CITY SANITATION PLAN OF KHARTOUM

A DISSERTATION

Submitted in partial fulfilment of the requirements

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ENVIRONMENTAL MANAGEMENT OF RIVERS AND LAKES

By

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CANDIDATE'S DECLARATION

I hereby certify that the work presented in this dissertation entitled, "**CITY SANITATION PLAN OF KHARTOUM",** in partial fulfillment of the requirement for the award of the degree of **Master of Technology in " Environmental Management of Rivers and lakes",** submitted in **Alternate Hydro Energy Centre, Indian Institute of Technology Roorkee** is an authentic record of my own work carried out during the period from July, 2015 to July ,2015 under the supervision of Dr. ARUN KUMAR, Alternate Hydro Energy Center, Indian Institute of Technology Roorkee

The matter embodied in the dissertation has not been submitted by me for the award any other degree or diploma elsewhere.

Place: Roorkee

Dated: 6th, May, 2016

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CERTIFICATE

This is to certify that the above statement made by the candidate is correct to the best of my knowledge and belief**.**

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ABSTRACT

A City Sanitation Plan (CSP) addresses social, technical, financial, institutional, capacity building and stakeholders' participation towards sustainable infrastructural development for sanitation. A Plan has been prepared based on primary as well as secondary data collected after extensive search with various city level offices, field visits and covers population, projects and households from different localities.

Emphasis was made on Sewage system, solid waste management, bio-medical waste management and electronic waste management as prevailing in the various localities of Khartoum,

Khartoum city is the capital of Republic of Sudan and it also state is made up of three cities comprising of Khartoum, Khartoum North and Omdurman. The city lies between longitudes 31.5°E to 34 °E and latitudes 15°N to 16 °N enclosing a total area of 22,142 km2 (8,549 sq. mi).

The Population is 7 million with a growth rate of 2.7 according to the 2015 census. Out of this, 19% live in rural area while 81% are living in the urban areas.

Total number of Houses in the city is 871,142 with 693,974 in urban areas and 177.168 in the rural areas. The percentage of people with access to improved sanitation facilities is 51% while 49% still practice open defecation.

Presently about 1450 MLD water is supplied in Khartoum. The total quantity of sewer generation in Khartoum is about 802MLD in the last five years under operations of the Khartoum state waste water corporation.

The existing sewer system covers between 6% of the city's total wastewater generation. The Soba sewage treatment plant has a daily wastewater Flow is 35 MLD while Wad Defiaa sewage treatment plant has a capacity of 17 MLD. These bring a total of sewage treated from the two plants to about 52 MLD out of the 802 MLD sewage generation.

In terms of solid waste, Khartoum generates a total of 6,600 ton/day out of which 4,200 ton/day goes to the four landfills. Khartoum has four landfills three caters for municipal waste from Omdurman, Bahri and Khartoum. The remaining one in Dongla Street is mainly for hazardous waste.

There are also three transfer station in Omdurman and handling of solid waste more than 1,500 tons/day, Bahri solid waste more than 1500 tons/day. Estimated number of beds in all hospitals of Khartoum state to 6757 beds (2015), the bio-medical waste in Khartoum state estimated 12.5 to 15 tons/day around. 1,215 tons/day is treated by primary company. The hazardous waste from hospitals and health centers can be estimated as 2.5 to 3 tons / day. The Electronic waste volume from statistical structural plan of Khartoum State in 2013 is estimated at 1135 tons/Year (including

mobiles and computers), Number of working in the field of computers and accessories in Khartoum state companies 377 companies and 972 work name, the amount of mobile phone is very high relative to the rates exceeded the reasonable limit, and has become the amount contained in the period (2010 -2015) 140,000,000 Telephone Based on information from traders and companies specialized in the field.

