at Moree across the sampling period

Bakano

Of the overall litter collected from the Bakano beach, plastics were the highest count 2156 with the lowest being glass with 3 litter items. Bakano had the most littered water column among the three beaches, December had the highest amount of litter (423) as May had the lowest amount of litter, recording a total count of 217. This is shown in Figure 13 and 15 below.

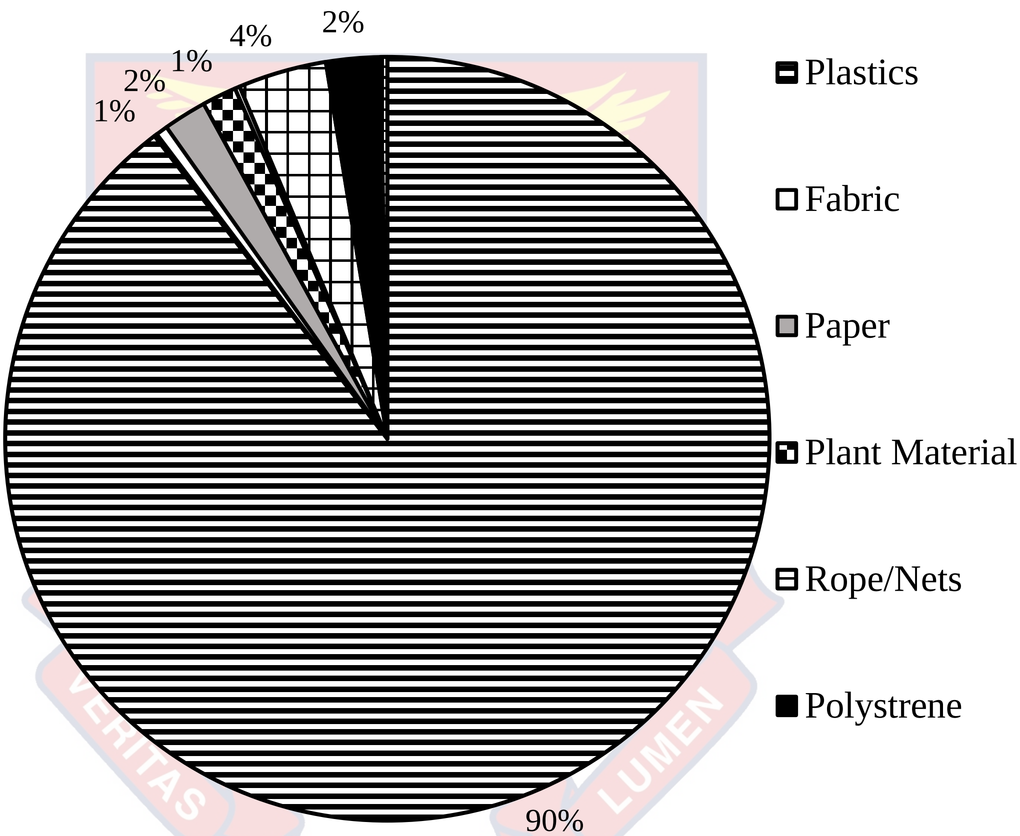

Figure 18: Total floating litter composition at Bakano over the study period

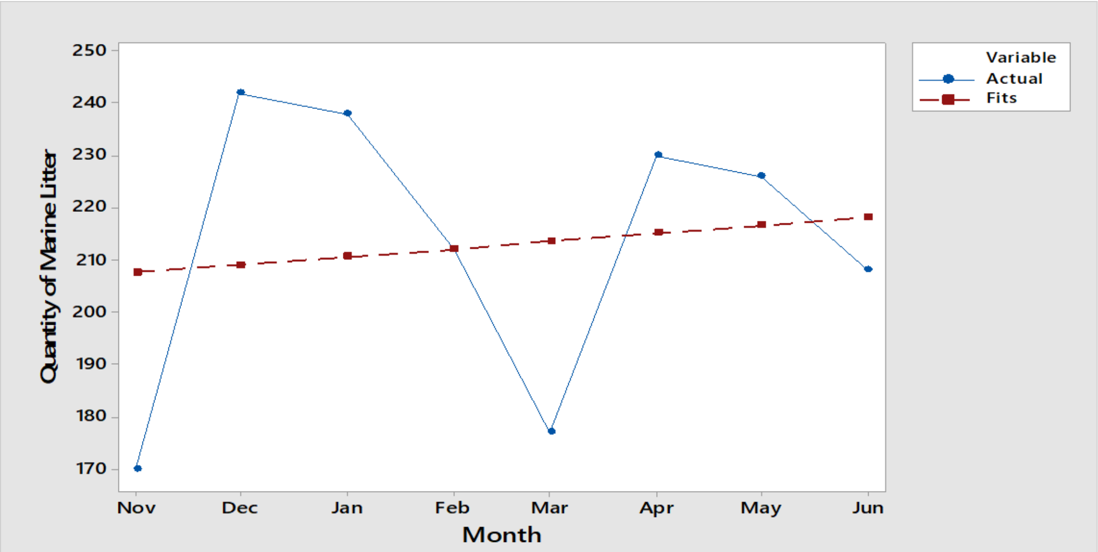

Figure 19 Monthly floating litter variations at Anomabo across the sampling period

Anomabo

Anomabo had its highest marine litter in December and lowest in April, recording 286 and 164 respectively. Again, plastic was the most dominant recording 1520 with the least dominant litter being other. Glass was not found within the water column in Anomabo. This is shown in Figure 14 and 15.

