SOLID WASTE MANAGEMENT IN KHARTOUM INDUSTRIAL AREA

By

Nazik Omer Ahmed El Sidig
B.Sc. University of Khartoum

A Thesis Submitted In Partial Fulfillment of The Requirements For The Degree of M.Sc in (Environmental Studies)

Institute of Environmental Studies
University of Khartoum

May (2004)
Dedications

Dedicated to:-

My parents,

Brothers,

And my sister
Acknowledgement

I would like to thank in particular, Mr. Antony Julu, Ehab Sir Elkhatem, Hassan Elsheik, Control manager of Khartoum Industrial Area and all those who supported and helped me during this study.

Thank are also extended to my supervisor,

Dr. Basheer M. Elhassan

And to all members of the staff and colleagues of the Institute of Environmental Studies, who offered me great assistance.
Abstract

This study was conducted in Khartoum Industrial Area (KIA). The study discusses solid waste generation issues in KIA as well as solid waste collection, storage, transport and final disposal methods. A focus on environmental impact resulting from the accumulation of solid waste was presented by reviewing solid waste management in developed as well as developing countries starting from generation to final disposal. Environmental health legislation in Sudan was investigated.

The study covers all the (eight) industrial sub-sectors presented in KIA.

The main objective of the study is to assess the situation of solid waste in KIA.

To fulfill the objectives of the study the researcher deemed it necessary to explore problems related to solid waste generation and solid waste arrangement with special emphasis on final disposal methods.

Practically, 31 (thirty-one) factories representing the different industrial sub-sectors in KIA were studied. This represents 25% of the total number of factories located in KIA.

Data were obtained by, questionnaires, interviews and observations mainly directed to concerned officials, solid waste workers, pickers and brokers.

Obtained data were stored, coded, tabulated and analyzed using the computer systems (excel & SPSS programmes).
The obtained results should clear deficiency in the management of solid waste which led to great environmental deterioration in KIA and neighboring residential areas.

The environment in studied area is continuously polluted due to high pollution loads and unproved solid waste management.

In order to maintain health environment operating factories have to pretreated their solid waste according to the recognized standards and waste minimization techniques such as recycling and reuse should be widely applied, moreover, running crash programme for environmental sanitation in Khartoum state should be expanded and improved to include special characteristics of solid waste from industries.

Finally, increase awareness among workers and solid waste pickers about environmental and health hazards of solid waste is very important.
الخلاصة

تُشير النتائج لأهمية الاستراتيجيات التي تساهم في تحسين النتائج، وتظهر أن استكمال النتائج يعد إحدى أهم النصائح في تحقيق النتائج. كما يتضح من النتائج أن تحسين النتائج مرتبط بشكل كبير بتقديم النتائج، ويشير النتائج إلى أن استكمال النتائج يعد إحدى أهم النصائح في تحقيق النتائج.

من الصعب قراءة النص بشكل طبيعي من الصورة المقدمة.
 Contents

vii
List of contents

Dedication i
Acknowledgement ii
Abstract In English iii
Abstract In Arabic v
Contents vii
List of table xi
List of Figures xiii

Chapter One

1.1. INTRODUCTION ....................................................... 1
1.2. General............................................................... 2
1.3. Industrial liquid wastes............................................. 6
1.4. Industrial gaseous wastes......................................... 7
1.5. Industrial solid wastes............................................. 8
1.6. Statement of the problem....................................... 9
1.7. Hypothesis.......................................................... 9
1.8. Objectives of the study......................................... 10
1.8.1. General objective.............................................. 10
1.8.2. Specific objectives ........................................... 10

Chapter Two

LITERATURE REVIEW

2.1 Definition of Solid waste...................................... 11
2.2. Classification of solid waste.................................. 12
2.3. Environmental Impact resulting from the accumulation of solid waste. ................................................. 21
2.4. Solid waste in developed countries ......................... 21
2.5. Solid waste in developing countries ......................... 24
2.6. Solid waste in Khartoum province - Sudan ................. 26
  2.6.1. Objectives of crash programme for environmental sanitation ........................................................................... 29
    a) General Objectives .......................................................... 29
    b) Specific objectives ......................................................... 29
  2.6.2. Notes about the crash programme ......................... 30
  2.6.3 Environmental Health legislation in Sudan ............ 32
2.7. Waste management ...................................................... 34
  2.7.1. Background .............................................................. 34
  2.7.2. Solid waste management ........................................... 35
2.8. Solid waste generation ............................................... 36
2.9. Storage of solid waste ............................................... 37
2.10. Waste collection ........................................................ 38
2.11. Transfer and transport ............................................. 39
2.12. Refuse transfer station ............................................. 40
2.13. Disposal methods ...................................................... 43
  2.13.1 Open dumping ......................................................... 43
  2.13.2. Ocean dumping ..................................................... 44
  2.13.3 Sanitary landfill ....................................................... 44
    a) Site evaluation ............................................................ 45
    b) Benefits (Advantages of landfill) ................................... 48
    c) Disadvantages ............................................................ 49
  2.13.4 Composting ............................................................ 51
  2.13-5. Incineration ........................................................... 53
    a) Basic phases .............................................................. 53
b) Advantages ......................................................................... 54

c) Disadvantages .................................................................... 55

2.13.6. Pulverization ............................................................. 56

2.14. Recycling ................................................................. 57

2.14.1. Recycling - Techniques and technology ..................... 58

   a) Pevulcnizing .................................................................. 58

   b) Pulping and converting to paper .................................... 59

2.15. Principles of waste avoidance and utilization .............. 61

2.15.1. Hierarchy of approaches ........................................... 62

2.15.2 Policy and Regulatory framework.............................. 62

2.15.3 Producer and consumer ............................................ 63

2.15.4. complexity ............................................................... 63

Chapter Three

MATERIAL & METHODS

3.2. Material & method ....................................................... 65

3.2. Material Used ................................................................. 66

3.2.1. Methodology ............................................................... 67

3.2.2. visits to sites, ministries concerned, offices and households .... 67

3.2.3 Data collection ............................................................... 68

3.2.3a. Primary data ............................................................. 69

3.2.3b. Secondary data ........................................................... 69

3.2.3c. Data Analysis ............................................................. 69

3.3. Study area (Khartoum Industrial area) ......................... 70

3.3.1. Geographical Location ................................................. 70

3.3.2 background .................................................................. 72

3.3.3. Obstacles of Khartoum industrial area ....................... 75

Chapter Four
RESULTS AND DISCUSSION
4.1. Results ................................................................................. 77
4.2. Discussion ........................................................................... 99
4.3. Environmental Impact of Khartoum industrial area .......... 106

Chapter Five
CONCLUSIONS AND RECOMMENDATIONS
5.1. Conclusions ...................................................................... 109
5.2. Recommendations .............................................................. 111
References .................................................................................. 112
Appendices .................................................................................. 116
   Appendix I: Plates ................................................................. 116
   Appendix II: Maps ................................................................. 129
   Appendix III: Questionnaires for data collection ...... 131
List of Tables

Table (2-1): some industrial operations that produce hazardous solid waste............................................ ... 19

Table (2-2): Typical composition of the gases extracted from a landfill....................................................... 51

Table (2-3): Various recycling routes of some common wastes....................................................................... 60

Table (3-1): percentage of the main industrial sectors in Khartoum Industrial Area. 1997-1998............ 74

Table (4-1): location and type of ownership of industries under study......................................................... … 77

Table (4-2): Type of solid waste in Industries under study ............................................................................. 79

Table (4-3): the total weight of solid waste in sectors under study ................................................................. 80

Table (4-4): weight (per day) from selected industries in Khartoum Industrial Area............................. 81

Table (4-5): Educational level of Solid waste workers .... 88

Table (4-6): Services provided to solid waste workers… 89
Table (4-7): type of solid waste collected by a solid Waste picker, quantity, marketing place, price............ 96

Table(4-8): Solid waste brokers around the dumping area... 97

Table (4-9): Quantity of solid waste bought by solid Waste brokers, marketing place and problems encountered……………………………………... 98

Table (4-10): The residential quarter, the type of industry neighboring it and the hazards resulting form that……………………………………………… 106
List of Figures

Fig (1-1) Constituents of solid and Liquid waste .......... 3
Fig (1-2) Waste creation within an economic system ..... 5
Fig (2-1) Municipal solid waste.............................. 14
Fig (2-2) Material flow and generation of solid waste in a technological society.............................. 16
Fig (2-3) Hazardous waste treatment and disposal in selected countries ........................................ 18
Fig (2-4) Component of combustible solid waste ...... 20
Fig (2-5) Component of non-combustible solid waste ...... 20
Fig (2-6) Solid waste collected in selected cities ........... 22
Fig (2-7) Total solid waste disposal in USA............... 22
Fig (2-8) A Healthy dumping site ............................ 31
Fig (2-9) Interference causes and effects of inadequate waste management............................... 36
Fig (2-10) Simplified diagram showing inter-relationship of the functional elements in a solid waste management system .................................. 42
Fig (2-11) Sanitary landfill operation ....................... 46
Fig (2-12) Examples of site classification .................... 47
Fig (2-13) Typical locations of sanitary landfills in Wisconsin and their effect on surface- (lakes, rivers) and groundwater quality ...................... 49
Fig (2-14) Flow chart of the cycle of processes in a typical incinerator............................................ 54
Fig (4-1) The percentage of complaints in solid waste management in industries under study.............. 82
Fig (4-2) Seasonal effect on solid waste disposal in industries under study........................................... 83
Fig (4-3) Contract with crash program for environmental sanitation.................................................. 85
Fig (4-4) Unsatisfactory situation against the present adopted way of collecting and disposing of solid waste. 85
Fig (4-5) Visiting of Health inspectors................................. 86
Fig (4-6) Recycling in industries under study...................... 87
Fig (4-7) Insurance for solid waste workers......................... 90
Fig (4-8) Health problems in solid waste workers............. 91
Fig (4-9) Benefit from solid waste...................................... 92
Fig (4-10) Age of solid waste pickers Around the sanitary land fill Area................................................. 93
Fig (4-11) Educational level of solid waste pickers Around the sanitary landfill Area.......................... 94
Fig (4-14) Residence of solid waste pickers Around the sanitary landfill Area...................................... 95
Chapter One
Chapter 1

1-1 Introduction

Current problems associated with the collection and disposal of house, trade and industrial wastes have combined to produce the most frustrating, complex and challenging era this service has yet known.

Inadequate waste collection and waste management systems are the cause of serious urban pollution and health hazards, especially in cities in developing countries.

Cities industrialized countries are now also facing the consequences of past environmentally damaging production techniques and inadequate waste disposal.

This has resulted in many different forms of pollution and in particular the formation of brown fields: a abandoned, vacant or under used former industrial areas where redevelopment is is hampered by environmental problems and lack of adequate information on contaminated land management (UNEP 2001).

Another problem emerging in developed countries is the lack of suitable land fill sites to cater for the increasing demand for solid waste disposal.

Over the past half century, Urbanization (the concentration of people and activities into areas classified as Urban) is set to continue well into 21st century, driving force include the opportunities and services offered in Urban areas.

In 1970s, a new phase of globalization started with the deregulation of labour markets liberalization of financial markets, and privation of government functions.

One of the results of globalization (the new industrial revolution) was increasing competition for foreign direct investment and employers found themselves able to shift the location of their production facilities more easily, which lead to huge quantities of industrial wastes with a wide rang in quality and forms.
1-2 General

Industrial activates have been precipitating huge quantities of industrial wastes with a wide range in quality and form. They may be in the form of solids, liquids, gases, heat, noise, vibrations, etc.

Unless properly handled, industrial wastes may have collectively or individually, serious impact on the Biosphere in general and on the immediate environment in particular. This may jeopardize man’s health or may render his existence within the Biosphere impossible.

Industrial wastes are normally heterogeneous and may vary seasonally and because of this there may not be a uniform approach to the problems they create. Two main classes of wastes are known. The first is the fermentable organic wastes, which decompose radically and which arise from food manufacturing or processing industry. The second type is the non-fermentable wastes which do not lend themselves to decomposition, or decompose very slowly (who, 1971).

Wastes from factories are as varied as raw materials and products that enter and leave those factories.

Usually these include packing off-cuts, spoiled material and unwanted by products.(Fig1-1)

The fuel used in the factories for power or chemical incineration adds waste residues.
Industrial wastes in the form of solids liquid and gaseous phases are directly the by-products of industrial plants and power generation units and indirectly from the consumption of industrial products. In most developed countries, industries have a larger load of organic wastes than municipalities. Wastes with high BOD loads are produced by textile industries, paper and pulp mills, rubber production and chemical industries. Metal industries and mining contribute to a lesser degree to organic loads.

Fig (1-1) Constituents of solid and liquid waste.

Source: Ibrahim, 1984
Industrial wastes mean differently to different people. The manufacturer wants to dispose of industrial wastes with the least possible cost. But sometimes a reasonable economic value may be found in industrial wastes i.e when the wastes is used as raw material in the same plant or in satellite or other plants. For example, molasses which is discharged into the river creating water pollution, may be used as raw material for the manufacturing of different products like spirits.

Wastes may be recycled in one way or another or they may be used as food for animals or fuel, when this is the case there will be no problem of waste disposal. The community will be disturbed if industrial wastes create economic and social problems to the immediate environment.

From the days of primitive societies, man and animal have used the resources of the earth to support life and to dispose of waste. In early times, the disposal of human and other wastes did not pose a significant problem, for the population was small and the amount of land available for the assimilation of wastes was large.

Wastes are not pollutants until they are discharged to and cause damage in the environment.

Furthermore, waste emitted at one point may be transmitted through various media (e.g, air, water) to produce pollutants at different Locations and points in time and different concentrations, often with alteration to their chemical and physical characteristics.

Accordingly, the effects of waste vary from one type to another. All wastes have much the same initial effect, when disposed on land they occupy valuable space and obliterate local fauna and flora. Fig “1-2”.
Fig (1-2) waste creation within an economic system.

Source: Sounders, 1976.

It is difficult to define industrial wastes in exact terms, what is considered waste in one plant, may be regarded as useful raw material in another.

**Industrial waste is that which is unwanted and is disposed of in one way or another either, voluntarily or spontaneously by the factory.** Industrial wastes may be in the solid, liquid or gaseous form, they may be organic or inorganic.
1.3 Industrial liquid wastes

Industrial liquid wastes may have serious impact on the environment if not satisfactorily managed. They may lead to the deterioration of sewage systems, pollute the environment and have negative impact on the aesthetic facet in a particular environment in some cases pre treatment will have to be done before releasing the waste effluent into the sewer, as toxic material may be contained in it. e.g cyanide, mercury, cadmium, etc….

Through sewer leakage, which is quite common nowadays, ground water may be threatened. The effluent may be at a high temperature and this may create problems. The PH of liquid waste, the suspended solids, grease, and oil, malodorous, gases, etc may be above the allowable international standards and may thus cause trouble to both man and his environment. What is going to happen to the sludge resulting from the treatment process? Again if not properly handled, valuable land may be spoiled.

Dilute waste waters are often discharged into rivers, lakes, or streams after appropriate treatment, but the proper dispersion of even treated water is an important consideration. The location of the discharge point and the type of dispersion equipment used are significant in their protection of other water sources and in maintaining an overall desirable situation. Plants located near the ocean or large lake or a large river may discharge their wastes through a pipe or ditch leading to the shore, but if the discharge of the pipe occurs above the main body of water, the formation of foam due to air entrainment, or in complete dilution because of a low water condition may result, giving high concentrations near the point of discharge. A properly designed subsurface dispersion system, however, will permit the receiving body to assimilate the waste properly.
This reduces treatment requirements. Some of these submerged devices include an open-end pipe with special nozzles or diffuser systems consisting of a series of smaller pipes with hole or slots. Waste should be discharge at the best angle to the flow of water in the main body to effect rapid dispersion.