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ABBREVIATIONS AND DEFINITIONS

AHEC: Alternate Hydro Energy Centre

BMW: Bio-Medical waste

CPS: City Sanitation Plan

COD: Chemical Oxygen Demand

KSWC: Khartoum State Water Cooperation

KSSC: Khartoum State Sanitary Cooperation

K-CSP: Khartoum City Sanitation Plan

KS: Khartoum State

FS: Financing Strategy

O&M: operation and maintenance

SFP: Strategic Financial Planning (or Plan)

SCEDL: Sudanese Company for Electricity Distribution

MWRIE: Ministry of Water Resources, Irrigation and electricity.

STPs: Sewage Treatment Plants.

MUP: Ministry of Urban Planning

MRB-KS: Ministry of Roads and bridges - Khartoum State

CCKS: Cleaning Cooperation - Khartoum state

UN: United Nations

PWC: Public Water Cooperation

SWC State Water Corporation

WES: Water and Environmental Sanitation

HCEA: High Council for Environmental Affairs

ULB: Urban Local Bodies

UNICEF: United Nation Children's Fund

UNEP: United National Environmental Program

WSS: Water Supply and Sanitation

WHO: World Health Organization

WASH Water, Sanitation and Hygiene

WFP: World Food Program WASH: Water and Sanitation Hygiene

Units:

Dia: diameter

Kg/day: Kilogram per day

Km: kilometer

KLD: kiloliter per day

Kw: kilowatt

m: meters

m/min: meters per minutes

MLD= 10^6 Litter per day

mg/l= milligram per litter

ppm: part per million

t/d: tone per day

Definitions:

BOD5 Biochemical Oxygen Demand (5-Day): The oxygen used in meeting the metabolic needs of aerobic microorganisms in water rich in organic matter - called also biological oxygen demand; the test requires five days of laboratory time and results may vary when toxic substances are present which effect bacteria.

DDT: Dichlorodiphenyltrichloroethane: A colorless odorless water-insoluble crystalline insecticide C14H9Cl5 that tends to accumulate in ecosystems and has toxic effects on many vertebrates.

Dissolved Oxygen (DO): The amount of oxygen dissolved in water. DO concentrations range from a few parts per million up to about 10 ppm for most Oklahoma streams. A level of DO around 7 ppm is essential to sustain desired species of game fish. If DO drops below 5 ppm the danger of a fish kill is present and malodorous conditions will result. The major factors determining DO levels in water are temperature, atmospheric pressure, plant photosynthesis, rate of aeration and the presence of oxygen demanding substances such as organic wastes. In addition to its affect on aquatic life, DO also prevents the chemical reduction and subsequent movement of iron and manganese from the sediments and thereby reduces the cost of water treatment.

Geographical Information System (**GIS**) is a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data. The acronym GIS is sometimes used for geographic information science to refer to

the academic discipline that studies geographic information and is a large domain within the broader academic discipline of geo informatics. What goes beyond a GIS is a spatial data infrastructure, a concept that has no such restrictive boundaries.

Latrine: can refer to a toilet or a simpler facility which is used as a toilet within a sanitation system. It can be a communal trenching the earth in a camp, a hole in the ground (pit), or more advanced designs, including pour-flush systems. Latrines are still commonly used in emergency situations, as well as in army camps.

pH : The negative logarithm of the effective hydrogen ion concentration or hydrogen-ion activity in gram equivalents per liter used in expressing both acidity and alkalinity on a scale whose values run from 0 to 14 with 7 representing neutrality, numbers less than 7 increasing acidity, and numbers greater that 7 increasing alkalinity.

ppm parts per million: This is a way of expressing very dilute concentrations of substances. Just as per cent means out of a hundred, so parts per million or ppm means out of a million. Usually describes the concentration of something in water or soil.

Sewage Treatment Plants (STPs): is the process of removing contaminants from wastewater, primarily from household sewage. It includes physical, chemical, and biological processes to remove these contaminants and produce environmentally safe treated wastewater (or treated effluent). A by-product of sewage treatment is usually a semi-solid waste or slurry, called sewage sludge, that has to undergo further treatment before being suitable for disposal or land application.

Suspended Sediment (SS): refers to small solid particles which remain in suspension in water as a colloid or due to the motion of the water.

