Sudan University of Science and Technology

Collage of Graduate Studies

Residential Domestic Solid Waste Collection Processer in an Urban Area: The Case of Greater Khartoum

عمليات جمع النفاياتالمحليةالمنزلية الصلبةفي المناطق الحضرية:

دراسة حالة الخرطوم الكبرى

A Thesis submitted as a fulfillment of the requirements for the degree of Ph. D. in Architecture

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الآيـــــــــة

قال تعالى:

(اقْرَأْ بِاسْمِ رَبِّكَ الَّذِي خَلَقَ * خَلَقَ الْإِنْسَانَ مِنْ عَلَقٍ * اقْرَأْ وَرَبُّكَ

الْأَكْرَمُ * الَّذِي عَلَّمَ بِالْقَلَمِ * عَلَّمَ الْإِنْسَانَ مَا لَمْ يَعْلَمْ *)

صدق الله العظيم

سورة العلق، الآيات (١-٥)

Dedication

To ones that brought me to life

Dedicate their being to me

To my nearest one, my father

To my dearest mother

To worthy husband, my daughter and sons

My supervisor Prof/ **Essam Mohamed Abdlmagid**

The staff of Sudan University of Science and Technology

To dealers of architectures aiming high

For glorious future to our country

For all great men and women who respect the human, humanity and the human rights

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Researcher

Table of Contents

List of Tables

List of Figures

List of Boxes

Abstract

As one of the major reasons causing ecological deterioration is absence or improper treatment of daily produced solid wastes from households in Khartoum state. For these solid wastes hasn`t received, and till now in Sudan, the proper solutions addressing transportation from their sources of production to be hygienically disposed in the allocated areas for this purpose.

This study aims at cleansing the state according to the modern sanitary methods adopting the best methods and technologies for solid waste storage, collection and transportation towards the final disposal of the collected wastes. Also, the study aims at laying certain specifications for to support solid waste collection, transportation and final disposal. Besides providing the minimum of human workforce, machinery and working capital for the project and all other activities in line of towns sanitation. Raising of the environmental awareness among citizens is another aim of this study . in addition to formulation of plans and accurate scientific programs to ensure service sustainability in correct manner with training programs provided to the working labour in order to cope with the sanitary level of modern towns and public health requirements. The study supports records keeping and conduction of more studies for further improvement of sanitary level and investing in solid wastes to encourage the private to join this field.

The study adopted the research methodology to realize the above aims depending upon references , textbooks , newspapers , magazines , periodicals , websites and field visits that are accompanied by photographing, report writing and interviews for the field applied study viewing the solid waste collection at the house hold level.

Also, a survey through questionnaire in household squares was conducted during the above mentioned field visits to investigate dwelling reality inside households and neighborhoods of municipal solid waste collection. The questionnaires were distributed among 83 individuals for each province of Khartoum three provinces and the obtained primary data were analyzed accordingly using Statistical Package for Social Science (SPSS) program, then Key Performance Indicaters System (KPIS) and computer modeling were used to reach the most important result of the this study which is that the solid waste material produced in Khartoum state consists mainly of reusable materials such as organic

materials , metal , glass , ragged clothes ,plastic , wood and bones. The total quantity of solid waste material produced in the state is 995358. 5 ton/year with production rate of 4000. 2 gm for person a day. Also, it was revealed that the organic materials are dominant in the municipal solid waste in Khartoum state. Most of citizens in the study area (83. 3%) depend on the waste vehicle for disposing the solid waste adopting house-to-house method beside some waste containers scattered all over the neighborhoods

Also, the house solid waste containers don't obey the hygienic pre-requisites as they are mostly opened for flies and subjected to dispersal of their contents. In order to remove solid waste accumulation in Khartoum state , the negative phenomena should be controlled as its confirmed by the prevalent ecological, hygienic and managerial indicators (flies density , stench odours , stagnation of solid wastes in their containers, transportation time, safe disposal , commitment of citizens to service fare and reduced complaints).

In absence of solid waste collection and sorting program, recycling of municipal solid waste is not found in Khartoum state and that is greatly attributed to absence of real market for recycling products besides, there is no program for recycling the organic waste using it as fertilizers even these operations have crucial economic , hygienic and ecological importance.

The improper management of the municipal solid wastes will lead to deterioration of the public hygiene of the community and pollution of water, air and soil. So, the main reason behind managing and controlling solid waste collection and disposal is the maintenance of the public health and hygiene of the community and this is the main aim of the study.

الملخص

لعل من أكبر مسببات تدهور صحة البيئة هو عدم معالجة النفايات التى تفرزها يوميا المساكن فى منطقة ولاية الخرطوم وهذة النفايات لم تجد حتى الأن فى السودان من يضع الحلول السلمية لنقلها من مصادرها وتحويلها ال أماكن التخلص الصحى السليم.

وهذة الدراسة تهدف الى نظافة الولاية وفق سبل مستحدثة وأتباع أسهل وأفضل الوسائل وتقنيات حفظ وجمع ونقل النفايات ومن ثم التخلص النهائى من النفايات المجمعة. ووضع مواصفات محددة لخدمة الجمع والنقل والتخلص من النفايات،توفير الحد الأدنى من القوة البشرية والألية وتكلفة تسير المشروع وكل مناشط العمل فى نظافة المدن،ورفع الحس البيئى لدى المواطنين،وضع الخطط والبرمجة العلمية الدقيقة لضمان أستمرارية العمل على وتيرة صحيحة،تدريب وتأهيل فرق العمل،مواكبة مستوى نظافة المدن الحديثة ومتطلبات أهداف الصحة العامة، عمل المراجعة والسجلات والدراسات لمزيد من ترقية مستوى النظافة وأستثمار النفايات وتشجيع ولوج القطاع الخاص فى هذا المجال

أعتمدت فى منهجية البحث لتحقيق الأهداف السابقة على المراجع والكتب والصحف والمجلات والدوريات والمواقع الألكترونية والزيارة الميدانية لمنطقة الدراسة وأخذ الصور وكتابة التقارير والمقابلات الشخصية وذلك للدراسة الميدانية التطبقية لظاهرة جمع النفايات داخل المنزل وفى الأحياء السكنية، إستخدام أستمارة البحث الميدانى ومن ثم الإطلاع على الواقع السكنى داخل المنزل والأحياء السكنية لطرق جمع النفايات المنزلية. وقد تم توزيع ٨٣ أستبيان داخل الأحياء السكنية لكل محلية من محليات الولايات الثلاثة بولاية الخرطوم ومن ثم تحليل هذة البيانات عن طريق أستخدام برنامج التحليل الأحصائى SPSS ومن ثم أستخدام نظامKPIS(Key Performance Indicaters System)، ونظامComputer Modeling

وذلك للوصول الى أهم النتائج وهى أن النفايات المنزلية المتولدة بمنطقة الخرطوم الكبرى تحتوى على مواد يمكن الأستفادة منها مثل المواد العضوية والجلد والزجاج والخرق والبلاستيك والأخشاب والعظام ،تبلغ كمية النفايات الصلبة التولدة بالمنطقة ٩٩٥٣٥٨,٥طن\السنة بمعدل٠٠,٢-٠٠,٤كيلو جرام لى الفرد الواحد /اليوم وقد أتضح بأن المواد العضوية تشكل النسبة الأكبر للنفايات المنزلية الصلبة بمنطقة الخرطوم الكبرى، معظم المواطنين بمنطقة الدراسة٨٣. ٣% يعتمدون فى التخلص من نفاياتهم المنزلية الصلبة على عربة النفايات وطريقة الجمع منزل لمنزل بجانب وجود حاويات لجمع القمامة بالأحياء.

ونجد أن مواعين حفظ القمامة بالمنازل لاتنطبق عليها الأشتراطان الصحية والبيئية إذا غالبا ماتكون مكشوفة للذباب وعرضة لتناثر النفايات الصلبة خارجها. وذلك للإزالة تراكم النفايات الصلبة بمنطقة الخرطوم الكبرى أزالت الظواهر السالبة وهذة ماأكده المؤشرات البيئية والصحية والأدارية السائدة بالمنطقة(كثافة الذباب-الروائح الكريهة-وجود النفايات فى الموقع والمواعين المخصصة لها-الترحيل فى الأوقات المتفق عليها-التخلص الأمن-ألتزام المواطنين بالرسوم-قلة الشكاوى. . . . الخ).

فى غياب برنامج الجمع والفرز لايوجد تدوير لمحتويات النفايات المنزلية الصلبة بمنطقة الخرطوم الكبرى والسبب الأساسى عدم وجود سوق حقيقى للمواد التى يمكن أن تفرز من النفايات الصلبة كما لايوجد برنامج لمعالجة المواد العضوية وأستخدام السماد العضوى رغم الأهمية الأقتصادية والصحية والبيئية لهذة العمليات.

أن الإدارة غير الجيدة للتعامل مع النفايات المنزلية تقود الى تردى الصحة العمومية للمجتمع بالإضافة الى أثارها البيئية وتلويثها للماء والهواء والتربة،ومن ثم فإن السبب الأساسى والرئيس للتحكم فى جمع النفاية والتخلص منها هو الحفاظ على الصحة العمومية. وهذا ماتهدف الدراسةالى الوصول أليه.

Chapter one

Introduction and research frame work

Chapter one

Introduction and research frame work

1-1 Background

Domestic waste materials are the outputs disposed regularly from houses, and they include leftovers of food, lass,vegetables,fruits, ash,dust,wood,papers,carbon, minerals and plastic materials. Solid waste materials, garbage and sweepings are generally the inhomogeneous mass of wastes disposed by the civil society, in addition to inhomogeneous aggregate from agriculture, industry and the mineral byproducts. Approximately, the daily production rate for a Sudanese typical individual falls between 0. 3 to 2 kg depending on manufacturing ratio, preparation and purchasing, cultural and social capability andother relevant factors and effects.

The removal of waste material has ever since been a greater challenge for environment maintenance administration bodies. In spite of all efforts exerted, the deterioration in sanitary services started in the eve of 1970s as result of beak down of trash trucks which coincided with the population growth reaching an annual rate of 4. 04%. In addition to the increasing migration from rural areas. The deterioration continued even though the state had made some arrangements like provision of some machineries utilizing from German and Japanese loans. And that was attributable to the incompetence of state administrations to utilize these arrangements efficiently. The situation in Khartoum state is now more critical for the waste materials quantity produced has reached 4800 m^3 per day, whereas the actual capacity of the state fleet of trucks doesn't exceed 800m^3 per day and the effect of private companies is very limited to cleansing of residential quarters. Likewise,this

research work revealed thatthis figure does not take into consideration the waste from shanty towns and the newly planned residential submitted to citizens during the last ten years. Equally important to mention that the mass of domestic waste materials increase every day, as a result of the huge migration towards the capital city accompanied by the lack of viable solutions for collecting, sorting and transporting the domestic waste materials in modern scientific manner, leading to minimization of the environmental pollution that occurs in residential quarters as a result of waste materials accumulation in front of houses and streets. This may lead to environment crisis and spread of many infectious disease affecting the personal health in particular and production in general.

Therefore, one of the major causes of environmental pollution and human health deterioration in the communities residential quarters in Khartoum state is the failure to designate correct and scientific solutions for managing and processing domestic waste materials throughout its collection, sorting and transporting stages from the source within houses in cost and time-effective scientific pathways up to the areas of disposition to be utilized from. This matter is tackled in detail in this study.

1-2 Research Question and Hypotheses

The idea of this research arises from answering the question: "what are the most suitable comprehensive scientific systems to process the domestic waste materials in effort and time effective way that minimizes the cost and ensures protection against occurrence of environmental pollution in residential areas with the possibility of utilizing these waste materials in recycling in future?"

Based on this question, the researcher assumed the following hypotheses.

1- The research tries to prove that the comprehensive planning system for processing the domestic waste materials will compensate the difference between the revenues and service cost.
2- The research tries to prove that the comprehensive planning system for processing the domestic waste materials will spread the environmental awareness culture.
3- The research tries to prove that the comprehensive planning system for processing the domestic waste materials will lead to increase of production through maintenance of personal health by minimizing the environmental pollution

1-3ResearchProblem

The increase in the population of Khartoum state as a result of migration from other states has lead to increase in residential quarters and expansion of shanty towns. This is accompanied by lack of comprehensive and scientific system for processing domestic waste materials in their stages of collection, sorting, transportation and disposal in correct manner. Thus, it has lead to great environmental pollution in the residential quarters in Khartoum state threatening for occurrence of major environmental crisis that will lead to spread of many infectious diseases affecting the personal health in particular and production in general. Moreover, the current system of processing the domestic waste materials in the national capital is an old and traditional one of big cost and it depletesthe state treasury and assists pollution in the area. The proposed system in this study will lead to reduction in those heavy costs and saving a great deal of state money ensuring protection against any potential environment pollution.

1-4 Importance and Significance ofresearch work

1-The study enables designation of comprehensive system for the processing of domestic solid waste materialism the stages of collection, sorting, transportation and disposal.

2-The study enables generalization of environment awareness and education culture as the main pathway for changing human behavior to react positively with the services offered by the state and private sector.

3-The study will pinpoint potential pathways to a change in the citizens' public health as a result of minimization of environmental pollution attributable to the domestic waste materials.

4-The study will lead to lay a comprehensive planning system for processing the domestic waste materials so as to compensate the difference between revenues and the service cost.

5- The study will enable cleaning Khartoum state according the modern methods adopting easiest and best ways and technologies of collection, sorting, transportation and disposal of waste materials.

1-5 Objectives of Research

1- To designate precise specifications for collection, sorting, transportation and disposal of waste materials

2- To provide the minimum of manpower, machinery,project costand all other activities for cleaning districts and quarters inside Khartoum state with an economical perspective for the cost.

3- To determine and construct basic dump areas and intermediary waste materials collection sites according to sound engineering and hygienic specifications.

1-6 Methodology of Research

To realize the above mentioned objectives, the research adopts the following methodology through:

i) References, magazines, periodicals, newspapers and websites were referred to for some information in this research.

ii) Studying, analyzing and adopting the best and the easiest ways for processing the domestic waste materials throughout its variable stages.

iii) Field visits to different residential quarters inthe area of research study and photos taking, personal interviews and reporting were adopted as field study to current processing of domestic waste materials with the so-called areas.

iv) Field research questionnaire was used in addition, to visual inspection of current situation of processing the domestic waste materials inside houses. Questionnaires were distributed in the targeted quarters and the results were analyzed accordingly using the Statistical Package for Social Science (SPSS)program.

1-7 Thesis Organization

In this research work there are five chapters. Chapter one discusses frame work of research undertaken, research problem, importance of research, research objective, research questions, hypotheses and, methodology of work undertaken. Chapter two tackles theoretical back and literature review.

Chapter three deals with research problem methodology of work, research are at Khartoum state. Chapter four addresses results and discussions as obtained with emphasis on waste collection, waste urban services, stages of collecting waste, trash and sweepingsolid waste collection routes transformationstations. Chapter fivehighlightsconclusions reached andrecommendations**.**

Chapter Two

Theoretical background and literature review

Chapter Two

Theoretical background and literature review

Section One:

2-1Introduction:

Waste material is defined as some of the things that became unneeded by its owner somewhere and at time and which has become of no value or importance[1 and 2]. Others [3-9] define wastes as one of the negative aspects arising from humane solid waste and scrap that related his behavior and methods of his life.

Domestic waste is the waste of human activity in their daily lives. Its rate increases in developing countries, especially in light of population inflation, these wastes may lead, in absence of health awareness, to serious damage and their accumulation is greatly due to several factors, including [1-9]:

- Population growth: As number of individuals increases, the amount of waste generated by each individual increases accordingly.
- Evolution of standard of living in terms of changing pattern of consumption habits such as: improper cooking of large quantities of food - or purchase - and they may not be consumed by individual taking its way to waste; or purchasing disposable cups, spoons, plates, plastic and paper that cannot be used again.
- Economic development, where factories have contributed to an increase in provision of canned food,disposable cups, spoons, plates, plastic and paper that are unusable again making them as the cause of accumulation of domestic waste.

Figure2-1. Method of municipal solid waste collection

Source: World Health Organization [2]

Solid waste items are unusable or unwanted resulting from the use or production of process behavior and went to the receiving media after treatment, which arise from the use of the following materials:

- Paper: newspapers, offices, schools, and other cartoon.
- Glass: bottles, refreshments, broken glass pieces.
- Aluminum: cans of soft drinks.
- Plastics: water bottles, plastic bags and blankets Agriculture other metals: canned food, batteries and automotive structures. Other materials used tires construction waste materials, furniture, used clothing.

Figure (2-2) Turbid water in vicinity of a shanty area

[*Source: World Health Organization, 2]*

Liquid waste regards water resulting from use at homes. It is turbid (see plate 2-1) with yellowish color or dark containing organic residuals food, urine and chemicals such as soap and detergents, which include kitchen wash water and baths water and hydrocarbons as well as some types of bacteria that cause serious diseases to humans.

Domestic waste and toxic waste gases resulting from the burning of wastes pose a threat to the environment and humans. Domestic waste management costs serious funds. Whereas, these wastes contain several materials that can be reused as raw materials.

Figure2-3. urban environment distortion

[Source: World Health Organization, 2]

2-2 Sources of solid waste:

Solid waste materials are endless, including earth- food waste - the remnants of packaging such as leaves, metal, wood and glass composed. And the amount of waste varies from one season to another and from one country to another, depending on: Economic and social situation (rising standard of living), population density,Source quality, environmental awareness,different seasons of the year, periods of collection andlaws and legislations.

The most important sources of waste are:

1-Domestic solid waste: are wastes from homes, restaurants, hotels and consist of food scraps, paper, glass, plastic and others.

2- Agricultural solid waste: results from agricultural plant and animal activities and abattoir waste and animal dung and carcasses and remains of feed and harvest residues and they vary depending on agriculture and production methods type.

3- Industrial solid waste: vary according to the type of industry and production. Method.

4- Mining waste: are dust generated from mining excavations

5- Building Demolition: are dormant waste with no risk to human health and safety and can be used in roads and slopes settlement.

6- Commercial solid waste: is a waste of commercial activities in markets, stores, printing presses and service stations, public and private institutions such as schools, hospitals, prisons and government departments.

7- Sludge waste: are organic and inorganic materials, which result from the treatment plants and contains germs and viruses and parasites, especially resulting from domestic wastewater.

The most important health and environmental impacts of solid waste are depicted in figure below.

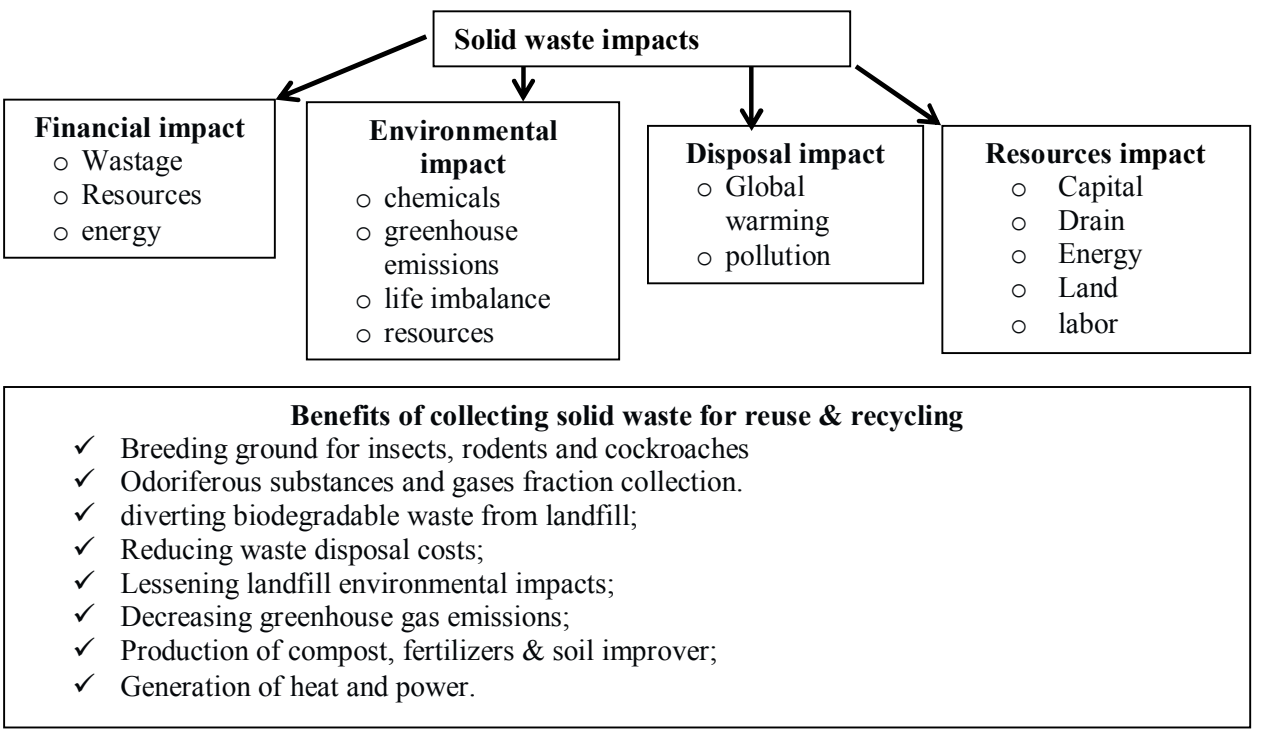

Figure. (2-4) Impacts of municipal solid waste.

Waste generation and disposal can have significant environmental impacts. These include emissions to air, land and water (including greenhouse emissions) at various stages in the product life cycle from extraction of raw materials to processing, marketing, transport and consumption, as well as direct impacts associated with disposal. Due to a range of market failures, and institutional and regulatory barriers, not all these environmental costs are reflected in market prices. The failure of some markets to get prices right can result in inefficient use of resources, lower economic growth than would otherwise be the case, and adverse environmental and social impacts. Collective action by governments and industry and the community to correct these failures can, if well designed, lead to improved social, environmental and economic outcomes. This article focuses on the non-hazardous solid waste generated by our communities. It also discusses emerging issues like household hazardous waste and electronic waste.

2-3 Domestic solid waste management system:

The management of solid waste means the ability to fully control the waste from the moment disposed of by its owner to be processed and final disposal in ways and methods to ensure preserving perfect advancement of this process in order to eliminate the negative effects of such wastes.

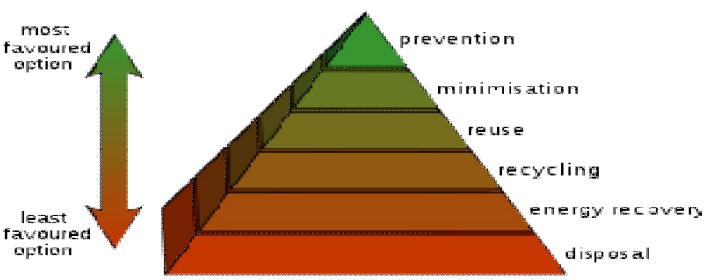

Figure 2-5. Pyramidical Sequence of waste materials

[Source: World Health Organization, 2]

Waste pyramid refers to the three concepts of a reduction and recycling and reuse of waste, which are classified as waste management strategies according to their desirability. The three concepts are hierarchically arranged according to their importance. Some experts [10-15] in the field of waste management recently incorporated 'fourth concept': "rethink", which means implicitly that the current system may have fundamental flaws, and the presence of an effective comprehensive waste management system may need an entirely new way of looking at the waste. Source rationing includes efforts to reduce hazardous waste and other materials by modifying industrial production.

2-4 Previous Studies.

2-4-1 Case Study No. 1:

Solid-waste management in Jalandhar city and its impact on community health [40]: In this comprehensive investigation, Jalandhar city was chosen as a model region of the Punjab province. Besides a dwelled suburban area, the population of this region is around 20 00 000. The city is located almost 375 km from Delhi and about 90 km from Amritsar. Jalandhar is named after Jalandhar, a demon king who lived in water, as suggested by his name. If the name is divided in two parts - JAL and DHAR - JAL means water and DHAR means to live in. The spread of education cannot be overlooked while assessing the progress of a particular society. It is correct to say that the spread of education, language and literature are responsible for the development of Jalandhar district. Only educated and conscious people can bring about any development. Jalandhar, with the passage of time, is being known as the Media Centre of Punjab. Here is a large industry that manufactures sports material and other products. The sports products are exported in a larger

quantity. Jalandhar falls in the Doaba region, comprising the districts Jalandhar, Hoshiarpur and Kapurthala. The Doaba region is surrounded by the rivers Beas and Sutlej. It has an urban population of almost a million, and another million live in the rural areas outside the city.

Statusand analysis of functional elements: The functional elements of SW management in this city include Waste Generation, Collection, Transportation, Processing and Final Disposal.

Waste generation: For efficient SW management, study of the generation rate is very important. The generation rate varies from activity to activity and the exact generation rate must be determined after averaging over the time factor and including several of the waste producers. The average waste generated in Jalandhar city is 350 TPD. In all, there are about 320 garbage bins placed in city. Garbage is finally disposed off in an open dump at Suchipind village on Hoshiarpur road and Wariana on Kapurthala.

Road. Garbage-lifting vehicles involved in this operation are: **Onsite handling, processing and storage:** In Jalandhar city, most of the habitable/residential areas have limited storage spaces. In these areas, the waste is of mostly of a biodegradable nature. In some places, open dumping of the garbage is noticed, which causes health hazards as well as fly nuisance. It refers to the activities associated with managing SW until they are placed in the containers used for their storage before collection or return to drop off and recycling centers. There are various problems that could be related to handling and storage of SW are seen, like there are a number of places where there are dumps of SW and thus these points if unattended create small nuisance and health hazards. Stray animals like pigs, dogs and cows further aggravate the

problem of spreading and littering of SW as they are seen at the site of handling and storage of SW in the study area.

Solid waste segregation: SW is not segregated; rag pickers collect SW from the streets, bins and deposit sites. Storage spaces are not often adequate. People drop the SW outside the bins.

Collection: SW is collected from the bins from every point and collection from residential areas is carried out daily as the organic matter decomposes rapidly due to a hot climate. The World Health Organization recommends that collection of SW should be carried out twice a week from bins in Jalandhar city Collection is only performed when the bins are filled up. Hand driver cart pullers collect the SW from door to door. These cart pullers segregate the plastic bags, polythene and metal, which is then sold to the kabariwalas. By this, non-degradable solids are separated from organic substances. This collection system is also economically feasible.

Transportation: Transportation means 'transfer' of SW from the storage place to the dumping ground. For this purpose, vehicles are dependent on the physical layout of the roads and the cost of manpower available, maintenance provisions, truck tippers, tractor trailer, etc. that are used for final transportation of SW to the site. About 350 TPD waste is generated on a daily basis.

Use of plastics and their recycling: Plastics, due to its advantages like its durability, lightness, and ease to be molded, are used everywhere, for example:

In domestic purposes: As carry bags, pet bottles, trash bags, containers.

In air, road, and rail travel: As cold drink or mineral water bottles, plastic plates, cups.

In hospitals: As glucose or other IV fluid bottles, disposable syringes and injections, catheters, wine bags, gloves.

In shops and hotels: As packing items, plastic bags and disposable utensils. Plastic contains a certain component called dioxin that is highly toxic and carcinogenic. After burning, especially PVC, it releases this dioxin and also furan into the environment. To avoid health hazards, plastics should be recycled.

Health impact of solid waste: As SW is a major part of environment pollution, it is responsible for spreading many harmful and infectious diseases. The increase in SW is due to an increase in the population. As the population increases, the demand for food and other essentials also increases such that waste is also increased. Some people throw this waste into streets, roads and at other public places, which attracts flies, insects, rats etc. , which helps in spreading the diseases. Unattended waste is normally wet and has a bad odor due to decomposition. This type of waste leads to epidemics in various parts of the country.

2-4-2 Case Study No. 2

Environmental Impact of Municipal Solid Waste Landfills in Semi-Arid Climates - Case Study – Jordan [2]: -

Land filling is the most commonly used method for solid waste disposal in Jordan. It is an important source of pollution, which can be displayed through analysis of data for climatic conditions, hydrology and geology of the country.

The migration of gas and leach ate from the landfill body into the surrounding environment present a serious environmental concern, which include ground-water pollution, air pollution with impact on climate through methane emission and potential health hazards. This paper presents an overview of these environmental concerns from land filling practices and their adverse environmental effects. In this paper, a number of remedial measures needed to minimize these environmental and socio-economic effects are suggested, with in total ten long term and eight short term measures for improving of the solid waste management system of Jordan. Land filling is the simplest and normally cheapest method for disposing of waste. In most low-to medium-income Developing nations, almost all generated solid waste goes to Landfill. Even in many developed countries, land filling is the most popular disposal method. In the European Union, Although policies of reduction, reuse, and diversion from Landfill are strongly encouraged, more than half of the Member states still send an excess of 75% of their waste to Landfill Additionally, although the proportion of waste to landfill may in future decrease and the total volumes of municipal solid waste (MSW) being produced are still increasing significantly for many developed countries. Landfill is therefore expected to remain a relevant source of groundwater pollutant for the foreseeable future. The impact on water resources from landfills in arid areas must be noticed. Even if low costs and high availability of marginal land have made land filling the most commonly used waste disposal method, land filling has many effects on water resources. In fact, most arid areas suffer from the sever rainfall erosion which could increase the possibility of surface and ground water contamination. Disposal of liquid waste is not uncommon in landfills in arid areas. Jordan, as an example for

the semi-arid and arid regions, has seen a large increase in population during the past five decades as a result of population growth and forced dmigrations. Accompanied of this increase, economical and cultural development has improved the standard of living and changed consumer habits in the community, resulting in a clear increase in the volume of waste. The rate of production of MSW in Jordan has been estimated at about 1,960,000 tons annually with an average generation rate of 0. 95 kg/day.

Landfill Gas Emissions: Organic waste can be decomposed forming gaseous products. When the degradation process slowly moves from aerobic condition to anaerobic condition, the carbon dioxide level continues to be high, gradually falling as the methane concentration builds up . Other than methane and carbon dioxide, there are also some trace levels of gases being generated during the degradation process including hydrogen, nitrogen, etc. Landfill gases, especially methane and hydrogen, are highly flammable and if they are not collected, used for energy utilization or flared off, they will lead to potential fire and explosion hazard. In some cases, incidents of fires and explosions due to lateral gas migration away from landfills have been reported in the literature. Landfills worldwide are estimated to produce 40 million metric tons of methane each year, which is approximately 7. 5% of the methane produced and released each year into the earth's atmosphere by all natural and anthropogenic sources . Landfill gas (LFG) emissions have a number of pollutants of concern to human health and the environment so landfills are identified as a hazardous air pollutant source under the Urban Air Toxic Strategy. In Jordan, it was found that the methane emission from Akaider landfill will reach 12 million M^3/year by the year 2021 and if it is utilized properly, the LFG will not only generate a green energy, but it also

will create a source of revenue . In another study the production of methane gas from Al Rusaifeh and Akaider landfills was estimated to generate electricity at very low cost with an annual savings of 4. 65 M$. This could be achieved by the replacement of fuel oil with the generated biogas. On the ground, the only positive utilizing experience was gained when a biogas company (a non-profit organization) owned equally by central electricity generating company and Greater Amman Municipality was established in 1997 on Al Rusaifeh closed landfill. The main objectives from the company were to reduce the greenhouse gases (GHG) emissions from the landfill, as well as utilizing the fresh organic waste in the production of methane gas for power generation. The electricity generated was around 2. 62 GWh during the period from 2000 when the factory start working to 2009. Also the factory managed to reduce the emission of a total of 106. 38 million M3 of biogas during the same period. Recently, because of the company success in achieving its goals an agreement with Finland government was signed to buy carbon credits from the factory in a price of 7. 78 Euros/ton of Carbon dioxide (CO_2) within the Clean Development Mechanism (CDM) of the Kyoto protocol. The plant reduces the emission of 5000 tons of methane and Saves 6000 tons of diesels. In a UNDP study . conduct for Jordan's Landfills the cost of emission utilization has been estimated compared to the potential revenues from the CDM. The result is presented in Environmental Impact of Municipal Solid Waste Landfills The Open Waste Management Journal, 2012, Volume 5 Map providing locations of wells 1- 4 with reference to

Discussion and conclusion: The current situation of landfills in Jordan does not fulfill The required national and international conditions for Environmental precautions; the weak financial status of Municipalities and

common services councils (CSC) which is responsible for managing dumpsites and landfill in the Country stand against getting modern solid waste collection and successful landfill operations. Landfill should be operated to a standard, which protects human health and the environment. Where landfill standards have not reached the minimum for protection of health, it is recommended that action should be taken immediately. However, the improvement of the landfills has to be done gradually according to the country's condition and its financial and technical abilities. Landfill gas and leachate generation are concerns for the practices of waste disposal in the landfills; measures are essential in order to minimize negative environment impacts of solid waste in Jordan. The following immediate improvements can be done to minimize these environmental and socio-economic impacts.

