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DEPARTMENT OF THEORETICAL AND APPLIED BIOLOGY

Assessing Theoperations and Management of the Kojorom Final Waste Disposal Site by the Sekondi Takoradi Metroplitan Assembly

A thesis submited to the Department of Theoretical and Applied Biology in partial fulfillment for the award of Master Of Science (Environmental Science) Degree

By

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DECLARATION

I hereby declare that this submission is my own work towards the MSC and that to my best of knowledge it contains no materials previously published by another person nor material which has been accepted for the award of any other degree in the University except where due acknowledgement has been given in the text.

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DEDICATION

I dedicate this work to my dear wife Alice and my two lovely kids, Terrence and Jenelle.

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I wish to thank my God for His blessings and staying power that has made it possible for me to complete this work.

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ABSTRACT

Rapid population growth and urbanization have resulted in poor environmental conditions in most urban settlements in Ghana. Solid waste disposal in particular has become a daunting task for the Metropolitan, Municipal and District Assemblies (MMDAs) in the country. Even though greater portions of internally generated and common funds of most Assemblies go into waste management, our streets and gutters are filled with rubbish which makes the environment very dirty. This study investigated the operations and management of solid waste dumped at the Kojokrom Dumpsite by the Sekondi-Takoradi Metropolitan Assembly (STMA), and the impacts of its operation on residents and the environment. The methodology used included questionnaires and interviews with key stakeholders, field measurements, and laboratory analysis of water samples from the Anankor river. The results show that about 202 metric tonnes of waste are received at the site daily. Also, the permanent technical staffs employed by the Assembly to manage the facility lack the requisite qualification to effectively do so. This contributed to the many environmental hazards experienced in the Kojokrom community. Majority (98.5%) of residents and scavengers had appreciable knowledge of the hazards they were exposed to from the dumpsite. About 90% of the respondents also agreed that the major hazards were odour, fire and smoke, windblown litter, surface water contamination, insects and rodents infestation, birds and leachate. The high mean values for the BOD (645.0 mg/L) in the Anankor river suggests that pollution of some sort has taken place in the study area. Some control programmes are in place to effectively reduce nuisances such as fire and smoke, pest, and accidents. However, in other cases such as leachate control and monitoring, surface water contamination, landfill gas, offensive odour and handling of hazardous waste, the control measures were not effective enough for the reduction of the nuisances. The poor management of the Kojokrom dump site is having a serious environmental consequence on the Kojokrom community and on the staff and workers at the dump site. It is recommended that the Assembly finds a suitable and sizeable land to construct an engineered landfill and employs qualified personnel to work at the waste management department.

TABLE OF CONTENTS

CHAPTER THREE

CHAPTER FOUR

CHAPTER FIVE

CHAPTER SIX

LIST OF TABLES

LIST OF PLATES

LIST OF ABBREVIATIONS AND ACRONYMS

BOD	Biological Oxygen Demand
CMA	Cape Coast Metropolitan Assembly
COD	Chemical Oxygen Demand
ENGO	Environmental Non Governmental Organization
EPA	Environmental Protection Agency
MMDA	Metropolitan, Municipal and District Assembly
NIMBY	Not In My Backyard
NMOC	Non Methane Organic Compound
RPC	Reasonable Preventable Condition
SPSS	Statistical Package for Social Sciences
STMA	Sekondi-Takoradi Metropolitan Assembly
TDS	Total Dissolved Solids
WMD	Waste Management Department

CHAPTER ONE

1.0INTRODUCTION

The problems of waste management have existed ever since humans made the transition from hunting and gathering societies to settled communities .Good waste management practice every where is known to provide a better living environment and reduce the risks of health hazards. It is also an essential factor contributing to productivity and welfare for the people. In pre-historic times, the accumulation of domestic waste around camps caused itinerant tribes to relocate to sites that were clean. The challenge facing most Metropolitan, Municipal and District Assemblies (MMDAS) in Ghana today is how to provide adequate disposal facilities effectively to handle the large volumes of waste generated. While cities in the developed countries have generally overcome the problem of waste accumulation and now grapple with finding appropriate methods of treatment and disposal, cities in the developing country are still grappling with the basic problem of waste accumulation as well as its disposal.

As observed by Pacione (2005), the main problems facing developing country cities with regards to waste management are related to the collection of waste from the city environments, with between one-third and one –half of all the waste generated in the cities remaining uncollected. Gilbertson (1969), noted that among the environmental problems, none has been of greater historical significance than the disposal of solid wastes. According to Rhyner *et al*. (1995), the first municipal dumps were established somewhat later in Athens when about 500B.C "the council of Athens began requiring scavengers to dispose of wastes no less than a mile from city walls" throughout much of the Medieval period on "out of sight out of mind "approach to the problems of human waste were very much evident.

A lot of environmental awareness creation is being undertaken by Non Governmental Organizations (NGOs) and as such communities, individuals and groups are becoming increasingly concerned about the serious implications for their health as a result of the escalating waste management problem now facing developing, as well as more highly industrialized countries.

In managing waste there are economic, legal, administrative, social and educational issues that must be considered. Concentrating only on the technical aspects of storage, collection, treatment and disposal will therefore not yield the desired results of safeguarding the environment and the well-being of the citizenry. The uncontrolled dumping of solid waste can spread diseases such as typhoid fever, cholera, dysentery, staphylococcal infections, infectious hepatitis and some vector borne diseases.

The population of Sekondi–Takoradi metropolis is about 38000 persons (Ghana statistical services, 2002), and this coupled with the influx of hundreds of economic migrants to the city every day as a result of the discovery of oil and gas in the region, has compounded the sanitation problem confronting city managers. Before the acquisition and use of the Kojokrom dump site, the Sekondi Takoradi Metropolitan Assembly had dumped solid waste in Ketan, Kwesimintsim, Kokompe No.1, Kokompe No.2 and the Diabene dump sites. These places were either a low lying area or abandoned stone quarry sites. These sites were so poorly managed that there was huge public outcry for the Assembly to discontinue their operations since the communities could no longer bear the hazards those dump sites created. The hazards ranged from smoke and fly

nuisance to leachate, foul odour, rodents, windblown littering, dust and cockroaches infestation problems. In the year 1999, the Sekondi-Takoradi Metropolitan Assembly(STMA) acquired a plot of land at Sofokrom for the construction of an engineered sanitary landfill that would be supported by the World Bank. Lack of funds and scarcity of suitable land space for the landfill has brought the project to a halt. The community also expressed her reservations about the negative impact likely to arise as a result of siting the landfill in the community. Meanwhile, the STMA had to locate a site for temporary disposal of the solid waste generated in the metropolis and a site in Kojokrom which was partly stone quarry site and partly a marshy land was chosen to deal with the waste generated in the metropolis. Unfortunately, the same situation of poor management continued to exist at the Kojokrom dump site and the people in the community on several occasions attempted to stop the STMA from dumping solid waste on their land. Accumulated putricible waste is known to be easily accessible to disease-carrying rodents. Some airborne viral infections are also associated with waste as well as habitat formation for breeding insects and mosquitoes .According to Push and Rushbrook (1999), uncontrolled waste also blocks drainage channels and increases health problems related to the ponding of stagnant water .In addition, accumulated waste provides the ever present hazards of physical injury to people coming into its close proximity, particularly, children. The collection, transportation and final disposal of waste is aimed at protecting public health and improving environmental protection and should therefore be carried out so as to accomplish this aim. Filth and rubbish are gradually consuming the city due to the improper management of waste. Gutters are choked with rubbish which make the environment dirty, breeds mosquitoes which spread malaria known to be a number one killer especially among children. Houseflies deposit pathogenic organisms that cause cholera, another deadly disease.

The Environmental Sanitation Policy (1999) stipulates that environmental sanitation is aimed at developing and maintaining a clean, safe and pleasant physical environment in all human settlements and to promote the social, economic and physical well-being of all sections of the population in Ghana. However, the way and manner in which our waste is finally disposed of has serious health impact on the environment with attendant social and economic costs. According to Rushbrook and Pugh(1999), solid wastes can come into contact with human beings at several stages in the waste cycle and the group that are at risk include the following: waste collectors, workers in facilities that produce infectious and toxic materials, people living close to waste disposal facilities, waste pickers or scavengers, and population whose water supplies have become polluted due to waste dumping or leakages from landfill sites .For example, groundwater used for drinking purposes can become chemically or microbiologically polluted if wastes are dumped in or near water sources. Handling of solid waste obviously entails health risks, potentially leading to infections and chronic diseases and accidents. Flooding also causes major damage to public infrastructure and private property while pollution of water resources increases the technical difficulty and cost of providing water supplies to citizens. Sanitation services must therefore be provided reliably and continuously to mitigate the negative effects of social and economic activity in human settlements.

The current environmental sanitation status of Ghana leaves much to be desired. Less than 40% of urban residents are served by a solid waste collection service and even in those cases where wastes are removed, it is disposed of in an in-sanitary manner, posing serious risks to human health and the environment, including the country's dwindling water resources. Vector-borne

diseases such as malaria and bilharzias are rife due to the virtual absence of pest and disease vector control programmes in landfill sites (Environmental Sanitation Policy, 1999).

The comparatively high temperatures experienced in Ghana coupled with the high relative humidity predispose the waste to a high rate of decomposition. Delay in the disposal of waste which is highly organic in nature has disastrous effects on the quality of the environment and in the long run on the health of residents. Organic domestic wastes in particular pose serious health risks since they ferment, creating conditions favourable to the survival and growth of microbial pathogens. They are especially hazardous if they become intermixed with human excreta due to poor sanitation. There is therefore the need to protect human health and the environment from the risks and impact associated with dump sites. In addition, the unsightliness and foul smell of inadequately managed wastes constitute a major discomfort to citizens and visitors alike to Ghana.

With the exception of Kumasi and Tamale Metropolitan Assemblies which have engineered sanitary landfill, the remaining Assemblies in Ghana still resort to the crude open dump practice. It is therefore becoming a canker for Metropolitan, Municipal and District Assemblies in Ghana not to manage their dump sites according to operational guidelines.

Solid waste management is an enormous problem for many city managers not only in Ghana but all over Africa, Asia, South America and even some European countries. According to a United Nation Development Programme survey of 151 Mayors of cities from around the world, the second most serious problem that city dwellers face (after unemployment) is insufficient waste

disposal. One to two-thirds of the solid waste generated are not collected. Even the waste that is collected is often disposed of in uncontrolled dumpsites or burned; polluting water resources and the air. The bare truth is that prudent waste management involves very costly activities whose short term returns are by and large intangible. The financial outlay in waste management is high and it is difficult to raise the capital needed to manage the waste generated effectively and efficiently. The dilemma facing city administrators is how to raise the needed capital to finance waste management services in a sustainable manner.

The final disposal method selected is very crucial if a lot of uncontrolled crude dump sites and irregular waste collection are to be minimized. Though landfilling is practiced as the final disposal method, the operation and management of the facility is very crucial. Deficiencies in the management of solid waste contribute significantly to the continuing high rate of infant mortality rate from diarrheal and vector borne diseases. More than half of all reported diseases in out-patient-departments in hospitals can be attributed to poor environmental sanitation. Studies have shown that a high percentage of workers who handle refuse, and individuals who live near or on disposal sites, are infected with gastrointestinal parasites, worms and related organisms. (Visvanathan et al.1999).

1.1STATEMENT OF THE PROBLEM

In recent times, public outcry has been rife on the environmental hazards associated with the inappropriate disposal of solid waste generated in the Sekondi-Takoradi metropolis. The inability of the Sekondi-Takoradi Metropolitan Assembly to manage the waste generated in the metropolis satisfactorily has been the centre of discussion on both Radio and Television and

among the populace. High government officials, including Ministers of State and Parliamentarians have also expressed their concerns about the deplorable solid waste disposal situation in the metropolis. Several Environmental Non-Governmental organizations (ENGOS), Institutions and individuals have also added their voices to the problem.