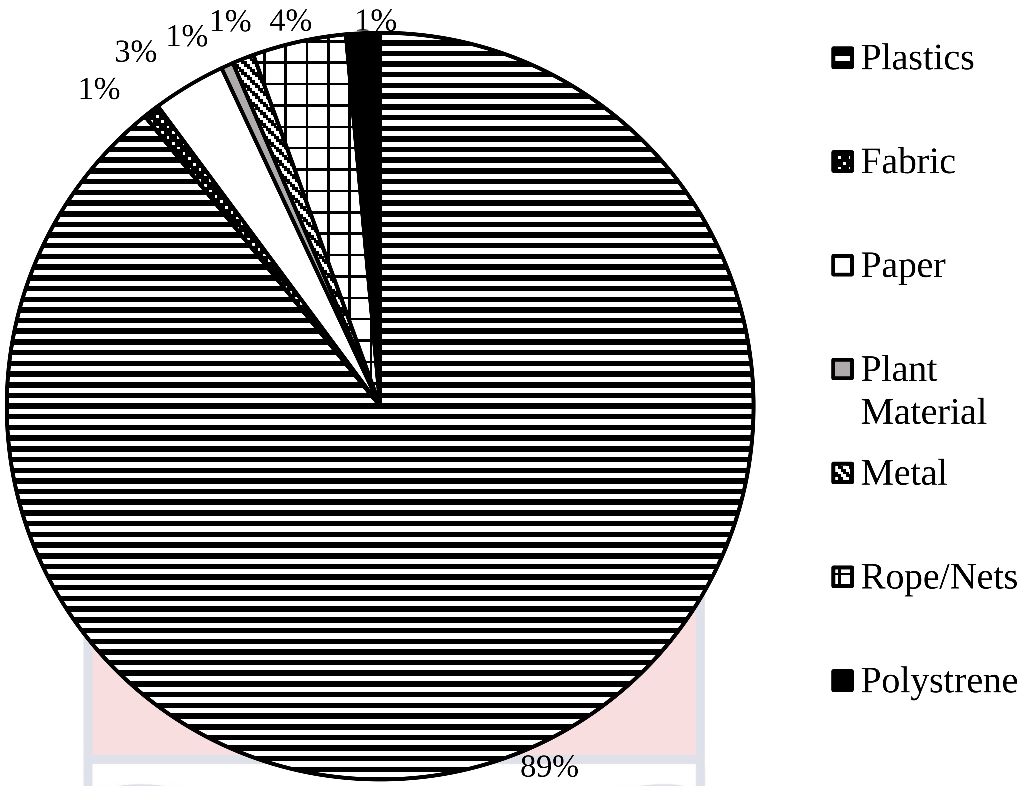

Figure 21: Total floating litter composition at Anomabo over the study period

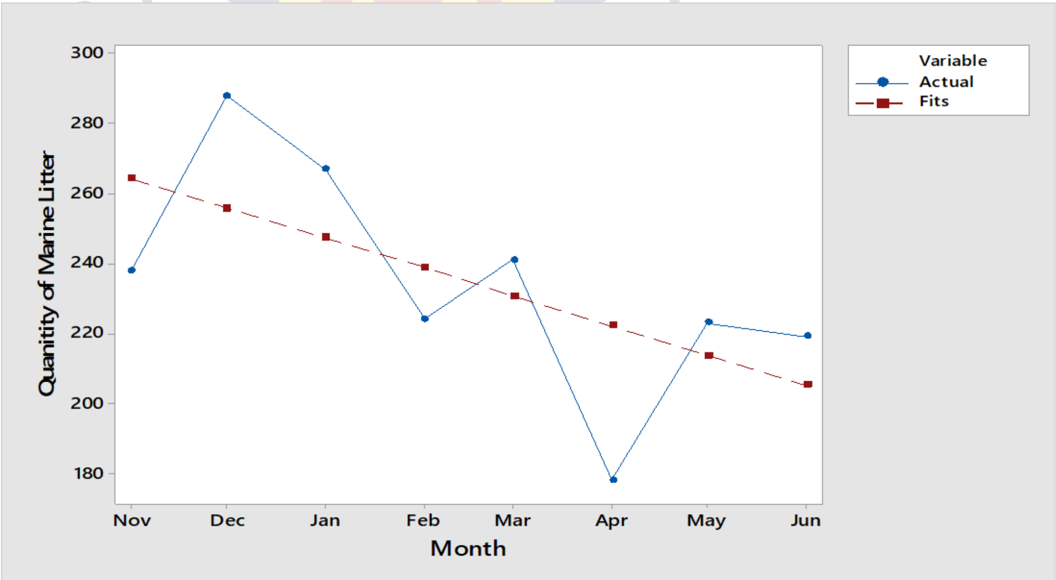

Figure 20Monthly floating litter variations at Bakano across the sampling period

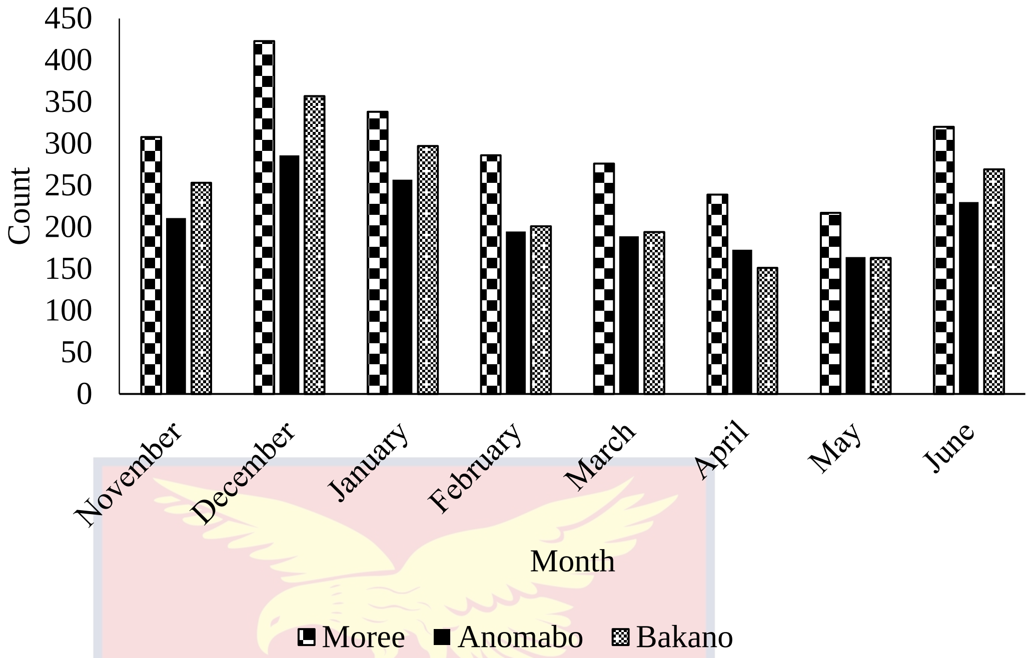

Figure 22: Monthly floating litter variations across sampling period at for selected study beaches of the central Region of Ghana

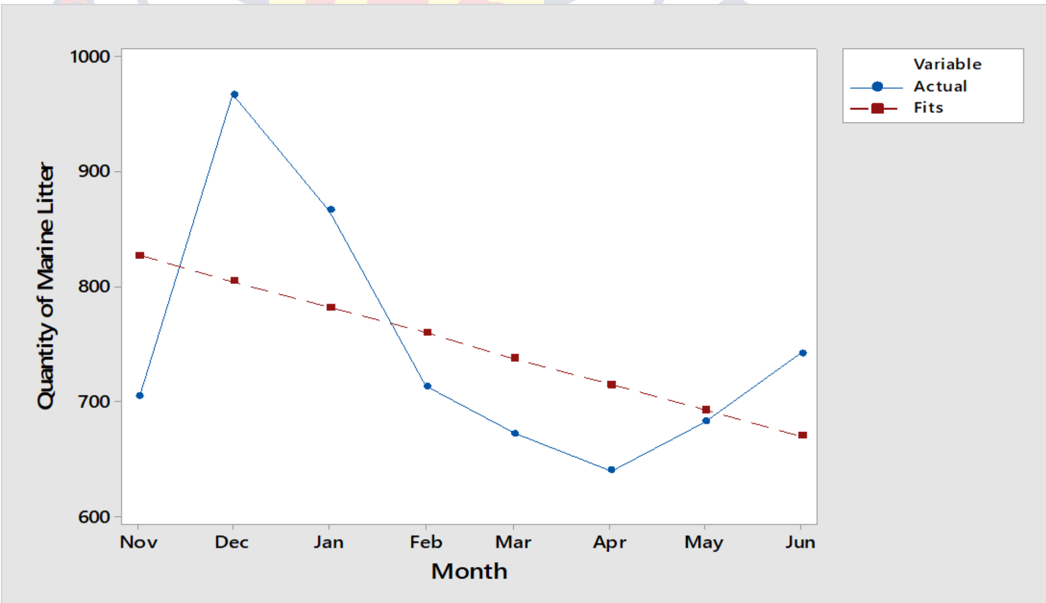

Figure 23 Monthly floating litter variations and best fits across sampling period at for all three study sites

Table 6 Information on models produced that may be used to monitor the behaviour of these series for years to come for floating litter

		Accuracy Measures			**Monthly Forecasts**			
Locations	**Equations**	**MAPE**	**MAD**	**MSD**	**Jul**	**Aug**	**Sep**	**Oct**
MOREE	$Y_t = 370.6 - 15.52 \times t$	16.6	50.8	3044.5	231	215	200	184
ANOMABO	$Y_t = 206.1 + 1.51 \times t$	10.4	21.1	624.9	220	221	223	224
BAKAANO	$Y_t = 272.7 - 8.43 \times t$	9.5	21.3	583.0	197	188	180	172
COMBINED	$Y_t = 849.4 - 22.4 \times t$	10.4	76.7	8205.0	648	625	603	581

Table (6) provides results on the models or equations, the accuracy measures of the models as well as monthly forecasts of the series for the next four months. Inverse relationships were observed in all the models, but Anomabo. This relationship resulted in the downward trends seen in the plots of all the series. It was even seen in the four-month forecasts.

Household Litter Survey

The components of the waste generated were sorted manually and the results of the waste composition at the household levels are presented in Figure 16. Figure 16 summarizes in percentages the 7 main fractions characterized.

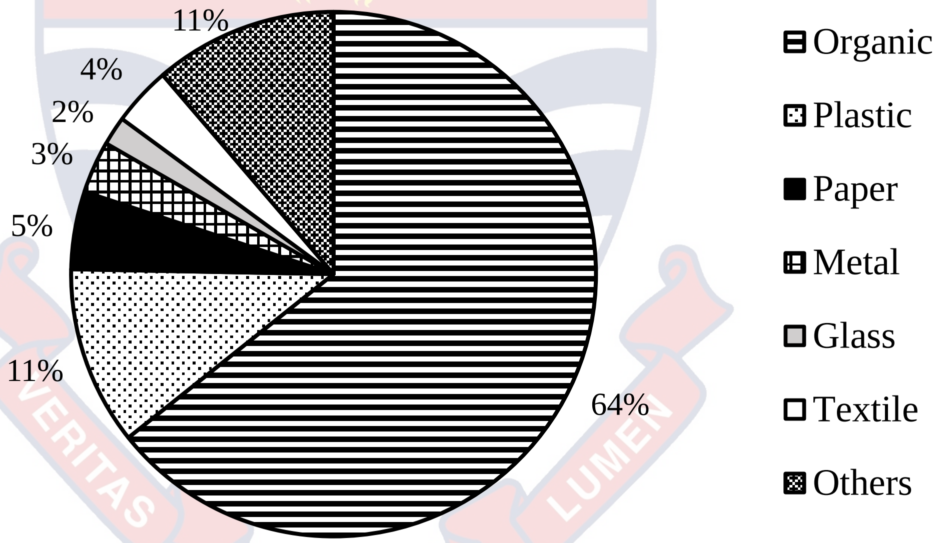

Figure 24: Total composition of household waste in selected communities adjacent study beaches of the central Region of Ghana

In this study, the main fractions recorded are organic (63%, 65% and 66%), miscellaneous (15%, 9% and 9%), and plastics (11%, 11% and 11%) for the Moree, Anomabo and Bakano respectively. The study shows that organic waste is the highest component of household waste in the study areas and this is consistent with other studies on household waste composition in Ghana and other developing countries, other research show that 60–70 % of household waste from Ghana is organic (Carboo et al., 2006; Fobil et al.,2002; Hogarh et al.,2008).

'Others' was defined by this study to include inert materials like sand and ash along with other components like wood and wigs. The higher percentages recorded could be due to the use of traditional cooking systems like coal pots which generate great amount of ash as well as sweeping of compounds which add soil particles to the waste stream. This is however lower than the 36% recorded by Mensah (2010) and the 34% recorded by Ketibuah et al.(2004). Plastic waste generation in all locations was similar at 11.01% and 10.71%. Plastics do not decompose and compact easily which is why it significantly affects transportation cost and landfill life.