Dispersion pipes should be located so that the discharge point is far enough from the shoreline that it will protect plant or other water intake systems. It should be directed so that existing current and tides tend to disperse the waste into the main body rather than to bring it back to the shoreline. (LUND, 1971.)

1-4 Industrial gaseous waste.

Industrial wastes are also given in the form of gases, e.g nitrogen compounds, carbon monoxide, carbon dioxide, mineral fumes, smoke, etc. In addition to particulates. All these have their adverse effect on man in the industrial environment itself or in the immediate residential area. (Ibrahim, 1984).

These pollutants gases and particulate are diffused to the atmosphere from many industries especially the metal industry which had been found to be a major source of particulate and acid gas emission. (Abdel Magied, 1984).

As a result of this some occupational diseases may appear among the workers involved and other citizens. This in turn will leads to lowering of productivity among the working force.

In the developed countries it is found that the industrial process accounts for the most deterioration of air quality resulted in a continuous poor air quality in some areas.
1-5 Solid industrial wastes:

The solid wastes include all unsellable factory wastes which comprise food wastes, Off cut and spoiled material of metal, plastic, wood, textile, glass, paper, packing material and others.

Refinaries also produce solid wastes much of it is bitumious. Some of these wastes are highly toxic, if these wastes are not controlled, they will release a number of pollutants.

Industrial solid wastes disposed create severe environmental problems: when the waste is burnt it causes air pollution, when it is disposed of on a dumping area, it will pollute and became a source of nuisance to the public. When water perculating solid wastes deeper into the ground it could pollute the underground water. Beside the aesthetical, economically and health effects caused by the uncontrolled disposal of solid wastes.

Most of the solid wastes effects are summarized in a study carried out in the United States of America in 1967 which can be cited out as follows:

“Hypothetically, solid wastes can produce undesirable effects by biological chemical, physical, mechanical or psycholoical means. For example human pathogens in feces provide a biological threat, industrial wastes create chemical hazards, flammable materials provide a physical hazard of fires or explosion, and broken glass and other sharp-edged wastes create mechanical hazards. These hazards, plus unsightiness, costs of waste disposal, special interest and jurisdictional disputes, threat properties and other factors provide a basis for potential psychological and behavioral distrubances. Ahmed, 1982.
1-6 Statement of the problem

Solid wastes present a many-faceted problem. The disposal of trash around the country creates litter. Its accumulation in trash cans on city streets attracts rats and flies, stimulates bacterial growth, and creates a collection problem. When large cities run out of space to dump the collected trash, a disposal problem is created. Finally, the accumulation of rusty old car bodies, cans, bottles, and other recyclable scraps hasten the depletion of non-renewable resources.

Litter is particularly vexing, because a small percentage of the population is responsible for a large nuisance.

In this study, Khartoum industrial area is taken as a case study, because it is one of the most important industrial areas in the Sudan.

The area between the Blue Nile and the White Nile is rich in small industries and some large ones which include Khartoum tannery and the White Nile Tannery, The Sudan Mit, cars workshops, asbestos factory………. etc.

These industrial could create intensive waste problems of local nature. It constitutes potential environmentally hazardous site in Khartoum and it may have asignificant impact on well-being and health of the surrounding environment.

Solid wastes in Sudan are causing real environmental problem. No modern waste treatment practices are applied and even the planning of existing dumping areas is questionable.

1-7 Hypothesis

Management failure results into accumulation of solid waste and environmental degradation.
1.8 The Objectives of the Study:

1-8-1 General objective:
To assess the situation of solid waste management in Khartoum industrial area.

1-8-2 Specific objectives:
1. To investigate various methods (systems) used in solid waste collection, treatment and disposal.
2. To determine the quantity and composition of solid waste in the area.
3. To study the situation of solid waste workers (educational level, health, services provided …etc) and to highlight on the solid pickers and brokers phenomena (situation) around the dumping area.
4. To identify the public health risks and environmental impacts of the industrial area.
Chapter Two
Chapter II
Literature Review

2.1 Definition of Solid Waste:

Solid waste is a terminology used world-wide. There are many definitions of solid waste. According to sources, solid waste can be defined as:

- Any garbage, trash, rubblish, waste tire, refuse, sludge from a waste treatment plant, waste from supply treatment plant or pollution control facility and other discarded materials, including solid. Liquid, semi solid or contained gaseous material. (Internet).

- The non-liquid wastes which result from various types of human activities being domestic, professional, commercial, industrial, agricultural or mining.

- A simplified definition of soild waste would include garbage, trash, recyclable materials, yard waste, and from industrial and commercail sources. It does not include hazardous waste from businesses. (Internet).

- (Adogjok, 1997) define solid waste as any solid matter which is discarded no longer useful in economy, consisting of organic and Inorganic matter in a wide variety of forms.

He also considered that solid waste involve all the waste arising from human and animal activities that are usually solid and are discarded as useless or unwanted, including and encompassing the heterogeneous mass of throw aways from residences and commercial activities as well as the more homogeneous accumulations of a single agricultural or industrial activity.
2-2 Classification of solid waste:

2-2-1 According to American public works association solid wastes can be classified according to type and sources as follows:

1. Home garbage:
   wastes resulting from preparation of food and different types of meals. Homes, restaurants and hotels are considered as the main sources.

2. Rubbish:
   These comprise the combustible waste and include papers and carton and material from which they are produced especially packaging bottles encasement, wooden boxes and barrels, tree branches, wooden wastes and their products and plastic materials in addition, non-combustible wastes such as metal pieces metal furniture, glass, and metal barrels.

3. Street refuse:
   These are dust, tree leaves and others that are collected from city venues and streets.

4. Metals and abandoned vehicles:
   This include types of metal parts, like air conditioners and others and car. Lorry, agricultural machinery junks and used spare parts.

5. Industrial wastes:
   Is all solid waste generated from industrial or manufacturing process and solid waste generated from manufacturing activities such as service and commercial establishments. Some are chemical in nature, others are very toxic. Other are organic compounds of different structures or crude (petroleum) or artificial oil.
6. **Waste of food industry. A bottarr and chicken farms:**

These are solid waste rich in organic substances that are biodegradable (easily decomposed) like plant and animal remnants.

7. **Demolition waste:**

From the processes of destruction and construction resulting into dusts, bricks, stones and concrete parts.

- **Special waste:**

  Include types of wastes of particular specification like explosives, radiation from radioactive materials (wastes from scientific institutes and hospitals that use radiation) and toxic wastes containing sprays, factories that use heavy metals, hospital wastes containing disease germs.

  These waste are termed toxic or hazardous wastes.

2.2.2 **Solid wastes can also be classified as follows:**

1. **Municipal Solid Waste:**

   Comprise about 13% of the solid waste that result from various residential areas, companies and small industries. These waste comprise mixture of heterogeneous paper, carton, fire wastes, glasses, rubber, textile, food waste and plastics.

   Figure(2-1) below shows municipal solid waste. It appears that paper waste form a greater percentage.
2. **Mining wastes:**

Comprise a high percentage more than 75% of the solid waste in industrial countries. It includes rocks and dusts resulting from the processes of drilling, mining, treatment and extraction of different economic metals. It is possible that these wastes can affect the nearby residential areas. In regions of humid climates, the flow of acidic water and dissolution of some toxic elements from mining waste can result into pollution of water sources and soil.

3. **Agricultural wastes:**

It is waste of agricultural crops and animals and chicken farms. It is possible that its percentage may reach more than 12% in some countries, (USA). Generally, these wastes contain important nutrient demand. Due to excessive use of chemical fertilizers and concentration of breeding of cattle and chicken in confined areas, thus
agricultural waste became environmental problem, the process of soil erosion and organic matter from fields have negative impact on environment, especially running water cut pollution by pesticides and chemical fertilizers.

4. **Industrial solid wastes:**

Industrial solid wastes differ according to the industry and production method except the hazardous industrial solid wastes, industrial wastes include paper, carton, wood, glass, plastic and organic matter, metals, rubber, cardboard and other wastes.

Solid industrial wastes are generally understood to be those wastes which arise from industrial process and legal definition may include all wastes produced on industrial premises, whether those wastes are produced from a manufacturing process or not. In either case they include the excess materials discarded by the manufacturer as non-reclaimable, or as being uneconomical to reclaim.

Industry, especially the process industries, produced solid, semisolid, liquid or gaseous wastes which must be disposed of within the framework of the law. Unfortunately the law is not all-embracing so far as it concerns the disposal of wastes.
Fig (2-2) the material flow and generation solid wastes in a technological society.

Source: Ahmed, 1982
2.2.3 Solid waste may also be classified as Hazardous and Non-hazardous.

1. Non-Hazardous waste:

These do not pose any substantial danger to living organisms immediately or over a period of time. Household refuse (or domestic solid waste) may contain small quantities of hazardous waste such as batteries and empty pesticide containers. These small quantities of hazardous material in non-hazardous waste are of an increase in many countries.

2. Hazardous wastes:

Certain industrial and institutional wastes are categorized as hazardous or toxic because of special care needed for their storage and disposal to ensure that they are isolated from human environment. Most toxic wastes come from the chemical industry but others, including the metal, petroleum, transport, electrical equipment, and leather and tanning industries, also produce significant quantities of hazardous waste. Sewage sludge and hospital wastes are also considered hazardous.

The nature of hazardous wastes varies considerably. Some are highly flammable, as are many solvent used in the chemical industry, reactive and can explode or generate toxic gases on contact with water or another chemical; some, such as sewage sludge or hospital waste, may contain disease-causing agents.

Some wastes are highly toxic, for instance cyanide, arsenic, and many heavy-metal compounds, and many are carcinogenic.

The nature, amount, and wide distribution of hazardous wastes and their potential danger to health have been recognized only in the past 15 years. The United States provides an example of the magnitude of the problem they create. Because little consideration was given to the regulatory aspects of hazardous wastes during the
nineteenth and much of the twentith century, there are now some 5000 land sites in that country where hazardous wastes may have been dumped without control and without provision to ensure that the wastes do not pollute the ground water.


Fig. (2-3) Hazardous waste treatment and disposal in selected countries.

**Table (2-1):** Some industrial operations that produce hazardous solid waste.

<table>
<thead>
<tr>
<th>Operation Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas production (mercury containing sludge and filter material, sulphur containing residues)</td>
</tr>
<tr>
<td>Production and application of zinc, production and zinc oxide, (zinc ashes and slags, jarosite)</td>
</tr>
<tr>
<td>Production and application of lead (lead ashes and slags, lead containing filter dust)</td>
</tr>
<tr>
<td>Production and application of arsenic (arsenic containing filter dust)</td>
</tr>
<tr>
<td>Production of steel iron (furnace dust)production of iron and steel with ozyconverters or electro furnaces (filter dust, fly ash, other dusts)</td>
</tr>
<tr>
<td>Production of primary and secondary aluminium (filter dust, electrode residues, furnace bricks)</td>
</tr>
<tr>
<td>Production or application of photo – chemicals (residues of fixation, developing and bleaching agents)</td>
</tr>
<tr>
<td>Production and application of asbestos and asbestos containing materials (asbestos containing residues)</td>
</tr>
<tr>
<td>Removal of paint layers by means of blasting (paint residues)</td>
</tr>
<tr>
<td>Production and application of paint, lacquers, varnishes, inks and coating (resides of paint lacquers, varnishes, inks and coating which have not fully hardened, sludge from water treatment)</td>
</tr>
<tr>
<td>Production and allocation of glue, adhesives and resins (residues of glue, adhesives and resins (not from animals) which have not full hardened, resins, oil residue)</td>
</tr>
<tr>
<td>Production and application of latex (residue of latex emulsion, not fully hardened)</td>
</tr>
<tr>
<td>Production and application of paint removers (residues)</td>
</tr>
<tr>
<td>Printing and photo –coping with liquidous inks (residues of ink, cleaning solvents, etc)</td>
</tr>
<tr>
<td>Production and application of enamel (enamel sludge and residues)</td>
</tr>
<tr>
<td>Production of chlorine with the diaphragm-electro process (asbestos containing residues)</td>
</tr>
<tr>
<td>Manufacture of metal products (selene containing metal waste, beryllium containing metal waste, cooling liquid based on oil products, oil, water sludge mixture)</td>
</tr>
</tbody>
</table>

Source: UNEP, (2001)
2.2.4 Solid waste can also be classified as combustible and non-combustible.

See the figures below

Source: Skitt, 1972
2.3 Environmental Impact Resulting From The Accumulation of solid Wastes:

1. Multiplication of bad odours.
2. Multiplication of flies and other disease vectors such as cockroaches and rodents.
3. Spread of harmful animals which transmit harmful diseases.
4. Jamming of traffic and hinderance of transportation.
5. Rise-up of dusts and the pollution of underground and surface waters.
6. Fire outbreak which leads to smoke and ashes.
7. Bad effects to beauty values of the area.

2.4 Solid waste in developed countries.

Solid waste generation, both municipal and industrial, continues to increase world wide in both absolute and per capita terms.

Wealth is a primary determinant of how much solid waste a city produces.

Wealthy cities such as Los Angelos and New York are vast producers of solid waste. Where as per Capita solid waste generation is still low in cities such as Calcutta, India, and Accra, Ghana. See Fig (2-6).

North American cities consume large amounts of energy and raw materials, and produce large amounts of waste and pollution. And with only five per cent of the world’s natural resources and a major producer of its wastes. As a result, its impact on the global environment is larger than that of any other region. At the same time, waste recovery is increasing and discards to landfill are decreasing. Fig (2-7).
Fig. (2-6): Comparison of per Capita solid waste Generation and percent of waste collected, selected cities.

Source: UNEP, (2001)

Fig(2-7): Total solid waste disposal in the United States is increasing less fast than before, landfill disposal is decreasing and recycling increasing

Source: UNEP, (2001)
Light weight but high-volume materials such as paper and plastic are replacing dense and heavy materials in waste stream which increases waste volumes.

The continued use of older technologies, coupled with a consumer life style based on the desire for mobility, convenience and product disposability, has limited the further advancement of resource efficiency and waste reduction (UN 2001).

In the Europe, waste generation per capita from household and commercial activities, which constitutes only part of the total amount of municipal waste, already exceeds the target of 300 Kg per capita per year set in the EU’s Fifth Environmental Actions Plan (EEA 2001) by 100 Kg. Most European countries have recycling schemes, particularly for paper and glass – although this development has been only a partial success because the generation of waste paper and glass has also increased.

Sludge from urban waste water treatment plants is estimated to have increased in the EU from 5.2 to 7.2 million tonnes dry solids during 1992-98, and further growth is expected (EEA 2001).

Such volumes are increasingly difficult to absorb through incineration, dumping in landfills and recycling in agriculture. The problem is being compounded by the fact that sludge is often contaminated with heavy metals and other toxic chemicals, which even in minute concentrations can affect human health.

In most European countries, landfilling is still the most common treatment route for waste, even though there is an increasing shortage of available sites. This is because, in both Western and Eastern Europe, recycling is rarely economically viable. However, producer responsibility for the environmentally sound disposal of packaging and products is achieving widespread acceptance (UNEP 1996).
Different approaches have been adopted in different countries. Germany is shifting responsibility for managing packaging waste to industry as a mandate, while in France agreements are mostly voluntary although stringent reporting is required.

