ASSESSMENT OF SOLID WASTE MANAGEMENT IN SMALL TOWNS: A CASE OF HIMO TOWNSHIP, MOSHI DISTRICT

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A THESIS SUBMITTED IN FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS OF SCIENCE IN ENVIRONMENTAL STUDIES OF THE OPEN UNIVERSITY OF TANZANIA

2013

CERTIFICATION

The undersigned certifies that he has read and hereby recommends for acceptance by the senate of the Open University of Tanzania a dissertation titled: *"Assessment of Solid Waste Management in Small Towns: A Case of Himo Township, Moshi District'"* in fulfillment of the requirements for the degree of master of Science in Environmental Studies of the Open University of Tanzania.

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Dr. Lawi Yohana

(Supervisor)

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Date

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DECLARATION

I, Mrema Dawood David, hereby declare that, this thesis is original and the result of my own work, and it has not been submitted for any academic professions in any other university.

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Signature

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Date

DEDICATION

With Faith, Hope, Love and Joy, I dedicate this thesis to the Almighty GOD for His faithfulness. He has seen the wickedness of his servant.

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ABSTRACT

This study presents the Assessment of Solid Waste Management, case of Himo township in Moshi district. The aim of the study was to address the problem of poor SWM that resulted in littering of the town, carried out between July, 2010 and December, 2012. Four specific objectives namely; characterization of the solid waste, examination of existing status of collection and transportation and identification of solid waste disposal methods in the study area were observed. Likewise, determination of the level of pollution in dumpsites and landfills for moisture, nitrogen, phosphorus, potassium and organic matter content were performed. Literature review, internet and journals, brochures, books and review of methodology for characterization and quantification of SW were sought, along with secondary data pertaining the study. Field investigation involved quantification and physical and chemical characteristics which enabled current SWM assessment. Results from analysis of data, using the Statistical Programme for the Social Sciences (SPSS) revealed that, SW was dominated by plastic and polythene bags by 24.4% and paper by 17.26%, and 65% of collection were household based. Phosphorus in all dumps and landfills were low, while Nitrogen level were elevated.

This research concludes that factors affecting SW management in Himo were typical of many tropical urban environments. Since 71.6% were not satisfied with SWM services, 73.3% were not aware of by-laws pertaining SWM. There was poor waste management regime. It is recommended that the frequency of solid waste collection be enhanced, along with construction of engineered landfills in the town. The review of SWM aspects should be strengthened and harmonized through by-laws on solid waste management.

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LIST OF ABBREVIATIONS

AfDB	African Development Bank
CBE	College of Business Education
CFC	Chlorofluorocarbons
DAICO	District Agricultural Irrigation and Cooperative Officer
DED	District Executive Director
DHO	District Health Officer
E – waste	Electronic Waste
ISWM	Integrated Sustainable Waste Management model
ISWM	Integrated Waste Management Approach
KCMUC	Kilimanjaro Christian Medical University College
Kg. /day	Kilogram per day
LGA	Local Government Authority
MENR	Ministry of Environment and Natural Resources
M&E	Monitoring and Evaluation
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
NGO's	Non - Governmental Organizations
RAS	Regional Administrative Secretary
RSWM	Rural Solid Waste Management
SSA	Sub Saharan Africa
SPSS	Statistical Package for Social Sciences
SW	Solid Waste

SWMoA	Solid Waste Management option for Africa
SWM	Solid Waste Management
UNCHS	United Nations Center for Human Settlement
UNEP	United Nations Environmental Programme
USA	United States of America
VEO	Village Executive Officer
WHO	World health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

One of the most earthly environmental problems in urban and rural areas is huge generation of Municipal solid wastes (Read, 2003). Municipal solid wastes are left over materials comprising of household garbage including kitchen waste, street sweepings, sanitation residues, construction and demolition debris, commercial and industrial refuse and also biodegradable waste (Transkanen, 2000). The state of solid waste management in small and growing towns and townships of most developing countries is fast assuming the scale of a major social and environmental challenge in present years than ever before (Daskalopolous, 1998a). Solid waste is any substance be it liquid, solid, gaseous or even radioactive, discarded into the environment because it is unwanted, which may cause significant nuisance or adverse impact in the environment.

In Sub-Saharan Africa (SSA) in particular, the combined influence of poverty, population growth and rapid urbanization has increased solid waste generation tendency (Johannessen and Boyer, 1999). In response to the solid waste challenges therefore, most of the developing countries have embarked upon ambitious environmental reforms, recording remarkable advances in best practices and sustainable management of their generated solid wastes. However, many developing countries including Tanzania have joined the global effort in sustainable solid waste management strategies in rural or urban areas. (Ezeah, 2009a).

A study in Ghana, Benin, Malawi and Nigeria by the African Development Bank (AfDB, 2002) on solid waste management options for Africa, revealed that solid waste management in most African countries is characterized by inefficient collection methods, insufficient coverage of the collection area and improper disposal of the solid waste so collected while waste characterization data specific to urban and rural areas in these countries are not lacking There is a general lack of regulatory initiatives to manage and solid waste handling.

In this regard Tanzania in the Africas' sub saharan countries can't be excluded in discussion regarding persistent solid waste management problems. In Tanzania, and in particular Himo, solid waste is not adequately handled to let the environment clean and aesthetic.

Solid waste is a result of human activities (Traskanen, 2000). It is a by-product of human activities, economic development in manufacturing industries, urbanization, and improvement of living standards of people living in cities and towns. Once produced they create a menace to public health and utilize valuable space needed for other purposes and generally become an unpleasant sight not tolerable to the public. Although MSW does not have the catastrophic potential of either global warming or stratospheric ozone depletion, it poses long term threats to the environment. Methane gas produced by the anaerobic decomposition of waste buried in landfills and open dumps is not a significant contributor to global warming. Emissions were estimated to reach 10^{12} g/yr (AfDB, 2002). Thus, managing and collecting SW is as important to the public as it helps to minimize the effects that might result from uncontrolled SW (Zavodska and Knight, 2002).

The management of SW is a cause of concern throughout the world, in both developed and developing countries (Tchobanoglous, G., Theisen, H. & Vigil, S., 1993) . Uncollected SW with its associated public health and environmental risks has become a common phenomenon in most urban and rural areas as well.

Any solid waste collection system has potential health risk depending on how it is carried out, including the cycles from collection to disposal. For example, a plastic bottle is unlikely to be responsible for any diverse health effects when buried in landfill. However, the same plastic bottle burned in a poorly managed incinerator (incomplete burned contents) could generate dioxins which could potentially lead to an increased risk of cancer to people working or living in the windward side of the incinerator or just around it (Read, 2003). For developing countries, such effects are likely to be more serious for women and children because of their daily involvement with waste related activities. SWM is a global problem, but the extent of the problem in developed countries varies from that in developing countries. In the developed countries the reasons for SW collection are well understood and acceptable, that is all wastes are collected, sorted, recycled and the refuse disposed in definite sites.

There exist problems of increased quantities of SW because of low capacity of recycling of wastes and use of packaging materials made from recovery of paper and plastic. (Morissey and Brown, 2001). In developing countries where large quantities of SW remains uncollected and the disposal systems are not well organized, and more so largely uncontrolled there has been a tendency of involving private companies in SWM management undertakings.

In Tanzania, the level of urbanization increased from 2.7% to 10.8% between 1980 and 2000, respectively (WHO, 1995). As a result, urban population has been growing and will still be growing. With so many people moving from rural areas to live in urban centers, changing lifestyles and modern living standards that are associated with the use of plastic items and paper packaging materials and wrappers. This has left the surroundings and the environment with a variety of refuse in uncontrolled dumps (WHO, 1995). As the human population increases, people express their desire for better standards of living, with economic activities expanding in scale and diversity. In this case solid waste disposal methods like engineered landfills and dumps should be considered to handle the waste.

Environmental pollution is a term that refers to all the ways and means that human activities harm the natural environment. It is the release of substances to environment, in quantities which are harmful to human beings and other living creatures embracing all the negative impacts caused by man, in and on the environment. The effects of pollution to the environment can be identified on land, water and air in various forms.

Open garbage dumping or automobiles air pollution; (exhaust releases) may represent some of them, being odorless, invisible, intangible and tasteless. Uncontrolled and unmonitored solid waste disposal is a public health problem and a concern to man, communities and states alike, because decomposing garbage and other solid wastes provide food and habitat for rats, rodents and other disease vectors including mosquitoes and houseflies. Such wastes provide opportunities for most species of flies to lay eggs, breed, feed on the exposed material and carry infection, likewise attracting rodents and other vermin, which spread the feces, creating an intolerable and health-threatening situations. In areas where no regulatory disposal policies are applied, solid waste could be disposed without consideration of space, type, time and nature.

Apart from causing direct effect on people's health, harmful materials are believed to contaminate water resources in rivers, streams, furrows and lakes, being sources for household water requirements (Da Rosa, C.D, and Lyon, J.S. (1997). Inadequate and unsanitary disposal of human excreta may lead to contamination of ground water supplies. In most developing countries, bacterial, parasitic and viral diseases are mainly caused by contamination of water itself, which accounts for more than 80% of all infections (WHO, 1995).

Polluted air is a major source of lung diseases such as pneumonia, lung cancer, asthmas and other pulmonary infections, while some air pollutants like Chlorofluorocarbon (CFC) gases causes Ozone (O_3) destruction or depletion, which has lead to fluctuations and alteration of the climate, with registered high temperatures on the earth today. Solid waste disposal is a continuous process (happening now and then) in varying magnitudes. In places where solid waste dumps have been erected or demarcated, solid waste could be collected to be disposed at distant locations. In both developed and developing countries too little attention has been paid to SW management (WHO, 1995).

Rapid industrialization, urbanization and population growth have added to lowering the value of the environment and depletion of natural resources. However, it is the development process which man makes, that increases the level of pollution of the earth.

Environmental sanitation refers to the control of all those factors in human physical environment which may cause negative effects on physical development, health and survival of man and other creatures. In a broad term it includes water supply, solid waste disposal (solid, soft or liquid), food sanitation, insect and rodent control, atmospheric pollution control, ventilation and air conditioning, lighting, housing, institutional sanitation, occupational health work, accident prevention and eradication of health threatening nuisance (Read, 2003).

In most of African governments, there is little pressure and political will in achieving development of the environmental sector. This is due to ignorance for most people in need of sanitation who have little or no knowledge on environmental matters, including general cleanliness of the household and their surroundings, sweeping, disposal of waste water, burying of thrash and other rubbish and making compost manure. In this view, communities are not motivated to initiate sanitary improvements that should involve all activities mentioned above. In this aspect, there is a direct relationship between unhygienic solid waste disposal, diseases and well being of the people. In other approaches, waste recycling could have economic benefits to the community, if it were at all practical (Read, 2003).

This scenario brings to focus the importance of the study: Assessment of Solid Waste management in small towns, a case of Himo Township in Moshi district. Findings of this study will improve the solid waste management practices in the study area and other small and growing towns in Tanzania, East Africa and the globe at large.

1.2 Problem Statement

Himo township is predominantly urban covering a total are of 242 km^2. Urban activities in Himo include commercial and small scale industries development and rapidly expanding residential areas. Improved living standards of the people in Himo due to its socio-economic development have led to generation of enormous quantity of solid waste. Himo faces crisis in solid waste management by lack of suitable and permanent sites for either dumping or integrated scheme for its sustainable Solid waste management.

Poor solid waste dumping is prevalent in Himo town due to improper disposal of Solid waste accompanied with lack of specific dumping sites. This has resulted into the presence of heaps of garbage spots in various locations within the town. The situation calls for quick action to address the problem before it grows into environmental and health hazards to the inhabitants of the town, by education and practical advice on management of Solid waste in general. However, information on the status of Solid Waste management is lacking. The present study attempted to provide an assessment of different aspects of Solid Waste Management in Himo.

1.3 Objectives of the Study

The General Objective of this Study was to Assess Solid Waste Management practice in Small Towns in Tanzania, a Case of Himo Township.

1.3.1 Specific Objectives

(i) To characterize the solid waste generated in Himo township

(ii) To examine the existing status of collection and transportation of waste.

(iii) To focus the solid waste disposal methods in the study area.

(iv) To determine the level of pollution in the dumpsites and landfills for moisture, Phosphorus, Calcium and Nitrogen content.

1.3.2 Research Questions

(i) What are the characteristics (type, quantity, composition) of the Solid Waste generated in Himo Township?

(ii) What are the methods used in collection of Solid Waste in Himo Township?

(iii) What is the waste disposal methods employed in the study site?

(iv) What is the extent of pollution in dumpsites in terms of moisture, organic matter, phosphorus and nitrogen?

1.4 Significance of the Study

Finding from the study shall enable the residents of the entire area to have extra knowledge on better means of solid waste collection in aesthetic means, yet learn better transport and disposal methods. The study will promote the awareness on Solid Waste management concept among different stakeholders in Himo town and impart a notion of cleaner environment for health. Training on SWM shall change the attitude of the residents, temporary dwellers and passers-by in Himo town towards solid waste management approach in general.

1.5 Theoretical Framework

Integrated Sustainable Waste Management (ISWM) model is a model that allows studies of complex and multidimensional systems in an integral way. The model was developed by waste advisors in urban environment and development partners or organizations working in developing countries in the mid 1980's. The model was further developed by the collaborative working group (CWG) on Solid Waste management in the mid 1990's (Thuo, A.D.M, 2011).

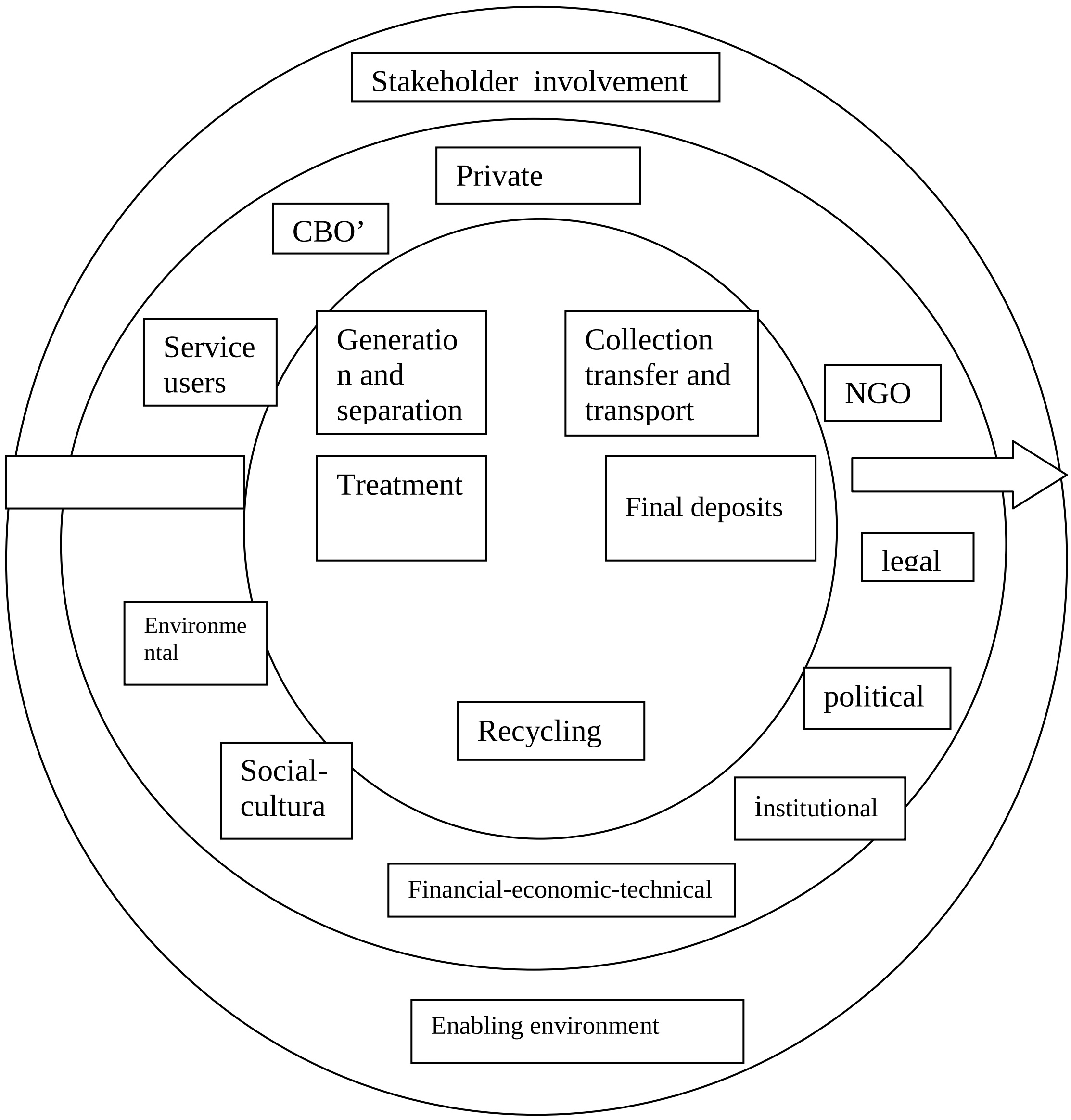


Figure 1.1: The ISWM Framework
Source: Researcher, (2013)

The model acknowledges the importance of three dimensions when analyzing, developing or changing a waste management system. The dimensions are the stakeholders that have interest in Solid Waste Management, the elements or stages of the movement or flow of materials from the generation points towards treatment and final disposal and the aspects through which the system is analyzed (Read, 2003).