In 1979, the percentage was 1.4%, and rose to 4% in 1993, in 1996/1997 the proportion of plastic waste was 5% and by 1999/2000 its proportion increased to 8%. Table 5, this shows much lower percentages of plastic waste recorded in household litter in past studies, this indicates and increasing percent of plastic waste in household waste.

Table 7: Percentage of plastic waste in municipal waste over the years

Year	% of Plastic waste
1979	1.4
1993	4
1997	5
2000	8

Source: (Quartey, Tosefa, Asare, Danquah, & Obrsalova, (2015)

Per Capita waste Generation Rate

The solid waste generation rate in kg/capita/day is presented in Table 6 for the three study sites. The rate of generation of solid waste was 0.35 kg/per capita/day in Moree, 0.49 kg/per capita/day in Bakano and 0.54 kg/per capita/day in Anomabo as the highest. Comparison of waste generated in developing countries recorded a range of 0.4–0.6 kg/person/day (Chandrappa and Das, 2012) and the values obtained in this research fall within this range.

Table 8: Summary of solid waste generated by households from the study sites

Study Site	Total Waste Analysed (Kg)	Total People in Household	kg/Capita/Day
Moree	2522.51	128	0.35
Anomabo	2177.67	72	0.54
Bakano	1876.08	68	0.49

Source Separation Efficiency

The source separation efficiency in this study assesses the ability of participating households to correctly sort the waste components into their designated bins. It is defined as the share of waste which has been correctly separated by households calculated based on the weight of waste in each bag (Asase and Oduro-Kwarteng, 2010). The results of the average separation efficiency of households over the study period is presented in Table 7.

Table 9: Efficiency for the source separated wastes

Sites	Organic Bin	Inorganic Bin
Moree	94.23%	81.44%
Anomabo	88.69%	77.12%
Bakano	79.51%	86.91%

The results as observed from Table 7 shows that separation efficiencies for all study sites were high. With Moree recording the highest for organic bin and Bakano the lowest, while Anomabo recorded the lowest for the in organic bin and Bakano recording the highest source separation percentages. However, in both groups, it is noted that separation efficiency was highest in the organic components except at Bakano.

Social Survey

Socio-demographic characteristics of respondents

One hundred and twenty people participated in the social survey, 40 people from each study location. The response rate to the survey was 100%. The data gathered from the survey is represented in Table 8.

Most (50.8 %) of the respondents were within the ages between 26 and 40 years old. Few respondents forming about 2.5 % were older than 60 years. In terms of gender, the male respondents numbered 69 and formed the highest percentage (57.5 %) than females who numbered 51 (42.5%). Out of 120 respondents, 30 representing (25%) live in the beach area, 12 representing 10% work in the beach area and 78, (65%) live and work in the beach area.

About 48.3% of the respondents were engaged in the fishing while 26 % engaged in Trading as primary occupation, 26.7% were fishmongers, 6% engaged in carpentry and 2.5% were unemployed. Results on the educational attainment of the respondents showed that 5 % of the respondents numbering 5 had not been to school; 6.7% numbering 8 got to SSS/Technical/Vocational school, with 77.5% getting to Primary school.

Table 10: Summary of demographic characteristics of respondents of a survey undertaken in the selected study beaches of the central Region of Ghana

Demographic Variable	Description	Categories	Frequency	Percentage (%)
Age	What age category do you belong to?	18-25 years	35	29.2
		26-40 years	61	50.8
		41-60 years	21	17.5
		above 60 years	3	2.5
		Total	120	**100.0**
Gender	Are you Male or Female?	Male	69	57.5
		Female	51	42.5
		Total	120	**100.0**
Live / Work	Do you live or work in this area?	live	30	25.0
		Work	12	10.0
		live and work	78	65.0
		Total	120	**100.0**

Table 10 continued

Residency	Where do you live?	Adjacent the beach	35	29.2
		Just close by	62	51.7
		1 Kilometre away	17	14.2
		More than 2 Kilometres away	6	5.0
		Total	120	**100.0**
Occupation	What is your primary occupation?	Fisherman	58	48.3
		Trader	21	17.5
		Fishmonger	32	26.7
		Carpenter	6	5.0
		Unemployed	3	2.5
		Total	120	**100.0**
Education	What is your highest level of education?	Not been to school	5	4.2
		Primary	93	77.5
		JSS/Middle School	14	11.7
		SSS/Tech/Vocational	8	6.7
		Total	120	**100.0**

Beach Usage

Respondents when asked about the importance of the beach, 86% believed the beach was very important, 14% indicated the beach was important. The reasons for their choice was detected that, 55 (45%) of the respondents find their source of living from the beach, 53 (44.2%) find their source of employment at the beach, and 12 (10%) using the area as a place for refreshment. The respondents that use the beach for fishing was 69 that is (57.5%), 31 (25%) use the beach as a trading area where they buy and sell goods, for 13 of the respondents (10.8%), the beach serves as a place for recreation and 7 (5.8%) the beach serves as a place for convenience as represented in Figure17.

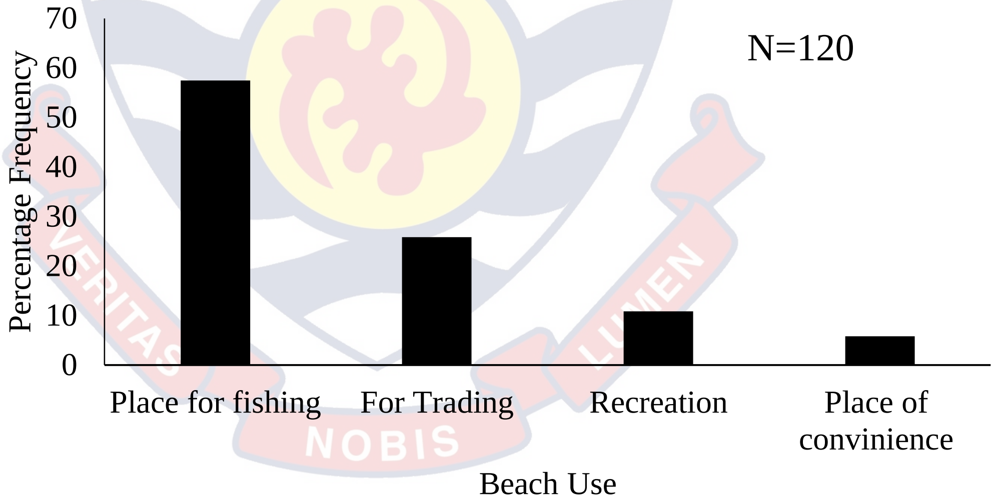

Figure 25: Summary of the uses of beach by respondents of selected study beaches of the central Region of Ghana

Table 11 Summary of Parameter Estimates for Factors Driving Beach Litter

		Estimate	Std. Error	df	p-value
Threshold	Heavily littered (more than two 50lt container)	-3.877	1.420	1	0.006
	Moderately littered (up to two 50lt container)	-1.519	1.337	1	0.256
Driving Factors	Daily Visits	0.003	0.595	1	0.995
	Monthly Visits	-2.505	0.842	1	0.003
	For recreation.	-2.732	1.010	1	0.007
	A place for relaxation	-3.064	0.904	1	0.001
	Direct deposition of litter by visitors on the beach	-2.558	1.069	1	0.017
	Deposition through run ways	-1.438	1.061	1	0.176
	Recreational activities on the beach	-1.325	1.136	1	0.243
	The use of beach as refuse dump.	-1.808	1.033	1	0.080

Respondents Perceptions on the Littering of the Beach

About 60% of the respondents agreed that poor facilities (toilet and bins) were issues they were unhappy with, debris on the beach was next with 14.2%, erosion and flies on beach 9.2% each and poor water quality representing 7.5%. 62.5% of the respondents believed the beaches were heavily littered and 30% indicating the beaches were moderately littered and 7.5 indicating the beaches were littered. 100% of the respondents agreed to have dropped litter on the beach at an instance. On assess litter load on the beach, 73.3% and 26.7% representing 88 and 32 said litter was increasing and decreasing respectively.

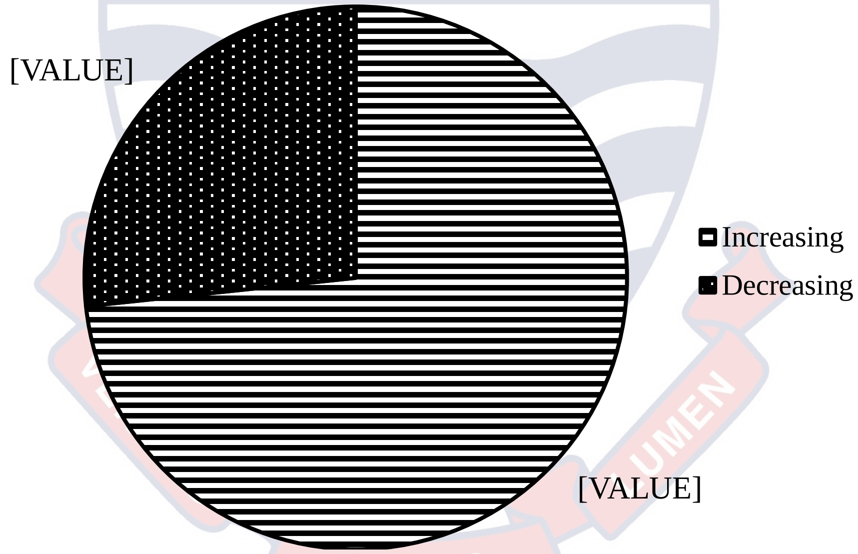

Figure 26: Perception on state of litter at beach by respondents of selected study beaches of the central Region of Ghana

Habits at the Beach

Majority of respondents (62.5%) usually consumed food and beverages at the beach. When asked what respondents did with litter generated at the beach, 87% admitted to leaving it directly on the beach. 9% reported they placed litter in waste bins and only 4% said they carried it home.

