

**ASSESSMENT OF MARINE DEBRIS AND WATER QUALITY ALONG  
THE ACCRA-TEMA COASTLINE OF GHANA**

**BY**

**IRENE POKUA HIMANS**

**(10183503)**



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## DECLARATION

I, **Irene Pokua Himans** hereby declare that this thesis, “Assessment of Marine Debris and Water Quality Along the Accra - Tema Coastline of Ghana” consists entirely of my own work produced from research undertaken under supervision of Dr. F. K. E. Nunoo and Dr. Elaine T. Lawson; 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.

Date.....

Signed.....

**Irene Pokua Himans**

**(Student)**

Date.....

Signed.....



**Dr. Francis K. E. Nunoo**

**(Supervisor)**

Date.....

Signed.....

**Dr. Elaine Tweneboah Lawson**

**(Supervisor)**

## DEDICATION

This thesis is dedicated to my wonderful husband Mr. George Kobina VanDyck. I also dedicate this thesis to Mr. Charles Fritz K. VanDyck and Araba Okyeso VanDyck. You are the people who inspire me.



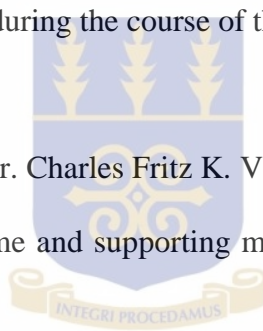
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## TABLE OF CONTENTS

CONTENT	PAGE
DECLARATION	II
DEDICATION	III
ACKNOWLEDGEMENTS	IV
TABLE OF CONTENTS	V
LIST OF TABLES	X
LIST OF FIGURES	X
LIST OF PLATES	XI
ABSTRACT	XII

### CHAPTER ONE

INTRODUCTON	1
1.1 BACKGROUND	1
1.2 PROBLEM STATEMENT	4
1.3 JUSTIFICATION	5
1.4 OBJECTIVES	6
1.5 HYPOTHESIS	6
1.6 THESIS ORGANISATION	7



### CHAPTER TWO

LITERATURE REVIEW	8
2.1 DEFINITION OF MARINE DEBRIS	8
2.2 HISTORY OF MARINE DEBRIS	8

2.3	SOURCES OF MARINE DEBRIS	10
2.4	TYPES OF MARINE DEBRIS	12
2.5	IMPACTS OF MARINE DEBRIS	14
2.5.1	Environmental Impacts	14
2.5.2	Ingestion	16
2.5.3	Ghost fishing	16
2.5.4	Alien Species Introduction and Habitat Destruction	17
2.6	SOCIAL IMPACTS OF MARINE DEBRIS	18
2.6.1	Reduced Recreational Opportunities	18
2.6.2	Loss of Aesthetic Value	19
2.6.3	Loss of Non-Use Value	20
2.6.4	Public Health and Safety Impacts	21
2.6.5	Navigational Hazards	21
2.6.6	Injuries to Recreational Users	22
2.6.7	Leaching of Poisonous Chemicals	22
2.7	ECONOMIC IMPACTS OF MARINE DEBRIS	24
2.8	MUNICIPAL WASTE MANAGEMENT IN AFRICA	25
2.9	BEACH LITTER SURVEYS IN GHANA	29
2.10	TYPES OF SHORELINE SURVEY	32
2.10.1	Beach Selection	33
2.11	CHALLENGES WITH LITTER ASSESSMENT	34
2.12	INTERNATIONAL LEGISLATION AND CONVENTIONS CONCERNED WITH THE PREVENTION OF MARINE DEBRIS	34
2.12.1	United Nations Convention on the Law of the Sea (UNCLOS), 1982	35
2.12.2	International Convention for the Prevention of Marine Pollution from Ships, 1973,	

as Modified By the Protocol Of 1978 Relating Thereto (MARPOL73/78)	37
2.12.3 International Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, 1972, and 1996 Protocol Relating Thereto	38
2.13 GHANA'S NATIONAL STRATEGY AND PROGRAMME SUPPORT ELEMENTS	40
2.14 SOCIAL DRIVERS OF LITTERING	42
2.15 MONITORING MARINE DEBRIS	44
 <b>CHAPTER THREE</b>	
MATERIALS AND METHODS	46
3.1 STUDY AREAS	46
3.2 DATA COLLECTION TECHNIQUES	50
3.3 METHODOLOGY	51
3.3.1 Social Survey	56
3.3.2 Recruitment of Participants	57
3.3.3 Development of Questionnaire	58
3.3.4 Stakeholders' Survey	59
3.4 ANALYSIS OF DATA	60
3.5 MICROBIAL WATER QUALITY TESTS	60
3.5.1 Sampling and Equipment Consideration	62
3.5.2 Membrane Filtration Method (MF) using Harlequin™ mLGA (Membrane Lactose Glucuronide Agar)	63
3.5.2.1 Sterilization	64
3.5.2.2 Preparation of petri dishes	64
3.5.2.3 Filtration	65

3.5.2.4 Interpretation of results	65
<b>CHAPTER FOUR</b>	
RESULTS	66
4.1 BEACH LITTER SURVEY	66
4.2 WATER QUALITY ANALYSIS	73
4.3 SOCIAL SURVEY	75
4.3.1 Characteristics of Respondents	75
4.3.2 Evaluation of Public Attitudes to Beach Litter	77
<b>CHAPTER FIVE</b>	
DISCUSSION	80
5.1 TREND OF QUANTITIES AND TYPES OF DEBRIS	80
5.2 CATEGORIES OF MARINE DEBRIS IDENTIFIED	82
5.3 SPATIAL AND TEMPORAL ABUNDANCE OF MARINE DEBRIS	83
5.4 WATER QUALITY ACROSS STUDY SITES	84
5.5 SOCIAL SURVEY	86
<b>CHAPTER SIX</b>	
CONCLUSIONS AND RECOMMENDATIONS	90
6.1 CONCLUSIONS	90
6.2 RECOMMENDATIONS	91
REFERENCES	94
APPENDICES	122

Appendix 1	Differences in coliforms and <i>E. coli</i> between the four study sites	122
Appendix 2	Beach Users Guide	123
Appendix 3	Stakeholders' Guide	127

## LIST OF TABLES

<b>TABLE</b>		<b>PAGE</b>
Table 4.1	Pollution types covered by MARPOL Annexes I-VI	37
Table 4.1	Overall Debris Density versus Nunoo & Quayson (2003) and Tsagbey <i>et al.</i> , (2009)	66
Table 4.2	Mean debris density across present study sites versus Nunoo & Quayson (2003) and Tsagbey <i>et al.</i> ,(2009)	67
Table 4.3	Marine debris types of present study versus Nunoo & Quayson (2003) and Tsagbey <i>et al.</i> , (2009)	67
Table 4.4	Dominant debris types at present study sites versus Nunoo & Quayson (2003) and Tsagbey <i>et al.</i> , (2009)	68
Table 4.5	Source and Types of Marine Debris based on Barr (2000) classification	69
Table 4.6	Relative composition of litter sampled from the four study sites ( <i>italics</i> show those in the world's 'dirty dozen')	70
Table 4.7	Summary of debris weight and count collected from sampled beaches over sixteen weeks	72
Table 4.8	Summary of the demographic variables collected for the social perception survey	76

## LIST OF FIGURES

<b>FIGURE</b>		<b>PAGE</b>
Fig.2.1	Steps in developing a marine litter assessment strategy	32
Fig.3.1	Map showing study sites	47
Fig.3.2	Schematic representation of belt transect	52
Fig.3.3	Walking pattern employed in collecting debris within Transect	55

Fig.4.1	Percentage of marine debris source count (m <sup>2</sup> ) detected during sampling	69
Fig.4.2	Percentage of marine debris source weight (kg/m <sup>2</sup> ) detected during sampling	70
Fig.4.3	Marine debris trends per study site measured in weight (kg/m <sup>2</sup> ) over sixteen weeks	72
Fig.4.4	Overall marine debris weight trend (kg/ m <sup>2</sup> ) over sixteen weeks	73
Fig.4.5	Overall marine debris count trend (m <sup>2</sup> ) over sixteen weeks	73
Fig.4.6	Mean Coliform and <i>E.coli</i> levels recorded at study sites over sixteen weeks	74
Fig.4.7	Total bacteria load recorded at study sites	74
Fig.4.8	Beaches most frequented by respondents	77
Fig.4.9	Evaluation of the perception of respondents to beach litter	78
Fig.4.10	Respondents' assessment of cleanliness of Ghana's Beaches	78
Fig.4.11	Management options by respondents to reduce beach litter	79

### LIST OF PLATES

PLATE		PAGE
Plate 3.1	GIS mapping of study site	53
Plate 3.2	Beach with debris during low tide	54

## ABSTRACT

With an estimated population of 3 million people living along Accra's coast, Ghana is facing major challenges in managing its waste especially solid waste in metropolitan areas. A survey of marine debris was therefore carried out over a period of sixteen weeks at four beaches along the Accra - Tema coastline namely Sakumono, La Pleasure, Mensah Guinea and Korle Gonno beach. The main objective of the study was to determine the beach and water quality at the study locations. A 10 x100 m belt transect was demarcated on each beach. Accumulated debris and one litre seawater samples were collected from the belt transects on all four beach sites on a weekly basis and analysed. A total of 18241 items of marine debris which weighed 297.59 kg were collected from the four beaches. Out of 51 individual marine debris items identified, 9 were found on the world's 'dirty dozen' list. Plastic materials dominated the debris collected accounting for 63.72% of total debris. Marine debris from land- based source formed the largest proportion of debris collected (93% of items/m<sup>2</sup> and 85% kg/m<sup>2</sup>). Water quality analysis revealed high mean levels of coliforms and *E.coli* above World Health Organisation (WHO) levels on all four beach locations. A social survey that mainly targeted beach users was also conducted over the same period. Respondents were in the habit of littering and acknowledged marine debris as a problem. They also believed that Ghana's beaches are not clean and identified beach users as the main source of litter generation on the beaches. Intensive education remains key to combating the issue of debris on Ghana's coastlines. Water quality levels should be constantly monitored to avoid disease outbreaks. Where the levels are deemed life threatening, the beach should be closed off to the general public until such a time when it is safe. Ultimately, enforcement of appropriate policy initiatives and continuous monitoring is vital to addressing marine debris along Ghana's coastlines.

# CHAPTER ONE

## INTRODUCTION

### 1.1 BACKGROUND

Coastal areas form an important interface between land and sea. Although they cover only 10% of the earth's land area, they are home to over 60% of the world's population (Lakshmi & Rajagopalan, 2000; Tudor & Williams, 2001).

Marine debris is a problem that affects these coastal areas and the sea floor at all depths, and its impact is of global significance (Tudor & Williams, 2001). Marine debris has been recognised as a serious pollutant for over 30 years (Carpenter *et al.*, 1972; Scott, 1972; Cundell, 1973) but has only gained widespread recognition in the past decade (Tudor & Williams, 2001). Marine debris also known as marine litter is defined as 'any man-made object discarded, disposed of, or abandoned that enters the coastal or marine environment' (NOAA, 2007; Sheavly, 2007; UNEP, 2009).

Marine debris range from common domestic material to industrial products, to lost or discarded fishing gear (NOAA, 2007). It has been described as one of the most pervasive pollution problems plaguing the world's oceans and waterways. 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 can be categorized as ocean/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/waterway-based sources (GESAMP, 1991; CMC, 2000; Rockefeller, 2008; 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.*, 2011).

Potentially harmful marine debris is often measured by land-based surveys along shorelines (Frost & Cullen 1997; Cunningham & Wilson 2003; Storrier *et al.*, 2007; Sheavly, 2007). Marine debris that collects along beautiful shorelines and waterways detracts from the aesthetic beauty and enjoyment of those beaches and negatively affects tourism (Rockefeller, 2003).

Debris can be a human health and safety hazard. Discarded fishing line, rope 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, and broken glass and other sharp objects pose obvious dangers for barefooted beachgoers (NOAA, 2010). Marine debris can also cause habitat destruction by affecting water quality and causing physical damage to sensitive ecosystems. Coral reefs, sea grass beds and their bottom-dwelling species are very susceptible to the impacts of marine debris. Marine debris can also be lethal for marine wildlife (NOAA, 2010). Many species accidentally ingest trash, mistaking it for food. Abandoned fishing nets and gear, discarded fishing line and other forms of debris can entangle marine wildlife – including sea turtles, manatees, sea birds and fish – maiming or even killing them (Sheavly, 2007). The International Convention for the Prevention of Pollution from ships (MARPOL) (1973) and the Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (1972) are two primary

international conventions that address waste and pollution in general and in the oceans by ships.

Ghana has a long and productive coastline of about 550 km facing the Gulf of Guinea (EPA, 2012). The coastal zones of Ghana are very productive representing a huge natural and economic resource for the country (Amlalo, 2007) with an estimated population of 3 million people living in Accra (Ghana Statistical Service, 2012). Plastics form the most dominant type of litter (UNEP, 1990; Topping *et al.*, 1994; Hoagland & Kitte, 1997; Nunoo & Quayson, 2003); a phenomenon consistent with research findings worldwide: the Black Sea (82.53%), the Indian Ocean (69.99%), North Sea (65.79%), Wider Caribbean (64.27%), the Pacific Ocean (62.95%) and Central Europe reporting the lowest plastic percentage with 42.79% (CMC, 1997; UNEP, 2009).

Marine debris is especially evident at beaches after rains and during low tides posing a threat to the booming tourist industry in Ghana (Nunoo & Quayson, 2003). The most common 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). Faecal deposits also frequently occur, especially in areas where the adjacent communities do not have adequate toilet facilities. With tidal cycles, these deposits are washed into the sea and degrade the quality of the water. There is also direct sewage disposal into the sea (Nunoo & Evans, 2007), which can cause health hazard to both the users of the beach and sea biota. Marine debris covers the sea floor and affects the production of marine benthos (Nunoo & Quayson, 2003). 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 cleanups (Nunoo & Quayson, 2003; Tsagbey *et al.*, 2009;

UNEP, 2009; NOAA, 2010; World Ocean Review, 2010).