The current work was set within an adapted ISWM framework (Figure 1). Specifically, it focuses on the characterization of solid waste generation, examination of solid waste collection, transportation and disposal methods.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview on Waste Management

According to the Longman Dictionary of Contemporary English (p.1612), solid waste is defined as unwanted material or substance that is left after having been used for something, while the New Shorter Oxford English Dictionary on Historical Principles defines it as unusable material left over from a process of manufacture, the use of consumer goods, or the useless by-products of a process. Another elaborate definition of waste is that it embrace all unwanted and economically unusable by-products or residuals at any given place and time, and any other matter that may be discarded accidentally or otherwise into the environment (Gilpin, 1996:228).

Gilpin also suggests that what constitutes waste must occur in such a volume, concentration, constituency or manner as to cause a significant alteration in the environment. Thus, apart from waste being an unwanted substance that is discarded, its amount and impact it makes on the environment also become important considerations in defining waste. (Troshinetz, A.M. and Mihelcic, J.R, 2009). Smith (1997) also refer waste as the unwanted materials arising entirely from human activities which are discarded into the environment. This notion, that waste results entirely from human activities is corroborated by Mac Donald (1999a) who noted that waste is human creation, and there is no such thing as waste in nature where cut-offs of one species become food for another. There is no constellation of properties inherent in any lump, object or material which will serve to identify it as waste; however an item becomes waste when the holder or owner does not wish to take further responsibility for it. As a default definition, Transkanen (2000) suggests any substance that is without ownership to be waste, also describes wastes as unwanted or unusable materials that emanate from numerous sources, such as industry and agriculture as well as businesses and households that might be liquid, solid or gaseous in nature, and hazardous or non-hazardous depending on its location and concentration.

This relative attribute of waste could be compared with the concept of resource which has also been defined as material that has use-value and a reflection of human appraisal (Richard Wright, 2007). Just as a material becomes a resource when it gains use-value, it also becomes waste when it loses its use-value. Like resources, waste is also a relative concept or human appraisal because what constitutes waste can vary from one person to another, from one society to another and over time. Drawing from the views expressed above, the definition of waste to be used in this study is any substance be it liquid, solid, gaseous or even radioactive, discarded into the environment because it is unwanted, which causes significant nuisance or adverse impact in the environment.

Generally, waste means something unwanted. Its precise definition and scope however differs from one country to another and places alike. According to Read (1999), waste is any substance which constitutes scrap material or an influent or other unwanted surplus substance arising from the application of a process or any substance or article, which is required to be disposed of as being broken, worn out, contaminated or otherwise spoiled. Waste comprises of household, commercial and industrial wastes that is be collected by local authorities or any assigned bodies. Household waste which is part of MSW is by nature one of the most difficult sources of wastes to manage because of the diverse nature of its material and where it appears to be placed or disposed. Deposition of the waste can pollute the environment and require collection of soil samples so as to determine the levels of elements that had been deposited in the soil. Care should be taken so as to get consistent and reliable results. In this case the right sampling procedures including sample locations can be chosen using haphazard sampling, judgment sampling or probability sampling procedures.

In haphazard sampling, accessibility, or convenience sampling involves a series of non-reproducible, distinctive decisions by the sampler and no systematic attempt is made to ensure that samples taken are representative of the population being sampled. This type of sampling is antithetical to scientific sampling designs. Judgment sampling, also termed purposive sampling (Patton, M. Q. (1990), involves the selection of sampling points based on knowledge held by the researcher.

Judgment sampling can result in accurate estimates of population parameters such as means and totals but cannot provide a measure of the accuracy of these estimates (Lisa M. Given (Ed.) (2008). Moreover, the reliability of the estimate is only as good as the judgment of the researcher. In probability sampling, (which has been selected for this study), points are selected at random locations using a range of specific sample layouts, and the probability of sample point selection can be calculated for each design. This also allows estimate to be made of the accuracy of the parameter estimates, unlike judgment sampling. This allows a range of statistical analyses based on the estimates of variability about the mean to be used, and is by far the most common type of sampling in soil science. Probability sampling was employed in collection of solid waste samples.

2.1.1 Global Perspective on Solid Waste Management

In the last twenty years, a number of solid waste management projects have been carried out in developing countries, in collaboration with external support agencies. Some projects were successful in producing lasting impacts on the improvement of solid waste management in developing countries. However, many projects could not support themselves or expand further when the external agencies discontinued their support. A number of technical, financial, institutional, economic, and social factors contribute to the failure to sustain the projects, and they vary from project to project. In most cases the projects were carried out in cities and municipalities forgetting juvenile or small towns.

Often, the recipient countries, cities and towns tend to accept whatever resources are provided to them without due consideration to subsequent resource requirements. The external support agencies have limitations in the amount of resources they can provide and the mandates and modes under which they can operate the projects in questions. Sometimes, projects are initiated with specific aims and expected outputs, but their scopes are not comprehensive enough to consider external factors influencing them. The external support agencies often do not fully understand socio-economic, cultural, and political factors influencing the selection of appropriate solid waste management systems. In other cases, very limited follow-up support, including human resource development activities necessary to sustain the project implementation is provided by the external support agencies.

These problems and constraints associated with external support agencies' collaboration with developing countries in solid waste management can be minimized, and the sustainability of such collaborative projects improved by packaging efforts of external support agencies; defining clear roles of relevant agencies and improving their coordination in developing countries; creating key human resources; supporting strategic planning and follow-up implementations; developing self-financing schemes and raising awareness of the public and decision makers.

As urbanization continues to take place, the management of solid waste is becoming a major public health and environmental concern in urban areas of many developing countries. The concern is serious, particularly in the capital cities than in small or growing towns, which are often gateways to the countries for foreign diplomats, businessmen, and tourists. Poor visual appearance of these cities will have negative impacts on official and tourist visits and foreign investment.

Recognizing its importance, a number of developing countries have requested collaboration of external support agencies, both bilateral and multilateral, in improving solid waste management in their cities in the last 20 years or so. Although some projects succeeded in providing lasting positive impacts on the management of solid waste in the recipient countries and cities, many failed to continue activities after the external support agencies ceased their support. This un-sustainability of collaborative projects is due to various technical, financial, institutional, economic, and social constraints faced by both the recipient countries, cities, towns and external support agencies.

Such constraints vary from country to country, from city to city, and town to town as developing countries and cities, municipalities and towns within them differ in Solid waste management problems and they and external support agencies have different, and often limited, resources available to resolve the problems. Therefore, in order to ensure the sustainability of collaborative projects, the various constraints of both developing countries and external support agencies should be carefully examined and an approach is developed to remove such constraints within the context of the collaborative projects. This paper outlines the common constraints and suggests possible ways of removing these constraints.

2.2 Problems and Constraints of Solid Waste Management in Developing Countries

Typical solid waste management system in any developing country may displays array of problems, including low solid waste collection coverage and irregular collection services, crude open dumping and burning without air and water pollution control, breeding of flies and vermin, and the handling and control of informal waste picking or scavenging activities. These public health, environmental, and management problems are caused by various factors which constrain the development of effective solid waste management system. They can be categorized into technical, financial, institutional, economic, and social constraints. Each of these constraints is discussed, in relation to the sustainability of solid waste collaborative projects, below.

(a) Technical Constraints

In most developing countries, there typically is a lack of human resources at both the national and local levels with technical expertise necessary for solid waste management planning and operation. Many officers in charge of solid waste management, particularly at the local level, have little or no technical background or training in engineering or solid management handling or approach. Without adequately trained personnel, a project initiated by external consultants or by the local government could not be continued. Therefore, the development of human resources in the recipient country of external support is essential for the sustainability of the collaborative project in SWM initiative.

Another technical constraint in developing countries is the lack of overall plans for Solid Waste management at the national and local levels. As a result, a solid waste technology is often selected without due consideration to its appropriateness in the overall solid waste management system.

In some cases, foreign assistance is given to a component of a solid waste management system for which the use of resources may not be most cost-effective. For instance, an external support agency provided its support to improve a general disposal site. However, the coverage of solid waste collection service is so low that solid waste generated is dumped at many undesignated sites (example open areas, water channels and streets).

As a result, improving the disposal site, although it may not be a bad project, would have little impact on the overall solid waste management effectiveness. In such a case, the low collection coverage is a bottleneck in the overall solid waste management system in the city, and it would be most cost-effective to provide resources to upgrade the collection service.

Research and development activities in solid waste management are often a low priority in developing countries. The lack of research and development activities in developing countries leads to the selection of inappropriate technology in terms of the local climatic and physical conditions, financial and human resource capabilities, and social or cultural acceptability. As a result, the technology selected can never be used, wasting the resources spent and making the project unsustainable. Several guides and manuals on appropriate solid waste management technologies in developing countries are available in literature, and the selection of technology could be made sometimes based on these guides or manuals.

However, in most cases, these guidelines and manuals must be modified to the local conditions prevailing in the country, and therefore local studies are normally still needed. Such studies can be relatively easily incorporated into a collaborative project and, to the extent possible, should involve local research institutions.

(b) Financial Constraints

In general, solid waste management is given a very low priority in developing countries, except perhaps in capital and large cities alone. As a result, very limited funds are provided to the solid waste management in small towns in the sanitation sector by the governments, and the levels of services required for protection of public health and the environment are not attained.

The problem is acute at the local government level where the local taxation system is inadequately developed and, therefore, the financial basis for public services, including solid waste management, is weak. This weak financial basis of local governments can be supplemented by the collection of user service charges. However, users' ability to pay for the services is limited in poorer developing countries, and their willingness to pay for the services which are irregular and ineffective is not high either. An effective strategy for raising funds needs to be searched in any collaborative project to ensure its sustainability.

In addition to the limited funds, many local governments in developing countries lack good financial management and planning. For instance, in a town in a developing country, over 90% of the annual budget provided for Solid Waste management was used up within the first six months. Lack of financial management and planning, particularly cost accounting, depletes the limited resources available for the sector even more quickly, and causes Solid waste management services to halt for some time, thus losing the trust of service users.

(c) Institutional Constraints

Several agencies at the national level are usually involved at least partially in solid waste management. However, there are often no clear roles or functions of the various national agencies defined in relation to solid waste management and also no single agency or committee designated to coordinate their projects and activities. The lack of coordination among the relevant agencies often results in different agencies becoming the national counterpart to different external support agencies for different solid waste management collaborative projects without being aware of what other national agencies are doing. This leads to duplication of efforts, wasting of resources, and un-sustainability of overall solid waste management programmes.

Lack of effective legislation for solid waste management, which is a norm in most developing countries, is partially responsible for the roles/functions of the relevant national agencies not being clearly defined and the lack of coordination among them. Legislation related to solid waste management in developing countries is usually fragmented, and several laws (example Public Health Act, Local Government Act and Environmental Protection Act,) include some clauses on rules or regulations regarding solid waste management.

The rules and regulations are enforced by different agencies. However, there are often duplication of responsibilities of the agencies involved and missing elements in regulatory provisions for the development of effective Solid waste management systems. It should be also noted that legislation is only effective if it is enforced. Therefore, comprehensive legislation, which avoids the duplication of responsibilities, fills in the gaps of important regulatory functions, and is enforceable, is required for sustainable development of solid waste management systems.

Because of a low priority given to the sector, the institutional capacity of local government agencies involved in solid waste management is generally weak, particularly in small cities and towns. Local ordinance/by-laws on solid waste management is not also well developed. These weak local government institutions are not provided with clear mandates and sufficient resources to fulfill the mandates. In large metropolitan areas where there is more than one local government, coordination among the local governments is critical to achieve the most cost-effective alternatives for solid waste management in the area. For instance, the sitting of a solid waste transfer station or disposal facility for use by more than one local government is cost-effective due to its economy of scale.

However, as these facilities are usually considered unwanted installations and create not-in-my-backyard (NIMBY) syndromes among the residents, no local government may wish to locate them within its boundary. Lack of a coordinating body among the local governments often leads to disintegrated and unsustainable initiatives for Solid Waste management.

(d) Economic Constraints

Economic and industrial development plays key roles in solid waste management. Obviously, an enhanced economy enables more funds to be allocated for solid waste management, providing a more sustainable financial basis. However, by definition, developing countries have weak economic bases and, hence, insufficient funds for sustainable development of SWM systems.

Local industry which produces relatively inexpensive Solid Waste equipment and vehicles will reduce, or in some cases eliminate totally, the need for importing expensive foreign equipment and vehicles, requiring foreign exchange. Such local industry can also supply associated spare parts, lack of which is often responsible for irregular and insufficient Solid Waste collection and disposal services. However, lack of industry that manufactures Solid Waste equipment and spare parts and a limited foreign exchange for importing such equipment or spare parts are the rule rather than exception in developing countries.

In developing countries, waste recycling activities are affected by the availability of industries for processing of recycled materials. For instance, the recycling of waste paper is possible only when there is a paper mill within a distance for which the transportation of waste paper is economical. Weak industry base for recycling activities is a common constraint for the improvement of Solid Waste management in most of the developing countries, such as those in the Pacific region where a large volume of package waste is generated.

(e) Social Constraints

The social status of solid waste management workers is generally low in both developed and developing countries, but more so in developing countries than in developed countries. This owes much to a negative perception of people regarding the work which involves the handling of waste or unwanted material and dirty materials. Such people's perception leads to the disrespect for the work and in turn produces low working ethics of laborers and poor quality of their work.

Because of insufficient resources available in the government sector, collaborative projects often have attempted to mobilize community resources and develop community self-help activities. Results are a mixture of success and failures. Failed projects with inactive communities usually did not provide people in the community with economic as well as social incentives to participate in activities. Social incentive is based on the responsibility of individuals as part of the community for the improvement of the community, and is created by public awareness and school education programmes. Lack of public awareness and school education about the importance of proper SW management for health and well-being of people severely restricts the use of community-based approaches in developing countries.

At dump sites, transfer stations, and street refuse bins, waste picking or scavenging activities are common scenes in developing countries. People involved have not received school education and vocational training to obtain knowledge and skills required for other jobs. They are also affected by limited employment opportunity available in the formal sector. The existence of waste pickers and scavengers often, creates obstacle to the operation of SW collection and disposal services.

However, if organized properly, their activities could be effectively incorporated into a SW recycling system. Such an opportunistic approach is required for sustainable development of solid waste management programmes in developing countries.

2.3 Constraints of External Support in Solid Waste Management

External support provided to SW management in developing countries has its own limitations and constraints. As constraints in developing countries, they can be divided into technical, financial, institutional, economic, and social constraints and are discussed below.

(a) Technical Constraints

Industrialized countries, which provide external support to developing countries, usually have technical expertise and human resources suitable for solid waste management in these countries. Their school and university education and subsequent on-the-job training are targeted for the technologies of solid waste management applicable to these countries. However, there is lack of human resources with sufficient experiences and knowledge of solid waste management in developing countries. Opportunities to learn solid waste management problems and practices in developing countries through regular training programmes and seminars are rarely provided in developing countries.

The lack of knowledge and experience in solid waste management situations in developing countries leads to a tendency to support and provide the technologies available in the donor country regardless of their applicability to the developing country situation. In some cases, the solid waste management equipment and facilities, which are obsolete and outdated in the donor country, are provided as foreign aid to the recipient country.

Communication between consultants provided by the external support agency and the local counterpart in the developing country sometimes becomes a constraint in implementing an effective collaborative project. The communication difficulty occurs in two different situations:

(i) There is no common spoken language in operations in solid waste management that exist between the external consultants and the local counterpart.

(ii) The local counterpart does not understand technical terms introduced as far as solid waste handling is concerned. Efforts by both sides to improve communication ability are being made in a number of countries.

As mentioned earlier, lack of an overall plan for solid waste management leads to a solid waste management system which is not cost-effective. It also encourages a piece-meal approach by the external support agencies. Referring to the earlier example of support for improvement of a disposal site, it can be easily seen that the external support agency made the decision to support without sufficient consideration to other components of solid waste management. Piece-meal, or not comprehensive approaches taken by external support agencies, often results in unsustainable solid waste management projects.