The major problem associated with dump sites has been attributed to the low caliber of technical staff involved in the management of the dump sites. Increase in population with its attendant high waste generation and inadequate resources available to the Assembly, do not ensure first-class quality management and sustainable operation at the dump sites. Improper management has led to serious environmental hazards which, if not checked, may lead to disastrous consequences. The fact is, the dump sites attract not only birds, but rodents, insects, reptiles, and flies among others, that feed on the waste which makes them more serious vectors of disease.

Equipment used at the dumpsite are old and breakdown frequently thus limiting the number of times the waste is compacted. Workers at the site are not provided with enough protective materials against the hazards that the dump sites generate .Regrettably, there are no materials piled at the site to cover the waste deposited in order to reduce odour and fly nuisances that are created as a result of the accumulation of waste.

The study therefore was to assess the operations and management of solid waste dumped at the Kojokrom dumpsite by the STMA and its effects on the environment and people living close to the site.

1.2GENERAL OBJECTIVES

The main objective of the study was to assess the operation and management of solid waste dumped at the Kojokrom dumpsite by the STMA and its effects on the environment and people living close to the dumpsite.

1.3 SPECIFIC OBJECTIVES

The specific objectives of the study were to:

- determine the volume of waste deposited daily at the dumpsite;
- assess the perception of residents and scavengers on the implications of the hazards they are exposed to;
- assess the water quality of the Anankor river
- investigate the effectiveness of any control programmes for the reduction of nuisances at the dump site and its surrounding areas.

1.4 STATEMENT OF RESEARCH QUESTIONS

The study attempted to answer the following main questions:

- What were the volumes of waste generated and its effect on the environmental hazards (nuisances) associated with the management and operation of the dump site?
- Has the leachate from the dumpsite affected the nearby water body?
- Are the people living close to the dump site aware of the implications of the hazards they are exposed to?
- What are the measures put in place for the reduction of environmental hazards associated with the management and operation of the dump site?

1.5 THESIGNIFICANCE OF THE STUDY

The research efforts examined the factors that have led to the poor management of the dump site and advance recommendations which when implemented will go a long way to help solve the problem of waste management in the Sekondi-Takoradi Metropolitan Assembly in particular and other Metropolitan, Municipal and District Assemblies in Ghana in general.

It was also meant to create awareness among workers (skilled and unskilled) and residents living around the dump site of the need to adhere to personal hygiene practices in order to prevent short and long term infections that might emanate from working at or staying close to the dump site.

It is hoped that the study will add to the search for a solution to the proper operation and management of dumpsites and landfills in Ghana which is of great interest to policymakers, administrators and the general public.

1.6 ORGANIZATION OF THE STUDY

The dissertation is organized in six (6) chapters. Chapter one (1) deals with the background and rationale of the study, statement of the problem, general and specific objectives of the study, statement of research questions, significance of the study and ends with the definition of terms. Chapter two (2) deals with the review of literature and conceptual framework related to the topic under study. It considers generation and sources, composition and classification, waste quantities, health implications and nuisances associated with poor disposal of solid waste. Chapter three (3), which deals with the methodology, discusses the methods used to collect data, sample size and methods used in selecting the sample from the population. Chapter four (4)

focuses on analysis of data collected, while chapter five (5) deals with discussions of the results. Chapter six (6), which is the final chapter, gives a summary of the major findings and recommendations.

1.7 DEFINITION OF TERMS

Domestic Wastes – wastes generated in homes and may consist primarily of vegetables and other putricible matter, paper, metals, textiles, plastics, glass, etc.

Environment– the physical surroundings including air, water, land, natural resources, flora, fauna, humans and their interrelationships.

Environmental Impacts– any change to the environment, whether adverse or beneficial, wholly or partially resulting from activities, products or services.

Industrial Wastes – solid wastes resulting from industrial processes and may include textile rejects, fish and canning wastes, wastes from demolition and construction activities, and agricultural farm wastes.

Leachate – liquid containing organic and inorganic chemicals from the decomposition of waste that drains from a landfill.

Refuse – domestic, urban and industrial solid waste not disposed of by water as the carrying capacity to differentiate it from liquid waste.

Scavenging – the uncontrolled picking through waste to recover useful items

Specialized Wastes – these are radioactive wastes, hospital and pharmaceutical wastes, condemned food, disused vehicles and plants and equipment.

Trade Wastes – wastes generated from retail, commercial, and business sources including markets. It includes paper, parking cases, vegetables and putricibles, plastics, glass, scrap metal, etc.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

This chapter discusses waste generation, sources, quantities, minimization, and storage. It also considers the nuisances associated with dump sites and their implications on human beings, land, air and water.

Available literature on the operation and management of dumpsites seems to be guided by the same principles throughout the world. Various terminologies and definitions have been given to the term "solid waste" over the years and have been used synonymously with refuse, garbage or simply waste. Gilbertson (1969),reaffirmed that the term "solid wastes" was brought into use recently in order to differentiate between the present-day broad concept involving waste management and the previous emphasis on garbage and other household wastes. He stated further that solid wastes are now taken to include all non-gaseous, non-liquid wastes resulting from a wide range of community, industrial, commercial and agricultural activities.

Similarly, refuse is described as domestic, urban and industrial solid waste not disposed of by water as the carrying capacity to differentiate it from liquid waste. It consists of domestic

garbage and other discarded materials, wastes that are swept up from the streets and unwanted items and materials of many kinds from commercial and industrial enterprises: these items are usually referred to as refuse (The United Nations Centre for Human Settlements – Habitat, 1994).

The objective of a solid waste service is to collect, transport or convey, and finally dispose of the waste in a hygienic and aesthetically acceptable manner at the lowest cost possible. This means that final disposal cannot be considered in isolation but in a well thought-out fashion with the waste stream since contamination and health hazards associated with waste may start from the generation, storage, collection, transportation to the final disposal of the waste in a landfill (Ellis, 1969).The waste stream takes into consideration, the time of generation of the waste through short-term storage in homes, collection and transportation until it is finally disposed of in a satisfactory manner such that the environment may be free from contamination or pollution. At each stage of the waste stream, various nuisances of varying degrees are created and these nuisances if not avoided or minimized at an early stage end up at the dump site and deterioration becomes faster.

Ellis (1969), acknowledged that there has been and certainly will be a marked increase in both the weight and volume of refuse produced both in developed and developing countries not merely by domestic users but also by trade and industry. He mentioned further that this will be due to increasing prosperity and higher standards of living leading to the consumption of a variety of consumer goods. The percentage increases in the volume and weight of solid waste that will be witnessed can be linked to the changing character of refuse, which in itself is the result of a number of factors. These factors range from the demand for consumer goods and the

intense advertising and publicity both in the print and electronic media given to various products resulting in very large increase in the amount of packaging material discarded as waste. The use of plastics has made a great impact in the packaging industry recently and this has led to the complexity of the types of waste being managed.

In today's consumer society a large amount of waste is being produced and accumulated but only a small portion is satisfactorily disposed of sanitarily. This situation is threatening our living environment and the earlier we changed from the variety of lifestyles of consumption the better it would be for us and posterity.

2.2 Generation and Sources of Waste

The characteristics of the waste and its constituents determine in most cases the type of treatment or disposal method that can be applied. Solid waste is generated from many sources such as domestic, trade, industrial, institutional, hazardous and specialized sources. Domestic wastes as the name implies are wastes generated in homes and may consist primarily of vegetables and other putricibles matter, paper, metals, textiles, plastics, glass, etc. Trade wastes are wastes generated from retail, commercial, and business sources including markets. It includes paper, packing cases, vegetables and putricibles, plastics, glass, scrap metal, etc. Industrial wastes are solid wastes resulting from industrial processes and may include textile rejects, fish and canning wastes, wastes from demolition and construction activities, and agricultural farm wastes. Specialized wastes on the other hand are radioactive wastes, hospital and pharmaceutical wastes, condemned food, disused vehicles and plants and equipment. Institutional waste generally includes components similar to both domestic and commercial waste. However, generally, there

is high proportion of paper than food waste. This waste is produced in establishments such as schools, government offices, military bases, religious buildings, etc.

In the quest for the final disposal of waste by land filling, the waste type and quantities to be generated should be taken into consideration for the determination of the lifespan of the land fill (Ghana Sanitary Landfill Guidelines, 2002).

2.3 COMPOSITION AND CLASSIFICATION METHODS

With reference to the method of classification of solid waste, there are two schools of thought. The first is the description of the waste according to the specific matter or origin of the waste and the second has to do with the classification into four groups according to treatment visibility. In group one (1) are matter that may either be incinerated or composted. Examples are organic kitchen waste, offal wastes (bones), vegetables, etc. Group two (2) is made up of matter that can only be incinerated such as wood, leather, rubber, plastics, cardboard, etc. In group three (3) are matter that can be neither incinerated nor composted (bricks, stones, glass, porcelain, pottery, iron and other metals) and in group four (4) are fine granular matter (saw dust, rice waste, etc).

2.4 QUANTITIES OF WASTE

In Ghana, unlike other developed countries, there is lack of relevant waste stream data on waste generated. Waste management policies are therefore produced based on assumptions and not on any hard empirical data. For instance, the waste management department of STMA has estimated the city's daily output of solid waste to be 285 metric tonnes based on the per capita waste generation given by the Ghana Statistical Service in the year 2000. But it is very difficult to

establish the accuracy of the per capita daily waste output calculated by the Ghana Statistical Service and the subsequent waste generation estimate made by the city authorities. Changes in lifestyle and consumption patterns among the population could bring changes in the levels of waste generated. It is also known that urban residents generate more waste than their rural counterparts due to their high consumption of products (Onibokun and Kumuyi, 1999).If this is true then the per capita daily waste generation in Sekondi-Takoradi which is a city in Ghana could actually be higher than the national average of 0.5kg. In this case the estimated waste generation given by the city authorities could be incorrect. Conduct of waste stream analysis to know the exact volume and composition of solid waste that need to be managed is therefore crucial.

According to Gilbertson (1969), it is safe to say, with regard to solid wastes, that the amounts produced by each person everyday and everywhere is increasing. This is as a result of social, economic and technological changes. In rural settlements, solid waste generated are in modest quantities and therefore do not pose so much problem as in urban areas where the problem associated with waste is predominantly high. As cities grow, the problems caused by solid waste become enormous and Ghana, for that matter Sekondi-Takoradi Metropolis, is not an exception.

Several methods have been used to estimate the volume of waste generated in a given locality. These are the specific weight method, specific refuse volume and bulk density. Of the three, the specific weight method gives the most reliable information on amounts of waste that can be obtained. This is done by weighing collection cars from a given locality and based on the number

of inhabitants (population), the specific weight of the waste may be obtained stating the weight per capita per unit time.

Ellis (1969), noted that the additional weight and volume of solid wastes has created and will continue to create many problems. The rapid urbanization taking place in many countries uses up vast areas of land for housing and industrial development. While more refuse is created by these developments, there is a shortage of land for purposes of waste disposal. In this connection, it is important to make an analysis of the distances that refuse can economically be transported to a disposal site, taking into account the cost of compacting waste materials.

Gilbertson (1969), acknowledged that there are significant and disturbing changes in the characteristics and composition of wastes. Cost of collection, treatment and disposal are rising year by year and often represent a high proportion of municipal budget. Waste characteristics and per capita generation rates are two important parameters in designing any effective solid waste management program. The generation rates vary depending on various factors such as the lifestyle of the people, state of the Nation's economy, the demographic profile of the population and seasonal variations..

Normally developed countries produce more solid waste per capita (0.7 – 1.8 kg/d) compared to middle income (0.5 – 0.9 kg/d) and low income countries (0.3 – 0.6 kg/d) (The United Nations Centre for Human Settlements, 1994).

Rushbrook and Pugh (1999), stated that in all communities, people produce domestic waste and urbanization and industrial development has rapidly increased the range and diversity, as well as

quantity of wastes that require collection and disposal. In order to plan the development of a waste management facility therefore, the waste manager requires information about the quantities and types of waste that are generated within and around the municipality which may be included in the waste management plan and in addition, projected increases in quantities of each waste stream should be estimated in order to plan for future provision of facilities.