Total Dissolved Solids (TDS): The complete amount of solid matter dissolved in water or wastewater

Total Solids (TS); The weight of all present solids per unit volume of water. It is usually determined by µg/L micrograms per liter Treatment plant: where the sewage is treated by physical and chemical methods.

Lift stations: used to pump and raise the sewage, height velocity, and pressure.

Pump stations: a structure that collects flow from a gravity system and pumps it through a force main, typically to a higher elevation.

Sewers: the pipes installed underground used to carry the sewage or rain water; they are divided into two types:

CHAPTER 1

INTRODUCTION

1.1 GENERAL

It is well known that half of the world's population, are now living in urban areas and this population has been growing in cities since ancient times. This phenomenon has contributed to the progress of civilization by focusing on culture , infrastructure and institutions. Also cities become better places to focus on economic opportunities and prosperity. This is still the positive aspects of life in the city, attracting people to the urban areas and urging them to stay.

There is therefore the need for cities to have a more efficient and sustainable waste management plan, to compliment anthropogenic actives toward achieving a more healthier , prosperous and esthetic environment.

1.2 CITY SANITATION PLAN

Sanitation can be defined as, a system for promoting sanitary health conditions. The use of the word 'system' suggests that sanitation is not primarily about physical facilities, but rather about the services that are provided through those facilities. It also suggests the need to consider sanitation services and facilities in terms of the social, institutional and financial systems that support them.

Sanitation is sometimes viewed in terms of either excreta disposal or solid waste management. In the much broader since however, promotion of sanitary health conditions also requires attention to storm and sludge water drainage as well as water supply.

This research focuses on proposing a more efficient and sustainable City Sanitation Plan for Khartoum.

City Sanitation Plan covers a very broad area including the following:

Awareness Generation, Sanitary Choices and Technical Options ,Operation and Maintenance, Service Delivery Systems , Institutional Responsibilities , Reaching out for the Poor and Unnerved Households , Legal framework, Responsibilities of Regulatory Institutional , Capacity of Building, Implementation Management, Technical Training, Monitoring , Supervision, City Reward Scheme, Planning and Financing.

1.3 IMPROVEMENT OF SANITATION

Different groups are likely to have different reasons for wanting to improve sanitation services.

1.3.1 Householders

The main concern here is often about the comfort and improvements in their immediate environment. Outlook sewage may be affected by social and cultural factors.

1.3.2 Health professionals

Health Professionals are primarily concerned with the health benefits and in particular the role of drainage to remove pathogens from the environment.

1.3.3Engineers

Engineers are often more concerned with the broader environmental aspect of the treatment and disposal of Waste, especially their effect on water resources ensuring an acceptable damage to major ecological components.

1.3.4 Politicians and local Councilors

Politicians and local Councilors may be concerned with all the above, but they will be aware that physical improvements in their constituencies will increase the number of people who vote for them.

1.3.5 Economists

They might argue that improvements in the health, environment and comfort are steps towards providing more economic benefits of a broader development perspective. Improved sanitation contributes to poverty alleviation through the reduction of exposure to diseases and allow people with low incomes to have better access to improved sanitation.

1.4 IMPORTANCE OF CITY SANITATION PLAN

City Sanitation Plan (CSP) is essential for addressing cities becoming free of waste , ensuring universal access and the basis to start planning towards achieving 100 % safe and sanitary disposal of waste.

The National Policy of Urban Sanitation (NUSP) recognizes that cities should consider a fully integrated system for city sanitation approach , covering the management of the waste in Sewage, Solid waste, Biomedical waste, Hazardous and Electronic waste with respect to Safe treatment and disposal.

1.5 THE OBJECTIVES OF THE CSP

Fundamentally, the objective of a CSP is to achieve a universal sanitation, to improve access to safe and hygienic sanitation facilities and disposal with respect to individual or communal toilets, for all urban population so that no one defecates outdoors.

it also aims to develop the management of sanitation facilitiesfor health life and environment ,savings in health care costs in terms of health agencies and individuals, saving time (working days gained) resulting from more convenient access to services and decreasing the dieses and pollution.