(b) Financial Constraints

Obviously, all donor agencies have their own upper limits to financial support. Solid waste management is one of many sectors for which an external agency provides its resources. For some donor agencies, solid waste management may not be a priority sector for support. As a result, there is a finite (and often limited) amount of funds that can be allocated to the sector.

Because of its inherent nature, SW management does not render itself to an operation which can easily generate revenues. This is particularly true in developing countries where the willingness and ability to pay for solid waste management services are low. For external lending agencies, this means that the risk of providing a loan to such a project is generally high. The high risk of loan projects can be lessened by building into the projects revenue raising systems (example user charges and sales of recycled materials).

(c) Institutional Constraints

External support agencies have their own organizational mandates and structure that limit their activities to certain operations such technical cooperation, loan of capital funds, training, and so on. Even in the same donor country, there are usually different external support agencies, each specializing in one area of support. The extent of their geographical coverage is also limited to certain countries for their support. These organizational mandates and operational coverage of external support agencies determine the levels and types of resources provided to SW management projects in developing countries.

There is also lack of coordination among the various external support agencies to complement each other's efforts, although it is gradually improving recently. With better coordination and communication among them, the sustainability of solid waste management projects in recipient countries will be improved.

(d) Economic Constraints

The economic situation of the donor is determinant to the amount of funds that can be allocated for foreign aid to developing countries. Thus, it influences the levels of resources provided to solid waste collaborative projects. However, the economic situation of one donor country is not so critical for the sustainability of solid waste management projects in developing countries.

External support agencies in industrialized countries tend to promote SW management technologies developed in their countries and use consultants from their countries. It is understood and often accepted that there is a bias in the selection of equipment, facilities, and consultants for solid waste management collaborative projects. As mentioned earlier, the provision of solid waste equipment was done from the point of view of the donor agency, instead of the need of the recipient country.

For instance, two large compactor trucks of 8-tonne capacity each were provided to the capital town of a small island country where an estimated 7 tons per day of solid waste was generated and there were many narrow streets. In another developing country where solid waste is wet and has a low calorific value, the construction of an incinerator was recommended by a group of consultants from a developed country where incineration is very common. Often, the appropriateness of a technology to be used in a developing country is not fully assessed, and the technology is adopted based on the norm and experience of the donor country.

(e) Social Constraints

In any country, developed or developing, there are social or cultural norms accepted only by the society. Such norms affect designs of solid waste management systems. Where the society allows only a certain social class or group to deal with solid waste, the availability of work force for solid waste collection and disposal becomes constrained by this rule. In some countries, directly handling human waste is a traditional taboo, which then prohibits the application of co-composting of refuse and human waste. The lack of understanding of local cultures and ways of life by the external support agency is often a cause of failure of a collaborative project.

Communication difficulty was cited as a constraint earlier. In addition to the language-related communication problem, the lack of decent attitude and experience of external consultants in working with officials of developing countries results in unnecessary tension between the consultants and local counterpart.

2.4 Keys to Successful Collaboration for Solid Waste Management

A number of external support agencies recognize SW management as a priority issue in developing countries and are interested in supporting to improve the situation. However, their approaches to solving solid waste management problems in developing countries have been piece-meal and not well coordinated. Also, their support has been provided mostly on a short-term basis. These characteristics of external support are inherent in the organizational mandates and operational modes of the external support agency, and therefore they cannot be easily changed.

What can be changed, however, is to combine support from different international aid agencies to make a collaborative project more comprehensive and long-term/continuous. This requires better coordination and communication among the external support agencies and development of partnership among them, removing the organizational egos and sharing and contributing their resources to the benefits of the recipient country. The collaborative project should be designed to improve the solid waste management situation gradually over a long period, instead of attempting a quick fix.

(b) Defining Clear Roles of Relevant Agencies in Developing Countries

Better coordination for effective implementation of a solid waste management collaborative project is also required by the various agencies involved in solid waste management in the recipient country. However, as mentioned earlier, many solid waste management projects in developing countries suffer from the lack of coordination among the relevant agencies, which often results from the lack of clear roles defined for these agencies in solid waste management. To ensure effective institutional support for a collaborative project for solid waste management, the roles and responsibilities of the various agencies involved should be defined clearly and a coordination mechanism be established. This can be done without drafting new legislation or amending the existing one, which is normally a time-consuming exercise in any country. A working group involving officials from the various agencies can be set up to discuss initially the roles and responsibilities of their respective agencies, and the working group can be later upgraded to an administrative committee or task force.

(c) Factors Affecting Solid Waste Management

For sustainable SW management in developing countries, human resource development should always be part of the external support package. Without local human resources, a collaborative project initiated by external support will not be able to continue. To develop human resources with technical expertise in solid waste management in developing countries, there are three strategically important groups for external support, namely.

(i) Key personnel in the national coordinating unit of the government;

(ii) Operational managers of selected Local Governments and

(iii) University and other higher educational institutions.

Among these target groups, strengthening of human resources in the national coordinating unit and one or two selected local governments is the first priority and should be done in short term while support to higher educational institutions is a long-term programme. It is the responsibility of the recipient country to select these potential target groups and improve their communication abilities. The donor countries should also improve their human resources in terms of their communication ability and knowledge of solid waste situation in developing countries.

(d) Supporting Strategic Planning and Follow-up Implementation

Overall SW management plans at both the national and local levels are essential for utilizing limited resources most effectively, and providing a frame of reference for potential external support. Therefore, the formulation of national and local strategic plans for SW management should be considered at the initial stage of the external support package.

Realizing the importance of strategic planning, many external support agencies have supported or are beginning to support the preparation of overall national and local plans before providing equipment and facilities. However, the operation of such technical assistance is often separated from that of the provision of loans and grants for facilities and equipment. As a result, the follow-up action to the planning assistance (such that provision of grants and loans for facilities and equipment) is delayed or not given at all. Consequently, there are many plans produced, but they have not been implemented. For the sustainability of a solid waste collaborative project, it is crucial to provide external support to follow up on the implementation of the plan prepared. Here again, the approach of packaging external support can play a key role.

(e) Developing Self-financing Schemes

The governments of developing countries have limited funds for solid waste management and must develop measures to reduce and recover the expenditure and increase revenues where possible. They need to turn their solid waste management systems to more self-financing programmes. External support can be effectively used to develop different alternative cost-cutting, cost-recovering, and revenue-raising schemes (example waste minimization, deposit-refund system for recyclable materials, import or sales tax on certain packaged products and collection of user service charges) and implement pilot studies on these economic incentive measures.

Private sector participation in SW management collection and disposal services is also a way to reduce the financial burden of the government. It can draw not only investment finance from private companies for SW management equipment and facilities, but also managerial expertise and technical skills. Experiences in developing countries, which are reported elsewhere, indicate that privately operated services are generally more cost-effective than public sector services. Therefore, the use of private sector resources through a contractual arrangement provides a potential alternative towards self-financing solid waste management, yet affective.

Effective application of economic incentive measures and private sector resources in solid waste management requires human resources to design and manage such schemes. Aside from human resources development in technical aspects of solid waste management, human resource development in financial planning and management is necessary and often a key to the development of more self-financing schemes.

(f) Raising Awareness of the Public and Decision Makers

Effective management of solid waste requires the cooperation of the general public. Lifting the priority of, and allocating more resources to, the solid waste management sector needs the support from decision makers. It is, therefore, important to ensure that public and decision makers' awareness activities are incorporated into the external support package. The aim of these activities is normally long term and it takes some momentum to build up before the effects are realized. But, once the interests of the public and decision makers in improving solid waste management are created, the sustainability of solid waste management projects will be significantly improved.

Enhanced awareness of decision makers may lead to changing national socio-economic and industrial development policies and associated government programmes in favor of improving solid waste management systems in developing countries. For instance, more financial aid and tax incentives may be introduced to encourage the development of recycling industry and business, or labourer protection programmes may be provided to improve wages and working conditions of laborers, including solid waste management workers. Changing national policies in donor countries could also improve ways in which their technologies are transferred to recipient countries.

2.5 Problems of Solid Waste and Solid Waste Management

Globally, MSW generation has continued to increase in line with growth in other socio-economic parameters such as population, personal income and consumption patterns (Sakurai, 1990; Achankeng, 2003). In the last two decades, per capita waste generation in the developed economies has increased nearly threefold and it has been projected that if current trends persist, a fivefold increase in global MSW generation is probable by the year 2025 (AfDB, 2002).

In 1997, a study of the Urban SW situation in eleven countries that form the Asian Productivity Organization (Smith Kofmacher, 1997) showed that SW management was a major challenge in Asian towns and cities. In 2002, each Chinas' household was generating 1 kilogram per day per person of municipal solid waste (WHO, 2002) and the World Bank indicated that by 2004 China had surpassed the United States of America to become the largest municipal waste generator in the world (World Bank, 2005). Lewin, K., (1995) also reported appalling waste situations in a number of Latin American cities including Bogota (Columbia), where some 2,500 tones of solid waste is left uncollected every day and is simply left to rot in small tips or in canals, sewers and streets; and Sao Paolo (Brazil) where one-third of the population is living in areas without any service to collect solid waste.

2.5.1 Solid Waste Management

The Basel Convention (Article 4) requires each party to the Convention to minimize waste generation and to ensure the availability of disposal facilities within its own territory (UNESC, 2009). Municipal Solid Waste (MSW) management has continually been an intractable problem in recent times beyond the capacity of most local or state governments. This has resulted in refuse heaps being dumped in the urban and rural landscape in heavily populated cities and towns as only about 40% to 50% of waste is routinely collected (UNESC, 2009).

Rising urban population growth, limited municipal resources, and the complexity of municipal solid waste management (MSWM) in both industrialized and developing countries have complicated the relationship between environmental management and the health of urban inhabitants. The combined effects of casual disposal of wastes, insufficient waste collection service, and inadequate waste disposal facilities have always had serious, adverse implications for public health. Among these are the direct transmission of diseases and the spread of epidemics, degradation of the quality of the urban and natural environments and, most importantly, the social reinforcement of poor hygienic habits and practices, all of which compose a vicious cycle.

It has been shown that poor SW management is a major threat to public health and environmental quality, and reduces the quality of life, particularly for the poorer inhabitants of towns and cities (Baabereyir, 2009). Waste management should therefore be geared towards protecting the environment from the polluting effects of SW materials in order to protect public health and the natural environment (Baabereyir, 2009). The goals of SW management as stipulated in the Recovery Conservation and Recovery Act (RCRA) of 1976 in the United States of America include:

(i) Protection of human health and the environment from the hazards posed by waste disposal

(ii) Conservation of energy and natural resources through waste recycling and recovery;

(iii) Reducing or eliminating the amount of waste generated and

(iv) Ensuring that wastes are managed in an environmentally-safe manner (Zavodska and Knight, 1976).

In principle, most authors have adopted these as the main goals of solid waste management. For example, Adogame, L, (2009) stated that the goals of municipal solid waste management as protecting environmental health and quality of the environment, supporting the efficiency and productivity of the economy and generation of employment and income to the people. On the other hand, Transkanen (2000) states that, “the overall goal of municipal solid waste management is to collect, treat and dispose of solid waste generated by all population groups in an environmentally and socially satisfactory manner, using the most economical means available”.

Although in developing countries the quantity of solid waste generated in urban areas is low compared to industrialized countries, the Municipal solid waste management still remains inadequate (Achankeng, E, (2005). Due to public good nature of solid waste, people often think that it is the government’s responsibilities to keep the environment clean (Mac Donald, 1999a). Thus, in most countries, local authorities have been charged with the responsibility of collecting and disposing of solid and liquid municipal wastes.

2.5.2 Solid Waste Management Practices

Every region or town has own formality of handling solid waste. The attitudes of people in different municipalities and towns of each region vary regarding to waste management practices. Lack of awareness in communities in connection with waste generation and handling can be considered as one reason why no single approach to waste management has been accepted as a best method. Since there is no preferred method, municipalities and small towns create their own best way to dealing with waste (Mungure, 2008).

The principles of waste management, as identified by Rathi, (1996), are to minimize waste generation, maximize waste recycling and reuse, and ensure safe and environmentally sound disposal of waste. This means that waste management should be approached from the perspective of the entire cycle of material use which includes production, distribution and consumption as well as waste collection and disposal. Studies in developing countries, however, have shown that the goals and principles of waste management in most developing countries are far from being achieved (Levin, K, 1994). Waste management practices vary from country to country in Africa. Collection rates across the continent range from 20 % to 80 %. Common feature of the municipalities and small or growing towns and settlements is that they are ineffective, under equipped and poorly maintained (often vehicle immobilization rates reach as high as 70%), inadequately funded and poorly staffed and maintained (Margaret B and Razack L. (2002)). The poorer areas in Africa are the least likely to have any way to safely dispose of their household trash and garbage. According to the International Institute for Environment and Development, in Kampala, for example, less than 20% of the population benefits from regular collection of household wastes and less than 20% of the solid wastes generated within the city are collected.

Open dumps are the preferred method for disposal of SW as an alternative of landfills in most African countries. In open dumps refuse is simply dumped in low lying areas on open land. Open dumps are characterized by an absence of engineered measures, no leachate management or consideration of landfill gas management, and few if any operational measures, such as registration of users, control of the number of tipping fronts, or compaction of waste (Assad, R, (2009).

Open dumps are commonly preferred in African municipalities and towns because they are considered as a cheap way to getting rid of solid waste (AfDB, 2002). These dumps make very uneconomical use of the available space, allow free access to waste pickers, animals and flies and often produce unpleasant and hazardous smoke from slow-burning fires. Financing of safe disposal of solid waste poses a difficult problem as most people are willing to pay for the removal of the refuse from their immediate environment but then “out of sight – out of mind” are generally not concerned with its ultimate disposal.

The disposal situation deteriorates even more with rapid urbanization settlements and housing infrastructure which increasingly encroach the existing dumps resulting to environmental degradation associated with these dumps directly affecting the population. Waste disposal sites are therefore subject to growing opposition from being located in residential areas. They should be at reasonable distance from collection area.

(a) Landfills

Citing landfills at greater distances to the central collection areas implies higher transfer costs as well as additional investments in the infrastructure of roads and dumpsites, hence intensifying the financial problems of the responsible authorities. In addition to all this, an increase in service coverage will even aggravate the disposal problem if the amount of waste cannot be reduced by waste recovery. Other reasons for inadequate disposal are the mostly inappropriate guidelines for citing, design and operation of new landfills as well as missing recommendations for possible upgrading options of existing open dumps.

In some developing countries semi-controlled or operated landfills are used. For these, waste is dumped at a designated site and the dumped refuse is compacted, then a topsoil cover is provided daily to prevent nuisance. All kinds whether municipal, industrial, or clinical/hospital waste is dumped without segregation. The dumpsite is not engineered to manage the leachate discharge and emissions of landfill gases. In Kenya, for example, there are no engineered landfills; hence MSW disposal is carried out in open dumps with attendant deleterious environmental consequences.

2.5.3 Integrated Waste Management Approach

Richard Wright, (2007) argued that. a single choice of methods for waste management is quite unsatisfactory, inadequate, and uneconomical. The concept of an integrated approach to managing solid waste therefore evolved in response to the need for a more holistic approach to the waste problem. Integrated waste management refers to complementary use of a variety of practices for safe and effective handling of municipal solid waste. Elements most commonly associated with integrated solid waste management include waste prevention, waste reduction/minimization, re-use of materials and products, material recovery from waste streams, recycling of materials, composting to produce manures, incineration with energy recovery, incineration without energy recovery and disposal in landfills in that order of priority.

2.5.4 The Peculiarities of Small Towns

Accepted definitions for a small town are generally lacking but a small town is usually referred to lie somewhere between rural and urban settlements. The criterion for defining a rural-small town-urban continuum varies from country to country, and the most commonly used criterion is based on population size of the primary town. However, even this criterion differs from country to country. Thus, while some countries categorize a small town as that having a population of between 5,000 and 50,000, others have populations ranging from 5,000 to 200,000 people.

Defining small towns purely based on their population size fails to adequately capture their dynamism and diversity. Some countries do include other elements such as relative percentage of the local economy that is not agriculture based (for example, in Nepal) or relative percentage of men not working in agricultural-related jobs (for example, in Bangladesh). Such criteria may, however, be sufficient merely to distinguish urban from rural. In Tanzania, small towns as defined in the Local Government Act of 1982 are based on population size of the range of 5,000 – 50,000 people.

Small towns are characterized by more mobility with relative stability, emerging cash economy with development of markets, increasing need to manage waste, and the population within these towns is inadequate to reap the benefits of economies of scale. Waste management in such towns goes beyond what households can manage alone and for proper waste management, payments for the service need to come from both the users and the public purse.