## **1.2 PROBLEM STATEMENT**

Ghana is facing major challenges in managing its waste especially solid waste in the metropolitan areas (Obirih-Opareh, 2002; Mariwah, 2012). In an effort to rid our cities of the mounting waste, much research and resources have been committed (Demanya, 2006). However, the waste continues piling up with 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 beaches. Although many projects have focused on the provision of improved sanitation and hygiene education in the coastal areas, improper disposal of municipal solid and liquid wastes remain widespread (Nunoo & Quayson, 2003). This has created a pressing sanitation problem as many towns and cities are overwhelmed with management of municipal solid and liquid wastes evidenced by the yearly outbreaks of cholera in the country.

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). Accra and Kumasi, with a combined population of about 4 million and a floating population of about 2.5 million generate over 3,000 tons of solid waste daily (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). The result is standard and unsafe facilities which poses public health risks and aesthetic burdens (GhIE, 2011). If this situation

is not given the attention it deserves major changes in environmental conditions or interdependent relationships can cause the marine ecosystem to fail and hence affect the coast's ability to adequately provide for the plants, animals and humans that depend on it and each other to survive.

### **1.3 JUSTIFICATION**

Data on continuous monitoring and litter quantification is lacking in Ghana. The majority of scientific studies on marine debris in Ghana have been either regional or local in scope addressing the type and quantities but not the trends and changes over the years (Rees & Pond, 1997; Jambeck *et al.*, 2001). 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 the trends and changes in marine debris will provide significant insight and understanding of this pollution problem and can function as an ongoing component of management strategies. Monitoring can be used to clarify the problem of marine debris – e.g. are the types, sources and quantities of marine debris changing and what is the degree of change? In addition, ongoing monitoring activities can be used to assess the effectiveness of management strategies, legislation, and other activities designed to control and abate this pollution problem (Coe & Rodgers, 1997 and Sheavly, 2005). Assessing the trends and changes in marine debris is an important component in dealing with this pervasive pollution problem. The information obtained from monitoring trends and changes in marine debris along the coast will provide a roadmap for addressing the sources of the debris and can also

be used to measure the success of the programs developed to abate marine debris (Sheavly, 2007). Successful management of the marine debris problem requires a comprehensive understanding of the issue, including identifying the dominant forms of marine debris, their abundance, potential sources and activities producing the debris.

This study will thus help answer the following questions:

- Are the types and quantities of debris on our coastlines changing?
- What are the major sources of the debris?
- What are the public perceptions associated with marine debris and their effect on the marine environment?

#### **1.4 OBJECTIVES**

This study sought to:

- i. determine trends in quantity and types of debris between 2000 and 2013.
- ii. distinguish litter collected as either land or sea-based marine debris.
- iii. establish the spatial and temporal abundance of the marine debris.
- iv. determine the water quality in the designated locations along the Accra-Tema coastline by examining the total and faecal coliforms and *E. coli* levels.
- v. evaluate public attitudes, perceptions and opinions about beach litter and other beach management issues.

#### **1.5 HYPOTHESIS**

The research tested the Null hypothesis ( $H_0$ ): the type and amount of marine debris along the coast has decreased as a result of increased public awareness of coastal pollution, attitudinal change and existing management practices.

## **1.6 THESIS ORGANIZATION**

This thesis is divided into six chapters. The first chapter is essentially the introductory chapter of the thesis and it provides a brief discussion of the background of the study, explains the objectives, and justification of the study and the general outlook of the thesis.

Chapter two, of the thesis highlights theories on the threats to the environment and inhabitants as a result of marine debris. It also highlights literature on the implementation of management programmes, associated problems, and the relevance of measures being implemented.

Chapter three provides a description of the study area and describes the methods and strategy adopted in the collection of data for the whole thesis.

Chapter four describes the results. This chapter contains the findings of the field work and interviews, which were conducted to achieve the objectives of the research.

Chapter five examines key findings of the thesis. Specifically, the chapter examines and discusses the perception of respondents and results of field work.

Finally, chapter six presents conclusions of the study based on the key findings and proposes some recommendations.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 DEFINITION OF MARINE DEBRIS**

Marine debris in the simplest form can be defined in just one word; Litter. It is nothing but 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).

#### **2.2 HISTORY OF MARINE DEBRIS**

Although societies have altered natural environments since time immemorial, the magnitude, intensity, and rate of change have increased dramatically in the last 75 years (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 fibers 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:

- (1) Entanglement of animals in loops and openings of derelict line, nets, strapping bands, etc.
- (2) 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).

### 2.3 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). Marine debris originates from a diverse range of land- and ocean-based sources (Derraik, 2002; Mouat *et al.*, 2010).

Land-based sources includes 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 cause 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):

1. Tourism related litter at the coast: this includes litter left by beach goers such as food and beverage packaging, cigarettes and plastic beach toys.
2. 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.
3. 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.
4. 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).

## 2.4 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 includes a wide variety of different types of debris and these 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, foil wrappers and disposable 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 (Velandar & Mocogni, 1998; UNEP, 2005b; 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 (Velandar & Mocogni, 1998; UNEP, 2005b; Galgani *et al.*, 2010 cited by Potts & Hastings, 2011).

## **2.5 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).

### **2.5.1 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 two 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, thousand 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).

### 2.5.2 Ingestion

Ingestion 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).

### 2.5.3 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). 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).

#### **2.5.4 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 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).

## **2.6 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 value (Cheshire *et al.*, 2009; Mouat *et al.*, 2010).

### **2.6.1 Reduced Recreational Opportunities**

Many residents and visitors to coastal communities value the beach as a public amenity (JurassicCoast, 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 more large 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).

### **2.6.2 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).

### **2.6.3 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).

#### **2.6.4 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).

#### **2.6.5 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 presents 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).

### **2.6.6 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 metal 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, fecal 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).

### **2.6.7 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, bioaccumulative, 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).

## 2.7 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).

## 2.8 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-Eurostat Joint Questionnaire on waste 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 firstly, it is constantly in motion and secondly, because the litter enters the marine environment from different pathways, making it difficult to quantify (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 (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.

## **2.9 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.

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 (Nunoo & Quayson, 2003). 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). The study determined how the degree of human pressure at the two beaches contributed to beach degradation (Tsagbey *et al.*, 2009).

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/yr of mainly non-hazardous waste Scheren *et al.* (2002).

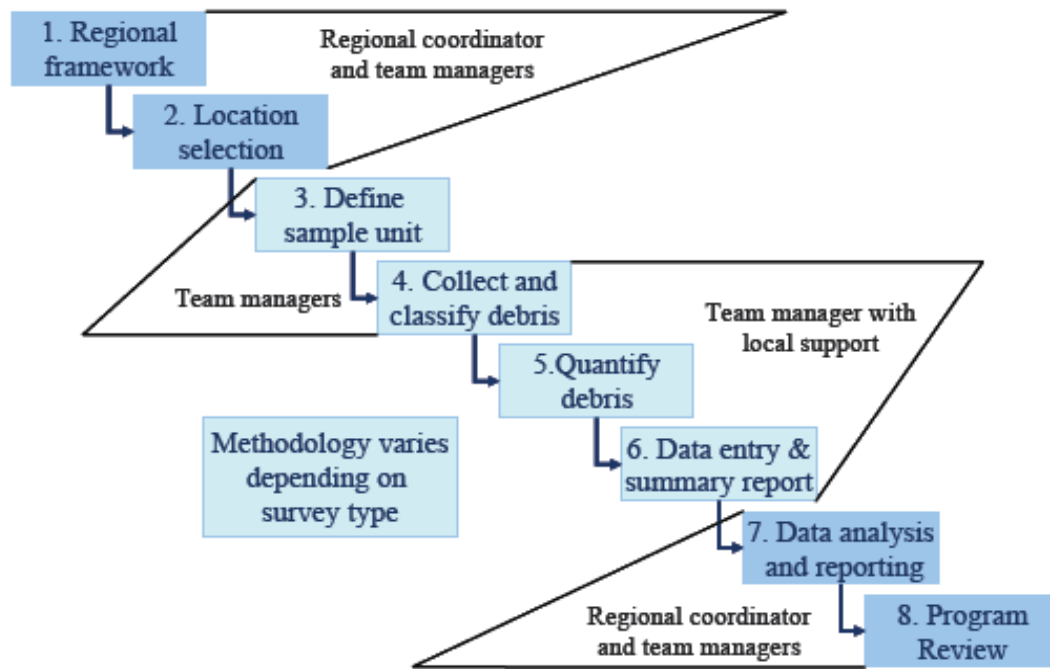
The Abidjan Convention for Co-operation in the Protection, Management and Development of the Marine and Coastal Environment of the West and Central African (WACAF) region was born out of the need to undertake regional and common approaches to the prevention, reduction and combating of pollution in the 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:

1. 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.

2. 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.

3. 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 (Fig.2.1) and are delivered consistent with the defined protocols.



**Fig.2.1: Steps in developing a marine litter assessment strategy** (Source: Cheshire *et al.*, 2009).

## 2.10 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).

### **2.10.1 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 (Å0.31 miles)
- 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 volunteers 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).

## **2.11 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).

## **2.12 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.

### **2.12.1 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).*

### 2.12.2 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 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 (2.1) below:

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

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

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).

### **2.12.3 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 Protocol's 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).

### **2.13 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):

1. 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.
2. A National Environmental Action Plan (NEAP) has been produced: The National Environmental Policy (NEAP) 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.
3. All relevant national technical institutions have been identified and associated with the NEAP:

4. The Ghana Environmental Resource Management Programme (GERMP) has been planned to help the Government implement the NEAP;
5. Ghana is signatory to various international conventions related to the problems of sustainable development and regional and international cooperation in matters of the environment;
6. 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 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).

## **2.14 SOCIAL DRIVERS OF LITTERING**

Littering pervades our life, causes environmental degradation, and is recognised as an anti-social behaviour that reduces societal benefits (Baltes & Hayward, 1976; Reich and Robertson, 1979; Cialdini & Baumann, 1981; Cialdini, 2003 cited in Slavin, 2011).

Public perception towards litter can vary widely (Arafat *et al.*, 2007) however, it is widely accepted within literature that littering is a fact of modern lives (Cialdini & Baumann, 1981; Cialdini *et al.*, 1990 cited in Slavin, 2011), with anthropogenic litter considered as one of the most visible forms of pollution and environmental degradation (Finnie, 1973 cited in Slavin,

2011).). A useful definition of littering according to Hansmann & Scholz (2003) cited in Slavin (2011) is the careless, incorrect disposal of minor waste. Sibley & Lui (2003) cited in Slavin (2011) asserts that behaviour related to littering can be either active or passive.

Active litterers knowingly place debris into the environment, while passive litterers fail to notice and remove litter (Slavin, 2011). Passive littering is difficult to combat (Sibley & Lui, 2003 cited in Slavin, 2011) because people are unaware that they have participated in the act of littering (Slavin, 2011). A number of different factors are believed to contribute to littering behaviour especially within a society or group (Slavin, 2011) specifically referred to as descriptive and injunctive norms (Cialdini, 2003; Schultz *et al.*, 2007).

Whereas a descriptive norm refers to a person's perceptions of what is normally done in a given situation, an injunctive norm refers to a person's perceptions of what is commonly approved or disapproved within the culture (Cialdini, 2003; Schultz *et al.*, 2007). Site factors are also powerful determinants of behaviour – the more litter that is present, the more people are inclined to drop litter (Arafat *et al.*, 2007).

In the interest of forming some generalizations, it is possible to identify several common findings on why people litter (Beck, 2007 cited in Torgler *et al.*, 2008). It seems that younger people tend to litter more than older people (Torgler *et al.*, 2008). In addition, men litter more than women; clear support for previous research which finds that women are more concerned with environmental issues (Zelezny *et al.*, 2000 cited in Torgler *et al.*, 2008).

Carelessness, laziness, the inconvenience of keeping the litter or accidents are some of the contributing factors in littering behaviour (Torgler *et al.*, 2008). Cialdini (2003) and Cialdini

*et al.* (1991) cited in Torgler *et al.* (2008) report a higher probability of littering in places where litter is already present compared to clean areas. This would suggest that if people notice other individuals are littering their willingness to litter increases, reducing the moral constraints which would ordinarily compel individuals to behave in an (ordinarily) socially accepted manner (Torgler *et al.*, 2008). Thus, an individual's behaviour is likely to be influenced by their perception of the behaviour of other citizens (Torgler *et al.*, 2008).

## **2.15 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 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).

## **CHAPTER THREE**

### **MATERIALS AND METHODS**

An examination of the various processes through which the research was developed is undeniably important. The chapter details a description of the study area and the methods by which data was acquired and their significance to the research.

#### **3.1 STUDY AREAS**

Four sites were chosen for the study. They were the Sakumono beach, La Pleasure beach, Mensah Guinea beach (i.e. Centre for National Culture beach) and Korle Gonno beach (Fig.3 1). The distance between La Pleasure beach and Sakumono beach is about 9.7 km. That of La Pleasure beach to Mensah Guinea beach is 7.1 km and from Mensah Guinea beach to Korle Gonno beach is 3.5 km.

These beaches were selected because there is available data on marine debris from the research carried out by Nunoo and Quayson in 2000 at the Sakumono and Mensah Guinea beaches and by Tsagbey *et al.* in 2009 at La Pleasure beach and Korle beach. It was therefore possible to do a comparative analysis to ascertain changing trends.

The sites chosen for the study also had differing socio-economic settings and various categories of tourists (Tsagbey *et al.*, 2009). Local communities can also be located in close proximity to these sites.



**Fig. 3.1: Map showing study sites**

The Sakumono and Mensah Guinea beaches are located in known national ‘hotspots’ of coastal pollution. Sakumono beach is a fish-landing site for people from Sakumono village. The village is made up of mainly small-scale artisanal fishermen, fishmongers and farmers, and is located about 8 km west of Tema on the Accra-Tema main coastal road. It is adjacent to Sakumono I Lagoon which is designated as a Ramsar site for its high bird biodiversity (Nunoo and Quayson, 2003).