1.6 ELEMENTS OF CITY SANITATION PLAN

Generally, the following constitutes the elements of a typical CSP**:**Water supply , water treatment and waste disposal, solid waste management , biomedical waste management , public toilets and rainwater drainage .

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

Growth of civilization and subsequent needs for a better standard of continues life, to feature prominently in global issues.

Sustainable waste management is one major problem facing the world, today and especially the developing countries.

The main environmental problems comes from the pathogenic, with improvement of the world in several activates such as industrial, construction, technologies, agriculture and mining these urban improvement create environmental problems. The air, soil and water can damage if we didn't use proper planning and management to face this problem.

2.2 OBJECTIVE OF PREPARING CSP FOR KHARTOUM:

City Sanitation plan has many objectives, the main objective is keeping the environment save and achieving for treatment system , to solve all the environmental problems, save the natural resource of the cities, increase the finance income for the cities by proper plan, free open defecation with provide enough public toilets, operate proper collection and transportation systems for the all type of waste(sewage, solids, medicals, hazardous and electronic) to operate the treatment and disposal process by engineering design, reach for improved institutions arrangement ,financial sustainability , and establish a proper system operation and maintenance argument ,financial sustainability , and establish a proper system operation and maintenance.

2.3 OPEN DEFECATION

To reach for improved area residents have use arrangements of sanitation facilities and hygiene for in order to discourage people from defecating indiscriminately. In order to achieve this objective, they carry out the following activities :

2.3.1 Promote access to household sanitation facilities (including appropriate arrangements for disposal) .

2.3.2 Promote toilets and managed under the community whenever necessary , by groups of households that have space.

2.3.3 Effectively manage the sanitation in the areas in order to have cities free of open defecation.

2.4 WATER SUPPLY:

The water supply consists of providing water for, domestic , industrial , commercial and institutional, among other numerous uses by individuals through a system of pumps and pipes.

2.4.1 Source of Water Supply

2.4.1.1 Surface Water

Surface water consists of water from rivers , lakes, and the oceans. Surface water is replenished naturally by rain and springs ,and it has surface water on a small percentage of salts compared to groundwater containing high proportions of them.

2.4.1.2 Ground Water

Is that water beneath the soil surface and stored in the pores of the earth itself , and between the pores of the rocks and in the sand, gravel , and other rocks of the upper part of the Earth's crust components. Most groundwater arise from water leakage through the layers of earth by gravity towards the seas and oceans or flowing streams and rivers.

2.5 WASTE WATER:

It is water that are affected by contaminants , rendering it unfit for human use or other designated uses such as for agriculture, cleaning. Wastewater may be categories based on the generating source which broadely includes domestic, industrial, commercial and institutional, stormwater and water from agricultural fields.

2.5.1 Types of Waste Water

2.5.1.1 Domestic Sewage

Domestic wastewater is that black or grey water comes from domestic or social uses such as faces, urine, bath water, washing and water of kitchens.

2.5.1.2 Industrial Waste Water

Industrial wastewater comes from industrial pollutants, such as mining and factories and industrial water and this activates source has so many hazardous pollutant and chemical and may be toxic component that why prefer to treat this type of water separated not combined.

2.5.1.3 Agricultural Waste Water

Agriculture waste The presence of water above agriculture field, and the collection of this type so important Because not collect , it affects the environment , agriculture and human and causes humans and plant diseases.

2.5.2 Waste Water Treatment and Disposal

More importantly, sewage treatment goal is to eliminate pathogens and pollutants that are harmful to human, plants and animal life. In general , water treatment schemes aims at protection of ground and surface water sources to prevent the spread of diseases, protect plant and animal life, prevent sediment flow into water bodies.

The Treatment can be divided to several levels and the treatment process itself can be used for different types of basins in addition to the diversity of possibilities to choose methods of contaminated runoff to be treated within the plant. Treatment involves Physical , chemical and biological treatment..