The most notable feature, and probably the most critical drawback for small towns, is that despite wide variation in national definitions of what constitutes a ‘small town’ as noted above, available data suggest that people living in these ‘intermediate’ settlements are among the worst served in terms of all basic services, including solid waste management. Investments in small towns have simply not kept pace with their large and growing need for services.

2.5.5 Stakeholders and Public Participation in Solid Waste Management

Waste management stakeholders can be defined as individuals or organizations with legitimate interest towards achieving the goal of minimizing solid waste. One way of minimizing solid waste is by allowing the public in general be aware of the problems posed by ineffective management of solid waste. Therefore the government, formal and informal sectors, civil society and environmental organizations and other groups can work together to create this awareness through formalized and well-organized solid waste management programs. The public involvement and participation is a means to create a sense of individual responsibility towards waste management and hence the sustainability of the solid waste management (SWM) systems.

Waste management stakeholders can therefore be viewed as an important element in reaching for the communities while creating awareness about the environmental impacts resulting from waste disposal. This can be organized through various environmental programs which will initiate motivation and hence ensuring a continuous participation.

2.6 Solid Waste Management in Small Towns in Various Parts of Africa

2.6.1 Solid Waste Management in Africa

In Africa, available studies on the African continent on solid waste management suggest that, in general solid waste management in small towns is characterized by inefficient collection methods, insufficient coverage of the collection systems and improper disposal of the solid waste itself. (Morissey and Browne, 2005). Minor urban settlements are, therefore, characterized by waste accumulations and poor environmental sanitation (UN Habitat, 1997; Onibokun and Kumuyi, 1999; Hardoy *et al.*, 2001; Pacione, 2005; Palczynski & Scotia, 2002).

It has been estimated that one person in Africa generate approximately 0.5 kg waste per person per day (Richard Right, 2007). Approximately one third of solid waste is not collected (Richard Right, 2007). In most growing towns Zambia, about 90% of the 1,400 tones of solid waste produced daily is left unattended (AfDB, 2002). In the year 2008, solid waste density in such towns was 280-370 kg/m3 with a waste generation rate ranging from 0.44-0.66 kilogram per capita per day (Read, 2003).

2.7 Current State of Waste Collection in Himo Township

In Himo township, waste management like in other small towns involves primarily, the collection, transfer and disposal in dumps and landfills of non –hazardous, municipal solid wastes or thrash, which consists of everyday items like abattoir refuse, packaging materials, grass clippings, furniture, broken glass, bottles, food scraps, newspapers, batteries and hair from barber shops.

Residential solid wastes account between 55% - 65%, while commercial wastes ranges between 45% - 50%. (VEO, Himo, 2009) Other wastes include those from schools, institutions and businesses. Climate change and level of commercial activities may contribute to variations of volumes of waste matter generated.

There is no data on the amount of solid waste produced in this town including Himo homes, institutions and businesses. According to unverifiable data available, the township generates more than 258 kg. of solid waste per day, that is 1,666 kg per week and 86,232 kg.(86.232) tons per year which is approximately 0.5 kg.-0.85 kg of waste per person per day (Himo Health Office, 2001). This involve at least 304 people from various households. About 2% of the Solid waste is recycled or composted as manure; nearly 1% is incinerated while 22% is disposed of, mostly in dumps, roadside dumping and landfills whereas more than 75% of the solid waste is burned (VEO Himo, 2009).

2.8 Empirical Reviews

2.8.1 Solid Waste Management in Limuru Town in Kenya

Solid waste management in Kenya is operated under the Ministry of Environment and Natural Resources (MENR) together with the Ministry of Local Government (AfDB, 2002). The main responsibilities of these ministries as regards SW management include environmental legislation, formulation of policies on solid waste management and monitoring and evaluation (M&E) of SW matters. Others are the issuance of licenses and permits to waste operators and environmental standards enforcement.

As in most countries in East Africa, local authorities are primarily charged with the responsibility for solid waste collection, transport, resource recovery, recycling and disposal within their jurisdiction in Kenya (Obera and Oyier, 2002). Estimates by USAID and World Resources Institute (WRI) show that these Authorities were only able to collect and dispose of 50-70% of the SW generated annually, spending over 30% of their annual budget in the SW handling operations in 1992 (Obera and Oyier, 2002). At present, Kenya has no modern or engineered landfills; hence SW disposal is carried out in open dumps with the thrash attendants facing adverse and harsh negative working environmental consequences. Solid waste management in Kenya is still highly centralized with operational decisions often having to wait for senior management roll out in most Council environmental departments. This often and in most cases results in long and unnecessary delays before the simplest of tasks could be carried out.

Lately a few Councils in Kenya have entered into contractual agreement with private waste operators to complement the efforts of Council waste departments in the SWM perspective. (AfDB, 2002). Limuru is a small town that is about 25 km North of the city of Nairobi with about 30,000 inhabitants. The community has a predominantly agriculture economy, although there is a Bata shoe factory as well as some other factories and businesses Like any other town in Kenya, Limuru town is also affected by a serious solid waste management problem. Its dumping site is about 6 km outside the town, and the waste volume at the site is low, estimated to generate 10 tons of solid waste per day, due to poor collection services. The town council organizes about 7 trips a week, either by dump truck or tractors pulling trailers. Of the waste generated, 95% is of domestic origin while 3% is industrial oriented and the rest 2% originate from businesses including shops, kiosks and grocery centers.

The council charges about 250 Kenyan shillings (Ksh.) per year per individual household or solid waste generator, which is about 2.5 Euros. The fee covers solid waste collection in sites and disposal charges. The town council collects 12 tons of the waste from markets, commercial buildings and residential areas leaving about more than 2 tons of the waste uncollected. The Bata shoe factory in Limuru town had its own incinerator which has been shut down from time to time by the council because most of their waste contains dangerous chemicals that are not adequately dealt with. There is poor incineration and the factory had been dumping their solid waste at the Dandora site.

Reasons for the uncollected waste in the Limuru town are caused by poor machinery, lack of trained personnel, and lack of awareness by the community on solid waste management and inability of the dumping sites to handle all the generated solid waste. The Limuru dumping site is located 6 km away in Bibirioni, covering about 0.5 hectare which is not sufficient for the solid waste dumping purposes. All types of solid waste are dumped at the site, some of which are dangerous not only to nearby residents, but also to animals in the area. Broken glass is scattered all over the site, posing obvious danger to passers by including children. Limuru town is also affected by serious plastic bags problems, with the bags being scattered all over the communities, and this affects both human and animals as discussed above.

Most plastic bags are discarded after market days and because the town lacks capacious garbage disposal units, the bags remain where they are discarded without being collected. Some of them are blown by wind to litter other places of the neighborhood. There is need for adequate dumping areas in Limuru because the town has a large market, resulting in considerable large volumes of solid waste generation during market days and in various generation areas in the town.

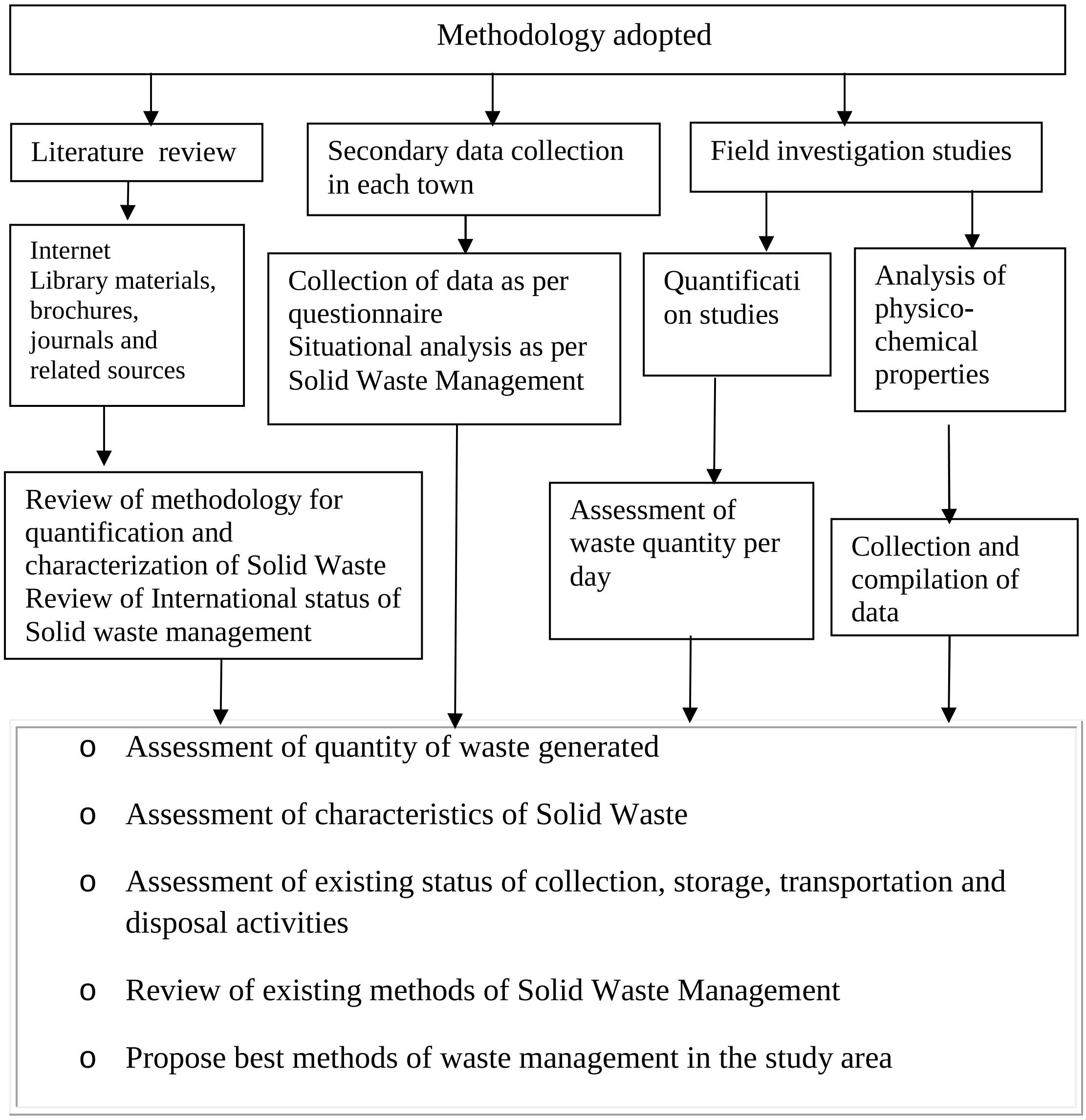
Future plans for Limuru town is to see to the closure of the existing dumping sites and relocation of a new dump-site at Ruai area, and development of awareness campaigns through SWM education. This shall also involve employment of qualified personnel in environmental work and acquisition of more collection machinery and transportation facilities (Troshineta A.M and Mihelcic J.R., 2009).

2.8.2 Solid Waste Management in Tanzania

(a) Solid Waste Management in Babati Town

The amount of solid waste generated in the entire town is estimated at 0.5 kg /person/day. Before 2005, disposal of solid waste was only accessible for half of the population of Babati (Babati Town Council, 2006). The solid waste management operates under the Health department of Babati Town Council. The council is responsible for the management of solid waste in streets and market and 20 people designated as council cleaners with a duty of routinely sweeping the streets and collection of all solid waste, while a community-based organization (CBO) and some private operators collect domestic wastes (AfDB, 2002). After Babati was upgraded to Town council in 2006, new by-laws and regulations were introduced. Waste pits were initially the common way to get rid of the solid waste generated.

Table 2.1: The Methodology Adopted in the Study Area



Although the pits are now forbidden in the central parts of Babati, where the density of people is high, it is still a common way to cater for common solid waste means of disposal. People in the town are supposed to own and use a refuse bin as part of a refuse collecting system, while the common and agreeable way to collect and dispose solid waste in rural parts is still the pit (AfDB, 2002). Transport to the landfill is a big problem. There is no reliable and identified transport facility to carry the solid waste from town to the newly identified landfill site, and without reliable transport facility (Lorries, tractor with trailer) it was impossible to move the old dump (Lewin, K., 1884). Little money and resources are allocated for SWM activities.

CHAPTER THREE

3.0 METHODOLOGY

3.1 The Study Area

Himo town is located in Kilimanjaro region, Northern Tanzania, at Latitude 3° 22' 60 S and longitudes 37° 32' 60 E respectively. The study was carried out in Himo Township in Moshi rural district, Kilimanjaro region. This town lies about 25 kilometers from Moshi town at Latitudes 3° 21' 48" S and Longitudes 37° 19' 37" E) to the West. The current birth rate of the inhabitants of the study area is 4% and a death rate of 0.12%, while 62% of the population resides in the periphery of the township, mostly engaged in agriculture and animal rearing with zero grazing.

Figure 3.1: Location of Himo town in Tanzania

(Source: Kilimanjaro Regional Profile, 2004)

3.2 General Methodology

3.2.1 Research Methodology Description

The review of literature provided an overview of stakeholders reports and factors affecting Solid waste management systems. The literature review provided information about the methodology, quantification and characterization of solid waste as well as the review of international status of Solid waste management. Furthermore, information was collected by means of questionnaires and interview from selected individuals, including questions about the stakeholders and the state of Solid Waste Management system in Himo township. Waste management practices were followed by on-site visits to households, hospitals, schools, construction sites, agriculture and commercial areas.

The following characteristics noted included, types of waste generated, waste collection, transportation and disposal methods. The findings were presented, analyzed and validated with relevant stakeholders from the visited sites. A total of 60 questionnaires each containing 36 questions (Appendix I) were administered to assess the solid waste management activities in the study site, of which 25 % were measured on a three to four point scale. Prior to data collection, the questionnaires were pre-tested for ease of understanding and content validity.

A group of stakeholders were asked to criticize them for ambiguity, clarity and appropriateness of the item used in the operation of each construct. The respondents were also requested to assess the extent to which the factors sufficiently addressed the topics investigated. Based on the feedback received, the instruments were modified accordingly and used to collect information about the State of Solid Waste management in the town.

(i) Sample Size and Sampling Techniques

A number of thirty households were randomly selected, so as to represent the entire town for inference. In this study, two respondents from schools, health facilities, shopping centers, hotels, market, kiosks, and guest houses respectively participated in the study which constituted a total of fourteen respondents which created homogeneity in participation. Purposively, ten local authority officials concerned with environmental and public health issues were involved in the study to give the real picture of solid waste handling at grass root level. two production managers, two administrative managers and two officials charged with industrial health at factory were also included in the study. The total number of participants in the study was sixty.

Table 3.1: Selection of Respondents

Description of Respondent	Participants
Households from the all over the town	30
Schools, health facilities, shopping centers, hotels, market, kiosks, and guest houses	14
Local Government Authority officials (environmental and public health)	10
Production managers from manufacturing industries	02
Administrative managers	02
Industrial health workers in leather factory	02
Total	**60**

Source: Researcher, (2013)

Since the respondents were selected randomly, Solid waste from dustbins and other collection containers for different groups were identified for physical contents respectively. This approach was important since there were variations in the composition of the Solid waste generated, methods of Solid waste collection and waste disposal methods among the stakeholders.

Further clustering was done in the peripheral settlements to get households near the dumpsites or landfills and those away from these sites. Households within a radius of 500 meters from the dumpsites were purposively selected to be included in the study. This was purposely done to capture information on nuisance and or benefits the residents encounter by virtue of location of the dumpsite. Both quantitative and qualitative research approaches were used so both quantitative and qualitative methods of data collection were employed.

Household survey was conducted using a questionnaires composed of both open and close-ended questions. Information sought comprised of socio-demographic and economic characteristics, composition of solid waste generated, volume of solid waste collected, disposal methods used and also household participation in solid waste management in general.

In-depth interviews on solid waste composition, collection and solid waste disposal methods were examined in other waste management stakeholders. On the part of local government officials, details on resource allocation, policy issues and by-laws on solid waste management were also examined. In-depth interviews using semi-structured interview methods were scheduled accordingly.

(ii) Demography

There were 14,800 residents in Himo by 2009 (Tanzania National Census, 2002). According to the at a projected growth rate of about 4% per annum, the population of Himo town is currently estimated to 22,990 people. This population, according to the Local Government Act of 1982 qualifies Himo to be a small town (RAS Kilimanjaro, 2010).

(iii) Other Attributes

The town has a market at Makuyuni area which operates on Mondays and Thursdays. Items sold on market days (Monday and Thursday) are mainly foodstuff and household items. Otherwise, the town is clustered with 3 other small market places which operate on daily basis, selling mainly foodstuff.

