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| An Integrated Approach For Sustainable Solid Waste Management In Low-income Countries.  Mohamed E M Elkhider  Diploma in Water Sanitation and Hygiene  Research Proposal  October 2019 | |

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| An Integrated Approach For Sustainable Solid Waste Management In Low-income Countries |
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| Diploma Thesis |
| by |
| Mohamed E M Elkhider |
| **The Hague** |
| **October 2019** |

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Abstract

Solid wastes are becoming one of the urgent problems in urban and rural areas in the recent years, particularly in places where displaced people are located. The reason behind increasing the volume of wastes in many places is reflected to the issue of overpopulation and overcrowded. The increase of wastes which was generated from large number of industries and households put more stress on the environment. Several policies and strategies were developed in developed countries in order to reduce the level of wastes and maximizing the level of diversion and quality enhancement while low-income countries are still suffering from mismanagement of solid wastes and rely on open areas for the disposal of wastes.

Several issues and challenges are encountered the development of a sustainable Solid Wastes Management (SWM): the first challenge is relating to the substantial arise of human activities and livelihood in urban and rural areas which results in generating an enormous amount of solid wastes. The large quantities of wastes in developing countries go beyond the capacity of the governments, agencies and local councils. Beside this, the issue of deposition and waste burning results in a profound contamination of ground water system and a potential air pollution. Therefore, for an effective and valuable solid waste management, there is need to understand the situation at present and determine the critical issues that can affect the ecology system and finally develop a comprehensive and ideal strategic plans in order to manage solid wastes in urban areas more effectively and enhance the quality of the environment.

In order to develop a sustainable approach for solid waste management. Several analysis will be conducted in this study. The first step is to obtain an extensive and sufficient data from a real-life case study. Afterwards, Different analysis and techniques will be established such as SWOT analysis, Gap analysis, stakeholder analysis and risk assessment.

Eventually, the study will develop strategies for solid waste management in a friendly framework to be as aguidance for developing countries. This guidance will be fruitfull for all decision makkers in low-income countries. It will remaind and support them for all necessay methods and tools that needed for SWM.

**Keywords:** Solid Waste Management. Wastes. Developing countries. Framework. Strategies

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Abbreviations

|  |  |
| --- | --- |
| SWM | Solid Waste Management |
| SW | Solid Waste |
| MSW | Municipal Solid Waste |
| US | United state |
| SA | South Africa |
| UN | United Nation |
| GHE | Green House Emission |
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Introduction

## Background

The entire world is facing an urgent problem in the issue of overpopulation and enormous development of human activities. In 2015 the number of population in the world reached about 7.5 billion people. A significant number of the population is concentrated in urban areas. The top10 highest populated cities are located in low-income countries. Sudan for example has the highest population growth in Africa with an average growth rate of 2% per year. The substantial number of people living in urbanized area lead to several issues including insufficient water supply, inadequate sanitation system, air pollution and enormous quantities of solid wastes (Hoornweg, (2012)).

No doubt, Wastes are becoming a severe problem in urban cities in the recent years, particularly in developing countries due to the issue of urbanization and overcrowded. The increase of wastes which was generated from large industries and households put more stress on the environment. Therefore, researches should be conducted in order to tackle these issues and scientists should working on discovering new strategies for solid waste management (Guerrero, (2013).).

Waste can be defined as any object, material or substances that have been discarded or to be discarded. In fact, waste can be classified into two main classifications as follows: hazardous waste and non hazardous wastes. An example of hazardous wastes is the chemical wastes while non hazardous waste could be packaging waste. Mismanagement of waste can threaten valuable natural resources and energy. Besides, biodegradable waste in landfill can emit methane and deteriorate the environment (Sharholy, (2008)).

Waste management is the process of collection, transport, treatment, recycling, monitoring and control of wastes that has been generated by human. Waste management has become an important business in the recent years. In developed countries, several policies and strategies were developed in order to reduce the level of wastes and maximizing the level of diversion and quality enhancement while developing countries are still suffering from mismanagement of solid wastes and rely on open areas for the disposal of wastes. However, today decision makers in low-income countries are more aware to give their attention to the issue of solid waste management. They intend to understand properly how to critically manage solid wastes in urban cities. Henceforth, scientists are aiming to develop a sustainable approach for solid waste management and working in reducing the quantities of solid wastes using ideal strategies and techniques in order to enhance the quality of the environment in urban cities more efficiently and effectively (Reed, (1995)).

## Problem identification

In order to build optimum strategic plans for a sustainable solid waste management considering the ecological manner, solid wastes should be treated as a resources and asset not treated as a nuisance. There is demand to develop a comprehensive strategic plans for solid waste management considering several issues including: urbanization, the environment, public health, economical perspective at current and future.