Hoornweg and Thomas (1999), noted that population growth is one of the major causes of increase in solid waste volume in many cities. The problem is severe in cities of developing countries, where about 0.76 million tons or approximately 2.7 million cubic metres of municipal solid waste is produced per day. They further stated that higher living standard results in higher solid waste generation rate and change in waste characteristics. The presence of degradable organic compounds, moisture contents, particle size and composition, density and compressibility are some of the solid waste properties playing major role in degradation rate in dumpsites.

Many reasons can be assigned to the increase in the quantity of waste produced worldwide. These include the standards and habits of living, degree of industrialization, climatic factors and population. The amount of waste increases as there is an unconscious tendency to throw away still usable and recyclable articles because of the attitude of always wanting something new. Excessive packaging, though nice to the eyes, is as good as buying articles with waste. Presently in Ghana and in Sekondi-Takoradi in particular, if you visit the market and buy five (5) items you are likely to have as many as six (6) packaging materials. Each item is put in a polythene bag and all are then parceled again in a bigger bag. Items like fufu and soup, rice and stew, cooking oil, water and many others are all packaged in plastics which end up in our environment and

finally at the dumpsite. Plastics are non- degradable materials and are known to remain in the ground for several years and contribute to soil infertility .Solid waste policies in most advanced countries are geared toward reducing waste volumes but this is not so in most developing countries like Ghana.

2.5 WASTE STORAGE, COLLECTION AND TRANSPORTATION

Waste storage is the time lapse between the generations of the waste until it is collected for final disposal. Basically, there are two storage facilities. The first is the indoor, where individuals are expected to store the waste in sanitary dustbins with close fitting lids. The second is the outdoor where individuals and households in high density low income areas collect and dispose of their waste in central containers provided by the Metropolitan, Municipal or District Assembly (MMDA).Depending on the type of waste being handled, care should be taken so that the waste does not keep too long for putrefaction to start before it is finally collected for disposal. Fly infestations commonly arise from wastes which have been awaiting collection for a long time to be transported to final disposal sites. This creates additional nuisance problems when conditions are rife and as a result bacteria increase in numbers thus leading to the spreading of disease pathogens.

2.6 WASTE DISPOSAL

There are various methods for the final disposal of solid waste. Among these are crude dumping on land, barging to sea, hog feeding, incineration and controlled tipping (landfilling for the purpose of land reclamation).

Gilbertson (1969), however, maintained that open dumping of solid wastes on land, though considered unsanitary and unaesthetic, is still the most common disposal practice. In addition to harbouring rats, flies, mosquitoes and other disease carrying vectors, the waste is burnt thereby creating serious problems of air pollution and safety while leakages from the dumps contribute to the pollution of surface and ground water.

There are three (3) generally accepted methods of treatment and disposal of solid wastes; composting, incineration and sanitary (engineered) landfilling. Various hazards are associated with each method of disposal. However, when the necessary precautionary measures are put in place at the planning stage of the process, most of the hazards could be minimized if not eliminated completely.

Luis *et al*. (1997), noted that the final disposal of solid waste, operation procedures, final cover system, after care, and after use of landfill depend on the waste characteristics. Controlled landfill is rarely practised in most developing countries with few exceptions. Most of the cities dispose of their waste in open dumps and these dumps lack proper equipment and trained manpower for its effective operation.

Rushbrook and Pugh (1999), believed that the inadequate final disposal of solid wastes thrives because of the mistaken belief that it is the cheapest disposal method. Depositing waste along roads and riverbanks or in abandoned quarries and hoping that the waste will go away is both naïve and dangerous. It is inevitable that the chemical and biological contaminants in wastes will find their way back to humans to affect their health, quality of life, and working activities. Soluble and suspended contaminants in water leaking from the site (leachate) will enter surface watercourses and underground water. Contamination may then directly affect the drinking water

supplies and/or the aquatic food chain. Grazing animals on dumps can pass on diseases via the terrestrial food chain as well as by pests through infestation. Those living on or near a dump are also at risk from direct hand-to-mouth transfer of contamination and from inhalation of volatile compounds and aerosols.

2.7 SOLID WASTE MANAGEMENT IN GHANA

The responsibility for waste management is placed on Metropolitan, Municipal and District Assembly (MMDA's). By the Local Government Act (1993), Act 462 section 10 subsection 3 (d and e), MMDAs are mandated to initiate programmes for the development of basic infrastructure and provide municipal works and services and also be responsible for the development, improvement and management of human settlements and the environment in the district. This means that all waste deposited in the public domain is the property of the District Assembly. The selection of a site for developing a dump site is therefore one of the most important decisions MMDAs make in executing their waste management responsibilities. They are further required to ensure that they make available adequate sites for the present and future storage, treatment and disposal of wastes by identifying, acquiring, demarcating and protecting suitable areas for such purpose (Environmental Sanitation Policy, 1999).

2.8 HEALTH IMPLICATIONS OF DUMPSITE OPERATIONS

Wastes are rejects from homes and industries whose concentration in a given locality constitutes an environmental hazard or nuisance. A number of problems occur from dumpsite operations. These impacts can vary from fatal accidents (e.g., scavengers buried under waste piles), infrastructure damage (e.g., damage to access roads by heavy vehicles), pollution of the local

environment such as contamination of groundwater and/or aquifers by leachate and residual soil contamination after dumpsite closure, to simple nuisance problems such as dust, odour, vermin, or noise pollution.

In Ghana, garbage is dumped into open drains, thereby creating not only a serious pollution problem, but also providing breeding places for disease carrying insects. Due to increasing awareness creation on environmental issues, communities are no longer willing to tolerate methods that in the past were quite readily accepted for final waste disposal. District Assemblies are responsible for managing and protecting the environment so as to prevent hazards to human health, conserve natural resources and maintain pleasant surroundings. In this regard, the collection, treatment and disposal of solid wastes are critical in safeguarding our water resources.

Oduro (2004), noted that solid waste management practices in Ghana have been beset with problems of health concerns for the citizens. The main solid waste management practices have been the use of uncontrolled to semi-controlled open dumps. These dumps have been of environmental concern with respect to the nuisance they created and continue to create. He went further to state that the dumps are the sources of pollution to the very ground water systems which are used by most of the citizens and the repercussion of such management practices has been poor health. Malaria, diarrhoea, and intestinal worms and upper respiratory tract infections are among the most frequent health problems reported at outpatient facilities in the country; with seasonal epidemic outbreaks of cholera. Diarrhoea, dysentery, intestinal parasites (worms), typhoid and cholera are all caused by poor disposal of solid waste.

Nogarh (2007), agreed that the occurrence of many communicable diseases in our communities is attributable to the deplorable state of waste management in the country. The state of our urban

environment where waste has accumulated virtually everywhere underscores great weakness in our waste collection system. Diseases that can be prevented these days are on the increase because of poor sanitation.

Labourers employed to work at dump sites and scavengers who have close contact with waste run the risk of cuts, infections and infestation by parasites. These people work without the use of protective clothing and practice poor personal hygiene.

2.9 SCAVENGING

Scavenging is the uncontrolled picking through waste to recover useful items. In most cases, scavenging is done by either people who live close to the dump site or people who have moved to settle in makeshift tents near the dump and earn their livelihood through the sale of recyclable materials. Most of the items that end up in our dumpsite can be recycled or reused. Scavengers therefore play an important role since they collect reusable and recyclable materials, increasing the longevity of the dumpsite and thereby reducing the pressure on urban land use.

According to Rushbrook and Pugh (1999), the most desirable situation is not to have scavenging operations at the site. However, the case for scavenging must be strong enough to counterbalance the objections that can be raised against it at the site since they are concerns that bother on safety hazards to personnel of both scavenging groups and dump sites employees. The interface caused by the scavenging activity prevents the efficient conduct of work at the dumpsite and have severe negative impacts on the productivity of the equipment and the efficiency of the overall operations.

The Ghana Landfill Guidelines (2002), argued out strongly that scavenging is unavoidable at dump sites/ landfill sites in developing countries and therefore should be rather organized as an auxiliary activity. For aesthetic reasons, scavenging can be confined to a specific area of the waste dump facility so that they do not interfere with normal operations.

Oduro (2004), pointed out that in most developed countries, scavenging of waste on a landfill site is strictly prohibited. This is so because most of the wastes are sorted at source. Whether landfill managers agree or not, this major activity will continue to go on at the dumpsite. Scavengers should therefore be organized into a workforce so that their operations could be monitored and supervised. In order to prevent and protect scavengers from attracting solid waste related diseases such as plague, typhus and dengue fever, there is the need to encourage the salvaging of waste by providing areas and facilities for separation of recyclable or reusable materials.

2.10 NUISANCES ASSOCIATED WITH DUMPSITE

At most dumpsites, the main nuisances encountered are related to windblown litter, odour, vermin and other pests, fire, gas, dust and leachate.

2.10.1 Windblown Litter

In an era where most of the waste produced especially in developing countries have a high constituent of paper and plastics, poor litter control is particularly offensive to neighbours. Windblown litter is an aesthetic nuisance in communities around dump sites. Good operational practice should be adhered to in terms of waste discharge, placement, compaction, and covering to minimize the occurrence of windblown litter. The sanitation of the dump site is judged by the

control of windblown litter which is normally done by fencing around the total area of the waste dump facility.

Rushbrook and Pugh (1999), indicated that a landfill is not well managed if paper or other lightweight material is blown around the site. They further expressed the fact that litter, though a highly visible sign of poor control of the waste being deposited, is also one of the simplest forms of pollution that can be contained in landfills if site operation and maintenance procedures are so organized in such a way as to minimize littering. Litter control is very difficult to manage particularly during windy days and various techniques have been devised to reduce the problem. The size of the working face and the method used for placing and spreading waste influence the effort required in controlling littering at dumpsites. When waste is discharged at the bottom/toe of the working face it prevents rubbish from being blown about as against the case where the waste is placed on top of the working face and open to the elements on the wind. Another method used to overcome littering at dumpsites is the provision of portable temporary litter screens installed around the working face of the dump site to collect/attract litter. These litter screens may be made of simple wooden or metal frames covered in wire mesh or netting. Additionally, a perimeter fence acting as secondary litter screen can be used to stop litter from traveling outside the landfill boundary. Dump site workers can be organized daily to collect litter not captured by litter screens.

They further recommended the application of water to dampen waste loads containing a high concentration of paper. This has been challenged by various writers on landfill management. Pacey (1999), argued that a major pollutant to ground and surface water is leachate which creates an environment in which microbes degrade. The use of large volumes of water for litter and fire

control with its attendant increases in the amount of leachate concentration therefore should be discouraged.

2.10.2 Odour Nuisance

Odour in dump sites come from a number of different sources and some of these are gases, fresh refuse, malodorous chemicals, agricultural and sewage sludge. Even the best landfill site will have many operational and environmental problems if it is operated badly. One of the most significant problems associated with dump site is odour which is due to the processes of waste degradation.

Odours cannot be eliminated in an open dump especially where there are no designated areas for dumping and cover for food waste. Odours are carried to areas several kilometres away from the dumpsite especially during the cool hours of the night. Normally, complaints from the public due to odourous emissions from municipal waste, especially people who live close to dumpsites or who use nearby land or roads, are increasing significantly in many developing countries. Odour is one of the main complaints made by nearby communities where waste dumps are situated and a major reason for the resistance to the selection of lands within communities for use as dumpsites.

According to Flintoff (1976), landfills should meet two basic requirements in order to reduce nuisances such as odour. These are waste deposition and compaction in thin layers to no greater than about 2m in depth and secondly, that each day the surface of the deposited waste should be covered with suitable soil or similar material of 15cm in thickness.