Long Term Remedial Measure:

1- Land fill should be designed, located and operated based on national, international guideline environmental impact analyses(EIA) and environmental friendly which take into consideration the accurate climate elate precipitation, evaporation temperature, and wind direction beside the location must also be recognized that good engineering and management of landfill can be used to maintain a perennial water deficit within the land fill by maximizing run off and minimizing infiltration into the waste. Authorities must make provision for future land fill needs by allocating suitable land in the long term strategies.

2- Operational standards(guidelines) for land fill practices needed to provide the requirements for environmentally sound design and operation which consider all sit specific conditions (especially climatic data, hydrologic and geologic factors.

Short Term Remedial Measures:

1- Ensure that daily covers and practiced leached problem could be minimized by limiting the water getting into the landfill through surface water diversion to ensure that no water can enter the landfill and also ensure alow water table within the land fill by frequent pumping that should be coupled with daily soil cover allowing permeability cover affects water content of landfill
2- Improvement of access road.
3- Constructing the basic infrastructure**,** fencing and weighbridge.
4- Stop open burning inside landfills.
5- Stop open burning inside landfills.

2-4-3 Case Study NO. 3

Domestic Solid Waste Management in South Asian Countries – A Comparative Analysis:

The South Asian region as a whole is experiencing rapid urban growth. Increasing population, urbanization, industrialization and changing consumption patterns are resulting in the generation of increasing amounts of solid waste and diversification of the type of the solid waste generated. Solid waste is the most visible environmental problem among many in urban areas. Increased solid waste generation creates more environmental problems in this region, as many cities are not able to manage it due to institutional, regulatory, financial, technical, and public participation shortcomings. The environmental degradation caused by inadequate disposal of waste can be expressed by the contamination of surface and ground water through leachate,

soil contamination through direct waste contact or leachat e, air pollution by burning of wastes, spreading of diseases by different vectors like birds, in sects and rodents, or uncontrolled release of methane by anaerobic decomposition of waste. The sustainability of the land filling system has become a global challenge due to increased environmental concerns. Growing public opposition together with unavailability of land is one of the reasons why obtaining sites for new landfill is becoming increasingly difficult. Locating a landfill far away from the urban area can be adventitious from public opposition. Site is far away from the source of waste generation increases transfer costs and additional investments for the infrastructure of roads, hence intensifying the financial problems of the responsible authorities. Common problems for Municipal Solid Waste (MSW) management in the region include institutional deficiencies, inadequate legislation and resource constraints. Long and short term Plans are inadequate due to capital and human resource limitations. There is a need human resource limitation. There is a need To Practice integrated solid waste management approach such asIncorporation of more environmental and economic friendly concepts of source separation; recovery of waste; legitimization of the informal systems; partial privatization and public participation Although some governments have formulated policies for environmental Protection, they were only implemented in the national capital cities. In rural areas, open dumping is still considered the most popular method of solid waste disposal.

Solid Waste Generation: In order to prepare a well-planned waste management system, It is essential to know the quantity of waste generated as well as Different categories of the waste Solid waste generation differs from

place to place to a great extent; its production and composition are influenced by consumption pattern, climate, s Eason, cultural practice.

Solid Waste Composition: The composition of the waste, in general, differs from country to country on the economic level of countries as well as other factors such as geographical location, energy resources, climate, living standards and cultural l habits. Most of the developing Asian countries have high percentage (50 to 80%) of organic matter in their waste stream with high moisture content making them unsuitable for incineration. Composition Ones of MSW in few South Asian countries/cities. It also reflects the heterogeneity of the waste stream. Over the years, many plastics and paper wastes had finds its way into the municipal l waste stream due to the rapid economic expansion.

Solid Waste Management: Capital cities of almost all South Asian countries are challenged by urbanization and industrialization trends, population n increase and consequent rise in waste. These cities therefore face major problems relating to public health and environmental pollution. Poor government policy and response, lack of political will, lack of appropriate economic and human resources, and weak local institutions result in poor waste management (especially in large cities). Although municipalities are increasingly involved in managing the solid waste, lack of resources, institutional and infrastructure re facilities are hindering the efforts. Box 1 describes the existing status of solid waste management conducted d in Indian Metro cities and state capitals after the inception of Municipal l Solid Wastes (Management and Handling) Rules.

Collection and Transport: Significant amount of the solid waste generated in urban centers of South Asian countries are not collected/ attended and either

burned openly in the streets or end up in rivers, creeks, 3 marshy areas and empty lots thereby posing a serious threat to public health. In developing countries, municipal solid waste management costs consume 20-50% of municipal revenues, Collection service levels remain low with only y 50- 70 % of residents receiving service and most disposal being unsafe [44-47] For instance, Kathmandu spends 38% of the municipal budget on MSW management; 93% of this is spent on sweeping, collection, transfer and transport **(Glawe et al. , 2005).** Marshy areas and empty lots thereby posing a serious threat to public health. In developing countries, municipal solid waste management. Costs consume 20-50% of municipal revenues; collection service levels remain low with only y 50- 70 % of residents receiving service and most disposals being unsafe [44-47]. For instance, Kathmandu spends 38% of the municipal budget on MSW management; 93% of this is spent on sweeping, collection, transfer and transport (Glawe et al . ,2005). The collection rate varies from city to city and sometimes within different sections of one urban area. Collection rate vary from 10-90 % of the total municipal waste generated. Collection facilities are either inadequate or in efficient in almost all of the cities. In low income or squatter settlements, garbage collection is often non-existence as these settlements falls outside official service areas **(UNEP, 2001c).**

Processing and Disposal of MSW: According to **AIT (2004),** final disposal in most of the economically developing countries is usually a matter of transporting the collected waste to the nearest available open space and discharging them. Open dumping is predominant except for the developed countries. Composting is not carried out to the capacity that can be achieved through almost half of the MSW can be reduced thus. Other forms of disposal

like animal feeding, ploughing into soil, open burning and dumping in water bodies or environmental hazards. Waste burning is practiced to reduce its volume and minimize the attraction of animals and vermin. Despite the degradation of valuable land resources and the creation of long-term environmental and human health problems, uncontrolled disposal system s are still prevalent in most of the developing countries **(IS WA & UNEP 2002)**. Sanitary land filling or Engineered land filling of MSW is often misinterpreted in the developing countries, especially when it comes to covering a dump site by soil. Financial and in situational constraints are one of the main reasons for inadequate waste disposal. Introduction of SWM user fees cover only the collection and transportation costs leaving practically no resources for safe disposal of the waste. Generally, when aesthetic values are in question most people are willing to pay for the removal of refuse from their immediate environment but are not concerned with its ultimate disposal.

Section Two:

2-5 Solid waste management in certain areas in Sudan:

In the best third world countries, the responsible authorities cannot remove more than a third or a quarter of the daily quantity generated because of the work force and economic cost. Solid waste is considered in Sudan as a major concern and that the lack of an effective and clear system for the disposal of solid and hazardous waste in a safe manner as not to cause any pollution to the surrounding environment as there is no system to benefit from the re-use of some waste such as organic waste, plastic, iron, paper and others. Estimated solid waste generated at the country level, including more than 5. 282 million tons per year, only 10% of this waste is being transported, and even this small percentage that are taken are not subject to the safe handling. So, it has become a big concern and the damage it caused, the state has recently focused on that and there are signs of good in all of Khartoum state and some other states(like Gedaref), some prospects here and there in the state capitals in regard to the allocation of budgets and opening the door for investment.

In Almatama locality, it's not much different from the waste accumulation in the cities and that solid waste management is one of the challenges facing local officials. The locality departments practice conventional methods for a long time in solid waste management, in which the lack of scientific methodology is prevailing. The aim of this research work is to highlight the most important weaknesses encountered in Khartoum state solid waste management experiences. This is to avoid mishaps when proposing a plan of action or a roadmap for the treatment of solid waste problem in the locality.

Solid waste management is the integrated system components that come together in order to pour in one box, which leads all outputs to achieve the objectives of the collection, transportation and treatment of solid waste, namely**:** protecting public health from contaminants, environmental protection and conservation and protect the health of workers in the collection and disposal.

The most important prospects which highlighted successes in Khartoum state are:

1- Providing political and material support for the project.
2- Pursuing tight management style in the collection and transportation of waste
3- Providing aids according to administrative and technical controls with the necessary flexibility in expenditure.
4- Providing means of movement and communication, which facilitated the follow-up and supervision and access to information operations.
5- Coordination between sectors and specialized units (Health - Engineering - Finance and Administration) in all cleaning operations, each according to its specialty.
6- Cancellation of random landfills and replaced with one location equipped under a health and engineering supervision.

The most important obstacles can be summarized as follows:

1. Lack of stability for the project throughout its duration as it started with the name of the Emergency Program. Then turning to the project of Khartoum state sanitation under the supervision of the state. in 2007 it became a sanitation corporation and then a number of corporations in

some localities and localities projects in other localities without clear legal subordination.

2. Lack of clarity in the relationship between the corporations and sanitation projects on the one hand and between localities that followed their sanitation according to the law on the other hand and the relationship between project management and coordination.
3. High cost of waste collection, transport and landfill operations and not to develop screening processes, reuse and recycling, which can contribute to reducing the cost.
4. High cost of the final disposing and the inability of localities and even state to continue support.
5. High cost of maintenance and the resulting depreciation of vehicles and the lack of an equipped workshop and neglecting the preventive maintenance.
6. Lack of labor stability that led to a lack of trust and instability of such labors.
7. Administrative conflicts led to neglecting strategic planning and in the end led to the privatization of a large part of Khartoum and Jebel Awlia projects and putBahry project for privatization.
8. Weakness and inability of companies that possessed Khartoum and Jebel Awlia projects and their inability to develop work but relied on cars and workers of the project and therefore did not achieve the desired success.
9. Lack of interest in necessary and advanced training. Non-cooperation of the Ministry of Health with the project at the beginning and the lack of clarity in the relationship so far.

10. High administrative expenditure and over employment.

Roadmap to address the problem and perform Solid Waste Management in Shendi stressed on plan of solid waste management should be according to its stages, namely: collection, temporary storage, transportation, processing and stage of final disposal (landfill). This is in accordance with the following objectives:

1- To provide service according to the means used and follow the best tools and technologies in waste treatment.
2- Provide a minimum of manpower and machinery to run the business.
3- Use core dumps and essential collection areas of waste in sanitary engineering specifications.
4- Application of standards and specifications set for the service and the collection, storage, transport and waste treatment.
5- Create training opportunities for workers in operations management inside and abroad.

In order to determine the responsible firm for conduction and execution of sanitation and transport of waste, according to internal and external experiences in different countries of the world, the following entities are responsible for waste handling, each according to conditions and its features which as follows

1 - that the program should be implemented through a corporation or local cross-body or a separate administrative body in terms of management and budget and finance, financial regulations and legislation, mechanisms and even buildings to ensure the success of the program. Therefore, the priorities do not intermingled nor the program affected by bureaucratic procedures within the local nature of sanitation that need to be flexible in

the financial procedures to meet daily requirements for maintenance and management (for example, the experience of the state of Khartoum)

2 - The program is implemented by private companies under local supervision based on the following conditions documented in the contract, namely:

A. the companies should have the financial of and administrative ability and registered. Also, they should have a fleet of waste vehicles and technical staff. They should be able to contract with qualified and trained technical staff that accept the terms of the contract, which includes standards of service that are placed by the General Directorate of Health Affairs including the company's performance evaluation under indicators to measure performance ratio in all activities assigned to them, and this is accomplished through a committee including representatives from the locality and the General Directorate of Health Affairs and representatives of the beneficiaries of the service and a representative of the company.

B. Companies should work for the collection of waste fees based on local authorization or the locality should do the work and paid to the company by the amount agreed upon.

C. That the company should prepare a workshop for maintenance associated with the machineries and capable of providing alternative ones.

D. Companies should be able to develop its performance and handle the liquid and hazardous solid wastes that require special treatments before disposal (the experience of Khartoum state companies).

3 - the program should be implemented by the General Directorate of Health Affairs in the locality according to a clear and agreed formula after

rehabilitating the fleet of vehicles to be closed waste vehicles and the establishment of management is concerned with the work of solid waste in accordance with a clear program covers all neighborhoods accompanied by establishment of a workshop for maintenance with allocation of private funds for this new unit and discrimination of its personnel according to their efforts being made, preferably adopted by locality commissioner following the adoption of the state governor of Khartoum sanitation project at the beginning of its reign.

2-6Solid and Hazardous Waste Management:

Solid wastes are all the wastes arising from human and animal activities that are normally solid and are discarded as useless or unwanted. The term solid waste as used in this text Is all- inclusive, encompassing the heterogeneous mass of throwaways from the urban community as well as the more homogeneous accumulation of agricultural, industrial, and mineral wastes. Because of their intrinsic properties, discarded waste materials are often reusable and may be considered as a resource in another setting. Integrated solid waste management is the term applied to all of the activities associated with the management of the community's waste. The basic goal of integrated solid waste management is to manage community waste in a manner that meets public health and environmental concerns and the public's desire to reuse and recycle waste material. Solid waste today contains many materials such as plastics that are not readily degradable and toxic materials, primarily various types of chemical waste produced by industry. Similarly, the amount of hazardous waste generated has been undergoing dramatic change. In addition, industries increase their annual discharges of toxic chemicals directly into the environment. Early civilizations did not have a problem with

Box 2-1 Solid waste in Ethiopia

In Ethiopia, particularly in Addis Ababa, an agency is responsible for the collection and disposal of solid wastes for the city of Addis Ababa with an estimated total population of 2.9 million in 2000. The agency has a clear mandate from the city administration of Addis Ababa. It has an institutional setup, separate budget, as well as the necessary equipment, manpower and logistics for the task. The activity is now carried out by 10 sub-city administration where a division runs the solid waste management program. At present, the agency has 3000 employees in the street sweeping unit and park development, and 128 permanent employees in the garbage collection units. It had a fleet of 74 heavy-duty trucks, (about 40 on the move) and two bulldozers and one compacter at the landfill site. The estimated solid waste generation of an Addis Ababa resident was about 0.24 kilogram per capita per day and a total of 163,200 tons per annum. The existing collection capacity covered less than 50 percent of the total wastes generated. The remaining wastes were dumped along the streets, on vacant plots, along streams, in ditches, bridges, etc. Solid waste management in other urban centers of Ethiopia are under the jurisdiction of Municipal Division of Health. All municipalities (except Addis Ababa) and certified urban centers are mandated by Proc. No. 206 of 1981 to provide, maintain and supervise environmental health services along with their other activities in their municipalities and urban Centers. Thus, solid wastes management services are the responsibilities of these municipalities and urban centers. Most of them have no institutional set up and resources for discharging their duties effectively. This is aggravated by the low priority usually accorded to sanitation activities. The sanitarians assigned to the regional health departments and health centers give technical advice whenever called for besides their routine activities. Therefore, the material that follows will discuss the major aspects of solid waste management including type, source, and public health and ecological impacts of solid wastes.

Waste because it consisted mainly of organic wastes and the decomposers converted it into useful materials. There were also fewer people, and they generated little waste. The problem became larger with more people generating more and a variety of waste. (Chemical, liquid, solid, nuclear, and hazardous). Little of this waste is food for the decomposers. Thus, a variety of methods must be used to manage the waste.

A comprehensive solid waste management program encompasses sweeping, storage, collection, and disposal of solid waste. Proper management in these four areas helps greatly in controlling insects, rodents and filth borne diseases.

Box 2-2 Waste production in Australia [16]

In Australia, waste generation per person increased from 1.23 tons in 1996–97 to 1.62 tones in 2002–03 (3). Australia's growth in income and wealth has created a large increase in the disposal of goods no longer needed or wanted, with an associated increase in waste diversity, toxicity and complexity. Governments across Australia and around the world have recognized the environmental effects of current consumption patterns and have, among other policy responses, adopted ambitious targets for reducing waste to landfill or adopted "zero" waste policies. Wastes may be solid, liquid or gaseous. They can be hazardous or non-hazardous. They may be classified according to their source (municipal, commercial and industrial, construction and demolition) or by composition (organic, paper, glass, metal, and plastic). The physical and chemical properties of waste materials differ based on these and other classifications. Every material has a unique life cycle, from raw material to final disposal, which affects its impact on the environment

2-7 Classification, generation rate and composition of solid waste:

The characteristics, quantities s, volume and composition of solid waste generated may differ from one country to another and between urban and rural areas. It depends mainly upon the customs, climate, living conditions and economic standard of the area. Solid waste can be classified into two categories by its characteristics: putrescible solid waste and non-putrescible solid waste (see table 2. 1).

Table (2. 1) Comparisonbetween putrescible and non-putrescible solid waste.

Putrescible wastes	Non putrescible wastes
• Are solid wastes that can be easily decomposed by bacterial action • Result from the growing, handling, preparation, cooking and consumption of food. • Their quantities are varying throughout the year, being greatest in amount during the summer months when vegetable wastes are more abundant. • Require careful handling with frequent removal and adequate • Are the most valuable component yielding fertilizers, or Soil conditioners, through composting processes and used as animal/hog feed (e. g. garbage).	• Consist of both combustible and non-combustible substances, such as cans, paper, brush, glass, • Cardboard, wood, scrap metals, bedding, yard clippings, crockery, etc. • Are frequently responsible for the creation of nuisances. And esthetic problems when they become scattered by the wind and careless handling (e. g. rubbish). • Are solid wastes that cannot be easily decomposed by microbial action.

Determination of the generation rate of solid waste is important to obtain data in order to determine waste volume and for subsequent solid waste management. Factors to consider for the purpose of determining the generation rate are:

- **Measures of quantities:** Volume measurement And weight measurement
- **Statistical Analysis:** It is necessary to have some statistical base for solid waste management system development. This includes placement

of containers, programming the collection program and allocation of vehicle type.

- **Typical** Generation Rate: This is the rate found by conducting a large survey very representative for a nation, state or locality. Factors that affect the generation r**ate of solid waste include:** geographical location (related primarily to the different climate that can influence both the amount generated. And collection operation), season of the year, frequency of collection, characteristics of population, extent of salvage and recycling, legislation and public attitude.

The domestic waste materials are the garbage and wastes discarded nearly every day from our houses and they contain (Food residues, Glass, Vegetables and fruits, Ash, Earth and dust, Wood, Papers, Minerals and Plastic. In general sense, waste materials are the solid byproducts resulting from the day-today human activities. So, storing and transporting of waste material to the final disposing areas are considered as necessary for maintenance of human health and environment in general. As the domestic and food waste materials represent all wastes produced by families in housing complexes as well as food leftovers of houses, flats and restaurants resulted from food handling and processing. The important properties of this type of waste materials is their aptitude to putrefaction and organic disintegration during summer season resulting in offensive odour that facilitate propagation of flies and other insects. Those materials can be utilized through transforming to organic fertilizer or feeding it to some animals and birds[1]. Waste materials and garbage are the unneeded and not useful things for human beings. For government, the waste materials represent a huge responsibility and burden. if it hasn't been managed properly and disposed, the government will subject

itself to serious political and social problems as the waste accumulates on streets , quarters and amusement parks causing offensive odour and restless to dwellers and visitors of those facilities as well as creating traffic problems and drainage canal pollution beside more other problems.

Day by day the person dump some things that he doesn't need like empty tooth paste tubes, matches boxes, old computers, biscuits boxes, old newspapers and old exam papers. The dumping will continue to include many materials in schools, houses, streets, shops, restaurants, workplace and theatres. i. e. any place reached by human being during his routine day action. So, the dumped daily quantity of waste materials will not be less than 0. 3 -0. 7 kg. with average of 0. 5 kg. of waste for one individual per day. By estimating the annual quantity and adding the daily individual waste product in Khartoum State which has a population 5 million persons, it is found that the annually discarded waste materials amount reaches 0. 9 million ton (0. 5 kg x 365 days x 5000000 persons). And this quantity is enough to be town street embankment layers of two meters thickness and for 250 km length. If this waste materials quantity is compacted, it will be enough to bury a farm of 25 hectares in area and for a depth of 10 meters of waste materials every year. The expected increase in the waste materials annually is put in consideration for the natural increase in population and improvement of handling and collection. So, the quantity of waste materials needed to be disposed may reach a rate of 150 tons per hour without addition of production and industrial wastes as well as the increasing electronic hardware waste materials in unrecorded momentum[15].

Box 2-3 Most important reasons for collection and disposal of waste materials

i- Maintenance of community public health ensuring satisfaction from beneficiaries.
ii- Evasion of offensive odor resulting from bacterial decomposition of organic materials.
iii- Prevention from health and relishing disorders caused by diseases transmitted through vectors such as rats , fleas and flies and other as they are displayed in table (2-1).
iv- Prevention from pollution from domestic waste materials, street sweeping and dump places.
v- Prevention from biological, microbiological and chemical pollution that affects ground and surface water as a result of unplanned disposition of waste materials.
vi- Prevention from air pollution, existence of organic and inorganic poisonous materials, especially in industrial waste materials.

The problems of waste materials began to come to human awareness since he thought about group peaceful coexistence in tribes, rural areas, villages and cities due to the increase in waste materials quantities. The practice of dumping waste materials and food leftovers on the streets and void squares of ancient towns has led to make those town good environments for rats, fleas and flies breeding and transmitting infectious diseases such as bubonic plaque. Also due to the lack of proper management for waste materials disposition, the Black Death disease (plaque) killed half of the Europeans population in fourteenth century and it lead to a series of epidemic and endemic diseases with high mortalities. Then in nineteenth century, hygienic measures were adopted and consideration was paid to public health in general leading to tackle the issue of waste material disposition seriously and some solutions were found to properly dispose these wastes and control the resulted diseases. Moreover, the improper management of waste materials leads to declining of community public health as well as the environmental impacts with air, water and soil pollution caused by those materials.

Table 2-2: Some health and environmental impacts resulted from insecure handling of waste materials [15].

Type of waste material	**Expected health and environmental impacts**
Chemicals	Fires, explosions, skin itch, harms to eye cornea, abortion , renal failure
Pesticides and their empty containers	Respiratory system disorders, eye disorders (conjunctivitis, pteygium, blindness), skin diseases, parasitic disease (Ascaris, *Ancylostomatrichuris*, *Schistosomahaematubium*), accidents, injuries, back disorders, possibility of attack ferom a stray dogs and other animals.
Hospital and health units waste materials	Infectious hepatitis, HIV, traumatic skin disease, intoxication , allergy , immunological disorders
Waste materials of technological industries and electronics	Accidents, explosions, poisonous gases, asbestos, cancer

This variation in the sources of waste materials imposes serious challenges that face the engineer in charge of the relevant institutions making him think of disposition issues for waste materials produced in his unit as he strives to design the unit for shelf life not less than 25 years which is relatively long period under the shadow of clear planning for waste materials handling and obliviousness about waste types and modes of production in the especially world[2]. Thus, the most important factors affecting the waste materials type and quantity are as follows: standards and measurements, living systems, industrial stage and the advancement level with civilization degree in the region, geographical location, climatic factors and weather, region and community size, season of the year and temporal changes, intervals of

collections and continuity, socio-economic factors, degree of recycling and reuse beside process undergone in disposal area, current legislations and laws, popular acceptance and existence of energy, gas and relevant cost. The waste material components typically consists of: 35 – 40% microelements (regularly dust, ash, furnace smog and fire debris); 15 – 25 % decomposed fruits wastes; 5 – 8 % minerals; 5 – 8 % glass and Small percentage of non-manufactured materials. Determination of these percentages in an accurate way is not feasible and it may be misleading for themixed nature of waste materials, difficulty of obtaining random sample that represents the whole materials and local and seasonal changes of waste materials contents

Table 2-3: The sources of waste materials production [15, 17, 18].

Source	**Production units**	**Waste materials type**
House / locality	Houses,flats , villas and dwellings.	Food leftovers, wastes and garbage, ash, special wastes.
Commercial	Warehouses , shops , restaurants , markets , offices , buildings , hotels , printing and press , hospitals , firms.	Food leftovers , wastes and garbage , ash , construction debris special wastes and dangerous wastes.
Industrial	Buildings,production,factories,refineries, chemical stations , mines, wood cutting , thermal station , destruction , reconstruction .	Food leftovers, wastes and garbage,ash , construction debris special wastes and dangerous wastes.
Squares and open areas	Streets,roads , corridors , pitches , shores , bathing areas , amusement parks.	Special wastes.
Agricultural	Crops, fruits gardens, cornflowers fields, cheese and butter laboratories , experimental fields , farms.	Food leftovers, agricultural wastes and garbage and dangerous wastes.

One of the most important categories according to the waste materials contents is as follows:

a) Describing the waste materials according to the material type or source.
b) Describing the waste materials according to types analysis and the possibility for processing such as:
    - Burnable and fertilizable materials
    - Organic waste materials from the kitchen ,fruit wastes in its all types , papers and paperboards and hay,
    - Bones and tissues after decomposition,
    - Burnable materials: wood, solid paperboard,skin, rubber and plastic.
    - Non-fertilizable or burnable materials
    - Glass , porcelain , stones and bricks
    - Iron and other minerals
    - Small particles burnable and fertilizable materials

Table 2-4: The situation after sievingSource [15, 18].

Category	**Classification**	**Size mm**
First	Small size waste material	Less than 8
Second	Medium size waste material	8 – 40
Third	Coarse waste material	40 – 120
Fourth	Sieve remains waste material	More than 120

Waste materials can be categorized according to particles size. This is one of the most important factors affecting waste materials production for the following aspects:

1- The socio-economic positions of dwellers group.
2- Consumption rate of manufactured materials and people preferences.

3- Waste materials collection intervals.

4- Waste materials collection systems as well as their programs and repetitions: increase in collection rates increase the annual collected quantity. Whereas the quantity of organic material is approximately constant, the increase may be attributed to disposal of more waste materials by people in a shape of papers and leftovers.

5- Collection fees.

6- Climatic factors.

7- Existence of waste crusher devices inside houses to lighten food leftovers.

8- Social norms and customs (the reading community produces newspapers and paper waste materials ; in labour community produces, the restaurant and markets leftovers increase as eating habit inside houses decreases or use them as cooking and warming fuel).

9- Individual income and the degree of community wealth as the area of lower income rate for individual produces less waste materials with high content of food leftovers.

10- Literacy

11- Population in the area (density).

12- Manufacturing and industrial production.

13- Development and construction

14- The geographical and hydrological characteristics of the area and climatic effects.

It is required to know the waste materials properties:

a- Knowing the dangerous materials found in the wastes for sorting and disposition.

b- Estimation of organic contents suitable for biogas.

c- Estimation of materials valid for incineration and energy

The most important waste properties are as follows:

- Material properties (particles size, contents , usage and purity)
- Natural properties (waste contents, moisture, particle size, chemical contents, biological properties) these properties affect the designation of collection, processing and disposition systems of waste materials as well as managerial frameworks of units and their performance.

1) Quantity assessment through element determination: The waste material quantity can be assessed using the statistics of the industrial and commercial production through input method by knowing the gross production and deducing that all products should be discarded or recycled. This method is viable for assessing the elements quantity in the waste material and determines it when data and statistics acquisition is facilitated by organizations and firms that have the financial, managerial and technical capabilities to undergo the routine task of data collection.
2) Product analysis method (output): For the local level, the most suitable method for assessing the quantities of waste materials and elements determination is output analysis method and undergoing case studies for manually collected samples and photographic ones (through a part of waste material and photo analysis).

The physical properties of waste materials affect designing the devices used in keeping wastes and garbage,transport, processing and purification. The most important properties are weight, thermal value,angle of repose (rest), moisture content, mineral intensity, particle size distribution and density.

- **The single contents:** Table 2-5 shows the optimum contents found in waste materials and any number of these contents can be chosen but those mentioned in the table are easy to be determined as stated in textbooks and references about waste materials. Also, they are considered as sufficient to determine the waste materials properties for relevant processes.
- **Volatile solids:** Found through loss upon burning and crushing of solid material. Then the sample is flamed to 550 °C for 4 hours. The lost part of weight is represented by the volatile materials that include fragmented and non-fragmented organic materials.
- **Angle of repose (rest):** It is the horizontal angle that made the materials piled and aggregated without being slipped. The sand has angle of repose 35° depending on the moisture content. And for waste materials, it is 45° - more than 90° depending on the changes in density, particle size and moisture content[8, 9].

Table 2-5: The waste materials properties [7]

Content	**Percentage mass**	
	Range	***Optimum***
Food leftovers	6 -26	14
Papers	15 -45	34
Board papers	3 – 15	7
Plastic	2 -8	5
Textiles	0 -4	2
Rubber	0 - 2	0. 5
Skins	0 – 2	0. 5
Garden shrubs	0 -20	12
Wood	1 – 4	2
Mixed organic materials	0 – 5	2
Glass	4 -16	8
Tins	2 – 8	6
Non-iron minerals	0 -1	1
Iron minerals	1 – 4	2
Dirt, ash and bricks	0 – 10	4

- **Moisture content:** The moisture content of the waste materials is needed to be known for analyzing the burial fluid production and designing of transportation systems materials to burial place. The moisture content changes from dustbin to the vehicle in regard to time. The newspapers and publications contains 7% moisture content weight upon laying them on waste receiver device but their moisture content surpass 20% upon taking out from garbage vehicle. The moisture content is referred to for its importance in burning of waste materials and obtaining gaseous burns. Or upon directly incinerate them.

Table 2-6: The moisture content of the waste materials changes considerably [7-9]

	Moisture content	**Percentage mass**
Content	**Range**	**Optimum**
a) domestic waste materials		
Tins	2 – 4	3
Board papers	4-8	5
Particles (earth . . etc)	6-12	8
Food wastes	50-80	70
Glass	1-4	2
Grass	40-80	60
Skins	8-12	10
Non-iron minerals	2-4	2
Leaves	20-40	30
Papers	4-10	6
Plastics	1-4	2
Iron minerals	2-6	3
Rubber	1-4	2
Steel cans	2-4	3
Textiles	6-15	10
Wood	15-40	20
Square sweeps	30-80	60
Garden shrubs	30-80	60
b) commercial waste materials		
Food leftovers	50-80	70
Mixed organic materials	10-60	25
Wooden loading cages and plant shrubs	10-30	30
c) Construction debris (mixed)	2-15	8
d) Dirt , ash , bricks. . etc	6-12	8
e) Locality wastes	15-40	

The moisture content of the waste material changes inside the garbage vehicle due to moisture transference operations among contents. It is observed that

the paper assimilates most of dirt liquids raising its moisture content. This reality change the moisture content of the waste materials compared to its value before collection and compaction in garbage vehicle.

Particle size: The particle size of waste materials is important for materials reclamation, especially upon using the mechanical methods such as sieve and magnet. Also, the particle size of waste material entering the burial affects handling, transportation and processing. The particle size is difficult to be determined and classified for the waste materials that are attributed to irregular shapes of particles in the wastes mix. For good management of waste materials, it is important to know the change in particles percentage in terms of number and quantity. The particle size depends on the average particle size which is known as the diameter when 50% from particles (in weight) is less than this diameter.

Bulk and material density: The bulk and material density is useful to assess waste material quantity in some cases and to assess health burial coverage materials. The waste and garbage alternating density that is dependable on the applied compaction, e. g. the fragmented wastes as disposed by owner has material density within 90 to 150 kg for cubic meter. Upon being pushed to dustbin, it may reach 180 kg/m^3 and inside the garbage vehicle where it is compacted, it may reach 350 kg/m^3 and 420 kg/m^3 . When it is laid on the dump area, the density rises to 700 kg/m^3, 1000 kg/m^3 for the area of healthy embankment that has good compaction. The waste materials density decreases upon increase of the economic development level from 400 to 200 kg/m^3 due to the little paper density and increasing food leftovers and ash.

