UNIVERSITY OF GHANA

ASSESSMENT OF BEACH LITTER AT THE SAKUMONO AND LA PLEASURE BEACHES

BY

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DECLARATION

I, **Obed Adjei** hereby declare that this thesis, "Assessment of Beach Litter at the Sakumono and La Pleasure Beaches" consists entirely of my own work produced from research undertaken under supervision of Dr. Angela M. Lamptey; and that no part of it has been published or presented for another degree elsewhere, except for the permissible references from other sources, which have been duly acknowledged.

Obed Adjei

(Student)

Signature:…………………………….. Date:…………………………………….

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(Supervisor)

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DEDICATION

This thesis is dedicated to my wonderful mother, Agnes Ocansey, my siblings, Jude Adjei and Marigold Adjei. You are such a great family and inspiration. God bless you.

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ABSTRACT

Ghana faces a major challenge when it comes to waste management, especially in the urban areas. Population growth even makes the situation more exacerbated in the coastal urban areas. Most of the waste that is generated and lost inland end up in the coastal and marine environment when the rains fall and wash the solid wastes downstream. Some of the waste is also produced on the beaches by revelers when they use the beaches for tourist and entertainment purposes. This study was carried out on two beaches in the Greater Accra Region, namely Sakumono and La Pleasure beaches. The main objective of this study was to assess the amount of beach litter at the two beaches. A transect of 1000 m^2 was used in the study. A total of 2,697 litter items were collected from the two beaches. The total weight of the litter throughout the survey was 50.07 kg from both sites. Weight of litter collected from Sakumono beach was 31.79 kg accounting for 63.49% of the total weight of litter surveyed whereas the weight of litter collected from La was 18.28 kg, also accounting for 36.51% of total litter surveyed. Plastics were found to be the most abundant both by number as well as weight. For both beaches, plastics made up 72.56% composition by number or quantity at 1975 items and 65.53% by weight at 32.81 kg. Sakumono beach was found to be more littered than La Pleasure beach. This was significant at an alpha value of 0.05 (p value = 0.02). Continuous monitoring, intensive education, and the enforcement of appropriate policy initiatives remain crucial to addressing the beach litter menace along the coasts of Ghana.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Coastal areas may commonly be defined as the interface or transition regions between land and sea, including large inland lakes (Masalu, 2000). They are diverse with respect to form and function. Coastal areas cover only 10% of the earth's land area but they accommodate over 60% of the world's population (Lakshmi and Rajagopalan, 2000). The coastal area is an area of intense activity. It is an area of interchange within and between physical, biological, social, cultural and economic processes and activities. Changes to any part of the system and at any point of the system can generate chain reactions far from the point of origin and possibly in an entirely different system whose environmental conditions will also be changed subsequently (Masalu, 2000). With the rising populations in coastal areas, there is an intense pressure and demand on the coastal area and coastal resources. A lot of these activities lead to the production of massive waste and litter in the coastal areas.

Debris is a problem that affects beaches throughout the world (Derraik, 2002; Gregory and Andrady, 2003; Ivar do Sul and Costa, 2007). In the 21st century, marine litter pollution has emerged as one of the major concerns on ecological disturbances caused by anthropogenic impacts (Barnes *et al*., 2009; Ryan, 2015). Marine litter is associated with various anthropogenic activities that may have taken place on the beach or far away, and transported via waterways towards the sea.

Marine debris or marine litter can be defined as any persistent, manufactured or processed solid material discarded, disposed of, or abandoned that enters the coastal or marine environment or Great Lakes (UNEP, 2009). They are also items that are made or used by humans and intentionally or unintentionally lost to the ocean including the transport of these items to the ocean by rivers, drainage, sewage systems, or even by the wind (Galgani *et al*., 2010). According to NOAA (2007a), marine debris or litter range from common domestic material to industrial products, to lost or discarded fishing gear. Natural disasters such as floods, landslides, hurricanes, and tidal waves could also cause substantial and large-scale introduction of all manner of litter into the marine environment (Thompson *et al*., 2005). Marine debris can be found on all kinds of beaches. They can be present at secluded shores as well as recreational beaches that are patronized throughout the world (Jambeck *et al*., 2001; Sheavly, 2007). Despite efforts made internationally, regionally, and nationally, there are indications that the marine litter problem continues to worsen (UNEP, 2016). Marine debris are not only problematic environmentally, but also economically and aesthetically (Sheavly, 2007; UNEP, 2009; NOAA, 2010; World Ocean Review, 2010).

Marine litter could either be categorized as ocean-based or land-based depending on where the litter enters the water (NOAA, 2007a; Sheavly, 2007; UNEP, 2016). The major ocean-based sources include fishing activities, shipping activities, offshore mining and extraction, legal and illegal dumping at sea, abandoned, lost or discarded fishing gear and natural catastrophic events (Thompson *et. al*., 2009). Some major terrestrial or land-based sources include industrial outfalls, wastes from dumpsites, discharges, fishing activities, tourism and also natural storm related events (Allsopp *et. al*., 2006; Mouat *et. al*., 2010). About 80% of the world's marine debris pollution is known to be of land-based source whereas the remaining 20% is known to be ocean-based sources (CMC, 2000; World Ocean Review, 2010). Other items are classified as general source items because they cannot be traced to a specific or sole source (Jambeck *et al*., 2015). Other factors, such as ocean current patterns, climate, tides, and proximity to urban centres, waste disposal sites, industrial and recreational areas, shipping lanes, and commercial fishing grounds, influence the type and amount of marine debris found in open ocean areas or collected along beaches and ocean (UNEP 2016). Beach litter that collects along beautiful shorelines and waterways affects the aesthetic beauty and satisfaction of those beaches and negatively affect tourism (Rockefeller, 2003). Aside being an eye-sore, marine debris can pose harm to the other organisms and equipment in the marine environment. Disposed fishing gears, ropes and plastic bags can get wrapped around and damage propellers of boats or they may even get sucked into the engines of the boat (UNEP, 2009). Medical wastes and other used medical equipment lying indiscriminately on beaches can carry diseases even as broken glasses and other sharp objects pose obvious dangers for beachgoers who may be barefooted (NOAA, 2010). Beach litter can also cause destruction of habitat of organisms by affecting water quality and physically damaging the sensitive ecosystems. Sea grass beds, coral reefs and their benthic species are also subject to the effects and impacts of marine litter. Marine litter can also be detrimental to marine biodiversity (NOAA, 2010). Many species mistake the litter for food and accidentally ingest them. Discarded fishing nets, fishing gear and fishing lines and other kinds of litter can entangle marine organisms, maiming or even killing them (Sheavly, 2007).

There are two primary international conventions that address waste and pollution in the world's oceans by ships. These are the International Convention for the Prevention of Pollution from Ships (MARPOL) and the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (1972), commonly called London Convention.

Ghana has a long and highly productive coastline of about 550 km which faces the Gulf of Guinea (EPA, 2012). Its productive nature is represented by abundant natural resources with immense economic benefit for the country (Amlalo, 2007). Plastics form the most dominant type of litter (Nunoo and Quayson, 2003); a phenomenon which has been consistent with various research findings worldwide (UNEP, 1990; Topping et al., 1994; Hoagland and Kitte-Powell, 1997; CMC, 2000; UNEP, 2009).

1.2 PROBLEM STATEMENT

Ghana faces a major challenge when it comes to managing waste, especially solid waste in the metropolitan areas (Obirih-Opareh, 2002; Mariwah, 2012). A lot of effort and resources, including research have been committed to eliminate waste in our cities (Demanya, 2006). The waste, however, keeps piling up with domestic solid waste, industrial waste and construction waste being the predominant wastes. Only a small portion of these wastes are sent to the very few dumpsites, and majority of them end up in drains, streams and open spaces and eventually to the beaches and the seas. There have been many projects that have focused on the provision of improved education on sanitation and hygiene in the coastal areas, however, improper disposal of municipal liquid and solid wastes remains prevalent (Nunoo and Quayson, 2003). This situation has resulted in the persistent sanitation problems where many towns and cities are overwhelmed with municipal solid and liquid wastes management. This is evidenced by the annual epidemics of cholera in the country (Mireku-Gyimah *et. al.,* 2018). It is estimated that Ghana produces an average daily waste of 0.45 kg per capita, which translates to 3.0 million tons of annual solid waste generation (GhIE, 2011). Combined, Accra and Kumasi is said to generate more than 3,000 tons of solid waste daily (GhIE, 2011).

Only about 10% of the solid wastes produced is disposed of properly mainly through land fill sites which are also rapidly running over (GhIE, 2011). For instance, the Kpone landfill, which serves majority of the city of Accra and the entire Tema is fast depleting to the point that waste is now dumped along the road to the main landfill. This results in the facilities being danger zones while posing serious public health problems as well as aesthetic problems (GhIE, 2011). If this problem is not given the needed attention that it deserves, the major changes that it will cause in the environmental conditions can cause the failure of marine ecosystems which will also affect the ability of the coastal area to adequately sustain the life that depend on it to survive.

1.3 JUSTIFICATION

There is very limited data on continuous litter quantification and monitoring in Ghana. The problem of marine debris still continues and is likely to worsen, in spite of measures in place to reduce and prevent the phenomenon (Van Dyck, Nunoo and Lawson, 2016).

Continuous monitoring of the trends and changes in marine litter will provide a lot of insight and understanding of this problem of marine pollution and can function as a benchmark and indicator for management strategies. Continuous monitoring can also help to properly ascertain the change in the types, sources and quantities of marine debris and rate of change. The effectiveness of management strategies, laws and other activities that are put in place to control and curb the issue of marine litter can also be assessed with continuous monitoring (Coe and Rodgers, 1997 and Sheavly, 2005). Data gathered from monitoring litter quantities and changes in marine litter will help provide a strategy for tackling the sources of the litter and can also be used to measure the success of interventions put in place to abate marine debris (Sheavly, 2007). Successful management of the problem of marine litter requires a wholistic understanding of the issue, including identifying the most dominant forms of marine litter, their abundance, their potential sources and the activities that give rise to the litter. Aside the last survey in 2013 (Van Dyck, Nunoo and Lawson, 2016), there hasn't been any current survey to assess the recent status of the litter on the beaches.

This study, therefore, seeks to assess beach litter on the Sakumono and La Pleasure beaches to make available recent data on the litter at the two beaches. Sakumono and La Pleasure beaches were selected because they are among the most patronized beaches in Tema and Accra respectively. Sakumono beach is not managed whereas La Pleasure is managed. Data from the two beaches will help to know the implications of management on the beaches and how it influences the amount of litter on the beaches.

1.4 OBJECTIVES

Main objective

To assess the litter at the Sakumono and La Pleasure beaches

Specific objectives

i. Identify sources of the litter at Sakumono and La Pleasure beaches
ii. Assess the quantity and the composition of beach litter at Sakumono and La Pleasure beaches
iii. Assess spatial variation in amount of litter at Sakumono and La Pleasure beaches

CHAPTER TWO

LITERATURE REVIEW

2.1 HISTORY OF MARINE LITTER

The natural environment has been altered by anthropogenic activities over the years but the extent, intensity, and rate of the change has increased intensely over the last 75 years (Laist and Liffmann, 2000; Potts and Hastings, 2011). Laist and Liffmann (2000) assert that this alteration is more evident in the coastal areas which is characterized by increasing populations, heightened demand for natural resources, and sophisticated modern technologies. These have combined to bring about widespread changes in the coastal and marine environments. Some marine litter impacts can be traced back to the 1940s where synthetic materials began to replace natural fibers in the manufacture of fishing nets and lines and everyday items. The low cost, light weight, and long life of these new synthetic materials resulted in more of them being discarded and transported to the most remote ocean shorelines and waters, posing a much longer hazardous life for marine species (Laist and Liffmann, 2000). The impacts of marine litter or debris pollution on marine life were not felt until 1984 when the National Marine Fisheries Service (NMFS), hosted the Workshop on the "Fate and Impact of Marine Litter in Honolulu, Hawaii, at the recommendation of the Marine Mammal Commission (Shomura and Yoshida, 1985; Laist and Liffmann, 2000). It was observed from data gathered at the workshop that marine litter was affecting more species in many more areas than had been previously observed (Laist and Liffmann, 2000). The biological impacts of the marine debris were also found to have two main forms which are:

1. Entanglement of organisms in loops and openings of abandoned fishing nets and fishing nets.

2. Ingestion of plastics damaging or blocking the digestive tracts of the organism which are both potentially fatal to marine life.

Laist and Liffman (2000) also noted human safety problems which could be caused by fouling and damaging of vessel propulsion systems. Prior to the global recognition of beach litter or marine debris, the issues were handled with minimal importance as the impacts that were observed seemed to be localized or rather regional at most (IOC, 2009). The Workshop on the "Fate and Impact of Marine Litter in Honolulu, Hawaii prompted national and international efforts to investigate, monitor, and mitigate the impacts of marine litter (Laist and Liffmann, 2000).