Nonetheless, the Sakumono beach has in recent times become a hub for recreational activities. The beach is sandy with vegetation at the back of the shoreline. It is of low to moderate slope ( $15-45^\circ$ ) from dune line that affords a litter trapping feature above high water level (Nunoo & Quayson, 2003). Although it is possible to drive along the beach, access to

the sampling site is pedestrian (requires walking). Channelized outlets or outfalls can be seen along the shoreline heading out to sea. The shoreline is also characterised by permanent and semi-permanent structures which are used for recreational purposes. The sampling site was located within these four points (N 05<sup>0</sup> 36.399' W 000<sup>0</sup> 03.569'; N 05<sup>0</sup> 36.405' W 000<sup>0</sup> 03.569'; N 05<sup>0</sup> 36.379' W 000<sup>0</sup> 03.621'; N 05<sup>0</sup> 36.373' W 000<sup>0</sup> 03.618')

La Pleasure Beach is located off the Accra-Teshie/Nungua Road. This beach shares boundaries with 4-Star La Palm Royal and 5-Star La Pleasure Beach hotels, and is patronised throughout the week by both foreign and local tourists (Tsagbey *et al.*, 2009). The beach is sandy, of a low to moderate slope and access to the study site requires walking. The back of the shoreline is characterised by permanent and semi-permanent structures where beach patrons can relax and enjoy the ocean view. The sampling site was located within these four points (N 05<sup>0</sup> 33.763' W 000<sup>0</sup> 08.175'; N 05<sup>0</sup> 33.768' W 000<sup>0</sup> 08.175'; N 05<sup>0</sup> 33.781' W 000<sup>0</sup> 08.121'; N 05<sup>0</sup> 33.786' W 000<sup>0</sup> 08.123').

The Mensah Guinea beach is mainly a tourist beach. It is located directly behind a major tourist market visited by people from a wide variety of economic background, both natives and visitors, in the centre of the city of Accra. Fishing activities, however, occurs rarely in this area (Nunoo & Quayson, 2003). The Mensah Guinea beach is predominantly sandy with a rock cliff at the back of the shoreline. The beach is also of low to moderate slope and accessing the site requires walking. The sampling site was located within these four points (N 05<sup>0</sup> 32.594' W 000<sup>0</sup> 11.823'; N 05<sup>0</sup> 32.599' W 000<sup>0</sup> 11.825'; N 05<sup>0</sup> 32.609' W 000<sup>0</sup> 11.771'; N 05<sup>0</sup> 32.615' W 000<sup>0</sup> 11.773').

Korle Gonno beach is located on the western side of Accra in the densely populated community of Korle Gonno, which is well-noted nationwide for its degraded environmental conditions (Nunoo & Evans, 2007). Beach visitors are normally local tourists who go there mostly on holidays and weekends (Tsagbey *et al.*, 2009). The Korle beach is sandy and interspersed with rocky patches. Structures for enjoying the ocean view and leisure mark the back of the shoreline. The sampling site was located within these four points (N 05° 31. 733' W 000° 13. 537'; N 05° 31.738' W 000° 13. 538'; N 05° 31.744' W 000° 13.480'; N 05° 31.752' W 000° 13.481'). Accessing the sampling site also requires walking.

These beaches are located in the Greater Accra Region, the smallest of the ten political regions in Ghana (Stephens, 1999 cited in Fobil *et al.*, 2005). The Greater Accra Region is the smallest of the 10 administrative regions in terms of area, occupying a total land surface of 3,245 square kilometres or 1.4 per cent of the total land area of Ghana.

In terms of population, however, it is the second most populated region, after the Ashanti Region, with a population of 2,905,726 in 2000, accounting for 15.4 per cent of Ghana's total population (GOG, 2013). It is the largest of Ghana's ten leading urban centres, and is widely believed to be exclusively the leading economic, commercial and industrial nerve centre of Ghana, broadly defined as Accra Metropolitan Assembly (AMA) and generally often analysed as part of a larger metropolis known as the Greater Accra Metropolitan Area (GAMA) (Fobil *et al.*, 2005). This consists of six districts namely, Accra Metropolitan Area, Tema Municipal Area, Ga East District, Ga West District, Dangme West District and Dangme East District (GOG, 2013).

Accra has a coastline of approximately 225 km, stretching from Kokrobite in the west to Ada in the east. The soils have low organic content with shallow top soil which limits the capacity for crop production. The vegetation is mainly coastal savannah shrub interspersed with thickets. Some trees are however found mostly in the Dangme West and Ga districts.

The region is relatively dry since it falls within the dry coastal equatorial climatic zone with temperatures ranging between 20° and 30° Celsius and annual rainfall ranging from 635 mm along the coast to 1,140 mm in the northern parts. There are two rainfall peaks one in June and the other October. The first rainfall season between April and July is associated with the major cropping season in the region. With the recent floods during the major season in parts of the region, however, a significant proportion of vegetable farmers are increasingly depending on the minor season (September-October).

The region is not well endowed with mineral resources and possesses only granite, clay and salt. The main rivers that flow through the region are the Volta and Densu. In addition, there are small seasonal streams flowing mostly from the Akwapim Ridge into the sea through numerous lagoons. Due to the fact that the region is bordered on the south by the Gulf of Guinea, there are ecologically very important but highly polluted lagoons and wetlands in Accra Metropolitan Area, Tema and Dangme East districts of Ghana (Government of Ghana, 2013).

### **3.2 DATA COLLECTION TECHNIQUES**

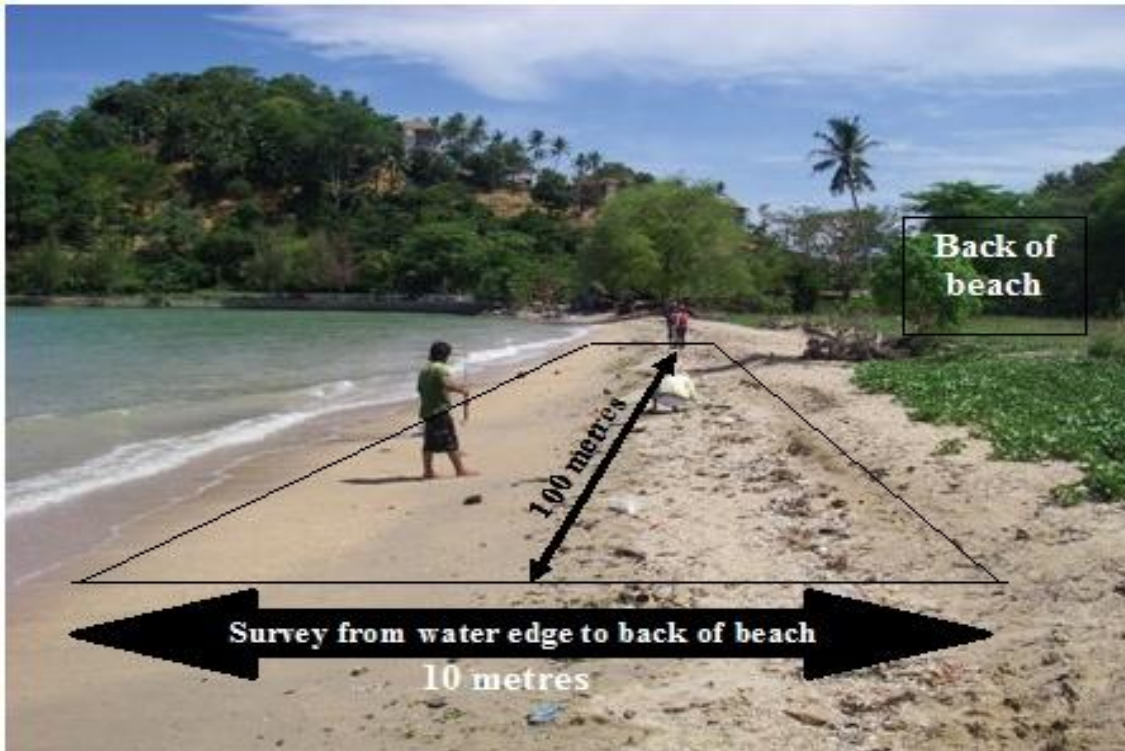
Data was obtained from primary and secondary sources. Secondary data was extracted from published works, typically journal articles, Internet, books and encyclopedia. Extensive use of Marine debris literature was presented in Chapter two of this thesis.

Primary data were derived from the field through beach surveys, structured questionnaire-interviews, microbial water quality tests and field observations. The questionnaire collected both quantitative and qualitative data from the individuals within the sample frame.

Microbial water quality tests were used to determine the presence of some bacteria in water and serve as indicators of the likelihood of faecal contamination and the potential for serious diseases. Finally, the field observations offered opportunities for objective assessment of on-site situations and also for further probing of issues that were initially unclear.

### **3.3 METHODOLOGY**

In this survey, a belt transect, representing a sampling area of 1000 m<sup>2</sup> (i.e. 10 m × 100 m) was demarcated at each beach between the low tide mark and the zone of emergent vegetation. The demarcated areas ran parallel to the sea (Fig.3.2).



**Fig.3.2: Schematic representation of belt transect** (Source: Cheshire *et al.*, 2009).

Each survey site was measured using a surveyor's measuring wheel and marked to assure length accuracy and repeatability of successive surveys. Taking a cue from Sheavly (2007), semi-permanent markers were placed at the beginning and end points of the 10 m × 100 m study site.

In addition to establishing visual boundary markers for each site, global positioning system (GPS) coordinates (latitude and longitude) were recorded for use in GIS mapping of the study sites and database manipulation (Plate 3.1).



**Plate 3.1: GIS Mapping of study site** (Source: Field survey, 2012)

Photographs of each selected survey site were taken, noting unique features and landmarks that would identify the site's location. Initial sampling visits to both beaches (1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> November, 2012) were used to meet the beach cleaning crew from ZOIL Services Limited (ZSL) to get their cooperation for study.

ZSL is a wholly-owned subsidiary of Zoomlion Ghana Limited (the largest private sanitation services provider in Ghana). The company's main areas of focus include coastal areas and beaches of inland water systems. ZSL has been tasked by the Government of Ghana to ensure the cleanliness of these beaches to enhance the growth of the hospitality industry in Ghana and to ensure a sustainable livelihood for the fisher folk in these areas.

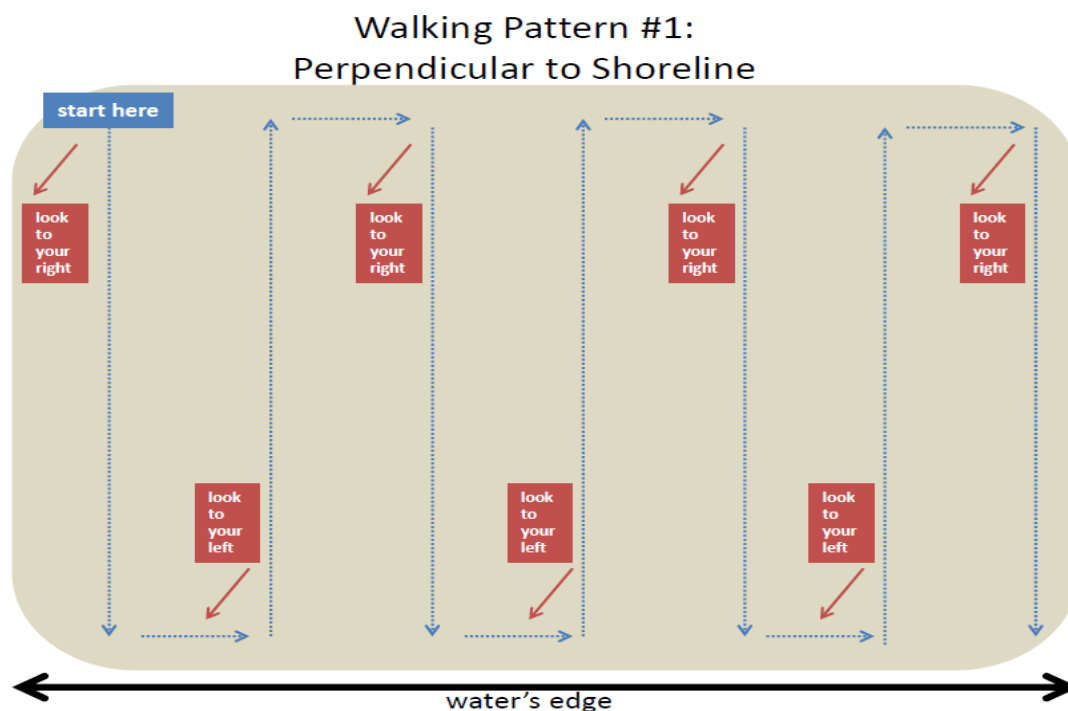
Visits to study sites also served as a clearing exercise where the sampling areas were totally swept clean. The sampling sites were thereafter monitored once a week (on same day) over 16 weeks (10<sup>th</sup> November, 2012 to 23<sup>rd</sup> February, 2013) during periods of very low tide (tidal level mostly < 0.4 m) (Plate 3.2). Debris were collected, placed into labelled bags and taken away for sorting and weighing.



**Plate 3.2: Beach with debris during low tide** (Source: Field survey, 2012)

To ensure that the entire transect was covered, a perpendicular walking pattern suggested by Opfer *et al.*, (2012) was employed (Fig. 3.3). The surveyor stands facing the water's 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.

The litter was sorted into identifiable groups in the laboratory after which they were counted and later weighed to the nearest kilogram using an electronic scale and spring balance. Debris was further categorised as either originating from the ocean or having a land-based source based on the classification by Barr (2000).



**Fig.3.3: Walking pattern employed in collecting debris within transect** (Source: Opfer *et al.*, 2012).

The average number and weight of each item per week was determined. A Chi-squared test was carried out on the numbers of litter from the four beaches to establish, if any, the relationship between the types and abundance of the litter and the study site.