Whona River passes through the vicinity of the town with two other streams, namely Saghana and Kilacha. The town is linked by four main roads, namely, Makuyuni, Marangu, Holili and Moshi roads. The town has several guest houses, shops, kiosks, bars, pubs, supermarkets and hotels. There is one leather industry known as Himo Tanneries, for leather and hides products. There are twelve waste collection centers in the town, two dumpsites and four sanitary landfills farther to the southern part of the town. The landfills accommodate much of the townships' generated solid waste.

3.3 Determination of Solid Waste Component

3.3.1 Physical and Chemical Analyses

3.3.1.1 Physical Analyses

In physical analysis, 8 grab samples were collected and weighed to determine the weight of each component present therein. Acquisition of a representative sample of solid waste for subsequent physical analyses was attained by drawing a composite sample of several sub-samples of the solid waste.

(i) Sampling Equipment

Sampling equipment and tactics for collections of the sub-samples were specified in that the collector picked a definite grab sample that was available to represent the rest of the matter. In which case, a shovel and mattock were used to extract a grab sample ranging from 2.2.0 kg – 10.6 kg, to ensure that the bulk of the waste was represented by the composite sample. The samples were weighed by hanged salter scale.

The sampling strategy required the collection of a minimum of 8 sub-samples that provide integration over both the depth and the surface area of the waste as contained in dustbins, roadside deposition spots, plastic bags, old buckets etc. The composite samples obtained in this manner were weighed to determine the composition of individual material in weight using a common weighing scale, displayed in kilograms, weighed in a hessian bag.

During the weighing procedure, precaution against breakage or loss of sample was observed, as well as provision for the maintenance of the homogeneity of the composite sample. It most cases, biasness was avoided so as to obtain genuine research results. The sampling procedure had provisions for ensuring the safety of the personnel collecting the samples to avoid injury, poisoning and nuisance. The content of the samples were organic matter, glass, empty beer and beverage cans, broken bottles and empties, plastic and polythene bags, cow dung or chicken manure and wood. This is elaborated in Annex II.

Table 3.2: Grab Sample Measurement Results

S/ N	Material in high quantity	Weight (kg)	Material in low quantity	Weight (kg)	Material not in sample
1	Cow dung or chicken manure	4.1	Glass Cans	0.1 0.1	Wood
2	OM	2.0	Metal	0.1	Beer cans and wood
3	Broken bottles and empties Plastic and polythene	2.1 2.0	Beer and beverage cans	0.1	Wood
4	Paper	2.1	Wood cans, metal	0.1 0.1	Broken bottles and empties
5	Paper	2.3	O.M, glass, cans	0.1 0.1	Metal
6	O.M	2.4	Glass	1.2	Broken bottles and empties
7	O.M	1.6	Broken bottles and empties	0.6	None
8	Plastic and polythene papers	3.1	Broken bottles and empties, glass	0.3 0.3	None

Source: Field Data

The total of twelve solid waste samples for laboratory analysis were randomly collected from the dumping sites at Himo. Wastes were primarily categorized into bio degradable and non-bio-degradable components. Each of samples of waste were segregated and categorized manually into various waste types like paper, plastics and metal, then put into plastic bags and weighed to determine its fraction in the total solid waste sample (Kumar *et al.*, 2009). The weight of the container was subtracted to obtain the net component weight. The percentage of weight for each subcategory was calculated using the following simple formula below:

$$PSW = \frac{NWS \times 100}{TWS}$$

Where PSW is the % of the subcategory of waste,

NWS is the net weight of the subcategory of waste in kg.

TWS is the total sample weight of the sample in kg.

(ii) Laboratory Analyses of Solid Waste

Laboratory analysis of solid waste were performed to determine the levels of Calcium, Phosphorus, Organic matter, pH (hydrogen ion concentration), Nitrogen and Potassium. The analysis procedure are described below:

(a) Determination of Soil Organic Matter

The sample organic matter was determined using the Walkley-Black Potassium Dichromate method as described by Olsen and Sommers (1982). For each sample, 200 mg air-dry sample was accurately weighed into a 500 ml-wide mouthed Erlenmeyer flask to which 10 ml of 1N Potassium Dichromate was added and the mixture was swirled to disperse the soil in the solution. Then, 20 ml of concentrated Sulphuric Acid was rapidly added and mixture thoroughly shaken. The mixture was left to stand for 30 minutes after which 200 ml of distilled water were added. The solution was then titrated against 0.5 N Ferrous Sulphate using o-phenanthroline indicator. The percentage of organic carbon was calculated using the following formula;

$$\%\ \text{Organic C} = \frac{[(\text{meq}K_2Cr_2O - \text{meq}/FeSO_4)(0.3) \times f]}{\text{Weight of oven dry soil} \times 100}$$

Where, f = 1.3, was a correction factor to account for the carbon that did not oxidize in the procedure. The organic matter content was eventually estimated by multiplying the organic carbon percentage by 1.72 (meq = millequivalent) (Olsen and Sommers, 1982).

(b) Determination of Phosphorus

Phosphorus was determined by first extracting phosphorous from the sample using the Olsen extraction method as described by Olsen and Sommers, (1982) and Emteryd (1989). One gram of air-dried sample was transferred into a 250 ml flat-bottomed flask, 50 ml of 0.5N Sodium bicarbonate solution was added and the mixture was then shaken for 30 minutes. The mixture was filtered and the filtrate used for the determination of phosphorus. Ortho-phosphate was determined calorimetrically using a spectrophotometer according to the ascorbic acid method of Allen (1989) and Olsen and Sommers (1982) in which the colour was developed using a mixture of ammonium molybdate solution and stannous chloride solution and the absorbance was determined at 660nm. The amount of phosphorus in the sample was extrapolated from the calibration curve of standard phosphate of potassium hydrogen phosphate.

(c) Determination of Total Nitrogen

Total nitrogen in the sample was determined using a semi-micro Kjeldahl digestion method (Allen, 1989). This method determines all sample nitrogen except that in nitrate and nitrite forms. One gramme (1 g) of air-dried sample was weighed then placed into a Kjeldahl flask. To the sample, 1 g of a catalyst mixture was added then put in the digesting tube (1 g of catalyst mixture contains 1.5g Selenium, 10g Copper sulphate and 100g Sodium sulphate). 10 mls of concentrated H_2SO_4 were added to the digesting tube then placed on the digesting block. The heat of the digesting block was adjusted to 360^0C till the digest was clear, white or pale green.

During distillation, 20 ml of 2% boric acid was mixed with an indicator solution into 150 ml conical flask using a dispenser. The conical flask was placed under the dispenser tube of the distillation apparatus. The digestion tube was then connected to the distillation apparatus; Fifty (50 ml) of 32% sodium hydroxide was dispensed to the digestion tube. The distillation maintained for 7 minutes. Immediately the sample was titrated with standardized sulphuric acid 0.02N, till the colour changed from green to light red. The calculation in determination of % N_2

$$\frac{(A\text{-}B) \times N \times 100 \times 14 \times Mc}{W \times 1000}$$

$$= \frac{(A\text{-}B) \times N \times 1.4 \times Mc}{W}$$

Where

A is ml of sulphuric acid used for titration

B is ml of sulphuric acid used for the titration of the blank

N is normality of the H_2SO_4

W is weight of the sample

14 is equivalent weight of Nitrogen.

Mc is moisture correction

The amount of total nitrogen in the sample (%) was determined by titration of boric acid which was titrated with standardized mineral acid.

(d) Collection of Solid Waste Samples for Laboratory Analysis

Eight solid waste samples, weighing 0.5 kg. each were collected around dumpsites and landfills. The locations were Whona bridge dump, Kwa - Festo dump, Makuyuni, Kwa -Huseni dump along Holili road and Mnadani along Dar es Salaam road. Two samples were collected in each sampling point. These areas have operational solid waste disposal sites in Himo township. In this case all deposition centers were covered.

At each dumpsite, two samples of dried and decomposed solid waste were obtained by first, getting rid of the top most solid waste at about 1-3 cm and opening by a shovel to the required depth of 30 cm - 60 cm and collect the required solid waste sample. By using a shovel a V shaped hole was dug at 30cm – 60 cm where soil sample were collected. The weight of each sample was 0.5 kg. The samples were put in clean plastic bags and packed in a box for submission to the laboratory after has been clearly labeled.

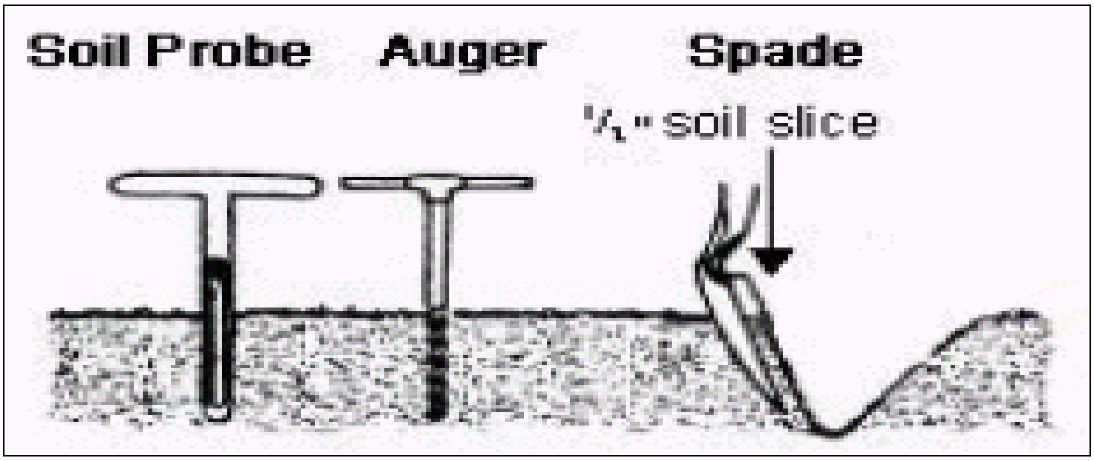


Figure 3.2: Solid Waste Sampling in a Dumpsite by Using a Spade

Source: Ezeah, (2009)

3.4 Data Processing and Analysis

3.4.1 Data Processing

Both quantitative and qualitative data on the findings in the solid waste management for the study were gathered through administration of questionnaires, interviews and documentary sources. After cleaning up the data from the household questionnaire survey and correcting the few mistakes that were detected in the filling of the questionnaires, the data were coded and fed into Statistical Package for the Social Sciences (SPSS 16.0 for Windows), computer program (Norusis, 1990).

Analysis was undertaken to generate a descriptive picture of the data gathered on such themes as household waste generation and handling practices, services available to households for waste disposal and householders' satisfaction with the quality of service. This also covered question items relating to the funding of waste disposal and environmental concerns of waste disposal. Simple percentages and means (central tendencies) were used to analyze the quantitative data obtained from the household questionnaire administration. Data following processing and analysis of the study were summarized using frequency distributions and charts. Descriptive quantitative summaries were used appropriately. Percentages of different parameters were also determined. The qualitative data from interviews conducted with all other categories of respondents were analyzed manually by making summaries of the views of the respondents and supporting these with relevant quotations that captured these views, supported with data from documentary sources and my own field observations of the waste situations in the two case-study towns of Babati and Limuru.

3.4.2 Data Analysis

Both quantitative and qualitative data were obtained using the questionnaires, while quantitative data were obtained by using laboratory analysis. After cleaning up the data from the household questionnaire survey and correcting the few mistakes that were detected in the filling of the questionnaires, the data were coded and fed into Statistical Package for the Social Sciences (SPSS 16.0 for Windows). Analysis was undertaken to generate a descriptive output especially for frequency and percentage response of the data gathered.

Apart from that, household waste generation and its associated handling practices, services available to households for waste disposal and householders' satisfaction with the quality of such services were also discussed, based on the SPSS descriptive output obtained. This also covered question items related to the funding of waste disposal and environmental concerns of waste disposal. However, for quantitative analysis, data from the laboratory were recorded and average of series of measurements was determined. The data were competed to arrive at average value which was later used to describe the findings, with the standard error specified.

3.4.2.1 Descriptive Statistical Analysis

Descriptive statistics describe samples of subjects in terms of variables or combination of variables (Tabachnick and Fidell, 2001). Descriptive statistical analysis therefore involves the use of frequencies, percentages, means and standard deviation to describe various variables encountered during the study. The first two techniques were employed for analyses of data related to the characteristics of the respondents or organizations they represented. Sometimes it was also necessary to employ these techniques for the initial analysis of certain variables even when a few of responses were measured on a Likert scale. However, graphical techniques were utilized for presenting the results from these analyses through charts and tables.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Introduction

Findings and analysis assessment of Solid Waste generated in the small town of Himo which is located in Moshi district, within Himo ward are presented. These results were obtained from the questionnaires, grab sample assessment and from physical and chemical parameters and as well as the data from the site including measurement of samples collected from different dumpsites and analysis of solid waste in the laboratory regarding Solid waste collection, storage transfer and disposal.

4.2 Social and Demographic Characteristics

This part reports and discusses the Social and Demographic characteristics of the respondents including age, educational level, gender, income and marital status.

4.2.1 Educational Level of Respondents

General results reveal that most of the respondents in Himo town had a scholastic education (Table 4.1). The results indicated that 41.7% were educated to ordinary level, while 28.3% and 15% had attended primary school and advanced level education respectively. Only 6.7% of respondents had a university level.

Table 4.1: The Educational Level of Respondent

Education level	Frequency	Percent
Primary education	17	28.3
O-level	25	41.7
A-level	9	15.0
University	4	6.7
Missing System	5	8.3
Total	**60**	**100.0**

Source: Researcher, (2013)

4.2.2 Sex of the Respondents

Male respondents were higher than female respondents, corresponding to 65% and females 35% respectively (Table 4.2). This could be the fact that most female respondents why was caused by most of the female respondents were afraid to respond to the questionnaires and directed some of the questions to be answered by males due to reason that in Chagga culture, men are the spokes persons of the family.

Table 4.2: Gender Distribution of the Respondents

Gender	Frequency	Percent
Male	39	65.0
Female	21	35.0
Total	**60**	**100.0**

Source: Researcher, (2013)

Table 4.3: Income Level of Respondents

Income per month (Tshs)	Frequency	Percent
< 50,000	7	11.7
50,000-100,000	11	18.3
> 100,000	39	65.0
Missing System	3	5.0
Total	**60**	**100.0**

Source: Researcher, (2013)

4.2.3 Income Level

The income level of individuals in Himo town generally indicated that most individuals were middle class and above, while only small population was in low class (poor). This is because in the study, about 65% of all respondents were earning monthly income of greater than 100,000 Tanzanian Shillings, while the remaining

30% (including 11.7% earned less than 50,000 and 18.3% earning 18.3% per month respectively). The results are presented in Table 4.3.

4.2.4 Marital Status

It was revealed that about half of the respondents (53.3%) were married in Himo township and disagreed by 38.3%. The results indicate that most individuals in Himo town are lived with their spouses either together under one roof or separately and this increased the amount of solid waste generation. The results are presented in Table 4.4.

Table 4.4: Marital Status of the Respondents

	Frequency	**Percent**
Ever married	32	53.3
Never married	23	38.3
Total	55	91.7
System	5	8.3
Total	**60**	**100.0**

Source: Researcher, (2013)

Table 4.5: Distribution of the Respondents

Age in years	**Frequency**	**Percent**
15-25	13	21.7
26-35	18	30.0
36-45	15	25.0
46-55	6	10.0
55 and above	2	3.3
Missing System	6	10.0
Total	**60**	**100.0**

Source: Researcher, (2013)

4.2.5 Distribution of the Respondents

In the study, about 30% of respondents were aged between 26-35 years dominating the group followed by those aged between 36-45 years (25%). Those aged between 15-25 were 21.7% while those aged between 46-55 years were 10%. Elders at 55 years and above were 3.3%. This is presented in Table 4.5.

Table 4.6: Household Composition

Age in years	Frequency	Percent
15-25	13	21.7
26-35	18	30.0
36-45	15	25.0
46-55	6	10.0
55 and above	2	3.3
Missing System	6	10.0
Total	**60**	**100.0**

Source: Researcher, (2013)

4.2.6 Household Composition

Most of the households within Himo town had families had more than 5 children as the administered questionnaire revealed. The respondents in the households agreed by 61.7% that their household composition was greater than 5 while 11.7% agreed that were below 5 people. The results are presented in Table 4.6.

Table 4.7: Solid Waste Generation Trend for Broken glass and Metal scrap

	Frequency	Percent
5 and below	7	11.7
Above 5	37	61.7
Missing System	16	26.7
Total	**60**	**100.0**

Source: Researcher, (2013)

4.2.7 Economic Activities

The people in this town were engaged in different economic activities which enabled them to earn income and live modestly in the community. These were mostly agricultural activities as well as business both in large scale, medium and small scale.