Marine litter becomes more evident at beaches after rainfall and during low tides which exposes the litter. This has a negative effect on the tourism industry of Ghana during the rainy season (Nunoo and Quayson, 2003). The most common types of beach litter along the beaches of Ghana include pieces of foam, fishing nets, cloth, foot wear, charcoal, wood, and husk of sugar cane and coconut (Nunoo and Quayson, 2003; Tsagbey *et al*., 2009). Also, frequently occurring are faecal deposits especially in areas where the adjacent communities do not have adequate toilet facilities. These deposits of feaces are subsequently washed into the sea with tidal cycles and affect the quality of the water. There is also usually direct disposal of sewage into the sea (Nunoo and Evans, 2007), which poses a health hazard to both the travelers of the beach for tourism and also to the marine biota. Marine benthos are also affected when marine litter cover the sea floor and inhibit growth of marine benthos and smothers them (Nunoo and Quayson, 2003). They may be smothered and even be suffocated.

2.2 SOURCES OF MARINE LITTER

The presence of marine litter is a problem along shorelines, in coastal waters, estuaries, and oceans throughout the world (Cheshire *et al.,* 2009; USEPA, 2012). It is estimated that about 6.4 million tonnes of litter ends up in the world's oceans each year, and this is distributed among all the oceans both in densely populated as well as remote areas far from human contact (UNEP, 2009).

Originating from both marine- and land-based activities, marine debris sources are numerous and extensive (UNEP, 2016). Marine litter can be found in all the ocean areas of the world. It is not only found in densely populated regions but also in remote areas that are far away from any obvious source (UNEP, 2005; World Ocean Review, 2010). Marine litter or debris travel over long distances with ocean currents and winds and are 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). Marine debris share a common origin, that is humans, although there may be different types. Mishandling of waste items and a host of other materials is the major cause of the problem of marine litter (NOAA, 2007; NOAA, 2012). Some of the litter, usually the smaller pieces, get buried and re-emerge later to worsen the litter problem at beaches (Williams and Tudor, 2001; Nagelkerken *et. al.,* 2001; Kusui and Noda, 2003). Sources of marine litter may be local as well as global (Department of Environmental Conservation, 2012) through the action of currents. Marine debris originates from a diverse array of both land and ocean-based sources (Derraik, 2002; Mouat *et al.,* 2010).

2.2.1 Land-based sources of marine litter

Marine debris from land-based sources originate from agricultural, domestic and industrial activities (UNEP, 2009) and may enter the marine environment through various pathways, including public littering, illegal dumping and poor waste management (Hastings and Potts, 2013; UNEP, 2009), transported to the seas by streams and rivers, sewage outflows and wind (Duckett and Repaci, 2015; Galgani *et al*., 2013; Poeta *et al*., 2014; Rech *et al*., 2014). Land-based sources account for approximately 80% of the marine litter found on the beaches and waters and the remaining 20% from ocean-based sources (GESAMP, 1991; NOAA, 2007; Sheavly, 2007; World Ocean Review, 2010; US EPA, 2012), though this may vary from area to area (Allsopp *et al.,* 2006; Mouat *et al.,* 2010).

2.2.2 Ocean-based sources of marine litter

Ocean-based sources are those that come about as a result of activities that take place at sea. Some of these ocean-based sources of marine litter include trash from ships, recreational boaters and fishermen and offshore oil and gas exploration and production facilities (Sheavly, 2007; World Ocean Review, 2010; USEPA, 2012).

The sources of marine debris can be further categorized into four major groups (Allsopp *et al.*, 2006; Mouat *et al*., 2010):

- Coastal tourism-related litter which is litter left by beach goers and revelers such as food and beverage packaging, cigarettes and plastic beach toys.
- Fishing-related litter which includes abandoned and damaged fishing lines and nets, fishing pots and strapping bands from bait boxes that were lost unintentionally by commercial fishing boats or dumped deliberately into the sea.
- Sewage-related litter which includes water from storm drains and combined sewer outflows which discharge waste water into the sea or rivers directly during heavy downpour of rains. The running waters carry along with them garbage such as street litter and other items such as condoms and syringes

- Wastes from ships and boats which also includes garbage which may be deliberately or accidentally thrown overboard.

There are some litter types whose direct origin may be difficult to distinguish, whether by beach users or from offshore (Hall, 2000; MCS, 2009). The growing populations in the coastal areas also adds to this problem. These factors, coupled with the growing demand for processed and packaged goods, have led to the rise in the amount of non-biodegradable solid wastes in our waterways (USEPA, 2012).

2.3 TYPES OF MARINE LITTER

Marine litter or debris by definition, encompasses a wide range of materials, however, most of the items fall into a relatively small number of material types and usage categories (STAP, 2011). Marine litter is made up of a wide range of different types of litter and these can be grouped into several distinct categories which include:

- Plastics in the form of molded, styrofoam, ropes, buoys, nets, monofilament lines and other fisheries related equipment, smoking related items such as lighters, and micro plastic particles
- Metals in the form of cans of drinks, aerosol cans, foil wrappers and disposable barbeques
- Glass in the form of buoys, light bulbs, fluorescent bulbs and bottles
- Processed timber in the form of pallets, crates and particle boards
- Paper and cardboard in the form of cartons, cups and bags
- Rubber in the form of tyres, balloons and gloves
- Clothing and textiles in the form of shoes, towels, attires and furnishings

- Sewage related litter in the form of cotton bud sticks, daipers, condoms and sanitary products (Fanshawe and 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).

It is widely appreciated that plastics make up the major constituents of marine litter (Barnes *et al*., 2009; Ryan *et al*., 2009; STAP, 2011a), though they vary in types and quantities. Plastic is largely the main constituent of marine litter (Barnes *et al*., 2009; Derraik, 2002; Poeta *et al*., 2014; Schulz *et al*., 2015; UNEP, 2009). This is partly due to the expanding popularity of plastics as a consumer product, and its high durability and persistence within the marine environment (Andrady, 2015; Barnes *et al*., 2009; Jambeck *et al*., 2015). Plastics are synthetic materials that do not bio-degrade but only fragment into smaller pieces (Sigler, 2014). There are some other synthetic materials that are similar to plastics in that they are used in a wide range of products, often cheap to produce and lightweight and thus are also common marine litter items. Some of these materials include glass in the form of light bulbs, fluorescent bulbs and bottles; rubber in the form of tyres, balloons and gloves; and metals in the form of cans of drinks, aerosol cans and foil wrappers. These items are able to undergo fragmentation over long periods of time and often do not completely biodegrade (Potts and Hastings, 2011). Processed wood in the form of crates, pallets, and particle board, and paper and cardboard items such as cartons, cups and paper bags, also add to marine litter but they usually found in much smaller amounts than the synthetic materials. This may be due to the shorter residence time of these materials in the marine environment as they are relatively faster to photo- and bio-degrade, and as a result, their collective impact may be much less (Velander and Mocogni, 1998; UNEP, 2005; Potts and Hastings, 2011). Textiles such as clothing, shoes, and furnishings also become marine litter or debris when they enter the marine environment. Specific impacts that these items pose are unknown, but are generally considered of lesser importance than the other synthetic materials (Velander and Mocogni, 1998; UNEP, 2005; Potts and Hastings, 2011). Marine litter is present on shorelines, floating on the surface, settled on the seafloor, inside and on marine organisms and as microlitter in the marine environment (Galgani *et al.,* 2013). An estimation of the marine litter distribution shows 15% floating on the sea surface, another 15% remains in the water column and 70% lies on the sea floor (UNEP, 2005).

2.4 IMPACTS OF MARINE LITTER IN THE MARINE ENVIRONMENT

Waste materials or debris in the marine environment pose a wide array of negative impacts environmentally, socially, economically and even to public health and safety (Allsopp *et al*., 2006; Mouat *et al*., 2010). Marine litter negatively affects coastal and marine ecosystems as well as the services they provide, thereby affecting the livelihoods and well-being of people (Oosterhuis *et al*., 2014; Gall and Thompson, 2015; Veiga *et al*., 2016a). The impacts of marine litter are diverse; however, they are often interrelated and usually dependent on one another (Mouat *et al*., 2010). For instance, ghost fishing as a consequence of abandoned fishing gear, can lead to economic losses in terms of fisheries as well as reduced opportunities for recreational fishing (Macfadyen *et al*., 2009).

2.4.1 ECOLOGICAL IMPACTS OF MARINE LITTER

Environmental impacts that marine litter poses are very dire and multidimensional (Valavanidis and Vlachogianni, 2011). They cause a wide range of adverse environmental impacts to individual organisms, species and even entire ecosystems (Mouat *et al*., 2010; Department of Environmental Conservation, 2012). Numerous scientific works document the threats that marine litter pose to wildlife and ecosystems at large. These impacts vary from entanglement and ingestion, to bio-accumulation and bio-magnification of toxic substances either released from disposed plastic items or adsorbed and accumulated on plastic particles, damages to benthic habitats and communities (Richards and Beger, 2011; Gall and Thompson, 2015; Fossi *et al*., 2018). These have been known to affect individuals of at least 267 species worldwide (Allsopp *et al.*, 2006; Mouat *et al*., 2010; NOAA, 2012). 86% of all sea turtle species, 44% of all seabird species and 43% of all marine mammal species including numerous fish and crustacean species have been involved in this tragedy (Allsopp *et al*., 2006; Mouat *et al*., 2010). There is however the possibility that the numbers of species listed is an undervalue because most affected organisms are likely to go undiscovered as they may either sink or get eaten by predators, making the exact magnitude of the problem a bit difficult to quantify (Baird and Hooker, 2000; Derraik, 2002; Allsopp *et al*., 2006). Marine litter can also impact the benthic environments negatively (Moore, 2008). An accumulation of litter 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). Benthic litter or litter that get to the seafloor tend to become trapped in areas with very minimal circulation and high sediment accumulation in contrast to floating litter, which rather accumulates in frontal areas or the shoreline. Debris that get to the seabed may have already been transported over a considerable distance and only sinking when weighed down by entanglement and fouling. This results in an accumulation of litter on specific seabed locations in response to local sources and oceanographic conditions (Galgani *et al*., 2000; Keller *et al*., 2010; Watters *et al*., 2010; Ramirez-Lolodra *et al*., 2013; Pham *et al*., 2013). Benthic organisms are also faced with the risk of being entangled or ingesting the debris that end up on the sea floor (Derraik, 2002) and potentially lead to the loss of ecosystem functions (Mouat *et al.,* 2010). Entanglement results in lacerations from abrasive or cutting action of attached litter that can lead to infections or loss of limbs; death by strangulation, choking, or suffocation; and can also impair organisms' ability to swim, which may lead to drowning, or make it difficult for the animal to move, find food, and escape from predators (USEPA, 2007; Derraik, 2002; Allsopp *et al.,* 2006).

2.4.1.1 Ingestion

Marine organisms may mistake litter for food many times and ingest them. Ingestion may sometimes happen accidentally, but generally animals ingest litter because they appear as food to them (Sheavly, 2005; Allsopp *et al.,* 2006; US EPA, 2007). Over 111 species of aquatic birds (Allsopp *et al.,* 2006), 31 species of marine mammal (Allsopp *et al.,* 2006) and 26 species of cetaceans (Derraik, 2002) have been reported to have ingested marine litter. Ingestion of marine litter causes physical damage to the digestive tract of the organisms including wounds, scarring and ulceration which could lead to infections, starvation due to the wounds and potential death.

There could also be toxic chemical poisoning of the organisms from contaminated plastics which could lead to reproductive disorders, increased risk of diseases, altered hormonal levels and even death (Derraik, 2002; Gregory, 2009; Mouat *et al.,* 2010; Sheavly, 2005; Allsopp *et al.,*2006; USEPA, 2007). Hydrophobic contaminants such as heavy metals and polychlorinated biphenyls (PCBs), from the surrounding seawater (Endo *et al*., 2005; Rochman *et al*., 2014). If ingested, these toxic compounds may be released into the tissues, potentially causing cryptic, sub-lethal effects for the organism (Batel *et al*., 2016; Laing *et al*., 2016).

2.4.1.2 Ghost fishing

Fishing gear that may have been lost or abandoned, either intentionally or unintentionally by fishermen, may continue to trap fishes and other organisms in their path (Allsopp *et al.,* 2006). Fishing gear are made of synthetic materials and therefore do not biodegrade. The process by which they continue to capture marine organisms such as fish and crustaceans and cause their death if they are not able to escape is known as ghost fishing (Sheavly, 2005; Allsopp *et al.,* 2006). By this process a cycle may be established whereby when the organisms are captured, they in turn, attract predators which may also be trapped (Allsopp *et al.,* 2006). As the organisms die and decay in the nets they also attract and trap other scavengers (Allsopp *et al.,* 2006). When abandoned in the sea, a single fishing gear may continue to trap marine organisms for decades (Mouat *et al.,* 2010).

2.4.1.3 Introduction of Alien Species

Anthropogenic activities cause organisms to be moved from their native habitats to other environments where they are alien through a process known as biological invasion (Allsopp *et al.,* 2006). Litter floating in the oceans serve as a means of transport for certain marine species (Lewis *et al*., 2005; Allsopp *et al.,* 2006, Mouat *et al.,* 2010). The introduction of large amounts of marine litter, especially plastics, into the marine environment in recent times has massively increased the tendency for the dispersal of marine organisms (Allsopp *et al.,* 2006, Gregory, 2009; Mouat *et al.,* 2010).