All respondents agreed to having left litter at the beach before. Of this 62.5% accepted it was a usual habit as 37.5% declined to this being habitual. The majority 69.3% admitted to never collect other peoples' litter. 22% rarely collected it and 8.7% said they only sometimes did. Also, 54.5% of the respondents admitted to never speaking to people they see littering at the beach as 43% rarely spoke to people about the issue and 2.5% of the people interviewed usually talk to people, they see litter. Of those interviewed, 38.3% attributed the main source of litter to be refuse dumps on beaches, 30.8% said the main source of litter was from direct deposition of litter by beach users. 18.3% attributed the source of litter on the beach to deposition through runways and 9.2% said source of litter was from fishing activities, as 3.3% thought litter source is from the seas (Figure 19).

Interestingly, a high percentage (92.5 %) of the respondents confirmed that there is direct defecation and disposal of human excreta on the beaches; this is an indication that the act is widespread along the study sites which many attributed to the lack of toilet facility within the community.

On the issue of why respondents leave their litter they generate on the beach, whereas 21% of the respondents were of the view that people dropped their litter around the beach because of their ignorance about the importance of the beaches, another equal high of other respondents (70%) explained that people act that way because of the lack of waste bins on the beaches but 9% of the respondents also said that litter is dropped on the beaches because people perceive beaches will carry litter away.

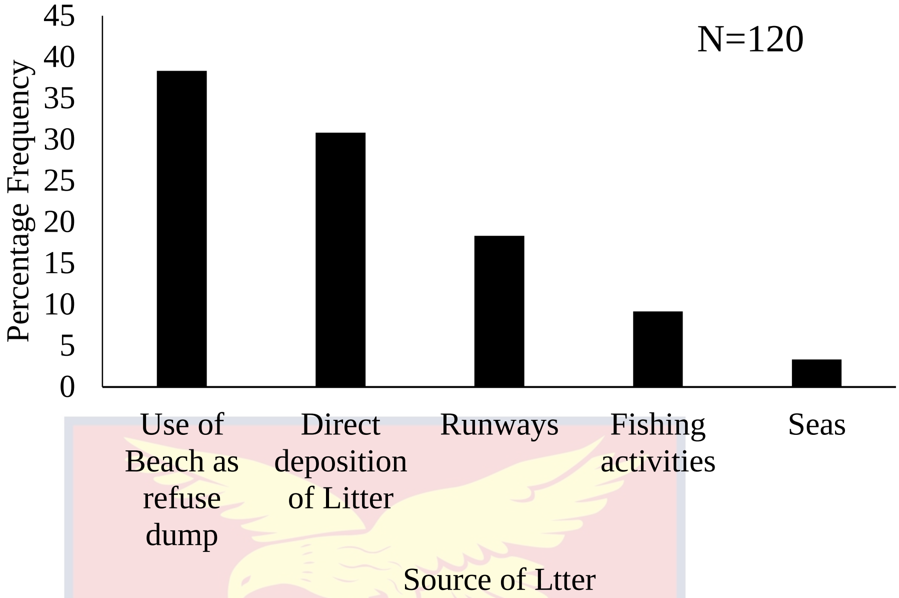

Figure 27: Perception on Sources of litter on beach

Respondents' Opinion on the Effects of Litter Accumulation on the Beaches

Majority of the respondents (86 %) have had a cut before while using the beach, 9 % have had a disease while the other 5 % feel some form of discomfort using the beach due to the litter accumulated at the beach. With respect to the main problems caused by marine debris, 55% agreed to human health being the main problem caused, 17.5% said its impact on marine life, 15.8% and 10% said marine debris makes beaches unattractive and destroys fishing nets respectively. According the respondents, the top 5 litter items are black polythene bags, pure water rubbers, metal cans, water bottles and wooden materials. Also, it was realised from the survey that metals were listed by a majority of the respondents (beach users) as the most dangerous litter item, followed by glass, plastics, wood and human excreta (Figure 20).

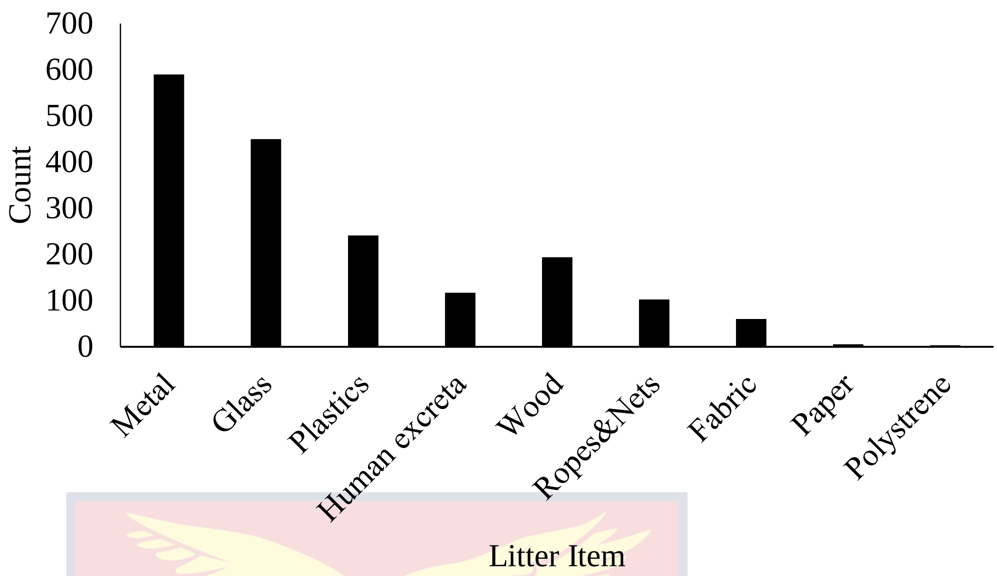

Figure 28: Litter items that possess danger

Management of Litter on the Beaches

Concerning the extent to which litter on the beaches were cleaned as many as (81.67 %) of respondents indicated that they had experienced cleanup activities organised on the beach; only 37 of them (37.75 %) indicated that the communities around the beaches organise cleanup activities to clean the litter on the beaches. When asked to indicate the frequency with which these cleanup activities were done, 28 respondents of the 37 (75.68%) did indicate that clean-ups were done weekly and 9 others (24.32 %) also said the cleanup exercises were done monthly. To assess the extent to which respondents who have witnessed some clean-up around the beaches 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 were asked whether they would get involved in clean-up activities should it be organised. All 120 respondents said they would take part. Also, majority of the respondents (56.7%) answered that the adjacent community is responsible for cleaning the beach, while 26.7% said the district assembly was responsible for cleaning the beach and 11.6% said zoom lion was responsible for cleaning the beach. Only 5% of the respondents think that the polluters of the beaches should be responsible for their own litter.

Solution to the Littering Problem

Majority of the respondents (67.5%) suggested that the provision of waste bins at vantage points around the beaches will help solve the litter problem, 23.33% rather suggested that some form of punishment should be instituted to deter users from littering, 26.7% also suggested that periodic cleaning of beach will help curb the problem but 9.17% were of the view that educating users of the beach will help to solve the littering problem.

CHAPTER FIVE

DISCUSSION

All three study areas indicate significant number of debris items documented on the World's Dirty Dozen list (Keep, Water, Healthy, & Veryone, 2017). The debris items found accumulated on the beach sampling sites were varied, the majority of which according to ranking were empty drinking water sachets, food wrappers, black plastic bags, plastic bottles and white plastic bags similar to the most common items found during clean-ups conducted onshore and/or underwater: cigarettes/cigarette filters, food wrappers/containers, (plastic) bags, and (plastic) beverage bottles according to the International Coastal Cleanup report (Ocean Conservancy, 2007).

Quantities and Categories of Debris on the Beach

The total quantity of marine debris collected for this study was 38,544 which indicates high numbers over the 8 months period is not only an indication that the rate of accumulation of litter on the entire Central regional coast is on an increasing trend but also that, solid waste pollution is a major environmental problem that is continually plaguing coastal areas and gradually bringing them to a state of disrepair. Therefore, the continuous deposition of litter on the beaches may lead to the collapse of their functional unit in Ghana if the situation continues unchecked unmonitored, and unmitigated. The enormous debris registered is also in agreement with Gregory (2009) that, litter on beaches persist in larger quantities.

In attempts to examine the relationships or generate a model that may best describe or monitor the situation of beach litter at the various sites, it was observed that the trend of beach litter at all the locations decreased over the period considered. As the quantities of litter decrease, all of them experienced ups and downs movements. Each of the locations recorded a very high or peaked in December of the year under review, but the least values were recorded at different months. The results of Bakano appears to be high as seen in figure 11. This is because its line appears to be above all the others. This confirms the earlier conclusions that it recorded the highest maximum, and even the minimum beach litter recorded at this place is even higher than the maximum at the other two locations. This means a lot of beach litter is generated at Bakano.