Sea water was also collected at the designated locations into two 500 ml sterile plastic bottles from each beach site and mixed together in a one litter sterile container in order to have one composite sample for bacterial assessment.

Water samples were collected from the surface of the water at a depth of 20 cm -30 cm, two meters from the shore for each beach location once a week for sixteen weeks. The bottles were dipped under the surface until full, returned to the deck and capped. Replicate samples consisting of two samples were collected from the same depth for all the study sites.

After collection, the samples were labelled, immediately kept on ice and analysed at the Microbiology Laboratory at the Water Research Institute (WRI) of the Council for Scientific and Industrial Research (CSIR) for total coliform (TC), faecal coliform (FC) and *E. coli* using the Membrane filtration (MF) method (USEPA, 2005) .

### **3.3.1 Social Survey**

A survey instrument (a copy of which can be found in Appendices 2 and 3), was used to collect data about littering and marine debris. The survey offered significant advantage in terms of the amount and quality of data that was collected. It offered a high degree of control over the data collection process. It also enabled the respondents to be asked to clarify any answers that the interviewer could not interpret.

The interviews were conducted at the four beach locations: Sakumono, La Pleasure, Mensah Guinea and Korle Gonno beaches over a sixteen week period from November, 2012 to February, 2013. According to Arafat *et al.*, (2007); Bator, (2001) cited by Slavin, (2011), people are the social drivers of the littering problem. It is therefore necessary for the people causing it to recognize this by coming to the realization that they contribute to it.

### 3.3.2 Recruitment of Participants

Data was collected on site using face to face interviews of adults eighteen years and above. Eighteen years is the legal age for voting in Ghana, where an individual is considered an adult able to make informed decisions. Slavin's (2011) combined skip interval, sample point sampling method was employed, with the next available person that walked past the sampling point at each location being asked to participate in the survey.

Surveys were conducted at all four study sites on weekdays and weekends (from 10th November, 2012 to 23<sup>rd</sup> February, 2013). The selection of respondents for the questionnaire-interviews was guided by a sampling procedure. The process involved (a) identification of the sample frame (b) determination of appropriate sample size, and (c) distribution of the selected sample size to ensure proper representation of the population.

In determining the sample frame, the basic criterion adopted was that the individual should be an adult over the age of eighteen. In spite of the fact that there are few surveys related to visits in all four study sites as well as non-existent and inadequate data on visitor numbers, the sample size was calculated to be 400 from the population of Accra (three million) according to GSS (2011) using a confidence level of 95% and a confidence interval of five (5).

100 interviews were carried out at each beach location targeting individuals within the sample frame encountered on the various beach locations making a total sample size of 400 respondents.

### 3.3.3 Development of Questionnaire

The survey questionnaire designed for the respondents to complete comprised close-ended and open-ended questions, multiple choice, and multi-method questions. Close-ended questions had fixed responses for some of the questions posed and respondents were required to select one of the options as their response.

In some cases an additional response such as other with a blank space or line after it was provided for the respondent to write in his or her own answer if they did not find any of the provided answers suitable. Some of the close-ended questions took the form of providing either dichotomous or multiple-choice responses. The dichotomous questions were those that demanded the choice from only two possible responses. Multiple-choice responses refer to those questions with three or more optional responses.

Open-ended questions allowed the respondents to write down their own answers. Multi-method questions combined close-ended and open-ended type of answers directing the respondent to the next question to be answered.

The main aim of the survey was to access people's beliefs about littering and their beliefs in whether their actions have an impact on the marine environment. The interviewer physically travelled to the respondent's location to conduct the interview. Respondents were approached courteously and the purpose of the survey explained to them, together with the affiliation of the surveyor. They were then asked if they would wish to participate in the survey.

The survey followed a guide without deviation. The interviews were conducted mostly in English. The local dialects - Ga and Twi were also used per the request of respondents.

Surveys maintained the confidentiality of respondents and took approximately 10 to 15 minutes to complete. The questionnaire included variables on socio-economic and demographic profiles (age, sex, profession, place of residence, level of education); their beach dislikes, habits using the beach and frequency of their visits; beach users' opinions on marine debris and propositions beach users have to improve the beach and its environment

### **3.3.4 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. Here, a motivation analysis employed by Roca and Villares, (2008) which is a method of interviewing selected representatives, who provide the opinion of their organisations, was employed.

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. Accra Metropolitan Assembly (AMA), Tema Metro- Solid Waste Management Department, Ministry of Environment Science and Technology and, Environmental Protection Agency (EPA) were purposefully identified using core functions of these organisations which are all tailored to enhance the quality of life of the people and the protection of the environment.

Some of the questions posed representatives of these organisations included whether marine debris a major problem in Ghana, the state of marine debris on Ghana's beaches, the impact of marine debris on Ghana's beaches in general, the main source of litter on the beach and the main reason for litter on Ghana's beaches among others.

### **3.4 ANALYSIS OF DATA**

Data was analyzed using Statistical Program for Social Science (SPSS 20.0), STATA, Microsoft excel and a crisp presentation with the aid of tables, charts, graphs, percentage frequencies. A one way analysis of variance (ANOVA) was used to examine the differences in debris composition and abundance (weight and count).

A range of descriptive methods were used to describe the data relating to people's beliefs and perceptions on littering. Chi-square ( $X^2$ ) tests of independence were used to analyse the survey data and was tested at the 5% level of significance ( $\alpha = 0.05$ ).

### **3.5 MICROBIAL WATER QUALITY TESTS**

For this study, water quality at the four study sites were carried out by testing for Total coliforms, faecal coliforms and *Escherichia coli*. Coliforms and faecal streptococci are used as indicators of possible sewage contamination because they are commonly found in human and animal faeces.

Faecal coliform bacteria occur naturally in the digestive tract of warm-blooded animals, where they aid in the digestion of food. Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems. Therefore, their presence in water bodies suggests that pathogenic microorganisms might also be present and that swimming and eating shellfish might be a health risk (responsible for dysentery, gastroenteritis, and hepatitis A) (US EPA, 2006).

Since it is difficult, time-consuming, and expensive to test directly for the presence of a large variety of pathogens, water is usually tested for coliforms and faecal streptococci instead. A common source of coliforms and pathogenic bacteria is raw sewage. In addition to the possible health risk associated with the presence of elevated levels of faecal bacteria, they can also cause cloudy water, unpleasant odours, and an increased oxygen demand (US EPA, 2006).

**Total coliforms** are a group of bacteria that are widespread in nature. This group is defined as gram-negative organisms, non-spore forming facultative anaerobic and capable to ferment lactose with the production of gas at 35 °C within 48 hours (Herve, 2008). Total coliforms are faecal and non- faecal origin. All members of the total coliform group can occur in human faeces, but some can also be present in animal manure, soil, and submerged wood and in other places outside the human body. Thus, the usefulness of total coliforms as an indicator of faecal contamination depends on the extent to which the bacteria species found are faecal and human in origin. For recreational waters, total coliforms are no longer recommended as an indicator. For drinking water, total coliforms are still the standard test because their presence indicates contamination of a water supply by an outside source.

**Faecal coliforms**, a subset of total coliform bacteria, are more faecal-specific in origin. Faecal coliforms are also gram-negative organisms, non-spore forming facultative anaerobic and capable to ferment lactose with the production of gas at 44°C within 48hours (Herve, 2008). For recreational waters, this group was the primary bacteria indicator until relatively recently, when EPA began recommending *E. coli* and enterococci as better indicators of health risk from water contact.

*Escherichia coli* is a species of faecal coliform bacteria that is specific to faecal material from humans and other warm-blooded animals. This organism is one of the worldwide organisms used as indicator of faecal pollution. *E. coli* is a gram-negative organism, rod – shaped bacterium and belong the family of Enterobacteriaceae. *E. coli* is a natural inhabitant of the intestinal tract of man and animal (Herve, 2008). The presence of *E. coli* in water is an indication of faecal pollution. EPA recommends *E. coli* as the best indicator of health risk from water contact in recreational waters (US EPA, 2006).

### **3.5.1 Sampling and Equipment Consideration**

For the seawater analysis, two 500 ml seawater samples were collected in sterile plastic bottles from each beach site and mixed together in a one litter sterile container in order to have one composite sample for bacterial assessment.

Samples were collected from the surface of the water at a depth of 20cm -30cm, two meters from the shore for each beach location. Seawater was collected on a weekly basis for sixteen weeks at all four study sites. Sterile plastic bottles were used from a practical standpoint because they will better withstand breakage. The bottles were dipped under the surface until full, returned to the deck and capped.

After collection, the samples were labeled, immediately placed on ice and sent to the Council for Scientific and Industrial Research (CSIR) microbiology laboratory for analysis using the membrane filtration method. As a quality control measure, replicate samples consisting of two samples were collected from the same depth for all the study sites. When testing within 4

to 6 hours was not possible, the samples were transferred to a refrigerator and tested within 24 hours.

In the test, known volumes of a water sample were filtered through membrane filters that have pores 0.45µm in diameter. Most bacteria, including coliforms, are larger than the pore diameter and hence bacteria are retained on the membrane filter. Once the water sample had been filtered, the filter disc containing bacterial cells was placed in a petri dish with medium. The plate was then incubated at 37 °Celsius for 18 to 24 hours during which time individual cells on the filter grow forming colonies.

Colonies present on the filter ferment the lactose in the medium producing acids producing a characteristic sheen. Colonies are easily counted on the filter disc and the total coliform count is determined based on the volume of water filtered (APHA *et al.*, 1998).

### **3.5.2 Membrane Filtration Method (MF) using Harlequin™ mLGA (Membrane Lactose Glucuronide Agar)**

In the Membrane Filtration (MF) method, 100ml of water was passed through a sterile filter paper with 0.45 microns pore diameter. These pores are small enough to filter out bacteria. The filter paper is then transferred to a Petri dish which contains a medium.

For this study, Harlequin™ membrane Lactose Glucuronide Agar (mLGA) was the media for coliform growth. Harlequin™ is a nutritive membrane-filtration media that simultaneously detects total coliforms and *E. coli* within 24 hours. The media is lactose based and contains inhibitors to selectively inhibit growth of non-coliform cells (HACH, 2003). Harlequin™ mLGA provides a clear and simple colour identification system allowing for easy colony

recognition and permits counts for both coliforms and *E. coli* to be obtained from a single membrane. Harlequin™ mLGA utilises the ability of *E. coli* to produce  $\beta$ -glucuronidase. This enzyme metabolises the X-Glucuronide present in the medium with *E. coli* appearing as green colonies, which are easily visualised, even on a crowded plate.

All yellow colonies are presumptive non - *E. coli* coliform bacteria and green colonies are *E. coli*. The combined count of yellow and green colonies is regarded as the number of coliform bacteria. The Petri dish is incubated at  $35^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$  for 24 hours, during which coliforms, if present, multiply and grow in size, and can thus be identified and counted. Visible coliforms form since dye present in the media causes the coliforms to appear coloured.

### **3.5.2.1 Sterilization**

Before testing the water samples, all the Petri dishes, pipette tips, and measuring cylinders were sterilized by boiling in water for 10 to 15 minutes and left to cool at ambient temperature before use. Isopropylene was used to clean all working surfaces.

The forceps were flame sterilized before every use. The Millipore stainless steel, portable filtration unit was sterilized by soaking the wick attached to its lower plate with methanol, igniting the methanol and immediately capping the filtration unit. The methanol ignition produces formaldehyde, which sterilizes the unit. The unit was left closed for 15 minutes for effective sterilization to take place.

### **3.5.2.2 Preparation of petri dishes**

To prepare the Petri dish, a 5.0 ml pipette was used to transfer 2.0 ml of the mLGA medium (agar) evenly on to the labelled Petri dish and left to stand.

### 3.5.2.3 Filtration

Using sterile forceps, a sterile membrane filter paper was placed in the filtration unit over the porous plate of the receptacle with the grid side up. Well mixed samples of 100 ml were then filtered under a partial vacuum. The membrane filter was then removed using sterile forceps and placed, with the grid side up, on the prepared Petri dish.

The sample was then incubated for 24 hours at a temperature of  $35\text{ }^{\circ}\text{C} \pm 0.5\text{ }^{\circ}\text{C}$ . A magnifying glass was used to determine colony counts on the filter papers. Sterile water was also run through the filtration unit, before each sample, to make sure there was no contamination. All waste material generated from the tests were disinfected and disposed off.

### 3.5.2.4 Interpretation of results

Green and yellow colonies combined indicated the sample had total coliforms, while green colonies indicated *E. coli*. The absence of Green and yellow colonies indicated that the sample contained no total coliforms or *E. coli*. The coliform density was directly given by the number of coliforms counted based on the formula below:

$$\text{CFU /100ml} = (N \times 100)/V$$

Where:

N = the number of colonies counted;

V = the sample volume in ml.

In cases where no colonies were observed, the coliform colonies were reported as 0 CFU/100 ml.

## CHAPTER FOUR

### RESULTS

#### 4.1 BEACH LITTER SURVEY

A total of 18,241 items of marine debris were collected from the Sakumono, La Pleasure, Mensah Guinea and Korle Gonno beaches over sixteen weeks. The findings of this study did differ significantly from that of Nunoo and Quayson (2003) at the Sakumono and Mensah Guinea beaches with debris density of 9,445 and that of Tsagbey *et al.* (2009) at the La Pleasure and Korle Gonno beach with debris density of 4,952 (Table 4.1).

**Table 4.1: Overall Debris Density versus Nunoo & Quayson (2003) and Tsagbey *et al.*, (2009)**

Study	Debris density(items/m <sup>2</sup> )	Duration (weeks)
Present study, 2012	18,241	16
Nunoo & Quayson, 2003	9,445	6
Tsagbey <i>et al.</i> , 2009	4,952	6

For this research, the calculated mean number of weekly litter accumulation in transect during the period was  $322.13 \pm 136.70$  at Sakumono beach. Mensah Guinea beach, however, had a mean count of weekly litter accumulated in the specified area to be  $309.25 \pm 101.62$ . The calculated mean count of weekly litter accumulation in transect was  $276.44 \pm 136.70$  on La Pleasure beach and  $232.25 \pm 77.49$  on Korle Gonno beach.