Due to the slow rate of the transport the alien species are able to adjust to changing environmental conditions (Allsopp *et al.,* 2006; Mouat *et al.,* 2010). As a result, marine litter could be more effective for the transport and introduction of alien species than ship hulls and ballast water (Allsopp *et al.,* 2006; Mouat *et al.,* 2010).

2.4.2 SOCIO-ECONOMIC IMPACTS

2.4.2.1 Economic Impacts

Evidence shows the impacts of marine litter to economic sectors, such as tourism and recreation, fisheries and aquaculture, maritime transport and navigation; as well as to infrastructure and services for individuals, the local coastal communities and enterprises (Mouat *et al*., 2010; McIlgorm *et al*., 2011; Leggett *et al*., 2014, Watkins *et al*., 2016; Brouwer *et al*., 2015; Vlachogianni, 2017; Schneider *et al*., 2018). Marine and coastal ecosystems are economically important, through industries they provide such as fisheries and tourism, and socially, through the benefits to health and well-being (Martínez *et al*., 2007; White *et al*., 2014). The presence of marine litter can, however, diminish these benefits. In the United Kingdom (UK) for instance, the economic losses to fisheries is estimated at £10 million per year in the repair of gear damaged by debris, time lost due to removal and other repairs and local authorities also spend about £15 million every year to clean beach litter (Hastings and Potts, 2013; Mouat *et al.*, 2010; Newman *et al.*, 2015)

2.4.2.2 Loss of Aesthetic Value

The coastal environment is very often the focus of many of the creative arts activities including paintings, literature and films and a loss of the aesthetics could adversely affect the inspirational quality of the marine environment (Mouat *et al.,* 2010). The aesthetic impact of marine litter has implications for tourism and human well-being. For instance, about 85% of 1000 residents and tourists said they would not visit a beach that has an excess of two litter items per metre (Ballance *et al*., 2000; Hastings and Potts, 2013). Tudor and Williams (2006) also reported that choice of beach was more strongly determined by clean, litter-free sand and seawater than by safety. Wyles *et al.* (2015) found that the presence of litter undermined the restorative psychological benefits that was experienced by people visiting the coast.

2.4.2.3 Navigational Hazards

Debris in the marine environment can also pose a significant navigational threat to shipping (STAP, 2011). Marine litter can present numerous safety risks for vessels, however, entanglement of propellers by derelict fishing gear such as nets, ropes and lines is a key example (Allsopp *et al.,* 2006; Mouat *et al.,* 2010). Abandoned fishing gear in the marine environment can be very damaging. An example of such threat was when a Russian submarine reportedly got entangled in a discarded fishing net in about 600 feet of water off the Kamchatka coast making navigation and surfacing challenging and this warranted an international rescue effort to rescue the seven-man crew. (TenBruggencate, 2005; Allsopp *et al.,* 2006; Mouat *et* *al.,* 2010). Derelict nets, ropes and other gear entangle propellers of vessels and rudders and may even 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 (Sheavly, 2005; Allsopp *et al.,* 2006; USEPA, 2007; NOAA, 2011). According to Cho (2006), 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 in 1993. 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).

2.4.2.4 Injuries to Beach Users

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

2.4.2.5 Leaching of Poisonous Chemicals

Aside the adverse physiological effects to marine organisms that arise from the ingestion of pieces of plastics, plastics in the marine environment may also pose an additional chemical hazard. This occurs especially with those that may contain known or suspected endocrine disrupting chemicals as additives or contaminants (Gallo *et al*., 2018). While plastics themselves are believed to be biochemically inert in the marine environment, they could carry toxic compounds that potentially pose health risks to both wildlife and humans (Allsopp *et al.,* 2006; Mouat *et al.,* 2010). Some plastic litter acts as a source of toxic chemicals: substances that were added to the plastic during manufacturing leach from plastic litter (Gallo *et al*., 2018). The chemicals found in plastic marine litter can be classified in the following four categories of origin:

- Chemicals intentionally added during the production process (additives such as flame retardants, plasticizers, antioxidants, UV stabilisers, and pigments);
- Unintentional chemicals coming from the production processes, including monomers (e.g. vinyl chloride and BPA.), which may also originate from UV radiation onto the plastic waste—and catalysts, normally present in traces;
- Chemicals coming from the recycling of plastic waste; and,
- Hydrophobic chemicals adsorbed from environmental pollution onto the surface of the plastics (Gallo *et al*., 2018)

Current research suggests that while there is significant uncertainty and complexity in the kinetics and thermodynamics of the interaction, plastic litter appears to act as a vector transferring Persistent Bio-accumulative Toxins (PBTs) from the water to the food web, increasing risk throughout the marine food web, including humans (Gallo *et al*., 2018)). Though it is not clear how long plastic items remain in their original form in the marine environment, some plastic items appear to be fragmented over time (Allsopp *et al.,* 2006). This process is thought to occur due to wave action, oxidation and ultraviolet light at sea (Allsopp *et al.,* 2006). On the shore, it may break up into smaller pieces due to grinding from rocks and sand (Allsopp *et al.,* 2006).

2.5 WASTE MANAGEMENT IN URBAN COASTAL AREAS

Coastal areas around the world are developed, overpopulated and coastal resources are overexploited (Hinrichsen, 1998). Coastal waters and bays are often heavily polluted with untreated or partially treated municipal, industrial and agricultural wastes (Rockefeller, 2008). This is as a result of the increasing population of coastal areas and the increasing need for resource use (Hinrichsen, 1998). It is said that poor waste management practices can be a major source of litter, with the litter eventually entering the marine environment through a variety of pathways such as wind and waterways (Potts and Hastings, 2011). All over the world and specifically in many developing countries in Africa, there has been tremendous population growth especially along the coast, accompanied by intense urbanization, and relative increase of industrial activities. Coast (2002) asserts that at the turn of the twenty-first century, global population had increased from five billion to an excess of six billion with developing countries, within a space of twelve years accounting for about 80 per cent of the world's population.

According to Coast (2002) again, growth rates in Africa still exceed 2.3 per cent per year, which is the highest growth rate of any major region. These transformations have brought enormous increase in the amount of solid waste produced and a wide diversification of other types of pollutants which include marine litter that reach the marine environment (Nunoo and Quayson, 2003). Anthropogenic waste includes all items that people have no use for, and either intend to get rid of or have already discarded. Some items which could be considered as waste include household rubbish, wastes from manufacturing activities, sewage sludge, packaging items, old electronic and electrical appliances and garden waste. By implication, all our daily activities give rise to a large variety of different wastes materials from different sources. With such huge amounts of waste being produced, it is important that it is managed in a way that waste does not cause any harm to either human health or to the environment (EIONET, 2009). Waste management along the coast was for a long time, regarded by coastal countries as an entirely aesthetic problem and therefore only coastal resorts and tourism players attempted to address the problem by regularly cleaning their adjacent beaches (World Ocean Review, 2010). According to the World Ocean Review (2010), the World's oceans are full of trash and the National Academy of Sciences in the USA also estimates that about 6.4 million tonnes of litter enter the World's oceans each year. It is, however, difficult to arrive at accurate estimates of the amount of litter in the oceans firstly because, it is constantly in motion and secondly, because the litter enters the oceans from different pathways, making it difficult to accurately quantify how much is entering (World Ocean Review, 2010).

According to the United Nations Joint Group of Experts on the Scientific Aspects of Marine Pollution, land-based sources make up about 80 percent of the world's marine pollution (GESAMP, 1991). According to the World Ocean Review (2010), the problem does not only affect the coastal areas but propelled by wind and ocean currents, the litter travels very long distances throughout the world's oceans and to remote beaches and islands that are uninhabited. Hinrichsen (1998) asserts that not much is being done to manage this crisis of our coast globally. The World Ocean Review (2010) also argues that marine litter, a major problem that must be taken seriously is only gradually being recognized.

2.6 WASTE MANAGEMENT IN GHANA

Ghana is a West African coastal state with an estimated population of about 28.83million and annual growth-rate of 2.5% (Ghana Statistical Service, 2017). Ghana has a long and productive coastline of about 550 km facing the Gulf of Guinea (EPA, 2012). The coastline of Ghana is dotted with extraordinary environmental diversity and beauty. The country is endowed with very productive coastal zones and they represent a huge natural and economic resource for the country (Amlalo, 2007). About 60 per cent of all industries in Ghana are situated in the coastal zone, mainly in the Accra and Tema metropolis which covers less than 1 per cent of the total area of the country. This concentration of industrial activity in the coastal area has led to the continuous migration of people from the hinterlands in search of jobs in coastal industrial centers, a contributing factor to the problem of waste generation (UNEP, 1999). Proper waste management in Ghana has been a major challenge for successive governments (Jospong Group of Companies, 2010). Mensah and Larbi (2005) assert that the major problems with solid waste disposal in Ghana principally relate to:

- Indiscriminate dumping
- Challenges with acquiring suitable disposal sites
- Challenges with conveyance of solid waste by road due to increasing traffic problems and the lack of alternative transport options
- Weak demand for composting as an option for waste treatment and disposal.

In the coastal communities of Ghana, most of the municipal and industrial effluents are directly dumped into coastal waters with little or no pretreatment including raw sewage. High concentrations of bacteria and pathogens in some of these areas pose a clear threat to human health (Hinrichsen, 1998). Increased rural-urban migration and subsequent congestion in coastal cities have resulted in major environmental and waste problems (Jospong Group of Companies, 2010). It is mostly in the urban areas of Ghana that most of the concern for waste management is prevalent. Variety of waste is produced in the urban areas of Ghana with some of the predominant wastes being industrial waste, domestic solid waste and construction waste. There are only a few dumpsites and landfills where these waste materials are sent to so majority of the wastes end up in drains, streams and open places and then eventually into the marine environment (United Nations Commission on Sustainable Development, 2012).

The poor state of waste management in Ghana cannot only be attributed to engineering problems. Increased rate of urbanization, poor financing ability of local authorities, low technical capacity for the planning and management of solid waste, weak or no enforcement of environmental regulations, have all contributed to compound the problem of waste management (Mensah and Larbi, 2005). According to the 2000 Housing and Population Census 4.8% of households have their waste collected directly from their dwellings, 7.9% burn their household refuse, 57.6% use various household receptacles for storage and send it to designated public dumps including communal-container stations or sanitary sites. It is reported that 3.9% of households bury their refuse while 25.9% dump at unspecified locations including vacant lots, drains, embankment of water courses, rivers, lakes and wetlands. In total, close to 85% of all refuse generated is currently not collected and disposed of in a proper manner (GSS, 2000). The case, however, had improved according to the 2010 Population and Housing Census (PHC), although there was still some form of improper disposal of waste. 37.7% of households disposed of their solid waste in open space at public dumps and 23.8% disposed of their solid waste into public containers. A combined percentage of about 25% households either had their solid waste collected or burned. However, in Greater Accra, almost half (48.5%) of households have their solid waste collected from their homes leaving the other half unaccounted for. Again, according to the 2010 Housing and Population Census, the two major coastal regions, Greater Accra and Central regions had the highest population growth rates (3.1%) (GSS, 2010) with Greater Accra having the highest proportion of urban population (90.5%) that same year. 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.

2.7 SOCIAL DRIVERS OF LITTERING

The view of society varies widely (Arafat *et al.,* 2007) however, it is widely acknowledged within literature that littering is a by-product of modernity (Slavin, 2011), with anthropogenic litter being identified as one of the most visible forms of pollution and environmental degradation (Slavin, 2011). Hansmann and Scholz (2003) defines littering as the careless, incorrect disposal of minor waste. Sibley and Lui (2003) also asserts that attitudes related to littering can be either referred to as active or passive. Active littering is when the environment is littered knowingly, while passive littering is when the environment is littered unknowingly (Slavin, 2011). Passive littering is difficult to combat (Sibley and Lui, 2003) because the person involved is unaware that they have participated in the act of littering (Slavin, 2011). There are a number of different factors that are believed to contribute to littering behaviour especially within a society or group (Slavin, 2011) specifically referred to as descriptive and injunctive norms (Caldini, 2003; Schultz *et al.,* 2007). The descriptive norm refers to a person's perception of what is done normally per a given situation, while an injunctive norm refers to a person's perception of what is approved or not per a given situation (Caldini, 2003; Schultz *et al.,* 2007). Environmental factors are also powerful determinants of behaviour of people in that, the more litter there is around, the more people are inclined to drop litter (Arafat *et al.,* 2007). Cialdini (2003) and Torgler *et al.* (2008) report a higher probability of people littering places where litter is already present as opposed to areas without litter. This would suggest that if people notice other individuals littering, their willingness to litter also increases, reducing the moral constraints which would ordinarily compel individuals to behave in a rather socially acceptable manner (Torgler *et al.,* 2008).Thus, an individual's attitude towards littering is likely to be influenced by their perception of the behaviour of others (Torgler *et al.,* 2008).