2.6 SOLID WASTE

Solid waste is also referred to as garbage . This includes domestic, commercial and residential areas of municipal solid waste or semi-solid with the exception of hazardous industrial waste.

2.6.1 Solid Waste Management (SWM)

Solid waste management collection, storage, segregation, transporting, , treatment and disposal. This process chain is referred to as the Life cycle of Municipal solid waste.

2.6.2 Life Cycle of MSW:

2.6.2.1 Collection Of SW:

It includes not only the collection or capture of SW from various sources , but also to refer to the location where the contents of the collection and unloading of vehicles .

2.6.2.2 Transportation of SW:

Transport of waste stored in waste repositories is essential to ensure that no bins or containers overflow and waste is not seen littered in the streets.

2.6.2.3 Disposal (Landfill):

The operation of the unit to the disposal method designed and engineered with the goal of minimizing the effect on the environment characterized by the presence of a liner systems and the collection of leachate to prevent contamination of groundwater.

2.6.3 Transfer Station:

A transfer station is a facility where collected waste can be stored temporarily, transferred in smaller collection vehicle to larger transport vehicles for transport to the final disposal site.

Transfer stations allows for the selection of best transport routes for collection vehicles, control traffic more (avoid traffic jams) and discharge improved operational efficiency (fewer trucks mean better traffic control) , the cost of lower overall distance.

2.7 BIO-MEDICAL WASTE(BMW)

Bio-medical waste is that waste generated from the medicine institutes such as hospitals, clinics and all the medical institutes.

Bio Medical Waste should not be mixed with other waste . It must be separated from the generation point before storage or transport. The container must be labeled..

2.7.1 Bio-medical Waste Generation:

The source of biomedical waste from hospitals, clinics, and any medical activates can waste medical products table 2.1 below show the quantities of biomedical waste from several healthcare units.

Table 2.1: Quantity of biomedical Waste From Health Care Units

Category of health care unit	Quantity (kg bed $^{-1}$ day $^{-1}$)
Paediatric unit	0.56
Eye unit	0.72
Orthopaedic unit	2.12
Gynaecology unit	1.56
Cardiology unit	0.73
Medicine unit	2.10
Surgery unit	1.52
OPD, burns, X-ray and canteen	2.63
General hospital	1.83
Multi-specialty hospital	2.53

Table 2.2: Proportion of Biomedical Waste (Check 100 %Total)

Type of waste	Range (%)
Non infectious	60.5-89.8
Infectious	15-38
Pathological	5-20
Hazardous waste	0.3-3

2.7.2 Biomedical Waste Composition

The table below shows the type of materials wasted from hospitals, clinics and pharmaceutical institutions.

Table 2.3: below showing the compositions of BMW

26.60%	Food material
10.24%	Paper, hard board, etc.
9.85%	Plastics: Poly Vinyl Chloride (PVC), etc.
1.09%	Disposable Syringes
0.12%	Glasses and crockery
39.17%	Cloth, bandages etc.
2.94%	Disposable needles
9.99%	Miscellaneous

2.7.3 Classification of Bio Medical Waste

All hospitals classifies BMW as follows: MSW - 80 % , Bio –medical waste is 20% with 15% of the BMW being Infectious waste (sharps, non - sharp objects, plastic, disposable , liquid waste) .

2.7.4Segregation of Bio medical waste

BMW must be separated at the point of generation prior to storage or transport. The container must be labeled.

General waste such as food , leaves, plastic cans , cans of soft drinks , tissue paper , or anything similar , non staining remnants of patients , must be collected and placed in their own bags.

Medical waste remain from patients care of various room sections, halls and chambers recovery, operations and hospital departments and specialized analyzes labs of all kinds , are placed in their own bags, assembled and handled with extreme caution.

Materials such as , used syringes, scalpels and broken glass in both cases polluted and unpolluted are segregated as shown below.