Table (2-7) shows waste material density and change percentage in waste density according the geographic location, season and period of time. Caution should be adopted in selection of optimum values for density.

Table 2-7: Shows waste material bulk density *[5, 10-12]*

Waste state	**Density**	**(kg/m^3)**
Fragmented waste materials (not compacted …etc)	90-180	130
Inside waste materials compaction vehicle	350-600	300
Bale refuse	700-900	800
Health dumping wastes (uncovered)	450-750	480
Food leftovers	120-480	290
Paper	30-130	85
Paper board	30-80	50
Plastic	30-130	65
Textiles	30-100	65
Rubber	90-200	130
Skins	90-260	160
Garden shrubs	60-225	105
Wood	120-320	240
Mixed organic mix	90-360	240
Glass	160-480	195
Tins	45-160	90
Non-ironic minerals	60-240	160
Ironic minerals	120-1200	320
Dirt, ash and bricks	320-960	480

Mechanical properties are beneficial knowing the mechanical properties of waste materials to evaluate the alternative operations and options of resuming energy concentrating on pressure strain, strain curve, reaction of some materials and elasticity coefficient.

Knowing the chemical composition of waste materials is beneficial for economics of material and energy reclamation. The methods used to determine the chemical composition of waste materials are as follows:

1- Proximate analysis:

For determining the organic volatile materials and fixed carbon in waste materials.

2- Ultimate analysis:

It depends on the components of elements. The marked difference and change are noticed in waste and that is due to its inhomogeneous nature, geographic and temporal changes.

The volatile solids could be assessed upon inflammation to 550 °C for long hours then cooling in drier. The lost part in volatile organic material weight including the fragmented and non-fragmented organic materials.

Table 2-8: Represents optimum data of ultimate analysis of optimum waste material contents from locality wastes of burnable contents [7]

Component	**Percentage in mass (upon dry basis)**					
	Carbon	**Hydrogen**	**Oxygen**	**Nitrogen**	**Sulphur**	**Ash**
Food leftovers	48	6. 4	37. 6	2. 6	0. 4	5
Paper	43. 5	6	44	0. 3	0. 2	6
Board paper	44	5. 9	44. 6	0. 3	0. 2	5
Plastic	60	7. 2	22. 8	-	-	10
Textiles	55	6. 6	31. 2	4. 6	0. 15	2. 5
Rubber	78	10	-	2	-	10
Skins	60	8	11. 6	10	0. 4	10
Garden shrubs	47. 8	6	38	3. 4	0. 3	4. 5
Wood	49. 5	6	42. 7	0. 2	0. 1	1. 5
Mixed organic materials	48. 5	6. 5	37. 5	2. 2	0. 3	5
Dirt, ash and bricks	26. 5	3	2	0. 5	0. 2	68

Heat value: The heat value is beneficial for resources reclamation. It is elaborated in kilojoules/kilogram and assessed in calorimeter where the sample is burned and the increase in temperature is recorded and through knowing the sample mass and produced heat from burning, the heat value is calculated.

The Biodegradability: It is one of the most important biological properties of respiratory activity and ability of gas production. Generally, 45% of waste materials is easily to decompose. Thus, processing frameworks should be thought of for biologically non-degradable materials to be disposed suitably and beneficially. For determining the waste materials properties, the methods illustrated in the standard characteristics including sampling and preparation as well as experimentation to know the property under test. For the practical life doesn't cope with sample taking within measurement perspectives and field reality.

Table 2-9: shows examples for some Requirements for sampling*[3, 19-31, 43]*.

Test	Sample quantity	Sample preparation requirements
Assessing the dry leftover and moisture content	No fixed value but it is suitable obtaining 0. 5gm from the dry leftover. For practical reasons , obtaining 25gm or more up to 500 gm to repeat the experiment for many times.	- Primary drying is not needed - Water should not be lost during sample preparation
Elements detection through digestion by acids	Less than 5 gm. For practical reasons , obtaining 400gm or more up to 500 gm from the dry material	- Least size of particles especially melting resistant samples - Drying is allowed to 40C as maximum - Evading the loss of volatile elements

Soil wash response test	Approximately 100 gm from the dry material	- No drying - Evading the loss of volatile elements upon drying - Crushing and mincing is allowed for obtaining the right particle size.

Source: Proceedings Sardinia

Box 2-4 Goals of waste materials collection.

The most important goals behind collecting waste materials are:

1. Sorting out the organic, plastic, glass, minerals, textile materials….etc.
2. Minimization of waste materials to be buried.
3. Introduction of fertilization and recycling concept
4. Raising the ecological protection level
5. Minimization of the cost to level bearable by the beneficiary.
6. Minimization of offensive stench resulted from decaying of organic materials found in garbage.
7. Prevention of spread of epidemics transmitted through vectors living in waste materials (flies, mice , rodents ..etc.).
8. Evasion of contamination possibilities of surface and underground waters by waste materials.

2-8 Solid waste collection:

Collection is putting two things adjacent to each other, as it is said "I collect them and they are collected together". Collection of waste materials required to be aggregated from variable locations of production and resources in a container through individuals (of both sexes) and to be put in waste materials vehicles for transportation to intermediary sites, so as to be further transported by bigger size trucks and vehicles or through railways to dumping areas or final disposing locations (table 2-11). In this cycle, some isolation process of

beneficial waste materials may be performed for recycling into useful items. Waste materials collection is considered as the most important activity in waste management operation and expensive element as it accounts for 30 – 90% of total cost.

Table 2-11: Comparison between methods used in waste materials collection [1, 32-42]

Method	**Advantages**	**Disadvantages**
Land transportation (tracklayer, truck,)	- Flexible - Small quantities - Transported according to needs - Waste can be transporting through different types of containers	- Waiting time in the final point (transformative station , burning and embanking station) - Not suitable for transporting greater quantities. - Higher level of ecological pollution
Railways and river transport (carriages and steamers)	- Larger quantities - No delay - Decreased ecological pollution	- Inflexible - Require advanced planning - Total cost should be assured for transporting greater quantities

Waste materials and Garbage and urban services (removal of waste in urban areas):

1) **The primary collection:** It is a process for serving homes or individuals through passing from house to house or from one employer to another, or to another facility for the collection by janitors and the collection of waste and garbage can save the waste within the facility for the pool before Janitorial operation. In this process ,following services occur:
    - Motion through paths in assembling and aligning all the waste collection points
    - Collection of wastes from every point collection and put it in a container and a junk car
    - Transference of the waste to the point of final disposal or transfer station for the collection of waste
2) Secondary **collection:** It is used to serve a group or the public or the group of young collectors and waste. The container forms the most important point location for secondary collection of the waste. As it will be possible for small towed container to discharge the contents without reaching an area of final disposal. These points operate as community transfer stations and may help in the collection of waste from areas that cannot be reached by a truck or waste collection workers.
3) Cleanliness **of the streets and control of the waste:** It is a service offered to the community or all sectors of the city and street cleaning would be accomplished either manually or through street cleaners or

mechanically through using different machines . The workers would be paid daily wages as bonuses or certified by the space that has been cleaned.

4) **Industrial and commercial cleaning:** It is a service offered to industry and trade shops or individuals and third value system is used on for the specific assembled flat rate estimated according to the number of hours for task accomplishment.
5) **Arial collection system sees:** It is the evolution of all the waste in avoidance of the traditional collection ,that accompanied with noise and odors and problems to the community, in a healthy and peaceful system by moving the waste inside the ground pipe to final disposal areas without ad-hoc basis for the use of the mechanisms and vehicles and trucks sometimes hampered traffic problems and limit movement alleys and fairy valuable historical cities old narrow streets and winding alleys and small squares. This method evades the risk of scattering garbage in the streets and areas of collection and change in non-peak hours or at night as followed in traditional systems. The waste is automatically collected in the center (fixed system) or rinse points (moving system) that easily reached by vehicle transporting waste that driven to the landfill and landfill for final disposal, and connecting the center with several points of collection of open ground waste boxes for receiving garbage. Each box has underground basin within to save the waste before running the role of the collection. This system is also suitable for airports and complex commercial buildings where it is safer and better for public health to shed clean environment. These variables affect the collection process performed by the official institutions ,

legitimate corporations, civil society organizations or any other private institutions. As the movement of waste is on the account of responsible party or through authorized contractor transport operator. The waste materials are separated and transported at night in commercial areas and throughout the day in the residential areas at the approved design rate.

The process of collecting waste, garbage and sweeping can be divided into five different stages as follows:

1. Stage of deporting the waste from the house to the trash and garbage bins inside or outside the house.
2. Stages of the waste movement from trash bins into a car and garbage waste by waste workers or the owner of the house
3. Stages of waste and garbage collection from the variable sources in efficient and the best ways to the final disposal areas
4. Stages of track paths via the city's roads
5. Stages of final disposal or recovery of materials.

1) Stages of waste deportation from home to the trash bin: These stages depend mainly on the owner of the house for collection, sorting or decision to get rid of unwanted materials. This is accompanied by making it difficult to conduct research or innovation around technologies and the failure of communities to define certain styles and patterns for collection process to be made by responsible municipal or corporate bodies for disposal of the waste and garbage. One of the innovative methods to convert the waste collection and disposal programs is as follows:

1. volume- based fee system in which the fees required from the owner are determined on the basis of the size of the trash or waste.

2. weight -based fee system is that the weight of all the wastebasket or trash is used to determine the fees to be paid according to waste weight produced.

2) Stages of transporting waste from trash to the garbage vehicle: The collector of garbage usually transport waste trash and garbage in larger containers and passes them on to the waiting car , and it is noted that workers will be exposed to various incidents at the waste transfer with stress , bruises or fractures. The conventional cars used to transport household and commercial waste is called packers which shipped wastes through rear-loaded and covered compactor. They have different sizes and patterns, design and common car with load capacity of 123 and 15 cubic meters and the car size is determined by weights of tires, not its capacity to carry waste and this it is important; especially roads and lanes in the Apostle are not designed to carry large loads tires. The waste from the trash in the background of a car is emptied with waste density of 60 to 120 kg/m^3 to about 360 to 420 kg/m^3

3) Stages of collecting waste by vehicle from house to house: When the waste and garbage are put inside the car, they will be subjected to pressure during the course of the car and its movement from house to house. As compaction ratio increased, the car will be able to carry more waste before its journey to the final disposal site. The collection crew can consist of one to more than five people, depending on the distance between the rubbish bins and the car site and the number of the baskets to be brought. It is noticed that there is increased efficiency and serious work in case of small number of collection crew working. As an indicator of the effectiveness in collecting household waste from the edge of the pavement, one waste car can serve a number of users and customers ranging from 700 to 1,000 customer per day

providing that the car doesn't transport wastes to the final dumping area. Perhaps the car can serve 200 people and customer before being filled with waste collected for health backfill area or final disposal site.

4) Stages of car waste route: Movement of the waste car and its change is called micro routing collection routes and the car traffic across a range of streets (single or two-way) should be newly planned in order to reduce the space covered for waste materials collection and evade dead heading. And there is more difficulty in planning and design of the sacs and the movement of waste car traffic with presence in one-way or dead ends and other traffic barriers.

The restrictions that should be imposed in the small route for the movement of the waste and garbage car are according to the following:

1. The cars routes should not intersect.
2. The starting point should be as the nearest as possible to waste car garage
3. Crowded streets should be avoided during peak hours.
4. The one-way that cannot be approached in a straight line must be entered from the upper end.
5. Affiliate roads are connected from the right side.
6. Collection should flow from lower mountainous and highland areas to facilitate the flow of any group of buildings.
7. Turns should be used clockwise (reverse direction of circumambulation) around any group of buildings.
8. The straight standard tracks should be used before putting them in clockwise loop.

9. The standard tracks should be used for some forms of buildings groups.
10. U-turns must be avoided because they prevent one-way street as entry and exit to the point of intersection
11. In this curve, computer ready-made software will be useful for design and coordinating this issue

5 Stage of waste truck for final disposal: The route of a truck for final disposal areas depends on the size of the community it serves and the road network and the remoteness of the final disposal areas. For the small isolated communities, the route takes a direct path from its end to the final disposal site. And the regional municipalities and large swathes needs to differentiate route via linear programming systems.

The routes of waste and garbage collection should be determined according to the devices used and labor in a way that facilitates optimal use. Among the factors that should be taken into account in the next place [9, 12]:

1. Identify the collection points and the frequency.
2. Following the instructions, regulations and laws to control traffic.
3. Coordination between the public order situations relevant to the preparation team, the type of car, its capacity and efficiency.
4. Track starts and end at major streets.
5. Topographical and physical boundaries are taken as the border of the track.
6. Designing the tracks so that the last gathering containers should be next to the final point of disposal.
7. The waste released from the crowded and congested traffic areas is collected at the beginning of the day as much as possible.

8. The waste and garbage is collected at the beginning of the morning from its production places in very large quantities.

1Track design steps include:

1. Preparation of different site maps.
2. Collection of information related to sources of waste production sites, the containers and the style of collection and frequency.
3. The data and information analysis.
4. Prepare the initial planning of the tracks.
5. The initial planning of paths and tracks should be compared with the development of the budget and take the appropriate decision.
6. Planning of major program for collection track with location assignment to lift the waste and service for the driver and cleaners to work daily and raise the daily and periodic reports for continuous evaluation and repair the track and choose the best path to increase benefits.

Transformative stations (intermediary transport stations): Transformative stations are the system that provide for waste and garbage transporting vehicles to unload wastes in more efficient trucks to be transported for long distances to the final disposal site. Transformative stations are used when the final disposal site is remote from the waste and garbage collection area and waste can be transported to the station from small cars to big waste ones such as tractors, carriages and flat boats or railway carriages and special attention should be given to the type of transport. Transformative stations would be relied in the following:

1. When traffic jam lead to the slow pace of the waste transport vehicles.

2. When the final point of disposal of the waste is remote from collection areas (i. e. when the municipality having problems about the final disposal site)
3. The existence of excellent service in rural areas, that does not have a waste collection system, (the residents themselves are collecting waste).
4. When the transport distance of the one-way for the final disposal is more than 20 kilometers and when the trip time in one direction is greater than half the distance
5. The existence of final disposal areas in random and non-formal beside large quantities of waste in streets, roads and squares trash.
6. Reliance on junk cars with small capacities.
7. Low population density residential areas.
8. Common usage of medium-sized containers for collecting waste from commercial sources.

Depending on the style used and objectives, these transformative stations can be simply or complexly designed. Especially small stations that depends on the floor covered with a layer of rubber where received cars load it and then load transport vehicles using compression devices, and some stations could be the tunnel facilitate included transport vehicles and there is curved groove or holes in the ceiling that allow to load these units to push the waste from over the edge.

Transformative stations can be divided according to capacity and size into the following:

1. Small transformative stations with a capacity of less than 100 tons / day.
2. The average transformative stations with a capacity of between 100 to 500 tons / day.

3. Large transformative stations with a capacity greater than 500 tons / day.

Table 2-12: Represents the most important advantages and disadvantages of transformative station [2-7].

Advantages	**Disadvantages**
- Facilitate the organization tracks. - Reduce the impact of roads on trucks tracks. - Reduce traffic jam. - Reducing the cost of transport to zones of final disposal. - Reduce the cost of running garbage collection cars. - Reduce the cost of the final disposing because of recycling systems. - Longer lifespan for collection cars. - Improve the productivity of collection cars and working teams. - Improve the operation of sanitary landfill for the small number of vehicles. - Flexible administrative system (for transport outside peak hours or qualified transport). - The possibility of waste inspection and screening for disposal. - The possibility of keeping the waste, recycling and sorting. - realizing profits from re-use of materials. - Appropriateness of the waste dumping center to the public (of the recyclable waste). - Providing an intermediate point between the collection and disposal of final points. - Full use of transport and collection cars and working teams.	- Lands of transformative stations are undesirable to the public and nonutility. - The difficulty of persuading the public to accept the site because of stance. - Need consultation. -The difficulty of obtaining a land within the city boundaries. - The possibility of harmful effects to occupational health and environment (noise, dust, odors and stinking garbage, etc.).

1. Discharge (dump) of reservoir where the waste and garbage are emptied either in the keeping pit or loading berth to trucks for final disposal and these trucks are carried in different kinds of devices.
2. Direct discharge disposition and reservoir dump (common flow) in some transformative stations using the two previous methods. Andthese

sites are usually multi-purpose to serve a broad range of users and host the extraction operations of materials.

3. When you selecting the station site and its design, there are some affecting technical factors to be taken into consideration such as the size of on-site waste and required services and community view and other relevant factors.

For the location of transformative stations, the following should be considered:

- Putting the station near the production site of waste and garbage and areas of service.
- Those areas should be within easy access of various main roads and tracks.
- Less objection from community about their presence and less environmental objections (increased traffic around the station and operating the station with odors, noise, and dust, waste and reduce the value of land)
- They should be economical in the establishment and operation.
- They should meet the prerequisites of sorting and extracting materials that are accepted from the competent authorities.
- They should meet the needs of underserved area for the reception of waste produced.
- Design, situating the station and be operated to meet requirements of public health, safety and protection of community welfare.
- Far from the flooding plain boundaries for a period of previous 100 years.

- It provides safety against fire hazards and supplies spills and accidents at work.
- Incoming and out coming traffic should not increase more than the current traffic.

The transformative station must bear a variety of waste collection trucks with open ceiling, closed trucks and light trucks and cars, particularly kinds of transportation vehicles effect on the capacity to accept the waste at a particular time.

Obstacles of reuse and recycling.

1. **Work Environment**:
   - Health risks, the risks of chemicals and high noise.
   - Unsafe conditions during collection and the numbers in the streets and near the old waste collection vehicles and devices.

2. **Weak environment protection**:

Ignorance and lack of knowledge about the risk of wastes.

Weak and limited investment potential.

Collection is not enough.

3. **The social and economic conditions**:

Low wage of socially unprotected workers and drain of socially vulnerable groups.

- The difficulty of obtaining the loan and interest low rates.
- The lack of a market for products due to competition in the relevant product between actors in the re-use, low customer's desire to re-use products, and because of the cultural and ideological and customary delimiters.

Litter and street cleanliness: Street waste is particular type of waste and garbage that is misplaced in locations in public areas and streets and alleys, roads and areas of empty land. This waste forms as health problems and breeding ground for vermin and rats and other domesticated animals as well as waste of financial resources, especially the difficult collection . The formation of street waste change by geographical area, habits, traditions and customs, and living conditions, and the degree of civilization and urbanization among the public. The street waste can be controlled through technological, intellectual and social means, by persuading citizens not to throw their trash and garbage in the streets, and through societal solution by depriving public of material that could constitute a Street waste or pay a heavy fine when registration violation. The solution of technological represents cleanliness after a trash in the street, for example, the area of sports stadiums and recreational areas. Notably, the growing practice of street waste dumping from young compared to older people and it is possible to mobilize certain groups for cleaning from religious persons and sports teams, police, schoolchildren and others.

Waste and garbage storage: Waste and garbage from urban areas constitute about 5 to 10 percent of the total waste of the nation, its management need greater effort than the other thing. So, it is the focus of attention for its existence in overcrowded and populated areas, where there is no adequate space for storage and coexistence for its changing character producing unacceptable environment for the individual. Waste storage means activity and the facilities required from time to time starting from the waste production to collection and household waste collection is greatly affected by people, and attempts to keep up with the civilization, and the legalization of the economies

of these operations. For basic improvements, it is usually useless and expensive due to:

High population density: Public housing and services (for example, alleys and narrow roads, and the intensity of public and private transportation systems, water supply systems, electricity, drainage systems and wastewater) will require a thorough planning to achieve the goals of the civil planning and elimination the waste problems through creating better systems in the future to store waste until being collected. Storing the garbage and waste is needed for the following reasons: to ensure the continuity of the waste incinerators work for converting wastes into energy, to supply incinerators with appropriate quantities of garbage and to bridge gap in garbage for manufacturing operations during weekly holidays or any official holiday (Supply change).

Box 2-5 Disadvantages of garbage storage.

- Risks to public health.
- The possible outbreak of fire
- Hotbed of vermin, rodents and mice.
- Odors of slow decomposition particularly garbage for those living downwind.
- Problems in Public Relations.
- Some aspects of waste and trash keeping are in small baskets and pots and other bags.

Waste storage in small pots: The basis of any system is a small container (pail or bag or waste basket) in the kitchen or in the vicinity. And these intermediary vessels must constantly be emptied repeatedly for their small size and the resulting decomposition of the waste and odors. These vessels are emptied in bigger containers where the waste is collected from. The basic requirements for the waste container are as follows:

1. Contents should not lead to any problems when waiting collection

2. These vessels must be designed to prevent the entry of animals, flies and rain . . . . . etc.
3. They must be lightweight for users and for the waste collecting labor.
4. They must be durable and strong sufficiently to prevents distortion 5. They must be provided with airtight lid.
5. They must be placed in appropriate areas easy to reach by the collection labor in a short time with less effort reducing the cost of collection.

Bin System: It is one of the most commonly used types to keep waste and garbage in several containers of various types and sizes inside and outside the home to serve as a system of keeping before garbage collection. This system requires several requirements from hygienically and economically that includes the following:

1. Bins must be as follows.
2. In sufficient number and suitable size to keep all the product of garbage during the collection period.
3. They should be equipped with hinged lid that is tightly good to prevent leakage, odors and to repel the entry of flies.
4. They should be constructed from non-corrosion materials, for example, of iron or plastic padded with Arsenic . . . . etc.
5. With a standard-size to reduce the cost of production.
6. They should be constructed with the standard criteria to facilitate the collection operations.

The bin location must be:

1. Near the house and easily accessible to facilitate the unloading operations
2. Near the road and easy to access to enhance collection and reduce the cost
3. Easy to clean for health and taste reasons.

The medium capacity of bin can be increased through supplying the public or selling paper or plastic bags which are common in hospitals, parking, and camping. . . . . etc.

As for bin site, it should have the following specifications:

1. It can afford keeping the number currently required bins, containers and in the future allowing users to offload garbage bags or boxes without touching the bin. It is preferably to have a corridor of at least 80 cm between each row of bins.
2. It is easy to access from homes and apartments, shops and the road or neighboring arena.
3. Upon using large containers, enough space should be given for loading and unloading containers and re-setting.

Flakirk bin: It has a metal belt at the top to ensure the cover to prevent animals that are specialized in lifting lids of bins.

Plastic bins and other trash baskets: The strong plastic bin that lasts longer than the metal one is preferred for the following reasons:

- Lightness.
- Easy to transport and dislocate.
- Easy to constantly being cleaned.
- Beautiful bright colors

However, the plastic bin is easy to disrepair and crush when they are misused, perhaps because of applying incendiary or hot materials in it, or placed directly under the sun.

The bin is manufactured in different sizes (small-sized 40 to 50 liters, and large-sized 70 to 80 liters or may increase).

Dustless Loading bin: It has hinged lid and designed for use with specific machinery. This bin allows good conservation and close garbage until collected. One of the most important standards and precautions to take to keep the trash and garbage is as follows:

- It should be cleaned immediately after discharge and beneficially lined with papers or newspapers.
- The contents of the bin should not be burned to avoid harassing neighbor or damage it.
- Waste should not be left inside the bin attached to evade breeding flies
- It must be cleaned with brush or washed down to remove the smell of garbage.
- It should be used in an acceptable and appropriate way.
- The dust bin lid must be laid properly so as not to be displaced by animals or children.
- The bin must be placed in a convenient location with easy rubbish put out by homeowners, and easy to access the site from the road.
- It should be well ventilated.
- The surrounding area must cleaned any unintentionally spilled trash, by users or garbage collection workers, should be removed.
- It must be strong to withstand any rupture or shocks that may occur to them.
- It must not be destroyed due to bad use.

the size of the trash or the size of keeping trash system is estimated according to the quantity of garbage produced , and several size factors affect the estimate including: qualitative weight and size of garbage, bulk density of the

garbage, frequency of collection, the rate of filling the keeping container, and the change in the production of garbage according to the size of the city.

Trash fly: The household garbage is a hotbed suitable for breeding of flies, which is one of the vectors of the disease. The types of flies that can be generated in the household garbage:

1. Blow flies: It is the type of flies that deposit their eggs on the meat . . . . etc) blue bottles and green bottles
2. Domestic flies: These types of flies increase during the summer months greatly in the fermented garbage to become a full fly within two to three weeks, whereas the blow fly only takes nine days to reach the stage of maturity, and blow fly larvae have the ability to migrate from their diet and therefore from the waste bin at their full maturity and it occurs during the next 7 to 12 a day in a regular household garbage. The weekly collection of household garbage throughout the year is less period that can prevent the breeding of house flies in the trash, and then it is the least period recommended for rural and urban areas garbage. There are special considerations for food garbage collection of shops, restaurants, hotels and hospitals. This kind of garbage ferments quickly. It is noted that the nymph of blow fly can deviate and grow the final stage at relatively high temperatures resulting in the garbage and migrates within three days from the time of eggs laid. When the bin is full or its internal wall is damp , the fly doesn't find it difficult to crawl out of it, so this kind of garbage must be collected at least twice a week.

Hours of garbage collection: The collection hours depend largely on local factors such as traffic. The economic and social advantages of easy and automatic gathering and final disposal of the waste and garbage should be

taken into consideration. The design and urban planning should have thorough attention for the activities orientation of modern collection ways. As it does not increase the size of the waste output of wealth growth, but also expected to increase the demand for standards of the final disposal of garbage.

Household garbage collection and disintegration: The household garbage collection is the basic service to the public as well as the water supply and wastewater disposal. It is not expected to be utilized and rationalized like other services as there is steady increase in the amount of waste produced. And this is related to operations of the garbage collection from preservation areas and transportation to a treatment or final disposal site.

Waste Collection Systems: These are all systems used in dealing with waste and garbage that require conservation at the site of collection and thus a large workforce needed.

Conventional systems for the collection and disposal of waste:

Kerb-Side collection:

It is a collection system in which the resident put his trash basket in front of his residence and disposed it after discharge. This is a cheap and fast system. However, it has some disadvantages including:

- It is primitive and old-fashioned and unhealthy system.
- When trashs are at the kerb for period of time they will be subject to exhume mediated by cats, dogs, children and passers-by, which may expose the lids to volatilization and scattering of some or all of the contents of the trash and dispersion.
- It brings hardship to the elderly and those with special needs and housewives.

For the reasons mentioned above, this system is inappropriate and undesirable, then it should be referred to and applied upon scarcity of other methods and better ways to collect garbage. Changes and improvements affecting the cost of collecting waste in addition to waste collector susceptibility to injuries:

1. Invention of the idea of green -can-on –wheels. Where the resident fills plastic container with huge rims mixed with the waste and garbage, including materials that can be recycled and waste arena and then push it to the edge of the sidewalk for collection. The waste cars unload bin through hydraulic machine that facilitates the labour not to touch the waste thus avoiding introducing injury with hazardous materials or exposure of wounds or bruises and bow, and this system is semi-automatic one. It can be daily operated by car waste driver in addition to one or more of the collection of waste and garbage workers.
2. **Snatcher truck:** It is equipped with long arms to reach the bins and lift them in the background of the car in fully automated system. This system is one of appropriate systems, especially when the street design and place contains the alleys and lanes behind the houses. This system greatly reduces the cost of (perhaps more than half the cost) collecting the waste with regard to reducing surgical and medical injuries of collection workers.
3. **Wider usage of bags and plastic sacks**, they are placed on the kerb for collection. and they are easy to deal with for their light weight and the scarcity of workers' exposure to injuries. The main defect of this plastic bags is the possibility to be torn by incidents and small animals searching for their food leading to scattering of their contents along the alley.

4- Skeps or skips: They are metal containers with a relatively large nozzle, where the garbage collector pour the contents of the trash leaving the bin in

its place without returning back to the house after emptying trash in the car. This system is time effective and convenient, however, it may leave the trash more than other systems and perhaps raised dust. Disadvantage include: chaotic and irregular system, it always raises dust even with great care, some garbage affected during transport from the basket, affected by strong winds that lead scattering of the waste hopper on the way to the car and workers get dirty significantly.

Collection and returning of the bin: The resident keeps his/her bin in suitable and easy-to-access location area (park, or arena, or behind the house) and the garbage collector carries it to the waste car where emptied and returned to its place.

Exchange bin: The garbage collector exchange an empty bin by full one with the resident. When he unload the full one,he exchanges it with another resident.

Relay system: When the garbage collector filling garbage car takes another empty one and continues to work meanwhile the filled car takes its way to the landfill (the warehouse or store)

Paper sacks: Paper sack is hinged from huge metal holder mediated attached by hinged cover. The carrier can be connected with the roof or free. The sack with its contents is removed in regular collection intervals meanwhile an empty sack is left in pots sites as a substitute. One of the main advantages of this system:

- Hygiene and public Health.
- Calmness and weight.
- Clean and easy work for the garbage collector.

- Reduce unit of garbage collection time in comparison with other systems.
- Free from dust and almost free from loading dust without the need for special loading machinery.
- Organizes unloading garbage cars in the landfill site.
- reduce delay of the collection process when granting extra sacks.
- Reduce cars erosion and corrosion.
- Block garbage away from the public eye.

The disadvantages of the system includes:

- Increase the total cost of collecting waste compared to traditional methods.
- Risk sack tearing if the resident tried to press trash and to increase the sack load.
- Lack of sack customization.
- Potential risks of damage from moisture, or broken glass pieces, or empty cans, or hot ash or animals, or strong air stream (wind).
- Reduce the pay load of cars because sacks are not compressed and the trash is loose.
- Reliability on the continuity of supply.
- Possible harm and accidents for children and pets from sharp objects, unless there is a guard official.

Planning factors during garbage collection:

1. The size and number of the accommodative devices depend on the size of the garbage produced, the changes in their production rates, and collection frequency periods.
2. The size and number of collection cars are affected by the following:

- Population density: high population density requires greater number of cars than those sparsely populated areas for economic reasons.
- Distance from the collection to treatment areas and final disposal,

3. The number of workers required to collect the waste, which determines the size of garbage and waste, and the volume of trash and garbage bins, containers used.

Issues of waste and garbage Collection: The most important problems related to waste collection and transportation issues are general organizational problems, as waste collection frequency is affected by the following:

- Climate and weather, especially average temperature, the maximum temperature, the rapid decomposition temperature of the waste and heat resulting in foul odors.
- The volume of waste and recycle bins.
- Population density.

The waste and garbage collection must be done in a way to prevent any problems for the public and collection workers as much as possible, and prevent the production of dust, noise without affecting traffic.

When thinking about management of waste collection,

The following should be considered:

1. Responsibility to collect the waste usually falls on the community for the collection and disposal, including the provision of baskets and containers.
2. The collection system.
3. The collection method.

Waste collection vehicles and their devices: Discharge must take the Following factors into account from the hygienic point:

- Prevent dust.

- Limit contact of collection workers with the waste as much as possible.
- Cars in different sizes for the collection of waste should be supplied to accelerate loading, thereby reduce cost.

The waste collection cars design depends on the following:

1. The desire of the public to raise the standard of cleanliness, the waste size, prevention of undesirable odors, and dust reduction or scattering of waste and garbage.
2. The need to carry more payload to keep pace with the increase in the volume of less density garbage, to reduce the cost of the car and especially the large devices capable of compacting and crushing garbage.
3. Recognizing the importance of improving working conditions for workers
4. Improvement in design by manufacturers to produce lightweight efficient devices that can withstand corrosion and erosion.

Waste collection cars are used in the most economical way when obtaining Pay- load \ volume ratio (PVR) for the car through compaction of garbage during collection.

It is important to take into account the following points when choosing a garbage collection car:

- Capital and operating cost.
- Clean Operating.
- Appropriate capacity
- Ensure reliability.
- Ensure continuity.
- Easy maintenance and cleaning.
- Ease of movement and energy.
- The impact of local factors.

- Integration of collection systems
- The types of devices used for reception.
- Management of waste collection that can be reused and recycled.