In France, municipalities remain responsible for waste collection but industry has been made responsible for recycling of only certain materials.

In the United Kingdom, all companies involved in the packaging chain are required to meet a share of the total responsibility: 47 per cent for retailers, 36 per cent for packers and fillers, 11 per cent for converters, and 6 per cent for raw material manufacturers.

2.5 Solid Waste In Developing Countries

In developing countries, the environmental impacts of improper solid waste disposal are especially severe. In many cities, only 30 to 50 per cent solid waste is collected the rest is either burned or dumped in unregulated landfills. Uncontrolled disposal of urban waste into water bodies, open dumps, and poorly designed landfills is a principal cause of surface water and groundwater contamination.

Many cities dispose of household waste along with industrial wastes, exacerbating pollution problem. In China, for example, most toxic solid wastes are disposed of in municipal waste stream without treatment, leading to contamination of sources and water bodies with heavy metals such as mercury, chromium, lead, and arsenic. These toxic can threaten or destroy marine life.

A cross Africa, only 31 percent of solid wastes in urban areas are collected. Inadequate urban infrastructure leads to untreated waste and waste remaining uncollected or improperly disposed of.

Only 2 percent of Africa waste is recovered and recycled. (UNCH 2001) due to lack of economic incentives and markets for recycled materials. The most
commonly recycled materials are paper, textiles, glass, plastic and metal. Composting is carried out to some extent in Egypt, Morocco and Tunisia.

In Asia, much of the solid waste generated in urban centres remains uncollected and either deposited in surface waters and empty lots, or burned in streets. This problem has worsened over the past 30 years. Collected waste is mainly disposed of in open dumps, many of which are neither properly operated nor maintained, and which pose a serious threat to public health.

Only a few Asian cities such as Hong Kong, Singapore and those in Japan, have adequate solid waste disposal facilities, but even these cities have problems in dealing with increasing volumes of waste.

The disposal and treatment of industrial, toxic and hazardous waste also causes serious problems. Dumping of hazardous waste is common in South and Southeast Asia. Countries such as Bangladesh, India and Pakistan have become dumping grounds for significant quantities of hazardous waste from industrialized countries, and are facing growing protests about-related pollution.

The lack of emission standards or enforcement of regulation in many developing nations compounds pollution problems. In addition, industrial activity in developing world tends to be concentrated in relatively few locations, often close to city centres.

Three quarters of all Thai factories dealing with hazardous chemicals are located within Bangkok’s metropolitan area and neighboring provinces. This includes five of Thailand’s seven lead smelting plants and more than 90 percent of its chemical, dry-cell battery, paint, pharmaceutical, and textile manufacturing plants.

The concentration of people close to these industries increases the risks of exposure.
Disposal of solid waste in legal landfills, as is the norm throughout the united states and Europe, averts many of these problems. Recycling plays a large role in solid waste management, especially in the cities in the developing countries, and should be encouraged not only to reduce the need to dispose of vast amounts of waste but also to protect new raw materials from extraction and use.

2.6 Solid Waste Management in Khartoum Province – Sudan

Most of the studies carried out in the cities (Arabic or foreign) showed great interest of the municipalities administration on environmental health because it is essential for the life of humans and their socio-economic activities.

In Khartoum State, there was no system that matches the systems of solid waste management in cities of the world, in which the management operations during the past periods fluctuate between political decrees and the capabilities available.

There were a number of decrees issued concerning the importance of waste management, sometimes these decrees were issued by the localities, another time by the ministry of health and once again by the localities, until the decree of establishment of the national council for the environment which was under the Ministry of Health and again placed under the localities and the decrees for establishment of firms for such matters.

All these resulted in the decline in the environmental health and the national capital turned into dumping sites.

Thus, Khartoum became surrounded by wastes from all directions and the spread of aimless dumping sites in all places resulting into heaps of wastes covering the main streets and pavements.
And there became a number of unregulated sites of which the forest area and the area south of central market and Shaggara dumping area and the area south of the green belt north of Mayo residential area and others. Plate (1).

In general, wastes in Khartoum province include domestic, commercial and industrial wastes.

After independence, national governments adopted the philosophy of promoting industry to diversity the economy of the country. The expansion of industries and other activities has resulted in many urban solid waste (S.W) in quantities and in qualities that exceed the capacity of cities and municipalities to manage.

As for the industrial solid waste, there was no set system for their final disposal, up to a recent time. Thus, most factories disposed of their waste by themselves. This is because most of the factories own special means for the transporting of their waste and disposing of it in the nearest random dumping site, without any controls.

Also, other rented special cars from local councils for transporting their waste to outside the industrial area. But; such system exposed them to punishments by the ministry of Health, for their non-adherence to the health regulation in waste disposal.

There is no differentiation in the treatment of waste in the Sudan. Industrial and municipal wastes are simply dumped in the same dumping site.

The medical waste are the most hazardous, until now there is no method for initial treatment before final disposal. And this is one of the hazards confronting the whole state not only the province.

Many laws, such as the local government Act 1957, peoples local Act 1981, the administration of national capital 1983 and the local government Act 1993
empowered the inspection. Supervision and final waste disposal and others to local council through environmental health authorities. And the diseases like malary, Bilhariza, dusentry from which cities of the state suffers is the result of environmental conditions, on the other hand, the responsibility of waste disposal became as specialized scientific jobs through the supervision and welfare by the Ministry of Health.

Both localities and Ministry of Health had failed in their trials (experiments) of improving the capabilities and plans for execution. The failure was due to lack of vehicles and lack of efficient labours provided by the localities and lack of funds.

All these were obstacles confronting the waste management. Also in addition, lack of orientation of the available cadres as team Work including all the technical cadres, management, health, engineering and accounting. All these were carried out by health inspectors. Moreover, the responsibility for informing the citizens about health issues.

This lead to the state decree establishing “The crash programme for environmental sanitation, in April 2001.

Technical cadres were formed comprising health, engineering and administrative to manage waste in the programme responsible for cleaning as fundamental (basic) work to manage the final waste disposal through specialized bodies with less responsibilities as in the localities.
2.6.1 Objectives of crash programme

1) General objectives

1. Cleaning of localities of Khartoum Province in accordance with modern methods and means in keeping, collecting, transporting and final disposal.

2. Minimize chances of multiplication of disease vectors.

3. Elimination of negative concepts (attitudes) or phenomena:

Specific Objectives:

1. Adoption of the modern scientific techniques for treatment of hazardous waste (Medical and industrial).

2. Submission of alternatives to methods of treatment (storage, transportation and final disposal).

3. Formulation of Standards and references Specific for these roles.

4. Building of Discharging modern discaders in accordance with the Engineering and health standards.

5. Formation of a modern scientific information system to open more horizons of studies for promotion of the servies.

6. Coordination between the project and the related bodies (drainage sewage – Town water- The Khartoum beautification company – Engineering Administrations of the localities).

The crash Programme for environmental sanitation in Khartoum State has many positives. It is considered a real addition to the public cleaning work and transporting of the waste matter in the state. There also come a time when the state was in bad need to such cleanliness, owing to the deteriorating situation because of the lack of financing and meagre budgets. But the implementation of the crash programme which carrys the name “Environmental sanitation came without the participation of the
ministry of Health, which is the only responsible, technically, about environmental reform, according to specified scientific standards, measures and specifications. Even if this matter was assigned to any other Department, it is seen very important that there is a necessity for providing role for the Ministry of Health and its apparatuses in the provinces and municipalities, through supervision, follow up and evaluation.

2.6.2 Notes about the crash programme:

1. The Ministry of Health has no role in this programme, whether in the stage of preparation or through the planning, programming and implementation stages.

2. There is no coordination or mechanism which provide any information to the Ministry of Health, or submit any report about the programmes. This confirms the inability of the Ministry to perform the tasks of follow up, evaluation and supervision.

3. The presence of the Health inspectors and Health officers in the Programme does not mean the existence of the Ministry of Health, as they were recruited in their personal capacities, without reference to the Ministry of Health.

4. The programme was started in the heart of Khartoum, a way from the marginal areas, such as, East of the Nile Region, Umbadda and the rural localities of the province where the environmental degradation and the extended random accumulations of waste matters, garbage, human waste matters and animal dung had reach great heights.

5. There is no efficient control on the dumping site as a result some of the residential areas particularly El-Gooz (about 2 km from sanitary landfill area) complaints of huge number of plastic bags and papers carried by the wind containing pungent odour.
6. Landfill Operation is not accomplished via scientific method. Healthy dumping site should include plastic layer, Fig.(2-8) that prevent infiltration of toxic wastes contents into underground water. This is not available in Sudan due to lack of resources.

Fig.(2-8): A Healthy dumping site.

Source:
2.6.3 The environmental Health Legislation

The legislation dealing with resource use and human activities in the Sudan are fragmented and do not contain adequate provisions for environmental health protection. The Environmental Health Act of 1975 deals with provisions dealing with pollution by waste and the measures for their prevention and control. This act represents the government’s degree of awareness and commitment to environmental health issues. The intention of the central government in this legislation is to enable lower institution at the state, provincial and district levels to protect the environmental health. Unfortunantly these institutions are not delegated sufficient powers to lay down regualtions necessary to implement the laws. It is as if these laws never existed since they are continuously being viloated as reflected in the misuse of natural resources, uncontrolled fires, environmental pollution from domestic wastes and human refuse, industrial waste, spraying of chemicals and disorganized keeping of domestic animals. The ineffectiveness of these laws is mainly due to the inefficiency of the law enforcement machinery.

This law is not only fragmented but sometimes conflicts with it self. It is more conservation and less developmentally oriented and does not take modern resource management principles into consideration. Because of decentralization and the limitations of state and district legislative activites, inconsistencis often prevail. The following legal constraints related to these inconsistencies are identified.

The inadequacy of the present Environmental Health Proctection Act; penalties and remedies for breach of Environmental Health Act are generally light and not compatible with the offense and the resulting damage (i.e not based on both criminal and civil laws to give adequate powers of punishment and restitution in providing to payment of compensation.
• The legislation only deals with offenses and not with the obligation of the persons towards the environmental health.

• Little reference is made to environmental health protection implemented by the private sector such as in road construction, provision of drainage systems and buildings and above all collection and disposal of solid wastes.

• Environmental health protection legislation is not adequately incorporated into land use legislation and other relevant laws.

• Customary laws dealing with environmental health protection issues are not adequately put into consideration.

• The 1975 environmental Health Act does not provide clear guidance on whether the local authorities are under an obligation to remove injuries for which no one can be identified as responsible to remove.

• The decisions of policy makers and executors are not based on valid environmental health criteria. They are not free from extraneous or outside influences from the government, business or commercial sectors. (adjgok, 1997)
2.7 Waste Management

2.7.1 Background

Waste management is an important part of the urban infrastructures as it ensure the protection of the environment and of human health. It is not only a technical environmental issue but also a highly political one. Waste management is closely related to a number of issues such as urban life styles, resource consumption patterns, jobs and income levels, and other socio-economic and cultural factors. (Internet).

One characteristic feature of sustainable waste management is that it is achieved by using the technical, organisational, and financial resources available in a particular locality.

The waste management situation in the countries around the world is by no means uniform. The vast majority of countries are busy struggling with such basic issues as ensuring sufficient collection services and implementing a minimal degree of control at disposal sites at the same time as they are facing increasing waste amounts due to the trend of urbanisation. They also lack the technical and financial resources to safely manage solid wastes. Which includes adequate provisions for sorting the waste at the point of generation as well as efficient and sufficient collection services. Final disposal in those countries is usually a matter of transporting the collected waste to the nearest available open space and then discharging them.

However, important progress has been made in the waste sector over the last few years. The most improvement is the increased level of awareness among both the public and politicians. This is the first step to ensure that action is taken and resources are allocated accordingly. On the other hand, the availability of resources is closely connected to the economic situation and waste management still holds a weak
position in this context compared development is also closed linked to the generation of waste, the last couple of years with strong economic development have resulted in increasing waste quantities.

2.7.2 Solid waste management:

Standards apply to all aspects of solid waste management including waste storage, collection, transfer, resource recovery, and final disposal. They include technical and operational standards, which apply to solid waste storage, collection, transfer, and disposal as well as the management, operation, and maintenance of solid waste facility. They also include regulations on waste reduction and recycling. Bernstein, 1993.

Technical and operational standards relating to solid waste collection specify types of storage bins, locations for pick-ups, and the amount or types of waste to be collected. They also specify the frequency of collection (for example, one or twice a week in residential areas) as well as requirements for the collection vehicles themselves. Standards have included noise emission requirements for truck chassis and refuse body compaction mechanism as well as requirement for computerized braking systems for air-barked trucks. Some jurisdictions require the collection vehicle to be covered at all times except while loading and unloading. Other jurisdictions require the vehicle to be maintained in good repair and emptied every night.
2.8 Solid Waste Generation:

Solid waste generation rates do vary from one area to another, due to factors such as economic status, social habits and season, as well as and extent of salvage and recycle operations. Generation rates in the urban areas are generally higher than for the rural areas. Nema, 1998.

In considering any waste management policy, it is necessary to consider the nature and quantity of waste arising. This will allow policies to be formulated on the type of storage facility provided, the type of collection method adopted, the type of transport required, and the options available for treatment and ultimate disposal. (Crawford et al, 1989).
It is particularly important to identify variations in the nature and quantity of arising and attempt to project trends for the future. The most accurate method of identifying the nature and quantity of arising is to carry out detailed surveys. It is worth while here to consider the factors which will define whether waste materials will require to be collected.

**2.9 Storage of solid waste.**

Storage of solid waste can be divided into two categories, namely, primary (or on-site) and secondary storage. Primary storage refers to the temporary holding of the solid wastes at or close to their point of generation, and often involves use of containers such as household and public bins, skips or open dumps.

Secondary storage refers to that occurring at an intermediate point between the primary storage stage and the ultimate disposal of the waste. Nema, 1998.

The method of storing waste materials varies throughout the world and will of course depend very much on the nature and quantity of waste arising, the method of collection and transport used.

Waste from industrial and commercial premises can be stored in much larger containers. These are normally formed in mild steel and can loosely be classified as:

1. Demountable containers.
2. Non-demountable containers.
3. Compaction containers.

Demountable container refer to containers which are located in position by specialist vehicle which can also up lift a container, transport it to suitable disposal site and empty it.

The most common example of this the “skip” regularly found near building or demolition sites but larger containers range from 4.5 to 33 m³.
Non-demountable containers are designed for use with mobile compaction collection vehicles. These containers remain on site and when full are emptied by a visiting vehicle. The containers are designed for use with waste materials which can be compacted compaction containers are totally enclosed and are designed for use with a static compaction mechanism which is usually bolted to the ground. This system is not suitable for use with waste that cannot be compacted. Containerized system are generally only suitable for solid waste, if liquid storage has to be provided then specially prepared storage tanks or lagoons are used.

2.10 Waste Collection:

In most cases the solid waste problem begins with collection. In considering the organization of waste collection services the person responsible must take account of the following:

1. The number and type of properties to be serviced.
2. The location of waste disposal sites.
3. The number and type of waste collection vehicles.
4. The number of personnel available.
5. Other factors such as collection policies.