Unpleasant odours may continue for a mile or more from the site, and cause unpleasant sensations, by triggering reflexes in the body that may result in nausea, vomiting, headache, upsetting of stomach or appetite, upsetting of sleep, shallow breathing and coughing, decreased heart rate and constriction of blood vessels in skin and muscles, irritation of eyes, nose and throat, annoyance, anger and depression and a general decrease in well-being and enjoyment. If odours themselves are not dangerous they still indicate that harmful odourless gases (methane) may also be present in the waste. Odours are also responsible for a number of pre-existing medical conditions, including 'morning sickness' in pregnancy.

Kleeberg*et al*. (2003), mentioned that odours are important sub-category of perceived air pollution which, together with noise and heat act as environmental stressors.

2.10.3 Vermin and Other Pests

Dumpsites harbour flies and vermin, creating a high level of nuisance among workers, scavengers and surrounding inhabitants. Vermin and other pests are a potential public health risk and should not be allowed to breed in dumpsites .According to Rushbrook and Pugh(1999), the abundance of these birds, vermin, rodents and flies around dumpsites, is a clear indication that the waste is not being managed properly. Sites accepting animal carcasses, tannery and food wastes are mostly prone to fly infestation. Ideally, therefore, the time lapse from the initial collection of waste to the final disposal should be kept to a minimum to reduce the risk of infestation by flies. Anti-fly measures such as earth cover, removal of reasonable preventable condition (RPC's) and spraying for the destruction of flies can be carried out to reduce and eliminate fly nuisance.

In the report of a recent study undertaken in Hungary by the Research Triangle Institute (1994) on the control of insects and rodents on waste dumps it was observed that pests can be a great nuisance and public health problem at any improperly managed dump sites. The research work further stated that flies and mosquitoes are two types of insects of primary concern because they both spread diseases. Flies spread many food borne diseases, such as Salmonella, by carrying bacteria from the waste to food. Mosquitoes, on the other hand, breed in water that collects in depressions on the landfill surface and in uncompacted and uncovered wastes such as piles of tires and other bulky items. Mosquitoes are known to carry diseases such as encephalitis, dengue fever and malaria. Rats and other rodents spread diseases such as rabies, rat-bite fever, leptospirosis, typhus, and bubonic plague. The same study pointed out that rodents are brought to the site in loads of waste or migrate from surrounding areas and remain at the facility if there is food, shelter and water. Regular inspections for the detection and destruction of rodents need to be carried out. During the poisoning of rodents, adequate signs should be displayed to inform landfill workers, visitors and scavengers of possible dangers.

Rushbrook and Pugh (1999), observed that birds are attracted to dump sites in large numbers, particularly where sites receive appreciable amounts of food wastes. Scavenging birds found at landfill sites constitute a potential health hazard and a nuisance because of noise and their droppings introduce pathogens to nearby water bodies and crops especially if residential areas are situated nearby. Vectors are generally not present at a properly operated and maintained sanitary landfill. The provision of daily cover is the primary safeguard against vector problems.

Well-compacted wastes and cover material effectively prevent vectors from emerging or burrowing into waste materials.

2.10.4 Fire and Smoke Nuisance

Fire in load refers to a load of wastes that are either on fire and/or smoldering or smoking. Open fires are a regular feature of open dumps. Most fires, though may be caused by landfill gas igniting itself, may also be caused by fire in waste transported from collection points in towns and cities due to hot ash deposited in central communal containers. Fire at dump sites is a major complaint by people living in nearby communities because of its attendant smoke nuisance including ash and particulate matter.

Open burning on dump sites are not to be permitted and fire outbreaks are to be extinguished immediately to prevent it from spreading. Burning areas are to be isolated by making a trench around fire. If the fire starts to blaze it should be left to burn out. If the fire continues to smolder, the burning material should be spread out and drenched with water until the fire is extinguished. This may be done by the Fire Service or using a cesspit emptier or water tanker. Fires in waste at dump sites are uncommon but do occasionally occur and it is important for site operators to be aware of the dangers associated with them. All fires on site should be treated as a potential emergency and dealt with accordingly (The Department of Environment, 1997).

2.10.5 Landfill Gas

Mixtures of gases that appear in waste dumps mainly originate from anaerobic degradation of organic wastes. Gas composition depends mainly on waste being degraded, usually Methane

(CH_4) and Carbon four oxide(CO_2) make up 40-60% each, and the remainder is Nitrous oxide (N_2O_2) and traces of other compounds, such as hydrogen Sulphide.

Gases from dump sites may not only have potential health effects on those people working at the site, but also on those living in the local area. Gases from waste dumps may spread for up to a mile or more from the dump site. The methane and the carbon dioxide which are the main constituents of these gases are known as greenhouse gases. Greenhouse gases form a layer surrounding the earth, trapping in heat thus resulting in global warming. Methane is one of the most significant greenhouse gases known and gases from waste dumps are also the greatest contributor of atmospheric methane. Gases from waste dumps therefore, have significant impact on global climate change. Methane and carbon dioxide can be harmful to the vegetation forming part of a dump site covering, as it does not allow oxygen to reach the roots. This may result in destruction of vegetation.

Uncontrolled waste dump gas poses great risks through its explosive, asphyxiate and greenhouse gas characteristics. Potential problems arising from waste dump gas can lead to asphyxiation of people entering buildings on or near dump sites, poses greater risks to human health, cause nuisance problems especially odour and can have detrimental effects on crops and vegetation on or adjacent to landfill sites (The Department of Environment, 1997).

Concerning waste gas, Pacey (1999), noted that depending on the availability of oxygen, the biodegradable wastes are converted to carbon dioxide, methane and water and the percentage of methane increases with reduction of freely available oxygen due to the placement of cover materials.

Gas from a waste dump is one of the significant ways a dumpsite can affect the immediate environment, so management and it's monitoring on and within the immediate environs of the landfill site is very important (The Ghana Landfill Guidelines, 2002).The U.S Department of Health and Human Services in a study conducted at the Alliance Landfill established that if not designed and operated properly, landfills can emit air contaminants at levels that could adversely affect nearby populations. Waste dump gas also includes small amounts of ammonia, carbon monoxide, hydrogen, nitrogen, oxygen, sulfides, and non-methane organic compounds (NMOCs) such as benzene, trichloroethylene, and vinyl chloride. Microorganisms within the waste dump produce methane and carbon dioxide under anaerobic conditions. Carbohydrates from paper, cardboard, and other paper products which form the major components of refuse decompose initially to sugars, then mainly to acetic acid, and finally to methane and carbon dioxide. The rate of landfill gas emissions depends on atmospheric pressure, wind speed, age of the dump site and composition, current activities, engineering controls, and odor-control practices (U.S Department of Health and Human Services, 2003).

2.10.6 Dust Nuisance

Dust from waste dump operations is mainly a problem during periods of dry weather but can also arise from dusty waste as it is tipped at the site (The Department of Environment, 1997).

In the control of dust emissions waste dump operating procedures call for water spraying in high-traffic areas and at soil stockpiles. Trucks are required to have their taps in place until just before tipping, and water is sprayed when the garbage is tipped. When high dust events occur, people with preexisting respiratory conditions (e.g., asthma, bronchitis, chronic obstructive pulmonary

disease (COPD), etc) could suffer adverse reactions (U.S Department of Health and Human Services, 2003).

2.10.7 Leachate

Rushbrook and Pugh (1999), stated that any waste dump facility has the capacity to generate sporadic leachate in excessively wet conditions. However, it is only necessary to install leachate management systems when leachate generation could impact adversely on the environment. Depending on the availability of oxygen, the biodegradable wastes are converted to carbon dioxide, methane and water. They also noted that leachate is created from water already present in the waste or entering from outside especially during rainfall and contains extracted contaminants from the decomposing waste. They pointed out further that the polluting potential from leachate depends on several factors including but not limited to the following;

- Quantity of free liquid not absorbed into the waste
- Concentration of pollutants in the leachate
- Rate at which leachate can leave the site
- Proximity of leachate beneath the site coming into contact with drinking water supplies
- Ability of environmental, physical, chemical and biological processes to reduce the concentrations of pollutants before they come into contact with water supplies

Pacey (1999) remarks that leachate is one of the major water pollutants produced in a waste dump and if not controlled can seep through to pollute ground and surface water. He further stated that the quality of leachate is complex and contains numerous types of soluble organic, inorganic and bacteriological constituents and suspended solids. It contains many harmful contaminants, some of which are carcinogenic.

Waste dump gas and leachate contribute to long-term effects by polluting air, water and land. In order to minimize leachate production, all run-offs from outside the site must be intercepted by suitable drainage ditches. Where necessary, culverts can be constructed to allow the water to pass under site roads, bunds or other obstacles. These waters, which may be discharged without treatment, shall be strictly segregated from leachate and run-off from operational areas of the dumpsite. The deliveries of large quantities of waste with high moisture content contribute significantly to high leachate generation and should therefore be discouraged.

2.10.8 Noise

Objections to noise are infrequent at dump sites. One of the most predominant sounds objected to, is the bleeping of heavy vehicles reversing to deposit waste. Where sites operate at night noise which would be tolerable during day time becomes intolerable to residents especially during the hours of darkness.

2.11 CONCEPTUAL FRAMEWORK

Different kinds of waste management concepts have been outlined especially for dump management. The bare truth is that maintaining environmental quality in dump site management is quite expensive. However, considering the fact it is even more expensive to repair the damage caused to the environment as a result of poor management, it is very proper not to neglect environmental quality in operations of dump sites. Pollution, whether of air, water or land, affects environmental quality and therefore the need to put in place measures to minimize environmental hazards should be top of our priorities.

2.12 SUSTAINABLE INTERGRATED WASTE MANAGEMENT AND4R CONCEPT

The goal of Municipal Solid Waste Management is to protect the health of the urban population, particularly that of low income groups who suffer most from poor waste management. Municipal Solid Waste Management aims at promoting hygienic disposal of waste by controlling pollution, protecting the environment and to preserve resources to ensure the sustainability of ecosystems. Finally, Municipal Solid Waste Management aims at generating employment and incomes in the sector itself.

All over the world, ignorance of the environmental and health hazards caused by final disposal of waste by landfilling, incineration and crude dumping has led to indiscriminate solid waste disposal practices. As the environmental problems due to improperly designed and sited waste disposal facilities become more acute and as existing disposal sites reach capacity, the costs and logistics involved in finding new facilities have become even more disheartening. Increased public awareness of the environmental consequences and enormous waste of resources represented by current patterns of conspicuous consumption has initiated a revolution in the policy and practice of how we handle our waste.

Tchobanoglous *et al.* (1993), described six functional elements of a solid waste management system. These include, waste generation **(**waste handling and separation, storage), processing at the source, collection (separation, processing), transformation of solid waste, transfer and transport and final disposal. Integrated solid waste management is the combination of a number of alternative waste control methods in a complementary manner, in a way that best meets local

needs. No single approach is capable of solving the mounting garbage crisis due to the diversity of waste stream components in different nations (Brown, 1999).

Communities develop an integrated solid waste management system when all the functional elements have been evaluated and matched for effectiveness and economy. In order to reduce environmental impact and maximize efficiency of materials use, ISWM hierarchies may be imposed. Hierarchies reflect the preferred waste management alternatives which should be explored, in order of preference (Tchobanoglous *et al.*,1993).

The 4Rs provide a useful conceptual framework for integrated waste management. The most appropriate hierarchical framework that has been developed to date is the "four Rs" approach. The 4Rs are reduction, reuse, recycling and recovery. It is an adaptive management approach based upon fundamental principles of sustainability. The 4R principles appear to be the most appropriate strategy for effecting change. If the policy framework for anticipated change is consistent across and within these jurisdictions, then policy development and program delivery can be coordinated and integrated to ensure complementarities across and within jurisdictional boundaries (Nickerson, 1993; ORTEE, 1994).

Techniques for managing waste include source reduction, reuse, recycling, energy recovery and proper disposal. Waste management should be approached from the perspective of the entire life cycle of material use, which includes production, distribution, and consumption as well as waste collection and disposal. While immediate priority must be given to effective collection and

disposal, waste reduction and recycling should be pursued as an equally important long-term objective.