With respect to the study of Nunoo & Quayson (2003), the calculated mean number of weekly litter accumulation in transect during the period was  $698 \pm 62.99$  on Sakumono beach. Mensah Guinea beach, however, recorded a mean count of weekly litter accumulated in the specified area to be  $876 \pm 79.93$ . The study of Tsagbey *et al.* (2009) recorded debris

mean of  $70.66 \pm 19.49$  on La Pleasure beach. That of Korle Gonno beach was  $86.81 \pm 29.28$  (Table 4.2).

**Table 4.2: Mean debris density across present study sites versus Nunoo & Quayson (2003) and Tsagbey *et al.*, (2009)**

Beaches	Debris Mean (Items $100^{-2}$ )	SE
<i>Present study, 2012</i>		
Sakumono	322.13	136.70
La Pleasure	276.44	98.86
Mensah Guinea	309.25	101.62
Korle Gonno	232.25	77.49
<i>Nunoo &amp; Quayson, 2003</i>		
Sakumono	698.00	62.99
Mensah Guinea	876.00	79.93
<i>Tsagbey <i>et al.</i>, 2009</i>		
La Pleasure	70.66	19.49
Korle Gonno	86.81	29.28

A total of fifty - one (51) debris items with nine (9) of them included in the world's famous 'dirty dozen' were identified. Comparatively, twenty – two (22) identified litter items were recorded with seven (7) of them included in the world's famous 'dirty dozen' by Nunoo & Quayson (2003) and thirty-two (32) types of litter were identified by Tsagbey *et al.* (2009) of which six are on the list of the world's "dirty dozen" (Table 4.3).

**Table 4.3: Marine debris types of present study versus Nunoo & Quayson (2003) and Tsagbey *et al.*, (2009)**

Study	Debris types	No. of dirty dozen items
Present study, 2012	51	9
Nunoo & Quayson, 2003	22	7
Tsagbey <i>et al.</i> , 2009	32	6

Plastic materials were found to be the most common debris type at all study sites with an average composition of 63.72%. Comparatively, plastic materials also dominated the total litter collected by Nunoo and Quayson (2003), accounting for 51.17% and 46.03% of total debris count at the Mensah Guinea and Sakumono beaches respectively. The study carried out by Tsagbey *et al.* (2009) also recorded plastic composition of 53% and 66% at La Pleasure and Korle Gonno beaches respectively (Table 4.4).

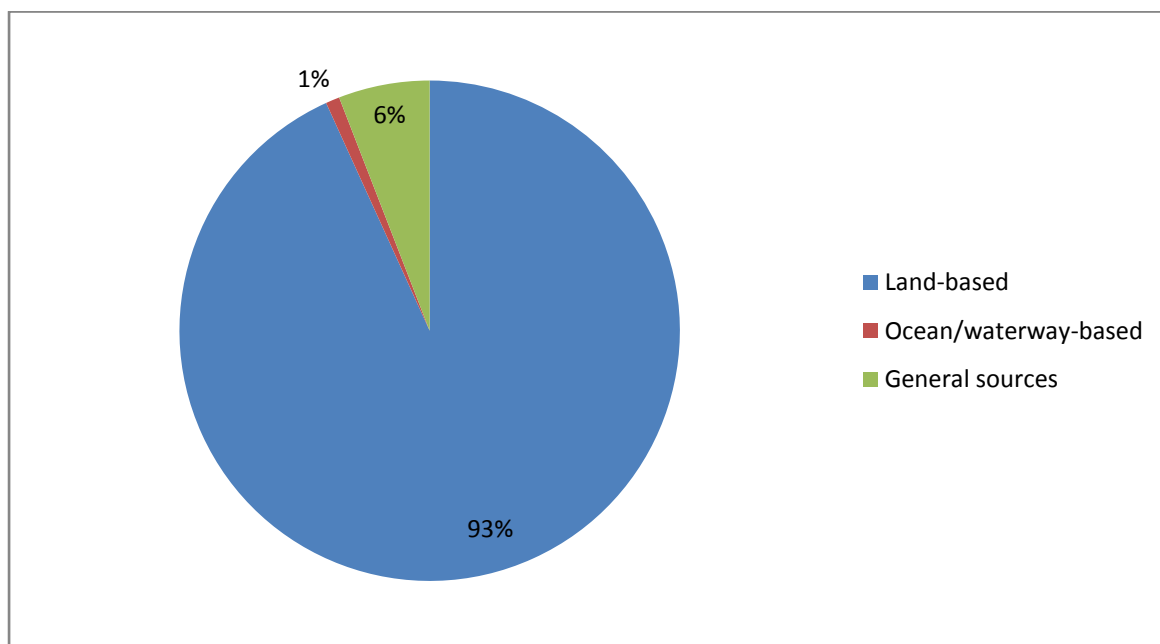
**Table 4.4: Dominant debris types at present study sites versus Nunoo & Quayson (2003) and Tsagbey *et al.*, (2009)**

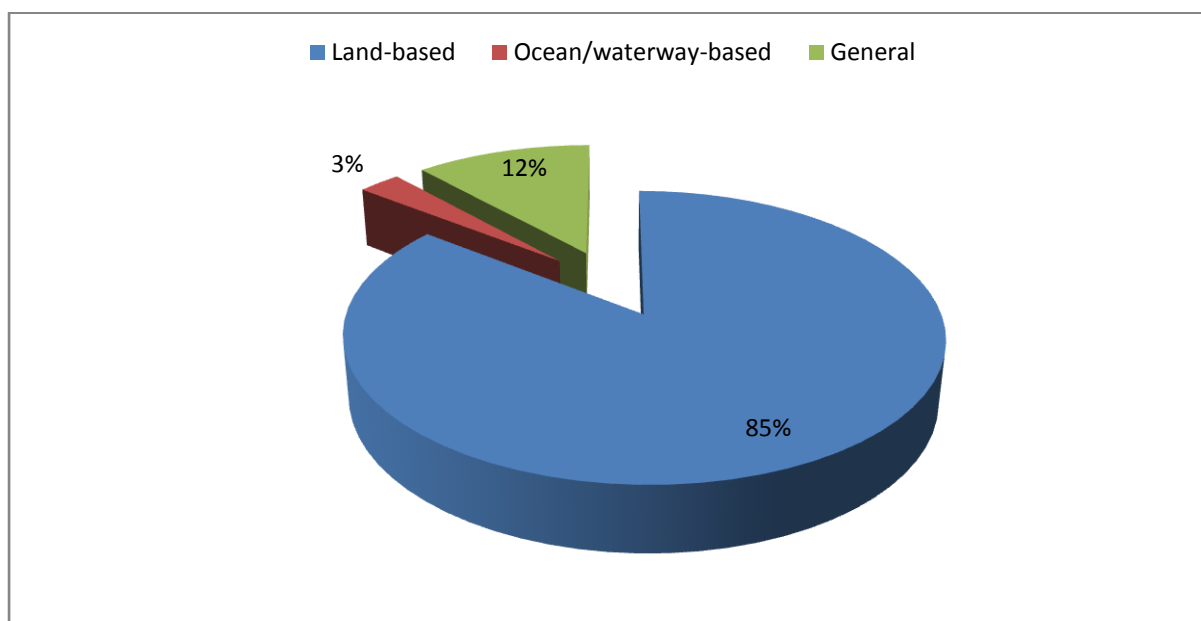
<b>Beaches</b>	<b>Dominant Debris</b>	<b>% Composition</b>
<i>Present study</i>	Plastics	
Sakumono		62.40
La Pleasure		65.48
Mensah Guinea		68.47
Korle Gonno		71.80
<i>Nunoo &amp; Quayson, 2003</i>	Plastics	
Sakumono		46.03
Mensah Guinea		51.17
<i>Tsagbey et al., 2009</i>	Plastics	
La Pleasure		53.00
Korle Gonno		66.00

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 (Table 4.5, Figs.4.1 and 4.2).

**Table 4.5: Source and Types of Marine Debris based on Barr (2000) classification.**

Sources	Types
Land-Based	Plastic Bottles, Straws (plastic), Black plastic bags, White plastic bags, caps/lids, Glass bottles, Pure water sachet, Balloons, Metal cans, Cigarette packaging/ wrappers, Crown corks, Disposable plates and spoons, Khebab sticks, Pieces of cigarettes, Footwear pieces, Clothing/textile, Used condoms, Syringes, Used diapers, Toys, Plastic cups, Food wrappers, Flip-flops, Batteries, Charcoal, Coconut husk, Comb, Fruit peels, Kenkey peels, Bags, Used sanitary towels, Aluminium foil, Newspaper/Magazine pieces, Bandages, Umbrellas, Paper drink packs, Toothbrush.
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.

**Fig.4.1: Percentage of marine debris source count (m<sup>2</sup>) detected during sampling.**



**Fig.4.2: Percentage of marine debris source weight ( $\text{kg/m}^2$ ) detected during sampling.**

**Table 4.6: Relative composition of litter sampled from the four study sites (italics show those in the world's 'dirty dozen')**

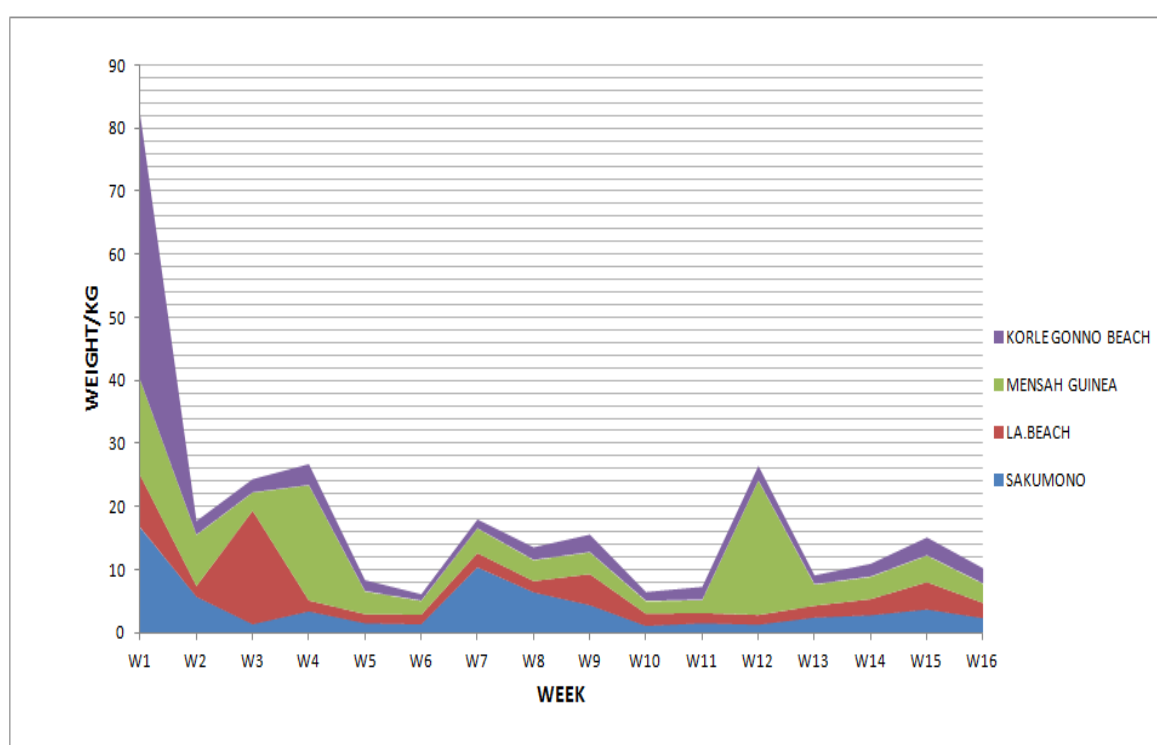
NO.	TYPES OF LITTER	TOTAL WT.	% WT	TOTAL NO.	% NO.
1	Plastic Bottles	11.712	3.94	1348	7.39
2	<i>Straws (plastic)</i>	0.123	0.04	580	3.18
3	<i>Black plastic bags</i>	39.41	13.24	2290	12.55
4	<i>White plastic bags</i>	7.038	2.36	1031	5.65
5	<i>Caps, lids</i>	0.139	0.05	733	4.02
6	Glass bottles	12.37	4.16	210	1.15
7	Pure water sachet	24.713	8.30	2606	14.29
8	Balloons	0.002	0.00	12	0.07
9	<i>Metal cans</i>	12.898	4.33	500	2.74
10	Nails	0.002	0.00	4	0.02
11	Cigarette packaging/ wrappers	0.322	0.11	335	1.84
12	Crown corks	0.596	0.20	447	2.45
13	<i>Cardboard pieces</i>	0.543	0.18	178	0.98
14	<i>Glass pieces</i>	2.395	0.80	44	0.24
15	Disposable plates and spoons	2.748	0.92	769	4.22
16	Khebab sticks	0.631	0.21	289	1.58
17	Metal pieces	9.249	3.11	171	0.94
18	<i>Pieces of cigarettes</i>	0.064	0.02	286	1.57

19	Footwear pieces	1.474	0.50	76	0.42
20	Clothing/textile	15.539	5.22	409	2.24
21	Used condoms	0.003	0.00	44	0.24
22	Syringes	0.011	0.00	8	0.04
23	Used diapers	3.643	1.22	53	0.29
24	Fishing net	3.864	1.30	17	0.09
25	Rope	3.729	1.25	54	0.30
26	Strapping bands	0.043	0.01	38	0.21
27	Car tyres	12.901	4.34	12	0.07
28	Toys	33.25	11.17	34	0.19
29	Plastic cups	3.732	1.25	634	3.48
30	Food wrappers	11.817	3.97	2349	12.88
31	Flip-flops (Rubber slippers)	1.34	0.45	235	1.29
32	Batteries	0.066	0.02	25	0.14
33	Charcoal	0.63	0.21	176	0.96
34	Coconut husk	8.617	2.90	141	0.77
35	Bones	3.693	1.24	47	0.26
36	Comb	0.004	0.00	6	0.03
37	Fruit peels	0.789	0.27	203	1.11
38	Kenkey peels	2.354	0.79	193	1.06
39	<i>Styrofoam pieces</i>	0.755	0.25	143	0.78
40	Bags	24.292	8.16	24	0.13
41	Used sanitary towels	27.749	9.32	34	0.19
42	Aluminium foil	0.038	0.01	33	0.18
43	<i>Newspaper/Magazine pieces</i>	2.056	0.69	542	2.97
44	Bandages	0.05	0.02	26	0.14
45	Umbrellas	0.025	0.01	1	0.01
46	Paper drink packs	4.361	1.47	316	1.73
47	Pieces of foam	0.573	0.19	95	0.52
48	<i>Plastic containers</i>	4.571	1.54	381	2.09
49	Incandescent bulb	0.605	0.20	42	0.23
50	Toothbrush	0.001	0.00	4	0.02
51	Seaweed	0.061	0.02	13	0.07
	<b>TOTAL</b>	<b>297.59</b>	<b>100.00</b>	<b>18241</b>	<b>100.00</b>
	<b>MEAN</b>	<b>5.835</b>		<b>357.667</b>	
	<b>VARIANCE</b>	<b>84.932</b>		<b>351108.187</b>	

Sakumono beach recorded the highest number of debris items with 5154 items over the duration of the study. The lowest quantity was recorded at the Korle Gonno beach (3716 items). However, in terms of weight, debris items at Mensah Guinea beach were the heaviest (99.91kg) followed closely by 72.58kg at Korle Gonno beach (Table 4.7).