At the outset it is necessary to define the collection frequency. For domestic collection services it is normal to provide one collection per household per week while for trade and business premises (especially in busy high streets) a daily collection may be required. The distance between the collection area and the disposal sites is critical. If specialist collection vehicles are to be used, then the time spent collecting waste should be maximized and the time travelling to disposal sites should be minimized. In some cases refuse transfer stations may be required.
The collection services which are provided for industrial and commercial wastes vary somewhat from those which are required for municipal wastes. Much depends on the form of contract which the contractor has with the customer. Contracts range from a prescribed number of containers being emptied in a given time (e.g. two containers per week) for a weekly contract price, to the situation where containers are emptied on request by the customer for an agreed charge. In many cases a container rental charge is applicable. Where elemountable containers are used the contractor tends to exchange the container. This means that his driver arrives with an empty container, exchanges it for the full container which is then subsequently emptied and used as the exchange for the next customer. This obviously saves drivers’ time and running costs. The only drawback’s where one customer produces an obnoxious waste. The residues of which adhere to container which is then sent of a customer who has a high standard of housekeeping.

It should be obvious that a significant part of the success of any refuse collection service (whether private or public sector) is based on vehicles. All vehicles used in refuse collection must be subject to rigorous road traffic legislation requiring annual testing, special driving licences for the operators, and rigorous examination by the statutory authorities in addition to the attentions of the police. The nature of the compaction mechanism required to compress refuse is such that it regularly attracts the attention of the Health and safety inspectorate. A considerable amount of the costs of refuse collection is taken up by transport

2.11 Transfer and transport:

There are two steps involved in the transfer of waste. Firstly, the transfer of wastes from smaller collection vehicles to large transport equipment and secondly, the subsequent transport of the wastes, usually over long distances to the disposal site.
The transfer usually takes place at a transfer station. The design of a transfer station must include factors such as the type of transfer operation to be used, capacity requirements, equipment and accessory requirements, as well as environmental requirements.

There are three types of transfer stations depending on the methods used to load the transport vehicle viz direct discharge, storage discharge and combined direct and storage discharge. In a direct discharge transfer station, the wastes from the collection vehicles are usually emptied directly into the vehicle used to transport them to the place of final disposal. These are usually constructed in a two arrangement and employ stationery compactors (Heeramun, 1993).

In a storage discharge transfer station, wastes are emptied either into a pit storage or onto a platform from which they are loaded into the transport vehicles by various types of auxiliary equipment. Some transfer stations use both direct discharge and storage discharge methods as multi-purpose designed to serve a broader range of users. These can also house a material salvage or solid wastes production area within easy access to roads; where there will be minimum of public and environmental objection; where construction and operation will be most economical.

2.12 Refuse transfer stations:

Waste disposal sites have tended to become more distant from waste collection centres. This is due to the most suitable sites being used up coupled with the increase in size of many major towns. At the same time the general public has become more environmentally aware of hazards of waste disposal sites, and proposals for new sites are generally met with strong opposition. Also refuse collection vehicles have become far more sophisticated and have therefore become more expensive, when the vehicle has to spend a considerable amount of its time travelling from the collection area to
the disposal sites and proposals for new sites are generally met with strong opposition. Also refuse collection vehicles have become far more sophisticated and have therefore become more expensive. When the vehicle has to spend a considerable amount of its time travelling from the collection area to the disposal site the transport cost of refuse collection then becomes significant. The problem is compounded by vehicles travelling to the disposal site at the end of their collection period. In many cases this may not coincide with the vehicles being completely filled.

One solution to the problem is to construct a refuse transfer station near the heart of the collection area. In the station refuse is transferred from sophisticated collection vehicles into bulk transport vehicles which then travel to the disposal sites. The bulk transport vehicles are normally fitted with some form of compaction and there are documented cases where the railway network has been used to good advantage. The use of transfer station means that every trip to the disposal site is made with the maximum payload. The collection vehicle’s time can be maximized collecting and not travelling. The collection vehicles are kept a way from the disposal site which means that there is no time lost with transporting crew. Where the disposal site is a landfill, damage to collection vehicles, punctures, broken springs etc) is reduced because these vehicles are never on the site. The station also allows storage of half loads at the end of a refuse collection period. The design and the capacity of the transfer station will depend on the nature and quantity of waste arising in the collection area but it will be obvious that.

Once the station has been established, it will be suitable for a number of different disposal sites, the only variable being the distance between these sites and the transfer station.
Waste Generation

Storage

Collection

Transfer and transport

Processing and recovery

Disposal
2.13 Disposal Methods:

2.13.1 Open dumping:

The most primitive waste repository is the open dump. Waste is collected and, to save space and transportation costs, is compacted. The compacted waste is hauled to the dumping site, usually in the morning, and spread on the ground, further compaction sometimes being effected by bulldozing. Organism matter rots or is consumed by insects, by rats or, of permitted, by bags. Various salvaging operations may go on during the day bottles, rags, knick-knacks, and especially metal scraps are collected by junk dealers or by individuals for their own use.

In some communities, the accumulation is set a five in the evening (or it may ignite spontaneously) to reduce the total volume and to expose more metal scrap for possible salvage of course, the organic degradation, the burning, and the salvaging are recycling operations.

However, there are serious detrimental features to the dump. Its biological environment differs.

From those that have envolved in natural ecosystems, and is not controlled by effective regulatory mechanisms.

The result is that the organisms that multiply at dump are not likely to be the type that are benign to people. The dump is a potential source of diseases, especially
those carried by files and rats. The fires, too, are uncontrolled and therefore always smoky and polluting. Rainfall enters the dump and removes a quantity of dissolved and suspended matter, including pathogenic microorganisms, that are water pollutants. And of course the dumps are ugly. (Stuck et al, 1978).
2.13.2 Ocean dumping:

Is practiced by many coastal cities. Barges carrying the refuse travel some distance from the harbor and discharge their loads into a natural trench or canyon on the ocean floor. In this way most of the trash is removed from sight, though not from the biosphere. Aquatic dumping areas are almost devoid of communities of benthic animals, and thus the normal food webs in the ocean are disrupted. Although plankton and fish may survive in dump areas, they are affected by unusual environment. For example, flounder caught in the former New York city dumping region have had off-tastes. Analysis of the stomach contents of these fish reveals that old adhesive bandages and cigarette filters constituted part of the animals diet. Such dietary aberrations certainly cause foul flavors.

2.13.3 Sanitary landfill:

Landfill means waste disposal on land. The practice has had various names over the years including tips (UK), Sanitary landfill (USA), coups (Scotland, controlled tipping (UK) and dumps (worldwide). (Crawford et al, 1989).

It is the most extensively employed disposal method today, in which waste is deposited in a trench that has been excavated in a low value area at the edge of town. Sometimes a borrow pit or a bandoned gravel pit is selected as a site. At the end of each day’s dumping, the accumutated trash is compacted and then covered with a layer of soil. This method obviously is superior to the dump-and-burn system, since it minimizes air and water pollution, restricts fly and rodent breeding, and reduces the possibilities for the dispersal of disease organisms.

When considering landfill as a method of waste disposal the project should be approached in the same way as the design of a new building, bridge or road. Decisions
have to be made on site selection, project extent, finance, construction materials, method of operation and site rehabilitation.

**a. Site evaluation:**

In considering the preliminary planning of a landfill, consideration should be given to the following which indicates the ideal landfill site:

1. It should be hydrogeologically acceptable, posing no potential threat to water quality when used for waste disposal.
2. It should be situated so as to give a short haulage distance.
3. It should be free from running or static water.
4. It should be situated at a distance of more than 200 m from any dwelling.
5. It should have good access from road systems and not interfere with existing traffic patterns.
6. It should have electrical, water and sewage facilities near by.
7. It should have a sufficient store of materials suitable for covering each individual layer of waste.
8. It should have an estimated life long enough to justify weigh bridge facilities.

In practice most sites cannot meet all these criteria and each site has to be evaluated in detail and costs of engineering the site to a suitable standard calculated. The study should take account of the following:

1. The nature and quantity of wastes which are proposed to be handled on site.
2. The compatibility of the landfill proposals with any planning constrain for the area in which the site is located.
3. The hydrology of the site in terms of both net surplus precipitation and geology.
4. The preparation works required.
5. The method of operation to be adopted.

6. The final reinstatement and subsequent use of the site.

Fig: (2-11) Sanitary landfill operation. The bulldozer spreads and compact solid waste. The scraper (for ground) is used to haul the cover material at the end of the days operations.

Note the portable fence catches any blowing debris.

Source: Owen, 1980.

The first stage in any survey of a site for a proposed landfill is to establish the annual recorded level of precipitation for the site and to plot the monthly rainfall to obtain the seasonal distribution. Alongside this the annual recorded evaporation rates should be calculated and compared with rainfall distribution on a monthly basis to obtain net monthly and annual surpluses. The geology of the site is then examined and this maybe undertaken either by consulting geological survey material or by undertaking test burings or trial holes on the sites. This should give an indication of the nature and type of strata surroundings and below the proposed site and may give some idea of the
location of aquifers together with flow rates and flow directions. In the development of any landfill protection must be provided for equifers which contain potable water supplies.

The site survey will indicate the classification of the site and examples of classification are shown in Fig. Depending on the outcome of the site investigations and the classification given to the site, the availability of the site for the proposed wastes can then be evaluated. It should be remembered at this time that in attempting to meet the criteria for the ideal landfill site, various engineering works can improve the classification of sites. A good example is the case of the class three site which is lined with an appropriate material which improves its classification to either class two or class one.

Fig. (2-12) Examples of site classification

Source: (Crawford, 1989).
b) There are also benefits that may accrue once the landfill sites use for solid-waste disposal has ended. A few examples follow:

1. Some sites have been converted into recreational facilities. A prime example is Mile-High studium in Denver, Colorado, where the Denver Broncos football team now cavorts. Mount Trashmore, a recreational area in Evanston, Illinois, was also built up from solid wastes. Until 1965 it was used for disposal of incinerated residue, at which time it had grown to height of 65 feet and embraced 48 acres. It was then made available as a recreational area replete with baseball fields, tennis courts, sled hills, and toboggan runs. During its first year of operation, 15,000 people made use of the facility. Since it is becoming progressively more difficult and expensive for municipalities to acquire suitable landfill sites, perhaps more trash hills, or even whole “mountain ranges” may be built in the future.

2. Landfills have also had landscaping value. In England, for example, the “hills” formed by the soil-and-vegetation-mantled waste have added interest to an otherwise flat, monotonous terrain.

3. Landfills have been useful in spoil-bank rehabilitation in western Maryland, where strip mining has left 2,000 ugly scars. According to Wilfred Shields, chief of Maryland’s Division of solid wastes, a modified landfill operation will be used to efface these scars. Waste will be transposed from 87 roadside and open burning dumps to a abandoned strip-mine site dissected by 50-foot gullies. The waste will then be covered with soil from spoil piles left after strip-mining operations. Not only will aesthetics be improved, but acid mine drainage will be curbed because of soil compaction, proper grading, and the strategic placement of drainage canals.
4. Former landfill sites on the edge of major cities have converted into “educational parks” where urban youngsters are afforded a first-hand opportunity to study wildlife and ecology.

C) Disadvantages:

One big drawback to the landfills is that they require large acreages of land. For example, a town of 10,000 people generates so much trash that a single year’s production would cover a whole acre to a depth of 10 feet. Gravel pits, abandoned stone quarries, marshes and “waste” areas are rapidly being filled up in major urban areas such as New York City, Philadelphia, and San Francisco. It was estimated that over 50 percent of the cities operating municipal landfills in 1972 would be forced to acquire new sites by 1978. Former landfill operations in San Francisco Bay have caused reduction of bay area and attended disadvantages to shipping, aesthetics, and marine life.

If the soil and/or rock below the compacted refuse is highly permeable to water (if it were very sandy or composed of porous limestone, for example) infectious organisms in the refuse may be carried downward through the soil and rock to aquifers which provide drinking water for some nearby communities. Such improperly sited landfills could be the cause of widespread epidemic of disease.

As the garbage and other organic refuse is decomposed by bacterial activity a potentially explosive gas, methane, is produced. Ordinarily the amount of methane produced is no cause for concern. However, if large concentrations of the gas accumulate, the possibility exists for an explosion which could be highly destructive to homes built on the landfill site after it had been filled in.

Typical locations of sanitary landfills in Wisconsin and their effect on surface-(lackes, rivers) and groundwater quality. Fig.(2-13) Rating of sites: A- High potential
for pollution surface water, low potential for groundwater; B- Low pollution potential;
C- High pollution potential for both ground and surface water, Dashed lines indicate
flow of polluted water from landfills. Solid lines indicate flow of unpolluted water.

Source: Owen, 1980
Table (2-1) Typical composition of the gases extracted from a landfill.

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Volume Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methane</td>
<td>47.4</td>
</tr>
<tr>
<td>Carbondioxide</td>
<td>47.0</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>03.7</td>
</tr>
<tr>
<td>Oxygen</td>
<td>0.05</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>01.0</td>
</tr>
</tbody>
</table>


2.13.4. Composting:

composting is the name given to the method of speeding up the aerobic degradation of organic matter in refuse and as a method of refuse treatment for centuries. The process is biological and involves encouraging the growth of a biomass by conditioning the waste with moisture and nutrients. In some cases heat may also be added. The objective is to produce a stable product which (in former years) has been useful as a soil conditioner. The mechanical composting of refuse has been used for many years. However, in the last 20 or 30 years there has been a dramatic reduction in the use of composting as a refuse treatment. This is due to the considerable costs of purchasing and running the equipment, and of the labour required to operate it. In addition to this, many Local Authorities having installed composting plants have discovered that there was no market for the sale of product. But the process works
well in some parts of the world. Particularly third countries where the composition of refuse is significant different from European waste. Typically wastes suitable for composting have a high moisture content and a high organic fraction, such wastes are found in the Gulf States, Libya and South America.

The objective is to produce a compost which typically a brown peaty material which consist mainly of humus. A good product should have the capacity to break down heavy soil. Strengthen light sandy sort, increase the water retention capability of the soil and encourage plant root mulch. In evaluating any particular waste for its suitability for composting, the main factors to be considered are the carbon: nitrogen ratio, moisture content, and PH.

The carbon: nitorgen ratio governs the growth of the bacteria. The carbon is used as an energy source and the nitrogen is used by the bacteria for building. And the initial carbon: nitrogen ratio will affect the speed of decomposition. In the ideal situation, the ratio should be between 30:1 and 35:1.

The moisture content also plays a significant factor in the aerobic degradation of waste. If the moisture content falls below 20% the decomposition process will stop, if it exceeds 55% the process will go anacerbic. This will cause the temperature to drop and result in obnoxious odour.
2.13.5. Incineration:

incineration is the name given to the practice of burning refuse under controlled conditions. Crawford, et al, 1989.

This method of waste disposal has been used for over 100 years. Normally the organic content of municipal waste is in excess of 50% therefore incineration offers the opportunity of significant weight reduction. However the main benefit is the volume reduction and reports of 95% volume reduction have been recorded.

a) Incineration has several basic phases:

1. The burning of waste in a specially designed furnace at temperatures around 1,900 F.

2. The control and removal of atmospheric pollutants from the stack emissions.

3. The recovery and use of waste heat.

4. The removal as ash residue to a sanitary landfill.

Some of the gaseous contaminants may be removed by consuming them in a secondary combustion chamber. Up to 95 percent of the fly ash and other particulate material can be removed from stack gases by an electrostatic precipitator.
Fig. (2-14) Flow chart of the cycle of processes in a typical incinerator.

Source: Skitt, 1972.