Obstacles to collect the waste and garbage are as follows:

1. High cost and the low level of service.
2. Low cost recovery for the audience irresponsiveness to pay the fees
3. Decrease of collection efficiency due to:
   - Lack of public collection container capacity in collection points.
   - Inadequate cooperation from citizens with collecting waste time and methods.
   - Poor management of workers and poor supervision.
   - Inadequacy of the type and size of vehicles.
   - Choosing the optimum route for the waste collection service.
4. Vehicles and devices stopped working because of the weakness of periodic preventive maintenance and lack of spare parts.
5. The presence of off-road areas for final disposal.
6. The difficulty of entering the waste collection vehicles to shanty towns.
7. The differences between the units and the environmental and health entities and departments of engineering relevant hygiene and enterprises of municipal waste.
8. Low social attitudes to the waste management.
9. Lack of good training and rehabilitation for workers in the waste, supervisors and administrators sector.
10. The absence of incentives for workers and low wages.
11. The lack of activities to raise awareness of social and counseling matters of waste and garbage.

Garbage Conveying: Several types of conveyors are used to move the waste and garbage to feed or loads of garbage and waste in devices to be configured or processed or finally disposed. Garbage transfer should be reduced within units and means. Some of them are:

1. Conveyors with rubber belts: They are used to move the non-fragmented raw garbage, this is useful in nonabrasive and less roughness loads. for example, in sorting of the recyclable and reusable materials.
2. Live bottom hoppers or feeders: They are used to move the garbage outside the baskets or tanker trailer where the base is moving on sliding beams in slow motion to fast forward then backward, which drives the garbage forward. These types are used to move the garbage to short distances as in transformative stations.
3. Pneumatic conveyors: They are usually used to collect raw waste in portable sacks or bags of hospitals and large buildings.
4. Vibrating feeder: They are used to balance the flow of materials and move small amounts of solid materials.
5. Screw conveyers: They are used to feed non-fragmented garbage inside the ovens applying aerial seal and allow balancing fuel feeding rate by changing the speed of rotation of the coil.
6. Drag chain conveyers: They are used to move the waste for special processing. The chained conveyer consists of the rectangular metal-tip open carrier that is closed from the top and functioning along both sides of the cuff, and at intervals of belt,there are metal or wood drawers, and the belt drag these drawers that move the garbage to be pushed through the sliding gate to dump location.

Chapter Three

Case study and methodology of work

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Case study and methodology of work

3-1 Background

Solid waste collection, transportation and disposal constitute the most substantive means for cleaning which became the predominant in environmental sanitation. And due to excessive growth in waste generation per capita attributed to the increase in living status, Khartoum state government perceived the importance of the issue and its danger on the environment. For this reason and for many years now the state has been conscious of the need to carry out a concrete study to revise its. Previous plans and place solid recommendation for combating waste hazards. Following the terms of reference, in the light of previously conducted studies and practical trials, a specialized committee proposed anew and radical strategy that updates previous efforts to be executed by new means and recent technology.

Questionnaire survey which was circulated to thirty-eight localities (see annex4 for sample size calculations) produced some data assisted in the preparation of the study that was categorized as follows: -

1-Part**1**: Defines Khartoum State from the geographical and demographically point of view as well as providing data for sanitation.

2- Part**2**: Analyzes the questionnaire data.

3-Part**3**: Gives full assessment of required machinery and equipment.

4-part**4**: Provides financial analysis for the project.

3-2 Khartoum State study area

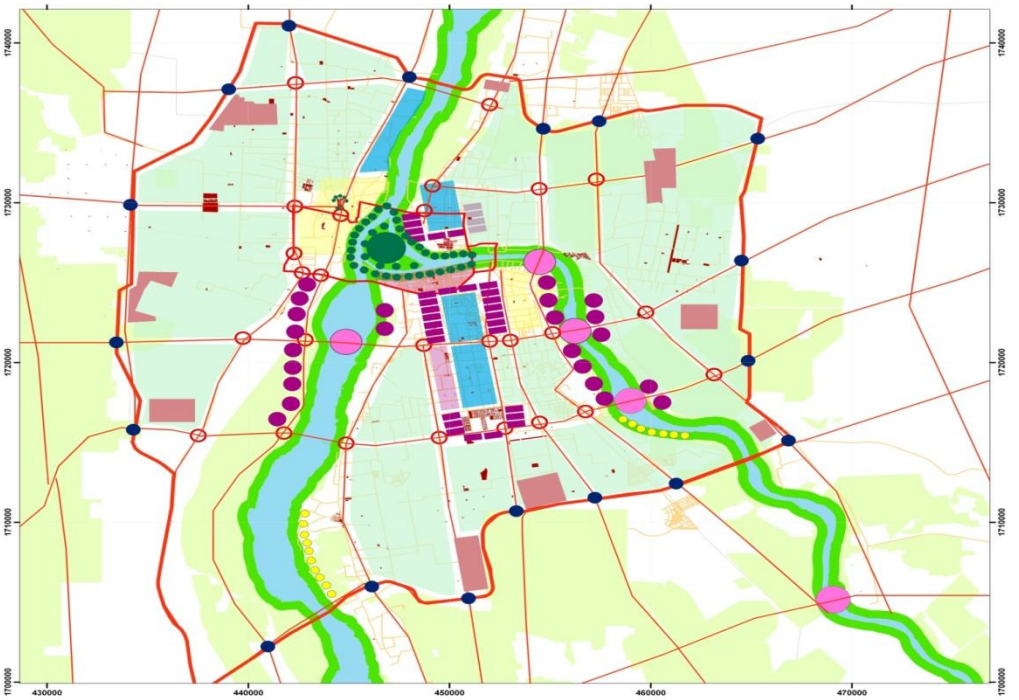

Figure 3-1. Khartoum Urban Territorial Level[Source: Abusin& Davies, 54]

Since the earliest of the 19th century Khartoum was known as the first administrative center in Sudan due to its geographical location. The increasing care devoted to political, educational and administrative fields encouraged the growth of trade and industry and encamped emigration from the rural areas to Khartoum. Khartoum is a dry hot State; the temperature ranges between43 degrees in June and drops to 14 degrees in December. The rainy season starts from June through October with scat rated rainfalls Khartoum being in the semi-arid area is considered as one of dustiest areas in the world. Khartoum executive capital of Sudan with 15. 8 million inhabitants(2014 estimate), situated at the junction between the Blue and the White Nile. Together with Omdurman to the west and Khartoum North to the north, form Khartoum Sudan's dominating urban center serves as the

legislative capital of Sudan. Khartoum is very poor, with few exclusive areas. Few streets are paved, but the center is well planned, with tree- lined streets. Khartoum is the administrative, economical and commercial center for whole of Sudan. Among the city's industries are printing, food processing, textile and glass manufacturing. The population of Khartoum is made up of all the peoples living in Sudan, making it relatively one of the least Arabic cities in the northern half of Sudan. Khartoum has rail lines from Egypt, Port Sudan and El Obied. The river traffic on the Blue and White Nile Rivers are very important. There is also an international airport. Khartoum has 3 universities, the University of Khartoum, Nilaein University (formerly a branch of Cairo University) and Sudan University of Science and Technology.

Founded by Muhammad AliBasha in 1821(A. c) the rule of Egypt, as a military post controlling Sudan.

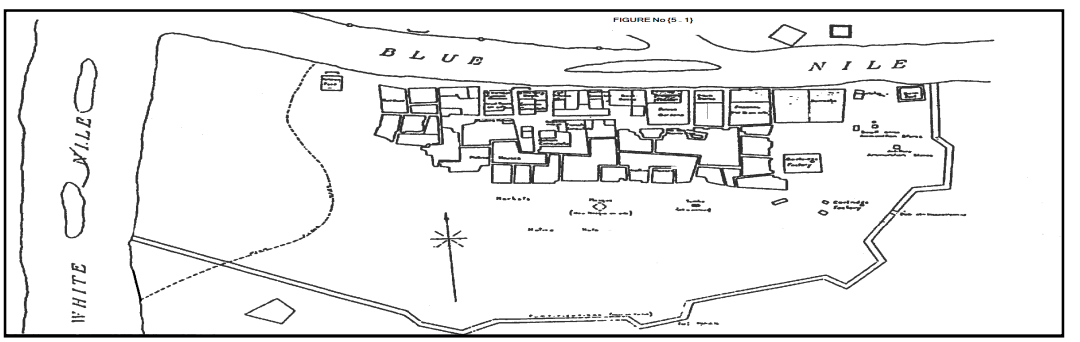

Figure 3-2. Khartoum Town during Early Turko- Egyptian[Source: Abusin& Davies, 54]

Khartoumcomeunder siege by El Mahdi in 1884, the following year in the massacre of an Anglo- Egyptian garrison and the British leader charles Gordon.

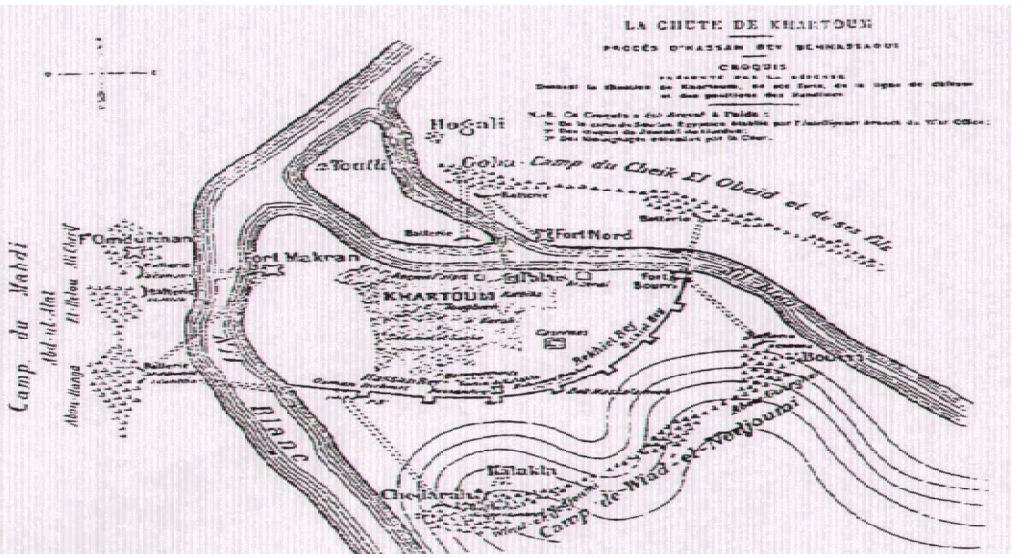

Figure 3-3. Mahdi Troops[Source: Abusin& Davies, 54]

Re-conquered by the British under the leadership OG H. H Kitchener in. 1898.

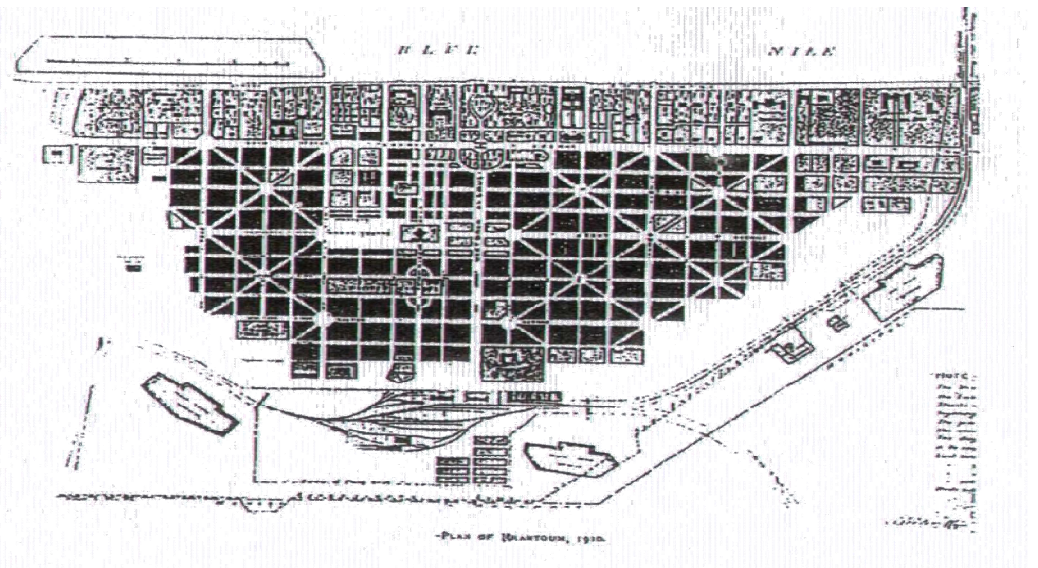

Figure 3- 4. Mclean plan 1910[Source: Abusin& Davies, 54]

Khartoum becomes the capital of Anglo-Egyptian Sudan in 1899. Independence of Sudan. , Khartoum becomes the capital of the country in 1956.

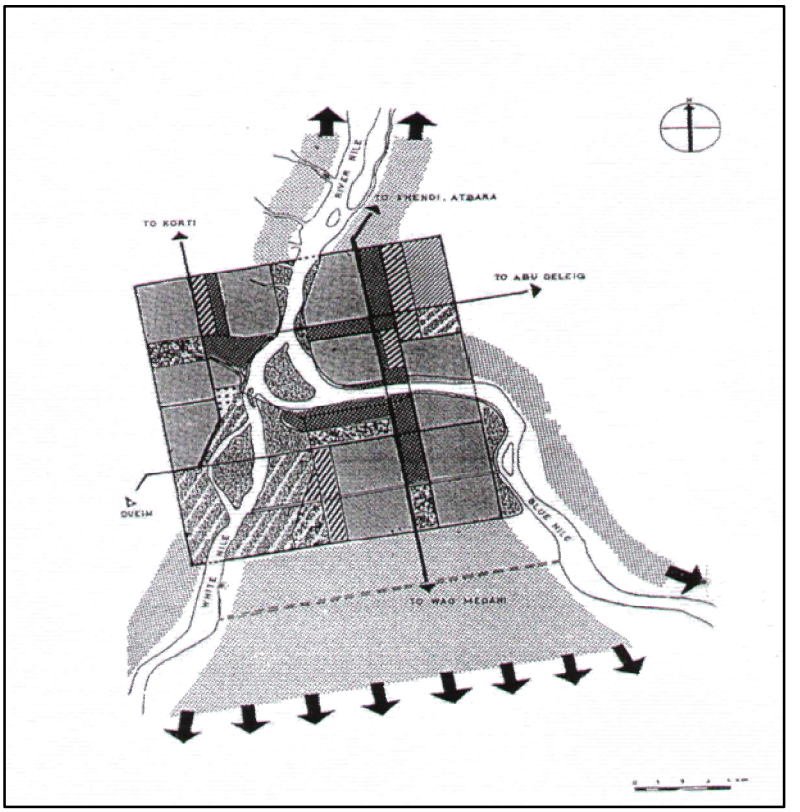

Figure 3-5. Doxiadis 1959[Source: Abusin& Davies, 54]

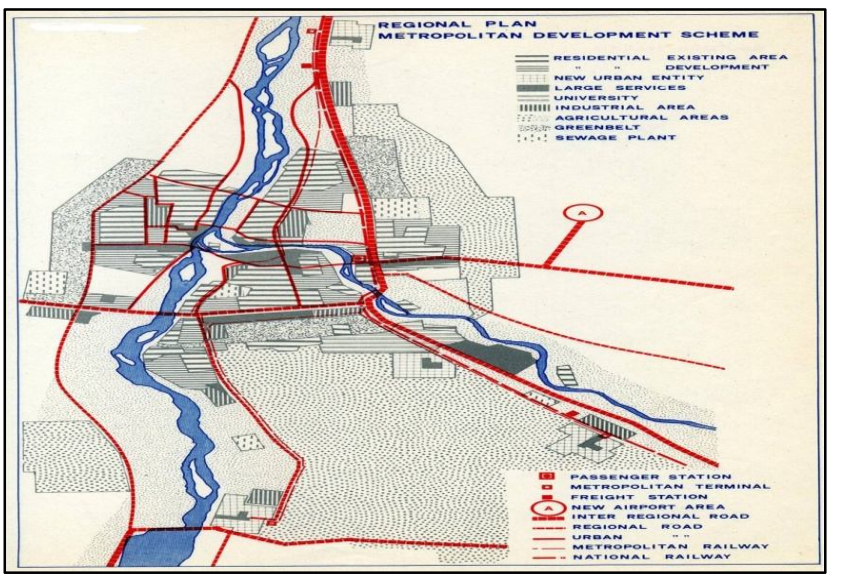

Figure 3-6. Mefit Plan 1978 [Source: Seif57]

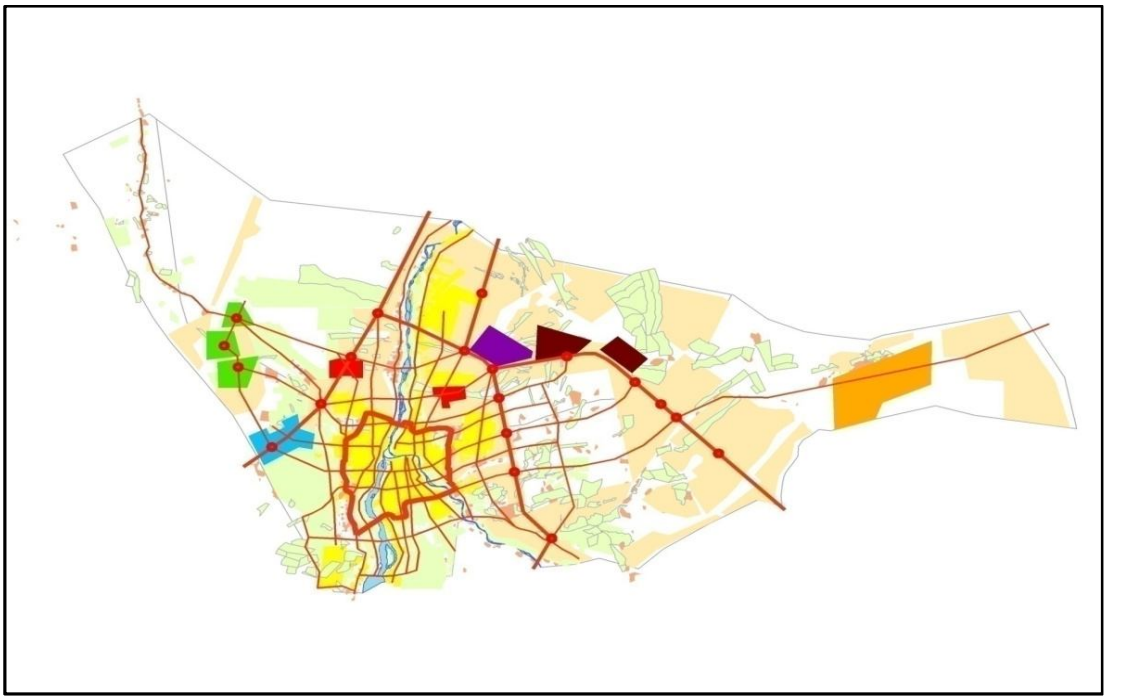

Figure 3-7. Mefit 2009 [Source: Seif57]

The Climate of the City of Khartoum City:

The city of Khartoum (lat. 15 36N long. 32 33 at. 38) is a rapidly expanding city with semi desert climate. It's affected by the river its sits at their confluence of the blue and white Nile. It is expanding along the rivers barks in a north south direction. The climate in winter is very pleasant with dry northerly winds from October to April and relative humidity below 30%. During this period there is no rain. The mean rain for October of 7.8 mm, November 0.7 mm and the rest of the months almost zero rain. The mean monthly temperature is lowest in Jan, about23C, and highest in April and October about 32C. The temperature drops steadily from October by about 4C every month from January it rises slowly during February by 1.5C. and then by 4C. every month until April. Jan. and Feb. are the coldest months.

The coldest temperature recorded was 7. 5C, in Jan. From April the temperature rises to 27. 5 in June. May and June are the hottest months in the city when the maximum can reach 47. 5C, and the mean maximum is above 41 C. By Jun the rain will be established to the south of the city and the city is under frequent dust storms with gust wind. During July the rain starts and the climate is modified accordingly July remains venerable to the highest temperature every other year. In august and September the city enjoys rainy conditions and the temperature is suppressed slightly. Relative humidity is above 40% for July August and September, the mean rain for July is 29. 6mm August 48. 3mm and September 26. 7mm. And sunshine hours drop to 8hours during these rainy conditions. Outside this period sunshine hours are more than 9hours [48].

Environmental Sanitation in Khartoum State:

Environmental sanitation is the most pressing issue for municipal health care department because it affects directly of healthof human life. For this reason most of the municipality's resources are allocated to incisive sanitation hazards. The approach to tackling environmental problems needs the adoption of a multidisciplinary method as well as competent solid waste management.

a: Waste materials collected from drainage trenches

b: Waste materials collectedin waste bags

c: transportation of waste bags in containers

d: Transporting waste bags from containers to the dumping place through waste vehicles

Figure 3-8. Solid waste management collection in Khartoum state

[Source: Elbaroudi, 64]

Khartoum State administration tried unsuccessful attempts to solve the problem. Although a considerable amount of money through loans and bilateral aids was devoted to the provision of machinery and equipment but still the environmental sanitation continued to resume; implication for nature conservation. This devastating situation was wholly attributed to improper management for the newly purchased vehicles. The deterioration in waste management became unbearable especially that of solid waste.

Waste generation accelerates by 4. 04% annually and by 2001 the total daily solid waste amount to 3000m. Particulars are specified as follows:

The daily generated solid wastes in Khartoum State.

Table 3-1: The daily generated solid wastes in Khartoum state [1, 49-53]

Waste source	Quantity (ton)
Sewer	-
Debris	298
Parking and parks wastes	194
Streets wastes	127
Public service	-
Commercial wastes	674
Timber and grass wastes	145
Houses holds wastes	2989
Hazard ous wastes	241
Total	4850

Out of the total amount of the daily revealed solid waste only 890 tons is disposed vides the means available to the different localities in balance of the wastes is either ignited or putrefied at random unhealthy cavages located adjacent to the residential areas. The result of this created a double problem to the environment, the principal was the contamination caused by effects of incineration and the other was the accumulation of residues caused by the continuesgenerate dated the situation and to achieve the following objectives:

1- Adoption of the easiest and best advanced means for waste storage, collection, transportation, and final treatment.

2- Specific specification of the operation to be exerted in solid waste management.
3- Provision of the minimum limit of human and technical resources as well as finance to secure the running expenses such provision should facilitate economically the disposal of wastes from the city center and peripherals.
4- Designation and construction of sanitary landfills and transfer locations.
5- Modernization of hazardous waste treatment systems by introducing incineration facilities at generation locations.
6- Separation and recycling of waste to produce economic out puts.
7- Provision of people's environmental awareness.
8- Preparation of scientific plans&programs to insure steady sustainability.
9- Monitoring staff training.
10- Adherence to modern cleaning system to meet the requirement of public health objectives.
11- Encouragement of the private sector to perform the solid waste operations.

3-3Waste in Khartoum state.

Background of the waste in Khartoum state:

The Ministry of Environment and Water Utilities in Khartoum revealed the presence of four thousands tons of waste daily produced, and warned of the danger of medical and electronic waste, at the time an environmental specialist revealed the disagreement in 2000 with governor of Khartoum state on waste. The Minister of Environment and Water Utilities in Khartoum State, Dr. YousifTibin, in a seminar about negative effects of waste on the environment

in Sudanese press services center that the volume of waste is calculated according to the rate of the population as half a kilo waste per capita, pointing out that the population of the state was, according to the last census, reached six million, and reported that the Khartoum state were dealing with the disposal of waste in an unscientific way through what he called dumping , burial and burning in the middle of neighborhoods, making it a hotbed for the breeding of flies and the diseases related to waste such as typhoid fever , adding that some sectors of society were benefiting from its existence in the middle of the living and returned to say that there are efforts exerted through the ministry of Health and Khartoum State to develop standards to deal with the diseases resulting from the presence of waste in a scientific manner according to deal with approximately 600 to 800 machineries that works in the field of hygiene in order to reduce the negative impacts of wastes through it reached to the work of tuning waste frequency During each two days a week and explained that the settings have found that it is transferred between 500 to 2 tons, and stressed their inability to get rid of it, especially in the suburban areas of the size which leads to the presence of indicators of some related diseases waste and increased (not strangeness of having disease), and added that the daily deficit made them do monthly campaigns.

The minister acknowledged the seriousness of the medical waste indicating that it includes many of problems and negative effects that increase the seriousness and of not dealing with it and not managed in a scientific way and went on (the incinerators are non-activated), and pointed to their efforts to run one of the incinerators broken during the current year, and revealed shortcomings in the sort medical waste from sources and criticized the deal with ordinary waste which constitutes a danger to the community,

He said hay that e-waste represents the most dangerous types of waste because they contain heavy metals which arranges serious health effects if exposed anyone and stressed the need for positive handling and society's perception of its seriousness, and warned of the importance of transforming this kind of waste to economics, and confirmed their quest with seven localities mandate to improve the situation and address the deficiencies that he described as the obvious ones. And raise the waste transfer rate of 2 tons and a half to 3 and half tons, in addition to holding a campaign to educate the community about the seriousness of medical waste when mixed with the rest of the waste.

The Minister of Environment in Khartoum clarified that there is private kind of wastes that need special treatment such as concrete wastes, and pointed to the presence of industrial wastes need to sort out first, and pointed to attempts by the ministry to raise the efficiency managements responsible for the cleanliness of the waste sorting in dumping areas. And stressed on the need to involve the community in the promotion of environment. In this context, environment specialist, Dr. Suleiman, stressed on the need to develop a complete plan and a comprehensive study of the surrounding environment and human activity to study the volume of waste and the source, quality and find the budget to address the feasibility of it, and said that one of the studies conducted through private committee formed in 2000, to study waste types, concluded comprehensive proposal for good treatment. In this course, the Committee came out with a range of conclusions and a proposal was presented to discuss the matter in order to provide locate wastes places and turned out of which the domestic waste represents (65%) of the total state. whereas, waste earth represents (65%) of them and organic waste (35%) and that when

assembled and it was found that it cannot be re- recycled to be economically feasible.

He added that the effluent need to be separated before getting out of the drainage network and stressed the need to gradual waste disposal. He said they found at that time twenty million tons of waste identified the cost of disposing of them in the twenty million dollars that the state contributes 20%, and he revealed that there is a dispute with the governor of Khartoum at the time, pointing out that the governor said that the cleaning Khartoum costs five million pounds in a month and demanded to reduce the amount, and he revealed that they told the governor that the reduction means a problem with the immediate and future environment.

He said a study was adopted for the establishment of Khartoum Company for cleanliness and chanted (unfortunately areas to landfill are not established as required), and added that the same study showed that the total waste in government and private hospitals, pharmacies and clinics amounted to 11 tons per day, and said that the committee submitted a proposal to handle such wastes in a manner other than incineration as its effects derail harmful toxic gases in the air and the emission of certain hazardous elements as well as the seriousness of the disposal of ash waste, which remains present in the incinerators containing mercury and dioxin. He added that there are other pitfalls in the disposal of medical waste through burial, indicating that the bacteria in the ratio of (2. 2%), and added: (unfortunately medical waste is completely neglected without a functioning station for effective treatment), and stated, (the operating station is old).

For his part, the president of the Sudanese Association for the Protection of Consumer Dr. NasreddinSholkamy, call the state to encourage investors and to

provide facilities in the field of waste recycling and added that dealing in waste disposal witnessed a slight progress, and went on " we hear about the existence of a political will to occur leap out of what he called the impasse waste and stressed the need to involve community. Especially, schools that lack the sanitation tools as well as the streets and demanded that the awareness work through the media and called for imposing manufacturers of products mainly of plastic nature with process to get rid of their waste as their relationship to the product ends after its distribution. Also, he stressed the need to find a strong and clear legislation restricting manufacturers to be responsible for disposal, collection and recycling of their wastes through enforcing tax for it.

He added that the fertilizers and their disposal are not in accordance with the applicable regulations. Arising from resolution issued for disposal of 2000 tons of fertilizer in the White Nile state and ask about how to get rid of them what he called the way non-scientific and call for disposition in accordance with international laws and went on a private expired radioactive isotopes medicines which of the most dangerous types currently used in the expansion of oil and disposal is carried out through the Ministry of Energy and there is a need for legislation.

Domestic solid waste problem:

The domestic solid waste problem seen today at the level of countries of the world as one of the major problems facing the modern human, especially in densely populated cities. And this problem is increasing in directly proportional with the increase in population and the progress of civilization.

In the absence of a clean environment in the housing, social, psychological and health disease spread. (Report of the World Health Authority has made it

clear that good and adequate housing of the natural and social environment and appropriate clean side of man provides good health either psychologically or natural or health)[Bartone, 1].

The problem of waste in Khartoum state:

Khartoum is one of the densely populated cities as a population is now about 6 million. So, the domestic solid waste management has become one of the challenges facing localities officials. these localities, since mid last century and until the end of it, performed the domestic solid waste management by traditional methods with a lack of resources and lack of scientific methodology till a 2001 decision of the governor of the state of Khartoum to form the State-level higher committee to develop a plan for the management of domestic solid waste, as a result, the project of Khartoum State sanitation came being. There is an effort exerted by the different sectors (administrative divisions that it`s established by Cleaning Project) in Greater Khartoum to collect and transport wastes to final disposal through landfill. reports from various sectors in greater Khartoum showed that the daily production of solid waste is equivalent to 50. 550 ton that wholly collected and transported in quantities without being sorted for use by recycling for the production of organic fertilizer, and there are also some negative environmental and health phenomena that occur from time to time, such as reproduction of flies and the incidence of watery diarrhea and overstock of domestic waste in certain areas (some main streets and streets and markets and some service and demographiccomplexesetc.). This poses a question about the effectiveness of domestic solid waste carried out by the various sectors since the establishment of the project in 2001 until the beginning of 2007 in terms of the combination,

deportation and the treatment and final secure disposal of domestic solid waste in accordance with environmental requirements

3-4The disposal plan:

First: the plan strategy: The strategic architectural development witnessed in Khartoum State in the recent years started from the architectural plans laid during the British colonial era to form the first nucleus of Khartoum civil plan of today. This has led to development in the housing sketches of cities and towns in the state as well as the neighborhoods that witnessed population progress which has been adopted as the main indicator for this study to propose a viable system for waste materials management to be suitable for these neighborhoods.

1- Clear identification of the roles and responsibilities of the concerned parties.
2- Provision of political, moral and legal support.
3- Provision of the necessary finance for capital expenditure and operational costs.

4- Intensification of information to elaborate broadly the project objective.

5- Causingthe projects working plan and insuring that every concerned party abides restrictedly by the decision.

6- Imputing environmental concept in all educational levels curriculum and encouraging advanced studies in waste management science.

Second: The plan requirements: The current structure of solid waste management accepts a low level of achievement compared with the

requirement of almost all other neighboring Arab countries. The key element of the requirement to tall with the high standards of modern waste management is sustained by clear analytical information. The aforesaid questionnaire together with WHO guidance placed strong and sounding information enough to plan for the beautification of the state. Depending on the past experience and the date avail by town planning laboratories department the study based the requirement, according to the following segmentations: -

1-Segment-one divided the state into seven sections and each section is divided into working sectors.

A. The first sector imputes the houses of first and second class. Each sector of this type is composed of 4,500 houses.

B. The second sector imputes the houses of the third class and it encompasses 6,000 houses.

C. the third sector resembles the houses in the suburban and rural areas.

2- Segment- two is for the commercial areas and each industrial area is considered as a commercial sector.

3- Segment three is for the industrial areas and each industrial area is considered as one sector.

4- Segment- four is for the hazardous wastes such as health care wastes and the residues of dangerous industries.

According to these segments the plan is specified as follows:

A- In the short run it is suggested that collection of waste will be done twice a week as door to door system. A use of compactor trucks will be introduced to collect urban areas wastes and for the rural areas the use of tractors and trailers was found to be the most practical and economic media. In the long run a bin storage system is introduced and the waste will be collected twice a week by the same kind of compactors trucks. This house to house system will insure healthy storage of the waste and reduce the chances of insect's generation.

B-For the commercial areas it is proposed that each shop should acquire 70-80 LTR containers to store its own wastes. Market cleaning labors dispose daily the content of these containers in a five cub. meters or other type of mass waste containers. Loading is continues process done by lugger arm lifter according to the type of containers.

C-For the industrial area every plant or workshop is required to acquire a five cub meter container and the collection of these containers will depend on the quantity of waste generated by the plant or the workshop. It should be known that the pretreatment of wastes is needed to remove the hazard beforetheir disposal.

D - Health care waste that is generated by hospitals, laboratories, pharmacies and other research institutes should be disposed according to the **WHO** regulations [2, 31].