2.13 PRIVATE SECTOR INVOLVEMENT IN WASTE MANAGEMENT

Informal waste recovery and scavenging may be rendered more productive through support measures and appropriate technical design of the waste management systems. Public sector involvement in waste recovery and/or leasing of waste recovery rights to private sector enterprise may be considered.

CHAPTER THREE

3.0 METHODOLOGY

3.1Introduction

This part of the project deals with the procedures and methods used to collect data from the field for the study. It also deals with the area of study and a brief description of the population, instruments used to collect data, sampling procedures, data collection techniques, type and sources of data and the technique used for data analysis.

3.2 AREA OF STUDY

The study was carried out at Kojokrom in the Essikadu-Ketan Constituency in the Sekondi-Takoradi Metropolis of the Western Region of Ghana. It is located about two and kilometers from Sekondi, the administrative Capital of the Region. Kojokrom lies between latitude 4º.55N and Longitude 1º.40W of the Greenwich Meridian. The dump site is about100 metres from Mpintsin and less than 50 metres from residential houses at the outskirt of the Kojokrom community.

The main occupations of the people are fishing, trading, stone quarrying and small scale crop farming. It was as a result of the stone quarry activities that voids have been created and the Sekondi-Takoradi Metropolitan Assembly is reclaiming the land with solid waste from the city.

Plate 1 The map of Kojokrom with demarcated area showing the dumpsite

3.3 POPULATION OF THE STUDY AREA

The population of Kojokrom is about five thousand, two hundred and forty four (5,244) people. There are a total of eight hundred and twenty nine (829) houses and two thousand two hundred and eighty seven (2,287) households (Ghana Statistical Service, 2002).The accessible population included adults aged twenty one (21) years and older and residing at Kojokrom. The target population included the people living close to the landfill and who are directly affected by the nuisances created at the dump site. There are some residential buildings that are located about thirty metres away from the dump site.

3.4 DATA TYPES AND SOURCES

Data used for the study were from both primary and secondary sources. It also included Water monitoring which was carried out at the downstream of the Anankor river in the community to find out if the leachate from the dumpsite has had any negative impact on the water body.

3.4.1 Water Monitoring

The water samples were taken at three different points from the Anankor river from August 2010 to February 2011.The samples were collected in 1000ml plastic bottles and were stored at a temperature of about three degrees Celsius in a box before they were transported to the EPA Laboratory in Takoradi for analysis .Temperature, pH, and conductivity were determined in-situ at the time of sample collection using TPS WPBI HANNA multifunctional meter. The temperature of the water sample was determined by immersing the thermometer into the water and then recording the readings on thermometer. The pH meter was used to determine the alkalinity or the acidity of the water

3.5 SAMPLING TECHNIQUES

3.5.1 Purposive Interview

From small staff strength of the Waste Management Department (WMD) of the STMA, 12 were purposively selected for the interview. These included the head of department and the operational and technical staff. The questionnaire was aimed at soliciting information on their operation and management skills, experience and technical competence in managing dump sites, noting gaps that exist. Monitoring and supervision staffs who work at the head office of the waste management department were also interviewed on the challenges they encounter in the course of their operation and how they manage the hazards that are generated at the site.

3.5.2 Data Collection from Residents and Scavengers

Probability methods were used in the sampling of residents from a sample size of one hundred (100) of people living within say 100 metres away from the dump site and the questionnaire administered on them. The houses within the vicinity of the dump area were numbered and the simple random sampling procedure was used in selecting the sample of 100. This was done to ensure that every individual household was given equal opportunity to be selected and also to the researcher generalize the findings of the study from the entire population.

Pieces of paper were cut into two square centimeters and numbered 1to 829; each representing a house. These were folded and placed in a box and the numbers were picked using the lottery method until all the sample size of 100 had been picked. After a sample has been picked, the box was reshuffled and the next sample picked without replacement and without looking into the box. In compound houses with multiple households, to arrive at the data producing sample, one member of each household was selected using the simple random sampling technique after the rational had been explained to them. Pieces of paper were cut based on the total number of households. One of the pieces of paper had "yes" written on it whiles the rest had "no" on them. The member of the household who picks the "yes"(in the lottery) was selected to complete the questionnaire. In single households, the head of family was purposively selected for cultural reasons.

The Waste Management Department (WMD) provided a list of sixty (60) registered scavengers at the site but on daily basis about 35 people go to the site to pick recyclable materials. Thirty (30) people out of the registered number of 60representing fifty percent (50%) were selected for the study. In selecting the scavengers for the study, the probability method was also applied in

sampling of the scavengers from a sample size of sixty that was presented by the waste management department of STMA. Here also pieces of papers measuring three square centimetres and numbered 1to 60 with each number representing the name of a scavenger as it appeared on the list, were placed in a box. They were then selected one after the other until the 30 had been selected and questionnaires administered on them.

Before the questionnaires were distributed, a research assistant who had been trained by the Researcher explained to each respondent the bases for the study and how the results could be of importance to them. The research assistant also assisted the illiterate members within the sample population to fill the questionnaires. Each respondent was given five days to complete the questionnaire for collection by the research assistant while the interview results were collected from the research assistant daily by the researcher for coding.

Further discussions were organized for all registered scavengers who collect recyclable and reusable materials (metals, plastics, bottles) from the dump site to ascertain the level of environmental hazards/risks they are exposed to.

A brief walk was undertaken to observe the degree of environmental degradation in the community. This was to serve the purpose of providing additional and accurate information on the hazards on the environment as provided by residents.

3.6 EXTIMATION OF VOLUME OF WASTE GENERATED

The volume of solid waste generated in the metropolis was estimated based on the estimated population of Sekondi-Takoradi using that of the year 2004 as a baseline. The per person generation rate of 0.53 kg per day and a population growth rate of 3.5% per annum were assumed.

3.6.1 Extimation of volume of waste dumped at the dumpsite

Unlike some dumpsites where an electronic weighing bridge has been installed at the site to check the weight of waste being deposited, the Kojokrom dumpsite has no such facility. The STMA has weighed all the waste collection containers (15 cubic metres) which have been placed at vantage points in the metropolis. Thus, the operators of the waste dump are able to estimate the volume of wastes that are carried by the vehicles to the site.

3.7 INSTRUMENTATION

A combination of different data collection techniques which complemented one another was skillfully used to maximize the quality of the data and reduce the chances of bias. The instrument consisted of a questionnaire designed by the researcher. This was chosen because it permitted anonymity and results in a more honest response. A separate questionnaire was designed for staff working at the dump site and monitoring and supervisory staff posted at the WMD of the STMA. The format of the questionnaire was in two parts. The first part consisted of the background of respondents. The second part was made up of questions to solicit information based on the objectives of the study, on preliminary consultation and works, how waste is accepted and deposited, knowledge of environmental hazards associated with the operations and management

of the dump site and measures put in place to manage such hazards, infection control and knowledge and practice of personal hygiene.

The second set of questionnaire was designed for residents and scavengers working at the dump site. The format, also like that for dump site staff, was in two parts. The first part consisted of the background of respondents. The second part was made up of questions to seek for information on the knowledge of environmental hazards associated with the operations and management of the dump site, infection control and knowledge and practice of personal hygiene. The structured questionnaire using a combination of open and close ended questions and Likert type scale with options namely: YES, not sure (NS), and NO were used. The questionnaire was distributed to be filled by the literate population while two trained research assistants assisted the illiterate population within the sample to fill the questionnaire, using it as an interview guide.

The chief and some opinion leaders in the community were contacted to provide background information on interactions that took place before the quarry site was released for the operation of the dump site.

3.8. DATA HANDLING, PROCESSING AND ANALYSIS

To ensure that the entire questionnaire distributed were returned, each was numbered and at the end of each day the interview guide filled with the help of research assistants were cross checked for inconsistencies. The analysis of field data involved description, summarization and interpretation of data. For consistency the questionnaire and interview schedules received were edited and coded, inputting and running of the results. Data obtained from the field was analyzed using computer software the Statistical Package for Social Sciences (SPSS).

CHAPTER FOUR

4.0 RESULTS

4.1INTRODUCTION

This section deals with the analysis of data collected from the study area which includes the responses on questionnaires and of the water samples collected from the Anankor river.

4.2 BACKGROUND CHARACTERISICS OF RESPONDENTS

The educational background of residents and scavengers are presented in Table 1. About 7.7% had no formal education, 46% had basic education (Junior High School), 26.9% had attained Senior High School education while 19.2% had attained tertiary education.

Table 1: Educational Background of residents and scavengers at the Kojokrom dumpsite in 2010

Level of Education	Number of respondents	% of Respondents
No education	10	7.7
Junior High School	60	46.2
Senior High School	35	26.9
Tertiary	25	19.2
Total	130	100.0

Of the six waste management staff of the STMA who returned their completed questionnaire, 4 (or 66.6%) have had middle school education, 1 (or 16.7%) has had secondary school education and 1 (16.7%) had tertiary education (Table 2).

Table2 Educational background of STMA waste management staff IN 2010

Level of Education	Number of respondents	% of Respondents
No education	0	0.0
Middle/junior high	4	66.6
Senior High School	1	16.7
Tertiary	1	16.7
Total	6	100.0

Table 3: Number of years respondents have stayed near or worked the Kojokrom dumpsite

Length of stay in area	Frequency	%
Less than 5 Years	58	44.6
Between 6-10 Years	39	30.0
Between 11-15 Years	16	12.3
Above 16 Years	17	13.1
Total	130	100.0

Of the 130 respondents (residents and scavengers), 58 (or 44.6%) had either stayed in the area or worked at the dumpsite for between 0 and 5 years;39 (or 30%) have lived there for between 6 and 10 years, and 16 (or 12.3%) between 11-15 years while 17 (or13.1%) had stayed or worked in the area for at least 16 years (Table 3).

Table 4: Years of service of employees in Landfill Management

Years of service	Number of respondents	% of respondents
1-5 years	2	33.3
Above 5 years	4	66.7
Total	6	100.0

Table 4 gives the number of years employees of the dumpsite / landfill site have practised dumpsite or landfill management. About 33% have practised for 5 years or less while 4, representing 66.7% 2 have worked for more than 5 years.

4.3 WASTE GENERATION AND COLLECTION

The annual and daily volumes of waste generated and disposed of at the dumpsite from the year 2004 to 2009 are shown in Table 5. The results show that the estimated generation of solid waste in the metropolis increased from the year 2004 to 2009. Similarly, the daily and yearly collection rates also increased consistently in the same period. Actual collection rates were between 73 and 83% in the metropolis for the years under review.

Table 5: Estimated quantity of waste generated and deposited at the Kojokrom dumpsite from 2004 to 2009.

Year	Estimated generation (Mt/day)	Actual collection (Mt/day)	Actual collection (Mt/year)	Daily percentage performance
2004	236.3	172.5	62955.5	73.0
2005	244.5	183.4	66944.1	75.0
2006	253.1	194.9	71134.8	77.0
2007	262.0	207.0	75536.8	79.0
2008	271.1	219.6	80159.9	81.0
2009	280.6	232.9	85014.0	83.0
TOTAL	-		441745.1	

Source: STMA Landfill Data (2004– 2009)

4.4 EXPOSURE TO HEALTH AND ENVIRONMENTAL HAZARDS

Table 6 below shows the perception of residents and scavengers about health and environmental hazards associated with waste dump operation and management.