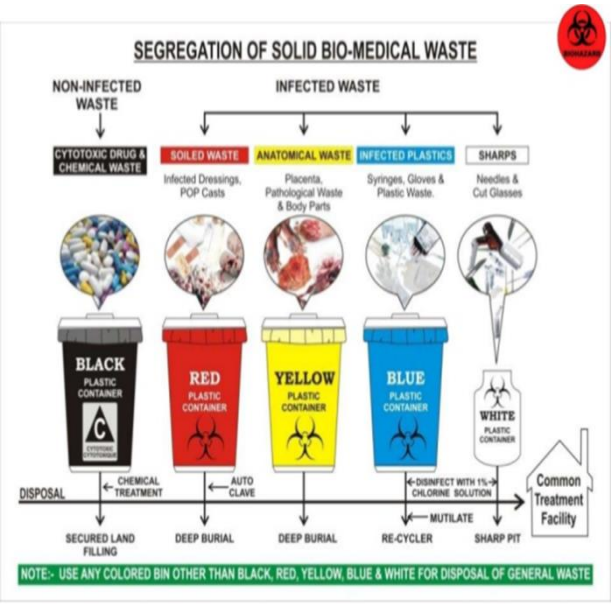

Fig 2.1: Segregation Of Solid Bio Medical Waste

Fig 2.1: Sharps Object

2.7.5Transportation

Transportation of BMW should be by special vehicles which are not used for other type of waste. These trucks must not have sharp edges and should be cleaned every day. Biohazard symbols should be painted on the cart and each healthcare center is required to have a health care waste management plan. This plan should include collection points and waste transport routes as well as a time table for the frequency of collection. The Figure 2.1 below show the transportation of Biomedical waste.

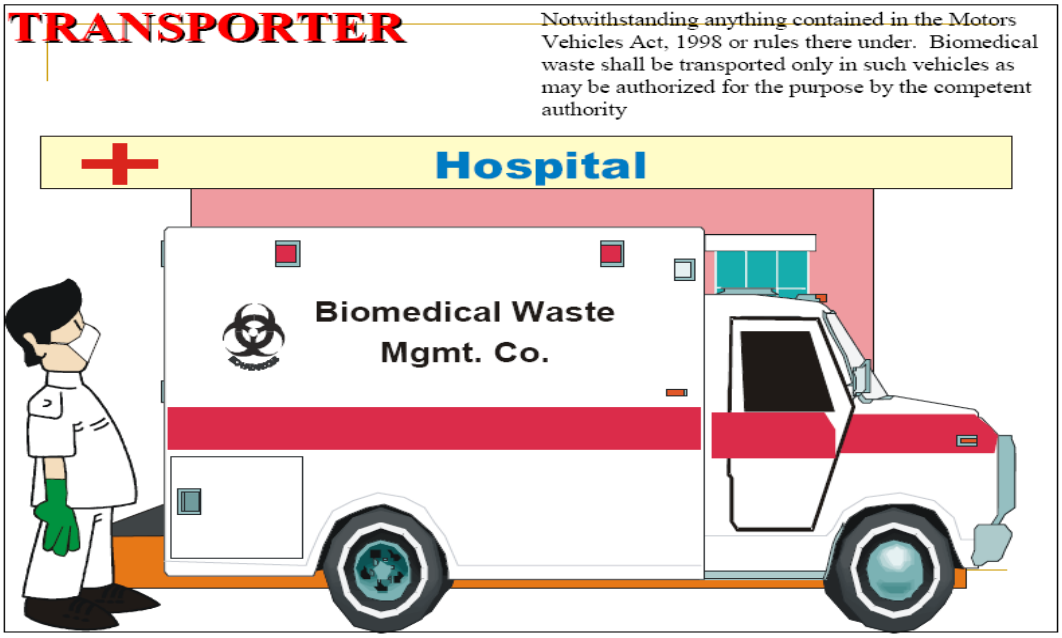

Fig 2.3: Transportation of Biomedical waste

Fig 2.4: Laboratory Waste Streams

2.7.6 Biomedical Waste Management

Proper disposal of medical waste is required to protect the Environment , People and Bio-systems. The need to use containers or small portfolios of reinforced plastics to collect the remains of needles and syringes immediately after use. and bags of garbage and disposable sterilized by incinerators should not be filled in folders more than three quarters.