The use of incinerators especially in hospitals reduces the chance for contamination, so it's recommended that each hospital should acquire an incinerator.

The wastes of the households and the commercial area will be transported either to the transfer stations or the landfills whichever is nearer. Industrial and health care waste will be transported directly to the landfills and dumped in certain areas.

Third: Machinery and technical requirements: Having stated the initial frameworks for solid waste management and outlined the basic informationtoallow for fair assessment, it became possible to initiate the beginning of a new mechanism towards determination of the needed machinery and equipment. A number of options were carefully studied and analyzed to determine the appropriate storage system to be adopted. It was agreed finally to evaluate the gradual introduction of the following system and if it proved positive then it may be developed and generalized in the future.

Table 3-2: The previous mentioned segments the machinery equipment [1, 9, 60]

Activity	Container	Remarks
Ordinary household	1. 1cub m.	Wheeled covered plastic container "asphalted roads"
Households/high building	2. 2 cup m.	Wheeled covered steel container automatic lifting equipment
Commercial premises		Wheeled covered plastic container
Markets	5 cub m.	Steel containers lifted by luggers
Industrial	5cub m.	To be lifted by luggers
	Or	
	10 cub m.	To be lifted by arm lifted

According to the previously mentioned segments the machinery equipment, which should be introduced, is as follows: -

1- 6-22-30 yard rear lifting containers for the urban sector households. Type of containers to be used depends on the road width and the maneuvering required.
2- Tractors and trailers for rural sector.
3- Loggers and arm lifters to be used in the commercial& industrial sectors.
4- Tipper trucks to be used for debris and mass wastes.

Transfer Stations: Transfer stations are located in suitable places in the different provinces and each one is composed of apressing unit. tractors, semitrailers and utilities It is designed to receive, sort and compact solid waste before disposal to the landfills. In addition to the cost reduction, as a result of sparing time and number of vehicles, the transfer station can act as a temporary storage area in rainy season when it is impossible or difficult for compactors to reach landfill. The transfer station should be isolated by barbed wire for an area of 80*100 meters where each site includes two administrative rooms two verandas, toilets and water&electricity services. The area of the station should be back filled withselited soil covered by 50cm thick heavy duty cement tiles. An area of 40*30m is designed for the unloading of solid waste to the pressing unit. The Edge of the area is four meters high adjacent to the press and slopes with inclination of 10% which died away, to the level at the transfer station.

the Dump Areas: The commencement of the**G**eneral **A**greement on **T**ariff and **T**rade (G. A. T. T), by January 2005 [51] requires considering the condition governing the commercial exchange. Landfills play a vital role in the success of the industrial and commercial exchanges abiding by the G. A. T. T. conditions. The agreement prohibits export of industrial goods unless a certificate of ISO is obtained indicating that industrial wastes are healthy dumped. Following this, construction of healthy landfills is not only required, but became a must to facilitate foreign trade transactions. It is inevitable that there will be occasional conflict of interest between waste disposal operations or proposals and site protection measure for nature conservation. However regular conflict between parties can be very costly in both environmental and financial resources and it is logical and highly desirable to look at ways that tackle both the nature conservation and the problems associated with the G. A. T. T. regulations. In addressing some of the problems.

For the conservation nature of the landfill operations ,some of the opportunities may be available if a sensitive approach is adopted in the location design and management of waste disposal project. There are many positive opportunities to integrate nature conservation with development. The presence of geological interest within the areas deemed suitable for landfills by no means precludes their issue; particularly there was a good Perrier consultation. All sites were found vertical facing exposures, and modern technology suggested will provide solutions to protect these areas from intruders and will stop transference of hazards from the landfill to the adjacent areas. Locations were already nominated but still the geographic studies were

not yet conducted, in addition to this and to maintain proper utilization of the dump areas the following should be secured: -

A) Prohibition of burning and precautionary preparation of non-spontaneous combustion should be catered for.
B) Dumping occurs in long ditches from two to three meters, well compacted, layers to be separated by 25 cm. earth layer behooving that dooming over layer should occur only when the degree of waste and earth equalize.
C) Landfill should be fenced in a way that prevents transference of light waste to the surrounding.
D) Design and specification of the landfills should meet all the requirement of the healthy landfill as defined by WHO.

Khartoum state maps:

MapA-1in Appendix shows that the Urban Development Land selection Zones & Areas. The map shows the stages of Khartoum state urban development according to its population increase and then enlargement of its towns and neighborhoods.

MapA-2 in Appendix showsUrban Development Connections Axis & Clusters. The map shows the axial enlargement of the dwelling areas inside Khartoum state, especially in its three main towns: Khartoum, Bahry and Omdurman, the study targeted areas.

Map A-3 in Appendix showsKhartoum2033. The map shows the future enlargement of the dwelling areas inside Khartoum state including its three main towns: Khartoum, Bahry and Omdurman, and the trends of population

growth till 2033. So, the effective system of solid waste management in Khartoum bears the future enlargement for it dwelling areas till 2033.

3-5 containers and application in temporary storage of waste materials.

Containers, in general, are vessels used to store the variable waste materials temporarily sooner to be disposed of. and waste materials containers are all types of vessels used for garbage collection from its sources, whether domestic, commercial or industrial till being transported and disposed of in the specified locations.

It is any item that contains subjects and the waste materials which contains garbage from its variable sources temporarily till being discharged in the specified locations. These containers can be domestic ones such as plastic bags or any plastic or suitable size metal containers to store the domestic waste materials for three or four days.

There are many types of containers used to store street , market, factories and other institutions waste materials according to the need and size.

Historical Background of Using Waste Materials Containers in Sudan:

Upon early establishment of Khartoum town, the containers were not well known as it is the case today. For the matter was just choosing a suitable site outside the house to dump garbage in to be later transported to another suitable location. Then using top and bottom opened metal containers where the garbage was dumped in and later development occurred in building red brick containers to accommodate the waste materials and being discharged regularly.

Modern Containers: With the development of the town and increase in its buildings, the containers in their previous shape have become unsuitable andnotpracticed to accommodate the waste materials produced from its variable sources. So, it becomes a necessity to find suitable alternatives coping with the development in the field witnessed regionally and globally.

German Loan: In the eve of 1970s in the previous century and according to loan allocated from the Republic of Germany, 3 meter containers and agricultural cranes were brought from Germany to make a very important qualitative transformation and this experience has broaden the scope of officials operating in the field about the possibility of being abreast with the scientific development in this viable field.

Japanese Donation: In the eve of 1980s in the previous century and to rehabilitate the equipment and machineries of the German loan, Japan offered a donation for Sudanese government to establish comprehensive business for handling waste materials in the National Capital. Within that donation , 3 meter containers and agricultural cranes were brought to take wastes outside

the town and used according to study made in this field forming a remarkable qualitative transformation at that time. But the experience was subjected to a dangerous setback that was attributed to depreciation of the equipment and bad use of citizens. So, other suitable waste materials handling alternatives became important to be made.

Globally Used Waste Materials Containers: There are many types and sizes of containers used globally and regionally and they have become insisting requisite for towns cleaning in the eve of enormous development witnessed in modern technologies. The manufacturing of such containers with their versatile shapes, colors and capacities made additive value to houses, streets and institutions. Many amendments were added to them to prevent spillage of waste materials, propagation of insects and emission of offensive odors and discouragement of town public scenery. Tacit movement and discharge were taken into consideration in manufacturing these containers to become highly effective. They start from merely plastic bags for houses, plastic or metal containers in attractive shapes and easy to use.

Figure 3-9. Shows the plastic waste containers used per houses and streets [Source: Khartoum State , 52, 58]

In the post collection operations of waste materials in terms of recycling they using such containers ensure sorting from the source and consequently facilitate. In case of multi-storey buildings, some containers were invented to be laid under the building in suitable engineering way to accommodate the dumped wastes easier and timely.

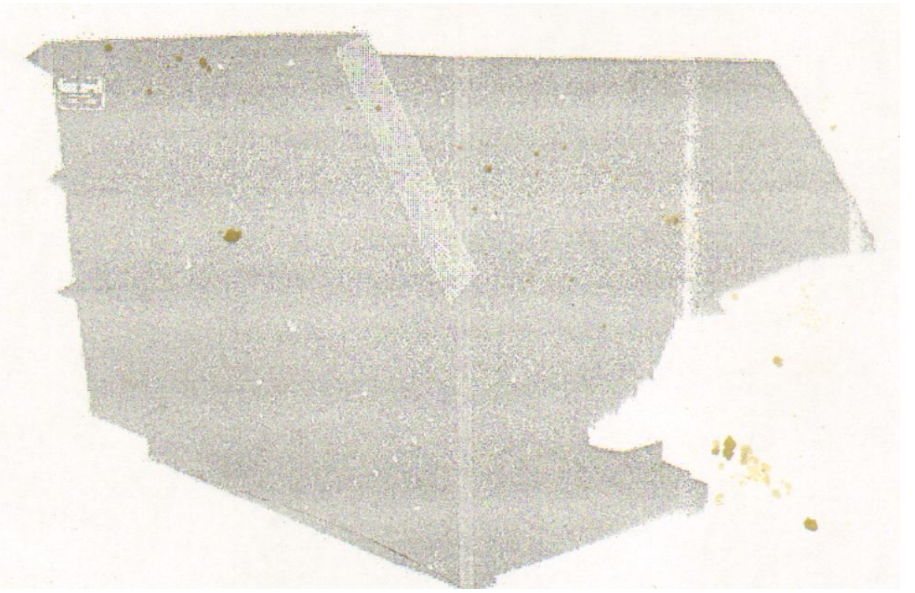

Figure 3-10. Shows the waste containers used per streets [Source: Khartoum State Sanitation Project, 52, 58]

There is no typical shape of such containers but it depends on the design of corporation performing waste materials management. However, the common measurement is 6 square yards, towards the suitable size for the quantity of sorted waste materials. For the streets and institutions waste materials, many containers have been invented to suit their activities nature and these containers have attractive shapes and colors, besides they are easier to use and discharge in small offices. This is in addition to baskets with variable capacities. In hotels and large financial institutions, more advanced types of containers are used and the aesthetical aspect of them is common and practicably play the same role of other regular containers.

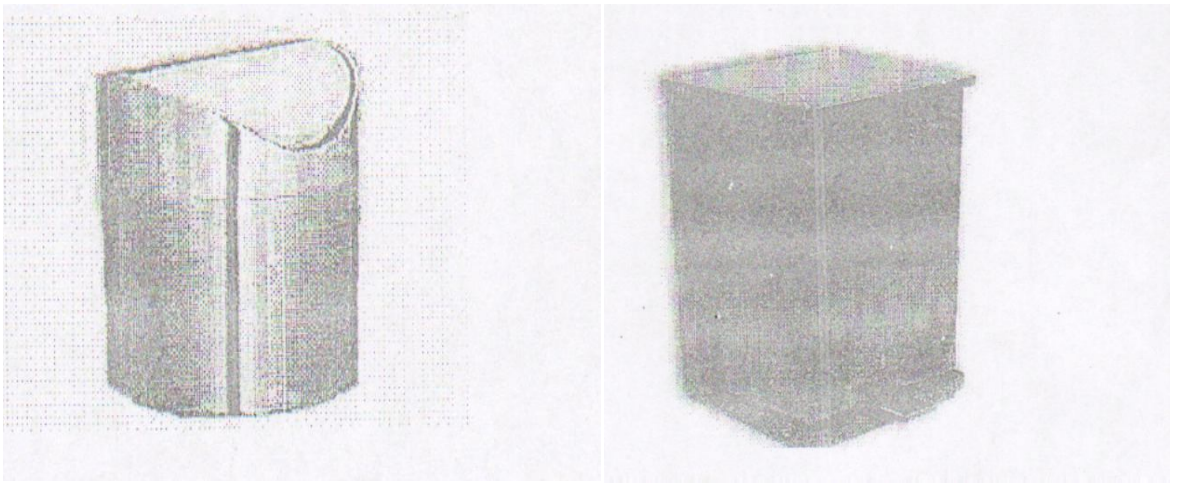

Figure 3-11. Shows the waste containers used in parks [Source: Khartoum State Sanitation Project, 52]

Figure 3-12. Shows the waste containers with cover used in parks [Source: Khartoum State Sanitation Project, 52, 64]

In parks and beaches, containers are used in design that maintains the aesthetic part of these places. Also they are designed in a manner that prevents animals from tampering with its contents. In the streets, many types of containers are used such as bags in a very simple and practical way and some of them is very good for accommodating all types of street waste materials

Figure 3-13. Shows the waste truck used in street [Source: Khartoum State Sanitation Project]

The sizes of these containers start of the housing 40 liters containers to even the huge installed capacity of up to more than 30 m^3. and some of these containers are like intermediary stations where appliances for compressing waste materials are installed to reduce its size and some of them are discharged through compressors and other through hooks and other through tractors. Each container has properties to suit manufacturing as it will be mentioned later.

The Current Situation of Containers:

In a study of Khartoum State project system starting in 1999 and ending in 2001, the recommendation was to apply containers in all the stages of wastes collection and storage so as to reduce cost and maintenance of sanitation for the citizen's interest. So, the proposed container was as follows:

- Plastic bags or the like to be used in the residential sector, which is 40 liters size and also, they can be used in the streets to collect the scattered garbage and in the shops.
- Containers with 180 liters capacity have multiple formsand used in the streets and small institutions, and they discharged directly into the compressors or any suitable machine.

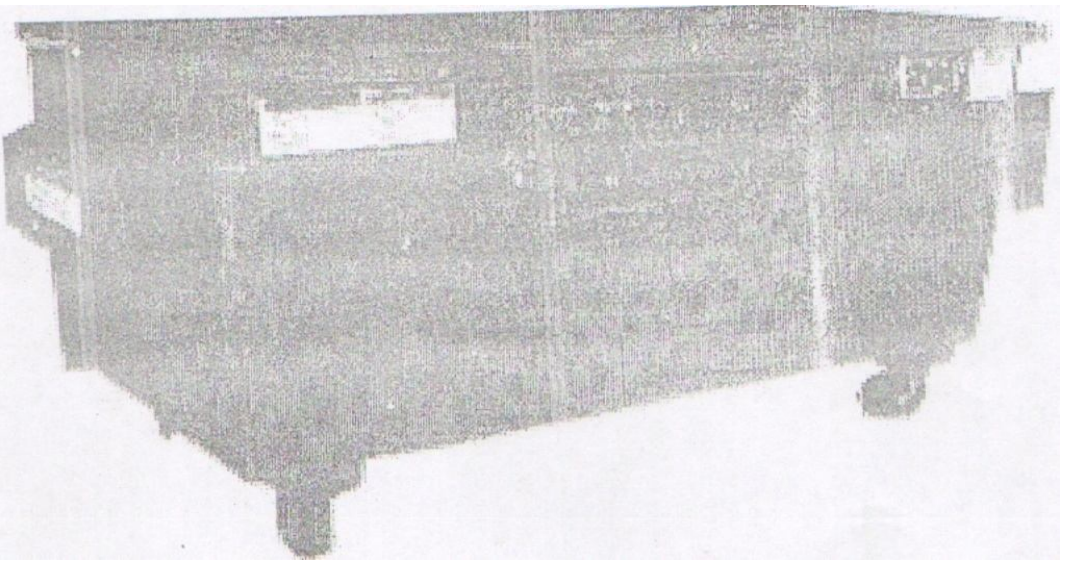

Figure 3-14. Shows the containers of stages of wastes collection used in residential sector

Source: Khartoum State Sanitation Project

- 2 cubic yards containers or 1,457 m3 are used in the streets and residential sectors as storage element besidetheplastic bags. The use of this type of container provides greater protection for the waste from animals, especially when they have tight lids, and containers. Less containers with 180 liters and 120 liters capacities can be used on the streets or any other containers.

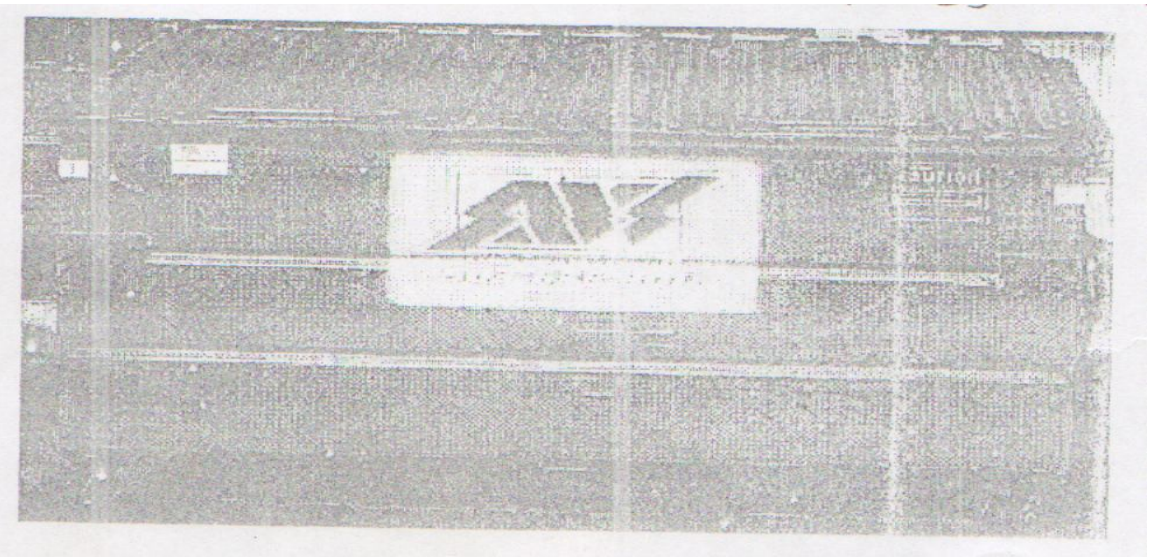

Figure 3-15. Showsthe 4. 6 cubic yard container

Source: Khartoum State Sanitation Project

- 6 cubic yards container or 4. 5 m^3.

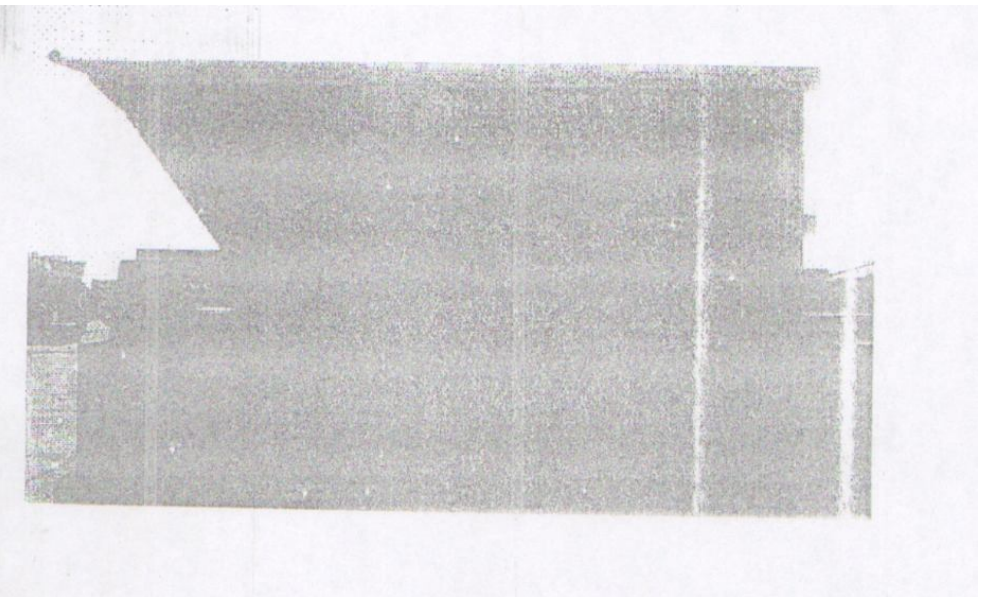

Figure 3-16. Shows the 5. 10m3 container used in market [Source: Khartoum State Sanitation Project]

These types of containers arepredominantlyused in the markets in some large squares and quarters. Especially containers with 5. 10 m^3capacity that are used in markets, commercial and industrial areas

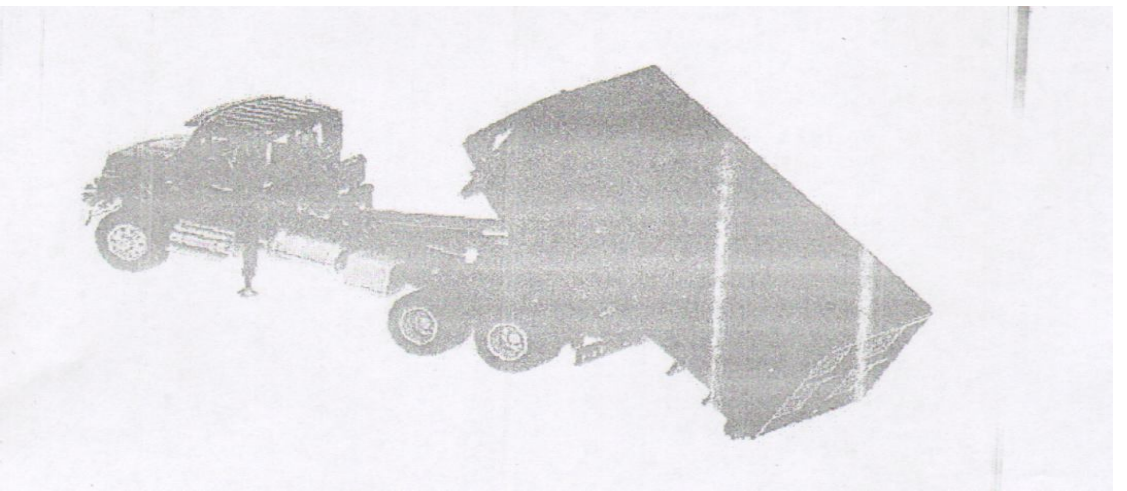

Figure 3-17. Shows the 6. 14m3, 20m3 container used in supermarkets and industrial areas [Source: Khartoum State Sanitation Project]

Containers with 6 . 14 m^3 and 20 m^3 capacities are used in supermarkets and industrial areas and they are to be lifted by hook cranes and tractors.

Evaluation of Using Containers: Needless to say that the container has become necessary and the best way to deal with waste in all stages and locations of its production and. it is used for the temporary storage and helps reduce labor and prevent scattering of waste and reduce health risks. Before starting the use of containers, waste materials used to be accumulated in dump places in a shape of rubble mounds and dust subjected to being scattered by the wind and stray animals, distorting the view of the city and become a fertile ground for the breeding of flies, insects and vermin.

Duration of German Loan and Japanese Donation: This period has lasted for 15 years incurring a remarkable transformation in the concepts of employees and labors working in waste sanitation business. Nevertheless, the

misuse sage of waste containers and unsettled work due to machineries breakdown have reflected bad impression about applying containers in garbage collection and that is greatly attributed to the following reasons:

1. The cessation of vehicles and irregular transfer of the containers made waste materials a breeding ground for the proliferation of flies, insects and sources of unpleasant odors
2. The lack of qualified workshops for the maintenance of vehicles and containers.
3. The number of containers is very few and capacity limitedness to accommodate all waste inside.
4. In the mid-nineties, all vehicles stopped almost entirely, making the sites of some of the containers as if they were final dumping areas.

Amid this total collapse, the work began in the emergency project in 2001 before the arrival of the machineries and equipment designated according to the study, which was made and approved by the Council of Ministers of Khartoum state and ordered to be implemented. The equipment and machineries used to collect waste from house-to-house has achieved remarkable success in the city's residential system.

Although the study of Khartoum State cleaning project has revealed clearly that it is necessary for the work to include collection and storage of waste materials in their all stages by using containers, The compressing vehicles arrived before containers. So, compressing vehicle replaced hired trucks operating in the same way, from house to house.

Upon arrival of the containers, they were few and projects demandwas for more compressing trucks to replace the hired ones in reduction of costs borne by the three major projects at that time.

When the first batch of containers has arrived, its distribution among the residential sector was rejected by some of the staff and some of the workers in charge because the unfavorable experience of 5 m^2 containers and the collapse of its machineries were inmind. This lead to consequent health problems and serious deviation in work performance.

Also, the above may be attributed to insistence of some to adopt the system of work transferring waste from house to house, requesting more containers. and the option of manufacturing new suitable ones was dismissed. Thus, compressors and machineries suffered operating major problems portrayed in streets during the autumn as well as fractures of water supplying pipes and work pressure

Estimating the Required Number of Containers:

For the work to return back on its track. ,the work through the container system should be readopted and accurate detailed study of neighborhoods and residential areas , streets, institutions and markets and factories should be carried out to determine the appropriate container types with their appropriate forms and sizes utilizing from their maximum potential. There of new containers should be requested matching work. Some misuse of containers and the problems could be overcome through the following:

1. If the work is strictly committed to and labors provide good service.
2. Containers should be placed in suitable places that are easily accessible and in usable forms.

3. Periodical system for washing the containers to prevent odors should be laid out
4. Periodical pesticide spraying system to prevent breeding and multiplication of harmful insects should be laid out
5. Strict legislation to urge citizens to properly deal with these containers and not to ignite the fires out and throw waste outside or scattering their contents should be laid out
6. Performing campaigns for guidance and health education to deepen the culture of cleanliness amid citizens.

General Information:

- The individual production of waste per day is 0. 6 kg.
  - The percentage of the weight of the waste to volume 1: 2. 8,i. e density 357 kg / m 3 .
  - Hence, the size that result from family is equivalent to 2. 8 × 3. 6 = 10. 08 liters per day.
  - The current container capacity found in the residential sector now = 1457 liters.
  - So, the number of homes that servea container per day are1457 ÷ 10. 08 = 146 home if the waste vehicle comes daily.
  - Time spent in the case of laying container 2 yards per 40 homes for every two and a half day.

The time required to lift the 40 houses` wastes in 3. 5 days , according to the current situation, is 40 minutes, that is equivalent to one minute for every home (20 minutes should be added for movement of the vehicle from a house to another one), while taking into account the operation of the cart machine

and meandering through the streets . Hence, the total time spent is 60 minutes, i. e. an hour. So, The time spent to lift the waste of 40 households is 3. 5 days . and for the proposed system of one container to another in asphalt Street with no any turnings is calculated by below equation :

Time = distance ÷ speed

The container emptied in the vehicle for 150 meters distance in5 minutes (studies and experiments have proved that). Hence, the total time spent in this system is 5 minutes (to unload the container) +60 seconds (from the container to another) equals 6 minutes (approximately) . so the surplus time available is 54 minutes from the current system) ,hence the container of 2 yards capacity (1457 liter) is suitable for the residential sector and the streets and in small markets in the city and shops.

The open system

T = d/v

t = time (minute)

d = distance (mile)

v = velocity

Compensation in the above equation, it is found that the time spent is six minutes in the open system.

• In comparison between the two systems, it is found that the system has provided 54 minutes from the current system.

Advantages of two-yard containers:

They are emptied by the pressing vehicle. Considering that the number of compressors is a large one and therefore they accommodate all containers needed for the residential sector.

They can be placed in places such as the residential sector and government institutions, small shops and also in small markets.

Disadvantages of two-yard containers:

Their wheels are prone to damage by fire or through any faulty usage which leads to the difficulty in unloading or scattering of waste materials,

• emission of foul odors if they are not discharged in a timely manner and

• some individuals throw waste outside containers causing nuisance to neighbors.

Figure 3-18. Shows the container used in street [Source: Khartoum State Sanitation Project]

3-6Other Types of Containers:

1 Domestic containers:

The size limits is (40) liters. i. e. collection of all 3. 5 days waste (half week).

The daily wastes produced size per family is almost 11 liters that is 40. 11 × 31/2 = 40 liters produced in 3. 5 days.

2 Streets Containers:

In the range of 180 liters (a result of past experiences).

3 six-yard containers:

It is 4. 5 m 3 equals 4500 liters and placed in large spaces inside the middle-market and small-featured and emptied by compressing

6-10-3 10m^3, 14 m^3 and 20 m^3 containers:

They can be placed in large markets, own factories,and unloading by hooks and tractors.

Table 3-3: The sites of sanitation services in Khartoum state:

Item	Khartoum	Jebel Awlia	Omdurman	Umbada	Kerare	Bahri Khartoum	ShargAl neel	Total
Houses	75260	15769	97850	155302	117164	93248	146882	843397
Firms	1197	1351	586	562	747	1093	787	6414
Markets	32	43	27	35	24	28	21	210
Main streets	73	73	99	26	12	32	10	264
Branch streets	117	117	73	436	46	99	21	530
Banks	159	159	103	80	55	111	27	640
Containers	389	389	107	44	22	120	18	775
Squares and pitches	149	149	81	613	335	49	131	1145

Source: Khartoum State Sanitation Project

Table 3-4: shows the number of two-yards containers required to cover the residential sector in Khartoum State:

Locality	Population	No of houses	Waste quantity per day (tons)	Required number of containers
Khartoum	449514	75260	260	1054
Jebel awlia	946146	157691	567	2190
Omdurman	587100	97850	352	1359
Ummbadda	931812	155302	559	2157
Karere	741186	117167	445	1927
Bahry-Khartoum	654828	93248	393	1295
Sharqelneel	802080	146882	481	204
Total				**11712**

[Source: Khartoum State Sanitation Project]

Essential Information:

The area of Khartoum state is 22500 km^2

The locations of dumping areas with the central stations:

- Khartoum : 23km Tayba , 40km Abuweleidat
- Bahry: 26km Hatab,
- Omdurman: 26 km Abuweleidat.

Daily Quantities of Waste Materials:

- Streets, markets and factories = 1200 ton
- Residential sector = 3057 ton

Total quantity of the town per day = 4257 ton

Waste Containers Economics:

1 labour: According to the current performance using compressing machines from house to house , the number of labor in each truck is 5 individuals (4 with the vehicle + alarm labor) and post service remuneration.

The monthly cost of labors in compressing machine SDG 350 x 5 = SDG 1750. In case of using two-yards containers, two individuals are assigned for each vehicle and the monthly cost for compressing machine is SDG 700

The monthly surplus from labor cost of compressing machine is 1750 – 700 = SDG1050.

2 Required machinery for the residential sector: The number of vehicles required depends on two main factors of time spent in loading and unloading equipment and waste transfer frequency. Generally, transport waste is twice a week, 3 times per week and beyond that in some regions of the exceptional natureand does not constitute an element. In light of this, the data sets benchmarksof the comparative cost. The number of houses in Khartoum state, which was in accordance to the statistics of houses that can be serviced in the state (a study conducted by the Central Bureau of Statistics for housing census). Daily per capita production of waste is 600 grams (latest study conducted by Khartoum State sanitation project, 2008)

Figure 3-19. Shows the machinery for the residential sector [Source: Elbaroudi, 64]

The total number of houses is16 m 3 ÷ 0. 00235 = 681 house.

The time it takes to load the cart home waste, on average, half a minute

The time it takes to charge the compressor 681 home 2/1 minutes = 340 minutes = 5 hours and 40 minutes.

The trip to the middle station and unloading and return takes about two hours and thus per trip time becomes 7 hours and 40 minutes time and thus be the work of the vehicle, on average is 2 day trip.

The number of homes served by the vehicle daily is 2 × 681 = 1362 home.

Number of compressors required 843400 ÷ (1362 × 2. 33) = 266 compressing machine.

3 **Using two-yard containers:** The total volume of container = 1. 457 cubic meters.

Containers required for each compressor 16 ÷ 1. 457 m 3 = 11 containers

The time that it takes to unload the container in compression and the journey from one container to another = 6 minutes.

The time that it takes one-pressing Shipping = 11 × 6 = 66 minutes.

Time of loading and unloading compressor is 3 hours.

Number of times the compressor frequency is 4 times per day

4 the required compressing machine: The total number of containers 843 400 ÷ 72 home per container = 11714 containers.

Number of compressors required 11714 ÷ (4 × 11) = 266 compressors.

There is surplus in the number of compressors

Frequency of twice a week 319-266 = 53 compressors

Frequency of 3 times per week 396-266 = 130 compressors

Savings, costs.

Count: Cost of house-to-house system is 264 compressors × 5 labours × SDG 350 = SDG 462 000.

Financial cost of movements system , 266 compressor × 2 labours × SDG 350 = SDG 186 200.

Savings = SDG 275 800.

Annual savings = SDG 3309600.