4.2.7.1 Agricultural Activities

This was the primary economic activity practiced by the people within Himo town. Maize, beans, banana and horticultural crops were grown widely. As far as Livestock keeping was concerned, cattle rearing, chicken, goat, sheep and swine that were reared as the source of food and for generation of income.

4.2.7.2 Business Activities

People in this area were business oriented, Himo being the hub for border trade with Kenya. There are small, medium and large businesses, operating in both retail and wholesale distribution.

4.3 Solid Waste Assessment

4.3.1 Sources of Solid Waste

Most of the solid waste generated in Himo town originate from households including wastes such as food remains, paper materials, yard wastes and plastics. Hazardous wastes were generated in Himo Tannery, the only leather industry in the town. Other waste source include the wastes were health centers, schools, training colleges, markets, kiosks and bars. The quantity of different types of generated solid wastes from different sources differ due to location, use and individual perception towards particular solid waste type. These solid waste characteristics are discussed below:

4.3.1.1 Broken Glass and Metal scrap

Most of broken glass and metal scrap were generated mostly by the small scale industries and artisans while less were generated from residential and commercial places. It was observed that generation rate of the broken glass was agreed by 18.3% to be high while 13.3% agreed it to be low. About 48% commented it to be low. As for metal scrap, 46% of the respondents agreed it to be low while 8.3% argued it to be moderate. About 18.3% of the respondents said it were high. Most of the metal scrap being generated either in households or residential places were recycled by iron smiths who reshape it into different items. This is presented in Table 4.7

Table 4.8: Solid Waste Generation Trend for Broken Glass and Metal Scrap

		High	Moderate	Low	Missing System	Total
Broken glass	Frequency	11	8	29	12	60
	Percent	18.3	13.3	48.3	20.0	100.0
Metal Scrap	Frequency	11	5	28	16	60
	Percent	18.3	8.3	46.7	26.7	100

Source: Researcher, (2013)

4.3.1.2 Plastic Wrappers and Food Left Over

The plastic wrappers and foods left over were wastes commonly generated mostly from residential and institutional facilities within Himo town. It was found that there was a high generation rate of the plastic wrapping materials as agreed by 61.7% respondents. Institutions and facilities like secondary schools, funeral and various anniversary celebrations and other gatherings ns where the plastic wrappers were used to carry hold food was most contributor in this aspect. As shown in table 4.8, the generations of food left over as a waste were agreed by 43.3% of respondents while 15% agreed to moderate and the remainder 15% agreed to low generation of food wastes. This was due to the reason that although the food waste was being generated in Himo town most of the waste was used to feed swine which are reared by many individuals. This is because although food wastes were highly generated their occurrence in the environment was rare.

Table 4.9: Solid Waste Generation Trend for the Plastic Wrapper and Food Left Over

		High	Moderate	Low	Missing System	Total
Plastic Wrapper	Frequency	37	11	4	8	60
	Percent	61.7	18.3	6.7	13.3	100.0
Food left over and vegetable peels	Frequency	26	9	15	10	60
	Percent	43.3	15	25	16.7	100

Source: Researcher, (2013)

4.2.1.3 Beer Bottles, Household Sweep and Cow Dung

Beer bottles are generated mostly in commercial facilities and residential facilities in small tendency as agreed by 24% of respondents. This was due to beer bottles being returned to the industry for refilling, which reduce the amount of bottles that remained in the environment as solid waste requiring disposal.

Household sweep and cow dung on the other hand was argued to be highly generated by 23.3% of respondents while 13.3% said it were generated moderately. About 41.7% argued it to be generated in low quantity. This is explained by the reason that the cow dung is stored left to dry and Decomposed farm yard manure is an important resource in agricultural production. This is presented in Figure 4.10

Table 4.10: Solid Waste Generation Response for the Beer Bottles and Household Sweep and Cow Dung

		High	Moderate	Low	Missing System	Total
Beer Bottles	Frequency	8	8	24	20	60
	Percent	13.3	13.3	40.0	33.3	100.0
Household sweep and cow dung	Frequency	14	8	25	13	60
	Percent	23.3	13.3	41.7	21.7	100

Source: Researcher, (2013)

4.3.1.4 Metal Cans and Paper Wrapping Material

Metal cans waste were mostly generated from residential places as well as the industrial places. Although it's was noted that there was slightly difference between individual response that agree and disagree, about 28.3% agree to high while 26.7% agreed it to be low.

Plate 4.1: Metal Cans Burnt in Dumpsite

Source: Field Data

As shown in a Table 4.11 paper wrapping materials were highly generated in Himo town as agreed by 63.35% respondents. This was caused by the presence of primary, secondary schools, teachers colleges, VETA centers that used paper on daily basis.

Table 4.11: Solid Waste Generation Response for the Metal Cans and Wrapping Materials

		High	Moderate	Low	Missing System	Total
Metal cans	Frequency	17	15	16	12	60
	Percent	28.3	25.0	26.7	20	100.0
Paper wrapping materials	Frequency	38	5	4	13	60
	Percent	63.3	8.3	6.7	21.7	100

Source: Researcher, (2013)

4.3.1.5 Waste Textile and Wastes from Barber Shops

The waste textiles were generated in a low quantity in Himo town and this was due to the textile industry being located in in Arusha region which is far from this town. The nature of disposal of old or worn out clothing was also evident. The argument is explained by 41.7% of respondents who agree that low amount of textile waste were generated. Waste from barber shops were also generated in Himo town in a small tendency as agreed by 45% of the respondents while 23.3% agreed it to be high. Most of the barbers used to burn their waste before disposal caused low wastes being deposited in dumps and landfills. The results are presented in Table 4.12.

4.4 Solid Waste Collection and Temporary Storage

After generation, solid waste was collected and either stored temporarily or transported to disposal site. The transport involved direct transport to dumpsites or landfills for ultimate disposal.

Table 4.12: Solid Waste Generation Response for Waste Textiles and from Barber Shops

		High	Moderate	Low	Missing System	Total
Metal cans	Frequency	18	5	12	12	60
	Percent	30	8.3	20	20	100.0
Paper wrapping materials	Frequency	14	7	27	12	60
	Percent	23.3	11.7	45.0	20.0	100

Source: Researcher, (2013)

4.4.1 Collection

In Himo town, the collection of solid wastes was commonly done, with the respondents at household level as agreed by 66.7% of respondents and also, by roadside uncontrolled dumping as agreed by 58.3% respondents. While the methods like use of collection points and collective waste containers were found not used by 61.8% and 51.7% respondents, respectively. This indicates the individuals in Himo town prefer waste collection at household level and roadside uncontrolled dumping other than other methods, and this was because of the methods being simpler, requiring no movement to collection points which were the transfer stations. However road side uncontrolled dumping although commonly used had the effect of contaminating the environment as the wastes were discarded uncontrolled into the environment.

Furthermore, the Local authority is the responsible for management of waste collection, nevertheless the results from the study indicates that the management was poor. This is because of the 66.7% respondents disagreed that the Local authority was responsible for the scheduled solid waste collection from various collection points and households. This is presented in Table 4.13 below.

Table 4.13: Local Authority Control of Waste Collection Schedules

	Frequency	Percent
Yes	19	31.7
No	40	66.7
Missing system	1	1.7
Total	**60**	**100.0**

Source: Researcher, (2013)

On top of collection schedules, collection frequency in the collection points and household was average for most individuals in Himo town and this is explained by low environmental consciousness on importance of solid waste management and less stringent regulations imposed on the community relating to solid wastes. Normally the solid wastes were to be collected twice weekly, depending on the production capacity and living standard of the community (Tchobanoglous, 1993). In the study it was revealed that, solid waste was not collected at all as agreed by 23.3% of respondents, while 38.3% agree that it were rarely collected and 30% agreed that it somewhat were collected and only 5% argued on frequently collected. This means the individuals in Himo collected wastes on voluntary basis other than health conscious.

Table 4.14: Respondents Results in the Frequency of Solid Waste Collection

	Frequency	Percent
Not collected at all	14	23.3
Rarely collected	23	38.3
Somewhat collected	18	30.0
Frequently collected	5	8.3
Total	**60**	**100.0**

Source: Researcher, (2013)

It was also unclear on whether the Waste collection workers were trained on the methods and proper handling of solid waste, as 60% of respondents didn't know about it. Results are shown in Table 4.15, indicating poor management for the solid wastes administration (Local Authority) as well as workers collecting wastes from different collection points.

Table 4.15: Workers Training on Solid Wastes Management

	Frequency	**Percent**
Yes	3	5.0
No	21	35.0
Dont know	36	60.0
Total	**60**	**100.0**

Source: Researcher, (2013)

4.4.2 Storage

Temporary storage of solid wastes occurred when there were small amounts of waste generated at time. However, solid waste storage was associated with presence of nuisance following allowance of waste to decompose at point of disposal, which provided breeding site for insects and flies that threatened human health. In Himo town, the most commonly used storage materials for temporary storage of solid waste before disposal were plastic bags as agreed by 48.3% of respondents, dust bins as agreed by 50% of respondents. Empty fertilizer bags and hessian sacks were not used as argued by 53.3% and 75% respondents, respectively.

4.5 Solid Waste Transport and Disposal

After collection, solid waste was transported to dumpsites and un-engineered landfills for ultimate disposal, with transportation vehicles described below:

Plate 4.2: Solid Wastes Temporary Stored in One of Canteen in Himo
Source: Researcher, (2013)

4.5.1 Transport

In Himo town solid wastes were transported to dump sites by using different waste handling vehicles, like lorries, pick-up trucks, wheelbarrows and ox-carts. Lorries were mostly owned by Municipal and Dstrict councils, while wheel barrows were mostly used in commercial places and institutions for movement of solid waste. The latter two were agreed to by 11% of respondents.

Other means employed were ox -carts as agreed by 13.3% which was commonly used by farming communities where animals (oxen and donkeys) were used for farming and transportation. Polythene bags were used mostly to transport wastes to temporary storage facilities and dumpsites as they were mostly used in households where there were little quantities of waste generated in day-to-day activities. Polythene bags were agreed by 38.3% of respondents while plastic baskets by 6.7%

of the respondents. In some cases tractor with trailer were used to move of wastes from collection sites to dumpsites.

Table 4.16: Carriage Used to Move Solid Wastes

	Frequency	Percent
Trucks (lorries)	11	18.3
Wheel barrow	11	18.3
Ox-carts	8	13.3
Polythene bags	23	38.3
Plastic baskets	4	6.7
Tractor with trailer	3	5.0
Total	**60**	**100.0**

Source: Researcher, (2013)

4.5.2 Disposal Methods

Common Solid waste disposal method in Himo was by dumping of solid waste into pits dug within most of the household's premises. Although this was the case for individuals with space within their homes, but for those who could not have the pits, had their SW collected into dust bins, plastic bags or polythene sheets then carried to dumpsites or non-engineered landfills for. About 58.3% of respondents had waste pits within their premises where some of solid waste was burnt after disposal and refilled when full by hoe and spade empting .The other 40% didn't own waste pits, but had their SW collected and deposited in specific dumpsites located in Makuyuni area within Himo town (Table 4.17).

Table 4.17: Individuals in Himo with the Solid Waste Pits within their Premises

	Frequency	Percent
Yes	35	58.3
No	24	40.0
System	1	1.7
Total	**60**	**100.0**

Source: Researcher, (2013)

Plate 4.3: Makuyuni Dumpsite in Himo Town

Source: Researcher, (2013)

On the other hand, the distances from which the waste pits were located from the household varied among the respondents such that, 65% agree to have waste pits 100 m from their homes while 13.3% agreed it was between 101 m to 500 m from their homes. This means that the majority of household members in Himo collected SW in the ground solid waste pits, while less waste from households was dumped into landfills and dumpsites. Wastes from institutions including hotels, training centers, schools and commercial institutions were dumped in the landfills because of their high generation rate, thus requiring a ample space for disposal.

Table 4.18: Distance From Homes to the Dumpsites

	Frequency	Percent
0-100	39	65.0
101-500	8	13.3
> 500	1	1.7
Missing System	12	20.0
Total	**60**	**100.0**

Source: Researcher, (2013)

4.5.3 Incineration

Incineration was one of solid waste management strategy practiced for control of medical wastes in some medical facilities in Himo town. There were three fully functional incinerators in the town. The health facilities where wastes were incinerated include Faraja Health Centre, Lazaro Hospital and Kwa Mlay Community dispensary.

4.6 Role of Local Government Authority on Solid Waste Management

In Himo town, solid waste management was operated under the supervision of the Local government authority. Management was involved in collection of wastes, transport and disposal in the area. Some respondents were not satisfied with the local government services towards solid wastes management. This was approved by 71.6% (including 63.3% not satisfactory and 8.3% very unsatisfactory). Results are shown in table 4.18 and are explained by poor follow up on the solid waste collection on the transfer stations across the town where wastes accumulated and overflow without being taken to dumpsites for disposal by the local government agencies in time. Lack of solid waste handling gear such as boots, gloves and goggles was a hindrance to smooth SWM in the town.

Table 4.19: Satisfaction Level of Respondents Towards SWM Services Provided by the Local Government Authority

	Frequency	**Percent**
Satisfactory	8	13.3
Fair	9	15.0
Not satisfactory	38	63.3
Very unsatisfactory	5	8.3
Total	**60**	**100.0**

Source: Researcher, (2013)

4.6.1 Awareness of Laws on SWM

However, about 73.3% of the respondents didn't know the by- laws governing solid waste management enacted by the Local government authority. About 26.7% of the respondents had knowledge of such provisions. There was little understanding of regulations governing SW management among the respondents in Himo on proper solid waste management strategy in general.

Table 4.20: Awareness on Laws Regulating Solid Waste Management in Himo

	Frequency	Percent
Yes	16	26.7
No	44	73.3
Total	**60**	**100.0**

Source: Researcher, (2013)

4.7 Solid Wastes and Contamination of Water Sources

Inappropriate solid wastes disposal might cause water sources contamination when the dissolved in water during the rain spell then conveyed it into the sources. The phenomenon was much common during the rain spell whereby through surface run off, the dissolved materials from solid waste were directed by furrows to contaminate water sources, such as river Whona.

It was clear that solid wastes were washed into the river during rainy spell. The respondents had variable views on this matter, whereas 36.7% agreed, while 45%. About 11.7% of the respondents did not know. This is presented in Table 4.21.

Table 4 21: Respondents Results on Whether Solid Wastes were washed into Water Body During Rain Spell

	Frequency	Percent
Yes	22	36.7
No	27	45.0
Don't know	7	11.7
System	4	6.7
Total	**60**	**100.0**

Source: Researcher, (2013)

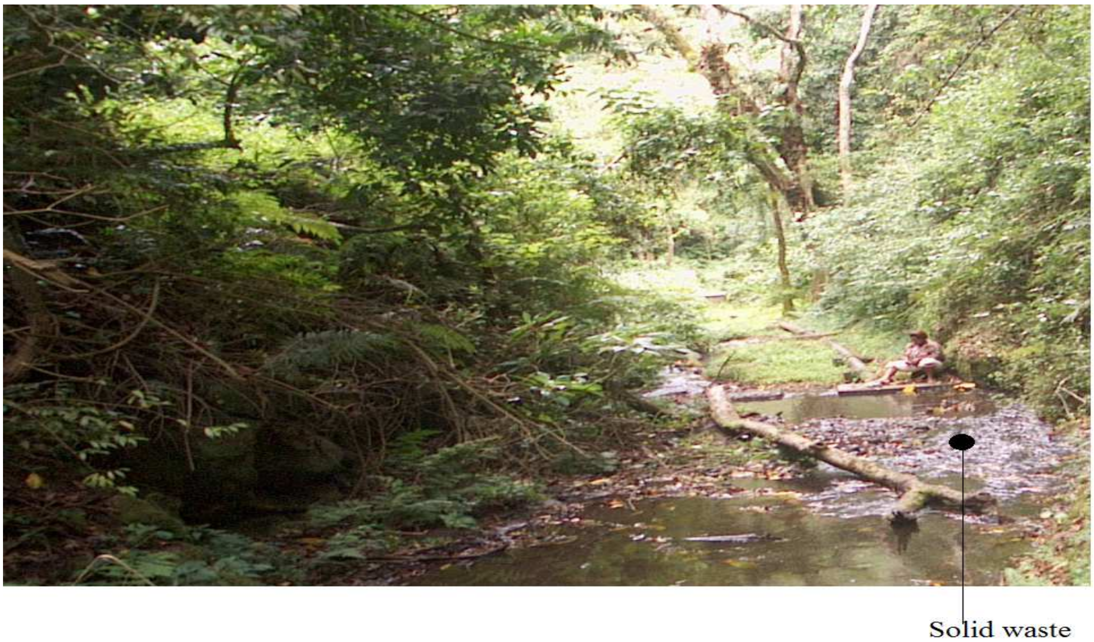


Plate 4.4: Solid Wastes Floating in Whona River in Himo

Source: Researcher, (2013)

4.8 Pollution level Within the Dumpsites

Solid waste samples were collected for analysis at TaCRI laboratory, whereby parameters like Nitrogen, Organic matter content, potassium and phosphorous level were determined. The dumpsites where the samples were collected were named according to their locations. They include Kwa Hussein, Saghana, Lower Himo, Kilacha, Makuyuni, Mnadani, Mabungo, Kwa Festo, Machinjio, Darajani, Marangu Secondary school, Himo market and Old abattoir area.