Several issues and challenges are encountered the development of a sustainable solid wastes management: the first challenge is relating to the substantial arise of human activities and livelihood in urban cities which results in generating an enormous amount of solid wastes. The large quantities of wastes in developing countries go beyond the capacity of the governments, agencies and local councils. Beside this, the issue of deposition and waste burning results in a profound contamination of ground water system and a potential air pollution. Also, the absence of policies and legalization in developing countries for realistic strategic plans lead to increase the volume of wastes in open areas and the accumulation of solid wastes in restricted area lead to contamination of soil and severe air pollution. Addition to this is the lack of proper disposal including unscientific and poor waste transportation. Furthermore, urban cities in developing countries suffer from inadequate storages and illegal disposal waste in ponds, rivers and drainage which put more stress on the quality of the surface water. Also, low-income countries have insufficient financial resources which limit the use of advance technology and equipments. The ineffective use of technology lead to irregular collection services and low collection coverage Additionally, there is lack of awareness regarding the basic principles in solid waste management among communities. Moreover, many studies were developed in solid waste management in developing countries, but most of these studies do not offer economical feasible strategies that could be implemented in practice due to its high cost and also most of these studies suffer from low data on how waste is produced. Finally, the traditional approach in solid waste management was not considered the ecological manner, the long-term degradation of water resources and the environmental aspect (Zhang, (2010)).

Therefore, for an effective and valuable solid waste management, there is need to understand the situation at present and determine the critical issues that can affect the ecology system and finally develop a comprehensive and ideal strategic plans in order to manage solid wastes in urban areas more effectively and enhance the quality of the environment.

## Goal and specific objectives

### Hypothesis

* Mismanagement of solid waste in low-income countries results in several problems including:
* Deterioration in water quality including surface water, ground water system and channels.
* Severe soil contamination due to the accumulation of the solid wastes in landfill and open areas
* Massive air pollution.
* For an effective and practical solid waste management, its important to involve local communities and all effective stakeholders through the different processes in solid waste management.
* Determination the potential resources of the wastes can results in saving about 40% of wastes from recycling and recovery. Also it will save the cost.

### Goal

The overall objective of this research project is to develop a sustainable and practical approach for low-income countries that results in optimizing all the processes in solid waste management including: collection, transportation, recycling process, different kinds of treatment and monitoring solid waste taking into account four main aspects to be minimized which related to environmental impact, sanitary landfill disposal, unrecycled waste and economic costs.

### Specific objectives

The specific objectives for this study can be classified into two main objectives:

**Objective1:** To evaluate and assess the current situation for the solid waste management using specific case study.

Specific objectives:

* To study the existing methods used in solid waste management including: collection, recycling, treatment and disposal.
* To assess the amount of wastes and determine the composition of wastes in the specific case study taking into account the uncertainties.
* To identify the environmental impacts and analyze the public health risks from the accumulation of solid wastes.
* To study the situation of all institutions, agencies and workers that engaged in solid waste management.
* To examine the level of general public involvement in solid waste management.

**Objective2:** To develop integrated strategic plans for solid waste management considering four main aspects to be minimized which related to environmental impact, sanitary landfill disposal, unrecycled waste and economic costs.

Specific objective

* To build a comprehensive strategic plan that addresses all elements that influence solid waste management including collection, transportation, treatment and disposal.
* To improve the role of general public in solid waste management planning and implementation.
* To develop an emergency plan for solid waste management in case of disasters.
* To develop performance indicators for SWM suitable for low-income countries.
* To develop a comprehensive and friendly framework for solid waste management as a guidance for low-income countries.

Literature Review

## Introduction

This chapter provides the overall concepts, theories and tools that have been developed by international agencies regarding solid waste management. The literature has been collected from different type of resources such as books, conference papers, dissertations, journals, reports and international organizations websites. This literature highlights and covers wide aspects of solid waste management concept. The chapter starts with defining the standard terminology of solid wastes, afterwards, explains the environmental impacts from mismanagement of solid wastes. Afterwards, it illustrates the regulations of solid wastes in developed and developing countries.

## Waste Definition and Categorizations

### Waste Definitions

The term waste can be defined as all refused material that has been generated from households (residential), industries, public institutions, commercials, constructions, water and wastewater treatment plants, agricultural activities, mining and manufacturing activities (Hoornweg, (2012)).

Municipal Solid Waste (MSW) is referring to any object or materials that are discarded by households and general public. It is the waste that has been generated from houses, schools, shops, offices and hospitals. it is called municipal solid waste because it is usually managed by municipalities and public authorities. Also, its commonly named rubbish or garbage (Ekvall, (2007)).