2.8 INTERNATIONAL LEGISLATION AND CONVENTIONS CONCERNED WITH THE PREVENTION OF MARINE LITTER

Humans, for many centuries, have deemed the oceans as unlimited source of food, a useful route of transport, and, unfortunately, a dumping ground for anthropogenic waste. The ocean was believed to be too vast to feel the effects of human action from use as dumping ground (Rockefeller, 2003). In coastal areas around the world, shoreline developments have led to the destruction of habitats and breeding grounds of several marine species (Rockefeller, 2003). Although there are laws that regulate the dumping of trash at sea and on shore, the global nature of marine litter, the inability to confine litter within territorial boundaries and the difficulty in identifying litter sources have made effective laws difficult to develop and even harder to enforce (Sheavly, 2007). The major key to controlling marine litter is to tackle it at source and this is not only consistent with the precautionary principle, but may be a management option that is economically sustainable in the longer term (Fanshawe and Everard, 2002). There are many international agreements and legislation that directly and indirectly address the problem of marine litter. Many of the legislations are specifically formulated to reduce marine litter and to prevent the discharge of waste into the marine environment but many of the existing agreements also take a broader approach and outline fundamental principles for the sustainable use and conservation of the oceans (Mouat *et al.,* 2010).

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

The UNCLOS is a convention designed to broadly govern the management and sustainable utilization of marine resources. Provisions of the Convention include territorial sea limits, marine scientific research, protection of the marine environment, conservation and management of living marine resources, economic and commercial activities, and a binding procedure for the settlement of disputes that are related to the oceans. The preservation and protection of the marine environment is addressed by Part XII of the Convention (Articles 192

- 237) which outlines basic responsibilities to prevent, reduce and control pollution of the marine environment from land-based sources; from sea-bed activities subject to national jurisdiction; from activities in the area; pollution by dumping; pollution from vessels; as well as pollution from or through the atmosphere. Marine litter was particularly addressed in November 2005 as part of the UN General Assembly Resolution A/RES/60/30– Oceans and the Law of the sea, which states that *'…The General Assembly, 65. Notes the lack of information and data on marine litter and encourages relevant national and international organizations 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 litter 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 litter at sea, and encourages States to cooperate regionally and sub regionally to develop and implement joint prevention and recovery programmes for marine litter;…" (Mouat *et al.*, 2010).

2.8.2 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 main international agreement formulated to prevent pollution of the marine environment by ships and comprises six annexes focusing on various types of pollution

Table 2.1: Pollution types covered by MARPOL Annexes I-VI

Annex I	covers oil and oily wastes; entered into force in 1983;
Annex II	covers noxious liquid substances in bulk; entered into force in 1987;
Annex III	covers harmful substances in packaged form; entered into force in 1992;
Annex IV	covers sewage; entered into force in 2003;
Annex V	covers garbage (that may become marine litter); entered into force in 1988;
Annex VI	covers air pollution from ships; entered into force in May 2005.

Annexes I (Oil) and II (Chemicals) are compulsory, however, the other annexes are voluntary (Fanshawe and Everard, 2002; UNEP, 2005; Mouat *et al.,* 2010). The Annex V regulates the types and amount of trash that ships may discharge into the sea and also specifies the distances from land that it can be discharged as well as the manner in which they may be disposed of (UNEP, 2005; Mouat *et al.,* 2010). For the purposes of Annex V, trash includes all types of domestic and operating waste, excluding fresh fish, generated during the usual operations of the ship (IMO, 2002; Mouat *et al.,* 2010). With respect to these regulations, the disposal of plastic waste into any part of the sea is strictly prohibited and the discharge of other waste materials is sternly restricted in coastal waters and other 'Special Areas'. The North Sea and adjacent areas are designated as 'Special Areas' under the MARPOL Annex V and in accordance with these regulations, the discharge of garbage into the sea is strictly prohibited, except food waste. As at March 2010, 140 states had ratified the MARPOL Annex V and these regulations now cover about 97.5% of the world's shipping tonnage (IMO, 2010). The MARPOL Annex V is currently under review by the International Maritime Organization (IMO), in consultation with other relevant stakeholders, to assess and enhance its effectiveness in tackling ocean-based sources of marine litter (Mouat *et al.,* 2010).

2.8.3 International Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, 1972 (London Convention, 72) and 1996 Protocol

The London Convention, (LC 72) seeks to promote the effective management of all sources of marine pollution and to prevent the dumping of waste materials and other matter at sea. This instrument works with a black- and grey-list approach. Dumping of items on the blacklist is strictly prohibited whereas dumping of grey-list items requires a special permission and is also subject to strict control; and the dumping of all other items is allowed with a general permit (UNEP, 2005; Mouat *et al.*, 2010).

Items on the blacklist are the contaminants that are most likely to cause grave harm to living resources and human beings, due to their lethal characteristics. These lethal characteristics include the tendency to bio-accumulate and bio-magnify in the marine food chain (Kimball, 2005). Items on the greylist are those that contain significant amounts of arsenic, chromium, beryllium, copper, nickel lead, vanadium, zinc, organosilicon compounds, cyanides, fluorides, and their by-products which are not covered in the Annex I (UNEP, 2005; Mouat *et al.*, 2010). Annex I of the London Convention explicitly prohibits signatories of the Convention from dumping persistent plastics and other non-biodegradable materials into the sea from vessels and other man-made structures (UNEP, 2005; Mouat *et al.,* 2010). In 1996, the London Protocol was agreed upon and it aims to modernize the London Convention. The objective of the Protocol is to protect the marine environment from all sources of pollution, thus, all dumping is prohibited under the Protocol with the exception of acceptable wastes. States can either be a Party to the London Convention 1972, or the 1996 Protocol, or both (UNEP, 2005; Mouat *et al.,* 2010).

The following agreements are also key for the protection of the marine environment as well as the prevention of marine litter.

2.8.4 Agenda 21:

The Agenda 21 is a comprehensive plan of action to be undertaken globally, nationally and locally by organizations of the United Nation, Governments, and Major Groups in areas where there are anthropogenic impacts on the environment (UNEP, 2005).

2.8.5 Convention on Biological Diversity, 1992 and the Jakarta Mandate on the Conservation on and Sustainable Use of Marine and Coastal Biological Diversity 1995

This convention emphasizes the need for co-operation among parties with respect to areas beyond national jurisdiction for the conservation and sustainable use of marine biodiversity, either directly or through competent international organizations (Kimball, 2005).

2.9 MONITORING MARINE LITTER

Marine litter or beach litter monitoring is defined by United Nations Environment Programme (UNEP) is the repeated surveys of beaches, seafloor and/or surface waters to determine amounts of litter or debris such that information gathered can be compared with baseline data to evaluate whether changes occur over time and / or in response to management strategies. This can be done in several different ways, although some basic principles need to be adhered to (Cheshire *et al.,* 2009). Most programs have unique objectives and employ a variety of region-specific methodologies, making across the board comparisons of debris estimates difficult (Barnes *et al*., 2009). For shorelines, some studies report the number or weight of items per unit length of the shoreline (Velander and Mocogoni, 1999) while others report the number or weight of items per unit area of shoreline (Acha *et al*., 2003). By enhancing our ability to undertake long-term, broad-scale monitoring programs, we will be able to make meaningful comparisons of marine litter or debris loads at various locations and the data acquired from the monitoring will help us to better identify the sources of various types of litter, leading to targeted control, specific education and other behaviour modification strategies. (Cheshire and Westphalen, 2007; Sheavly, 2007).

Until recently, amounts and types of marine debris is often measured by land-based surveys along shorelines (Frost and Cullen 1997; Cunningham and Wilson 2003; Storrier *et al*., 2007; Sheavly, 2007). Other techniques include the sea surface technique for assessing floating debris, at-sea visual technique for ship-based surveys for floating debris and the benthic technique for evaluating debris on the seafloor (UNEP, 2015).

2.10 TYPES OF SHORELINE SURVEYS

2.10.1 Standing-stock surveys

Standing-stock surveys are undertaken to measure the density or concentration of litter at a shoreline over time. Each even of survey is a snapshot of the concentration of litter at the shore, and a series of these snapshots over time gives information on changes in the baseline concentration of litter. Knowing the density of litter at various shoreline sites is important in evaluating the overall impact of litter at a given site and on a regional scale. In standing-stock surveys, the measured debris concentration or density reflects the long-term balance between inputs which could be land or sea based, and removal through export, burial or degradation. An understanding of how the amount of litter changes over time facilitates analysis of the factors of debris deposition (Lippiat *et al.*, 2013).

2.10.2 Accumulation surveys

During accumulation surveys, the litter is removed from the shore. Accumulation studies require the initial removal of all litter from the shore followed by regular surveys to record and again remove all litter. Because the litter is removed from the shore, the data that is collected over time provides an estimate of the flux of debris onto the shoreline with respect to time, as opposed to the concentration or standing-stock of litter. Both types are useful for developing models of the life cycle and movement of marine litter among environmental compartments. Accumulation survey data indicate the net flux of litter onto the shoreline, and assume that the rate of litter accumulation is the same between sample events. Litter flux data can be used to assess changes in at-sea litter loads, but cannot be used to evaluate the debris load or cumulative impacts of debris. Compared to standing-stock surveys, accumulation studies are more time consuming and require more money as they are more thorough, require the removal of the litter, and need to be undertaken more frequently. The shoreline being surveyed may have a relatively rapid litter turnover rate, so in order to accurately estimate debris flux onto a shore, it must be sampled frequently (Lippiat *et al.*, 2013).

2.11 BEACH SELECTION

Selection of a beach for marine litter surveys follows the approach detailed in the NMDMP which are similar to the OSPAR and AMDS criteria (Sheavly 2007; OSPAR 2007; Cheshire and Westphalen, 2007), although the requirement for sandy beaches could be relaxed so that gravel beaches can also be included. The basic beach selection criteria should therefore include:

- Beach length of at least 500 meters (0.31 miles)
- Low to moderate slope (15-45º)
- Composed of sand to small gravel
- Clear, direct access to the sea (not blocked by breakwaters or jetties)
- Accessible to surveyors all 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 as much as possible, but could be modified also (Opfer *et al.,* 2012).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study area

For this particular study, two beaches were selected, which were the La Pleasure Beach and the Sakumono Beach (Figure 3.1). The distance between the two beaches is about 12 km. Aside these two beaches qualifying for the requirements for beach monitoring as mentioned earlier (Opfer *et al.,* 2012), they were selected because one (La Pleasure Beach) is a managed beach while the other (Sakumono) is a free and open beach. Both beaches are about 550 m long.

The Sakumono beach is located in the Tema Metropolis and the beach serves as a fish-landing site for people from the Sakumono township. The people of Sakumono engage mainly in small-scale artisanal fishing and farming. The Sakumono beach is adjacent the Sakumo II Lagoon which is designated as a Ramsar site due to its high diversity of bird species (Nunoo and Quayson, 2003). The Sakumono beach is a sandy beach protected by a sea defense structure and serves as a recreational hub for the people from both far and near. The beach is bordered by the Tema Port to the left and the Regional Maritime University to the right. The Sakumono beach is a low-lying beach with a gentle slope in the semi-arid coastal zone of Accra. The beach consists of fine to coarse sand grains and an average of 800 mm rainfall over two rainy seasons.

The La Pleasure beach is also located at La, off the Accra-Teshie/Nungua Road in the La Dade-Kotopon Metropolis. The beach is one of the most patronized beaches in Accra and is patronized throughout the week by both foreign and local tourists (Tsagbey *et al.,* 2009). Just like the Sakumono beach, the La Pleasure beach is also a sandy beach, also with fine to coarse sand grains. The La Pleasure beach is a gently sloping beach.

The two beaches are all located in the Greater Accra region. The Greater Accra region, with a population of 4,010,054, representing 16.3% of the population of Ghana, is the smallest region in terms of size and covers a total land area of 3,245 km^2 (GSS, 2014). The Greater Accra region has a coastline of approximately 225 km, stretching from Kokrobite in the west, to Ada in the east.

These two beaches were selected for the survey because Sakumono is an open access beach where entry is not restricted, i.e., entry is free, and also there is no restriction to what revelers can bring onto the beach. The La Pleasure beach on the other hand, is more restricted and revelers have to pay to enter the beach.