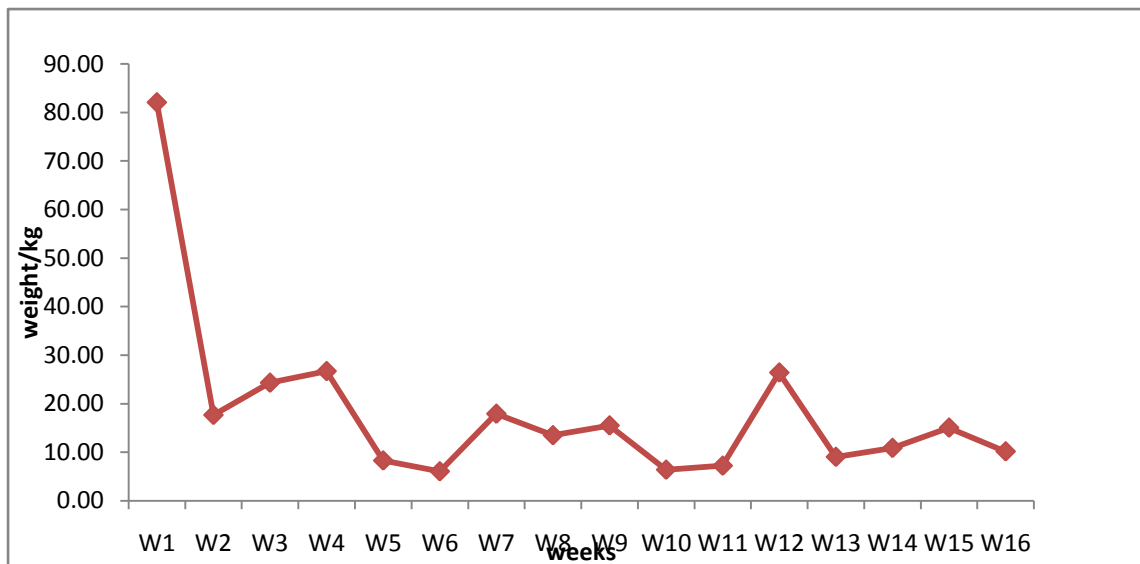
**Table 4.7: Summary of debris weight and count collected from sampled beaches over sixteen weeks.**

<b>Beach</b>	<b>Weight (kg/m<sup>2</sup>)</b>	<b>Density (items/m<sup>2</sup>)</b>
Sakumono	67.21	5154
La Pleasure	57.88	4423
Mensah Guinea	99.91	4948
Korle Gonno	72.58	3716

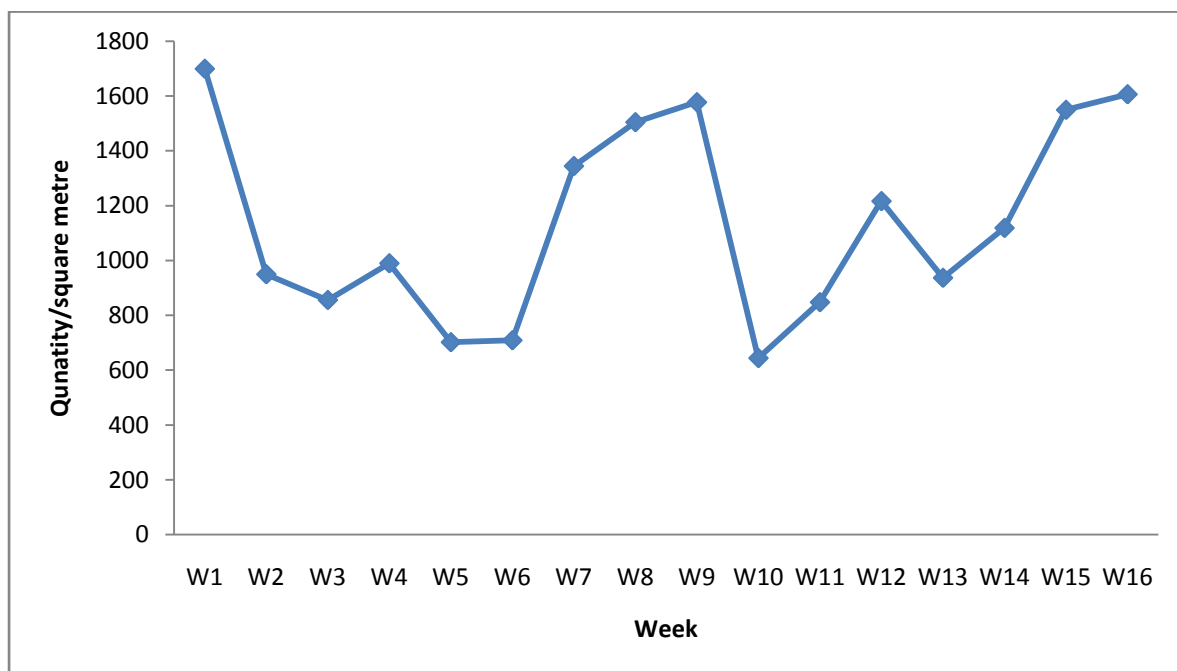


**Fig.4.3: Marine debris trends per study site measured in weight (kg/m<sup>2</sup>) over sixteen weeks.**

Fluctuations in both debris count and weight were observed at all four beach sites over the study period (Figs.4.3, 4.4 and 4.5).



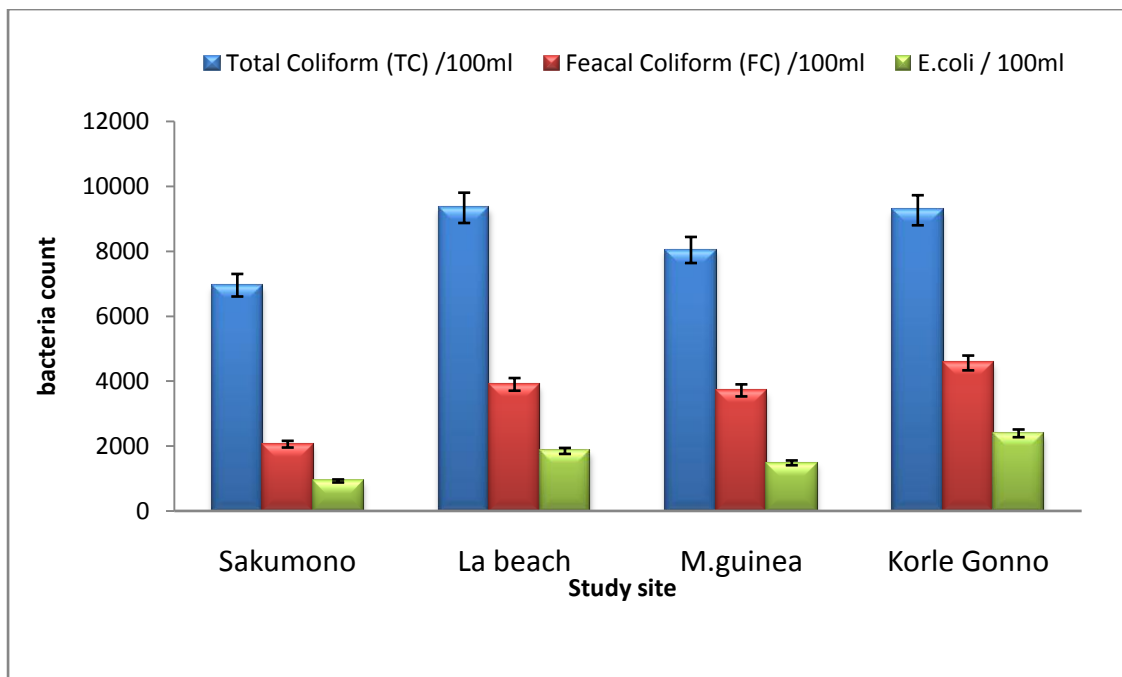
**Fig.4.4: Overall marine debris weight trend (kg/ m<sup>2</sup>) over sixteen weeks.**



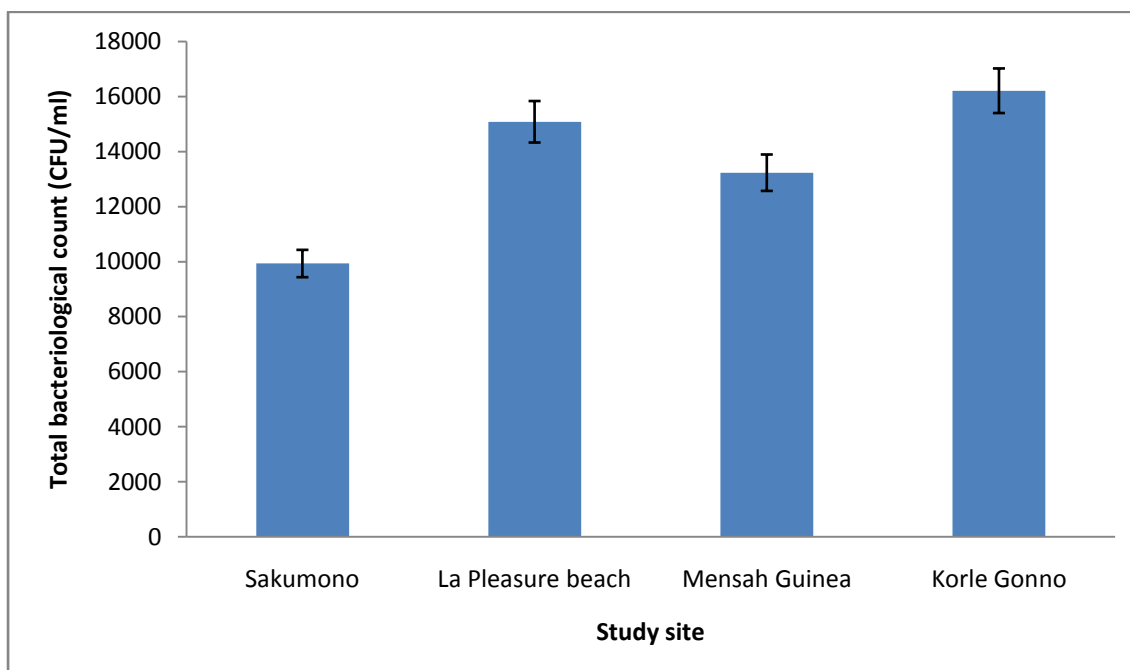
**Fig.4.5: Overall marine debris count trend (m<sup>2</sup>) over sixteen weeks.**

## 4.2 WATER QUALITY ANALYSIS

Water quality analysis carried out at all the study sites over sixteen weeks revealed differing levels of Coliforms and *E. coli*. (Figs. 4.6 and 4.7).



**Fig.4.6: Mean Coliform and *E.coli* levels recorded at study sites over sixteen weeks.**



**Fig.4.7: Total bacteria load recorded at study sites.**

## **4.3 SOCIAL SURVEY**

### **4.3.1 Characteristics of Respondents**

100 people participated in the survey at each beach location making a total of 400 people, with a response rate of 100%. Some general trends are summarised in Table 4.8. The majority of participants were in the 18-25 years and 26-40 years category.

There was no significant difference between the number of males and females who took part in this survey. The majority of respondents (48.3%) had other secondary occupations. 21.8% were traders followed closely 19.3% unemployed.