### Wastes Types and Categorizations

**2.2.2.1. Waste Types:**

There is no one agreed method to categorise waste in specific form. Surely, there are several kinds of wastes but the main types of wastes can be determined as follows:

1. **Municipal waste:**

Includes any items used in daily basis such as paper, clothes. Municipal waste can be divided into three kinds of waste as follows:

**A.1. Household waste:** such as refused food or materials from houses.

**A.2. Commercial waste:** such as refused food or material from shops or schools.

**A.3. Demolishing waste:** such as refused material generated from the destruction of any sort of structure including bricks, concrete, steel and wood.

1. **Hazardous waste:**

Includes wastes comes from industries and carry one of these properties: toxicity, corrosiveness, reactivity and ignitability.

1. **Biomedical waste:**

Includes any wastes generated from medical services such as hospitals.

**2.2.2.2. Waste Categorization**

Waste can be categorising as follows:

1. **Solid waste:**

It contains any items that coming from houses, offices, schools, commercials places, large or small industries and agricultural. Solid wastes includes the following:

**A.1. Wet waste:** Dissolved liquid based comes from domestic residential or sludge generated from wastewater treatment plants.

**A.2. Dry waste:** It is not coming in form of liquid such as papers.

**A.3. Biodegradable waste:** Any kind of organic waste which can break the waste to carbon dioxide, water and methane or organic molecules by specific organism.

**A.4. Non biodegradable waste:** Any kind of waste that cannot break the wastes down into carbon dioxide, water and methane.

1. **Liquid waste:**

This kind of wastes comes in form of liquid only and it can be treated through wastewater treatment plants.

## The Environment Impacts from Solid Waste

### General overview

Mismanagement of MSW can cause different kind of pollution on air, soil and water bodies. In urban places, MSW can clog main drains in rainy season which can results in flooding and development of good environment for insects breeding and growth. The issue of mismanagement of solid waste in open areas can lead to air pollution, the process of burning solid wastes and inadequate incineration process can contribute hugely in air pollution. Green House Emissions (GHE) are generated from the process of burning solid wastes and decomposition of organic wastes from open areas. Around 300,000 tons of different gases per year were emitted due to the issue of improper incineration of MSW in open landfill. Methane only emits about 15 million tons per year (Ramachandra, (2018)).

The impact of MSW on surface and ground water is vital. Still there is no exact number regarding the affect of MSW on surface water and ground water bodies. However, plastic materials and papers on surface water have a significant impact on human health and livelihood. Different sort of leaks from wastes can lead to sever health issue in case the waste contaminate the surface water or the soil and ground water (Gupta, (2015)).

Open disposal areas for MSW lead to degrade natural habitats. These open areas are not hospitals for plants or wildlife.

## The Public health concerns from solid waste

### General overview

No doubt that any unscientific approach for solid waste management will lead to increase the chances of infection diseases. Large numbers of population who live in area closed to waste dump have higher percentage to receive infectious disease than other people. Wastes can attract insects and vectors which can spread different kinds of infectious diseases such as cholera. Exposure to solid wastes particularly chemical waste or medical waste can affect directly on human health. Waste from industries or agricultural activities can cause several health issues. People who exposed to chemical, toxicity and radioactive hazards are more likely to live short life (Cimino, (1975)).

## Solid Wastes in Developed and developing countries

### General overview

For more sustainable approach for solid waste management it is important to understand the different perspective between developed and developing countries.

### Solid wastes in Developed countries

The principles of MSW in developed countries are based on three main factors: the first one is to reuses the waste, then recycles and finally recovery. Developed countries developed regulations and rules for MSW. Therefore, the management of solid waste is controlled to some extent.

### Solid wastes in Developing countries

In developing countries, the issue of uncontrolled MSW and improper incineration process of MSW can lead to severe health issues. In India for instance, around 90% of solid wastes are disposed directly to open areas. The collection of solid waste in India is reported to be lower than 60%. (Marshall, (2013))

## Regulations for solid wastes in developed and developing countries

In 1965, the United State (US) developed legislation for solid waste disposal. The legalisation was concerned with promoting better process of MSW. Also it is recommended to support resources recovery. In 1970, the US issued a respected report regarding the process of hazardous wastes. In 1984, the US developed the Hazardous and Solid Waste Amendment (HSWA). This regulation includes the minimum standards including monitoring the ground water system in order to insure that no contamination in ground water bodies (Van der Sloot, (1991)).