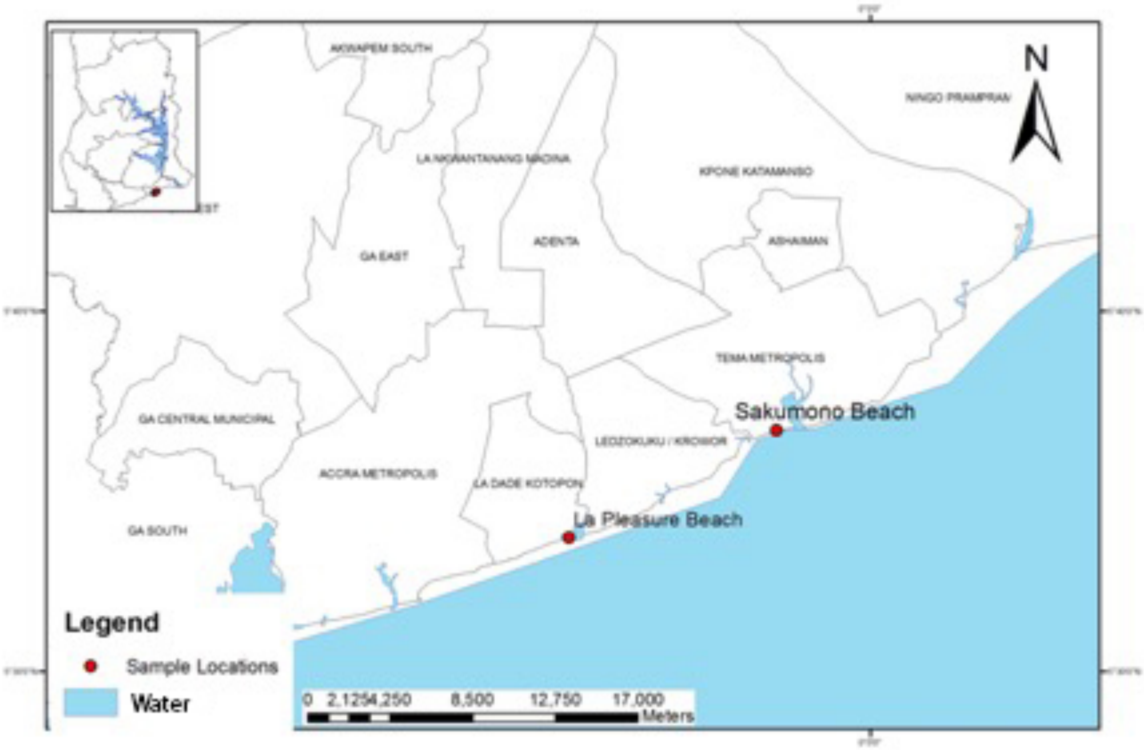

Figure 3.1: Map of Ghana showing study sites

3.2 Data collection and analysis

A preliminary survey was undertaken at the two beaches to determine the stations and familiarize with the beaches a week before the start of the survey. During the preliminary survey, the two beaches were divided into five 100 x 10 m (1000 m^2) transects each for surveying. The points were georeferenced using the Garmin etrex 10 GPS. After every 100 m, the coordinates were taken and marked as waypoints on the GPS. This was done to serve as sampling frame for random selection during each visit. The 100 x 10 m transects were denoted as La1 – La5 and Sak1 – Sak5 corresponding to the two beaches surveyed. It was ensured that the edge of the transect begun from the low tide mark and run parallel to the shoreline. The preliminary survey was also used to clear the beaches of any debris that was collected on the shores already.

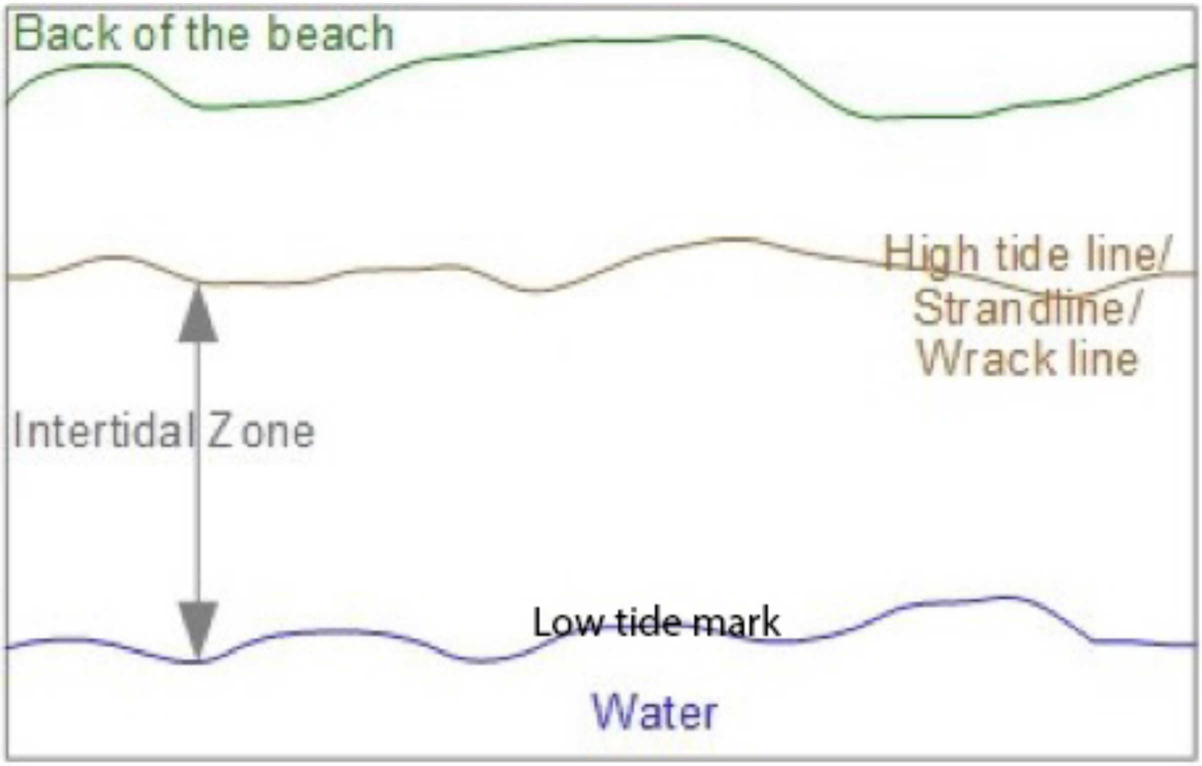

Figure 3.2: Diagram showing water level for sampling

The beaches were surveyed twice a month on the same day (Thursdays) from January to April, 2019 during low tide which was usually between 0.3 m and 0.5 m tidal level. On each survey event, a 1000 m^2 transect at each beach was selected at random for survey by balloting. Pieces of paper with the codes for the various transects were folded and one picked at random giving all the transects an equal chance of being selected. All litter within the transect was collected into labelled trash bags and sent away for sorting and weighing. The litter was hand-picked with latex gloves worn on the hands for protection. Any litter that was poking out of the sand was gently pulled out and if was torn in the process, it was ignored. This was done so that no litter within the transect was overlooked and those that were deeply buried were avoided so that the phenomenon where a chunk of the piece of the litter is buried and may not be accounted for is avoided.

Laboratory analysis

In the laboratory, the litter was sorted and categorized into identifiable groups. The litter was air dried after which they were counted and then weighed to the nearest kilogram using an electronic scale. This was done to reduce the amount of sand and water in the litter as much as possible and to get the actual weight of the litter. Each bag was weighed and then marine litter items were sorted and classified according to the Master List of categories of the guidance document (TGML/JRC) (Galgani *et al.,* 2013b). The basic material types are as follows:

(i) plastic,
(ii) metal,
(iii) rubber,
(iv) glass/ceramics,
(v) natural products and
(vi) miscellaneous with a total of thirty-nine (39) subcategories.

The litter was further categorized as either ocean-based or land-based based on the classification by Barr (2000).

Data analysis

The check lists were transferred to an electronic version (Excel 2019, ©Microsoft) to calculate statistical parameters and weight percentages as well as the count on all items was registered as a whole and for each beach individually. The same Microsoft Excel 2019 was used to run a t-test and Analysis of Variance (ANOVA) on the data to determine whether litter from the two beaches were significantly different from each other.

CHAPTER FOUR

RESULTS

Over the entire period of the study, a total of 2,697 items were collected from the Sakumono and La Beaches (Table 4.1). The total weight of the litter throughout the survey was 50.07 kg from both sites (Table 4.2). Weight of litter collected from Sakumono beach was 31.79 kg accounting for 63.49% of the total weight of litter surveyed whereas the weight of litter collected from La was 18.28 kg, also accounting for 36.51% of total litter surveyed.

Table 4.1: List of litter items and numbers for both beaches

Item	Number	% Number
Plastics		
Bottles	282	10.4560623
Cutlery	67	2.48424175
Cigarette lighters	19	0.70448647
Cigarette butts	205	7.60103819
Styrofoam	160	5.93251761
Cups	20	0.7415647
Water sachet	424	15.7211717
Bags	320	11.8650352
Caps/lids	125	4.63477938
Toys	13	0.48201706
Synthetic rope	65	2.41008528
Fishing net	14	0.51909529
Strapping bands	17	0.63033
Crates/containers	23	0.85279941
Diapers	34	1.26065999
Sanitary towel/tampon	32	1.18650352
Straws	137	5.07971821

Table 4.2 (cont'd): List of litter items and numbers for both beaches

Item	Number	% Number
Metals		
Cans	87	3.22580645
Other pieces of metals	23	0.85279941
Crown corks	198	7.34149055
Rubber		
Balloons	46	1.70559881
Slippers	31	1.14942529
Condoms	56	2.07638116
Gloves	2	0.07415647
Tyres	4	0.14831294
Pieces of foam	30	1.11234705
Glass/ceramics		
Bottle	34	1.26065999
Pieces	32	1.18650352
Natural products		
Processed wood	14	0.51909529
Rope	15	0.55617353
Paper/cardboard	32	1.18650352
Juice carton	94	3.4853541
Miscellaneous		
Clothing/rags	27	1.00111235
Shoes	12	0.44493882
Bags	3	0.11123471
	2697	**100**

Table 4.3: List of litter items and weights for both beaches

Item	Weight	% Weight
Plastics		
Bottles	2.45	4.89981385
Cutlery	0.24	0.48171317
Cigarette lighters	0.00	0.00796864
Cigarette butts	0.05	0.09007158
Styrofoam	0.85	1.69358529
Cups	0.12	0.2396583
Water sachet	4.03	8.04453011
Bags	1.28	2.55635515
Caps/lids	0.03	0.04992881
Toys	12.70	25.3658334
Synthetic rope	4.49	8.97021027
Fishing net	3.18	6.35533856
Strapping bands	0.02	0.03734675
Crates/containers	0.28	0.55121408
Diapers	2.34	4.66494872
Sanitary towel/tampon	0.74	1.46990421
Straws	0.03	0.05472198
Metals		
Cans	2.18	4.3438066
Other pieces of metals	1.24	2.48046336
Crown corks	0.26	0.51406704
Rubber		
Balloons	0.01	0.0183738
Slippers	0.19	0.37147036
Condoms	0.02	0.04473622

Table 4.4 (cont'd): List of litter items and weights for both beaches

Item	Weight	% Weight
Gloves	0.00	0.00119829
Tyres	4.30	8.58775558
Pieces of foam	0.18	0.35948744
Glass/ceramics		
Bottle	2.04	4.07419102
Pieces	1.60	3.19544394
Natural products		
Processed wood	0.00	0
Rope	0.00	0
Paper/cardboard	0.12	0.23646285
Juice carton	1.30	2.59070617
Miscellaneous		
Clothing/rags	1.03	2.04907842
Shoes	0.23	0.46493709
Bags	2.57	5.13467897
	50.07	**100**

The mean weekly number of litter for Sakumono was 209 ± 92.66 (Table 4.3) and mean weekly weight of 3.97 kg ± 2.86kg (Table 4.3). For La Pleasure beach, there was a mean weekly number of litter of 129 ± 30.63 and a mean weekly weight of 2.28 kg ± 0.92kg (Table 4.3).

Table 4.5: Mean weekly weights and number of litter for both beaches

Beach	Mean Weekly Weight (kg)	Mean Weekly Number
Sakumono	3.97 ± 2.86	209 ± 92.66
La Pleasure	2.28 ± 0.92	129 ± 30.63

Plastics were found to be the most abundant both by number as well as weight. For both beaches, plastics made up 65.53% (Fig. 4.3) by weight at 32.81 kg and 72.56% (Fig. 4.4) composition by number or quantity at 1975 items.

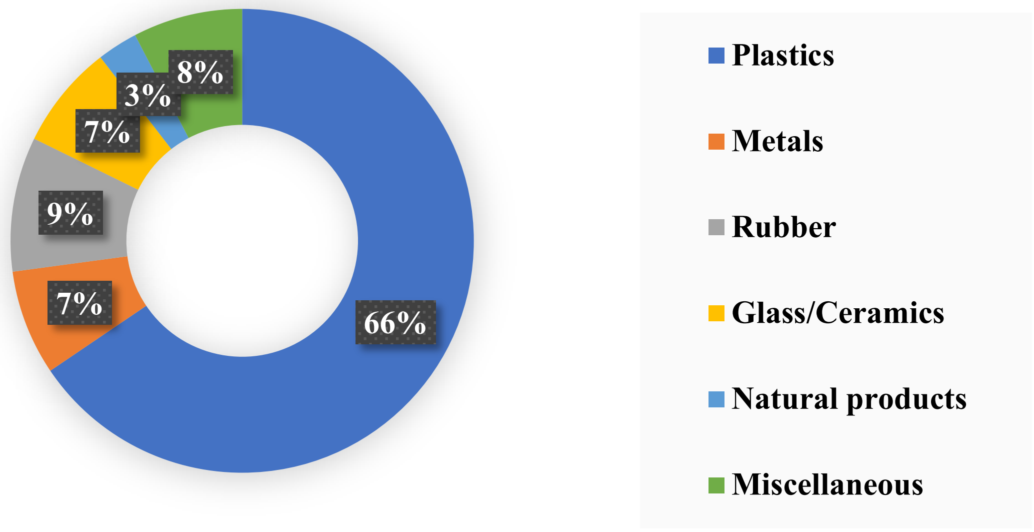

Figure 4.3: Composition of total litter by weight at both beaches

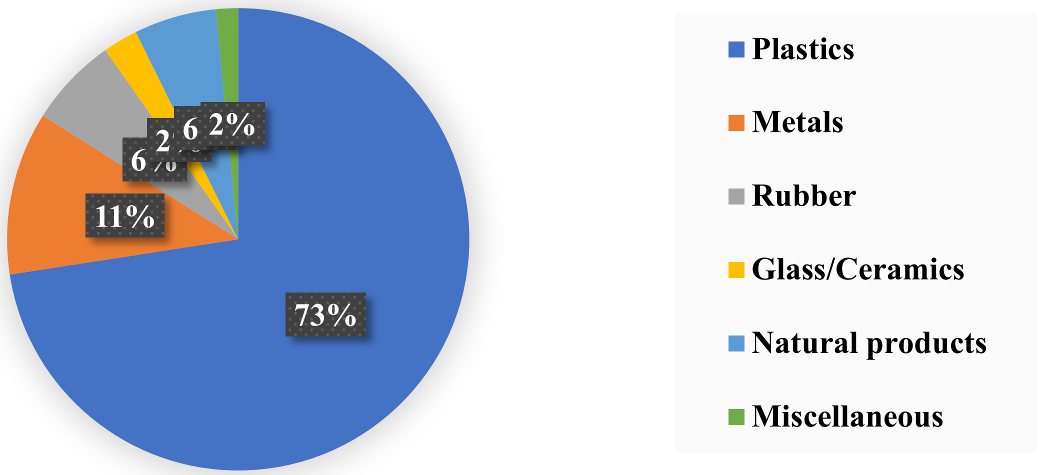

Figure 4.4: Composition of total litter by number at both beaches

This trend of composition was not different at the various beaches. At Sakumono, plastics were the most dominant both by weight and number at 67% (Fig. 4.5) and 75% (Fig. 4.6) respectively. La Pleasure beach also recorded plastics as the most dominant litter also by weight and number at 62% (Fig. 4.7) and 69% (Fig. 4.8) respectively.