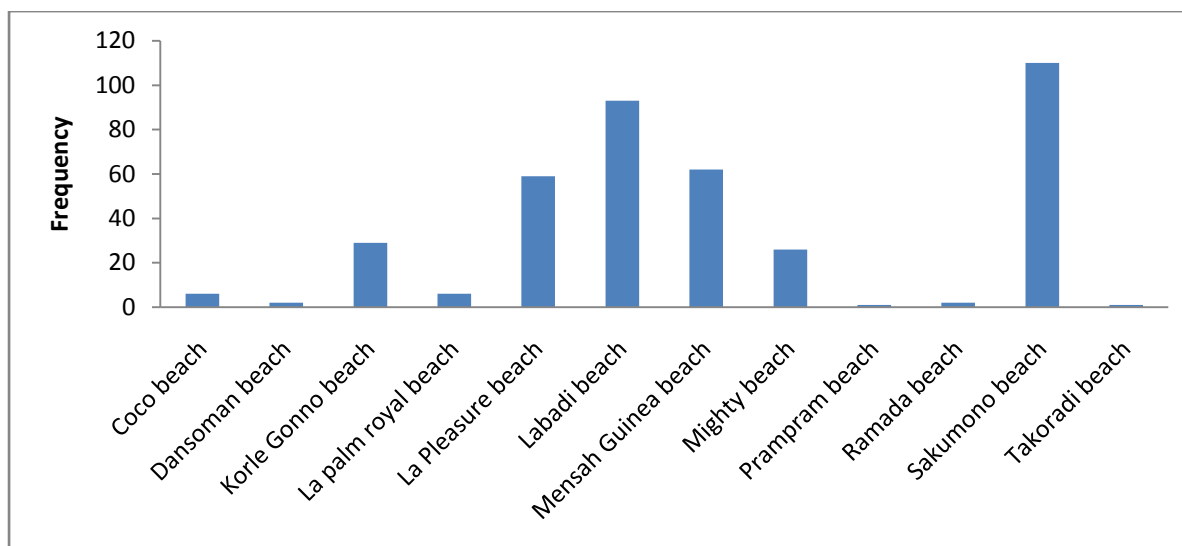
The majority (30%) of the participants fell into the choose not to answer income bracket followed closely by those in the income bracket of GHS 500-700 and those earning less than GHS 400.

Most participants had attained some level of education with a majority (31.5%) falling in the SSS/Technical/Vocational category and 25.3% being graduates.

Most (82%) of the participants were local residents, with 55.8% participants visiting beaches occasionally. Labadi, Sakumono, La Pleasure, Mensah Guinea and Korle Gonno beaches are among the most frequently patronised beaches by participants.

**Table 4.8: Summary of the demographic variables collected for the social perception survey.**

Demographic Variable	Description	Categories	Frequency	Percentage (%)
Study site	Beach locations where survey was carried out.	Sakumono beach	100	25.0
		La pleasure beach	100	25.0
		Mensah Guinea beach	100	25.0
		Korle Gonno beach	100	25.0
Residency	Place of residency at the time of survey.	Local resident	328	82.0
		Ghanaian tourist	10	2.50
		International tourist	59	14.8
		Other (Expatriate)	3	0.8
Age	Age of respondent. Age category with no response was eliminated from analysis.	18-25 years	149	37.3
		26-40 years	180	45.0
		41-65 years	71	17.8
Gender	Asked respondents their gender; male, female.	female	189	47.3
		male	211	52.8
Occupation	Primary occupation of respondent	Fisherman	43	10.8
		Trader	87	21.8
		Unemployed	77	19.3
		Other	193	48.3
Income	Average monthly income in GHS	Less than GHS 400	97	24.3
		GHS 500-700	113	28.3
		GHS 800-1000	38	9.5
		GHS 1000+	32	8.0
		Choose not to answer	120	30.0
Education	Highest level of education attained	Illiterate	25	6.3
		Primary	70	17.5
		JSS/Middle school	54	13.5
		SSS/Technical/vocational	126	31.5
		Graduate	101	25.3
		Postgraduate	17	4.3
		choose not to answer	7	1.8
Beach visits	How often respondents visit the beach	Daily	98	24.5
		Weekly	52	13.0
		Monthly	25	6.3
		Yearly	2	0.5
		Occasionally	223	55.8



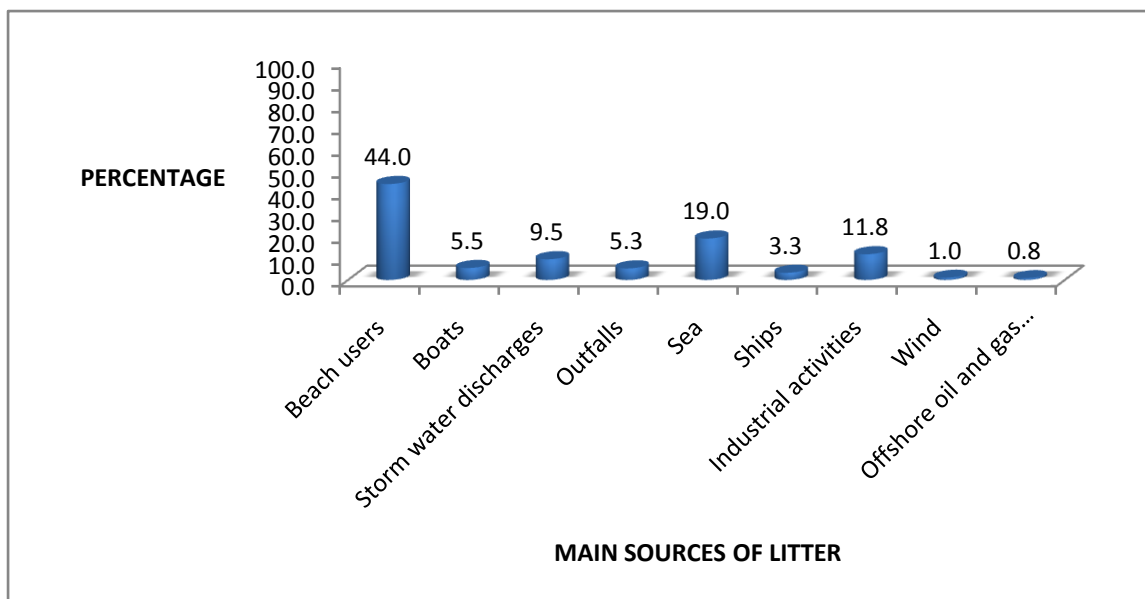
**Fig.4.8: Beaches most frequented by respondents.**

#### **4.3.2 Evaluation of Public attitudes to beach litter**

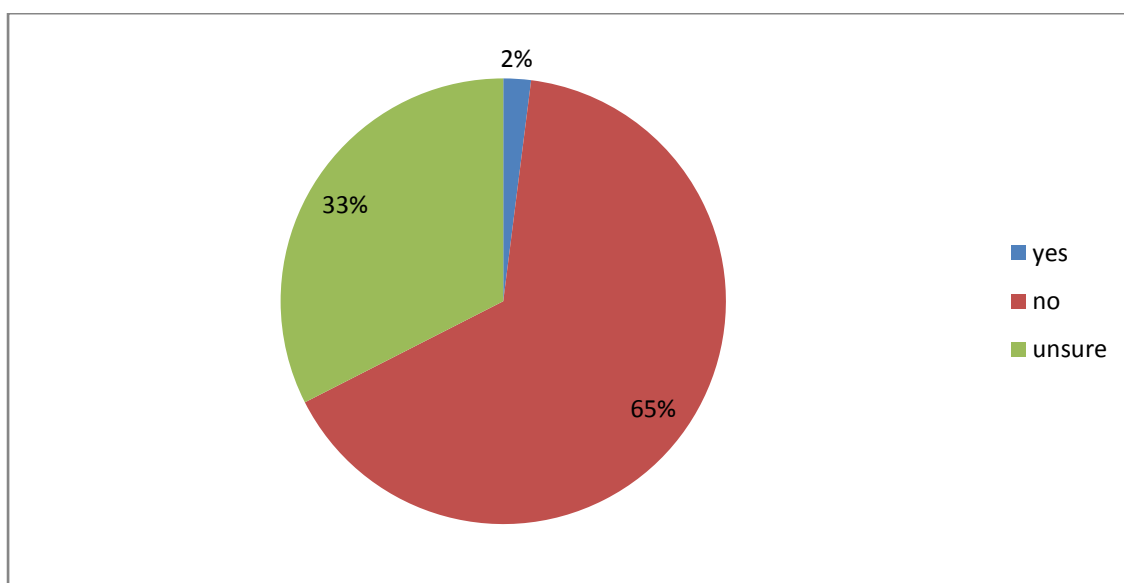
The majority of respondents (77.5%) consumed food and beverages at the beach. When asked what respondents did with litter generated at the beach, 55% admitted to leaving it directly on the beach. 34% reported they placed litter in waste bins and only 4.5% said they carried it home. 6.5% of respondents however chose not to answer.

Of those interviewed, 87.8 readily admitted to having left litter on the beach at least once with 67.4 admitting that this was their usual habit. The majority (66.8%) admitted to never collect other people's litter. 16.5% rarely collected it and 16.8% said they only sometimes did. Similarly, 56.8% of respondents admitted to speaking to those they see littering at the beach about the issue of marine debris. 24.5% rarely did so and 17.8% did so sometimes.

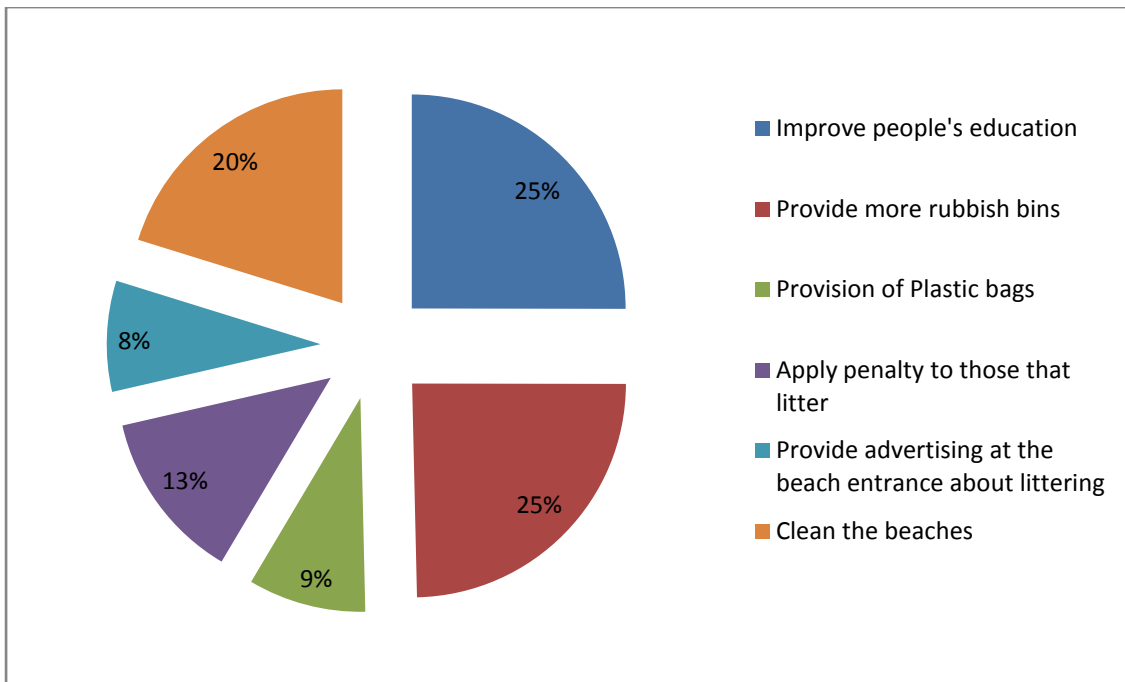
44% of respondents attributed the main source of litter on the beaches to beach users. 19% and 11.8% attributed litter source to the sea and industrial activities respectively (Fig.4.9).



**Fig.4.9: Evaluation of the perception of respondents to beach litter**



**Fig.4.10: Respondents' assessment of cleanliness of Ghana's Beaches**



**Fig.4.11: Management options by respondents to reduce beach litter.**

## CHAPTER FIVE

### DISCUSSION

#### 5.1 TREND OF QUANTITIES AND TYPES OF DEBRIS

The total quantity of marine debris collected for this study (18,241) was higher than that of Nunoo & Quayson (2003) (9,445) and Tsagbey *et al.*, (2009) with a total of 4,952. The difference in the debris density between this study and that of Nunoo & Quayson (2003) and Tsagbey *et al.*, (2009) was significant ( $f= 7.63$ ;  $p < 0.005$ ).

Fifty- one 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. The reasons for such discrepancies could be attributed to the fact that the surveys conducted by Nunoo & Quayson (2003) as well as Tsagbey *et al.*, (2009) sampled litter over six weeks from within an area of 1000m<sup>2</sup> and 500m<sup>2</sup> respectively whereas this research concentrated on debris from within an area of 1000m<sup>2</sup> for a much longer duration of sixteen weeks. As a result, the relative densities were used for the comparisons.

All three studies however, indicate a significant number of debris items on the world's dirty dozen list. The debris items found accumulated on the beach sampling sites were varied, the majority of which were the ever ubiquitous drinking water sachets, food wrappers, black plastic bags, plastic bottles and white plastic bags (Table 4.6), 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).

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 trend was not evident in my 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, 2011b) and selected beaches in Europe (OSPAR, 2007).

The quantities of plastics recorded at the beaches also compare favourably with that recorded by and Nunoo & Quayson (2003) and Tsagbey *et al.*, (2009) 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).

Plastic is generally a durable 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).

Non- degradable plastic materials remain predominant on Ghana's beaches reflecting the extensive use of plastics in everyday activities such as purchasing of groceries and packaging of several items and poor disposal of these items.

## 5.2 CATEGORIES OF MARINE DEBRIS IDENTIFIED

Unlike Slaters research (1991, 1992 cited in Slavin, 2011), 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 (Table 4.5).

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).

The high percentage of land-based marine debris recorded can be attributed to beach location, accessibility, status as a tourist hub and human behaviour. Again, based on the findings of Slater (1991); 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. 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 debris.

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 need to occur over a longer temporal scale to capture seasonal affects.

### 5.3 SPATIAL AND TEMPORAL ABUNDANCE OF MARINE DEBRIS

The highest amount of debris by count was recorded at Sakumono beach followed closely by Mensah Guinea and La Pleasure beaches respectively (Table 4.7 and Figs.4.3, 4.4, 4.5). The highest weight of debris was recorded at Mensah Guinea beach out of the four sampled beaches with La Pleasure beach recording the lowest. The Korle Gonno beach had comparatively few debris items but those present were heavy.