4.8.1 Potassium

Pottasium level were determined in the Saghana, Lower Himo, Kilacha, Mnadani, Mabungo, Kwa Festo, Marangu Secondary school and Himo market dumpsites. On the other hand dumpsites of Kwa Hussein, Makuyuni, Machinjio and Abattoir area, the result were recorded as shown in Table 4.21.

4.8.2 Calcium

For Calcium, as the chemical parameter measured in the solid wastes, all the readings recorded in the dumpsites were above the standard for the average levels of Calcium required in the sample which was 3.57 kg/Ha. This indicate that the dumpsites were polluted with Calcium. The dumpsites include Kwa Hussein, Makuyuni, Machinjio and Abattoir area where the reading were recorded. The results are presented in Figure 4.2.

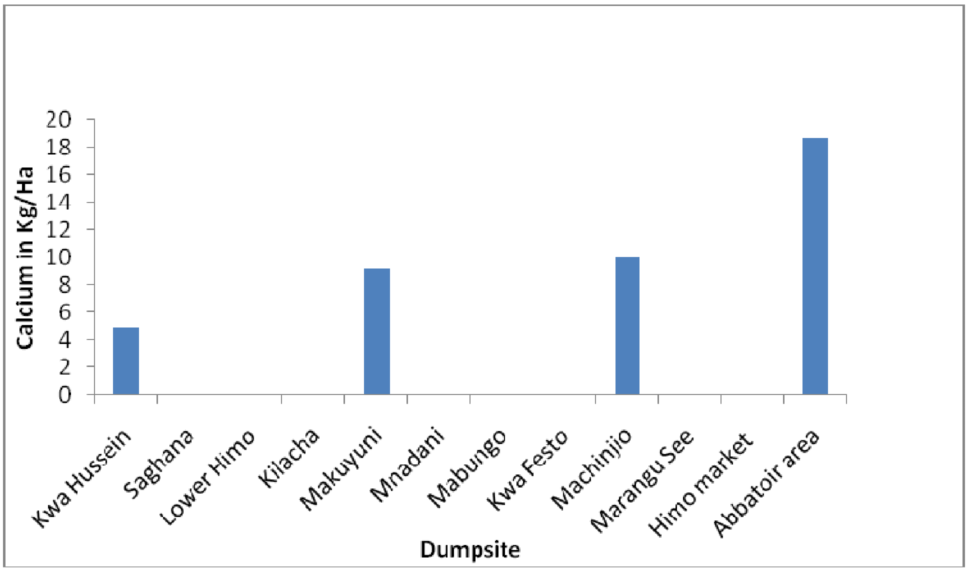


Figure 4.1: Calcium level in Dumpsites in Himo Town

Source: Researcher, (2013)

4.8.2.1 Potassium

For potassium, the recorded values were below 140 Kg/ha indicating low level of potassium amount in the dumpsites. This was because of most of the wastes dumped in Himo town are low in potash. At Kwa Hussein it were 1.8 kg/ha, Makuyuni 2.2 kg/ha and for Machinjio and Abattoir, the results were 2.1 kg/Ha and 2.2 kg/ha. respectively. In comparison with the standards for dumpsites pollution level, whereas potassium should be less or equal to 0.68 kg/ha all the dumpsites where potassium reading was recorded were above the standards and hence polluted. Low potassium levels were caused by leaching due to high porosity of the soil itself and water logging.

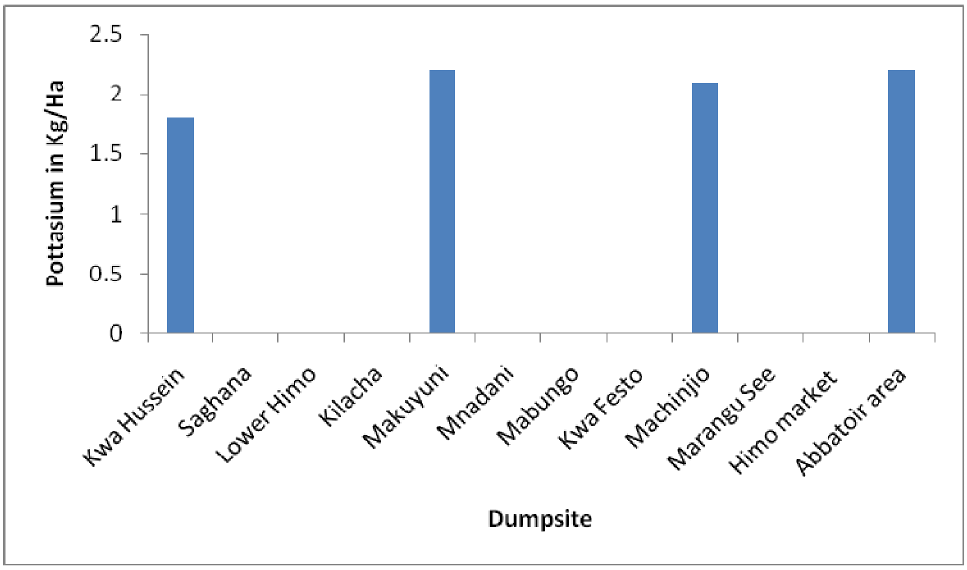


Figure 4.2: Potassium Level in Dumpsites within Himo Town
Source: Researcher, (2013)

4.8.3 Phosphorous

In solid wastes, phosphorous originated from agricultural wastes and domestic wastes especially from the stuff used in homes. Phosphorous were determined in the solid wastes at the dumpsites and the result revealed that for all dumpsites the phosphorous content was low as it was below 50 kg/Ha. Although the content is low within the dumpsites the level of phosphorous were found to differ such that the lowest results was which both have recorded in the dumpsites at Machinjio which was 13.8 kg/Ha, Marangu Secondary school and Abattoir area dumpsites to which both a results of 13.9 kg/Ha was recorded. Moreover Kwa Hussein and Saghana results were 23.2 kg/Ha while in Lower Himo dumpsite it were 23.1 kg/Ha and by comparing with the standard guidelines there were very low phosphorous contents in the wastes.

The other five dumpsites have the phosphorus level in the wastes range between 33-70 kg/Ha which is low phosphorous content, caused by the low level dumping of agricultural wastes due to lack or limited agricultural activities in these areas. The dumpsites located at Kilacha, Makuyuni, Mnadani, Mabungo and Kwa Festo were having the phosphorous content of 39.6 kg/Ha, 39.2 Kg/ha, 39.2 kg/ha, 39.4Kg/ha and 39.2 kg/ha respectively as was explained by dumping of agricultural phosphorous materials due to agricultural activities in the areas where the dumpsites were located (Annex IV, laboratory results).

In comparison with the standards required for the dumpsites pollution, the dumpsites of Kilacha, Makuyuni, Mnadani, Mabungo and Kwa Festo are termed as polluted as results showed that have Phosphorous levels above the standard which is 26.8 kg/ha. The In other dumpsites had Phosphorous levels within the required standards. Phosphorus is not toxic and would not be a problem except P is the nutrient that limits biological activity in most of clear water lakes and streams. Nitrogen and potash generally occur naturally in the environment in sufficient quantities to support algae.

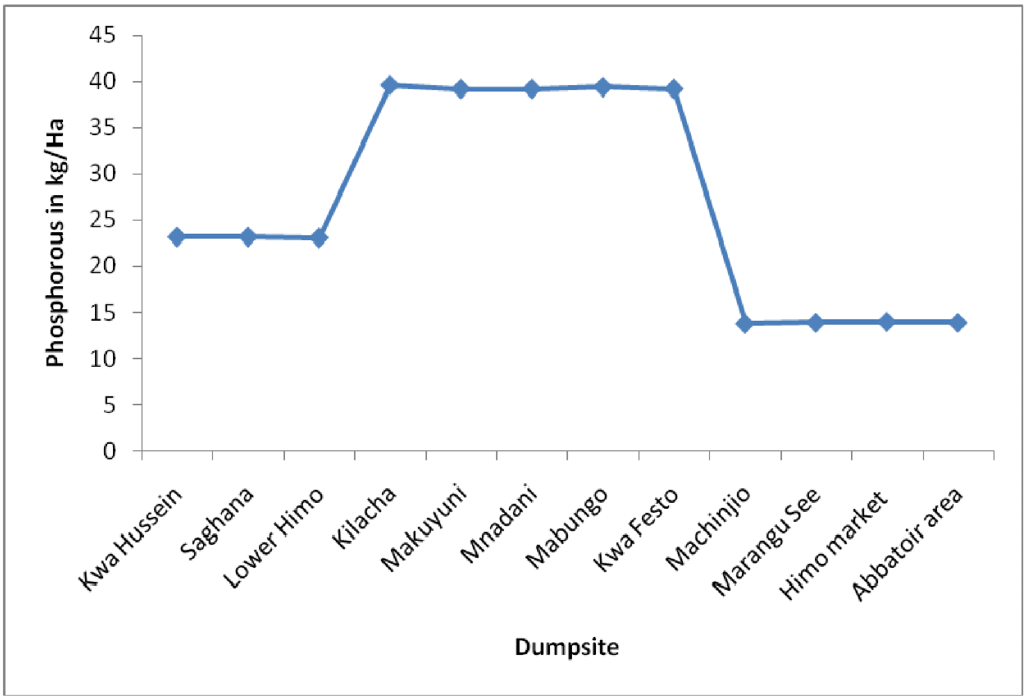


Figure 4.3: Phosphorous Content Variations in Dumpsites

Source: Researcher, (2013)

4.8.4 Nitrogen

Nitrogen as one of the elements that constitutes different Solid wastes types was determined. In the Solid waste samples collected at the dumpsites at Kwa Hussein, Saghana, Lower Himo Kilacha and Mnadani indicated elevated levels as shown in figure 4.5. Nitrogen levels were 1.44 kg/ha, 1.45 kg/ha, 1.51 kg/ha, 1.45 kg/ha and 1.37 kg/ha respectively. This was caused by the type of wastes usually dumped within these sites which were high in Nitrogen in nature while the dumpsites like Makuyuni, Mabungo, Kwa Festo, Machinjio,Marangu Sec., Himo Market and Abattoir area indicated low levels of Nitrogen ranging between 0.21kg/ha-0.34 kg/ha this was caused by low decomposition of organic matter in the dumpsites.

However, overall results of nitrogen indicated low level in all dumpsites as it was below 1.3 kg/ha in all dumpsites.

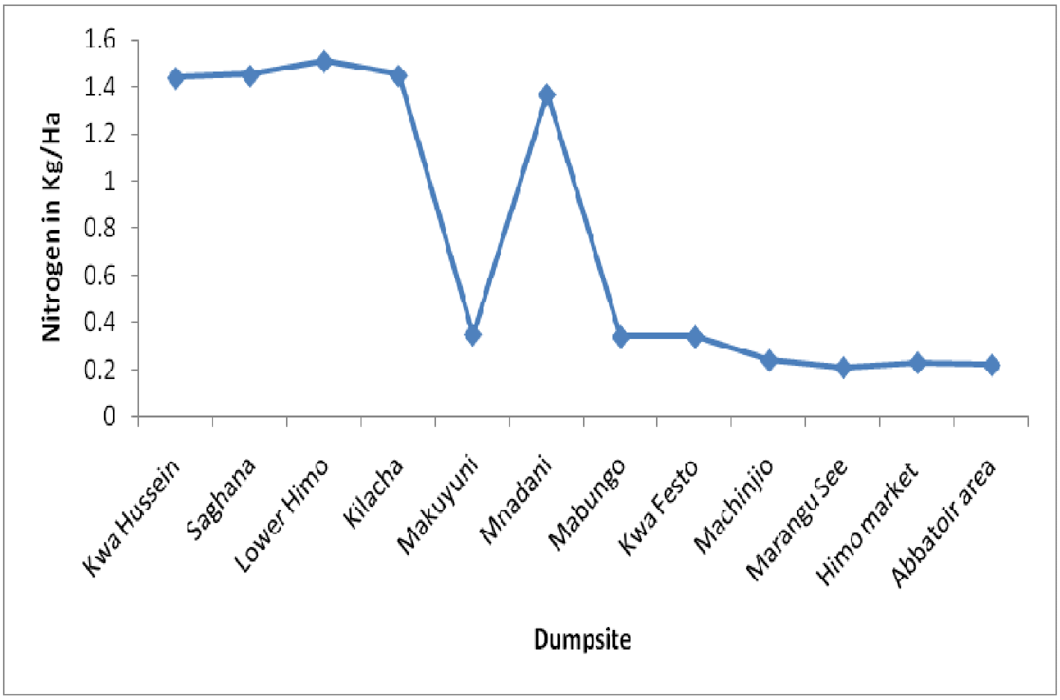


Figure 4.4: Nitrogen Content in Dumpsites

Source: Researcher, (2013)

4.8.5 Organic Carbon

In all dumpsites the amount was in low content, ranging between 0.7 % and 2 %. However with comparison with the (Bolsa Analytical Technology) standards for dumpsites pollution level which was 1.49 %. About eight dumpsites were termed to be polluted as the Nitrogen level was above the recommended standard. These dumpsites include Kwa Hussein (1.59 %), Saghana (1.61 %), Lower Himo (1.62 %), Kilacha (1.62 %), Makuyuni (1.59 %), Mnadani (1.52 %), Mabungo (1.52 %) and Kwa Festo (1.52) as results showed in Figure 4.5. The remaining dumpsites had nitrogen levels within the recommended standards that was below 1.49 %. This includes Machinjio, Marangu Sec., Himo market and Abattoir area.

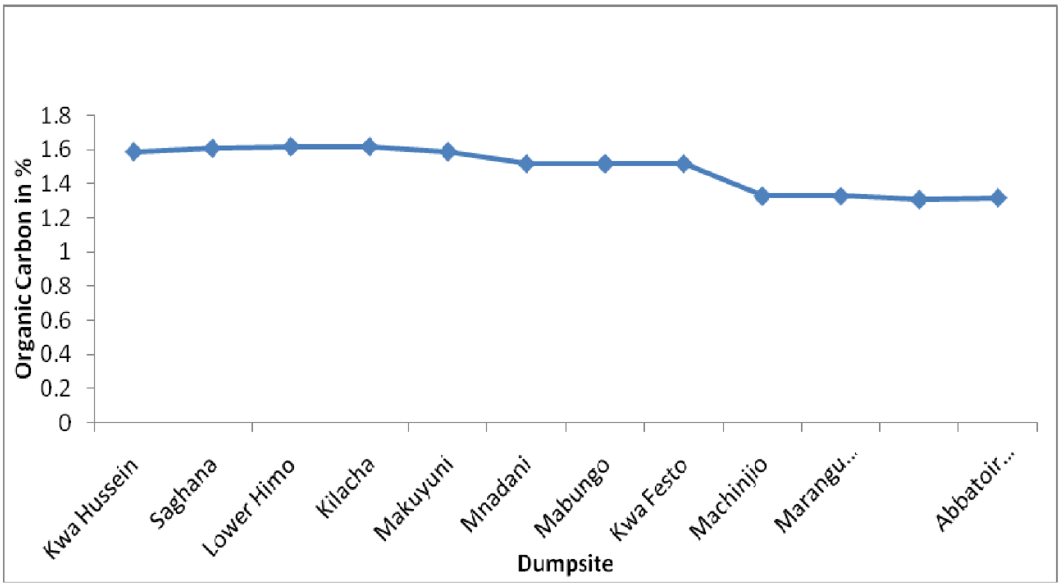


Figure 4.5: Variations of Organic Carbon in dumpsites

Source: Researcher, (2013)

Table 4.10: Standard % Organic Matter Index (TAcri SW analysis)

% Organic Matter	Level
< 0.7	Very low
0.7 - 2.0	Low
2.0 - 3.5	Medium
3.5 - 4.5	High
> 4.5	Very high

Source: Bolsa Analytical Technology

4.8.6 Moisture Content

Moisture content was determined in the solid wastes sample collected within the dumpsites in Himo town that originated from biodegradable wastes which moisture aids their decomposition. Moisture may have been generated in the course of degradation of solid waste themselves. The SW had high moisture content which was above the recommended standard for dumpsites which was 12.33 %. This indicated that the dumpsites were polluted, having elevated levels of MC. One reason could be that the SW were not compacted enough as to allow slow decomposition. The polluted dumpsites include Kwa Festo and Himo market both with a moisture content of 12.9 % and Abattoir had the moisture content of about 13%. This was explained by the reason that most of the solid wastes were of clay in nature and samples were collected in the rain spell the other dumpsites were within the recommended standard to which the moisture content levels were below 12.33 % (Figure 4.6, Annex IV).