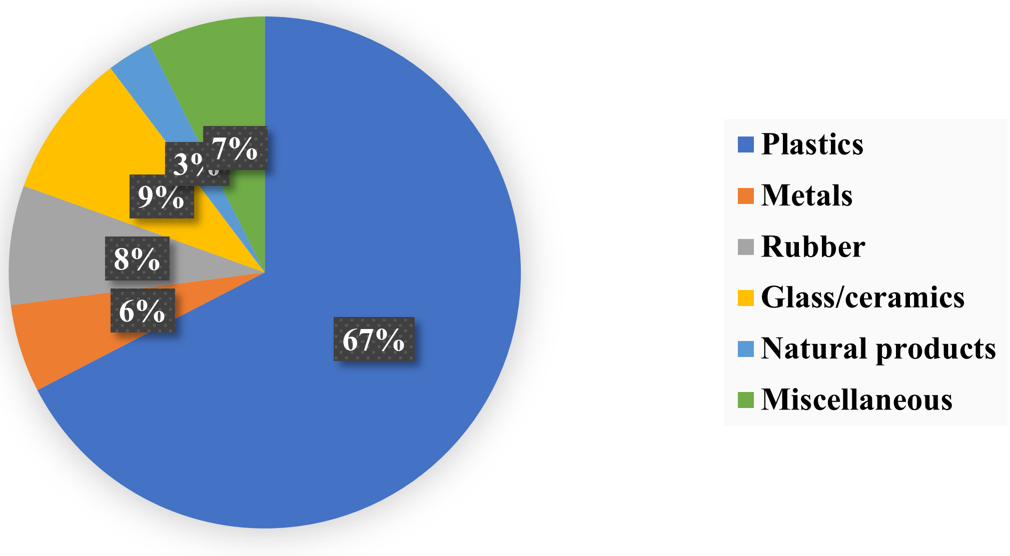

Figure 4.5: Composition by weight of litter at Sakumono

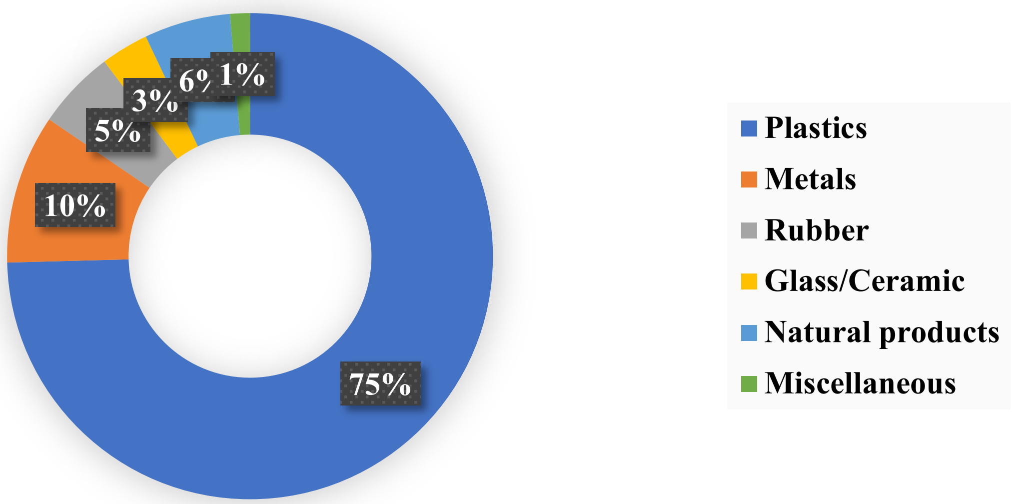

Figure 4.6: Composition by number of litter at Sakumono

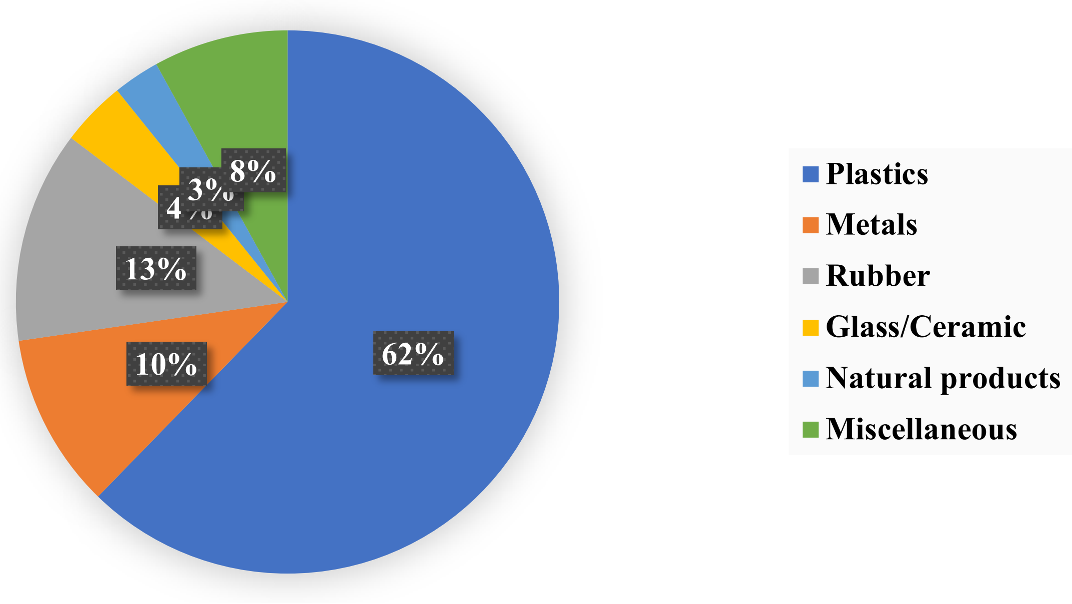

Figure 4.7: Composition by weight of litter at La

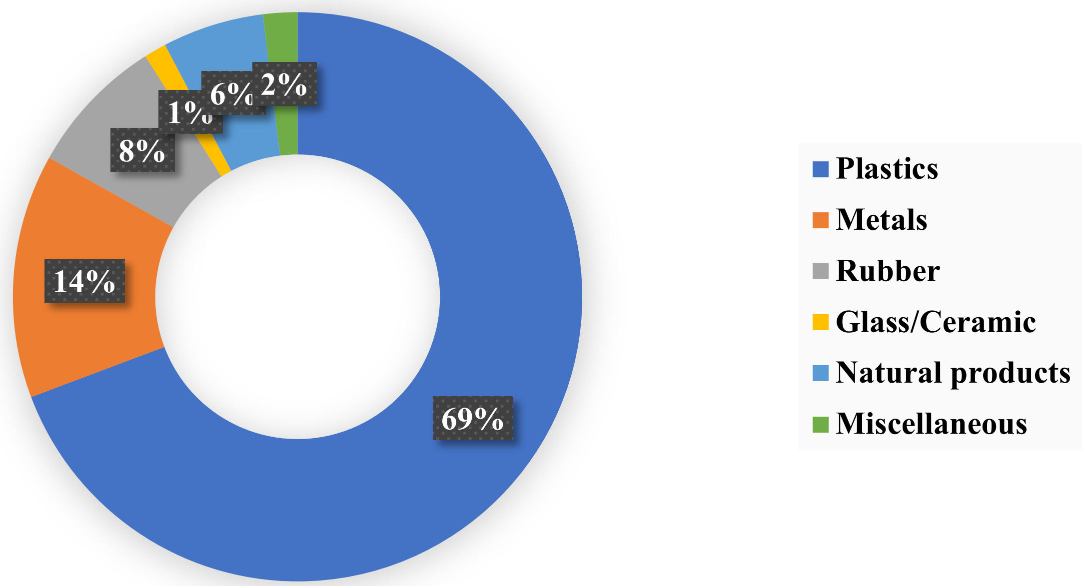

Figure 4.8: Composition by number of litter at La

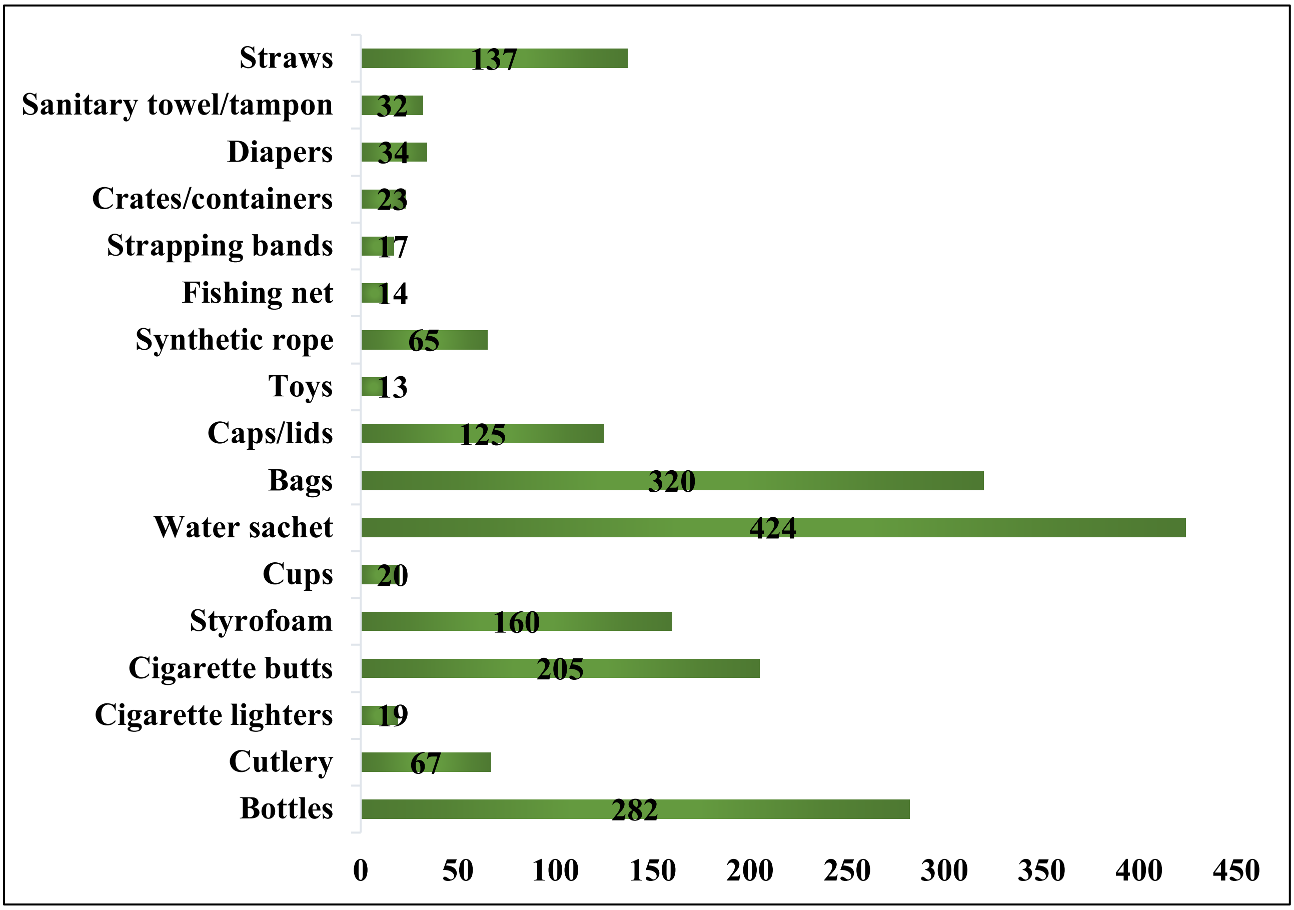

Figure 4.9: Abundance of most dominant litter type (Plastics)

By numbers, water sachets were the most abundant in terms of plastics (Fig. 4.9). By numbers, the water sachets made up 22% of the plastics collected from both beaches (Fig. 4.11). Although water sachets were most abundant in numbers, toys far weighed more than them. Toys made up about 39% of the total weight of plastics (Fig. 4.12). In terms of numbers, toys were however the least, at only 13 (Fig. 4.9).