**b) Advantages:**

Modern incineration techniques have several distinct advantages.

1. The incinerator requires, proportionately much less space than a sanitary landfill. For examples it takes only 5 acres of land to accommodate an incineration that is capable of consuming 400 tons of refuse per day.
2. The cost of waste collection for municipal incinerator is less costly than for a landfill, because the incinerator may be located much closer to the point of waste generation, in other words, within the town proper.

3. Incineration can dispose of both domestic garbage as well as rubbish (furniture, tries, mattresses, waste paper, plastic toys) without a costly separation process.

4. If the incinerator is provided with water-containing chambers in its wall, steam can generated from the waste heat and sold for residential or industrial heating purposes. The huge municipal incinerator in Chicago, which consumes 1.600 tons of refuse daily, generates 44.000 pounds of steam per hour. It is estimated that in 1980 at least 80 American communities will be generating electricity by using the steam produced from waste heat of their incinerators.

C) Disadvantages:

Incineration is vexed with certain negative features:

1. Cost: A modern incinerator is not just a gigantic oil drum, as was used by many families for burning domestic refuse back in the 1960s. It is a highly sophisticated and product of intricate design and engineering skill. As a result, it is costly. For example, in 1972 New York city decided to cancel an order for an incinerator when the city fathers were informed that it would cost at least $200 million. Not only this, but the consumption of a ton of waste by incineration costs 6 to 12 dollars plus collection costs, or roughly twice the cost of landfill disposal.

   One reason for the high cost is that each incinerator must have a design “tailor made” for specific type of solid waste which it is to receive.
An incinerator which will efficiently burn waste that is 60 percent combustible simply will not work well if it is fed refuse with only 15- percent- combustibles. Furthermore, the proper operation and maintenance of a municipal incinerator requires the service of highly trained and therefore highly paid personnel.

2. Emission of corrosive gases. A variety of corrosive may be generated in an incinerator, depending upon what type of waste is consumed. For example, one of these highly destructuve gases is hydrogen chloride (HCl). This gas is generated during the burning of plastic wastes, which contain the chemical polyvinyl chlorid, or PVC, over a million tons of which is produced in the United States annually. When PVC, present in such items as plastic toys, garden hoses, shoe soles, and raincoats are burned, the HCl gas is released. If the gas reacts with water it forms highly corrosive hydrochloric acid, which can be highly damaging to some internal structures of the furnace. However despite these disadvantages, It would seem that more and more communities a cross the face of America, will be turning to incineration for at least a partial answer to their waste-disposal problems. Certainly the increasing costs of suitable landfill sites, as well as the rapidly decreasing availability of such sites in the edge of urban centers, will make incineration a more and more attractive disposal method.

2.13.6. Pulverization:

Pulverization is the name given to the mechanical treatment of solid wastes to break down the larger material and reduce the average particle size. Pulverization has been in use as a form of refuse treatment since the beginning of the 20th century. It has to be recorded that it is not a final treatment prior to some further process e.g compositing, incineration, hydrolysis, recycling, refuse derived fuel, or landfill.
The process has the effect of reducing the voids in solid wastes so that if the waste is used for landfill, the latter should be subject to far less settlement that formed from untreated waste. Any settlement which does occur should be more even. The result should be that infilled land will become stable in a shorter period and can therefore be put to use in a shorter time.

There are two distinct types of process used to pulverize solid waste. In the first, sometimes called the “dry” process, the waste is broken down in hammer mills and in the second, sometimes called the “wet” process, the waste is broken down in a rotating drum with measured quantities of moisture.

2.14 Recycling:

Most refuse contains a wealth of valuable raw materials that can easily reused or recycled, to produce, new products.

In general, recycling conserves not only material resources but fuel reserves as well. For example, nearly twenty times as much fuel is needed to produce a luminum from virgin are as from scrap a luminum, and over tiwce as much energy is needed to manufactures steel and paper from virgin materials as from scrap.

In many cases, recycling operations also emit less pollution than the original process. Significant quantities of contaminants are released when paper is manufactured form wood pulp or when metal is refined from ore. For example, both pulping plants and smelters discharge various sulfur compounds that foul the air and water. The Environmental Protection Agency recently estimated that recycling all the metal and papers in municipal trash in the United States would prevent the release of over 2000 metric tones of air pollutants and 700 metric tons of water pollutants annually .stuck et al ,1978
But not all items are reparable or reusable. A tire can be recapped only once with safety. Week-old newspapers and spoiled meat are useless to most people. When an item cannot be in its present-condition, it must be destroyed and treated somehow to extract its useful raw materials. For example, used tires can be repulped and converted to new papers can be rendered and converted to tallow and animal feed.

At best, recycling processes conserve both energy and materials. However, not every item can be recycled efficiently. Recycling operations, despite their theoretical appeal, lose their effectiveness if waste is widely dispersed.


Much municipal, industrial, and agricultural trash can neither be reused nor repaired, and consequently must be reused to raw materials suitable for remanufactures. Several techniques are available for this type of recycling.

Melting:

Many materials such as metals, glass, and some plastics can be melted, purified, and recast or remolded.

a) Pevulcnizing:

Rubber is one plastic material that cannot simply be heated and remolded. Raw rubber is gooey and formless and must be reacted with sulfur to bind individual rubber molecules together in a cohesive form. Used rubber goods can be shredded, broken down chemically, and then rebonded in a process known as revulcanization. Recycled rubber manufactured in this manner lacks the strength and resiliency of material made from virgin stock; therefore, for some applications it is useful only when mixed with more durable fibers.
b) Pulping and converting to paper.

Any material containing natural cellulose fiber such as wood, paper, cloth, sugar cane stalks, and march reeds, can be beaten, pulped, and made into useful fiber. The basic technology behind recycling of paper is as old as the technology of manufacturing paper. The initial step in reclamation of fiber is to mix three parts of waste paper with 97 parts of water in a hydropulping machine. Here the scrap is stirred and beaten vigorously with a device similar to an egg beater until a slurry forms. If paper from municipal sources is being pulped, de-inking chemicals are added to the pulping mixture. The de-inked-pulp slurry is screened to remove large objects, which might have contaminated the original stock and then rolled through wringers to remove inky water.

Small impurities are removed in a centrifugal separator and the fibers are then converted into paper by conventional procedures.
<table>
<thead>
<tr>
<th>Waste</th>
<th>Recycling possibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper</td>
<td>Use the backs of business letters for scrap paper stationery: lend magazines and newspapers to friends, etc</td>
</tr>
<tr>
<td></td>
<td>Repulp to reclaim fiber.</td>
</tr>
<tr>
<td></td>
<td>Compost</td>
</tr>
<tr>
<td></td>
<td>Incinerate to heat</td>
</tr>
<tr>
<td>Glass</td>
<td>Purchase drinks in deposit bottles and return them; use other bottles as storage bins in the home</td>
</tr>
<tr>
<td></td>
<td>Cruch and remelt for glass manufactures.</td>
</tr>
<tr>
<td></td>
<td>Cruch and use aggregater for building material or anti-skid additive for road surfaces.</td>
</tr>
<tr>
<td>Tires</td>
<td>Recap yasable casings</td>
</tr>
<tr>
<td></td>
<td>Use for swing, crash guards, boat bumpers, etc.</td>
</tr>
<tr>
<td></td>
<td>Grind and revulcanize</td>
</tr>
<tr>
<td></td>
<td>Pyrolyze.</td>
</tr>
<tr>
<td></td>
<td>Grind and use as additive in road construction</td>
</tr>
<tr>
<td>Manure</td>
<td>Compost or spread directly on fields.</td>
</tr>
<tr>
<td></td>
<td>Ferment to yield methane, use residue as compost.</td>
</tr>
<tr>
<td></td>
<td>Convert to oil by chemical treatment.</td>
</tr>
<tr>
<td></td>
<td>Treat chemically and reuse as animal feed.</td>
</tr>
<tr>
<td>Food scraps</td>
<td>Save for meals of left-overs.</td>
</tr>
<tr>
<td></td>
<td>Sterilize and use as hod food.</td>
</tr>
<tr>
<td></td>
<td>Compost</td>
</tr>
<tr>
<td></td>
<td>Use as culture for yeast for food production.</td>
</tr>
<tr>
<td></td>
<td>Pyrolyze.</td>
</tr>
<tr>
<td>Slaughterhouse and butcher shop wastes</td>
<td>Sterilize and use as animal feed.</td>
</tr>
<tr>
<td></td>
<td>Render</td>
</tr>
<tr>
<td></td>
<td>Compost</td>
</tr>
<tr>
<td></td>
<td>pyrolyze</td>
</tr>
</tbody>
</table>

2.15 Principle of waste avoidance and utilization

The minimization of waste requiring disposal is increasingly important as available disposal options become more and more constrained, and particualary as more substances enter everyday use that are not readily decomposed in the natural environment and that can present long term hazards.

The problem are typically associated with non biodgradable or bioaccumulative substances such as waste pesticides, solvents, heavy metals, and chemical sludges.

The need to avoid or minimize the release of complex organic or inorganic substances into the environment is all the greater because of uncertainty about their effects on human health and the natural environment and the very high costs of retrofitting or cleanup.

Waste minimization comprises both avoidance and utilization. Avoidance refers to actions by producer to avoid generating the waste. Utilization includes range of actions that make the waste a useful input to other processes, eliminating the need for disposal. Proceses that reduce the toxicity or potentially harmful impacts of a waste can in some cases be regarded as minimization, although in other circumstances such changes represent treatment before disposal.

Although the terminology used may vary, a number of important activities can be distinguished. Reuse refers to the repeated use of a “waste” material in a process (often after some treatment or makeup). Recycling refer to the use by one producer of a waste generated by another. Recovery is the extraction from a waste of some components that have value in other uses.
2.15.1 Hierarchy of Approaches.

Waste avoidance and utilization can be seen as part of a broader hierarchy of approaches to achieving sustainable development. At the highest level are approaches that seek to satisfy human needs and requirements in ways that do not waste resources or generate harmful byproducts or residuals. These approaches include changing consumer behavior and reexamining the range and character of the products and services produced. Lower level are efforts to redesign products and services and to raise consumer’s awareness about the impact of their decisions. Applications of techniques such as life cycle analysis (LCA) is part of the difficult analysis of the overall impacts of products and services on the environment. Such approaches are at present adopted mainly by more advanced organizations industrial countries.

More directly relevant to industrial activity in developing countries are approaches focused on improvements in production processes. These approaches include cleaner production, pollution prevention, and waste minimization, all of which are related, to a greater or lesser degree, to better management, improvements in production processes, substitution of hazardous inputs, reuse and recycling of waste and so on. The next step, which should be minimization but is not to be neglected, is treatment and proper disposal of wastees. The lowest level in the hierarchy, and the one that all the other levels strive wastes discharged to the environment. Cleanup is costlier than prevention.

2.15.2 Policy and Regulatory framework

A clear and effective governmental framework for waste management is necessary. Such a framework should include the delegation of relevant powers to lower levels of government that are typically responsible for implementation. It should be based on clear and broadly accepted long-term policy and should include a
predictable and flexible regulatory regime and targeted economic incentives. At the same time, programs should be put in place to increase a wariness and education, with the long-term objectives of changing the behavior of manufacturers and consumers in the direction of minimizing waste generation.

2.15.3 Producers and consumers

Efforts must be made to involve both producers and consumers in waste minimization and utilization. Producers can improve their performance through both management changes and technological improvement, some producers in industrial countries are now making serious efforts to examine the impacts not only of their production processes but also of the products themselves. LCA is still an evolving tool, but it does focus attention on the over all impact of the production, use, and disposal of products.

Consumer in some of wealthier countries are moving toward a greater a wariness about the need for waste reduction, as shown by participation in recycling schemes and some demand for environmentally friendly products. However, progress is often slow, and there is a need for on going education and a wariness, as well as careful analysis of options and incentives. In developing countries, the demand for resources of ten loads to significant recycling of materials such as glass, metals, and plastics. These recycling systems gave important social and economic consequences at the local level, and their “improvement” must be approached with care.

2.15.4 Complexity:

Waste management efforts are linked closely with income levels. There is a broad progression from recycling of most materials in the poorest societies, through increasing consumerism—often with little concern for waste problems—in low-and middle-income countries, to the environmental activism of some rich countries. The
appropriate waste avoidance and utilization strategy for any situation must take into account the level of the economy, and the environmental circumstances. As with any others environmental strategy, there is a need for public involvement and political support in the indentification of priorities and the implementation of the necessary enabling measures.
Chapter
Tree
Chapter III

Materials and Methods

The study has been conducted in Khartoum industrial area (south of Khartoum).

It is worth mentioning that no such comprehensive study was carried out since the establishment of the industries in this area.

The main purpose of this study is solid waste management. The study aims at the major industries in the area responsible for the production of solid wastes.

According to the first industrial conference under the auspices of the general administration of industries of the Ministry of Economic affair of Khartoum State (1998), these industries are grouped (categorized) into eight major industrial sub-sectors these include:

1. Food industries.
2. Spinning and textiles industries.
3. Wood and metal products industries.
5. Chemicals industries.
6. Mining and non metallic products industries excluding petroleum and coal.
7. Basic metallic products industries.
8. Metallic products, machines and equipment industries.

The study comprise survey research through interviews and questionnaires. The management staff of each industry were interviewed by the researcher on general aspects such as establishment date, production stages, types of solid waste and others,
solid waste workers from each industry were also interviewed on collection and disposal methods and their relationship with management staff.

Detailed survey was carried out by the researcher through four questionnaires.

**Questionnaire [I]** include questions to answered by the management staff of the industries under study. Its components include questions such as name of industry, type of ownership (private, public, company or coorperative), solid waste products (type), quantity, collection and disposal methods, public health inspectors visits, opinion on current collection and disposal methods and improvement if necessary.

**Questionnaire [II]** concentrated on questions about the status of solid waste workers, the questionnaire included questions on, occupation, educational level, employment record, impact of solid waste on health and benefits from the solid waste if any.

**Questionnaire [III]** comprise questions on solid waste pickers and brokers around the dumping sites. These include questions on the age, marital status, residence, level of education, type of solid waste picked or sold, to whom sold, prices, problems encountered during picking, opinion on the job, market place or places.

**Questionnaire [IV]** was concerned with questions about the effects of solid waste disposal on the households at the vicinity of industrials under study. Questions here include name of the residential area, name of the nearby industry, problems encountered due to Industrial waste disposal.

### 3.2 Material used:

For the purpose of quantifying the volume of solid wastes produced by each industrial sector, the following material were purchased and used by the researcher during the study period.
i. Graduated weighing machines.

ii. Grabage plastic bags.

iii. Hand gloves.

iv. Questionnaire papers

v. Tray.

vi. Note book

3.2.1 Methodology:

Include visits to sites (industries and dumping areas), Ministries concerned, offices of crash program and households, interviews and then questionnaire filling, quantifying the solid waste and data processing and analysis.

3.2.2 Visits to sites, ministries concerned, offices and households:

Industries were visited for the purpose of the study. During the visits interviews were conducted with the management staff and solid waste workers by the researcher and questionnaire were in issued to be filled respectively.

Questionnaire were collected after been filled by the management staff and solid waste workers after from the date issued.

In the dumping areas the researcher had the opportunity to see the new cells under construction. Also the methods of collection was observed. General overview of the population of solid waste workers and the brokers were determine by the interview. In addition, the researcher had a chance to visit the only transfer station in the Sudan which was still under construction.