## Solid waste management and sustainable development goal

In 2002 in South Africa (SA), the world discussed the important of MSW. They were more aware about the important of MSW and they asked to give more attention to waste reduction and recovery. One of the main agenda for United Nation (UN) by 2030 is to make cities and human settlement inclusive safe, resilient and sustainable. The UN has number of sustainable development goals and goal 11 is concerned with the issue of solid waste management, in target 11.6 member states agreed to reduce the amount of wastes by paying more attention to the issue of environment and air pollution. Also, goal 12 describes the guidance to ensure sustainable consumption and production pattern. The member states also agreed to reduce food losses and supply chains including post harvesting losses (Vera, (2007)).

Research Methodology

## Introduction

This section provide the research methodology including all the necessary tools and techniques that will be used in order to reach the overall and specific objectives of this study, based on objective-oriented method. These will include identify specific case study, data collection. The study eventually will develop potential strategies which will be presented in a friendly framework. Figure 1.1 shows the general methods and procedures and the different level of the research.

Desk study

Identify specific geographic region. Example: Khartoum state

Data Preparation

-**Quantitative data** (Household survey questionnaire, management staff questionnaire, field survey)

-**Qualitative data** (Interviews, specific group discussion with stakeholders)

-**Numerical data** (Population growth, weather data)

Creation of database

Gap analysis

Risk assessment

SWOT analysis

Uncertainty analysis

Stakeholder analysis

Build strategies for the policies & capacity building

Development of Strategies to optimize the processes of solid waste management

Develop Strategies for stakeholder engagement

Figure 1‑: Overall research plan

Development of performance indicators for SWM

**Development of practical framework**s for an effective SWM

## Desk study

The first step in order to meet the specific objectives is to review the literature extensively in order to understand all available methods and theories that are applied commonly for solid waste management.

## Data preparation

In order to develop a comprehensive plan for solid waste management, it is required to obtain sufficient data from a real-life case study. The data should be taken from low-income countries that have high population growth rate. Khartoum city in Sudan for instance considered as one of the highest population growth rate with large number of industries. The city has extreme quantities of solid wastes in open areas with poor performance in the issue of solid waste management and public health.

## Creation of database

After developing sufficient data, the research project will establish different analysis and techniques in order to develop a constructive understanding for the current situation in solid waste management. Each analysis are illustrated as follows:

* **Stakeholder analysis**

In this part, the study will develop a stakeholder register and identify their level of effectiveness (power). Also, this analysis will analyze the desired situation for each stakeholder taking into account their main interest, Additionally, the study will develop a stakeholder relation diagram in order to understand their level of independencies.

* **Risk assessment**

In this part, the study will determine the environmental impacts including the level of contamination in water bodies (surface water, ground water, channels) also the air pollution and soil contamination. Besides, the study will analyze the composition of the wastes and identify the health concerns from each composition.

* **Uncertainty analysis**

As the measurement of the solid wastes is uncertain issue, there is need to conduct uncertainty analysis using propagation error theory in order to improve the level of accuracy in the assessment.

* **SWOT analysis**

This evaluation technique will identify the strengths points in solid waste management in the specific case study and the weaknesses. Also it will examine the opportunities and threats for a sustainable solid waste management.

* **Gap analysis**

This evaluation technique will be accomplished into two main scales:

the first scale is related to the missing rules, policies and regulations for solid waste management and the second scale is related to the missing of tools, methods, technologies and equipments for each individual processes in solid waste management.

## Development of a comprehensive strategies

The study will eventually develop practical and sustainable plans for solid waste management in friendly framework. The study will also develop strategies in cases of disasters. Addition to this, the strategies will focus on capacity building and stakeholder engagement, this entire plan will be formulated in friendly framework to be as guidance for low-income countries to remained and support leaders for decision-making. In addition, the study will suggest performance indicators for solid waste management to be as a reference to low-income countries.

Expected Results

## Expected Outcomes

This chapter presents the expected outcomes from each objectives of this study.

Main Outcomes are described as follows:

* Its expected to find out a large quantities of solid wastes and high population growth in the specific case study area.
* The outcomes from the public health assessment and the environmental impacts will reveal a respected amount of air pollution, soil contamination and water pollutant sources and high rate of pollution in drainage channels and rivers.
* A development of sustainable and practical strategies that consider the ecology with advance collection, transportation, recycling system and reuse the solid waste as a source of energy taking into account the economical perspective.
* Development of performance indicators suitable for low-income countries for the solid waste management to make a standard reference for solid waste management.
* A development of an integrated solid waste management taking into account the four main aspects as mentioned in chapter one.
* Development of a long term plan in friendly framework for solid waste management considering the ecological aspect, environmental manner, stakeholder engagement and the policies and regulations.
* The framework is realistic and will be as guidance for low-income countries to support decision makers to implement the strategic plans for solid waste management

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