The consistent dominance of the plastics in the eight month 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). This was also confirmed with the high numbers of 'pure water' wrappers and black polythene. Also confirming the assertion of Derraik (2002), Allsopp *et al., (2006) and* STAP (2011a) that plastics are the main source of marine debris worldwide; between 60% and 80% of litter collected. The nature of wastes from human society has dramatically changed over the last 30 to 40 years due to the introduction of synthetics like plastics (Sheavly, 2005).

In the US, Spain and Brazil, cigarette butts have been shown to be the main source of marine debris on beaches (Moore *et al.*, 2001; Martinez -Ribes *et al.*, 2007; Oigman – Pszczol and Creed, 2007 cited in Slavin, 2011). This was not evident in this study, where plastic materials were found to be the most common debris type, similar to studies carried out on South African beaches (Ryan *et al.*, 2009 cited in STAP, 2011) and selected beaches in Europe (OSPAR, 2007).

Plastic is generally a durable non-biodegradable material which is resistant to natural biodegradation processes. Consequently, it does not readily break down in the marine environment ((Moore *et al.*, 2001; Allsopp *et al.*, 2006; STAP, 2011). Once it reaches the ocean, about half of plastic debris floats and can therefore travel on currents for thousands of miles and become widely dispersed over the oceans (Derraik, 2002; Sheavly, 2005) which may be the reason for the high plastic dominance in the floating litter survey.

Fabric litter deposition along the beaches could only be associated with direct deposition by beach attendants or indirectly by wave and current action. Naturally, most fabric items easily sink to the bottom of the water and so their accumulation on the beaches could only be by direct deposition, wave or fast-moving currents. Metallic and glass debris deposition could also be direct or carried by swift currents from adjoining areas since they are prone to sink. Paper and processed wood litter may have also been deposited on the beaches through direct deposition by beach users as was observed on both Moree and Bakano beach where there are small wood processing and boat making industries which led to higher numbers of wood materials being recorded on those beaches.

The results indicate a high diversity of litter collected from the study sites. The most likely explanation for this diversity is related to the uses of the selected site. The highest amount of debris by count was recorded at Bakano beach followed closely by Anomabo and Moree beaches respectively (Table 4). The highest weight of debris was recorded at Bakano beach out of the three sampled beaches with Moree beach recording the lowest. The counts of items found at the study sites could be attributed to the fact that these sites are used as working area by diverse groups such as fishermen, traders and wood workers, and most accessible to the local public and tourists and the use dump sites. The litter items found at these sites, particularly, plastic bottles and bags, metal cans, and pieces of glass are associated with and indicative of the activities of beach goers in accordance with the assertion of (Al-Najjar & Al-Shiyab, 2011). Storm water drains and sewage outfalls also transport debris into marine and coastal environments (Williams & Simmons, 1997).

Again, with the location of the study sites in close proximity to local communities, there would be more pressure on storm water drains and sewage outfalls, which would lead to more litter being swept into drains and deposited onto the beaches. This compares favourably to the study of Slavin (2011) were low debris quantities were attributed to small population density with less pressure on these outfalls and drainage systems.

Forty-one different debris items were collected for this study whereas Nunoo & Quayson (2003) and Tsagbey *et al.* (2009) indicated twenty-two and thirty- two debris items respectively. This could be attributed to the longer period of this survey, varied locations of the survey and the types to material used within the area of study. Whereas Nunoo & Quayson (2003) and Tsagbey *et al.* (2009) were carried out in predominantly urban areas, this work was carried out in both rural and urban areas.

Results of solid waste composition analysis conducted during the study in households also revealed that the organic waste was the most prevalent in all three communities, followed by plastic and paper. This did not follow the trend for both beach litter and floating litter, which may be because of the biodegradable nature of organic waste. The high proportion of organic components in the waste stream can be explained by the fact that there is a high level of consumption of fresh food products. Furthermore, most of the staple food products yield a lot of waste during preparation and consumption (Boateng, Amoako, Appiah, Poku, & Garsonu, 2016).

Over 64.5% of the waste stream from all the sites was organic followed by plastics, miscellaneous, paper, metals, glass, textiles and leather in that order. The high organic waste in Ghana's waste could be due to her high dependency on agricultural products (Miezah, Obiri-danso, Kádár, Fei-baffoe, & Mensah, 2015) The high biodegradables (organics and papers) recorded in this study, 69%, could serve as a guide for bioconversion programmes such as biofuel production and composting. A careful segregation of these can serve as raw material base for value addition of waste and a safe haven for disposal of this problematic waste. The recyclables including plastics, textiles, metals and glass on the other hand formed about 22% of the waste which is enough for utilization in any recycling activity.

Trends in the Types, Quantities and Seasonality of Debris Deposition

Slight fluctuations were observed in the overall debris trend over the eight months period. The highest debris count was recorded between November 2017 and January 2018, with the highest being in December 2017 for all the study sites. This could be attributed to the festive seasons that occurred prior to debris collection with high beach patronage during the period around Christmas celebrations which leads to direct deposition of litter on to the beaches by beach users. Also the sight increase in litter recorded in April could be attributed to rainfall and Easter festivities around that time of the year.

The plots from the time series shows an inverse relationship which resulted in the downward trends seen in the plots of all the series. It was even seen in the four month forecasts of the series. For instance, Bakano beach litter is expected to record a beach litter quantity of 1053 in July of the year under review, but by October, the value is expected to further decrease to 734. The result is similar for the other series, as well as the combined one. Bakano floating litter is expected to record a marine litter quantity of 231 in July, but by October, the value is expected to further decrease to 184. The results is similar for the other series as well as the combined, except Anomabo.

Like other beach litter surveys (Corbin and Singh, 1993; Golik and Gertner, 1992), this study has confirmed 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 Bakano beach, like all the other sites, plastic litter dominated in terms of abundance and diversity.

Over the last few decades, there has been a steady increase in the use of plastic products resulting in a proportionate rise in plastic waste in solid waste streams in large cities in sub-Sahara Africa. Plastics are used extensively in both food and water packaging industries because of their inherent properties such as low bulk densities and inertness which make them convenient carrier materials with low risk of contamination. Plastic bottles and sachets used to package water have become widespread in the sub-region. (Quartey, Tosefa, Asare, Danquah, & Obrsalova, 2015). The continual increase of the share of plastic waste among solid waste is a result of the huge demand for plastic products in the country, propelling private enterprises to commit huge capital to the plastic industry. By 1996, there were about 20 plastic producing establishments in Ghana and by the turn of the century there were about 40 plastic manufacturing companies producing about 26,000 metric tons of assorted plastic products annually (Fobil, 2000).

In the household study, the effect of seasonal variation on generation and composition of household waste was not considered since this is believed to have no effect on change in waste composition and generation in Ghana proved by separate surveys. For instance, separate studies conducted in Kumasi (Ashanti Region of Ghana) by Adjei (2013), Asase (2011), Ketibuah et al. (2004), Kotoka (2001), Opoku (1999) within the wet and dry seasons did not show any trend in variation of the composition and generation of waste.(Miezah et al., 2015). Seasonal variation normally affects generation of outdoor waste such as yard waste and the amount depend on the trimming rate (Hancs et al., 2011). In comparison, waste fractions from the three areas did not show significant variation in their composition.

It is also realised from the results that very large quantities of organic waste and paper waste was produced from the household litter from households adjacent the beaches, but this trend is not evident in the litter collected from both the beaches and floating litter. This may be, because most organic waste and paper are easily biodegraded whilst plastics remain in the systems much longer. To add to that, organic waste could be used as source of feeding for other animals which inturn reduces the amount of waste that ends up at the beach.

On the average, rate of waste generation was 0.46 kg/person/ day for all the three study sites. Anomabo recorded the highest waste generation rate of 0.54 kg/person/day which was above that of Bakano 0.49 and Moree the lowest with rates of 0.35. The much lower waste generation rate in Moree could be attributed to the low economic activities in the area compared to the other two areas. Waste generation rates across Ghana irrespective of the socioeconomic considerations ranged from 0.2 to 0.8 kg/person/day. This is also the range for most of the cities in Sub-Saharan Africa (Friedrich and Trois, 2011; UNEP, 2013). However, higher generation rates have been reported for OECD countries, 1.39 kg/person/day (OECD, 2010).

Sorting and separation into appropriate bins was effective in most of the areas as it averaged 87.5% for the ‘‘biodegradables except paper waste” and above 81.8% for the ‘‘other waste”. A nationwide average of 84% was obtained for separation into the biodegradable waste bin and 76% for the other waste bin (Miezah et al., 2015). The high separation efficiency is an indication that the one-way separation system employed was convenient for the participating households and therefore could be employed in the management of waste. It can be anticipated from the high organic separation efficiency that if separately collected could lead to high recovery of organic waste. The higher separation efficiencies of over 80%, for the organic, papers and plastics and other wastes respectively in this research compared to the over 50%, 30% and 50% respectively achieved by Asase and Oduro-Kwarteng (2010), can be attributed to the fact that, participating households where available, were reeducated each day on the sorting procedures. This underlines the effect more education could have on improving source separation programmes.