3 Number of times: Labor cost system for a house 266 compressor × SDG 350 = SDG 465 500. S

Labor cost of the container system 266 compressor x 2 = SDG186 200.

Monthly savings = SDG 279, 300.

Annual savings = SDG160,00.

4 Capital expenditures: Estimated consumption of container 11714 × 1200 ÷ 5 repairs = 281. 360SDG

Annual consumption of compressor = 46000SDG

The annual consumption of the number of compressor 46000 × = 9200SDG

5 Net savings:

Frequency twice a week:

- The savings in labor = 3309600 SDG.
- Savings in capital costs = 2811360 SDG.
- Annual net savings = 498 240 SDG.

Frequency 3 times a week: -

- The savings in labor = 3351600 SDG.
- Savings in capital costs = 2903360SDG.
- Annual net savings = 448 240 SDG

There are some operational costs of containers provided by using containers system, which lead to an increase in savings and that include:

1. Reduction of the maintenance cost to reduce the rates of recurrent cessations.
2. The savings in the use of tires.
3. The savings in the use of oils.
4. The savings in fuel use.

These need technical study to determine the savings in operating cost accurately.

Table 3-5: Present and required waste materials containers with variable capacities in Khartoum state

Locality	20 m^3			14 m^3			10 m^3			5 m^3			6 $yard^3$			2$yard^3$			180 yard		
	Present	Required	Total	Present	Required	Total	Present	Required	Total	Present	Required	Total	Present	Required	Total	Present	Required	Total	Present	Required	Total
Khartoum	5	51	20	8	20	82	10	-	10	-	-	-	114	100	214	161	893	1054	-	-	-
Jebel awlia	-	5	5	-	12	12	-	-	-	-	-	-	-	40	40	-	2190	2190	-	-	-
Omdurman	-	10	10	21	10	31	-	-	-	-	-	-	44	100	144	30	1329	1359	5	-	-
Ummbada	-	5	5	7	6	31	-	-	-	-	-	-	4	40	44	9	2148	2157	3	-	-
Karere	-	5	5	21	6	16	-	-	-	-	-	-	12	40	52	-	1627	1627	-	-	-
Bahry	-	-	5	8	6	27	-	-	-	30	-	30	60	40	100	9	1295	1295	-	-	-
Shargalneel	-	-	5	75	8	30	-	-	-	-	-	-	16	40	56	6	198	204	-		-
Total	5	45	50	75	82	157	10	-	10	30	-	30	250	40	650	215	9671	11713	-		

Chapter four

Results and Discussions

Chapter four

Results and Discussions

4-1 Proposed collection system

In this dissertation the following system is to be proposed:

1- The current system (House to House):

The loss of time for the garbage car, high consumption garbage of vehicles fuel and spare parts, use large number of workers high frequency and repetition of trips to the landfill with a small amount of garbage.

See Table7-4 and**MapB-1** in Appendix

2- The proposed system (Truck to Truck):

It save time with 1 : 10 of the current, save fuel and spare parts for garbage vehicle, use small number of workers, limited trips with the largest amount. See Table4-1 and**Map B-2** in Appendix

Table 4-1: A comparison between the current system and the proposed system:

The current system (House to House)	The proposed system (Truck to Truck)
1. The loss of time for the garbage car 2. high consumption garbage of vehicles fuel and spare parts 3. use large number of workers 4. high frequency and repetition of trips to the landfill with a small amount of garbage	1. it save time with 1 : 10 of the current 2. save fuel and spare parts for garbage vehicle 3-use small number of workers 1. limited trips with the largest amount

[Source: Elbaroudi, 64]

Determining the needs of the proposed system work plan:

To determine the needs of the proposed system work plan (Turck to Turck), specific survey questionnaire was carried on localities to provide the necessary information and then get that information that can support and the application of the initial groundwork for cleaner cities issued by the (World Health Organization) plus scientific experiments through the past administrations and the information that has been obtained from the Urban Planning and Civil Development Departments. The State was divided into work areas, as the province account for the work area. and then it was sub-divided into sections where each representing a locality. The sections has been divided into household sectors of work, including the first and second grade sector place with 4800 houses while third-degree sector includes 600 houses.

These houses space and shape of sectors and the time expected to be spent loading and transporting the waste have been taken into account and the number of job sectors totaled 104, including 15 sectors from first and second class and 89 sectors from the third class with 26 sectors of the countryside.

The study suggested that the solid waste is collected in the short term directly from houses to compacting vehicles or other means of transportation twice a week. Every house should prepare suitable waste containers indoors until being collected and transported. In the long run, small closed containers should be provided with 120 or 240 liters capacity according to the size of produced wastes generated by the housing units.

Technical and mechanical needs:

The study proposes to improve the means of storage of the waste after generation, through an integrated system for the storage of waste before being collected and transported in the same sizes of containers defined previously. The alternatives set for various types of these containers have been studied and it was decided to develop the following system gradually so as to be evaluated and propagated.

Table 4-2: The collection and transportation systems [1-9]

Activity	**Container Type**	**Notes**
Regular residential Sector	180-240liter size	plastic wheel container with lid on the paved streets
Multi-storey residential Sector	2 cubic yards	iron wheel container with loader cover on the dirt streets equipped to be lifted automatically

For the collection and transportation, the study suggested that the collection and transport should be in closed systems so that the system does not allow any collection or transport of the waste in open systems like trucks and tractors except only in the outskirts of the city and rural localities and they should be covered with standard wax and equipment that has been proposed. Also the use of major compactor with rear background capacity of not less than 19 cubic yards equipped for automatic loading of container with 6n cubic yards. Should be adopted.

4-2 Results of the questionnaire:

Data Analysis:

The acquired primary data was analyzed accordingly using Statistical Package for Social Science [SPSS, 65] program. The first part of the questionnaire dealt with general information about the targeted respondents including: name, neighborhood, family members, literacy level of father, occupation, average salary, number of rooms and building material. These types of information helped a lot to reflect the socio-economic status of the respondents within their housing units.

Results:

The statistical analysis was concentrated upon the frequency tests for the qualitative data acquired from the answers of questionnaire prepared targeting sample of 83 houses in each three cities (Omdurman ,Bahry and Khartoum) in each cities (these 83 houses are classified into first , second and third classes) randomly, about location, transportation and storage of domestic solid waste materials produced by households in the area of study and that was as follows:

Table4-3: showsfamilies members in the house.

fami. Members

Valid		Frequency	Percent	Valid Percent	Cumulative Percent
	2	2	2. 0	2. 4	2. 4
	3	1	1. 0	1. 2	3. 7
	4	9	9. 0	11. 0	14. 6
	5	8	8. 0	9. 8	24. 4
	6	15	15. 0	18. 3	42. 7
	7	15	15. 0	18. 3	61. 0
	8	15	15. 0	18. 3	79. 3
	9	4	4. 0	4. 9	84. 1
	10	2	2. 0	2. 4	86. 6
	11	5	5. 0	6. 1	92. 7
	12	2	2. 0	2. 4	95. 1
	13	2	2. 0	2. 4	97. 6
	14	1	1. 0	1. 2	98. 8
	15	1	1. 0	1. 2	100. 0
	Total	82	82. 0	100. 0	
Missing	**System**	18	18. 0		
Total		**100**	**100. 0**		

As it`s shown in table (4-3), most of respondents families have members between 4 and 8 individuals (9. 8% - 18. 3%)and fewer have less than 4 individuals and there is no families with more than 15 members.

Table 4-4: shows qualification of the father families.

qualification

Valid	Frequency	Percent	Valid Percent	Cumulative Percent
	18	18. 0	18. 0	18. 0
graduate	31	31. 0	31. 0	50. 0
illiterate	1	1. 0	1. 0	51. 0
intermediate	11	11. 0	11. 0	62. 0
postgraduate	13	13. 0	13. 0	75. 0
primary	9	9. 0	9. 0	84. 0
secondary	16	16. 0	16. 0	100. 0
Total	100	100. 0	100. 0	

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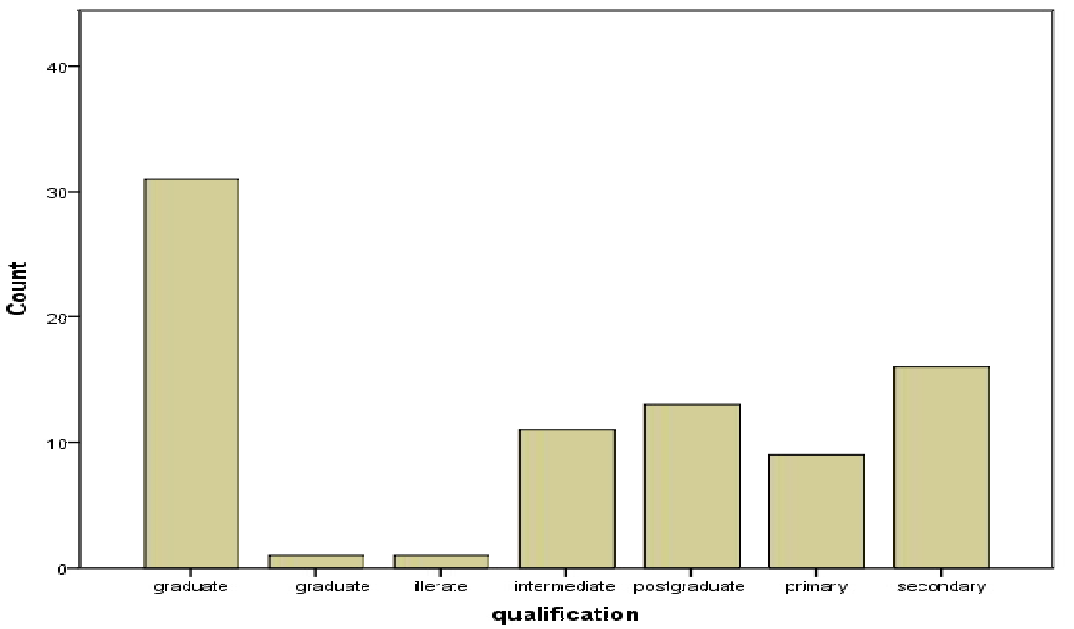

Figure 4. 1: shows The qualification in the targeted groups

As it`s shown in table (4-4) and figure 4. 1, the literacy level among the fathers of respondents family is high as most of them is secondary (16%) graduate (31%) or post graduate (13%).

Table 4-5: shows father job in the family.

fath. Job

Valid	Frequency	Percent	Valid Percent	Cumulative Percent
	18	18. 0	18. 0	18. 0
employee	43	43. 0	43. 0	62. 0
free business	25	25. 0	25. 0	87. 0
labour	4	4. 0	4. 0	91. 0
other	8	8. 0	8. 0	99. 0
police officer	1	1. 0	1. 0	100. 0
Total	100	100. 0	100. 0	

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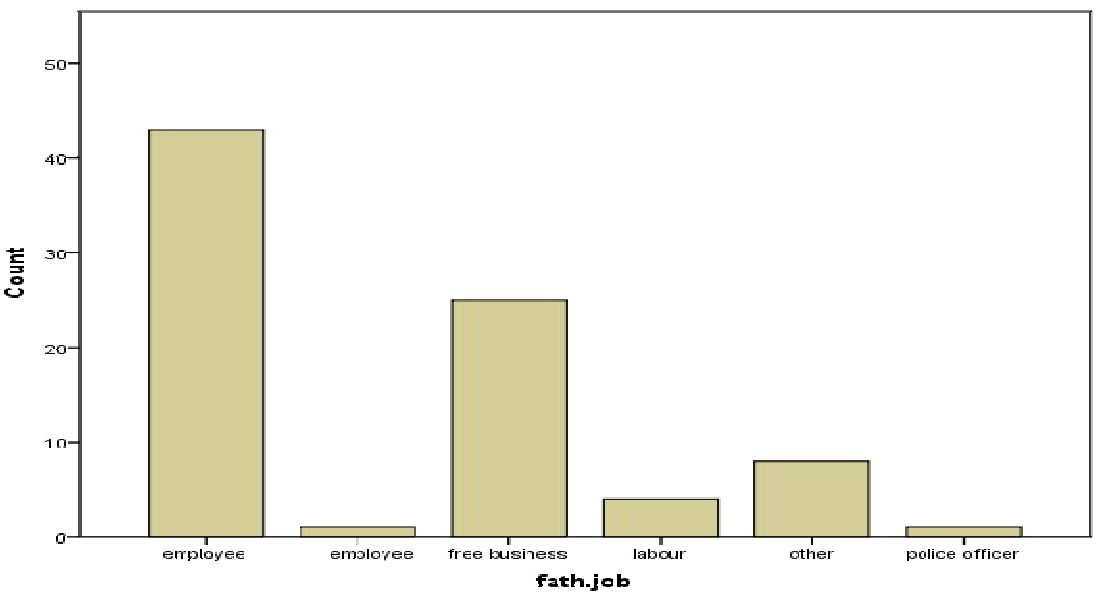

Figure 4. 2: shows The father job in the targeted groups

As it`s shown in table (4-5) and figure 4. 2, the dominant careers among the fathers of respondents families are as employees (43%) and free business (25%).

Table 4-6: shows average of salary in the family.

av. salary. Thou

Valid	Frequency	Percent	Valid Percent	Cumulative Percent
	18	18. 0	18. 0	18. 0
between 10- 25SD	4	4. 0	4. 0	45. 0
between 25 - 50SD	19	19. 0	19. 0	64. 0
between 50 - 100SD	22	22. 0	22. 0	86. 0
more than 100SD	14	14. 0	14. 0	100. 0
Total	100	100. 0	100. 0	

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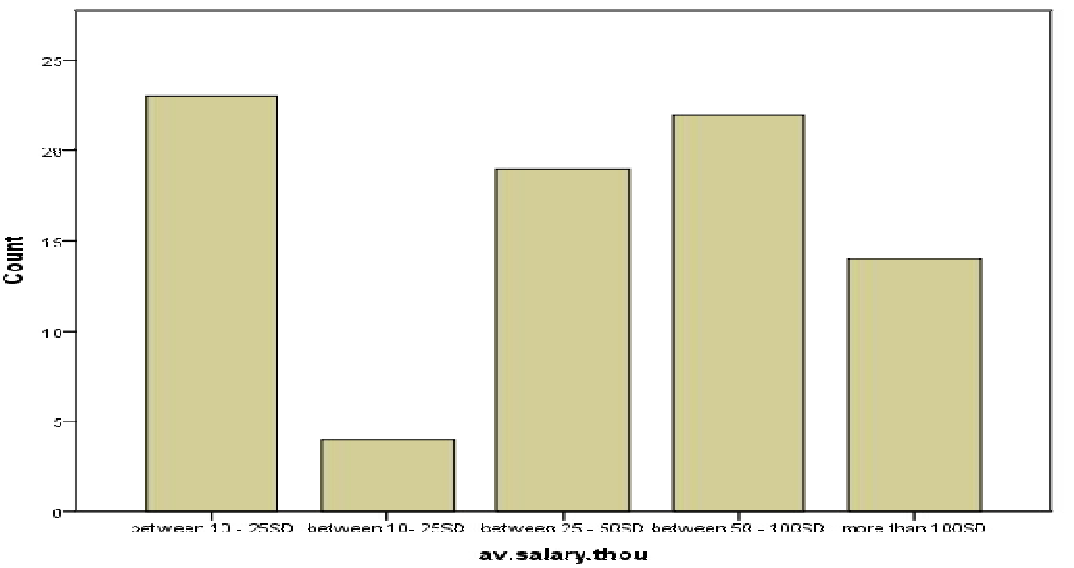

Figure4. 3: shows The average of salary in the targeted groups

As it`s shown in table (4-7) and figure 4. 3, most of the fathers of respondents families earn monthly salary ranging between 25 to 100 SD.

Table4-7: shows the number of the rooms in the house

Rooms

Valid	Frequency	Percent	Valid Percent	Cumulative Percent
	18	18. 0	18. 0	18. 0
more than three	27	27. 0	27. 0	45. 0
One	3	3. 0	3. 0	48. 0
three	34	34. 0	34. 0	82. 0
Two	18	18. 0	18. 0	100. 0
Total	100	100. 0	100. 0	

As it`s shown in table (4-8) ,most of the respondents houses are medium or big size ones according to the number of the rooms, more than three (27%) or three rooms (34%).

Table4-8: shows the build material in the house

build. Material

Valid	Frequency	Percent	Valid Percent	Cumulative Percent
	18	18. 0	18. 0	18. 0
brick	42	42. 0	42. 0	60. 0
ferroconcrete	32	32. 0	32. 0	92. 0
unbaked brick	8	8. 0	8. 0	100. 0
Total	100	100. 0	100. 0	

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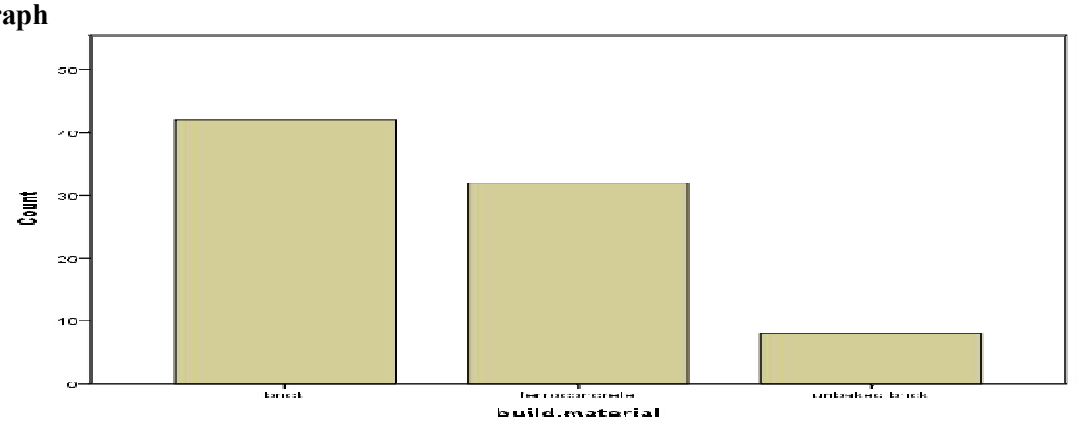

Figure4. 4: shows The building material in the targeted groups

As it`s shown in table (4-9) and figure (4-4), the dominant materials used in the respondents houses are bricks (42%)and ferroconcrete (32%). This clearly reflect the socio-economic status of the respondents

Table4-9: shows the City in Khartoum state

town

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		18	18. 0	18. 0	18. 0
	Bahry	29	29. 0	29. 0	47. 0
	Khartoum	26	26. 0	26. 0	73. 0
	Omdurman	27	27. 0	27. 0	100. 0
	Total	100	100. 0	100. 0	

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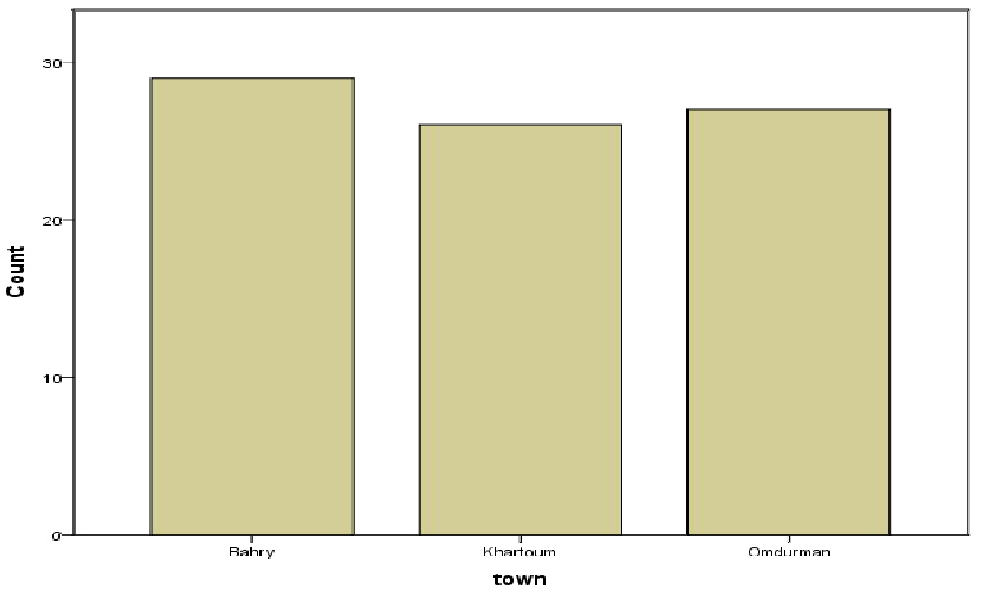

Figure4. 5: showsthe town in Khartoum state.

As it`s shown in table (4-10) and figure (4-5), most of the respondents houses are in Bahry (29%) and this is greatly attributable to responsiveness of the targeted group dwelling in this area.

Table4-10: shows the location in Khartoum State.

Location

Valid	Frequency	Percent	Valid Percent	Cumulative Percent
	18	18. 0	18. 0	18. 0
Alryad	5	5. 0	5. 0	23. 0
Mulazmin	1	1. 0	1. 0	24. 0
Arkaweet	4	4. 0	4. 0	28. 0
Althoura qua2	1	1. 0	1. 0	29. 0
Alawuda	1	1. 0	1. 0	30. 0
Almaigoma	9	9. 0	9. 0	39. 0
Almuhandiseen block28	7	7. 0	7. 0	46. 0
Alhajyousif	1	1. 0	1. 0	47. 0
Alkhatmia	4	4. 0	4. 0	51. 0
Allamab	1	1. 0	1. 0	52. 0
Albuadam	2	2. 0	2. 0	54. 0
Manshia	4	4. 0	4. 0	58. 0
Immtidadnasir	2	2. 0	2. 0	60. 0
AlsafiaJanoob	1	1. 0	1. 0	61. 0
Alhillajedida	1	1. 0	1. 0	62. 0
Alshajara	1	1. 0	1. 0	63. 0
Alsajana	2	2. 0	2. 0	65. 0
AlkalaklaSangat	1	1. 0	1. 0	66. 0
Burri	1	1. 0	1. 0	67. 0
Althoura qua17	1	1. 0	1. 0	68. 0
Alfeteihab	1	1. 0	1. 0	69. 0
Alrikabia	1	1. 0	1. 0	70. 0
Banat Grub	7	7. 0	7. 0	77. 0
Umdurman block55	1	1. 0	1. 0	78. 0
Abosiid block11	2	2. 0	2. 0	80. 0
Althoura qua7	1	1. 0	1. 0	81. 0
Ombadda	2	2. 0	2. 0	83. 0
Aldawha	1	1. 0	1. 0	84. 0
Alwaha	4	4. 0	4. 0	88. 0
Kober-Alwaha	4	4. 0	4. 0	92. 0
Kober	1	1. 0	1. 0	93. 0
Hilathammud	1	1. 0	1. 0	94. 0
Alsababi	6	6. 0	6. 0	100. 0

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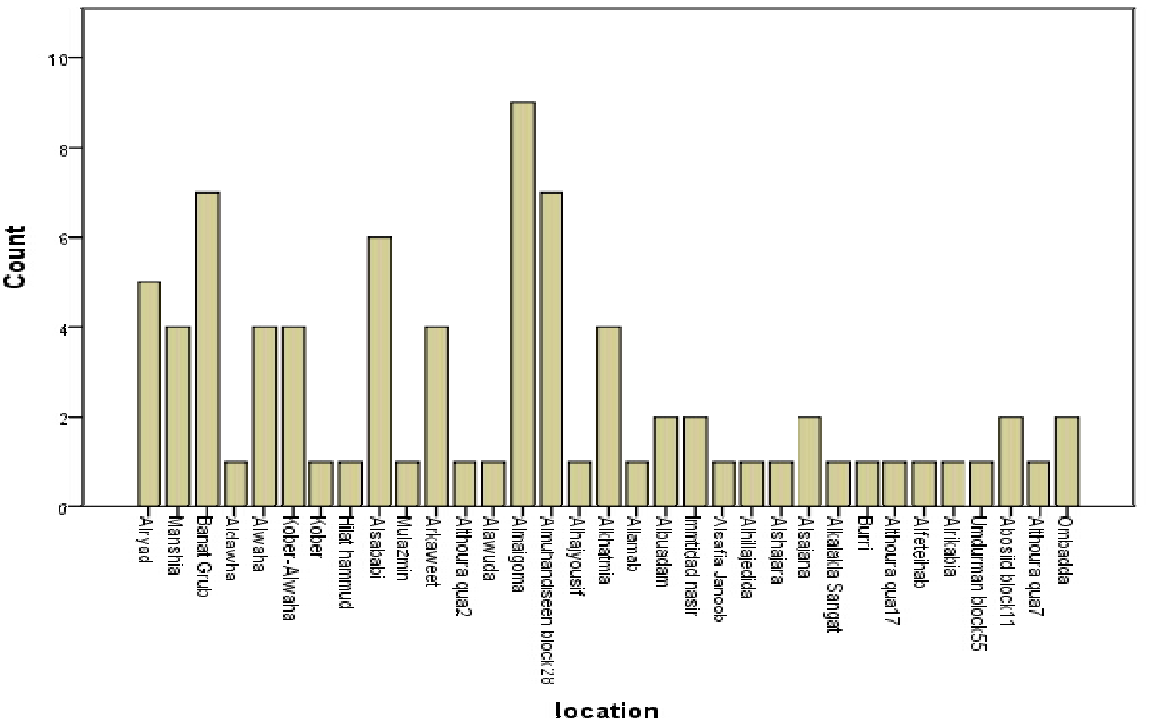

Figure4. 6: shows The location in Khartoum State

As it`s shown in table (4-11) and figure (4-6), most of the respondents houses in Bahry locates in Almaigoma, Alsababi, AlKhatmia and KoberAlwaha; in Khartoum locates in Manshia, Alryad and Arkweet; in Omdurman locates in Banat Grub, Omdadda and Abosiid.

Table4-11: shows the house grade in Khartoum State.

house. Grade

Valid	Frequency	Percent	Valid Percent	Cumulative Percent
	18	18. 0	18. 0	18. 0
first	26	26. 0	26. 0	44. 0
second	29	29. 0	29. 0	73. 0
third	27	27. 0	27. 0	100. 0
Total	100	100. 0	100. 0	

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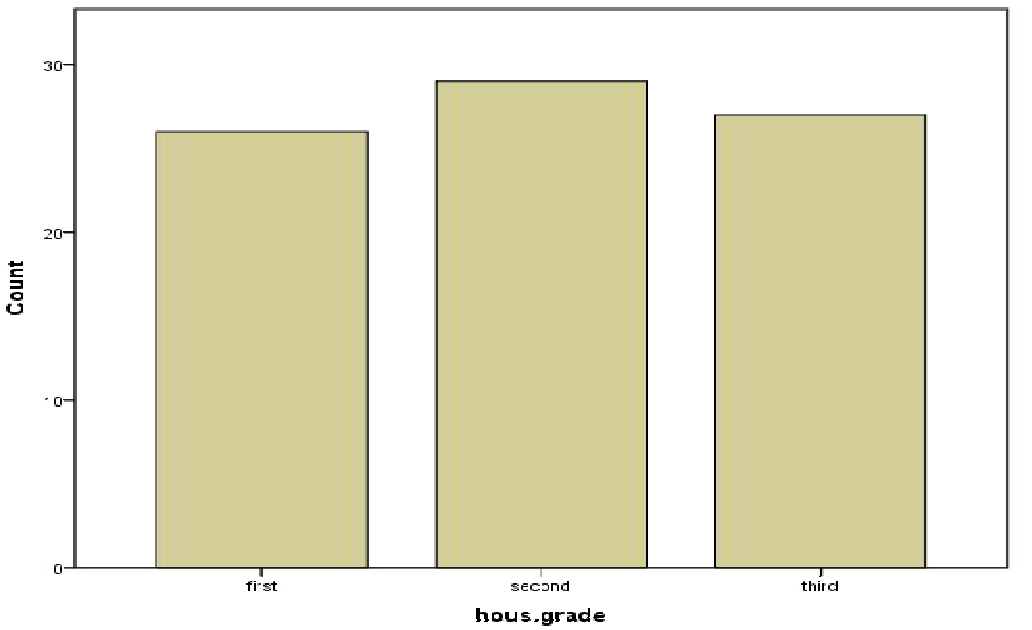

Figure4. 7: shows the house grade in Khartoum State.

As it`s shown in table (4-12) and figure (4-7), the respondents houses ofsecond grade (29%) score the higher percentage and first grade the lower (26%).

Data Analysis:

The acquired primary data was analyzed accordingly using Statistical Package for Social Science (SPSS) program. And the second part of questionnaire investigate the issue of waste material handling by the respondents including waste containers, locating the waste materials , waste transporting frequencies and alternatives as well as the dumping areas

Results:

The statistical analysis was concentrated upon the frequency tests for the qualitative data acquired from the answers of questionnaire prepared targeting sample of 83 persons in variable quarters in the three provinces of Khartoum states about location, transportation and storage of domestic solid waste materials produced by households in the area of study and that was as follows:

Table4-12: shows waste collection methods adopted by the targeted groups

Valid	Frequency	Percent
	5	5. 7
barrels	17	19. 5
plastic bags	64	73. 6
sacks	1	1. 1
Total	87	100. 0

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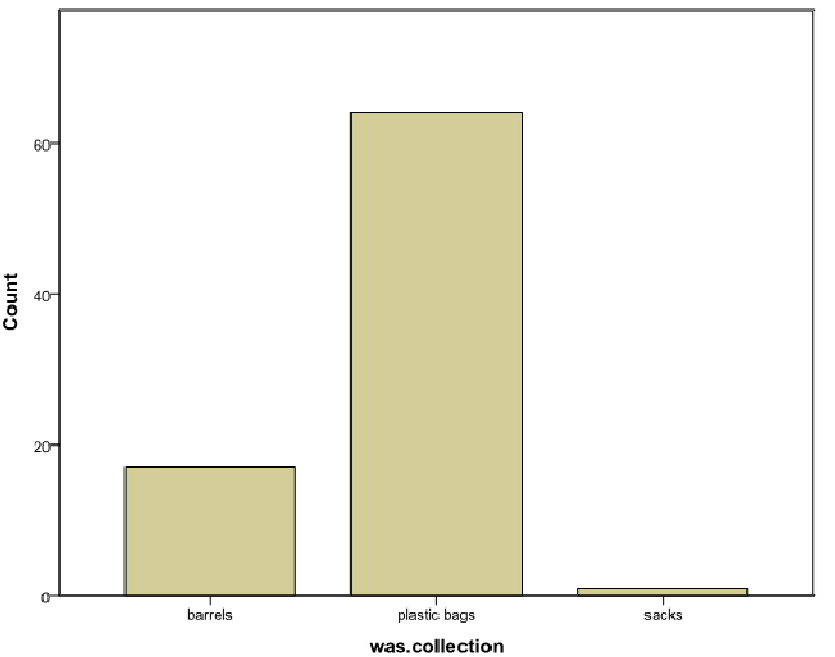

Figure 4. 8: shows waste collection methods adopted by the targeted groups

As it`s shown in table (4-13) and figure 4. 8, the dominant methods of solid waste collection is through the plastic bags (73. 6%) followed by barrels (19. 5%)

Table 4-13: shows waste location, before being transported for disposal, adopted by the targeted groups

Valid	Frequency	Percent
	5	5. 7
house yard	44	50. 6
in street	6	6. 9
inside kitchen	12	13. 8
near kitchen	19	21. 8
outside house	1	1. 1
Total	87	100. 0

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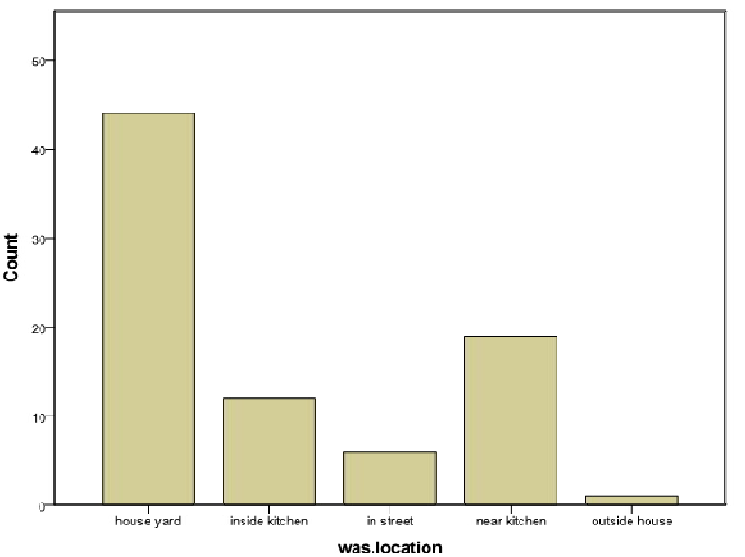

Figure4. 9: shows waste location, before being transported for disposal, adopted by the targeted groups

As it's shown in table (4-14) and figure 4. 9, the dominant waste location, before being transported for disposal, adopted is the house yard (44%). And rarely locating wastes outside houses and streets.