However, there was no significant relationship between debris count and weight. For a value of  $\alpha = 0.05$  indicating a 95% confidence level the F observed was 195.45 which was larger than the F critical of 5.99 indicating with 95% confidence that the variance between groups is not due to random chance.

Slight fluctuations were observed in the overall debris trend over the sixteen week period. The highest debris count was recorded in the first week. This could be attributed to the late - evening heavy rainfall that occurred prior to debris collection the following day as study sites had been cleared prior to start of week one of data collection.

Seawater was observed to be highly turbid. Weeks 6,7, 8 and 9 (December 9 - 30, 2013) coincided with the christmas season. This resulted in high patronage of the beaches as a result of the beach parties to mark the occasion. The sharp decline in debris count in week 10 (January 6 -12, 2013) could be attributed to the uneasy calm in the country prior to the declaration of the presidential election results. The gentle rise in debris quantities from week

11 through week 16 could also be attributed to high beach patronage due to the New year festivities culminating in valentines day celebrations (January 13 – February 17, 2013).

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 higher counts of items found at the study sites could be attributed to the fact that these sites are popular and most accessible to the local public and tourists.

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 coastlines. This compares favourably to the study of Slavin (2011) where low debris quantities were attributed to small population density with less pressure on these outfalls and drainage systems.

#### **5.4 WATER QUALITY ACROSS STUDY SITES**

Water quality analysis carried out over the sixteen week period revealed high levels of coliforms and *E. coli* for all four beach locations (Figs 4.6 & 4.7). There was no significant difference in water quality between the sites ( $T_{Cal} < 1.697$ ) (see Appendix 1). The very high levels of total coliforms is not very surprising as they are widespread in nature, are both

faecal and non-faecal in origin. The relatively high faecal coliform and *E. coli* levels at all the beach sites confirm the pervasive practice of disposal of sewage into the sea without any treatment in Ghana. At Sakumono beach, the high faecal coliform and *E. coli* levels could be attributed to the proximity of sewage outflow pipes which lead into the sea.

Proximity to the local community which increases the likelihood of litter from recreational sources as well as the proximity to the port which increases the likelihood of accidental or illegal dumping from vessels could also be a factor.

At La Pleasure beach, a drainage system from the township and the hotels along the beach, which ends up in the sea could be a contributing factor. At Mensah Guinea beach the local community is found close to the shore and the inhabitants use the beach as a refuse dump and place of convenience. Korle Gonno beach is also in close proximity to the Korle community as well as a popular site known as the “Lavender hill” where septic sewage from homes in Accra is directly discharged into the sea in the absence of a proper sewage treatment plant.

Comparing the mean levels of Total coliform , Faecal coliform and *E. coli* at all four sites to the WHO international standards (APHA/WWA-WPCF, 2001), sea water at all beaches is at undesirable levels for intake, i.e. a swimmer who gulps some amount of water when swimming may develop some health issues such as gastrointestinal illness, eye, ear and skin infections.

For primary contact, i.e. swimming, the levels of the coliform (total and faecal) at all beaches compared to WHO international standards were found to be permissible, but not desirable. For fishing and boating, the levels of coliform are within the acceptable range. Water quality

results for this study is comparable to that in the Halifax harbour where raw sewage has been discharged for more than 200 years (Buckley & Winters, 1992). Bacterial contamination is pervasive throughout the harbour, and the waterfronts along Halifax and Dartmouth are aesthetically poor owing to particulates, floatables, and odour (Walker *et al.*, 2006).

## 5.5 SOCIAL SURVEY

In this study, it was assumed that survey participants were in the habit of littering. This assertion was confirmed when almost all of the participants admitted to consuming food and beverages at the beach, 87.8% of respondents admitting to having left litter at least once on the beach with almost all respondents acknowledging that this was their usual habit.

Again, 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 believe that Ghana's beaches are not clean and yet surprisingly 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 my results as relatively high amounts of debris were collected during the beach survey.

When asked about issues that participants were not happy with along the beach, the majority stated poor facilities (toilets, litter bins) as their main concern followed by washed up 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 the 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). 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, providing advertisement at the beach entry about littering 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 four local organisations that had experience and knowledge of the beaches under study. They were:

- Accra Metropolitan Assembly (AMA)
- Tema Metro- Solid Waste Management Department
- Ministry of Environment Science and Technology and
- The Environmental Protection Agency (EPA).

The core functions of these organisations are all tailored to enhance the quality of life of the people and the protection of the environment. All the representatives from these organisations were of the view that marine debris is a major problem in Ghana. According to the representative from the Tema Metro- Solid waste department, this is so because:

- Marine debris pollutes the environment and mars the aesthetics of the beaches and thereby reduces patronage.
- Marine debris negatively impact on the health and safety of beach users (local and foreigners).
- They also affect the ecological and biological lives of marine fishes.

Again, all the representatives were of the opinion that debris on Ghana's beaches are decreasing and assess the impact of marine debris on Ghana's beaches as high with EPA's representative citing the following reasons:

- Marine debris presence affects the nation's foreign exchange earnings to be derived from high beach patronage (by both locals and foreigners).

- Their presence also degrade the beaches and its immediate environs and to the detriment of the humans and animals.

Furthermore, the main source of debris on the beach was attributed to beach users, boats, storm water discharge, outfalls, the sea, ships, industrial activities, offshore oil and gas platforms and exploration.

All representatives for the four organisations were of the view that Ghana's beaches are not clean. Each representative had suffered some kind of problem associated with litter on the beach- these included wounds, 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.

Education and sensitization, provision of more litter bins, application of penalty to those that litter, the provision of advertisement at beaches about littering and beach clean ups were some of the suggestions on how to reduce litter quantities on Ghana's beaches.

## CHAPTER SIX

### CONCLUSIONS AND RECOMMENDATIONS

#### 6.1 CONCLUSIONS

Although litter density found along the Accra – Tema coastline of Ghana seemed to be very low when compared with other regions of the world, the results of this study showed higher density of litter than similar studies of Nunoo & Quayson (2003) and Tsagbey *et al.*, (2009) that examined the same sampling sites. Comparisons of this study with that of Nunoo & Quayson (2003) and Tsagbey *et al.*, (2009) also indicate debris quantities have changed between 2000 and 2013, showing a significant increase at all four study sites.

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 four beaches were generally large and underwent weekly fluctuations with quantities peaking on occasions where beach patronage was very high and also in the event of heavy rainfall. However, Sakumono beach recorded the highest debris quantity. The results reflect the popularity of these beaches with beach goers.

Mean water quality levels in all four study locations remain high in comparison to WHO guideline levels. However, Korle Gonno recorded the highest bacteria load reflecting the use

of this beach as a popular site where septic sewage from homes in Accra is directly discharged into the sea in the absence of a proper sewage treatment plant.

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.

Results from the beach and social surveys were employed in testing the hypothesis and it can be inferred from the study that public attitudes towards littering has not changed and the type and amount of marine debris along the coast has not decreased in spite of increased public awareness of coastal pollution and existing management practices.

## **6.2 RECOMMENDATIONS**

In the short to medium term, 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.

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.

In the short to medium term, provision of access routes to beach locations by the Ministry of roads and transport will help ensure vehicular movement to carted debris collected and will help curb the practice of burying of debris on beaches and their subsequent exposure with high tidal and wave action.

Again, in the short term, the provision of collection, disposal and treatment infrastructure by the metropolitan assemblies and private waste management contractors remain important to help curb the practice of disposing of sewage directly into the sea without prior treatment.

Water quality levels should be monitored regularly by the Ministry of Environment, Science and Technology in conjunction with the Environmental Protection Agency to avoid disease outbreaks. Where the bacteria levels are deemed life threatening, the beach should be closed off to the general public until such a time when it is safe.

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 particularly the police service 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 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 by the Environmental Protection Agency 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 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 1****Differences in coliforms and *E. coli* between the four study sites**

<b>SITE</b>	<b>MEAN/100ml</b>	<b>Mean difference</b>	<b>t-calculated</b>	<b>t-critical</b>
<b>Sakumono</b>	620.7	-321.9	0.205	1.697
<b>La Pleasure</b>	942.6			
<b> </b>				
<b>Sakumono</b>	620.7	-205.7	0.206	1.697
<b>Mensah Guinea</b>	826.4			
<b> </b>				
<b>Sakumono</b>	620.7	-392.4	0.097	1.697
<b>Korle Gonno</b>	1013.1			
<b> </b>				
<b>La Pleasure</b>	942.6	116.2	0.378	1.697
<b>Mensah Guinea</b>	826.4			
<b> </b>				
<b>La Pleasure</b>	942.6	-70.5	0.431	1.697
<b>Korle Gonno</b>	1013.1			
<b> </b>				
<b>Mensah Guinea</b>	826.4	-186.7	0.254	1.697
<b>Korle Gonno</b>	1013.1			

## **Appendix 2**

### **Beach users guide**

#### *Introduction*

*Hello, my name is Irene P. Himans. I am an MPhil student with the Institute for Environment and Sanitation Studies at the University of Ghana. I am conducting a survey of adults, 18 years and above on marine debris (trash and other solid material that enters oceans and coastal waters and often ends up on our beaches. Also known as litter). This survey seeks to assess perceptions on marine debris- their beliefs about littering and beliefs in whether their actions have an impact in the marine environment. These questions will be used to determine if trends in litter type exist between the different beaches and people's perception of their own contribution towards this issue. The survey will be carried out at the Sakumono, la Pleasure, Mensah Guinea and Korle gonno beaches in Ghana.*

*The survey will take 10-15 minutes to complete and all your answers are anonymous and will be kept completely confidential.*

#### **Would you like to partake in this study?**

(a) Yes (Go to Question One) (b) No

#### **Demographic information**

##### **1. Do you live/work/ in this area?**

(a) 'Local' resident (b) Ghanaian tourist (c) International tourist (d) Other

##### **What age category do you belong to?**

(a) 18-25 years (b) 26-40 years (c) 41-65 years (d) above 65years (e) Choose not to answer

##### **2. What is your gender?**

(a) Male (b) Female

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

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

**4. What is your average monthly income?**

- (a) less than  400 (b)  500-700 (c)  800-1000 (d) above  1000 (e) Choose not to answer

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

- (a) Illiterate (b) Adult Literacy (c) Primary (d) JSS/ Middle School (e) SSS/Tech/ Vocational  
(f) Graduate (g) Postgraduate (h) choose not to answer

**6. How often do you visit the beach?**

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

**7. Which beach do you visit the most?**

.....

**8. In your opinion what is happening to amount of litter along the beach?**

- (a) Increasing (b) decreasing (c) remaining constant (d) so small that it doesn't really matter  
(e) no idea.

**Beach dislikes****9. What issues are you not happy with along the beach?**

- (a) Poor facilities (such as toilets, litter bins) (b) Beach erosion (c) Excrement /Bad smells  
(d) Washed up debris (e) Flies and other insects (f) Noise from vehicles (g) Crowded beaches  
(h) Poor water quality (i) Rocky beaches

**Beach Behaviour**

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

(a) Yes (b) No

**11. 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 (d) Choose not to answer

**12. Have you at least once left litter on a beach?**

(a) Yes (b) No

*(a) If you answered yes, is this your usual habit/ do you usually throw things away?*

(a) Yes (b) No

**13. If you see other people's litter do you collect it?**

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

**14. If you see other people 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

**15. What do you think is the main source of litter on the beach?**

(a) Beach users (b) Boats (c) Storm water discharge (d) Outfalls (e) Sea (f) ships (g) Industrial activities (h) Wind (i) offshore oil and gas platform and exploration

**16. In your opinion, what is the main problem that marine debris can cause to beach users?**

(a) Impact on human health (b) Impact on marine life (c) Beach becomes unattractive (d) injury (e) discomfort (f) Unsure (g) other

**17. Have you suffered any kind of problem directly associated with litter on the beach?**

(a)Yes (b) No

*a) If you answered yes, what happened?*

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

**18. Do you believe that Ghana's beaches are clean?**

(a)Yes (b) No (c) Unsure

*a) If you answered no, does this cause you any problem or concern?*

(a)Yes (b) No (c) Unsure

**19. What can be done to reduce the amount of litter at the beaches?**

(a) Improve people's 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 (g) other

**20. Who is responsible for keeping Accra-Tema beaches free from litter?**

.....

**Thank-you for participating in this survey.**

|

**Appendix 3**

**Stakeholders Guide**

**Would you like to partake in this study?**

Yes (Go to Question One) No

**Background Information**

**1. Name of organization**.....

**2. Core functions**

.....  
.....  
.....

**3. In your opinion, is marine debris a major problem in Ghana?**

(a) Yes (b) No

**4. What are the reasons for your choice?**

.....  
.....

**5. In your opinion, what is the state of marine debris on Ghana's beaches?**

(a) Increasing (b) decreasing (c) remaining constant (d) so small that it doesn't really matter  
(e) Not sure

**6. 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

**(a)What are the reasons for your choice?**

**7. What do you think is the main source of litter on the beach?**

(a)Beach users (b) Boats (c) Storm water discharge (d) Outfalls (e) Sea (f) ships (g) Industrial activities (h) offshore oil and gas platform and exploration (g) All the above (h) other

**8. What do you think is the main reason for litter on Ghana's beaches?**

(a) Easy way to get rid of things (b) Low sense of responsibility (c) Convenience (d) lack of understanding of the consequences (e) All the above (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)Unsure

**10. Have you suffered any kind of problem associated with litter on the beach?**

(a)Yes (b) No

*a) If you answered yes, what happened?*

(a)Wounds (b) Disease (c) Discomfort (d) loss of revenue (e) other.....

**11. Do you believe that Ghana's beaches are clean?**

(a)Yes (b) No (c) Unsure

*a) If you answered no, does this cause you any problem or concern?*

(a)Yes (b) No (c) Unsure

**12. What is your suggestion to reduce the litter quantity on Ghana's beaches?**

(a) Improve people's 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 (g) All the above (h)other.....

**13. Who is responsible for keeping Accra-Tema beaches free from litter?**

.....

**Thank-you for participating in this survey**