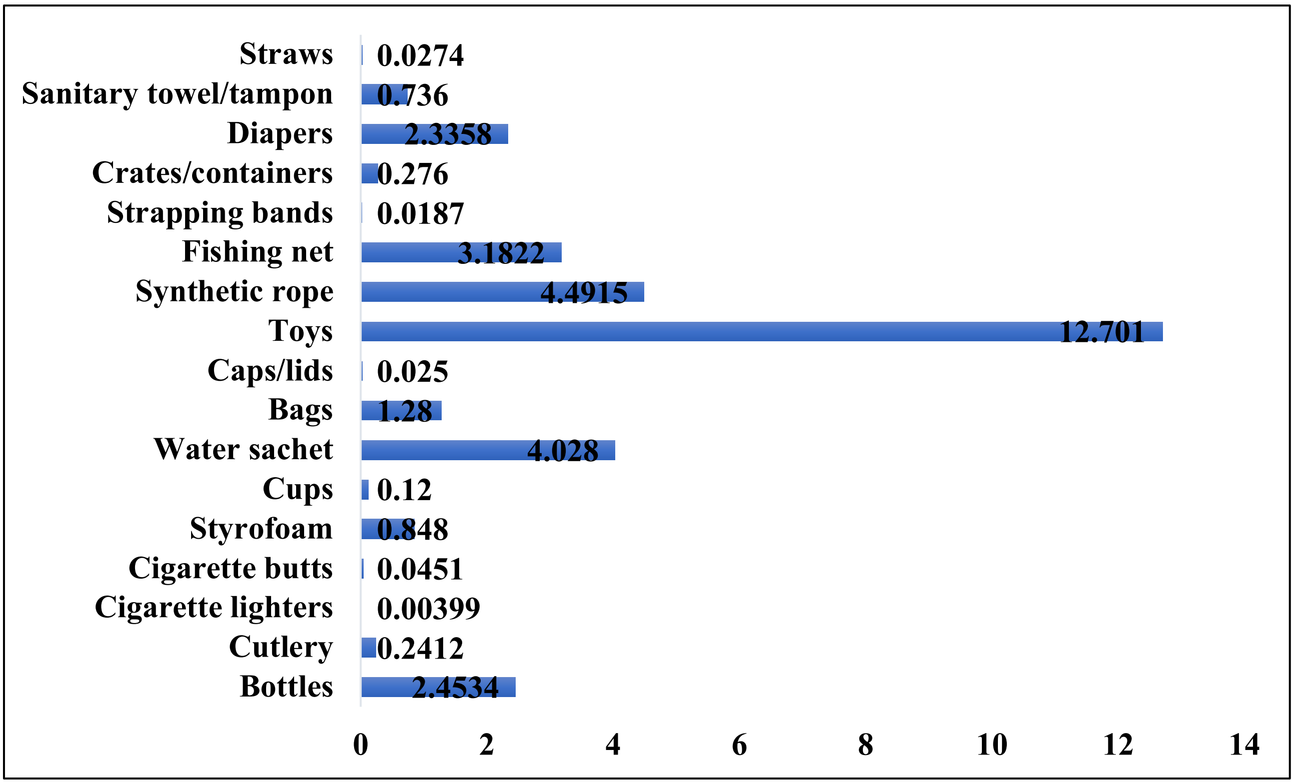

Figure 4.10: Weights of most dominant litter types

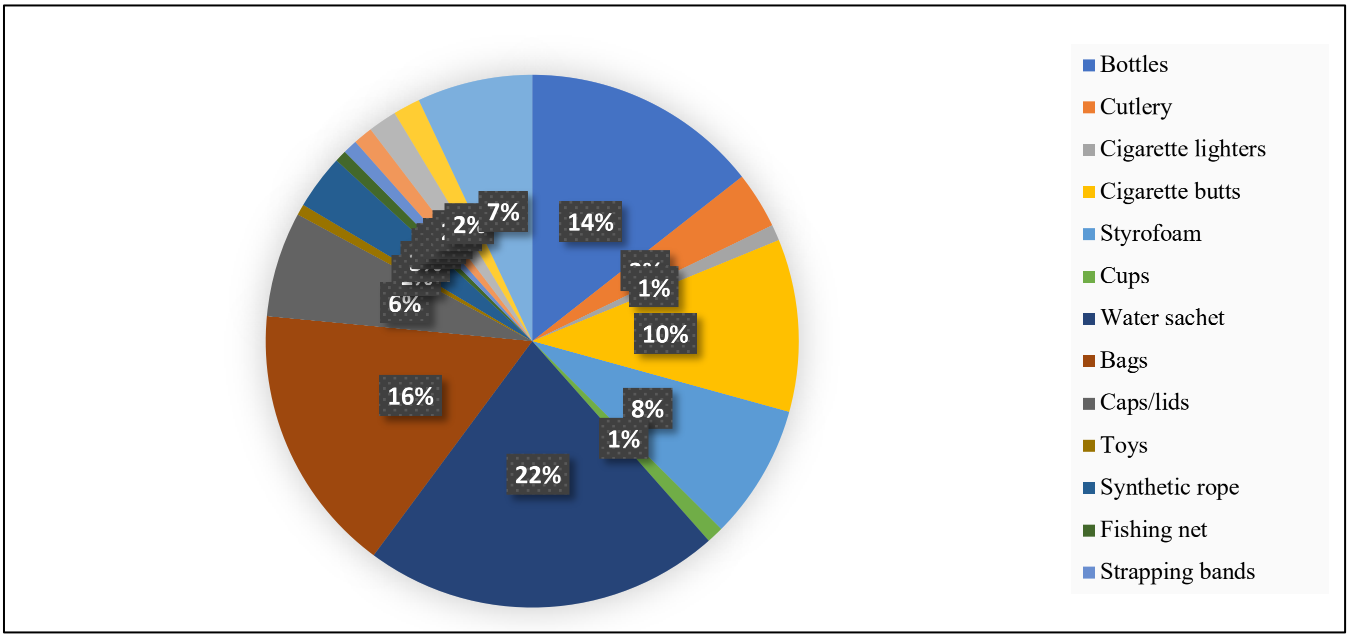

Figure 4.11: Percentage by number of Plastics at both beaches

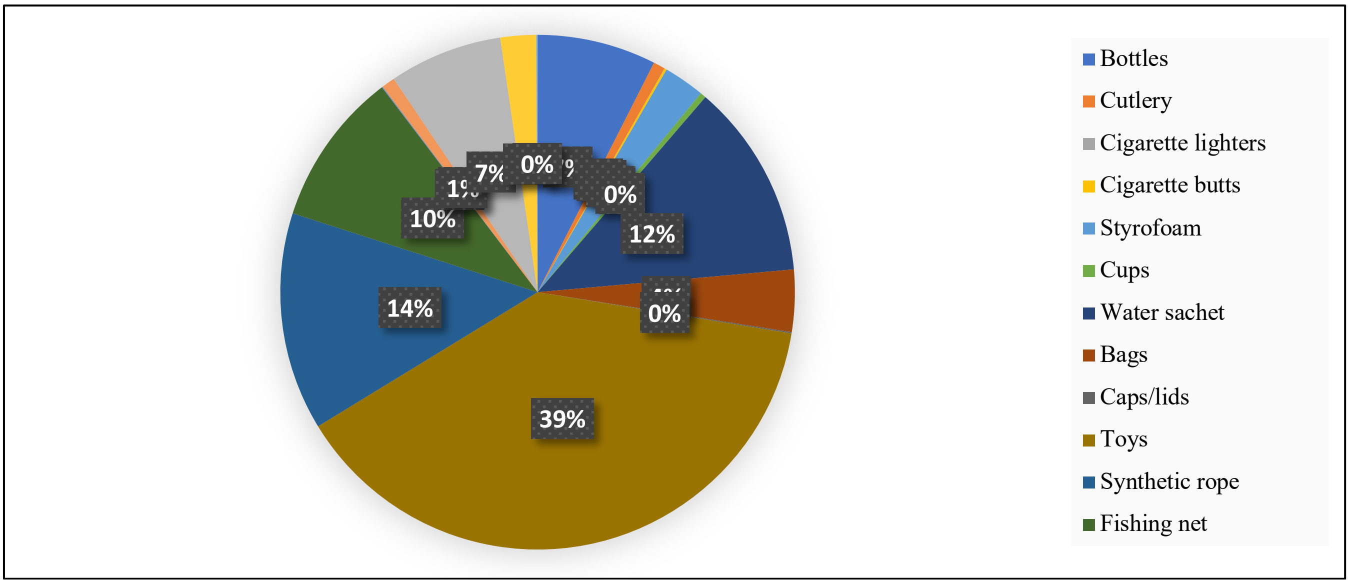

Figure 4.12: Percentage by weight of Plastics from both beaches

Twenty-five (25) of the thirty-five (35) litter types collected during the survey were identified as land based marine litter with only three (3) litter types identified as ocean based (Table 4.4).

Table 4.6: Sources of litter items (Barr, 2000)

Sources	Types
Land-Based	**Plastic Bottles, Straws (plastic), Plastic bags, caps/lids, Glass bottles, Water sachet, Balloons, Metal cans, Cigarette packaging/ wrappers, Crown corks, Styrofoam packs, plastic cutlery, cigarettes butts, shoes, Clothing/textile, condoms, diapers, Toys, Plastic cups, rubber slippers, Bags, sanitary towels/tampons, Newspaper/Magazine pieces, juice cartons.**
Ocean/Waterway-Based	**Fishing net, Rope, Strapping bands.**
General	**Nails, Cardboard pieces, Glass pieces, Metal pieces, Plastic containers, Styrofoam pieces, Pieces of foam, Car tyres.**

Over the 4 months of the survey, it was observed that there was a decrease in the weight and amount of litter at the two beaches (Figs. 4.13 and 4.14). This trend, however, changed during the fourth month which was April. There was a general increase beyond the previous month. For the weight however, Sakumono beach recorded the highest in April (Fig. 4.13). This was also the highest weight throughout the entire survey. The weight of litter collected at Sakumono beach in the month of April was 11.16 kg (Fig. 4.13) and it made up about 22% of the total litter collected throughout the survey. The least litter in terms of weight was recorded in the month of March. This was at the Sakumono beach (Fig. 4.13).