Sources and Driving Factors Accounting for the Beach Litter

Unlike Slaters research (1991, 1992 cited in Slavin, 2012), that found that a large proportion of debris was ocean based, and Slavin‘s (2011) study that did not detect any trends with regards to where marine debris originated, land based source formed the largest proportion of debris collected for this study (Figure 5). This corresponds with the assertion in literature that land-based sources cause approximately 80% of the marine debris found on our beaches (GESAMP, 1991; NOAA, 2007; Sheavly, 2007; World Ocean Review, 2010; US EPA, 2012) and consistent with study carried out on the West coast of the United States and main Hawaiian islands (Sheavly, 2007). This shows land-based sources of marine litter is on the increase since earlier studies showed lower proportions of land-based sources of beach litter. Again, based on the findings of Slater (1991) and Slater (1992) as cited in Gregory & Ryan (1997) ocean-based debris accounted for the least amount of debris in origin supporting the least amount of ocean-based debris recorded for this study.

The high percentage of land-based marine debris recorded can be attributed to beach location, accessibility, status as working area and human behaviour. It could be inferred from the results that all the respondents agree that the debris on the beaches were deposited there through one source or the other and that human activities were responsible for the presence of the litter on the beach. On the whole the respondents admit that their actions to a large extent also contribute to the accumulation of litter on the beaches.

Additionally, over 10,000 metric tons of finished plastic products are imported annually into Ghana (Owusu, 2013). However, plastic recycling has not received the needed attention; it is believed that less than 2% of plastics are recycled in Ghana; the rest form major pollutants in public places and environmental receptacles in Ghana (Miezah et al., 2015). Scrap metal is one of the waste components that has a great market in Ghana and beyond. This reason makes them attractive to scrap collector and itinerant buyers therefore reducing their composition in the waste stream to about 1%. They are utilized in local steel industries and are even exported.

We observed from the Table 11that for the frequency of visits, only monthly visits have significant effects on the state of litters at the beach (p-value=0.003; df=1). For usage of the beach having effects on its littering activities, we observed that recreation and relaxation activities of people affect the litter situations at the three locations (p-value=0.007; df=1; p-value=0.001; df=1). That is, beach litter is caused by people who go to the beach to refresh themselves and relax. With respect to the sources of litter having influence on the state of litter, we observed that only the first source (Direct deposition of litter by visitors on the beach) has significant effect on the state of beach litter at the locations (p-value=0.017; df=1). That is, the respondents were of the strong convictions and views that the quantity of beach litter is influenced mainly by visitors directly depositing litter on the beach.

Public Perceptions Associated with Beach Litter and their Resultant Effects on the Marine Environment

In this study, it was realised that survey participants were in the habit of littering the beaches. This may be caused through the consumption of food and beverages at the beach and the absence waste bins on these beaches. 87.8% of respondents admitted to having left litter at least once on the beach with almost all respondents acknowledging that this was their usual habit. Respondents were not in the habit of collecting litter they encountered on the beach nor were they willing or inclined to talk about the issue of marine debris when they encountered other people littering. Almost all respondents believed that Ghana's beaches are not clean yet they all admit to the fact that this gives them cause for concern. This development can be attributed to the fact that people have become desensitized to the litter campaigns that have been in the media for many years and may believe that littering is not their problem but rather belies a belief that regulators need to control and respond to littering (Arafat *et al.*, 2007a). Again, there is strong evidence that people are more likely to litter in places where litter is already present (Heberlein 1971; Geller *et al.*, 1980; Cialdini *et al.*, 1991; Al Khatib, 2009 cited in Slavin, 2011). People litter more when in an unclean environment as their social norms indicate that as the environment around them is unclean it is acceptable to litter (Cialdini *et al.*, 1990; Sibley & Lui, 2003 cited in Slavin, 2011). This supports the results as relatively high amounts of debris were collected during the beach survey.

Participants were not pleased with some issues along the beach, the majority stated poor facilities (toilets, litter bins) as their main concern followed by debris. This finding is quite similar to other studies that have shown that most participants recognize marine debris and sewage related debris to be a strong beach dislike (Williams *et al.*, 2000; Tudor & Williams 2003; Slavin, 2011).

The results from this survey also confirms the assertion by Slavin (2011) and Santos *et al.,* (2005) that people's actions and attitudes contribute to the issue of marine debris; evidenced in the social survey with the majority of respondents admitting to littering and the relatively high amount of debris collected during the beach survey. Participants who were beach users themselves also identified beach users as a main source of litter generation on the beach with the resultant problem of unattractive beaches. This trend is supported in the literature where beach litter is considered to be a major problem for people who visit the beach and plays a major role in selecting a suitable beach for recreation (Nelson 1998; Santos *et al.,* 2005; Tudor & Williams 2008 cited in Slavin, 2011).

The analysis of the results from the social survey confirms that the occurrence of glass and metallic litter around the beaches could render the beaches unsafe to users as more than 50% of the respondents interviewed confirmed that they have had cuts from such debris when using the beach. 35 % others also showed that they have discomforts using the beach 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 beaches pose significant threat to biodiversity as they can cause smothering of benthic organisms and injury to users of the beach (UNEP, 2005).

Almost all participants believe that Ghana's beaches are not clean and increased education and awareness creation, provision of more litter bins and the distribution of plastic bags will help reduce litter amounts. However, applying a penalty to those that litter, and beach clean ups were the least recommended. It can thus be inferred that littering and marine debris is a problem they acknowledge.

Responses were obtained from three local organisations that had experience and knowledge of the beaches under study. They were, Cape Coast Metropolitan Assembly (CMA), Zoomlion, Assembly members of the three study areas. All of these organizations' key tasks are geared to the improvement of people's quality of life and protecting the environment. All the representatives from these organisations were of the view that marine debris is a major problem in Ghana. The respondents also agreed that litter on beaches and in our coastal water bodies are increasing stating that the impact of marine litter is high. According to the respondents, litter on the beaches is a major problem, stating these reasons;

Marine debris pollutes the beach environment and makes the beaches unpleasant which eventually reduces the patronage of these beaches by tourists.

Marine debris are harmful to beach users and cause safety and health issues by causing injuries, and producing bad smell.

Marine debris alters the environment of the marine ecosystems, they are sometimes seen as food by fishes and other organisms in the marine environment and are ingested, this causes death of many of the organisms especially fishes.

Marine debris has affected catch of fishermen, as they cite instances where fishermen have complained of reduced catch and landing huge numbers of litter, mainly plastic rubbers (pure water wrappers), was asserted by assembly members of assembly Moree and Anomabo. This they said has affected the livelihood of many people especially fishermen within the communities.

The persistence of debris on the beaches also degrades the beaches and its environs which deters beach visitors especially foreigners and therefore reducing the income generation from these beaches and loss of foreign exchange.

To add to that, the main source of debris on the beach was attributed to beach users (fishermen, traders and visitors), adjacent water inlets, the sea, ships, industrial activities.

Representatives of all the organizations agreed to be beach goers and had suffered some kind of problem associated with litter on the beach, some of which included wounds from metal cans, diseases, discomfort and loss of revenue. Impact on human health and safety, impact on marine biota, unattractive beaches leading to low beach patronage were expressed as the main problems that marine debris can cause.

All the assembly men were of the opinion that bins should be labelled and made available on the beaches. This they believed will drastically reduce the litter load on the beaches of the central region.

Also, all the assembly men said that beach visitors should be made to pay tolls, which will in turn be used in running the beaches especially the collection of litter and security at the various beaches and this should be done at the at the district to make it functional.

The Assembly man at Moree was of the opinion that even if litter is segregated at source, collection becomes a problem. They as a people need to move around looking for people to collect litter especially pure water sachets. He also asserted that according to the people, even when waste is segregated, zoomlion waste carriers lump all together then transport them to dumpsites. Assembly man from Moree also asserted that road access to the Moree beach was very bad and this deters visitors from going to the beach.

Representative of Zoomlion when asked about this assertion from the Assembly man of Moree, was of the view that collection of segregated litter was not in full force and only available in certain areas because segregation is not done throughout the country. Respondent from Zoomlion stressed it was very important to segregate waste to make recycling and reuse easy, this he said would drastically reduce the amount of litter encountered on beaches and reduce the work load of the company since segregation is currents done by their outfit. Also, the respondent from Zoomlion the Moree beach is in a very remote area and there isn't a direct road access to the area, without road access their vehicles will not be able to access these areas.

All the respondents added that education and sensitization, the provision of advertisement at beaches about littering, provision of more litter bins, application of penalty to those that litter, and beach clean ups were some of the suggestions on how to reduce litter quantities on beaches within the central region.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Plastic materials were the dominant litter item, in particular drinking water sachets, food wrappers, black and white plastic bags, plastic bottles and containers. This reflects the extensive use of plastics in everyday activities such as purchasing of groceries and packaging of several items and the activities of beach users. Secondly, marine debris from land-based sources remains the highest source of beach litter and ocean-based sources the least. Thirdly, marine debris quantities at all three beaches were generally large and underwent monthly fluctuations with quantities peaking on occasions where beach patronage was very high and also in the events of rainfall. However, Bakano beach recorded the highest debris quantity. The results reflect the variety of activities (wood processing industry, fishing, trading) on the beach and the popularity of the beach with beach goers.

The results of the social survey support the results of the beach survey as most survey participants admitted to littering. Respondents acknowledged the fact that marine debris is a problem and associated it with injuries, wounds and discomforts experienced at the beach. They are also aware of some beach management practices being undertaken and the organisations responsible for keeping the beaches clean. Respondents were of the view that Ghana's beaches were generally not clean and beach users were the main source of marine debris along the beach. However, attitude towards littering remains exceedingly poor as almost all respondents acknowledge the fact that they are in the habit of littering. It can be inferred from the study that public attitudes towards littering is bad and the type and amount of marine debris along the coast is increasing in spite of increased public awareness of coastal pollution and existing management practices.