Table 6: Perception of residents and scavengers at Kojokrom dumpsite on exposure to health and environmental hazards in 2010

Response to Health / environmental hazard	Number of respondents	Percentage
Health		
Yes	128	98.5
No	2	1.5
Not sure	0	0
Odour		
Yes	125	96.2
No	4	3.1
Not sure	1	0.7
Fire and smoke nuisances		
Yes	124	95.4
No	4	3.1
Not sure	2	1.5
Pest nuisance		
Yes	118	90.8
No	8	6.2
Not sure	4	3.0
Bird nuisance		
Yes	115	88.5
No	8	6.2
Not sure	7	5.3
Wind-blown litter		
Yes	112	86.2
No	10	7.7
Not sure	8	6.1
Leachate		
Yes	123	94.6
No	5	3.8
Not sure	2	1.6
Surface water contamination		
Yes	118	90.8
No	11	8.5
Not sure	1	0.7
Landfill gas generation		
Yes	95	73.1
No	10	7.7
Not sure	25	19.2

On the exposure to health risks, 128 (or 98.5%) of respondents were aware that they were exposed to a high level of risk for either staying close to the dump site or for working as scavengers;2 (or 1.5%) were not aware that they were exposed to any form of hazards. Health and environmental risks mentioned included contamination of river and other water bodies, odour, noise, littering, dust, smoke, fire, rodent infestation, mosquitoes, birds, cuts, accidents, and diseases such as cholera, diarrhoea, malaria, typhoid, intestinal related diseases and chicken pox.

On odour, 125(96.2%) of the residents sand scavengers attributed the strong stench experienced in the area to the poor operations and management of the dumpsite while4 (or 3.1%)did not agree that the odour experienced was as a result of the dumpsite operations. One respondent (0.7%) did not have any opinion.

On the frequent incidence of fire and smoke nuisance in the community, 124 representing 95.4% agreed that the dumpsite was the cause, 4 (or 3.1%) did not agree but rather attributed the fire and smoke nuisances to activities of carpenters and charcoal producers while 2 (or 1.5%) were not sure if the dump site could create fire and smoke hazards in the area (Table 6).

On the issue of pest infestation, 90.8% of respondents strongly shared the view that pests were a nuisance created from the dump site, 6.2% did not share that view whilst3.0% were not sure (Table 6).

From Table 6, 115 of respondents, representing 88.5% agreed that birds pose a great nuisance at the dumpsite while searching for their feed. Eight, representing 6.2% did not agree that birds were a nuisance whiles 7(or 5.3%) were not sure of the hazards caused by the birds.

One hundred and twelve of those interviewed representing 86.2% strongly agreed that windblown litter, especially plastics, was a nuisance, 7.7% did not perceive thus as a problem while 6.1% were not sure of the extent to which windblown litter caused nuisance (Table 6).

To the question of whether the dumpsite leachate posed a health risk to residents and scavengers, 123 (or 94.6%) said yes while 5 (or 3.8%) disagreed. Two or (1.6%) did not know whether the leachate poses any form of risks (Table 6).

On the contamination of surface water with leachate from the dump site 118 (or 90.8%) agreed that this was possible because it was visible that the leachate from the dump site that runs through drains and open spaces entered a river and could contaminate surface water. Eleven (or 8.5 %) disagreed, and 1 respondent (or 0.7%) was not sure whether surface water is being contaminated by the refuse dump.

The Table 6 above also indicates responses on the nuisance of landfill gas. Of the respondents interviewed 73.1% agreed that the dump site produced a lot of gas. This gas according to respondents can be seen mostly in the afternoon when the sun is hot(my frequent visit to the dumpsite, collaborated this view expressed by the respondents). A thin layer of whitish gaseous

substance comes out of the dump site which is visible. 10 respondents (or 7.7%) did not agree that landfills can generate gas; while as many as 25 (or 19.2%) did not have an opinion.

4.5 WATER QUALITY OF THE ANANKOR RIVER

Table7: Water quality parameters of the Anankor River

Parameter	Mean	Ghana EPA Guideline
TDS (mg/)l	492,67	1000
E C (µS/m)	989.67	1500
pH	7.16	6-9
Temperature (^{o}C)	25.77	>3
BOD (mg/l)	645.00	50
COD (mg/l)	124.33	250

The mean value of the Biological Oxygen demand was far greater than the Ghana EPA set value of 50mg/l. The pH which is a measure of alkalinity or acidity of the water, recorded a mean value of 7.16.All the remaining parameters recorded mean values that were below the EPA guidelines.

4.6 NUISANCE CONTROL METHODS AT THE KOJOKROM DUMPSITE

The methods put in place to control the various nuisances at the dumpsite are summarized in Table 8. While the STMA has some form of control measures in place for nuisances such as odour, pests, dust, and smoke and fires, no apparent measures were in place to check or control leachate, landfill gas, surface water contamination and birds infestation.

Table 8 Various nuisance control methods adopted at the Kojokrom dumpsite

Type of Nuisance	Method of control
Odour	Spraying of odour neutralisers
Fire and smoke	Compaction of refuse with available equipment
Pest	Spraying of pesticides
Dust	Spraying with water
Leachate	None
Landfill Gas	None
Surface water contamination	None
Birds	None

CHAPTER FIVE

5.0 DISCUSSION

5.1 Background characteristics of Respondents

About 92% of residents and scavengers had attained at least Junior High school Education. This gives a fair, balanced and broad spectrum of views or opinions from respondents on their perception of the potential hazards emanating from the dumpsite which they have experienced over the years.

All together, about 55% of respondents were resident in the area before work commenced at the landfill. This means that majority of them have a fair knowledge of issues concerning the operation, maintenance and nuisances created at the dumpsite and could therefore provide useful information since they knew the conditions that existed before the dumpsite operations commenced in 2004.

The majority of the personnel of the dumpsite have worked in landfill management for more than five years, and they should have been able to find solution to minimize the nuisances that occur at the dump.

5.2 WASTE GENERATION, COLLECTION AND DEPOSITION

Between 2004 and 2009, the average daily rate of waste generation was about 258 metric tonnes out of which an average of 202 metric tonnes were collected and deposited at the dumpsite. The environmental and health effects of the deficit of about 56 metric tonnes of uncollected waste accumulating daily over the years in the metropolis cannot be over emphasized. The collection

rate of 73-83% is quite high, and could cause a lot of nuisance (e.g. odour) in case of equipment breakdown.

5.3 TYPES OF WASTE RECEIVED AT THE DUMP SITE

Apart from human corpses, all types of waste that are generated in the metropolis are dumped at the site. These include organics, papers, plastics, glasses, metal, textiles, inert materials, infectious hospital waste and in some cases, human excreta in black polythene bags.

It is important that the managers of dumpsites obtain more information on the chemical composition of the industrial waste being produced in his area in order to ensure the suitability of the waste for disposal in land (Rushbrook and Pugh, 1999). Separate cells are to be allocated at the landfill where these wastes are disposed of. Health Care Wastes (HCW) and carcasses are to be covered immediately with chlorinated lime and a layer of cover material due to their infectious nature. This is not so at the Kojokrom dump site. There is no cover material application for even waste that have been deposited and compacted. Again, drivers of closed vehicles (such as compaction trucks) are to declare the type of waste they are carrying. This should be cross-checked by dumpsite staff at the tipping area and sanctions are to be applied to those making false declarations.

5.4 EXPOSURE TO HEALTH AND ENVIRONMENTAL HAZARDS

5.4.1 Health hazard

Most residents settled in the community long before the STMA made the decision to dump refuse at Kojokrom and could not relocate when dumping commenced. Scavengers were well aware of hazards they were exposed to yet they continued to exploit at the dump site since

according to them that was their only source of livelihood. These were the people who used to work at the abandoned dumpsite at Kokompe, Ketan and Kwesimintsim and have relocated to Kojokrom. According to the Waste Management Staff at the dumpsite, these scavengers are able to pick about one tonne of recyclable materials daily. These materials, consisting of metal scraps, copper wires, bottles and plastic materials are then offered for sale to contractors who come to collect them at the end of every week.

5.4.2 Odour

According to Flintoff (1976), landfills or dumpsites should meet two basic requirements in order to reduce odour: firstly, waste deposition and compaction in thin layers to no greater than about two metres in depth, and secondly, the surface of the deposited waste should be covered with suitable soil or similar material up to 15cm in thickness at the end of each working day. Odour is one of the main complaints made by residents in the communities that are close to the dumpsite. The odour is as a result of the high composition of organic waste in the total waste collected and the absence of waste segregation.

Odour is a major reason for the resistance to the selection of lands within communities for use as dumpsites (Flintoff, 1976).

5.4.3 Fire and Smoke

A refuse dump can ignite itself when there is high production of methane gas and conditions are favourable. This generates smoke nuisances which can spread to areas few miles away from the dumpsite. While a majority of the respondents attributed the fire and smoke nuisances to the self-ignition potential of the dumpsite, a small proportion (1.5%) held the view that dumpsite fires

result from the activities of carpenters and charcoal producers in the community instead of the dumpsite. This view is supported by the Department of Environments(1997) that asserts that smoke from fires in wastes at dumpsites are uncommon but do occasionally occur.

Open fires are a regular feature of open dumps. Most fires may either be caused by dumpsite gas igniting itself, or by fire in waste transported from collection points in towns and cities in central communal containers. All fires on site should be treated as a potential emergency and dealt with accordingly. Fire at dumpsites is a major complaint by people living in nearby communities because of its attendant smoke nuisance including ash and particulate matter.

5.4.4 Pests and insects infestation

Looking at the proximity of these respondents from the dumpsite location, it was observed that the responses were related to the distance to the site location. The farther a respondent's house was from the dumpsite the less they experienced pest infestation. Those living close to the dump site therefore experienced pest infestation most of the time, hence the response. This observation is collaborated by Research Triangle Institute (1994) and Rushbrook and Pugh (1999).

Rodents are brought to the site in loads of waste or migrate from surrounding areas and remain at the facility if there is food, shelter and water (Research Triangle Institute, 1994). Vectors are generally not present at a properly operated and maintained landfill. The provision of daily cover is the primary safeguard against vector problems. Well-compacted wastes with cover material effectively prevent vectors from emerging or burrowing into waste materials.

5.4.5 Birds

Birds can hardly be prevented from dumpsites. However, with poorly managed dump sites, their numbers are always beyond belief. The high percentage recorded reflects the observation of Rushbrook and Pugh (1999) that birds are attracted to landfill sites in large numbers, particularly where sites receive appreciable amounts of food wastes. Scavenging birds found at dump sites constitute a potential health hazard and a nuisance because of noise while their droppings introduce pathogens to nearby water bodies and crops especially if residential areas are situated nearby.

5.4.6 Windblown litter

The dump site area is not completely fenced and windblown litter, especially plastic bags and other lightweight materials could be seen trapped in nearby bushes and drains around the dump site area. Rushbrook and Pugh (1999) indicated that a landfill or dumpsite is not well managed if papers or other lightweight materials are blown and spotted around the site. They further expressed the fact that litter, though, a highly visible sign of poor control of the waste being deposited, is also one of the simplest forms of pollution that can be contained in landfills if site operation and maintenance procedures are organized in such a way as to minimize littering. The problem of windblown litter cannot be completely eliminated at any dumpsite. It can, however, be kept to a minimum where waste is placed, compacted and covered in accordance with good practices.

According to the Ghana Landfill Guidelines (2002), fencing of landfills or dumpsites is a very important practice in the management of waste disposal sites as it helps to control access to the site by stray animals and unauthorized persons.

For effective control of windblown litter at dumpsites, Rushbrook and Pugh (1999), recommend two methods. The first is to reduce the size of the working area with the provision of portable temporary litter screens installed at the working area to attract the litter. Secondly, regular daily cover of the waste deposited can also go a long way to reduce windblown litter at the site.

5.4.7 Leachate

It is very visible to see leachate from the dump site flowing through drains into the river when a cursory walk is made into the community. There is no liquid waste treatment facility where the leachate could be channeled for treatment before discharging into the Anankor river.

5.4.8 Landfill Gas

Biodegradable wastes are converted to carbon dioxide, methane and water depending on the availability of oxygen. The percentage of methane increases with reduction of freely available oxygen due to the placement of cover materials (Pacey, 1999).

The U.S Department of Health and Human Services (2003) in a study conducted at the Alliance Landfill, established that if not well designed and properly operated, landfills can emit air contaminants at levels that could adversely affect nearby populations.