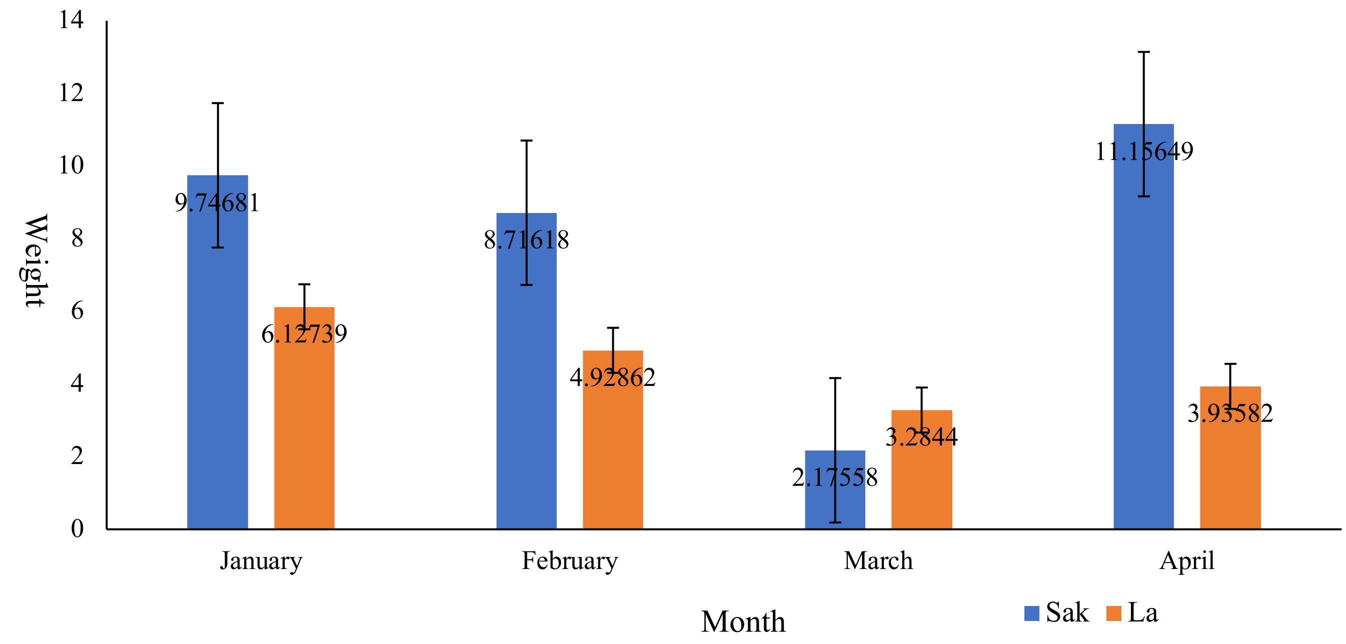

Figure 4.13: Monthly variation by weight

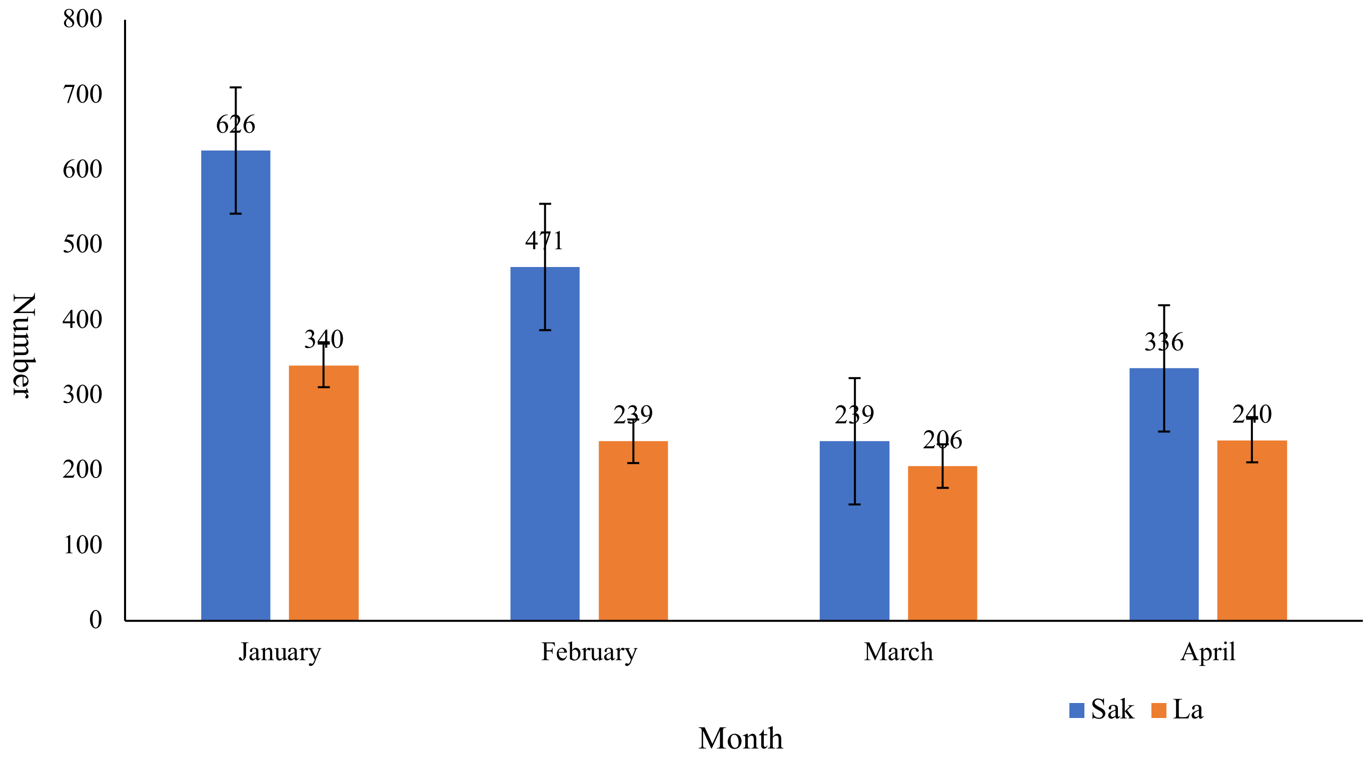

Figure 4.14: Monthly variation by number

With an average of 418 and 256 monthly litter items at Sakumono and La respectively, the density of litter at the two beaches was 0.418 items/m^2 and 0.256 items/m^2. Running ANOVA at a confidence level of 95%, there was a p value of 0.02 (Table 4.5).

Table 4.7: ANOVA Table for spatial variation in amount of litter at Sakumono and La Pleasure beaches

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	52326.125	1	52326.125	9.0298544	0.02385469	5.98737761
Within Groups	34768.75	6	5794.79167			
Total	87094.875	7				

CHAPTER FIVE

DISCUSSION

5.1 Types and quantities of marine litter

A total of 2,697 marine litter items, with total weight of 50.0713 kg were collected for this study. This quantity was lower than that of Van Dyck, Nunoo and Lawson (2016), which was 18,241 and weighed 297.59 kg. This difference could be attributed to the number of beaches surveyed by Van Dyck, Nunoo and Lawson. For that particular study, four beaches were surveyed (Sakumono, Mensah Guinea, La and Korle Gonno beaches). Only two of these beaches were surveyed for this current study (Sakumono and La beaches). The difference in amount of litter could also be attributed to the duration of the study. The current study was undertaken over eight weeks as compared to sixteen weeks by Van Dyck, Nunoo and Lawson (2016). The difference in weight could also be attributed to the methodology used. In this current study, the litter was air dried and as much sand as possible was removed from the litter in order to obtain the actual weight of the litter as much as possible. This detail was not outlined in the study by Van Dyck, Nunoo and Lawson (2016). This current study as well as that by Van Dyck, Nunoo and Lawson (2016) were conducted within 1000 m^2 transects but for this study every survey was done by choosing a transect at random such that every part of the entire shoreline had equal chance of being surveyed. For the study by Van Dyck, Nunoo and Lawson (2016), a fixed 1000 m^2 transect was surveyed throughout the study.

The litter items found and collected from the beaches during sampling were varied, with drinking water sachets being the most abundant. Over the years, people seem to have lost confidence in water that runs through the taps in their homes. This may be attributed to the widespread knowledge of the polluted nature of water bodies which serve as the sources of the water that runs through our taps. The trust has been shifted to sachet water as there is the notion that it is purer than what runs through the taps. On the other hand, not all homes have water running in their homes and so they resort to sachet water for all they may need water for. This rise in interest in sachet water has also led to the springing up of many sachet water producing factories and in effect increased amount of water sachets, especially in the urban areas. Drinking water sachets was followed by plastic bags, plastic bottles and then cigarette butts. This trend is comparable to the most common items that are found during many clean-ups that are conducted onshore and/or underwater. Some of these items include plastic bags, plastic beverage bottles, food wrappers/containers and cigarettes or cigarette filters according to the International Coastal Clean-up report (Ocean Conservancy, 2009).

Plastics were found to be the most common and abundant litter type in this study. This finding is comparable to other surveys undertaken on South African beaches (STAP, 2011b) and some other selected beaches in Europe (OSPAR, 2007). The amounts of plastics recorded at the Sakumono and La beaches (66% by weight and 73% by number) also compare favourably with what was recorded by Van Dyck, Nunoo and Lawson (2016). This confirms the assertion that plastics are the major source of marine litter worldwide, accounting for 60% to 80% of litter collected (Derraik (2002); Allsopp *et al.,* (2006) and STAP (2011a)). The introduction of plastics and synthetics in the past few decades, has considerably changed the nature of anthropogenic wastes over the last 30 to 40 years (Sheavly 2005).

Plastics are generally very durable materials and are resistant to natural biodegradation. As a result, plastics does not easily and readily break down when they enter the marine environment, but only get torn into pieces by abrasion against rocks and other hard surfaces as well as by wave action (Moore *et al.,* 2001; Allsopp *et al.,* 2006; STAP, 2011b). When plastics reach the marine environment, about half of them are kept afloat because of their light nature and can therefore travel on currents over very long distances and widely spread over the oceans (Derraik 2002, Sheavly 2005). This light nature of the plastic products is observed in the weights of the litter as recorded. Water sachets were the most abundant in terms of number but were among the least heavy items in terms of weight due to their light nature.

Plastic wastes remain prevalent on the beaches of Ghana. This indicates the widespread use of plastics in everyday activities such as packaging of items and the eventual poor disposal of these plastic items.

Cigarette butts have been reported to be one of the main sources of marine litter on beaches in Brazil, Spain and the US (Slavin, 2011). In this current study there was a similar trend. This was evident by the fact that cigarette butts were the fourth in terms of abundance, after water sachets, plastic bags and plastic bottles. This implies the heavy use of the beaches for recreational activities where there is also a lot of smoking. This is also indicative of the large number of smokers among those that patronize the beaches.

5.2 SOURCES OF LITTER IDENTIFIED

From this study, twenty-five out of the thirty-five litter items collected during the survey were land based. This agrees with the assertion in literature that land based sources of litter types make up approximately 80% of the litter found on beaches (GESAMP, 1991; NOAA, 2007; Sheavly, 2007; World Ocean Review, 2010; US EPA, 2012). This is also coherent with a study undertaken on the West Coast of the United States of America and Hawaiian Islands (Sheavly, 2007). The high amount of land-based litter recorded could be attributed to the location of the beach, accessibility to the beach, status of the beach as a tourist hub and human behaviour. The proximity of the beach to inflow from inland could also be an attributing factor to high amounts of land-based types litter. This could make waste produced inland, flow through rivers and lagoons to the beach. Again, based on the findings of Gregory and Ryan (1997), ocean-based litter accounted for the least amount of litter in origin supporting the least amount of ocean-based litter recorded for this study. There are few major shipping routes in this region due to the presence of only one major port that operates in Tema, which may explain the low levels of ocean-based litter.

5.3 SPATIAL AND TEMPORAL ABUNDANCE OF MARINE LITTER

Sakumono beach generally recorded the higher amount of litter by count and weight followed by the La beach. This trend could be attributed to the fact that the Sakumono beach is an open beach where people don't have to pay to get onto and it mainly patronized by local tourists or revelers. There is also no restriction as to what revelers can bring onto the beach; anything can be brought onto the beach. There is also minimal management of waste on the Sakumono beach. The La Pleasure beach on the other hand, is a managed beach and entry to the beach is regulated. The beach has foreign tourists visiting the place almost every week. The La beach is also better managed in terms of waste. The vendors on the beach clean their various sides of the beach but there is also general cleaning that is supervised by the management of the entire place.

At an alpha value of 0.05, the p value from running ANOVA on the amount of litter surveyed at both beaches was 0.02. This indicates that there is significant difference in the amount of litter found at both beaches. From the analysis it was observed that Sakumono beach was more littered than La Pleasure beach. The statistical test supports the observation and further indicates the result of management of the La Pleasure beach. This compares favourably with the survey undertaken by Van Dyck et. al., (2016) where Sakumono beach had more litter than La Pleasure beach.

In the month of March, Sakumono recorded higher amount of litter by count but lower by weight. This phenomenon could be attributed to the presence of lighter litter than the other months. For instance, in the first week of March, more condoms and crown corks were recorded than any other month. Survey for that week was also done on the 7^{th} March, a day after the 6^{th} March holiday. More litter was expected in the month of March at the two beaches due to the festive activities, especially during the first week. This was, however, not the case. There was rather an increase in the following month. This could be attributed to the effect of currents probably moving litter from elsewhere to the beach and not necessarily from anthropogenic activities only, leaving litter on the beach. Tides rise and fall daily and carry and deposits items off and on the shore as it rises and falls as the items are moved by currents. The highest weight of litter was recorded at Sakumono in the month of April with the same beach recording the lowest weight in the month of March.

There was generally a decrease observed in the overall litter trend over the eight-week period which may be as a result of the continuous removal of the litter from the beach over the weeks. The highest litter count was observed in the first month and at the Sakumono beach. This observation could be attributed to the continuous celebrations and festivities from the month of December (Christmas period) through to the month of January (New Year celebrations).

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

At both beaches, plastics were the most dominant litter type, especially drinking water sachets, followed by plastic bottles and then plastic bags which indicates the widespread use of plastics in everyday activities such as packaging of items and the eventual poor disposal of these plastic items. Plastics made up the bulk of the litter surveyed in terms of quantity.

Marine litter of land-based sources were the highest during the survey which is also indicative of the fact that majority of the litter generated is from inland and activities on the beaches.

There was a general decline over the weeks as the litter was collected from January to March and a sudden rise in the month of April. From this survey, however, Sakumono beach was more littered than La Pleasure beach.

From this survey, it can be concluded that La Pleasure beach is less littered with 18.28 kg by weight and 1025 litter items than Sakumono beach at 31.80 kg by weight and 1672 litter items, possibly because it is a managed beach and efforts are made to reduce litter on the beach.

6.2 Recommendations

- This study was conducted within a relatively short period and did not cover the entire year and both rainy and dry seasons so it is first of all recommended that a more extended survey is done, possibly all year round to have a better picture and understanding of the trend of litter accumulation. The limited funds also influenced the length of the study so availability of sufficient funds could also help to do a more extensive work.

- Within the short to medium term, there could be intensive education on issue of marine litter along the coast. Communities could be educated intensively on the health and environmental hazards as well as economic implications. The situation where litter is landed instead of fish could be leveraged in the education to help community members better understand the impact. Education may also be extended to basic schools as well. School children are able to reduce information to as lay as possible and it could help them better communicate to their parents.
- Communication and education could also be effectively done by the use of posters and handbills which carry the information pictorially. Opinion leaders in communities could also be engaged and sensitised to provoke change in the behaviour and attitude of members of the community towards proper management of waste and littering habits.

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