Table 4-14: shows domestic solid waste transportation through regularity of waste vehicles in terms of times per week for the targeted groups

Valid	Frequency	Percent
	5	5. 7
more than three times	1	1. 1
once	27	31. 0
three times	6	6. 9
twice	48	55. 2
Total	87	100. 0

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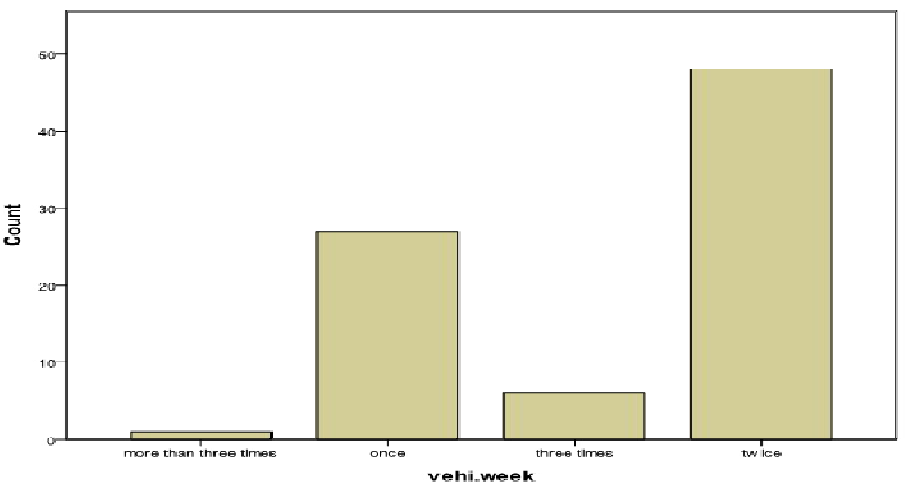

Figure 4. 10: shows domestic solid waste transportation through regularity of waste vehicles in terms of times per week for the targeted groups

As it's shown in table (4-15) and figure4. 10, the dominant pattern of regularity in transportation through waste vehicles is twice a week (48%) and once a week (27%)

Table 4-15: shows domestic solid waste alternative transportation for disposal method in absence of vehicles adopted by the targeted groups

Valid	Frequency	Percent
	5	5. 7
by cart	27	31
by my own car	31	35. 6
other place	23	26. 4
other places	1	1. 1
Total	87	100. 0

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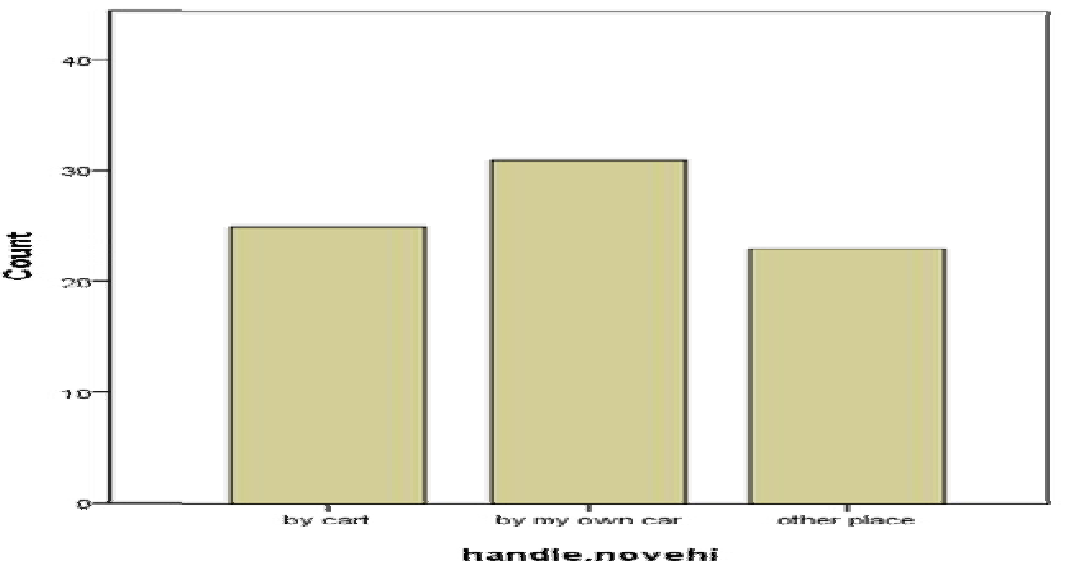

Figure 4. 11: shows domestic solid waste alternative transportation for disposal method in absence of vehicles adopted by the targeted groups

As it's shown in table (4-16) and figure 4. 11, the most of the targeted group transported their solid waste materials through their own cars (31%) and use draught animals through carts (27%) as two dominant methods adopted.

Table 4-16: shows the dumping areas of domestic solid waste before applying the system of vehicles adopted by the targeted groups

Valid	Frequency	Percent
	5	5. 7
adjacent to waste container	1	1. 1
grave yard	1	1. 1
other places	62	71. 3
vicinity	15	17. 2
waste collection areas	3	3. 4
Total	87	100. 0

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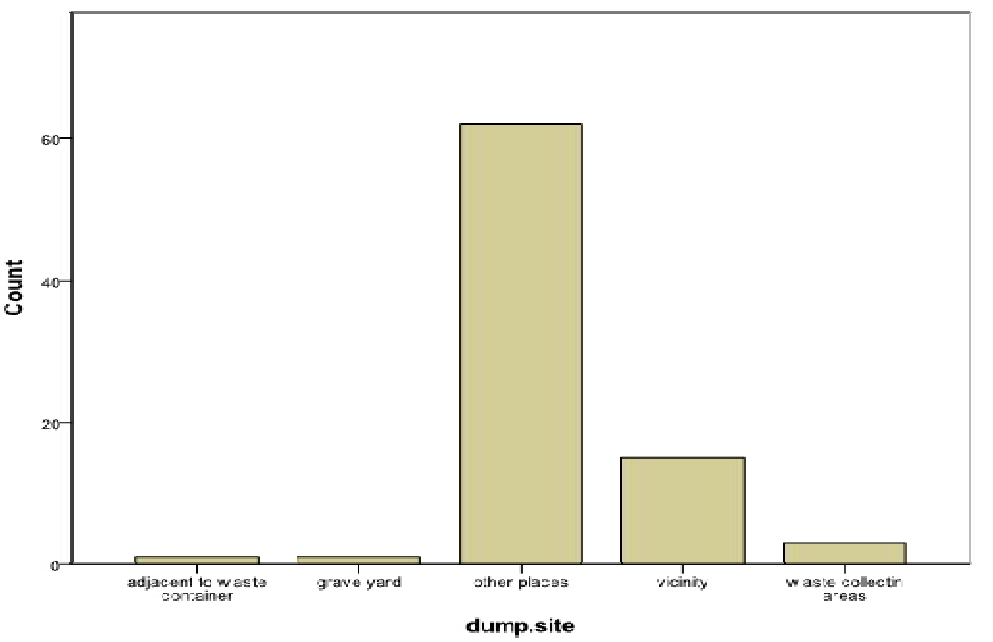

Figure4. 12: shows the dumping areas of domestic solid waste before applying the system of vehicles adopted by the targeted groups

As it's shown in table (4-17) and figure 4. 12, the targeted groups tend to use other places (62%) rather than the vicinity (15%), waste collection areas (3%) as dumping areas for daily produced solid waste materials.

Discussion:

The quantity of solid waste generated in Khartoum is 995,358. 5 tons \ year at a rate of 00,2-0,4 kg per capita for a day

Most citizens in the study area, rely on waste vehicle to get rid of their domestic solid waste and method of house-to-house collection beside the presence of containers for garbage collection upgrading and containers.

It appeared from interviews and questionnaire that waste vehicle pass on the house twice or more per week (table 7-15), and most of them use the plastic bags dominantly, table 3-1, as main collection tool and to less extent , barrels are the second choice which comprises the important part of solid waste management

There are a considerable number of citizens, (table7-16) retain their wastes in case of delay in the vehicle and this is evidence of the awareness of citizens in the region, although there is a small percentage of citizens throwing their waste in the process of sorting exercise. .

Data Analysis:

The acquired primary data was analyzed accordingly using Statistical Package for Social Science (SPSS) program. The third part of the questionnaire investigate the respondents about the domestic waste materials contents and containers used in collection and disposal.

Results:

The statistical analysis was concentrated upon the frequency tests for the qualitative data acquired from the answers of questionnaire prepared targeting sample of 83 persons in variable quarters in the three provinces of Khartoum states about contents of domestic solid waste materials produced by households in the area of study as well as containers used, and that was as follows:

Table 4-17: shows the variable mixes of domestic solid waste contents produced by the targeted groups

		Frequency	Percent
Valid		5	5. 7
	cardboard	1	1. 1
	cardboard-earth	1	1. 1
	food leftover	12	13. 8
	food leftover-cardboard- earth	1	1. 1
	food leftover-cardboard- other	1	1. 1
	food leftover-cardboard-glass-earth	1	1. 1
	food leftover-cardboard-leather-ceramic-glass-mineral-	1	1. 1
	food leftover-cardboard-plastic	11	12. 6
	food leftover-cardboard-plastic- glass-bones	1	1. 1
	food leftover-cardboard-plastic- ragged cloth-glass	1	1. 1
	food leftover-cardboard-plastic- rubber	2	2. 3
	food leftover-cardboard-plastic- rubber - glass	5	5. 7
	food leftover-cardboard-plastic- rubber-leather	1	1. 1
	food leftover-cardboard-plastic-bones	3	3. 4
	food leftover-cardboard-plastic-bones - earth	1	1. 1
	food leftover-cardboard-plastic-earth	1	1. 1
	food leftover-cardboard-plastic-glass	2	2. 3
	food leftover-cardboard-plastic-glass-bones	1	1. 1
	food leftover-cardboard-plastic-glass-minerals	1	1. 1
	food leftover-cardboard-plastic-glass-other	2	2. 3
	food leftover-cardboard-plastic-leather	1	1. 1
	food leftover-cardboard-plastic-leather-wood	1	1. 1
	food leftover-cardboard-plastic-minerals	1	1. 1
	food leftover-cardboard-plastic-other	1	1. 1
	food leftover-cardboard-plastic-ragged cloth-glass	1	1. 1
	food leftover-cardboard-plastic-rubber	2	2. 3
	food leftover-cardboard-plastic-wood	2	2. 3
	food leftover-cardboard-ragged cloth	1	1. 1
	food leftover-earth	2	2. 3
	food leftover-other	2	2. 3
	food leftover-plastic	3	3. 4

	food leftover-plastic-bones - earth	1	1. 1
	food leftover-plastic-earth	4	4. 6
	food leftover-plastic-glass	4	4. 6
	food leftover-plastic-other	1	1. 1
	food leftover-plastic-ragged cloth	1	1. 1
	food leftover-plastic-rubber	1	1. 1
	food leftover-wood-earth	1	1. 1
	other	2	2. 3
	Total	87	100. 0

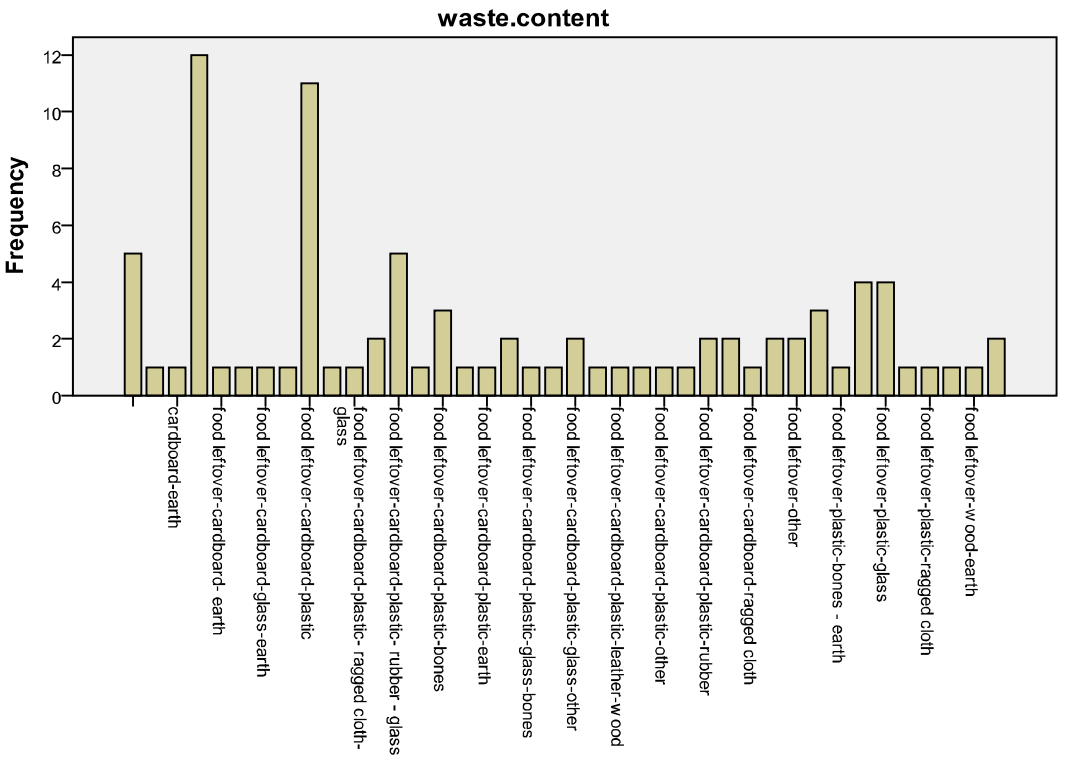

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Figure 4. 13: shows the variable mixes of domestic solid waste contents produced by the targeted groups

As it`s shown in table (4-18) and figure 4. 13, the dominant mixes of domestic solid waste contents produced at domestic level in Khartoum state is mainly food leftovers (12%) followed by the mix of food left over ,cardboard and plastic (11%).

Table 4-18: shows waste containers types adopted at domestic level by the targeted groups

Valid	Frequency	Percent
	5	5. 7
barrels	17	19. 5
plastic bags	64	73. 6
sacks	1	1. 1
Total	87	100. 0

GGraph

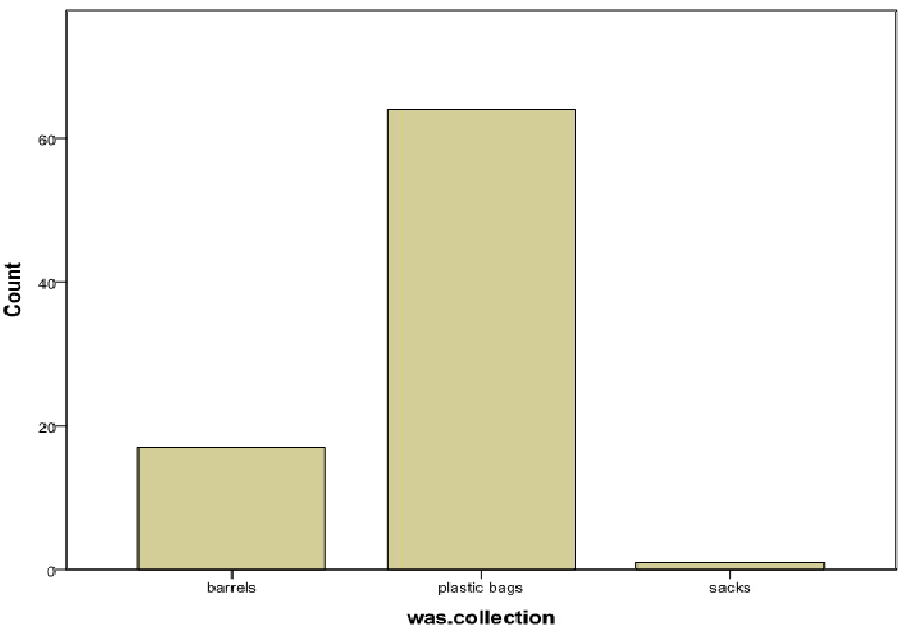

Figure 4. 14: shows waste containers types adopted at domestic level by the targeted groups

As it`s shown in table (4-19) and figure 4. 14, the dominant waste containers types adopted at domestic levelfor solid waste collection is through the plastic bags (73. 6%) followed by barrels (19. 5%).

The proposed system for the disposal of waste according to the point of researcher: In studying the current system, it was found that it is House to House system for waste disposal. The total time for the collection of garbage from (40) houses is an hour and 40 minutes to extract the garbage from all homes with one minute for every home and 20 minutes to operate the vehicle.

- **The Proposed system (Truck to Truck).**

From container to container by the equation:

t = d \ v

t = time (time per minute)

d = distance (meter)

V = Velocity Speed

With compensation in the equation below, we found that the time taken is (V)(minutes of the proposed system has provided (53) minutes from the current system.

Capcity of truck =Tc

Family Production =Fp

Number of House = HNO

HNO = $\frac{Tc}{Fp}$

Since the garbage car comes every 3. 5 day i. e twice a week

HNO = $\frac{HNO.d}{13}$ = 40 house

HNO. d = the number of houses per day

K = value of second (twice a week)

The source of the vehicle to collect garbage that is, every day 3. 5days.

Existing container capacity in the residential sector.

Containers:

Container capacity 2 yards (1,500 liters) is suitable for the residential sector and some small streets and markets downtown.

Advantages of this container:

1. They are emptied by compactor car
2. They are placed in the residential sector, government institutions and small shops.

Disadvantages: Their wheels are damaged by either fire or wrong use and that will lead to difficulty in discharge or dispersion of waste that inside.

Other types of containers:

Household containers: In the range of (40) liters i. e assembly of (3½) day (half week) (previously reported that the size of single-family daily production of garbage is between (3½ liters per day to 40 liters).

Streets containers: Determined (180 liters). Container capacity 6 yards between 4. 5 m3 equal to 450 liters in large spaces in neighborhoods and in medium and small markets and its advantages to unload cars placed in the main streets stages that are difficult for vehicles to enter unpaved streets and they are served by containers. Container with 10 m3 capacity collect waste materials from large markets, factories, private companies. A sample of the third class dwelling quarter that has (40) houses was taken to conduct experiment of transporting a greater amount of homes trash container (2

yards) and shorten the time of garbage cars trip to the intermediate or final landfill station. Since the daily per capita production of garbage is 0. 6 kg

Density is 1 - 2. 8

The family production (while the average number of family is 6 member according to data conducted)

6 × 0. 6 = 3. 6 kg per day

The size produced by family = liters per day

3. 6 × 2. 8 = 10. 08 = 10. 1

Size:

Kg equivalent = 1 liter

Ton is equivalent to m3

Current container capacity in the residential sector: Container capacity existing in the residential sector is 11. 5

2-yard 1458 liters \ Day -1500 liters \ Day

The number of houses served per container a day in 1500/10. 00 almost 142 meters yards equals 150 houses daily

Because the garbage car comes 3. 5 days a week (twice a week)

The number of houses that fill the container of 3. 5 day

$= \frac{150}{3.5} = 80$ 41 – 40 house

Time:

- The time it takes to take (40) house in (3. 5) day for the current situation (House to House) is 40 minutes (i. e. minute per home) with (20) minutes of the movements of the vehicle from one house to another, taking into account in the process of running the car machine and meanders of the streets . i. e the total time spent is

D+ T = M i. e one hour

40 +20 = 60 i. e one hour

- The time it takes to take (40) house in (3. 5) day for the proposed system (Truck to Truck) in a dusty street, there are no meanders and asphalt.

Time = $\frac{distance}{speed} = \frac{150\ m}{20\ km/h} = \frac{150}{20x60}$ = 1 minute + 45 seconds (the other to try to run the 2 \ 3 1 = 2)

Note that when the container is filled, car takes (5) minutes (proved studies and experiments)

• Total time spent in this system is 5 minutes (to unload the container) + 1minute (from container to container with an attempt operating = 7 minutes

Note:

From the table below we can deduce that the new proposed system for waste collection and disposal is time and cost effective saving 53 minutes spent in waste collect and transportation operations. So, the system ensures speed in collection and consequently lead to healthy dwelling environment

Table 4-19: Time saved is 53 minutes from the current system.

1	2	3	4	5	6
7	8	9	10	11	12

Source: researcher

4. 3Discussion of Interviews:

It appeared from interviews and questionnaire that the major content produced in the domestic waste materials in Khartoum is food leftover (table 7-18) which accompanied by other contents materials in variable mixes. According to the study, the researcher has furnished 30 mixes alternatives of other content materials of domestic wastes such as cardboard, plastic,ragged, cloth, glass. . etc. and from analyzing the obtained results it is suggested that the dominant nature of domestic waste materials produced in Khartoum state is more organic rather than other industrial and physical types.

Also, the dominant containers used for temporary storage of domestic waste materials at house hold levels is through plastic bags (table7-19) followed by the barrels and at the bottom comes the sacks and this suggests an increased degree of awareness about using the modern house hold containers for temporary waste storage .

The secondary data analysis revealed that containers were to apply in all the stages of wastes collection and storage so as to reduce cost and maintenance of sanitation for the citizen's interest.

Solid waste management Key Performance Indicators (KPIs)

Judgments about quality of performance in relation to specified standards may be based on general impressions; general opinions with supporting appropriate evidence [66]. Decisions should be made about some specific items of information that can be expressed in quantitative terms and used as performance indicators. These should be identified in advance as part of a planning processes and may be used consistently to monitor performance, provide for comparisons of performance between units, and permit authorities,

committees and administrators to monitor overall quality on a continuing basis. Data on these indicators should be collected in standard form and retained in a central data base so there can be comparisons within the facility and over time. An evaluation of the effectiveness of these processes will consider whether appropriate indicators have been identified, whether the data is consistently collected and recorded, and whether the information is used in monitoring and analyzing quality of performance [66].

Identifying certain key performance indicators, KPIs, for information collection and attitude significance has several objectives such as: provision of common set of statistical data that can be used for comparisons of performance and benchmarking and assisting monitoring quality of performance of system as a whole.

KPIs ought to be introduced to assess, evaluate and monitor solid waste administrative factors and management of quality and improvement in municipal solid waste schemes and programs. Suggested indicators may include, but not limited to, service performance (physical asset, staffing, operational, customer satisfaction, difficulties in collecting the data required to use the available systems of performance indicators, lack of skilled personnel), financial and economic performance (financial resources for efficient operations) and accountability indicators. Municipal solid waste related indicators would be a valuable addition to such a protocol and patterns of solid wastepracticemaybe evaluated for adding to the list of KPIrs[61]. Individual KPIs also ought to be evaluated with respect to its understandability, measurability, and comparability (i. e. , within and across solid waste utility comparisons) [62, 67].

Figure (4-15) and table (2) gives a general summary of recommended KPIs. The list ought to be improved by adding additional indicators that relate to specific public solid waste criterion, issue, objective, and priority for improvement, reduce, reuse, recycle and rethink domains.

Indicator Standard/Broad Area													
Accountability and Liability	Administration & Support Services	Community Service, Raising Public Awareness & Participation	Context and Framework	Customer Service Functions	Facilities & Equipment	Financial Planning, Economic Perfomance & Management	Functioning and Operational	Governance & Administration	Health and Well-being Related	Research and Development	Service Performance	Training & capacity building Performance	Environmental& social satiation

Fig. (4-15): Recommended KPI's comb.

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Table (4-20) A General Summary of Recommended KPIs. [16, 61- 63, 68-70]

Standard/Broad Area	Key Performance Indicator	Need & Level at Which Data is Required
Accountability and Liability Indicators	• MDGs parameters as per strategy • Fragility of the country • Change in solid waste production and generation patterns	• Need: record systems must be reliable and responsive, with confidentiality of records maintained in keeping with stated policies • Level: public and private sectors
Administration and Support Services Indicators	• Ratio of employees to administrative staff • Proportion of total operating funds allocated to provision of solid waste services. • Staff evaluation of professional & career counselling	• Need: rights and responsibilities must be clearly defined, understood, with transparent and fair procedures available for discipline and appeals • Level: Institution and municipality
Community Service, Raising Public Awareness &Participation Indicators	• Proportion of staff actively engaged in community service activities. • Number of community education programs provided as a proportion of the number of departments • Number of NGOs and CBOs handling solid waste agenda	• Need: availing facilities & services to assist community developments, encouraging staff to be involved in community education programs, perceptions, development projects, monitoring, strategies, participation, services & activities to assist individuals, organizations • Level: Institution
Context and Framework Indicators	• Natural context (Population growth, availability of solid waste reuse/recycling/reduce facilities, rainfall, climate change),	• Need: benchmarks when assessing achievements • Level: institutionand

	• Infrastructure (solid waste collection, transferring, sorting and treatment capacity, transfer stations andstorage), • Human and economic capitals.	municipality
Customer Service Functions Indicators	• Volume/weight records, accounting, control • Customer relations and management	• Need: Satisfying customer requirements • Level: Institution
Facilities and Equipment Indicators	• Annual expenditure on equipment as relaed to number of staff. • Number of accessible equipment per staff • Average overall rating of adequacy of facilities and equipment in a survey of staff.	• Need: resources and provisions must be planned to meet the particular requirements of institution's programs and provided at an adequate level • Level: Institution or municipality
Financial Planning, Economic Performance &Management Indicators	• Financial accounting of expenditures for solid waste collection, transfer, sorting, segregation, treatment and final disposal • Total operating expenditure	• Need: for efficient operations • Level: Institution
Functioning and Operational Indicators	• Physical asset, • Staffing • Operational • Customer satisfaction, • Difficulties in collecting data required to use available systems of performance indicators, • Availability/lack of skilled personnel • Laboratory investigation, testing and reports • Interviews with staff, employers, and users • Solid waste properties (annual reuse/reduce/recycling of components as a ratio of total amount generated and produced • Zero solid waste goal • Solid waste actually disposed of and/or beneficially utilized • Solid waste diversity (per sectors: municipal, agriculture, domestic, industrial over total production) • On stream waste potentialities: (change in production and generation • Trade &waste reuse/recycle	• Need: describing the dynamic functioning of the water sector at the national level • Level: Laboratory and R&D sectors

	• Share of white, green, waste used with added value in the Sudan	
Governance and Administration Indicators	• Waste management and control. • Policies, strategies & plans. • Documents relating to decisions by authorities. • Assessments and survey results. • Policy documents and regulations. • Risk assessment analyses. • Oversight of controlled entities. • Discussions with staff. • Survey results with stakeholders. • Information on websites and social media platforms. • Advertisements. • Awareness of requirements on the part of staff. • Faculty & staff employment processes. • Proportion of staff leaving institution for reasons other than age retirement. • Proportion of staff participating in professional development activities. • Legislation/institutions that support plans • On job training & development.	• Need: to track explanations, differences, levels of performance, diagnosis of possible weak spots stipulating further investigation and possible improvement or reforms. • Level: governing body and major committees,
Health, Wellbeing and Environs Related Indicators (Patterns of Cleanliness Behaviour)	• Disease and injury incidence • Mortality rate (general, infant) • Morbidity rate • Life expectancy • Injuries, damages, wounds and harms to labours, workers, collectors and scavengers	• Need: within and across utility • Level: institution and enterprise
Research and Development Indicators	• Number of refereed publications per staff. • Number of citations in refereed journals per staff. • Proportion of full time member of staff with at least one refereed publication • Number of papers or reports presented at professional conferences per staff . • Research income from external sources as a proportion of the number of staff • Proportion of total operating funds spent on research • Number of web site subscriptions as a proportion of the number of programs & achievements • Employees evaluation of services • Internet bandwidth per user	• Need: with a research strategy consistent with obligations, staff be involved in sufficient appropriate activities to ensure remaining up to date with developments & technical updates • Level: Institution and municipality

Service Performance Indicators	• Efficiency/productivity • Effectiveness & impact • Access to waste disposal or reuse facility • Value added in agriculture or industry (productivity) • Solid waste treatment and disposal rates • Solid waste properties and quality control	• Need: considering the functioning of sector in relation to its objectives and within a given context &provision of institution-wide support services • Level: institution and utility .
Training & capacity building Indicators	• Ratio of trainees to staff • Trainees overall rating on quality of training. • Proportion of staff with verified professional qualifications	• Need: ensuring that programs meet high standards of approvals, monitoring of performance, and provision of services Data acquisition for all • Level: Institution, utility

The Role of Computer Modelling and Applications

Computer programming and applications in the solid waste reduce, reuse, and recycle field has many uses (See figure 1):

- Use of social media and the internet to broadcast guidelines, alerts and messages regarding reduce, reuse, and recycle of municipal solid waste.
- Professional training of solid wasteworkforceand employees in computer usage to help them develop useful protocols, good presentations and perform statistical analysis.
- Teaming between solid wastestaff,personnel and workers and professional programmers, forming cohesive units that efficiently will develop computer modules specialized for solving specific problems, monitoring performance indicators, plotting disease incidence and progression over

time, calculating hazardous and toxic solid waste concentrations, and other health or environs related tasks and duties.

- Development of nationwide databases that hold information about solid waste reduce, reuse, and recycle programs, their respective data (contaminant concentration, biodegradability, prevalent pathological entities, etc.), and the scaling of their performance indicators over time.
- International coalition between country-specific databases for exchange of information, and development of international protocols
- Programming of specialized websites with dedicated database servers to provide an open access information database for the public and media.

The advocated RASE (Resources, Activities, Support and Evaluation) model is a suggested platform for the interactive management of solid waste reduce, reuse, and recycle systems. The components of the model are (summarized in Figure 4-16):

- **Resources:** these include databases, both on- and off-line, including data about the solid waste reduce, reuse, and recycle systems, contaminants and hazards involved, and the guidelines/protocols applied to the system. The online (web) content is becoming a centerpiece in the resources used in the model, including specialized websites, applets, database servers, social networks and media, Rich Site Summary,RSS and newsfeeds.
- **Activities:** includes solid waste research (ranging from case series and reports, to cross-sectional and cohort studies, and randomized controlled trials, RCTs. Combination of different sources and studies culminating in systemic reviews and meta-analyses). This step also involves application of evidence-based research and technology into both the observational and interventional types of studies.

- **Support:** merging data gathered from the resources and activities, to formulate protocols, prepare user-friendly frequently asked questions (FAQs); and involves broadcasting this information through online systems discussed under "Resources" above.
- **Evaluation (assessment):** the step of collecting user feedback, interpreting report data, reading online forum material, applying various statistical tests to validate studies' results; and then compiling these into a set of guidelines, updates and enhancements, applying the updates/patches, and starting a new cycle.