5.5 ANALYSIS OF THEA NANKOR RIVER

According to Rushbrook and Pugh (1999), there are two main reasons for undertaking water quality analysis at dumpsite; to safeguard the environment and public health (i.e., to demonstrate that water is safe to drink or use for animals and food crops, and is not dangerous for natural

wildlife), and to provide information to the managers of dumpsite on the composition of the leachate within the dumpsite.

5.5.1Total Dissolved Solids (TDS)

Total dissolved solids are a measure of the inorganic salts, organic matter and other dissolved materials in the water (US EPA, 1980).Total dissolved solids are generally present in water or are as a result of human activities such as industrial treatment of water (Webber-Scannel and Dufffy, 2007). Dissolved salts and minerals are necessary components for good quality water as they help maintain the health and vitality of the organism that rely on this ecosystem service (Barnes *et al*., 2000).The mean value obtained for the TDS was within the acceptable limit of 1000mg/L recommended by EPA.

5.5.2 Electrical Conductivity (EC)

Electrical conductivity is a measure of the ability of water to conduct electric current; the greater the ion contents in the water, the more current the water can carry (Dharmappa *et al*., 2000).The Electrical Conductivity is primarily influenced by dissolved salts such as Sodium Chloride and Potassium Chloride in the water .The source of EC may be an abundance of dissolved Salts due to poor irrigation management, salts from urban rain water runoff, or other discharges.Local geology, such as the underlying rock of the soil nearby can also have an influence in EC levels of a water body (Barnes et al, 2000). There exists a correlation between electrical conductivity and the amount of Total Dissolved Solids in water, hence the value recorded for the EC which also lies within the acceptable limit set by the EPA.

5.5.3Temperature

According to (Fritz, 2001) the temperature of water could be affected by the weather, storm water and ground water influx .Water Temperature is a controlling factor for aquatic life: it controls the rate of metabolic activities, reproductive activities and therefore, life cycles. If stream temperatures increases, decreases or fluctuate too widely, metabolic activities may speed up, slow down, malfunction or stop altogether. Water temperatures can fluctuate seasonally, daily and even hourly, especially in smaller sized streams. Spring discharges and overhanging canopy of stream vegetation provides shade and helps buffer the effects of temperature changes. Water temperatures are also influenced by the quantity and velocity of stream flow. Temperature affects the concentration of dissolved oxygen in a water body .Oxygen is more easily dissolved in cold water (Streamkeeper's field Guide, 1991). Wastes often raise water temperatures. This leads to lower oxygen levels and weakens many fish and insects. Thermal pollution is one of the most serious ways humans affect temperatures of rivers. The temperature recorded falls within the range recommended by EPA and this might be due to less influence on the water body by the factors listed above.

5.5.4 The pH

The pH is a measure of the amount of free hydrogen ions in water. Acidity of water increases with decreasing pH. The pH of natural water is between 6.5 and 8.2.At extremely high or low PH, the water becomes unsuitable to most organisms. Most aquatic organisms adapt to a specific pH level and may die if the PH changes even slightly. PH can vary from its normal levels (6.5-

8.2) due to pollution from automobiles and Coal-burning power plants. Drainage from mines can seep into streams and ground water and make the water acidic as well. As acidity increases most metals become more water soluble and more toxic (Holmbeck-Pelham and Rasmussen, 1997).The mean value recorded in the experiment falls within the acceptable range recommended by EPA because the activities described above which can alter the pH, do not take place at the upstream of the Anankor River.

5.5.5 Biological Oxygen Demand (BOD)

Biological Oxygen Demand is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions. If effluent with high BOD levels is discharged into a stream, it will accelerate bacteria growth in the stream and consume the oxygen levels in the stream. The oxygen may diminish to levels that are toxic to most fish and aquatic organisms. The increase in the BOD value in the Anankor river may be attributed to the continuous dumping of waste by artisans along the banks of the stream and the washing of waste into the stream from waste dump. This conforms to the observation made by Pacey (1999) that if the leachate from the dump site/landfill is not properly controlled, it could seep through to pollute surface waters.

5.5.6 Chemical Oxygen Demand (COD)

The industrial and municipal waste water effluents may contain very high amount of organic matter and if discharged into natural water bodies, may cause complete depletion of dissolved oxygen leading to mortality of aquatic organisms. The amount of oxygen needed to consume the organic and inorganic material in the water is called the Chemical Oxygen demand. It is the measure of the amount of the total oxygen needed to oxidize all organic materials into CO_2 and

water. There exists a definite correlation between Chemical oxygen demand and Biological Oxygen Demand,(BOD) (Holmbeck-Pelham and Rasmussen, 1997). The mean value of the COD recorded for the Anankor River even though lie within the acceptable limits was on the high side and it was an indication that the river has been polluted.

5.6 EFFECTIVENESS OF CONTROL PROGRAMMES FOR THE REDUCTION OF NUISANCES

In refuse dump management the programme(s) that are undertaken to control nuisances are very crucial. At the Kojokrom dumpsite, various control methods are in place to ensure that nuisances are reduced to the barest minimum. This section examines the nuisances and the adequacy of the measures put in place to reduce them as and when they occurred.

5.6.1 Odour Minimization

Odour reduction is done periodically when residents complain of excessive odour especially when it rains. The Environmental Health and Sanitation Department of the STMA is directly responsible for controlling odour and pest control at the dump site and its surrounding areas. Their activities include spraying of pesticides and odour neutralisers such as Ona Gel Polar Crystals and Ecoclinic on the dumpsite and its surrounding areas. These activities are carried out occasionally when funds are funds are readily made available by the Assembly. Until such times that the spraying is carried out, the operators of the dumpsite do nothing to control the offensive odours that emanate from the dumpsite.

Smell at dump sites come from a number of different sources among which are landfill gas, leachate, fresh refuse, malodourless chemicals and odour counteractants. In dumpsite

management, odour is best controlled with cover material so that oxygen is reduced to slow down on putrefaction (Flintoff, 1976).

5.6.2 Control of Fire and Smoke

In the Kojokrom dump site, open burning is not allowed and therefore smoke nuisance is expected to be minimum. However, most of the waste vehicles carry the fire from the collection points and transport same to the dump site and therefore perpetuates the smoke nuisance which is a bother to residents. There are various ways of controlling fire at the Kojokrom dump site.

Dumped refuse is properly compacted with available equipment to prevent fire outbreak. In case of fire outbreak, which is not common at the dumpsite, there is an earth excavator and a water tanker which are used to fight the fire. In severe cases, vacuum trucks are used to suck leachate from the sumps to put off the fire. At certain times when fire is detected, a void is created and the spot is covered with fresh refuse and compacted. At other times water is used to put off the fire. Should the fire be high, the Fire Service is called in immediately to handle the situation with their fire tenders.

Since there are no leachate treatment facilities at the site, the use of water will increase the amount of leachate production. From the interview, all the staff at the dumpsite agreed that soil cover is also used in some circumstances. Observational visits to the site indicate that there are no signs of any accumulation of cover material for the purpose.

The Department of Environment (1997), recommends that open burning on landfill sites are not to be permitted and fire outbreaks are to be extinguished immediately to prevent it from spreading. If the fire starts to blaze at this stage, it should be left to burn out. If the fire continues to smolder, the burning material should be spread out and drenched with water until the fire is extinguished. This may be done by the Fire Service or using a cesspit emptier or water tanker.

For good management practice, various measures and techniques are put in place for controlling fire. Waste vehicles are inspected at the gate for possible transfer of fire to the dumpsite. The most common technique at sites where leachate minimization is practiced is to excavate a trench around the burning area of waste to isolate it from the remainder of the site and then the burning waste is smothered with sand or soil. Water is used only in exceptional cases. In extreme circumstances, city fire tenders may be used. An alternative technique to extinguish shallow fires is to dig a fire hole where the burning waste can be exposed to the air, to either burn out rapidly or be smothered with sand (Rushbrook and Pugh, 1999).

5.6.3Pest Control

Fumigation is carried out at the dump site on an irregular basis to control vermin. The best form of pest control includes effective compaction of waste, regular cover, minimum working area and well managed drainage. In cases where the population of insects or rodents reach unacceptable levels, appropriate and EPA approved rodenticides and insecticides are to be applied.

The Ghana Landfill Guidelines (2002), recommends regular inspections for the detection and destruction of rodents and adoption of anti-fly measures such as earth cover, removal of reasonable preventable condition (RPC's) and spraying for the destruction of flies. During the poisoning of rodents, adequate signs are to be displayed to inform workers at the site, visitors and scavengers of possible dangers they would be exposed to. Rodents found in dump sites should be exterminated so that they do not migrate to surrounding areas. In most cases, poison baits are used and since there is no such thing as absolutely safe rodent poison, accidents can occur with anti coagulants.

5.6.4 Control of Birds

No control measures have been put in place at the dump site for minimizing the number of birds at the site. The presence of large number of birds at the dumpsites clearly indicates that the waste is not being managed properly. Sites accepting animal carcasses, tannery and food wastes are mostly prone to attract birds and fly infestation. When waste deposited is properly covered immediately on deposition it ensures that bird attraction is minimized.

5.6.5 Control of Wind Blown Litter

The method used in the control of windblown litter by the STMA is periodic picking. An appreciable amount of waste deposited at the dumpsite is mostly plastic and paper which have the tendency of being blown away especially during windy days.

5.6.6 Leachate Control and Monitoring

There is a sump constructed to collect leachate from the dumpsite and when the sump is full the leachate is pumped from the sumps into a nearby stream. However, there are plans to install submersible water pumps to re-circulate leachate. There is, however, no treatment for the leachate and any first time visitor to the site can see visible signs of leachate flowing through drains in the community.

There is no universal approach to managing leachate at landfill sites. If the site has been designed to allow some seepage of leachate into the underlying strata, no collection or treatment of leachate is needed. However, groundwater should still be monitored to check that the leachate concentrations are continuing to be diluted and are acceptable. Onay and Pohland (1998), noted that leachate recirculation and moisture movement to the interior of the landfill creates an environment in which naturally occurring microbes degrade the waste at a much greater rate than they normally would. Recirculation also reduces the burden of continuous leachate treatment. Rushbrook and Pugh (1999), also noted that leachate is created from water already present in the waste or entering from outside especially during rainfall and contains extracted contaminants from the decomposing waste.

Pacey (1999) asserts that leachate is one of the major water pollutants produced in landfills and if not controlled can seep through to pollute ground and surface water. The author further noted that the quality of leachate is complex and contains numerous types of soluble organic, inorganic and bacteriological constituents and suspended solids and other many harmful contaminants, some of which are carcinogenic.

In order to minimize leachate production, all run-offs from outside the site must be intercepted by suitable drainage ditches. Where necessary, culverts can be constructed to allow the water to pass under site roads, bunds or other obstacles. These waters, which may be discharged without treatment, are to be strictly segregated from leachate and run-off from operational areas of the dumpsite. All drains shall be kept clean and all cracks and uneven areas rectified to avoid blockages and mosquito breeding (The Ghana Landfill Guidelines, 2002).

5.6.7 Surface Water Contamination

By best practices, surface water should be intercepted by perimeter drainage ditches. Routine inspection, cleaning and maintaining of the existing drainage channels is crucial since this can reduce the amount of leachate production. However, the management and control of surface water contamination is nonexistent at the Kojokrom dumpsite. The prevention of water entering dumpsites is an essential requirement throughout the operation of a better managed dumpsite.

5.6.8 Control of Landfill Gas

Currently, the STMA has not put in any measures in place for managing methane gas at the dumpsite. The Ghana Landfill Guide (2002) acknowledges that landfill gas is one of the significant ways a landfill site can affect the immediate environment and so it is important to monitor it on and within the immediate environs of the site.

In dump sites, anaerobic decomposition leads to the production of a mixture of carbon dioxide and methane gas, as well as traces of other gases. The generation of landfill gas is considered as inevitable. The natural tendency is for landfill gas to migrate upwards from areas where waste is

placed before eventually dispersing into the atmosphere. Landfill gas vented through vertical pipes should be ignited to oxidize the methane to the less potent greenhouse gas (Carbon dioxide).