Three Ministries of concern were visited. These included, the Ministry of Health. Industry and Investment and Ministry of Planning and Public Utilities.
It was found out by the researcher that the Ministry of Health is concerned with setting of regulations, guidelines on health and the follow up of their implementation. The Ministry of Health also directed the researcher to the offices of the crash programme for environmental sanitation-Khartoum State.

Historical background on the establishment date, total number of industries in Khartoum industrial area and problems facing these industries were highlighted during the visit to the Ministry of Industry and Investment-Khartoum State.

From the Ministry of Planning and Public Utilities two Maps were purchased.

During the visits to the offices of the crash programme for environmental sanitation, the researcher was enlightened about the historical background and objectives of the programme. Also in collaboration with the programme the researcher paid visits to the unregulated dumping sites to assess the condition of solid waste before and after the establishment of the crash programme. During the visits various methods of solid waste collection were indentified and photographs from different locations and sites were taken. Four residential areas were identified around the industries under study. In each residential area five questionnaires. Were issued to be filled by each household head.

It is worth noting that during each of a fore mentioned visits interviews were conducted by the researcher and questionnaire provided to be filled.

In each of the industries the different types of solid waste were measured using the weighing machines.

Results were tabulated.

3.2.3 Data collection:

during the study, the researcher applied two methods for data collection. These include the primary and secondary data collection.
3.2.3 a. Primary data:
These were obtained from interviews conducted by the researcher and questionnare.

3.2.3 b. Secondary data:
These comprise literature reviews of relevant references to augment the finding of the theoretical and practical component of the research.

3.2.3 c. Data analysis procedures:-
After the completion of the survey the data were sorted, coded, the tabulated using the computer system (Excel & SPPS programmes).
3.3 Study Area

The Industrial Area – Khartoum

3.3.1 Geographical Location:

1. The Old Industrial Area (Khartoum South):

   It is bordered northwards by Hurriya bridge up to White Nile, eastwards by the
   Hurriya street and southward by the medical supplies administration.

   This area is characterized by the following:

   - The Khartoum central foundry.
   - The Sudan Mint Co. L.T.D
   - The currency printers.
   - Saad Sweets Factory.
   - The New Industries Company (King Cola).
   - Looli food industries.
   - And different types of industries and workshops.

2. The New Industrial Area:

   It is bordered northwards by King Colla company up to the White Nile west,
   eastwards by forest street up to Al-Rimeila cemetery, westwards by the white Nile
   and southwards by Al-Rimeila area and Al-Qoaz market.

   It is developed in the sixties, and this is represented by the Atlas Packing
   Factories and the Sphinx Factory for macaroni and its last product was refrigerator (El
   Madina Factory for Refrigerators).

   This area also witnessed the introduction of new industrial workshops working in
   furniture manufacturing, inpesticide, plastics, ice and cooling stores.
3. The Industrial area west of Horse race track:

It is bordered northwards by Shajara street from Abu-Hamama to Al-Rimaila cemetery, southwards by the northern fence of the Armed Forces, Shajara, westwards by the inlet passing by Shajara and eastwards by the Horse race track.

It developed in the Nineties, this area is distinguished by the presence of Moawia El Bireir Group Companies and Abu El Tayeb Sweet Factory. There are factories for plastics, different food industries and also there is Saria Industrial complex.

4. The Industrial Area of Shajara:

It is bordered northwards by Al-Rai Al-Masri residential area, southwards by administration of Fisheries, west by White Nile and eastwards by the railway.

It developed at the beginning of the eighties. In this area, found the drug industry and it is a joint of Sudanese and Korean Company for investment. There is an Asbestos Factory and other fine sweets industry, flour mill and dried fish factory.

5. The Industrial Area south of Local Market, (Block 35) and Southern of Sahafa:

It is bordered northwards by the local market, southwards by the Green Belt area, eastwards by Al-Azhar city and westwards by the Reservoirs, Shajra and Jabra.

It is a newly developed area, lacking the fundamental infrastructure (roads, electricity), but there is individual investments which erected some units economic outputs to the country in terms of iron and steel, Zalal Slabs (floor tiles). It is also distinguished by a huge factory for empty syringes which is the only factory in the country.
6. The Soba Industrial area:

   It is bordered northwards and westwards by Madani street, northwards by Gazeera State boundaries, westwards by the Blue Nile and eastwards by Soba East and south Ma’moura.

   Characterized by the following:
   - Bule Nile for Milk products.
   - Manara Biscuits.
   - Bisfoor for Furniture.

3.3.2 Background:

   The industrial area in Khartoum started in the fifies after independence. It was mainly for small scale industries. There were foreign skills centred only in Hasuna Company. This company contributed in training of technicians in the fields of mechanics, electricity and Iron frames services. It expanded by time and reached to 1000 workshops termed as the industrial area-Khartoum. This area helped the government of Khartoum, by then establishing a central workshop which helped to service government vehicles. This workshop has a unit for cement works. It manufactures bridge tools which are used in the field of drainage in Khartoum province. The workshop, also produces electrical cement poles.

   Among these workshops prosperous industries emerged such as Saad Sweets. Al Qadi ice Factory and Pepsi Cola Factory which was lately turned to King Cola.

   In this area, also, found the Sudan Mint Co. L.T.D followed by the Khartoum central foundry which considered as the state backbone in servicing and manufacturing of spare parts and especially for Sugar factories. Found in the industrial area a unique factory of its kind especialized in manufacturing of human extremities (lims) parts. (prosthetic and orthentic corporation).
During the sixties, there found the Khartoum tannery and the white Nile tannery and the Nasr tannery in the eighties.

Lastly, the paints industry prospered by the shift of the Nile paints factory from Omduraman to the industrial area – Khartoum.

There is a factory for Liquid Air, and this is the second factory in the country, and is the first factory, to win the ISO certification.

Lately, the government, has established the so called “Currency printers). They are owned by the state, and has a high quality and technology.

There is some stationeries under construction and have economic outcome (revenue) to the area, when completed this area will be economically activated and can provide new job opportunities in addition to its association with the local market. This will facilitate very much the means of marketing and minimize the cost of transportation and hence helps the reaching of goods to the consumer in reasonable prices.
Table below shows present stage of the main industrial sub-sectors in Khartoum Industrial Area. 1997-1998:

Table (3-1):

<table>
<thead>
<tr>
<th>Serial No</th>
<th>Sector</th>
<th>Operational</th>
<th>Non-operational</th>
<th>Under construction</th>
<th>Not constructed</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Food Industries</td>
<td>40</td>
<td>19</td>
<td>17</td>
<td>11</td>
<td>87</td>
</tr>
<tr>
<td>2</td>
<td>Spinning and textiles industries</td>
<td>2</td>
<td>6</td>
<td>----</td>
<td>50</td>
<td>58</td>
</tr>
<tr>
<td>3</td>
<td>Wood and metal products industries</td>
<td>37</td>
<td>17</td>
<td>----</td>
<td>4</td>
<td>58</td>
</tr>
<tr>
<td>4</td>
<td>Paper industries, Paper products, Printing press</td>
<td>17</td>
<td>6</td>
<td>---</td>
<td>13</td>
<td>36</td>
</tr>
<tr>
<td>5</td>
<td>Chemicals industries</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>48</td>
<td>58</td>
</tr>
<tr>
<td>6</td>
<td>Mining and non metallic products industries</td>
<td>21</td>
<td>6</td>
<td>1</td>
<td>------</td>
<td>28</td>
</tr>
<tr>
<td>7</td>
<td>Basic metallic products industries</td>
<td>1</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Metallic products machines and equipment industries</td>
<td>-------</td>
<td>1</td>
<td>1</td>
<td>-------</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>124</td>
<td>57</td>
<td>20</td>
<td>126</td>
<td>327</td>
</tr>
</tbody>
</table>

Source: The first industrial conference, 1997-1998
3.3.3 Obstacles of industry in Khartoum industrial Area

1. **Funding:**

   Funding is connected with the monetary and import policies and the provision of foreign currency. The liberalization policies has helped very much in provision of manufacturing supplies (import inputs) but variables of exchange rate and the policies adopted out the beginning of liberalization led to diminishing of operating capitals for a period of time, and as a result some factories went out of function when they failed to pay back their bills to funders due to the abrupt rise in the constant value of currencies.

   Also, despite of large deviation in the local currency the bodies concerned didn’t put any consideration to the stationeries (Tools-machines) according to current value of currency in their transaction with the industrial sector.

2. **Infrastructure and Services: Energy, Electricity**

   If we totally forget about the off-functional factories, we will find the electrical energy is the reason for the low production in the industrial sector followed by lack of use (exploitation) to the resources (machines, workers) and freezing of stationeries of industrialists.

   All these affect the productivity a bundance and as such lead to increase in the cost and (financial surdends) which leads to elevation of prices.

3. **Petroleum:**

   Increase in their prices, then increase rise, in cost of transportation and the saphiyation which might seasonally happen.
4. **Water:**

Water scarcity is still near to situation (Position) of electricity despite the fact that many of the factories posseses their own reserve wells but this is affected with electricity.

5. **Roads:**

The roads of the industrial area are still very weak especailly in the season of Autum. This effects transportation of supplies, Goods and workers.

6. **Public Environment and Healthy drainage:**

Problems of Healthy drainage is clear in El Shaggera Industrial Area. Nothing about its Healthy drainage is mentioned nor the roads no even waste size streams which keep rain waters.

7. **Training:**

Til now it is poor and lacking.

8. **Marketing:**

Marketing is one of the biggest issues which confort the industrial sector, and here consideration should be given to the external market not the internal a lone as we are welcome the globalization which will be imposing to many things.

Marketing is collective responsibility between the producer and the state. We’ve remained long without carring for the world demands of quality because we stood on the domestic market with all means of protections, and now it’s invading use under the umbrella of liberalization policy before the globalization could.
Chapter Four
Chapter IV

Results and Discussion

Solid waste Management in Khartoum Industrial Area

Sample of survey (31) factories

4-1 Results:-

Table (4-1) shows location and type of ownership of industries under study.

<table>
<thead>
<tr>
<th>Serial No</th>
<th>Name of industry</th>
<th>Location</th>
<th>Type of ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sudan Mint Co. LTD.</td>
<td>Khartoum-South</td>
<td>Cooperative</td>
</tr>
<tr>
<td>2</td>
<td>Packing Factory</td>
<td>Khartoum-South</td>
<td>Private</td>
</tr>
<tr>
<td></td>
<td>“Saria Industrial complex”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Shoe Making Factory (Saria)</td>
<td>Khartoum-South</td>
<td>Private</td>
</tr>
<tr>
<td>4</td>
<td>Abd El Moniem Ind. &amp; Eng. Co</td>
<td>New Industrial Area – Khartoum</td>
<td>Private</td>
</tr>
<tr>
<td>5</td>
<td>General Medicine Company</td>
<td>El Shagara</td>
<td>Private</td>
</tr>
<tr>
<td>6</td>
<td>National leather Tech. Centre (NLTC)</td>
<td>Khartoum-South</td>
<td>Public</td>
</tr>
<tr>
<td>7</td>
<td>The Sudanese Company for leather Industries “White Nile Tannery”</td>
<td>Abu Hamama</td>
<td>Private</td>
</tr>
<tr>
<td>8</td>
<td>The new Industries company – “King Cola”</td>
<td>Khartoum-South</td>
<td>Public</td>
</tr>
<tr>
<td>9</td>
<td>Atlas Packing Co. LTD</td>
<td>Abu Hmama</td>
<td>Private</td>
</tr>
<tr>
<td>10</td>
<td>Printing House</td>
<td>Khartoum-South</td>
<td>Private</td>
</tr>
<tr>
<td>11</td>
<td>Frigon food/gargash</td>
<td>Khartoum-South</td>
<td>Private</td>
</tr>
<tr>
<td>12</td>
<td>Modern Sudan’s printing press</td>
<td>Old Industrial area (Khartoum South)</td>
<td>Private</td>
</tr>
<tr>
<td>13</td>
<td>Saad Sweets Factory</td>
<td>Khartoum South</td>
<td>Private</td>
</tr>
<tr>
<td>14</td>
<td>Plastic Factory – Saria</td>
<td>Khartoum South</td>
<td>Private</td>
</tr>
<tr>
<td>15</td>
<td>Sandwiche panel Factory</td>
<td>South of Sahafa (south of local market)</td>
<td>Private</td>
</tr>
<tr>
<td>16</td>
<td>Prosthetic and Orthetic corporation</td>
<td>Khartoum Nes Industrial area.</td>
<td>Private</td>
</tr>
<tr>
<td>17</td>
<td>El Taysir printing Press</td>
<td>Khartoum South</td>
<td>Private</td>
</tr>
<tr>
<td>18</td>
<td>Knitting</td>
<td>Khartoum South ind.area</td>
<td>Public</td>
</tr>
<tr>
<td>19</td>
<td>Plastic factory</td>
<td>Khartoum – new Industrial. Area</td>
<td>Private</td>
</tr>
<tr>
<td>20</td>
<td>The Anchor Trading Co.</td>
<td>Khartoum South</td>
<td>Private</td>
</tr>
<tr>
<td>#</td>
<td>Company Name</td>
<td>Location</td>
<td>Type</td>
</tr>
<tr>
<td>----</td>
<td>---------------------------------------</td>
<td>---------------------</td>
<td>--------</td>
</tr>
<tr>
<td>21</td>
<td>Building Material Company</td>
<td>Khartoum South</td>
<td>Private</td>
</tr>
<tr>
<td>22</td>
<td>Automotive Battery M. Plant. Sarra Ind. Complex</td>
<td>Khartoum South</td>
<td>Private</td>
</tr>
<tr>
<td>23</td>
<td>Aina International Co.Ltd.</td>
<td>West of Horse Race</td>
<td>Private</td>
</tr>
<tr>
<td>24</td>
<td>El-Rida Factory for Confectionaries</td>
<td>El-Shagara Industrial area</td>
<td>Private</td>
</tr>
<tr>
<td>25</td>
<td>Abdel fattah workshop for wood industries</td>
<td>West Horse Race</td>
<td>Private</td>
</tr>
<tr>
<td>26</td>
<td>Suleiman Carpentry workshop</td>
<td>West Horse Race</td>
<td>Private</td>
</tr>
<tr>
<td>27</td>
<td>Dan Fodio for iron/steel works</td>
<td>West Horse Race</td>
<td>Private</td>
</tr>
<tr>
<td>28</td>
<td>Hammed carpentry workshop</td>
<td>Khartoum South</td>
<td>Private</td>
</tr>
<tr>
<td>29</td>
<td>Yasin workshop for welding</td>
<td>West Horse Race</td>
<td>Private</td>
</tr>
<tr>
<td>30</td>
<td>Mohammed Adam workshop for iron-steel works</td>
<td>West Horse Race</td>
<td>Private</td>
</tr>
<tr>
<td>31</td>
<td>Al-Medina refrigerators factory</td>
<td>Khartoum South</td>
<td>Private</td>
</tr>
</tbody>
</table>
Table (4-2) shows:
Type of solid waste in Industries under study.