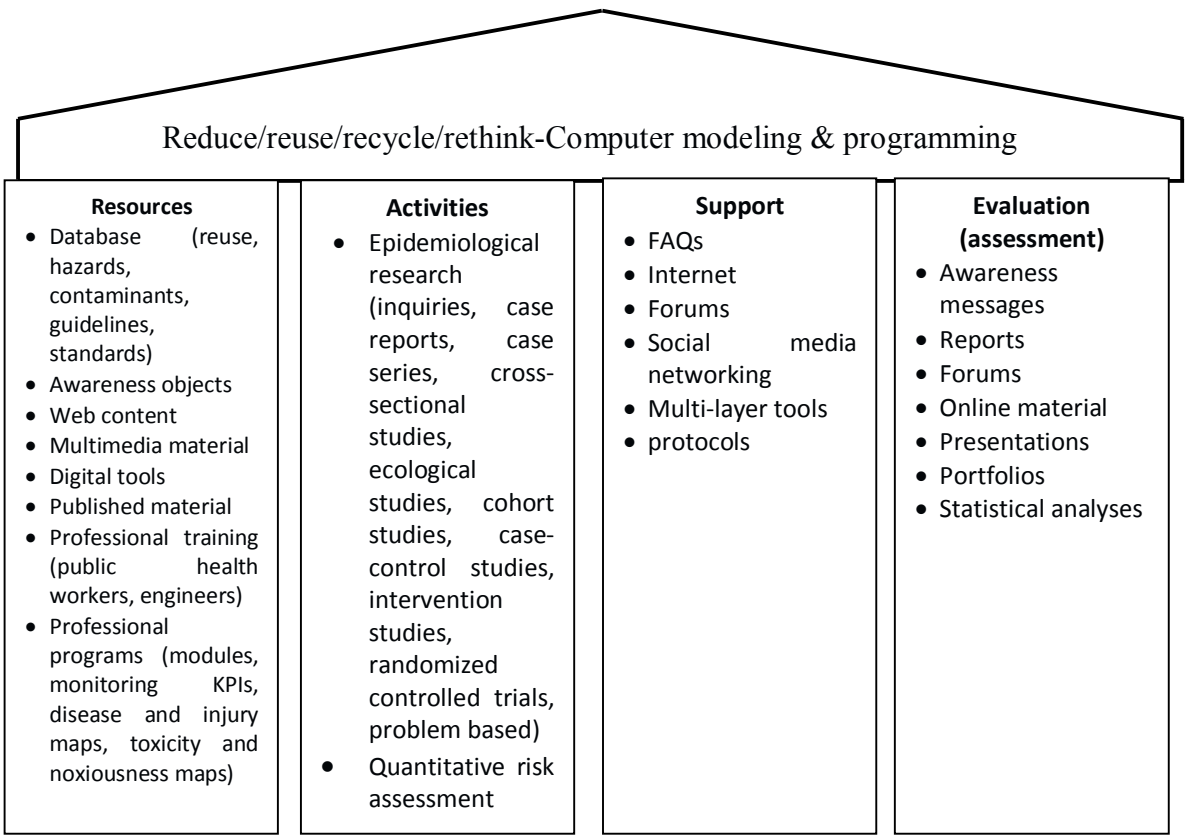

Fig. (4-16) RASE 4-Pillar for augmenting Solid Waste Reuse, recycle, reduce, and rethink - Computer Modeling Bond.

Chapter Five

Conclusions and Recommendations

Chapter Five

Conclusions and Recommendations

5-1Summary of results:

- The domestic waste is generated in greater Khartoum containing materials that can be utilized such as organic materials, iron, glass, rags, plastic, wood, bone and rubber.
- The quantity of solid waste generated in the region 995,358. 5 tons \ year at a rate of 00,2-0,4 kg per capita for a day It was clear that the organic materials constitute the largest percentage of domestic solid waste in greater Khartoum. Most citizens in the study area, 83. 3%, rely on waste vehicle to get rid of their domestic solid waste and method of house-to-house collection beside the presence of containers for garbage collection upgrading and containers. It appeared from interviews and questionnaire that waste vehicle pass on the house twice or more per week (96. 7%),
- There are a considerable number of citizens,76. 6%, retain their wastes in case of delay in the vehicle and this is evidence of the awareness of citizens in the region, although there is a small percentage of citizens (1%) throwing their waste in the process of sorting exercise.
- The sorting of domestic solid waste is not carried out in scientific manner to recycle the beneficial substances, whether at the source or intermediate stations and that is attributed to the absence of the plan and the program despite the fact that 60% of citizens expressed their willingness to sort their solid waste and These are encouraging ratios to be the beginning of a screening program.

The citizens are compelled to pay waste fees (90%) and participation in sanitation campaigns (60%) and dissatisfaction to burn solid waste near their homes guide the awareness of the citizens of this region of the importance of service and maintain the health and the environment, however, there are 50% of them prefer to use plastic bags when shopping and 60% of them expressed their unwillingness to enter for the manufacture of organic fertilizer and a negative trend that can be corrected to raise awareness of the participation of civil society organizations in reducing the amount of generated solid waste in the Khartoum area garbage containers in houses do not comply to the health and environmental requirements if tends to be exposed to flies and prone to scattering of solid waste . project succeeded to remove the accumulation of solid waste in greater Khartoum and removed the negative phenomena prevailing before the establishment of the project, as it is confirmed by the environmental , administrative and health indicators prevailing in the region (density of flies – offensive smells - the presence of the waste at the site allocated to them - a lack of commitment from citizens . . . . etc.)

In the absence of a program for sorting, there is no recycling of the contents of domestic solid waste in greater Khartoum and the main reason is absence of a real market for materials that can be excreted from the solid waste. Also, there is no program for processing organic materials and extraction of organic manure, despite the economic, environmental and health importance of these processes.

5-2Recommendation:

1. A clear program for sorting (see figure 5-1) and coordination (see figure 5-2) between the consumer and the investor should be developed to find a market and create incentives such as the sorted materials for homeowners pricing and reduce electricity, water and energy to the owners of the factories fees. And the need to provide the necessary health barges \ bags or drums) to facilitate the task of the individual.

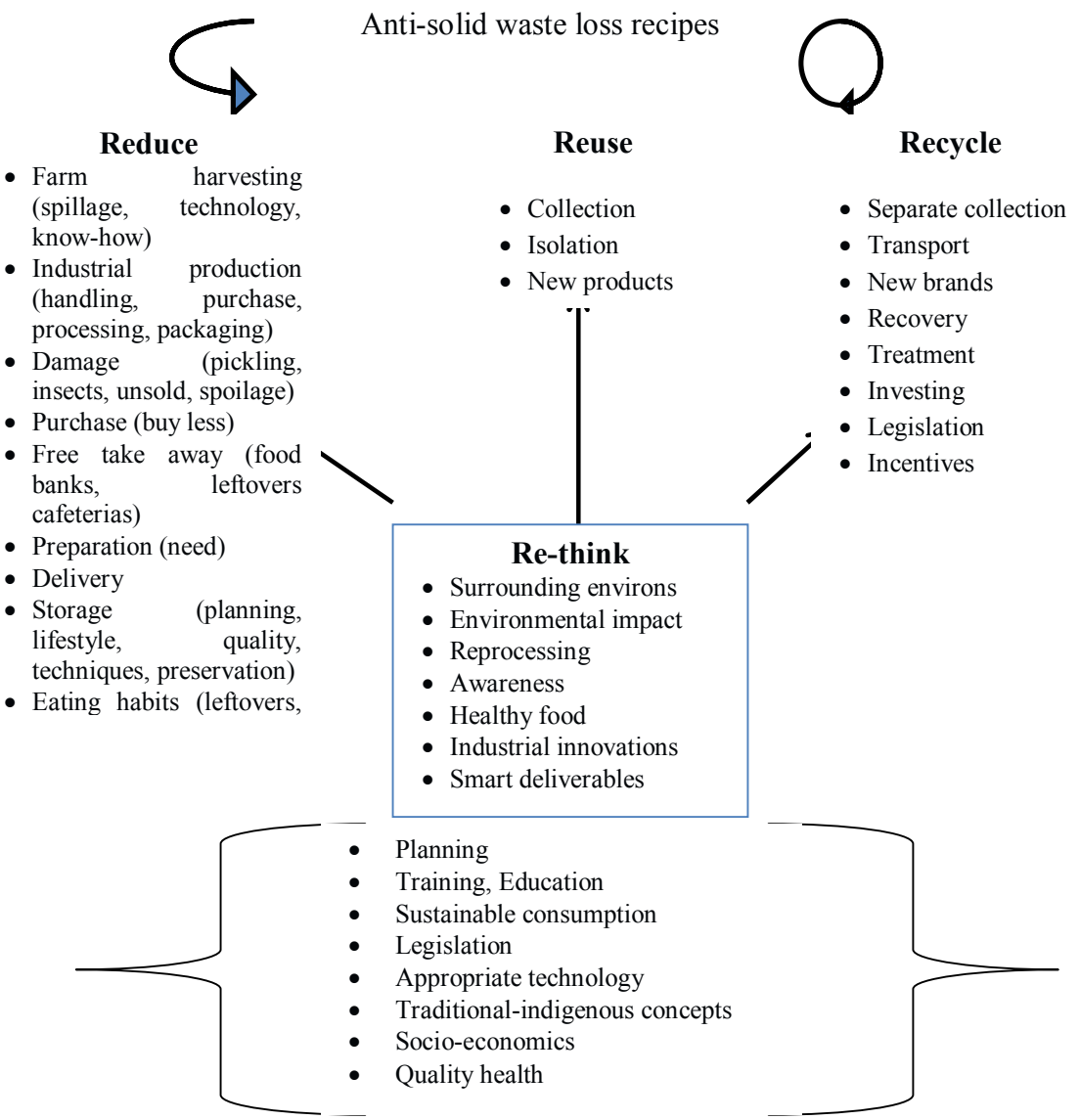

Fig. (5-1) Anti-solid waste perception.

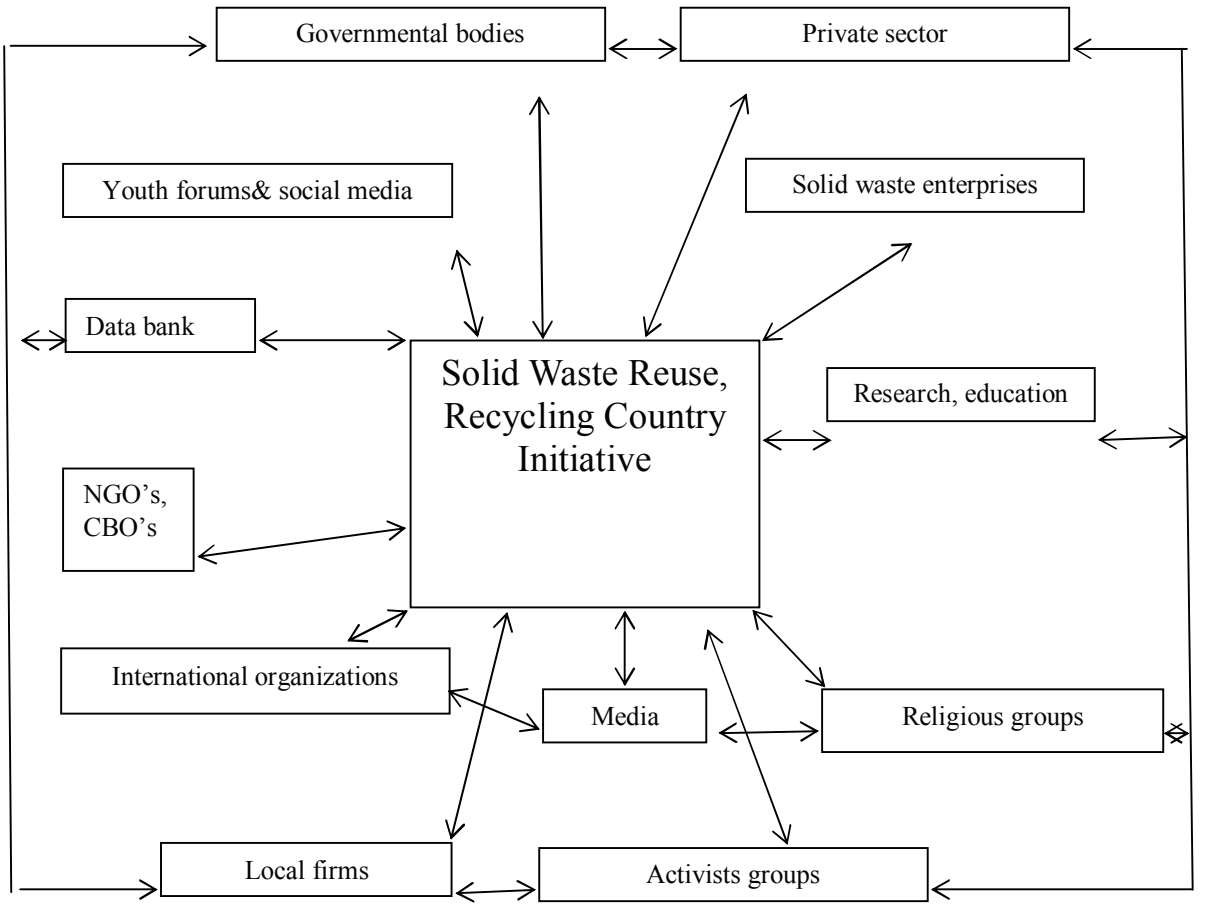

Fig (5-2) Coordination and collaboration between sectors dealing with municipal solid waste in the Sudan.

2. Encouraging companies and investors to enter into organic fertilizer industry and take advantage of sorted materials in recycling.
3. Work on the fairness of the distribution of transport vehicles. Especially, to the suburban areas in Khartoum to reach service rate up to twice or more per week and work to increase the rates of increase more than three times a week.
4. Coordination with production companies to introduce advanced cleaning technology and alternative materials for the production of goods for less polluted environment to get rid of plastic bags.

5. Encourage the participation of civil society organizations to raise awareness about proper disposal, security and economic domestic solid waste
6. The sanitation project should come closer towards landfill with environmental and health requirements.
7. Attention should be paid to clean side streets and alleys to allocate workers for this purpose and compel citizens to clean the area in front of their homes.
8. Dedication of prize for the best clean District to create a spirit of competition between neighborhoods.
9. Laying of barrels in street for pedestrians to be able to put waste in. Covering sewage and drainage to prevent accumulation. Determination of the roles and functions of each related parties (ministries, provinces, municipalities, voluntary associations etc. . . . .)
10. Providing political, moral and legislation support for the success of the project.
11. Providing annual financial budget (providing automatic and human components).
12. Intensification of media work to spread the objectives of the project on a larger scale.
13. Discussion and approval of the project work plan with all stakeholders and a commitment and full agreement on the specific responsibility of each party
14. Learning from past experiences and utilization from local and international experience.

15. concepts of cleanliness of the environment is included in all different stages of education and to encourage studies in the fields of dealing with waste processors and benefit from the manufacture of some components of private universities and institutes.
16. Establishment of a Department of environmental awareness is concerned with school and family awareness and industries and regular forces and employers. Where that environmental education is the only way to change the behavior of people to interact with the services.
17. Publishing a booklet in collaboration with the Ministry of Education that aims at how to deploy and conduct environmental education and the development of hygiene and the consolidation of thought among the citizens and the people of operations.
18. Preliminary categorization of states districts to 31 one to the sector within the seven major provinces with certain aids to provide all the work of the management and workers and equipment and the budget to run. 21. Increase the number of in the project so that the cleanliness of the project attractive for employment and run three thousand workers become in addition to training and raise their level of practical and cultural. So that those with a social worker hygiene and appearance of the value of good training and awareness of their role in developmental and social process.
19. Development of appropriate key performance indicators, KPIs, for municipal solid waste engineering and management for greater improvement and better utilization of reduce/recycle/reuse opportunities, projects, programs and facilities.
20. Coordination and cooperation between different partners and stakeholders addressing reuse/recycle/reduce of municipal solid waste streams should be

carefully chosen, accredited, monitored, evaluated and frequently upgraded.

21. Use of the RASE model (Resources, Activities, Support, Evaluation) to apply computer programming and modeling, and the use of social media and online material/content, to solid waste reduce/recycle/reuse/rethink systems and arrangements.

Recommendations for further work

1. Adoption of RASE model by other states in the country.
2. Launching a national SW road map and strategic plan initiative.
3. Establishment of Integrated Solid Waste Management, ISWM, enterprise to address strategic & operational planning issues & tasks.
4. Introduction of SW data bank in the country.
5. Establishment of sound SW legislations and codes of practice.

5-3 Conclusions:

1. One of the major reasons of environment deterioration is the improper handling of domestic waste materials that are daily produced from houses. And there is no potent solution for that matter in Sudan till now for collection and disposal of wastes in the assigned locations, as it is clearly apparent in many parts of the national capital each day. The waste mass increases every day with population increase met by lack in waste materials collection.
2. For the traditional methods used in waste collection in the national capital, it is found that they are not sufficient to deal with such problem. According to the latest statistics by Ministry of Health and Environment about the waste materials quantity produced in Khartoum to be 4800 m^3 per day and just 800 m3 is transported every day. So, it is noticed that big figure doesn't take the shanty area wastes in consideration as well as the areas planned during 10 recent years. The above number will double if we revise the so-called statistics. This forms the base from which this study arises as it aims at laying solutions and recommendations for the proper methods of collection and transporting the domestic waste materials in way that incur efficiency for time use and manpower. For the improper management of domestic solid wastes leads to deterioration in public health of the society beside polluting water, air and soil.
3. Encourage participation of civil society organizations to raise awareness about proper disposal, security & economic domestic solid waste
4. concepts of cleanliness of environment is included in all different stages of education & to encourage studies in fields of dealing with waste

processors & benefit from manufacture of some components of private universities & institutes.

5. Establishment of a Department of environmental awareness is concerned with school & family awareness & industries & regular forces & employers. Where that environmental education is the only way to change the behavior of people to interact with the services.
6. Publishing a booklet in collaboration with the Ministry of Education that aims at how to deploy & conduct environmental education & the development of hygiene & the consolidation of thought among the citizens & the people of operations.

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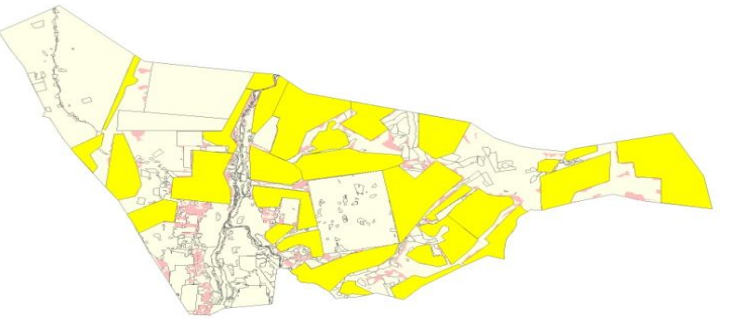
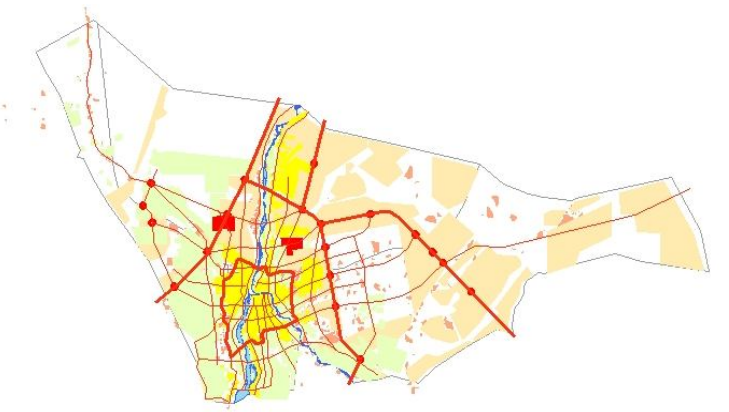
Appendixes

APPENDIX (1):



MapA-1: Urban Development Land selection Zones & Areas*[Source: Seif, 57]*



2018

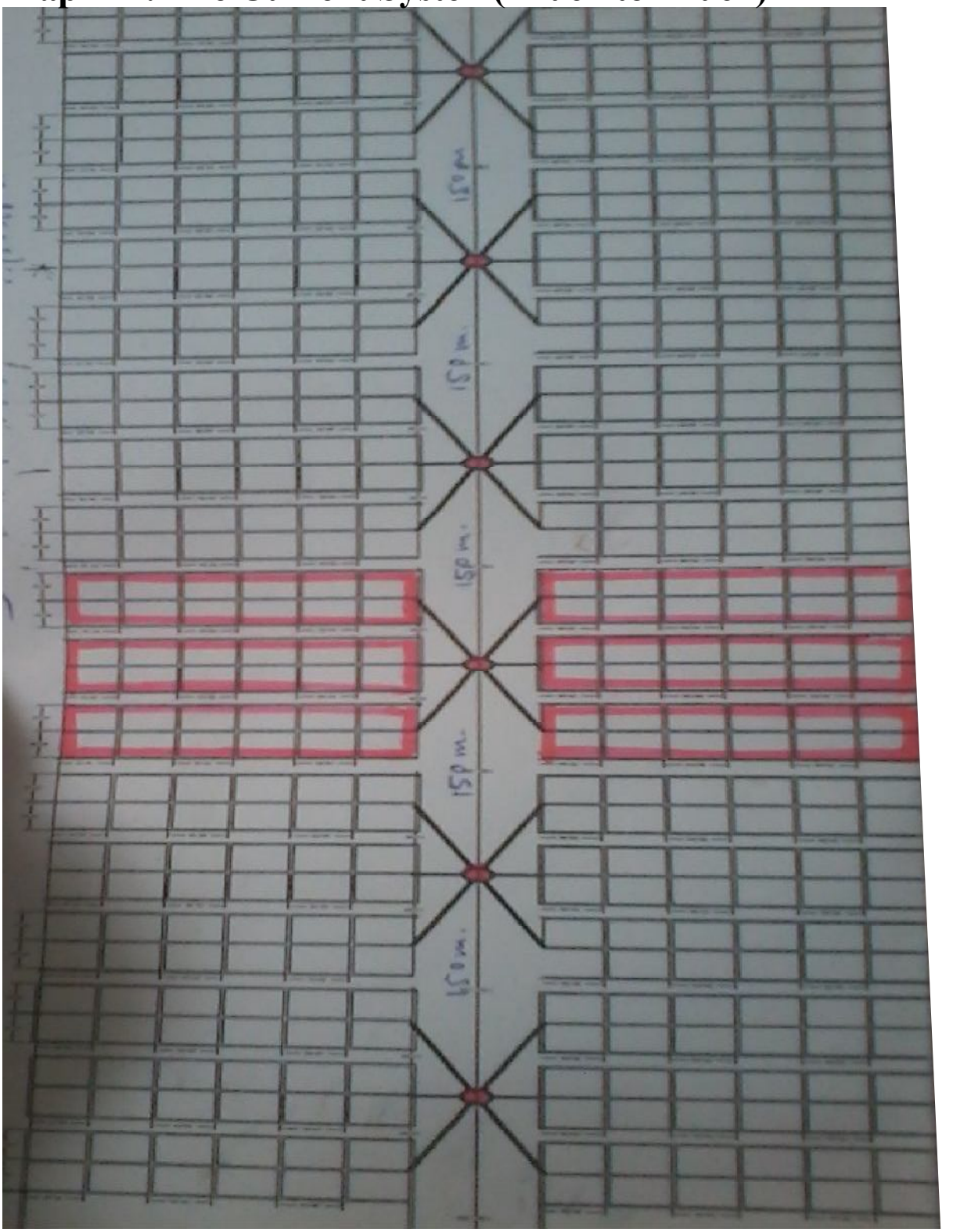
2023

MapA-2: Urban Development Connections Axis & Clusters*[Source: Seif, 57]*

Map A-3: . Khartoum2033 [*Source: Seif57]*

APPENDIX (2):

Map B-1: The Current System(Truck to Truck)



APPENDIX (3):

Tables showing the operating system after analyzing the questionnaire data through the statistical program.

Frequencies

Notes

Output Created		Jan 11th 2015 – 13: 34: 23
Comments		
Input	Data	C: \Users\Data soft\Desktop\analysis. waste\analysis. first. sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	100
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data.
Syntax		FREQUENCIES VARIABLES=Sample location fami. members qualification fath. jobav. salary. thou rooms build. Materialhouse. grade town /STATISTICS=STDDEV MINIMUM MAXIMUM MEAN MODE /ORDER=ANALYSIS.
Resources	Processor Time	00 00: 00: 00. 032
	Elapsed Time	00 00: 00: 00. 023

Source: SPSS

Frequencies

Notes

Output Created		١١-يناير-٢٠١٥ ١٤:٠٤:٠٢ AST
Comments		
Input	Data	C: \Users\Data soft\Desktop\analysis. waste\anayliss. first. sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	100
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data.
Syntax		FREQUENCIES VARIABLES=Sample location qualification /NTILES=4 /STATISTICS=VARIANCE RANGE MINIMUM MAXIMUM MEAN MEDIAN MODE SKEWNESS SESKEW KURTOSIS SEKURT /GROUPED=Sample location qualification /ORDER=ANALYSIS.
Resources	Processor Time	00 00: 00: 00. 047
	Elapsed Time	00 00: 00: 00. 065

Source: SPSS

APPENDIX (4):

Determining Sample Size[1]

In order to prove that a process has been improved, process capability must be measured before and after improvements are implemented. This allows quantifying the process improvement (e. g. , defect reduction or productivity increase) and translates the effects into an estimated financial result. When data is not readily available for the process, number of population members should be selected to ensure that the data is properly represented. Sampling also enables deciding on its suitability when collected[71].

Determining sample size is a very important issue because samples that are too large may waste time, resources and money, while samples that are too small may lead to inaccurate results. In many cases, the minimum sample size needed to estimate a process parameter, such as the population meanμ can easily be determined[71].

When sample data is collected and the sample mean $\bar{x}$ is calculated, that sample mean is typically different from the population mean μ. This difference between the sample and population means can be thought of as an error[2]. The margin of error E is the maximum difference between the observed sample mean $\bar{x}$ and the true value of the population mean μas presented by equation (1) and figure (1) [71].

$$E = {}^{z_\alpha}/_{2} \cdot \frac{\sigma}{\sqrt{n}} (1)$$

Where:

E = Error.

$z_{\alpha/2}$ = the critical value, the positive z value that is at the vertical boundary for the area of $\alpha/2$ in the right tail of the standard normal distribution.

μ = Population mean

σ = Standard deviation of population.

n = Sample size.

[1] How to Determine Sample Size, Determining Sample Size, http://www.isixsigma.com/tools-templates/sampling-data/how-determine-sample-size-determining-sample-size/

[2] Increasing sample size reduces standard error. Sample most likely becomes more representative of the population.

Standard deviation of population σmay be estimated from:

- ✓ Previous studies using the same population of interest.
- ✓ Conducting a pilot study to select a preliminary sample.
- ✓ Using a judgment or "best guess" forσ. A common guess is the data range (high – low) divided by 4.

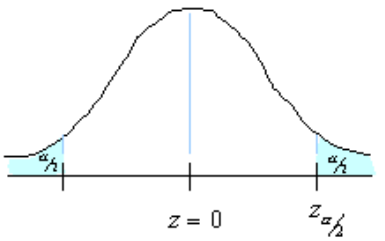


Fig. (1) Population mean and critical value (standard normal curve, z-curve) {1}.

Rearranging equation (1), one can solve for the sample size necessary to produce results accurate to a specified confidence and margin of error as shown in equation [72].

$$n = \frac{\left[z\alpha_{/2}\right]^2 \sigma^2}{E^2} (2)$$

Equation (2) can be used when one knows σ and want to determine the sample size necessary to establish, with a confidence of 1 -α, the mean value μ to within±E. Equation (2) can still be used even if one doesn't know the population standard deviation σ and when one has a small sample size. Although it's unlikely that one knows σ when the population mean is not known, one may be able to determine σ from a similar process or from a pilot test/simulation.

Sample size calculation for estimating solid waste generation (sample size for municipal solid waste source points)

1) Number of households are to be randomly selected in such a way that to be 95 percent sure that the sample mean is within 1 unit of the population mean. From a previous survey of household roof tanks it has a σ of 7.
2) Assuming a 95% degree confidence corresponds toα = 0. 05. Each of the shaded tails in Figure (2) has an area of α/2 = 0. 025. The region to the left of $z_{\alpha/2}$ and to the right of z = 0 is 0. 5 – 0. 025, or 0. 475. In the table of the standard normal (z) distribution, an area of 0. 475 corresponds to a z value of 1. 96. The critical value is therefore $z_{\alpha/2}$ = 1. 96.

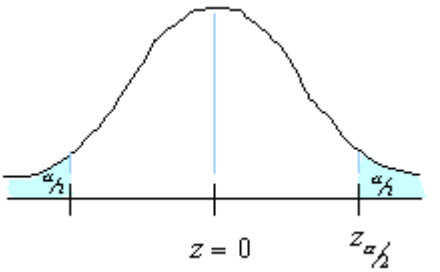


Fig. (2) Population mean and critical value [71].

Table (1) Degree of freedom and confidence level [74]

Degrees of Freedom	Confidence Level %			
	50	90	95	98
1	1.000	6.314	12.706	31.821
2	0.816	2.920	4.303	6.965
3	0.756	2.353	3.182	4.541
4	0.741	2.132	2.776	3.747
5	0.727	2.015	2.571	3.365
6	0.718	1.943	2.447	3.143
7	0.711	1.895	2.365	2.998
8	0.706	1.860	2.306	2.896
9	0.703	1.833	2.262	2.821
10	0.700	1.812	2.228	2.764
15	0.691	1.753	2.131	2.602
20	0.687	1.725	2.086	2.528
25	0.684	1.708	2.060	2.485
30	0.683	1.697	2.042	2.457
40	0.681	1.684	2.021	2.423
60	0.679	1.671	2.000	2.390
120	0.677	1.658	1.980	2.358
∞	0.674	1.645	1.960	2.326

3) Taking a margin of error E = 1 and a standard deviation $\sigma = 7$ and using the formula for sample size, one can calculate the sample size n as:

$$n = \frac{\left[z_{\frac{\alpha}{2}}\right]^2 \sigma^2}{E^2} = \frac{[1.96]^2 7^2}{1^2} = 188.2$$

Thus, there is a need to sample at least 189 randomly selected households. With this sample one will have a 95 percent confident that the sample mean $\bar{x}$ will be within 1 unit of the true population of the household or solid waste generation sites.

Sample Size Calculation for finding responses to questionnaire

1. Number of employees or residences to be interviewed may be determined from equation (3) [73].

$$n = \frac{N}{1+Ne^2} \qquad (3)$$

Where:
n = sample size
N = Total population number (employees or inhabitants)
e = error = 1 – confidence level

2. As such, the number of questionnaires to be distributed within the study area (Khartoum metropolitan area, KMA) depends on population size of around 200 solid waste companies, firms and enterprises{**????**}. The city is estimated to have around 5% of that number due to the huge building activities within. Taking this number (10) departments within KMA for distributing controlled number of questionnaires for them. This is due to limitations in human factors, working team and time constrains. This gives an estimate for number of enterprises to be interviewed to be taken as:

APPENDIX (5):

Questionnaire

In The Name of Allah

Questionnaire

Domestic Waste Materials Collection and Transportation in Khartoum State.

Date : …. /. . /…….

Researcher name: …….

Section one: General Information:

1- Father`s name…….
2- Neighborhood……
3- House no…… .
4- Family members……
5- Father`s literacy

Illiterate ( ) Primary ( ) Intermediate ( ) Secondary ( )

Graduate ( ) postgraduate ( )

6- Father`s occupation:

Labour ( ) employee ( ) free business ( ) other ( )

7- Average salary of the family father:

10000 – 25000SD ( ) 25000 – 50000SD ( ) 50000 – 100000SD ( ) more than 100000SD ( )

8- Number of rooms in the house

One room ( ) two rooms ( ) three rooms ( ) more than three ( )

9- The building materials of the house:

Ferroconcrete ( ) Bricks ( ) baked brick ( ) Grass ( ) Other ( )

Section two: Information about waste materials:

1. What are the disposed waste contents:

No	Contents	Tick
1	Food leftover	
2	cardboard	
3	plastic	
4	rubber	
5	Natural and manufactured Skin	
6	wood	
7	Ragged cloth	
8	glass	
9	Mineral	
10	bone	
11	Earth	
12	Other	

2- How do you collect wastes inside the house?

Plastic bages ( ) Barrel ( ) other ( )
specify……
……

3- Where do you locate waste materials?

Kitchen ( ) near kitchen ( ) yard ( ) other ( )
specify……
……

4- What is the frequency of waste vehicle coming for collection in the week?

Once ( ) twice ( ) three times ( ) more than three times ( ) Other ( )

5- To what extent the waste vehicles are committed to appearance in the area?

Committed ( ) not committed ( ) sometimes Other ( )

6- Do you pay the waste collection fees?

Yes ( ) no ( )

7- If the answer is "yes" how much do you pay as waste collection fees?

400 SD ( ) more than 400SD ( ) less than 400SD

8- Are you convinced with the fees you pay?

Yes ( ) no ( )

9- if the answer is "yes" , mention the reasons…….

…….

10- How do you handle your waste materials upon the absence of waste vehicles?

Transport it by cart ( ) Transport it by my own car ( ) Other ( )

11- Previous ways of handling wastes before vehicle services.

Dump in the vicinity ( ) dumped near grave yard ( ) Other places ( )