The study revealed that the main factors driving the beach litter at the three locations are the frequency of visits (monthly basis), the usage of the beach. That is, the purpose for which people go to the beach (recreation and relaxation purposes) as well as direct deposition of litter by visitors on the beach. Thus, these three activities are collectively the main causes of beach litter at the three locations even though the analysis revealed that there are other unexplained factors that may also be accounting for it.

The categorization of household waste helped identified the waste fraction which could be targeted for the purpose of recycling. The major fractions were organics, plastics, papers, metals, glasses, textiles, leather and rubber, inert materials and miscellaneous items.

Recommendations

The duration of sampling was relatively short and amount of debris present on the beaches sampled was relatively small compared to international surveys and hence potentially, this may have influenced findings. Also, sampling periods may correspond to a temporal period when amount of debris present on beaches is high. To test this idea further, future study is needed to occur over a longer temporal scale to capture seasonal effects. Also, studies must be done to sample solutions to reduce litter on beaches and curb the effects of marine debris.

Inverse relationships were observed in all the models for both beach and marine litters at the three locations. This relationship resulted in the downward trends seen in the plots of all the series. It was even seen in the four-month forecasts of the series. This could simply mean that if efforts put into the collection of litter from beaches is intensified, collection could yield positive results and rid the beaches of litter.

Intensive education remains key to combating the issue of marine debris on Ghana‘s coastlines. It is a fact that people become accustomed to and desensitized by familiar images thus the use of images not familiar in any media campaigns could act as more of a shock tactic and cause people to sit up and pay closer attention to their environment. As seen in the segregation of litter from households, if education is intensified, along with segregation of waste recycling could be made possible and easy.

Educational and public awareness programs using tools such as brochures, leaflets, stickers and posters should be made available and directed at reducing all litter and target users of the marine environment including local coastal communities, beach goers, school teachers and students. This is an activity that should be promoted by Civil Society Organizations (CSOs).

Provision of access routes to beach locations, especially Moree, beach will help ensure vehicular movement to carte debris collected and will help curb the practice of dumping and burying of debris on beaches and their subsequent exposure with high tidal and wave action and washing into the seas. Appropriate means of dumping refuse, such as house to house collection must be encouraged especially for households along beaches since they have shown ability to also segregate waste before collection. They have direct impact on accumulation of litter on beaches which subsequently end up in the seas.

The informal waste recycling activity which includes small scale collection and marketing of sorted recyclable materials, picking of recyclable materials especially plastics from streets and dump sites is a phenomenon that should be encouraged to help remove the already large waste dump sites especially on the beaches. In Ghana, the informal collection and recycling sector is an important, but often unrecognised, part of the solid waste and resources management system, and it is estimated that about 20%–30% of recycling is achieved by way of informal recycling systems, reducing collection and disposal costs. They play a vital role in the value chain by reprocessing waste into secondary raw materials. (Quartey et al., 2015)

A community-based approach to waste management especially plastics in which responsibilities are shared between households, municipal authorities and producers of plastics is needed. Through producer responsibilities and community participations, a greater portion of the waste, which usually ends up at dump sites, the environment and beaches, can be recovered efficiently and at low cost. The success of recycling not only depends on participation levels, efficiency of the equipment and infrastructure but on the quality of recovered waste. Therefore, it is necessary to recover recyclables at the early stage before they are mixed with other waste streams or end up at landfills. This can be seen from Table 7 possible since sorting efficiency was high.

The adoption of appropriate policy initiatives and suitable regulations and long term enforcement of the already existing ones to ensure compliance with these regulations by the law enforcing agencies is vital to addressing marine debris along Ghana‘s coastlines.

Multi-agency clean up campaigns must be adopted and maintained the year around and data of the campaigns made available to the participants, decision makers, stakeholders, and the public. Currently, beach clean ups and monitoring are not being carried out on more popular beaches (urban or semi-urban beaches). As a result, the information available on the issues; types, levels and trends could be skewed because of this. It is imperative that beach clean ups are carried out on a larger scale in conjunction with other environmental non- profit organisations in order to obtain a comprehensive picture to fully understand regional differences and what the main problems are. This will give a clearer picture of where resources are best aimed. Ultimately, cooperation and coordination by the government of Ghana with other riparian especially countries along the Gulf of Guinea to take the necessary measures and actions including cleaning campaigns that can help keep the coastline free from marine debris in the long term.

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APPENDICES

APPENDIX A

BEACH USER'S INTERVIEW GUIDE

UNIVERSITY OF CAPE COAST

Department of Fisheries and Aquatic Sciences

QUESTIONNAIRE

Introduction

My name is Nunana Agbemabiese. I am an MPhil student with the Department of fisheries and aquatic sciences at the University of Cape Coast. I am conducting a survey on marine debris. This survey aims at collecting the views on people's perceptions on beach litter to determine the social drivers, impact and mitigation measures on marine debris. The survey is being carried out at Bakano, Moree and Anomabo beaches in the Central Region. All your answers are anonymous and will be kept completely confidential.

Will you like to take part in this survey? YES [ ] NO [ ], if YES, please go to Question 1

Demographic Data

1. **What age category do you belong to?**

(a)18-25 years (b) 26-40 years (c) 41-60 years (d) above 60years

2. **Gender**

(a)Male (b) Female

3. Do you live or work in this area?

…………………………………………………..

4. **Where do you live?**

(a) Adjacent the beach (b)Just close by (c) 1 Kilometer away (d) More than 2 Kilometers away.

5. **What is your primary occupation?**

(a) Fisherman (b) trader (c) farmer (d) unemployed (e) other………………………

6. **What is the highest level of education that you have attained?**

(a) Not been to school (b) Adult Literacy (c) Primary (d) JSS/ Middle School (e) SSS/Tech/ Vocational (f) Graduate (g) Postgraduate

BEACH USAGE

7. How important is the beach to you?

(a) Important (b) Very important (c) Not important at all

8. What is the reason for your choice?

…………………………………………………………………………………………

…………………………………………………………………………………………

9. How often do you visit the beach?

(a)Daily (b) Weekly (c) Monthly (d) Yearly (e) occasionally

10. How do you use the beach / what do you do at the beach?

(a) A place for worship (b) For washing (c) A place for fishing (d) For recreation. (e) A place for relaxation (f) place of convenience (g) for irrigation

11. What issues are you not happy with along the beach?

(a) Poor facilities (such as toilets, litter bins) (b) Beach erosion (c) Bad smells (d) Debris on the beach (e) Flies and other insects (f) Noise from vehicles (g) Crowded beaches (h) Poor water quality

12. What in your opinion on the state of litter on this beach per 100m?

(a) Heavily littered (more than two 50lt container) (b) Moderately littered (up to two 50lt container) (c) Littered (up to one 50lt container) (d) Not littered at all.

13. What is your assessment of litter load on the beach for the past 10 years?

(A) Increasing (b) Decreasing (c) Remaining constant (d) Very negligible

14. Do you usually consume food and beverage at the beach?

(a)Yes (b) No

15. What do you usually do with the litter you generate at the beach?

(a)Leave directly on beach (b) Carry it home (c) Place in waste bins

16. Have you at least once left litter on a beach? (a)Yes (b) No

17. If you answered yes, is this your usual habit? (a) Yes (b) No

18. If you see another person's litter do you collect it?

(a)Never (b) Rarely (c) Sometimes (d) Nearly Always (e) Always

19. When you see other people's litter on the beach do you speak to them about the issue of marine debris?

(a)Never (b) Rarely (c) Sometimes (d) Nearly always (e) Always

20. What in your opinion are the sources of litter on the beach? (***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 on the beach.	[ ]
Deposition through run ways	[ ]
Recreational activities on the beach	[ ]
The use of beach as refuse dump.	[ ]
Fishing activities	[ ]

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

There are flies and insects around the beach.	[1]	[2]	[3]	[4]	[5]
The sprawl of settlement/development around the beach.	[1]	[2]	[3]	[4]	[5]
Waste water is discharged into the beach.	[1]	[2]	[3]	[4]	[5]
There is direct defecation and disposal of human excreta on the beach	[1]	[2]	[3]	[4]	[5]
The beach is used as a dump site.	[1]	[2]	[3]	[4]	[5]
The stench around the lagoon is unbearable.	[1]	[2]	[3]	[4]	[5]

22. Does the community around the beach organize any cleanup activity that extends to the

beach? (a) YES (b) NO

23. If yes, how often is the cleanup exercise organized?

(a)Weekly (b) monthly (c) quarterly (d) annually (e) other………………..

24. Do you actively involve yourself in such clean up activity?

(a)Yes (b) No

25. What do you think will stop people from littering around the beach?

Punishing those who litter.	[ ]
Provision of waste bins at vantage points around the lagoon and the beaches	[ ]
Provision of some education to users of the beach and lagoon about Littering	[ ]
Others, specify …………………………………………………………………	

26. Who is responsible for keeping beaches in central region free from litter?

……………………………………………………………………………………

27. In your opinion, what is the main problem that marine debris can cause?

(a)Impact on human health (b) Impact on marine life (c) Beach becomes unattractive (d) Injury (e) destruction of nets (f) other ………………………

28. Have you suffered any kind of problem directly associated with litter on the beach? (a)Yes (b) No

29. If you answered yes, what happened?

(a)Wounds (b) Disease (c) Discomfort (d) other…………………

30. Does litter on the beach affect economic activity? (a)Yes (b) No

31. If yes which litter item affect you most and how?

……………………………………………………………………………………

32. What are the top 5 litter items that poses danger?

……………………………………………………………………………………

Thank you for participating in this survey.