<table>
<thead>
<tr>
<th>Serial No</th>
<th>Sector</th>
<th>No. of factories</th>
<th>Type of solid waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Food Industries</td>
<td>6</td>
<td>Packing papers, Cartons, Plastic bags, Food waste, Glass, Ballest, Crates</td>
</tr>
<tr>
<td>2</td>
<td>Spinning and Textiles industries</td>
<td>5</td>
<td>Treads, Iron ball, sand, packing material, Plastic bags, cloth, string, leather, cartons polyvinyl chloride granules, Fleshes, Shavings (Chrome), hair and Trimmings.</td>
</tr>
<tr>
<td>3</td>
<td>Wood and iron products industries</td>
<td>6</td>
<td>Wooden remnants tins of wood, Polish (tins), some broken glasses, empty tins, of polish and glue welding remnants Iron pieces</td>
</tr>
<tr>
<td>4</td>
<td>Paper industries, paper products, printing press</td>
<td>4</td>
<td>Paper</td>
</tr>
<tr>
<td>5</td>
<td>Chemicals Industries</td>
<td>5</td>
<td>Remianders of plastics, pieces of carton and paper, packing materials, powders, plastic raw materials such as PVC, PP, PE, lead oxide, lead sulphate in form of dust of powder, spong, elastics, cottons.</td>
</tr>
<tr>
<td>6</td>
<td>Mining and non metallic product industries</td>
<td>3</td>
<td>Concrete: Iron, Spong Materials, Lime and broken plates.</td>
</tr>
<tr>
<td>7</td>
<td>Basic Metallic Products Industries</td>
<td>1</td>
<td>Remants of iron, Lead and bronze aluminum</td>
</tr>
<tr>
<td>8</td>
<td>Metallic products, Machines and equipment Industries</td>
<td>1</td>
<td>Plastic, glass, iron and aluminum</td>
</tr>
</tbody>
</table>
Table (4-3) shows the total weight of solid waste in sectors under study.

<table>
<thead>
<tr>
<th>Serial No</th>
<th>Sector</th>
<th>No.of Industries</th>
<th>Solid waste weight (Kg per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Food Industries</td>
<td>6</td>
<td>150</td>
</tr>
<tr>
<td>2</td>
<td>Spinning and textiles industries</td>
<td>5</td>
<td>4011.1</td>
</tr>
<tr>
<td>3</td>
<td>Wood and metal products industries</td>
<td>6</td>
<td>432.1</td>
</tr>
<tr>
<td>4</td>
<td>Paper industries, paper products, printing press</td>
<td>4</td>
<td>550.69</td>
</tr>
<tr>
<td>5</td>
<td>Chemicals Industries</td>
<td>5</td>
<td>346.7</td>
</tr>
<tr>
<td>6</td>
<td>Mining and non metallic product industries</td>
<td>3</td>
<td>5150</td>
</tr>
<tr>
<td>7</td>
<td>Basic Metallic Products Industries</td>
<td>1</td>
<td>30.3</td>
</tr>
<tr>
<td>8</td>
<td>Metallic products, Machines and equipment Industries</td>
<td>1</td>
<td>150</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>31</strong></td>
<td><strong>10.820.89</strong></td>
</tr>
</tbody>
</table>
Table (4-4) showing weight (per day) from selected industries in Khatoum Industrial Area

<table>
<thead>
<tr>
<th>Serial No</th>
<th>Sector</th>
<th>No. of Industries</th>
<th>Solid waste weight per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Food Industries</td>
<td>Saad Sweets Factory (Toffee and Sindibad Sweet section), “Tahniya section is closed “</td>
<td>30 Kg</td>
</tr>
<tr>
<td>2</td>
<td>Spinning and textiles industries</td>
<td>The Sudanese Company for leather Industries, “The White Nile Tannery” Abdel Moneim Engineering Co.</td>
<td>2500 Kg</td>
</tr>
<tr>
<td>3</td>
<td>Wood and iron products industries</td>
<td>Abdel Fattah Carpentry workshop. dan Fodio for iron /steel works</td>
<td>8.5 Kg</td>
</tr>
<tr>
<td>4</td>
<td>Paper industries, paper products, printing press</td>
<td>The printing house. Modern Sudan’s Printing Press</td>
<td>27 Kg. 166.7 Kg.</td>
</tr>
<tr>
<td>5</td>
<td>Chemicals Industries</td>
<td>Prosthetic and Orthetic corporation.</td>
<td>29.5 Kg 100 Kg</td>
</tr>
<tr>
<td>6</td>
<td>Mining and non metallic product industries</td>
<td>Aina International Co. Ltd.</td>
<td>2400 Kg</td>
</tr>
<tr>
<td>7</td>
<td>Basic Metallic Products Industries</td>
<td>The Sudan Mint Co. Ltd.</td>
<td>20.6 Kg</td>
</tr>
<tr>
<td>8</td>
<td>Metallic products, Machines and equipment Industries</td>
<td>Al. Madina Referigerators Factory</td>
<td>150 Kg.</td>
</tr>
</tbody>
</table>
Fig(4-1): The percentage of complaints in solid waste management in industries under study.

Source: Field Work
Fig(4-2): The seasonal effect on solid waste disposal in industries under study.

Source: Field Work
Fig(4-3): Contracts with crash programme for environmental sanitation.

Source: Field Work
Fig(4-4): Unsatisfactory situation against the present adopted way of collecting and disposing of solid waste.

Source: Field Work
Fig(4-5): Visiting of Health inspectors in industries under study.

Source: Field Work
Fig(4-6): Recycling in industries under study

Source: Field Work
Solid waste Workers in Khartoum Industrial Area

Sample of study (31)

Table (4-5): Educational level of solid waste workers

<table>
<thead>
<tr>
<th>Educational level</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>basic</td>
<td>14</td>
<td>45.2</td>
</tr>
<tr>
<td>Secondary</td>
<td>8</td>
<td>25.8</td>
</tr>
<tr>
<td>University</td>
<td>2</td>
<td>6.5</td>
</tr>
<tr>
<td>None</td>
<td>7</td>
<td>22.6</td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: Field Work
Table (4-6): Services provided to solid waste workers

<table>
<thead>
<tr>
<th>Protective Material</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mask</td>
<td>4</td>
<td>12.9</td>
</tr>
<tr>
<td>Glasses</td>
<td>3</td>
<td>9.7</td>
</tr>
<tr>
<td>Clothes</td>
<td>8</td>
<td>25.8</td>
</tr>
<tr>
<td>Boots and Gloves</td>
<td>6</td>
<td>19.4</td>
</tr>
<tr>
<td>No Services</td>
<td>10</td>
<td>32.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>31</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Source: Field Work
Fig(4-7): Insurance to solid waste workers.

Source: Field Work
Fig(4-8): Health problems in solid waste workers. 38.7% Suffer from different kinds of diseases.

Source: Field Work
Fig(4-9): Benefit from solid waste.

Source: Field Work
Solid waste Pickers Around the sanitary landfill Area

Sample of study (30)

Fig.(4-10): Age of solid waste pickers Around the sanitary landfill Area.

Source: Field Work
Fig.(4-11): Educational level of solid waste pickers Around the sanitary landfill Area.

Source: Field Work
Fig.(4-12): Residence of solid waste pickers Around the sanitary landfill Area.

Source: Field Work
Table (4-7):-

Type of solid waste collected by a solid waste picker, quantity, marketing place, price:-

<table>
<thead>
<tr>
<th>Solid waste type</th>
<th>Quantity per day</th>
<th>Marketing place</th>
<th>Price/ sack or kilo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic, cartons,</td>
<td>4-5 sack</td>
<td>1. Khartoum popular market</td>
<td>*1000-4000 SD (per sack)</td>
</tr>
<tr>
<td>metals, Egg palce,</td>
<td></td>
<td>2. Mayo market</td>
<td>* 100-2000 SD (per kilo) / for</td>
</tr>
<tr>
<td>Empty plastic and</td>
<td></td>
<td>3. Omdurman market.</td>
<td>Metals</td>
</tr>
<tr>
<td>jute sacks … etc.</td>
<td></td>
<td>4. Merchants inside the site</td>
<td></td>
</tr>
</tbody>
</table>

Source: Field work.
Table (4-8):-
Solid waste brokers around the dumping area. Sample of study (25):-

<table>
<thead>
<tr>
<th>Age</th>
<th>Residence</th>
<th>Educational level</th>
<th>Marital status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean of age: 45 years old</td>
<td>* Omdurman (40%)</td>
<td>* primary (30%)</td>
<td>(80%) married</td>
</tr>
<tr>
<td></td>
<td>* Mayo (20%)</td>
<td>* Khalua (10%)</td>
<td>(20%) not married</td>
</tr>
<tr>
<td></td>
<td>* El-Shaggera (12%)</td>
<td>* None (60)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>* Ishlag (16%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>* Kalakla (12%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Field work.
Table (4-9):-
Showing quantity of solid waste bought by solid waste brokers, marketing place and problems encountered:

<table>
<thead>
<tr>
<th>Quantity of solid waste bought</th>
<th>Marketing place</th>
<th>Problems encountered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>* Omdurman market.</td>
<td>* theft and conflicts between waste pickers</td>
</tr>
<tr>
<td></td>
<td>* Mayo market</td>
<td>* Killing</td>
</tr>
</tbody>
</table>

Source: Field work.
4-2: Discussion:

This study covered the Industrial Area in Khartoum. Practically, 31 Factories were studied comprising eight different sectors, i.e. 25% of the total factories in the area.

Throughout these sectors, the management of solid waste was studied.

Table (3-1) shows the most important sectors operating in the area and the present situation in the Industrial Area, Khartoum South.

Table (4-1) shows the names of Industries which were examined by the study, their locations, and type of ownership. It is observed that the majority of the factories are privately owned, while others are cooperative or public enterprises.

Table (4-2) shows the type of solid waste in the Industries under study in each of the eight sector. So, representative samples were taken from each sector; (e.g. in sector of food industries, six factories were selected; while in the textile sector, five factories were selected and six workshops were selected in the wooden and iron products sector. It is noticed that packing materials, plastics and cartons of all types, produce a high ratio of solid waste.

Likewise, the total volume of the solid waste was studied in total sample of the sectors, table (4-3), shows that the highest ratio of solid waste is produced mining and in the non-metallic products industrial sector (excluding petroleum and coal industrial sector). These amounted to (5150 Kg per day).

Next comes the textile sector (4011.1 Kg); the wooden and iron products sector (550.69 Kg per day); then the chemical industries (346.7 Kgs. Per day), then the metallic products, machines and equipment industries solid waste (150 kg per day) and Food Industries waste (150 kg per day) and the least ratio of solid waste was found in dample of the Mint, which was (30 kg per day).
Table (4-4) shows the weight of the solid waste produced during the day in selected samples of the factories. For example, in the food industries sector, solid waste was studied in Saad Sweets Factory (Toffee and Sindbad sweets section – while the “Tahniya” section is closed. The volume of waste amounted to (30 kg per day).

In the textile sector, the Sudanese company for leather industries (White Nile Tannery) was selected. Thus, the weight of the solid waste was found to be (2500 kgs per day).

Meanwhile. The solid waste of Abdel Moniem Engineering Co., (which operates in the field of producing shoe-laces and wax) was found to be (8.5 kgs per day).

In the paper products, printing and publishing industries, the solid waste of the “printing House” amounted to (29.5 kg per day). Also in the Modern Sudan’s printing press, solid waste amounted (100 kgs per day). Also, in the chemicals sectors, the solid waste of the prosthetic and orthetic corporation amounted to (50 kg per day). In the non-metalic products sector excluding petroleum and coal, the solid waste in the sample of “Aina International Co. amounted to (2400 kgs per day); while the solid waste of the Mint (The Sudan Mint Co. Ltd) amounted to (20.6 kg). Finally, in the metallic Products, machines and equipment industries, sector ( AL-Medina Refrigerators Factory), solid waste amounted to (150 kgs per day).

The two tables (4-3) and (4-4); shows that the volume of solid waste in the industrial Area-Khartoum is less than recognized standars. The reason is that most of the factories produce and operate at (15-20% of their designed actual productive capacities. This is due to the weakness of financing, the competition of the imported goods (which are cheaper and of better quality), the rise of the cost of electricity, high taxes and others.
Despite the smallness of the volume of the produced solid waste, it is observed that there is a clear deficiency in their management. It was found, in the field visits that the Industrial area is surrounded by great amount of solid waste. Also, there is a deficiency on the part of the factory owners in controlling such waste inside their factories (plate (2,3) and plate (4)). This is due to the importer primary treatment of such waste. So, some factories do not care to dispose properly of their waste; while all the factories which were subjected to study, use the manual method in collecting solid waste inside the factories, then carry all the accumulated waste to barrels or the open disposal containers in which it stays, for more than two weeks for some of the factories.

From the field work, it was found that there is a ratio of complaints (Fig (4-1) on the management of solid waste, which often come from waste workers, and sometimes from the households in the residential areas near the Industrial Area.

Likewise, factories suffer from the deficiency of treatment. One of the reasons is due to the determination of the “crash programme for environmental sanitation” which is put into effect for two days per week for each factory to carry a way its solid waste, in lieu of (SD 2000-3000) for workshops or (SD 15.000-25000) for some factories. At the same time, the deficiency in the number of vehciles leads to the reduction of specified period for each factory. Sometimes, in addition to above, the truck for carrying a way solid waste is delayed because of the non-asphalt roads which delay their access to the factories. This leads to more deterioration.

All this led to an unsatisfactory situation against the presently adopted way of collecting and disposing of waste from most of the factories. Thus, it is found that (67.7%) of factory owners are not satisfied of the present method, as it is less effective in management of this process. Thus, the method needs to be reviewed and developed.
Meanwhile, some other factory owners (32.3%) (Fig 4-4) see that the method is “Not Bad” as it is solved the problem, to some extent (as it reduced the amount of fines they used to pay to the Ministry of Health); because, in the past, most of the factories were individually responsible of disposing of their waste, by throwing in the nearest random place for disposal. This used to expose them to fine.

It was found out that 19.4% of the total industries covered do recycle their waste such as "the Sudan Mint, Prothetic and Orthetic Corporation, modern Sudan's Printing Press, Aina International Co. Ltd. .....etc. Fig (4-6).

The study also exposed a clear deficiency by the Ministry of Health in following up of the health aspects inside the factories. Yet, some waste materials capture the interest of this ministry; such as, those of the food industries sector, while some others are completely ignored.

Figure (4-5) shows that (67.7%) of the factories are regularly followed by the Ministry (once or twice a month) and (32.3%) are not followed. The study also dealt with the present situation of the solid waste workers in the factories. It took samples of these workers and found that (45.2%) of the workers had some basic education. As for others, they were as follows:

(25.8%) received their secondary education;

(6.4%) received university education; and

(22.6%) were illiterate. (see Table (4-5)).

Table (4-6), the services provided in this realm. Thus, (67.7%) of the factories provided protection requirements, while the remaining (32.3%) do not-owing to the degraded level of education amongst the waste workers; and their non understanding of the use of the protection instruments, they do not use them. Evenmore, the factores neglect this problem and do not oblige the workers to use them.
Clothes, also, are not provided for all the workers. Thus, only (19.4) of the factories provide boots and gloves and (12.9%) provide muzzles and (9.7%) provide glasses for workers. Thus, this negligence of the protection equipment had led to the appearance of disease cases, such as, chest, eye and skin diseases. So, (38.7%) of the workers suffer from these diseases, while (61.3%) are free from them (see fig 4-8).

In the field of “benefiting from the solid waste (74.2%) view that there is no benefit from the solid waste and there is no use of them, while (25.8%) see that use could be made of the cartoon, plastic bags and similar waste.

Such deficiency in the treatment of the solid waste and the non-provision of means of reuse or recycling of solid waste in the area, led to the flourishing of the trade of such waste and the emergence of solid waste pickers and solid waste brokers around the sanitary landfill area, behind Al Gooz treatment plant in Khartoum. This is because the cars of the crash programme come loaded with huge amounts of solid waste, in a good condition which encourages their reuse. (plate (9). Shows the assembly of the waste pickers around the waste materials trucks; waiting for emptying it.