5.6.9Prevention of Accident

"Signal men" have been employed to control movement of vehicles on the working area of the dumpsite and there is regular education for drivers and scavengers on accident prevention and control. According to the Staff at the site, children under 18years are prohibited from working at the landfill as scavengers but my visit to the site proved otherwise.

As one of the conditions for allowing the STMA to use the Kojokrom site, they were required to fence the site appropriately to prevent unauthorized entry. Warning signs were to be posted at appropriate locations to warn people of the dangers they are exposed to but these have not been fully adhered to.

5.6.10 Handling of Hazardous Waste

There are no designated areas or procedure for hazardous waste disposal. At the Kojokrom dump site hazardous waste is buried together with other wastes from the metropolis. This is not good practice and may increase nuisances at the site.

According to the Ghana landfill Guidelines (2002), hazardous waste, chemicals and carcasses of dead animals are not to be disposed of together with normal solid waste. Separate cells are to be allocated at the landfill where these wastes are disposed of. Good landfill practice dictates that Health Care Wastes (HCW) and carcasses are to be covered immediately with chlorinated lime

and a layer of cover material. A signboard is to be erected by each special waste cell to identify the type of waste that can be deposited therein. Detailed records and maps of all special wastes disposed of on the site are to be maintained. The area containing the special waste cells is to be fenced off from the rest of the site and access restricted to personnel specifically authorized by the Site Manager. There shall be strict control at the site entrance to guarantee that hazardous waste, be it industrial or health care waste is separated from normal municipal waste.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

This study was undertaken to assess the environmental hazards associated with the operations and management of the solid waste disposal site at Kojokrom in the Sekondi-Takoradi Metropolitan Assembly (STMA), and to assess any measures put in place to minimize these hazards.

The study concludes the following:

- The large volumes of waste received and managed at the dumpsite contributed to the numerous hazards experienced at the site. Most of the hazards identified could not have occurred if the volumes of waste discharged at the dumpsite were reduced to allow for adequate time for good compaction.
- Qualifications of the permanent technical staff employed at the dumpsite for its management was low and their exposure to dumpsite management woefully inadequate. The dump site Supervisor has had no technical training in dumpsite management. These contributed to the many environmental hazards experienced.
- The waste dumped was spread and compacted concurrently but without any soil cover at the end of the day's activity. This has therefore increased the nuisances experienced at the site.
- Residents and scavengers had appreciable knowledge of the hazards they were exposed to but were helpless in finding any solutions to them. This can be deduced from the high percentage (98.5%) recorded for those who strongly agreed to their knowledge of the

implications of the hazards they were exposed to. About 90% of the respondents also agreed that hazards such as odour, fire and smoke, windblown litter, surface water contamination, insects and rodents, birds and leachate were evident.

- On the effectiveness of control programmes put in place for the reduction of nuisances at the dump site, it was found out that in some instances such as fire and smoke, pest, accident prevention and control, the measures were effective enough for the reduction of nuisances. However, in other cases such as leachate control and monitoring, surface water contamination, landfill gas, offensive odour and handling of hazardous waste, the control measures were not effective enough for the reduction of the nuisances.
- The high mean value recorded for the biological oxygen demand in the Anankor river suggests that pollution of some sort has taken place in the study area. Leachate from the dumpsite and waste from artisans who operate near the upstream of the study area might have played a significant role in the pollution of the Anankor river.

6.2 RECOMMENDATIONS

For the reduction in the environmental hazards associated with the Kojokrom dumpsite, the following recommendations are made:

- The Ghana EPA should exercise its monitoring and sanctioning roles adequately. It should put in place a systematic process of checking, observing, inspecting, regulating or otherwise controlling key parameters and characteristic activities at the dumpsite to ensure compliance with specific standards or other performance requirements to measure progress toward reduction of environmental hazards.

- The Ministry of Local Government, Rural Development and Environment (MLGRD&E) through the EPA should prepare an inventory of industries and the quantity and nature of solid waste they produce and come out with policies to enforce standards for their disposal.

- The STMA should consider as a matter of priority the use of other methods of waste disposal and reduction strategies such as the use of food waste and other organic components of waste to generate compost for use in agriculture and incineration.
- The STMA should embark on a vigorous campaign for waste segregation since reusable or recyclable articles are not waste and can be used again and again before discarding. This can commence with institutions such as first and second cycles, tertiary institutions and in offices.
- The STMA should widen the polluter pays principle in waste management where waste generators are made to pay for the disposal cost of the waste they generate by volume in the Metropolis. This will be a very useful waste management tool which when properly applied can generate sustainable funds while creating economic incentives for waste minimization at source.
- The STMA should consider the possibility of privatizing dump site management so that realistic prices would be charged to generate enough funds that can be used to manage the dump site and also inject the needed high caliber of technical staff which the STMA lacks.

- The STMA should make full use of the media (print and electronic) present in the Metropolis to intensify the education on environmental cleanliness. Fora and public lectures should be organized for identifiable groups to increase awareness on the health hazards associated with inadequate solid waste disposal.

- The STMA should establish special programmes to upgrade and improve the living and working conditions of waste management personnel in order to attract highly qualified staff (engineers) to manage and supervise work at the dump site.
- As a matter of urgency the STMA should take the necessary steps to ensure that she constructs a sump for leachate collection.
- The STMA should regularly provide their staff at the dump site with personal protective clothing (Dust masks, Ear muffs, Safety gloves, goggles, hard hats, wellington boots, overall Eye protection etc.). Improved working condition should be put in place to attract more qualified personnel to the waste management department.
- The EPA should monitor the leachate production from the dump site by measuring the following parameters (pH, Potassium, Chloride and Chemical Oxygen Demand) to ensure that they are within acceptable standards.
- The STMA should try to look for funds to continue the construction of the engineered sanitary landfill at Essipon since the Kojokrom site is already full to the brim and should be closed immediately.
- The EPA should continue to monitor the surface water body near the dumpsite and until the quality improves to an acceptable level, activities such as fishing and bathing in it should be discouraged.

- Finally further research should be undertaken to look at the prospect for waste recycling in the Metropolis, this is to find out the viability of encouraging investment into the recycling business in the Sekondi-Takoradi Metropolis.

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QUESTIONAIRE FOR STAFF AT THE DUMPSITE

The questionnaire is to find out the hazard associated with the operations and management of the Kojokrom dumpsite on the environment. It would be appreciated if you could find time of your busy schedule to answer the questions below. I wish to assure you that any information given will be handled strictly confidential. The result of the study will be communicated to you after the study

BACKGROUND DATA

1. Sex

(a) Male
(b) Female

2. Position/Rank

3. Qualification(s)

4. Years of service in the organization

(a) 1 – 5yrs (b) 6-10yrs (c) 11 – 15 yrs (d) 16

5. Years Spent working at the dumpsite

SITE DESIGN AND PREPARATION (PRELIMINARY)

6. When did operation at the dumpsite start?

7. What reason (s) led to the choice of the Kojokrom stone quarry for the Disposal of waste?

8. What preliminary works were carried out before commencement of dumping?

9. Were any preliminary consultations made with the people?

Yes ☐ No ☐

10. If your answer is yes, give details

……

……

……

11. Was any environmental impact Assessment (EIA) conducted?

Yes ☐ No ☐

12. If yes, what hazards were identified?

……

……

13. What mitigation measures were suggested in the EIA?

……

……

14. What is the estimated life span of the dumpsite?

……

……

15. Is there a weighing bridge installed at the site?

Yes ☐ No ☐

16. IF your answer is no, how do you estimate the amount of waste received at site?

……

……

17. Do you keep records of waste delivered at the dumpsite site?

Yes ☐ No ☐

18. What type(s) of waste is handled at the dumpsite site?

……

……

19. Is the waste segregated before reaching dumpsite?

Yes ☐ No ☐

20. What is the average quantity of waste handled daily at the dumpsite?

……

……

21. Are vehicles checked for unwanted waste while tipping?

Yes ☐ No ☐

22. Is the waste received spread and compacted?

Yes ☐ No ☐

23. If your answer is yes, how often is the spreading and compaction done?

……

……

24. Is open burning allowed on the site?

Yes ☐ No ☐

25. Is waste placed covered?

Yes ☐ No ☐

26. If yes, what type of cover material is used?

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……

27. What is the depth of the cover material used?

……

……

28. Is the total dump site area fenced?

Yes ☐ No ☐

PROGRAMME FOR NUISANCE CONTROL

What procedures are in place for managing the following nuisances at the landfill?

29. Odour ……...
30. Fire…….
31. Smoke……...
32 Pest (fly, rate Vermin)…….
33. Birds……..
34. Windblown litter……..
35. Leachate (Water from Landfill)……
36. Surface water contamination…….
37. Landfill Gas(Methane)……
38. Accident prevention and control……
39. How is hazardous waste handled at the dumpsite?.....
40. What mechanism are put in place for managing complaints received form residents?.....

41. How are scavengers managed at the dumpsite?

……
……

42. Are you exposed to any type of risk for working at the dumpsite?

Yes ☐ No ☐

43. If yes, state type of risk?

……

……

44. Do you undergo any medical examination?

Yes ☐ No ☐

45. What steps do you have in place to minimize/manage hazards?

……

……

……

46. Have you had any training in landfill management?

Yes ☐ No ☐

47. What further training (including workshop, and seminars) have you been Given?

……

……

……

Scavenging

48. Do you allow scavenging on site?

Yes ☐ No ☐

49. If yes, how many scavengers work at the site?

……

……

50. How are they organized?

……

……

51. Do scavengers receive any training in infection control?

Yes ☐ No ☐

52. If yes, state the content of training you give them.

……

……

EQUIPMENT HOLDING AND MANAGEMENT

53. What type of equipment do you have on site?

……

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54. What preventive maintenance schedules are available for the dumpsite equipments?

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55. What is the cost of operation and management of equipment?

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58. General remarks

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QUESTIONNAIRE FOR RESIDENTS/SCAVENGERS

This questionnaire is to find out the hazards of the operations and management of the Kojokrom landfill on the Scavengers and people living close to the dumpsite. I t would be appreciated if you could find time of your busy schedule to answer the questions below. I wish to assure you that any information given would be handled strictly confidential. The results of the study will be communicated to you after the study

BACKGROUND DATA

1. **Sex**

(a) Male

(b) Female

2. **Occupation**……

3. **Religion**

(a) Christian

(b) Moslem

(c) Traditionalist

(d) Other

4. **Marital Status**

(a) Married

(b) Single

(c) Divorced

5. **Educational Background**

(a) Middle School/JHS

(b) Secondary School/SHS

(c) Polytechnic

(d) University

6. Number of Children

(a) 1 – 2

(b) 3 – 4

(c) 5 – 6

(d) 7 and above

7. Length of stay in the area

(a) Less than 5yrs

(b) Above 5yrs

PERCEPTION OF HAZARDS ASSOCIATED WITH THE DUMPSITE

8. Are you exposed to any type of risk for living close to the dump site?

Yes ☐ No ☐

9. If yes, state type (s) of risk (s)

(a)

(b)

(c)

(d)

10. What steps do you have in place to minimize/Manage risk (s)

(a)

(b)

(c)

(d)

For questions **in 19,** indicate your perception on the following hazards associated with refuse dumps.

11. Odour

(a)Yes

(b) No

(c) Not Sure

12. Fire

(a) Yes

(b)No

(c) Not Sure

13. Smoke

(a) Yes

(b) No

(c) Not sure

14. Pest (fly, rats and vermin)

(a) Yes

(b) No

(c) Not sure

15. Birds

(a) Yes

(b) No

(c) Not sure

16. Litter

(a) Yes

(b) No

(c) Not sure

17. Leachate(black liquid from landfill)

(a) Yes

(b) No

(c) Not sure

18. Surface water contamination

(a)Yes

(b) No

(c) Not sure

19. Landfill Gas (Methane)

(a) Yes

(b) No

(c) Not sure

20. General Remarks

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