APPENDIX B

STAKEHOLDER'S INTERVIEW GUIDE

My name is Nunana Agbemabiese. I am an MPhil student with the Department of fisheries and aquatic sciences at the University of Cape Coast. I am conducting a survey on marine debris (trash and other solid material that enters oceans and coastal waters and often ends up on our beaches.). This survey seeks to assess perceptions, impact and mitigation measures on marine on marine debris. The survey is being carried out at Bakano, Moree and Anomabo beaches in the Central Region. All your answers are anonymous and will be kept completely confidential.

Background Information

1. Name of organization you represent ………………………..………………

2. What are your core functions?

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3. In your opinion, is marine debris a major problem in the Central Region?

(a) Yes (b) No

4. If yes, why are they a problem?

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5. In your opinion, what is the state of debris on beaches of Cape Coast?

(a) Increasing (b) decreasing (c) remains constant (d) Not sure

6. What do you think is the main source of litter on the beaches of Cape Coast?

(a)Tourism (b) Fishing activities (c) Run off (d) Sea (e) Industrial activities (f) other …………………

7. How would you assess the impact of marine debris on Ghana's beaches in general?

(a) No impact (b) Low impact (c) Moderate impact (d) High impact

8. What do you think is the main reason for litter on beaches of Cape Coast?

(a) Easy way to get rid of things (b) Low sense of responsibility (c) Convenience (d) lack of understanding of the impact of litter (e) inadequate dust bins (f) other.

9. In your opinion, what is the main problem that marine debris can cause?

(a)Impact on human health and safety (b) Impact on marine biota (c) Beach becomes unattractive leading to low patronage (d) fishing activity (d) Unsure

10. What are the top 5 litter items that poses danger?

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11. What would be the top 3 priority litter issues with which the Central Region is confronted?

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12. What is your suggestion to reduce the litter quantity the beaches of Cape Coast?

(a) Improve education (b) Provide more rubbish bins (c) Distribution of plastic bags (to collect your litter in) (d) Apply a penalty to those that litter (e) Provide advertising at the beach entry about littering (f) Clean the beaches (h) Other …..

13. What are your sector's activities to reduce marine litter?

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14. How does marine litter harm the mission or economic interests of your sector?

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15. Which EXISTING measures are presently taken to avoid or mitigate marine litter?

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16. Which possible NEW measures could be taken?

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17. At what administrative level should the measures be taken?

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18. Are there geographic constraints for the measures: remoteness, population density?

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Thank you for participating in this survey

APPENDIX C

TWO WAY ANOVA TABLE FOR BEACH LITTER

Tests of Between-Subjects Effects

Dependent Variable: Litter amount

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	54726.446[a]	3	18242.149	6.674	0.003
Intercept	470698.513	1	470698.513	172.215	0
Months	21489.446	1	21489.446	7.862	0.011
Sampling location	33237	2	16618.5	6.08	0.009
Error	54664.179	20	2733.209		
Total	1607891	24			
Corrected Total	109390.625	23			

a. R Squared = .500 (Adjusted R Squared = .425)

APPENDIX D

TWO-WAY ANOVA TABLE FOR FLOATING LITTER

Tests of Between-Subjects Effects

Dependent Variable: Litter amount

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	1498500.4	1	1498500	90.1706	0.01
Months	71857.958	7	10265.4	33.456	0
Location	33237	2	16618.5	54.1613	0
Total	1607891	24			
Corrected Total	109390.63	23			

a. R Squared = 1.000 (Adjusted R Squared)

APPENDIX E

TOTAL BEACH LITTER COUNTED AT MOREE

litter Items	November	December	January	February	March	April	May	June
Plastics	739	1158	947	633	721	514	634	568
Glass	49	57	51	40	36	42	41	43
Fabric	27	32	31	24	19	27	25	24
Paper	118	136	106	164	73	75	76	61
Plant Material	181	199	189	109	132	148	123	106
Metal	23	24	20	17	15	10	9	8
Rope/Nets	61	64	68	58	52	50	45	38
Polystyrene	81	84	81	59	53	51	46	42
Others	29	30	27	18	17	21	18	16

APPENDIX F

TOTAL BEACH LITTER COUNTED AT ANOMABO

litter Items	November	December	January	February	March	April	May	June
Plastics	818	1002	885	630	549	529	425	387
Glass	30	33	27	25	23	22	22	19
Fabric	23	22	20	17	16	15	16	12
Paper	377	396	368	339	336	324	319	199
Plant Material	55	58	52	46	43	35	39	22
Metal	43	46	43	39	38	38	34	28
Rope/Nets	134	147	139	132	126	117	112	147
Polystyrene	93	97	91	77	72	71	70	63
Others	18	20	18	14	14	11	9	8

APPENDIX G

TOTAL BEACH LITTER COUNTED AT BAKANO

litter Items	November	December	January	February	March	April	May	June
Plastics	1109	1188	937	731	776	915	602	501
Glass	54	61	50	35	37	32	28	26
Fabric	42	45	40	31	30	38	27	18
Paper	295	304	298	235	207	214	195	190
Plant Material	116	138	100	81	72	68	68	66
Metal	106	111	101	95	91	87	83	74
Rope/Nets	66	73	66	58	48	37	43	35
Polystyrene	128	135	122	101	111	103	89	80
Others	34	34	30	25	23	20	16	18

APPENDIX H

TOTAL FLOATING LITTER COUNTED AT MOREE

Litter Items	November	December	January	February	March	April	May	June
Plastics	196	261	225	161	156	124	132	208
Glass								
Fabric	3	6	5	2	1			3
Paper	10	15	12	7	5	4	4	8
Plant Material	22	33	27	21	19	15	17	24
Metal	3	6	2					3
Rope/Nets	9	16	13	5	8	5	6	11
Polystyrene	7	12	9	5	5	3	4	8
Others	3	8	4					4

APPENDIX I

TOTAL FLOATING LITTER COUNTED AT ANOMABO

Litter Items	November	December	January	February	March	April	May	June
Plastics	186	242	229	174	176	161	154	198
Glass								
Fabric	2	4	2	1				3
Paper	8	13	8	6	5	3	2	9
Plant Material	1	4	2		1			1
Metal	3	4	1	2	1	2	1	2
Rope/Nets	9	12	11	8	5	7	6	11
Polystyrene	2	6	4	4	1		1	6
Others		1						

APPENDIX J

TOTAL FLOATING LITTER COUNTED AT BAKANO

Litter Items	November	December	January	February	March	April	May	June
Plastics	268	363	305	264	256	224	199	277
Glass		2					1	
Fabric	3	2	3					4
Paper	7	11	8	4	5	2	1	6
Plant Material	6	10	3	3	1	2	3	7
Metal	1	3						1
Rope/Nets	14	19	10	9	9	7	9	13
Polystyrene	8	11	9	5	5	4	4	9
Others	1	2		1				3

APPENDIX K

TOTAL HOUSEHOLD LITTER WEIGHED AT MOREE /KG

House Hold Waste	Week1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Organic	192.12	200.63	180.12	195.66	209.4	206.4	250.33	150.4
Plastic	35.48	33.45	30.11	33.29	42.69	39.5	37.16	34.91
Paper	10.67	12.25	9.23	15.44	9.21	12.34	10.37	10.65
Metal	3.22	3.32	4.22	2.96	3.92	4.05	4.37	4.26
Glass	2.94	2.94	2.32	2.22	3.9	2.06	2.93	2.44
Textile	15.14	10.23	15.7	14.66	14.23	15.32	14.6	20.21
Others	49.27	30.75	50.24	55.31	45.35	50.24	56.91	50.47

APPENDIX L

TOTAL HOUSEHOLD LITTER WEIGHED AT ANOMABO / KG

House Hold Waste	Week1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Organic	175.06	175.8	178.23	170.44	180.23	182.53	175.23	176.11
Plastic	28.47	30.2	32.1	27.4	28.39	25.21	27.14	34.4
Paper	12.12	15.44	11.96	12.05	16.2	14.41	10.63	15.42
Metal	12.48	11.98	11.02	13.1	12.42	12.63	12.79	12.89
Glass	6.94	6.05	5.89	6.73	7.99	7.21	6.01	8.9
Textile	9.43	9.35	6.12	9.54	10.02	10.3	9.99	12.65
Others	23.77	27.98	40.79	19.75	23.25	16.43	19.35	18.75

APPENDIX M

TOTAL HOUSEHOLD LITTER WEIGHED AT BAKANO / KG

House Hold Waste	Week1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Organic	153.27	155.63	159.4	155.9	153.74	143.78	152.94	154.21
Plastic	25.63	22.36	23.35	23.45	28.91	27.34	27.3	25.99
Paper	14.1	13.28	15.23	16.41	12.33	14.36	16.78	14.2
Metal	10.58	9.36	11.93	10.86	10	9.38	11.21	9.29
Glass	4.98	5.1	5.32	4.03	5.1	4.96	4.36	5.12
Textile	5.13	6.32	6.14	5.1	5.03	4.65	5.01	4.1
Others	19.44	20.42	19.44	21.78	20.31	23.1	19.41	19.23