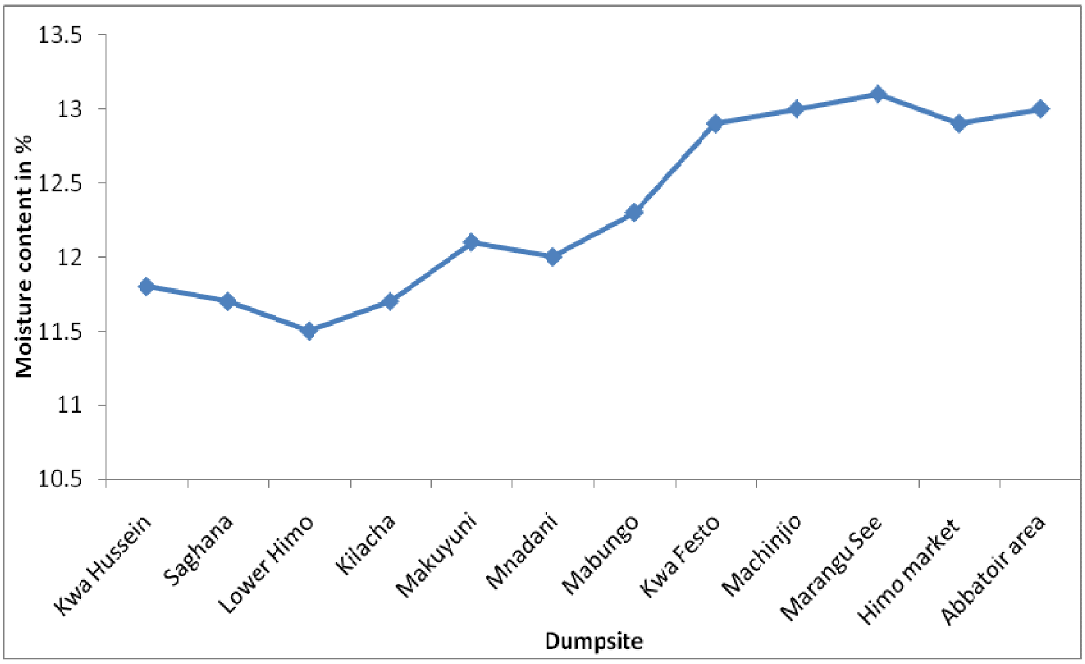


Figure 4.6: Moisture Content Variations in Dumpsites in Himo Town

Source: Researcher, (2013)

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter focuses on the generalization of the findings obtained from the study. The study aimed to assess the solid waste management undertaking, a case of Himo town, located in Moshi District, Kilimanjaro Region.

5.2 Conclusion

The solid waste generated in Himo town originated mainly from households whereby, wastes like food remains, yard cleaning wastes, paper and plastics were commonly generated, while from the industries, wastes like leather and waste textile were obtained. Other solid waste sources were from institutions including health centers, dispensaries, schools, folk training centers, markets, bars, kiosks and stationeries, whereby papers waste, cardboard and broken glasses were commonly generated.

Broken glass and metal scrap were the solid wastes generated mostly by small scale industries and less from residential and commercial places. In the study, it was observed that generation rate of broken glass was found to be less generated as agreed a total of 61.6 % of respondents while that of metal scrap was 0.8125 kg/day as agreed by 55 % of respondents.

It was found that there was a high generation of the plastic wrapper material wastes as agreed by 61.7 % of the respondents, with indicated a generation rate of 1.875 kg/day and this resulted in day to day activities in institutions where plastic wrappers were used to carrying or wrap and cover foodstuff. Food left over was not highly generated, but its occurrence was rare because it was being used to feed swine reared by many people within the town.

In the study it was revealed that beer bottles were generated in small tendency, with a generation rate of 0.4375 kg/day as agreed by 24 % of respondents and this was because they were returned for refilling at industry. The household sweep and cow dung indicated a generation rate of 1.2 kg/day and, the small generation rate of this wastes was explained by the reason that the cow dung was stored and left to rot and decompose thereafter to be used as farm yard manure. The average generation rate of paper as wrapping materials was 1.325 kg/day, as wastes it were generated in Himo town as agreed by 63.35 % respondents. This was caused by the presence of primary and secondary schools, VETA and a Teacher Training College which produces waste paper daily.

Residents in Himo town preferred SW collection at household as agreed by 66.7% of respondents and roadside uncontrolled dumping as agreed by 58.3 % of the respondents. This was because such solid wastes methods were simple and did not require movement to collection points, which are the transfer stations. However, uncontrolled road side dumping, although commonly practiced had the effect of contaminating the environment as the Solid Wastes were discarded all over the place in some parts of the town.

There was inefficient management and schedules of SW collection activities by the Local Government Authority as the solid wastes were rarely collected or somewhat collected. In general, there was irregular collection of Solid Wastes in the town.

It was also unclear on whether the SW collection workers were trained on the methods of proper handling of solid waste, as 60 % of respondents had no idea about it. Most commonly used handling and storage materials for temporary storage of solid waste before disposal were plastic bags as agreed by 48.3 % of respondents, and dust bins as agreed by 50 % of respondents.

The solid wastes in this town were transported using wheelbarrows and trucks (lorries) in institutions and by ox-carts and polythene bags in some households. Majority of individuals about 58.3 % of respondents had waste pits 100 meters from their premises, where the waste were burnt after disposal and empted when full. The wastes from institutions were collected and dumped straight to Makuyuni dumpsite.

Incineration was practiced in Himo town, especially for medical and hospital wastes generated from hospitals and health centers. Furthermore, it was revealed that most respondents were not satisfied with the Local Government Authority services towards SW management. This was agreed by 71.6 % of the respondents, while 73.3 % of the respondents were unaware of the and by-laws governing solid waste management.

5.3 Recommendations

The frequency of collection of solid wastes should be at least three times per week, so as to avoid accumulation of solid wastes in the bins and as well improve wastes degradability conditions. This should be backed by training of wastes collectors on best methods of solid waste handling and disposal should be provided to collection workers on how to effectively collect and dispose solid wastes safety. The training should be done in conjunction with provision of protective gloves, goggles, gumboots and working tools such as wheelbarrows, mattock, spades and hoes.

Local government should establish strict penalties for people and institutions that fail to comply with the by-laws of SW management strategy existing in Himo town especially banning of waste dumps near water sources.

Engineered landfills should be constructed on the southern part of Himo as agreed by 46.7 % of respondents to dump the wastes from the entire town. In which case, waste from institutions and facilities like market and hotels should be dumped in time to avoid nuisance and odour caused by the common open solid waste dumping that is practical across the town now.

There should be a comprehensive review of all aspects related to solid waste management in the town with a view to strengthening, harmonizing and aligning them to the objectives of the solid waste hierarchy which will enable introduction of Integrated Waste Management policy that will provide framework for local government authority in management of solid wastes.

Further study is recommended in examining the relationship between solid wastes and water sources contamination. This may be possible by maintaining water quality following dumping of SW in water bodies. Considerably, recycling of solid wastes especially the drinking water bottles should be considered in the near future.

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APPENDICES

Appendix I: Questionnaire

(i) Name of respondent (optional) ………………………………………

(ii) Sex ☐ male ☐ female (Tick as appropriate)

(iii) Age ………………….. years

(iv) Education level ☐ primary education ☐ O-level ☐ A-level ☐ University (Tick one)

(v) Place of residence ☐ center of town ☐ periphery of town (Tick one)

(vi) Marital status ☐ever married (married, cohabitation, widowed, divorced) (Tick one)

☐ never married (singles)

(vii) Household composition (no. of permanent residents) ………………(fill)

(viii) Income range per month (Tshs.) ☐ < 50,000 T.shs.

☐ 50,000-100,000 T.shs. (tick the correct response)

☐ >100,000 T.shs.

(ix) Origin of solid waste generation ☐ commercial/ business area

☐ town centre

☐ periphery area

☐ institutions (tick correct response)

☐ residential area

B Characteristics of solid waste generated

(i) What are the types of material generated**?** ☐ broken glass

☐ metal scrap

☐ plastic wrappers

☐ food left over, vegetable peels

☐ beer bottles,

☐ household sweep and cow dung

☐ bones, hooves, cattle/goat horns (slaughter waste)

☐ wood pieces

☐ metal cans

☐ paper wrappers (tick as appropriate)

☐waste textiles

☐ litter from chicken (guano)

☐ hair from barber shops

☐lawn cuttings

(ii) What type of waste do you think is a problem in your compound?

High☐ Moderate☐ Low broken glass ☐ …… metal scrap…☐

plastic wrappers ☐ ☐ ☐

food left over, vegetable peels …………………….. ☐ ☐ ☐

beer bottles ☐ ☐ ☐

household sweep and cow dung …………………☐ ☐ ☐

bones, hooves, cattle/goat horns …………………… ☐ ☐ ☐

Others

wood pieces ……………………………………… ☐ ☐ ☐

metal cans …………………………………… ☐ ☐ ☐

paper wrapping materials …………………… ☐ ☐ ☐

waste textiles …………………………………… ☐ ☐ ☐

litter from chicken (guano) ………………… ☐ ☐ ☐

hair from barber shops ……………………… ☐ ☐ ☐

C Collection perspective

(i) What among the following is applicable to waste dumped near your area ?

(a) Stink,

(b) Attract flies

(c) Source of feed for dogs and cats (Circle one)

(d) Haven for rats .

(ii) What are the types of material incinerated ? …………………………………

(iii) What are the sources of the solid waste in the township? ……………………

(vi) Types of carriage used to move solid waste ☐ trucks (lorries)

☐ wheel-barrows

☐ ox-carts (tick as appropriate)

☐ polythene bags

☐plastic baskets

☐ tractor with trailer

(v) How do you rate the frequency of solid waste collection ?

☐ Not collected at all

☐ Rarely collected

☐ Somewhat collected (Tick as appropriate)

☐ Frequently collected

(vi) Does the Local authority control waste collection schedules? ☐ Yes ☐ No

If yes, explain the control measures taken ……………………………………

(vii) Which of the following method/s for solid waste collection exist in the area?

	Commonly used	somewhat used	not used
-Household level	☐	☐	☐
-Collective waste containers	☐	☐	☐
-Collection points	☐	☐	☐
-Roadside uncontrolled dumping	☐	☐	☐

viii. How is waste stored in most households in the compound?

	Commonly used	somewhat used	not used
-Old buckets	☐	☐	☐
-Plastic bags	☐	☐	☐
-Hessian sacks	☐	☐	☐
- Used fertilizer bags (viroba)	☐	☐	☐
- Dust	☐	☐	☐

(Tick as appropriate)

(ix) Are waste collection workers trained ? ☐Yes ☐No ☐Don't know

D. Solid Waste disposal methods

(i) What in your opinion do you think is the quantity of waste generated daily ?

☐Small ☐Moderate ☐Large (Tick correct responce)

(ii) Is there a dump in your area? ☐ Yes ☐ No

If yes, how far is it located from your house (in meters)?

☐ 0-100 ☐ 101-500 m ☐ > 500 m

(iii) Is the solid waste washed into any water body during rain spell?

☐Yes ☐No ☐Don't know

(iv) How would you describe the solid waste situation in this town? ………………

(v) In your opinion, what is the fate of the generated solid waste ?

☐ Some of the solid waste is burnt

☐ Most solid waste is deposited in landfill

☐ Don't know (Tick as appropriate)

(vi) Is incineration practiced in the township? ☐ Yes ☐ No ☐Don't know

(Tick one). If yes, where is it done? ……………………………………………………

(vii) How would you index your level of satisfaction in solid waste management service provided by the LGA ?

☐very satisfactory

☐satisfactory

☐fair (Tick one)

☐not satisfactory

☐very unsatisfactory

(viii) Are you aware of laws regulating waste management? ☐ Yes ☐ No

(Tick) If yes, explain the answer ………………………………………

(ix) Is public education on waste management provided? ☐Yes ☐No

If yes, on what parameters ………………………………………………

(x) Please list 1 factor that could constitute barrier to sustainable solid waste management in the township. …………………………………………

(xi) In your opinion who is best equipped to manage the solid waste problem in the town?

☐government agencies

☐private organizations (Tick as appropriate)

☐joint of government and the private sector

☐households

(xii) For your choice, what is the best place to locate a dump for the township?

☐ Makuyuni area past the livestock market site ☐On the Southern part of Himo township

☐At Kwa Huseni area along Holili road ☐Lower Mabungo area (Tick one)

(xiii) Why do you select the area above ? ……………………………………………

(xiv) Where did you obtain the knowledge on solid waste disposal? …………….

(xv) Is collective street cleaning practiced in the area? ☐ Yes ☐ No

If the answer is yes, how and when is it done?

(xvi) Has there been a study on the solid waste situation in this town? ☐ Yes ☐ No

If yes, when was this conducted ? ……………..

Who was responsible? ……………..….........................

Appendix II: Result of Solid waste Grab Sample Measurements in Percentage (%)

No. of Sample	1	2	3	4	5	6	7	8	Total weight	Average weight	% in lot
Paper	0.5	0.8	0.4	2.1	2.3	2	1.3	1.2	10.6	1.325	17.26
Greens and dry matter (Organic matter)	0.4	2	0.2	1.2	0.1	2.4	1.6	1.1	9	1.125	14.7
Metal	0.6	0.1	0.1	0.1	0	1.5	0.9	1.2	4.5	0.5625	7.3
Glass materials (broken)	0.1	0.2	0.2	0.2	0.1	1.2	1.4	1.3	4.7	0.5875	7.7
Cans (beer and beverage)	0.1	0	0.1	0.1	0.1	0.3	0.9	0.6	2.2	0.275	3.6
Broken bottles and empties	0.2	0.2	2	0	0.2	0	0.6	0.3	3.5	0.4375	5.7
Plastic and polythene bags of various colours	2	0.5	2	2	2.2	1.8	1.4	3.1	15	1.875	24.4
Cow dung and chicken manure	4.1	0.2	1	0.2	2.2	0	1.3	0.6	9.6	1.2	15.6
Wood	0	0	0	0.1	0.6	0.6	0.6	0.4	2.3	0.2875	3.7
TOTAL	8	4	6	6	7.8	9.8	10	9.8	61.4	7.675	99.96

Appendix III: Result of Solid Waste Grab Sample Measurement by Weight (Kg.)

No. of Sample	**1A**	**1B**	**1C**	**1D**	**1E**	**1F**	**1G**	**1H**	**Total weight**	**Average weight**
Paper	0.5	0.8	0.4	2.1	2.3	2	1.3	1.2	10.6	1.325
Greens and dry matter (Organic matter)	0.4	2	0.2	1.2	0.1	2.4	1.6	1.1	9	1.125
Metal	0.6	0.1	0.1	0.1	0	1.5	0.9	1.2	4.5	0.5625
Glass materials (broken)	0.1	0.2	0.2	0.2	0.1	1.2	1.4	1.3	4.7	0.5875
Cans (beer and beverage)	0.1	0	0.1	0.1	0.1	0.3	0.9	0.6	2.2	0.275
Broken bottles and empties	0.2	0.2	2	0	0.2	0	0.6	0.3	3.5	0.4375
Plastic and polythene bags of various colours	2	0.5	2	2	2.2	1.8	1.4	3.1	15	1.875
Cow dung and chicken manure	4.1	0.2	1	0.2	2.2	0	1.3	0.6	9.6	1.2
Wood	0	0	0	0.1	0.6	0.6	0.6	0.4	2.3	0.2875
TOTAL	8	4	6	6	7.8	9.8	10	9.8	61.4	7.675

Appendix IV: Laboratory Results

Sample number	pH	Ca	K	P	Nitrogen	Organic carbon	% MC
1	5.9	4.9	1.8	23.2	1.44	1.59	11.8
2	5.8			23.2	1.45	1.61	11.7
3	5.7			23.1	1.51	1.62	11.5
4	5.8			39.6	1.45	1.62	11.7
5	6.7	9.2	2.2	39.2	0.35	1.59	12.1
6	6.0			39.2	1.37	1.52	12.0
7	6.1			39.4	0.34	1.52	12.3
8	6.0			39.2	0.34	1.52	12.9
9	7.0	10.1	2.1	13.8	0.24	1.33	13
10	7.0			13.9	0.21	1.33	13.1
11	7.0			14.0	0.23	1.31	12.9
12	7.1	18.7	2.2	13.9	0.22	1.32	13.0