Through out the field work, it was clear that (80%) of the waste pickers around the sanitary landfill area, are less than (20) years of age, (20%) are between (20-30 years) fig (4-10). The educational level of these pickers is as follows:

Primary (66.7%)

None (33.3%)

These youngsters often live in the lower-income areas; such as Mayo, Ingaz, the horse race area or even in the sanitary landfill area itself. This is exposed in details as follows:

(46.7%) live in Mayo area.
(33.3%) live in the Horse Race Area.

(6.7%) live inside the sanitary landfill area.

(3.3%) live in Al-Jebel

(3.3%) live in Hilla Al-Gadeeda in Omdurman. Fig (4-12)

These youngsters sort out all types of solid waste. Some are specialized in plastics (empty plastic bottles of pepsi and fresh drinks (plate (15). Others are specialized in cartons (plate (11). Egg plates (plate (12) and some others in empty plastic and jute socks (plate (14). This occurs, also in addition to the various types of metals (iron, copper and aluminum).

After the end of the sorting out operations, the solid waste is packed into sacks, to facilitate their transport by the help of waste carrying trucks to the areas of their marketing.

Each picker collects between (4-5 sacks per day) and market, them in “the Suq Shaabi” in Khartoum, Mayo, Omdurman and inside the sanitary landfill area itself; as follows:

(43.3%) Khartoum. (Popular Market of Khartoum.

(26.7%) “Mayo market”

(16.7%) Omdurman market”.

(13.3) Merchants inside the site.

Most of these children have become accustomed to this type of life. They say they have no alternative, as this place provides them with their daily bread.

The sock of solid waste is sold for (SD 100-200). In case of metals, it is sold for (SD 10-100 per kg).

The most important problems from which these pickers suffer are the robberies and thefts inside the site, by the adults who steel the children’s sacks by force and murders
because of the abundance of all types of wines and spirits. Also, sometimes, the police try to control these situations, which causes a lot of disruption for the pickers’ work.

The waste brokers amongst the elders found their way to trade, through trading in the solid waste. Most of them found their happiness in this work because it is lucrative.

So, now, most of them have private cars which they use for transporting their purchases from the solid waste pickers, at low prices. They also depend upon “Suq Shaabi” for marketing.

Table (4-8) and (4-9) give information about the solid waste brokers.

Plate (13) show one of these brokers and around him some solid waste pickers.
The Environmental Impact of Khartoum Industrial Area.

The Khartoum Industrial Area, as said before, is originally a six – industrial areas complex. This proves that it is a vast area which occupy a good space in Khartoum. Thus, its environmental impact is remarkable.

The environmental effect of the area is studied through taking samples of the neighbouring residential areas (Hilla Gadeeda, Shaggara, Hia Paris, Shaheed Widatalla Camp (The Army Borracks).

The following table (table (10), shows the residential quarter, the type of industry neighbouring it and the hazards resulting form that.

<table>
<thead>
<tr>
<th>Name of the Residential area</th>
<th>Type of the Neighbouring industry</th>
<th>The environmental Hazards</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Shaggara</td>
<td>“Tahniya” factories drugs and medicences factory, Asbestos factory (now closed)</td>
<td>1. Bad odours resulting from washing sesame. Improper disposal of the sesame left-outs had led to the rise of the ratio of the incidence of malarya, because of increase of mosquito, firees and other insects. 2. Toxic gases emitting in the form of black smoke led to the increase of chest infections and sensitivity. 3. Several somplaints against the Asbestos Factory and the dangers resulting from it/led its closure.</td>
</tr>
<tr>
<td>Name of the Residential area</td>
<td>Type of the Neighbouring industry</td>
<td>The environmental Hazards</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>2. Hilla Gadeeda</td>
<td>Industries based on metals e.g the Mint and the central foundry</td>
<td>The gases emitting from forging metals led to the rise of chest diseases and sensitivity.</td>
</tr>
<tr>
<td>3. Shaheed Widatalla Camp (Army Borrocks)</td>
<td>The Tanneries (Khartoum tannery and “the white Nile Tannery)”</td>
<td>The bad odurs which come out of the processing of skin the increase Malarya case because of the increas of mosquitoes etc.</td>
</tr>
<tr>
<td>4. Hai Paris</td>
<td>LooLI ice-cream factory + some laboritories</td>
<td>Water drains do not operate in a good way. Hazards in septic tanks. The area cannot accommodate a factory because of the houses syphons.</td>
</tr>
</tbody>
</table>

- The old industrial area (Khartoum South), have wide drains which flow to the White Nile, but they are uncovered, which increases the probability of environmental pollution.
- Also, Khartoum South area are full of workshops which work in iron and car maintenance. Most of cars, thus are repaired there. So, since the 1950s, no change was made to it and thus it suffers from the improper disposal of solid waste, which cause many constraints to traffic in the area.
- The industrial area (Shaggara) is a new area; and there is no sanitary drainage system. Some of the factories, especially those which produce “Tahnia” suffer from the problem of “washing sesame” and the lack of a sanitary drainage system. This had led to the accumulation of the sesame waste’ which had led to environmental hazards (insects, bad odours etc).
• Also, the area has several factories operating in the field of plastic, yet, there is deficiency in the treatment of its left-outs. This leads, in the long run, to major harms to the environment.

The paints industry is considered of a major environmental effect; (such as, the chemical mixes which result from the pastes etc)

• The liquid lime which results from some industries, such as liquid air industry, sometimes it is sold to citizens and sometimes it is stored, which forms a burden on the environment, because it contains blistering materials.

• Tanneries are also amongst the dangerous industries. Now they have become in the heart of Khartoum, which forms a major environmental problem.

• In Soba, some factories dispose their waste directly in the Nile, this will lead to water pollution and harmful effects to aquatic life.

• Also, some of factories which operate in the field of minerals and others, dispose their waste inside the industrial area, a long the railway line which divide the insutrial area into two parts-Eastern and Western this minerals affect the nature of the agricultural land. This had led to harmful effect on plants in the area. Most of these plants suffer from drought and others suffer from dwarfness.
Chapter Five
Chapter V

Conclusions and Recommendations

5.1 Conclusions:-

Solid waste management is a threat in all countries of the world. In the Sudan it is not an exception with Khartoum industrial area as a major contributor to the problem.

The management of solid waste in Khartoum is uncoordinated and not subject to any form of overall control. Management of solid wastes, whether from local authorities or industrial sources need integrated use of management facilities.

Provided good management practice and any appropriate precautions are adopted, risk to public health is not likely to arise from refuse disposal by existing methods.

About 25% of the industries in the study area were examined, operating under their calibrated capacity with low waste production.

Solid waste management is often haphazard because their dumping sites are visited by both man and animals. Therefore easily communicated (transferred) within the food chain.

Khartoum industrial area has a number of residential areas that are expanding very fast hence the location of existing industries in the area may pose environmental problem in the future. These industries should be located far from residential areas and proper control over the management of the solid wastes must be emphasised by the factories owners.

Most of the industries studied lack proper treatment methods moreover some do not care to dispose their wastes properly. Accordingly, for effective management
of the solid wastes, effective management should be applied which include for example, daily collection of solid waste, storage and their transfer to dumping site.

Solid waste workers in the study area are inflicted by several occupational diseases. These include chest eye and skin diseases as such protection equipment to be availed to every worker to reduce or curb the incidence of these diseases. Moreover, some solid workers are provided protective equipment whereas others are not, yet a sizeable number who are provided do not use them.

Hence, there should be a strict law pertaining to the provision of safety equipment to all solid waste workers and the benefits fully explain for the sake of their health and objective of the industry.

In the Sudan in general and Khartoum industrial area in particular, there is lack in the recycling of solid waste. This study show that of the industries covered only 19.4% do recycle their solid waste. Therefore, the other industries should be encouraged for recycle their wastes.

The study found out that in Khartoum Industrial Area there is no survey done to formulate solid waste disposal policy. Therefore, running programme should be maintained to ensure progressive availability of solid waste disposal facilities for ten years a head.
5.2 Recommendations:-

1. Problems of sanitary drainage especially in El Shaggara industrial area to be resolved.

2. Transport routes to the industrial area to be availed for easy communication.

3. Provision of protective equipment to solid waste workers and laws for strict use of protective equipment to be emphasized to all solid waste workers.

4. Education and training of the solid waste workers on waste management to encourage them take responsibility for the waste they generate.

5. Expansion and improvement of the “crash programme for Environmental sanitation” and increase in the number of trucks involved in the project.

6. Industries should embark on the recycling of solid waste of reduce their effect on the environment, and availability of markets for the recycled products.

7. Future Industries to be established far a way from residential areas i.e where the raw material are found.

8. Sanitary landfill sites to be established in remote areas.

9. Education and Rehabilitation to be provided to the solid waste pickers

10. Management system should be found to follow up regulations of solid waste problems.
References


**Internet**

1. WWW.Unep.org


115
Appendices
Plate (1): Unregulated dumping site in the area southern of Shafa
Plate (2) and (3): shows the deficiency in solid waste management in the White Nile Tannery.
Plate (4): Improper management of solid waste, waste paper thrown randomly inside the 'printing house'
Plate (5): Solid waste produced during the day in 'Sindbad section' – in Saad Sweets factory.
Plate (6): A Worker in Saad Sweet factory weighs the solid waste of 'Toffee Section'.
Plate (7): Solid waste worker in the 'printing house' weighs solid waste produced during the day.
Plate (8): Collection method of solid in the industrial area. A worker collects waste paper of the printing house.
Plate (9): crash programme trucks on way to the dumping site.
Plate (10): Solid waste pickers around the crash programme trucks, waiting for emptying it.
Plate (11) and (12): Solid waste pickers with different types of solid waste sorted around the sanitary.
Plate (13) and (14): A Solid waste broker around him solid waste pickers in sanitary landfill area.
Plate (15): A Solid waste pickers with the collected empty plastic bottles of Pepsi and fresh drinks.
Plate (16): Recycling of solid waste by a waste picker who made the table and the box from the solid waste of the dumping area.
(I)

Questionnaire form for Data Collection on the Management of Solid Waste for Industries in Khartoum Industrial area

1. Serial No. (    )
2. Name of Industry ............................................
3. Location........................................................
4. Type of Ownership
   (a) Private (    )
   (b) Public (    )
   (c) Cooperative (    )
5. Solid waste production:
   (a) Type(s)
       ………………………………………………………………..
       ………………………………………………………………..
6. Seasonal effect on solid waste disposal
   Yes(    )    No (        )
   ………………………………………………………………..
   ………………………………………………………………..
7. Have you received any complaint(s):

Yes(    )             No(    )
If Yes. From whom?
(a) Solid waste workers (Please specify) .................

(b) Neighboring industries (Please specify) ..............

(c) Households at the vicinity of the industry (specify) ...

If No. Why?

8. Have you ever visited by any public health inspector?

Yes(    )             No(    )
If Yes. Specify reason(s) and date of visits

If No. Why not (state reasons)

9. Are you satisfied with the Current collection and Disposal methods?

Yes (    )             No (    )
If Yes. State reasons
If No. State reasons

………………………………………………………………………………………………………………………………………………………………………………
………………………………………………………………………………………………………………………………………………………………………………
………………………………………………………………………………………………………………………………………………………………………………

10. What are the solid waste problems?
………………………………………………………………………………………………………………………………………………………………………………
………………………………………………………………………………………………………………………………………………………………………………
………………………………………………………………………………………………………………………………………………………………………………

11. How would you improve the present disposal management methods. Give suggestions and or recommendations
………………………………………………………………………………………………………………………………………………………………………………
………………………………………………………………………………………………………………………………………………………………………………
………………………………………………………………………………………………………………………………………………………………………………
Questionnaire form for data Collection on Status of Solid Waste for workers of Industrial Area

Date:

1. Age.................................

2. Martial status:
   Married (  )                Single (  )

3. Occupation............................

4. Educational Level:
   (a) Basic (  )
   (b) Secondary (  )
   (c) None (  )
   If No. Why?

4. Services provided
   (i) Protective material (Garments)
      (a) Clothes (  )    (b) Boots (  )    (c) Gloves (  )    (d) mask
      (e) gasses

5. Insurance:
   (a) Health (  )
   (b) Social (  )
   (c) Disability (  )
   (d) Others (  )

6. Any health complaints?:
   Yes (  )               No (  )
   If Yes. What?
   ................................................................
   ................................................................
   ................................................................

7. Do you benefit from solid wastes in any form?
   Yes (  )               No (  )
   If Yes. (How?)
   ................................................................
   ................................................................
   ................................................................
(III)

(a) Questionnaire form for data Collection on Solid for Waste pickers around the Dumping Area

Date:  Serial No: (  )

1. Age ..................................

2. Martial status:
   Married (  )       Single (  )

3. Residence .................................................................

4. Educational level:
   (a) Primary       (b) Secondary (c) Other

5. Type of solid waste picked
   ..............................................................................
   ..............................................................................
   ..............................................................................

6. Quantity collected?
   ..............................................................................
   ..............................................................................
   ..............................................................................

7. To whom do you sell?
   ..............................................................................
   ..............................................................................
   ..............................................................................

8. Price?
   ..............................................................................
   ..............................................................................
   ..............................................................................

9. Problems encountered?
   ..............................................................................
   ..............................................................................
   ..............................................................................

10. Are you Satisfied on the trade?
    Yes(  )       No(  )
If Yes. How?

………………………………………………………………………..
………………………………………………………………………..
………………………………………………………………………..

If No. Why not?

………………………………………………………………………..
………………………………………………………………………..
………………………………………………………………………..
………………………………………………………………………..
(III)

(b) Questionnaire form for data Collection on Solid for Waste Brokers around the Dumping Area

Date: Serial No: (  )

1. Age: ........................................

2. Martial status:
   Married (  )  Single (  )

3. Residence: .................................................................

4. Educational level:
   (a) Primary  (b) Secondary  (c) other

5. Type of solid waste bought
   ………………………………………………………………………
   ………………………………………………………………………
   ………………………………………………………………………

6. Quantity bought?
   ………………………………………………………………………
   ………………………………………………………………………
   ………………………………………………………………………

7. To whom do you sell?
   ………………………………………………………………………
   ………………………………………………………………………
   ………………………………………………………………………

8. Price?
   ………………………………………………………………………
   ………………………………………………………………………
   ………………………………………………………………………

9. Market place?
   ………………………………………………………………………
   ………………………………………………………………………
   ………………………………………………………………………

10. Problems encountered?
    ………………………………………………………………………
11. Are you Satisfied with the business?
   Yes(  )               No(  )

If Yes. How?
   …………………………………………………………………
   …………………………………………………………………
   …………………………………………………………………

If No. Why not?
   …………………………………………………………………
   …………………………………………………………………
   …………………………………………………………………
Serial No:....................

1. Name of residential area ...........................................

2. Name of nearby Industry .............................................

3. Type of wastes disposed by the Industry?
   .............................................................................
   .............................................................................
   .............................................................................
   .............................................................................

4. Quantity .................................................................
   .............................................................................
   .............................................................................
   .............................................................................
   .............................................................................

5. Problems due to industrial wastes disposal?
   .............................................................................
   .............................................................................
   .............................................................................
   .............................................................................

Questionnaire form for Data Collection on Solid Waste for The Households at the Vicinity of Industries Under Study