The use of alternative ways to get rid of some of the medical waste instead of burning such as sterilization and chemical processing before dispose the waste should be explored.

2.7.7 Biomedical Waste Treatment

The treatment of biomedical waste has many methods depending on the type of medical waste under consideration..

2.7.7.1 Autoclaving

Involves exposing waste to saturated steam under high pressure in a private closed basins called autoclaving. These basins must also be resistant to shocking against heat , pressure arising from the operation.

In addition to the counters and indicators of heat and pressure, the waste is placed with a biological indicator to determine the validity of this device to get rid of germs during the sterilization process. Monitoring of all stages of sterilization operations, control , sterilization and the amount of time pressure , and heat index through the stages of sterilization are also required.

2.7.7.2 Microwaving

This is sterilization method which is good and safe for used but with a disadvantage of high operating and maintenance cost, Micro waving is only for liquid medical waste and medical waste containing infectious liquids.

2.7.6.3 Incinerators

Incineration is waste disposal method which involves the process of burning waste and it is referred to as the process of oxidation (Oxidation) of hazardous waste. Wastes such as hazardous organic and other inorganic materials are reduced (Reduction) to water and energy.

2.7.7.4 Deep Burial

Also called landfill or burial , a traditional method based on burying medical waste in deep dug out pits.

2.8 Electronic waste (E-Waste)

Electronic waste includes expired components from computers and all peripherals devices , mobile devices , electrical appliances such as microwave and refrigerator , televisions , receivers and transmitters , cameras, photocopiers and printing equipment , compact and fluorescent lights.

E- waste contains toxic substances harmful to human and the environment when disposed off randomly leaking components of toxic elements into the water resources, air, soil and up through the food chain, or by way of inhalation into humans**.** In figure 2.5 below shows the E-waste types and how they are disposed near water bodies.

Fig 2.5: Electronic Waste disposed near a water body, source: (http://www.theguardian.com/sustainable-business/electronic-waste-developing-world)

2.9.1 Recycling.

Is the act of producing new usable items from waste. Some components of waste can be recycled into manufacturing new items.

In addition, recycling helps to reduce the amount of waste to be sent to the Landfill sites and thus help reduce the amount of toxic chemicals such as fluorescent lamps (aluminum, glass , mercury), Dry -Batteries, mobiles batteries recharged (reuse of cadmium, nickel and iron), TV (reuse of glass and lead), computer (reuse of mercury, steel, plastic and gold), Computer screens (re- use of glass , gold, lead) will otherwise be buried within the ground.

2.9.2 Electrical and electronic waste management policy.

Activate policies that prevents electrical and electronic waste thrown into landfills of solid waste as household waste and handling special manner commensurate with the seriousness and the development of appropriate mechanisms for sorting , collection and recycling, treatment and disposal or exported for processing. Reduction of electrical and electronic waste production to reduce the impact on the environment.

2.9.3 Environmental Impacts caused by improper e- waste management

The presence of toxic substances in the waste and the absence of the necessary safety and prevention conditions during handling, is a danger to health, natural resources, especially soil and water .

CHAPTER 3
STATUS OF AREA UNDER STUDY

3.1 GENERAL

Khartoum is one of the Eight States of the Republic of Sudan and has a population of about 7 million people. Khartoum has a land area of 22,000 km^2 and lies between the longitude of 31.5 to 34 ° E and latitudes 15-16 ° N. the State is divided into seven localities namely Karari, Ombaddaa, Omdurman, Bahri, Shareq_Alneel, Al Khartoum and Jabal_Awliya.

Khartoum is the Largest industrial state of Sudan. Khartoum has seven Localities namely towns, Khartoum, Khartoum North and Omdurman. The latter is the largest of the three towns, located west of the White Nile river and covers an area of approximately 320 km^2.

In 2002, the population in Omdurman was estimated at 2,931,200, which is expected to increase to 9.8 million in 2040. Below is a figure showing the Map of the Republic of Sudan.

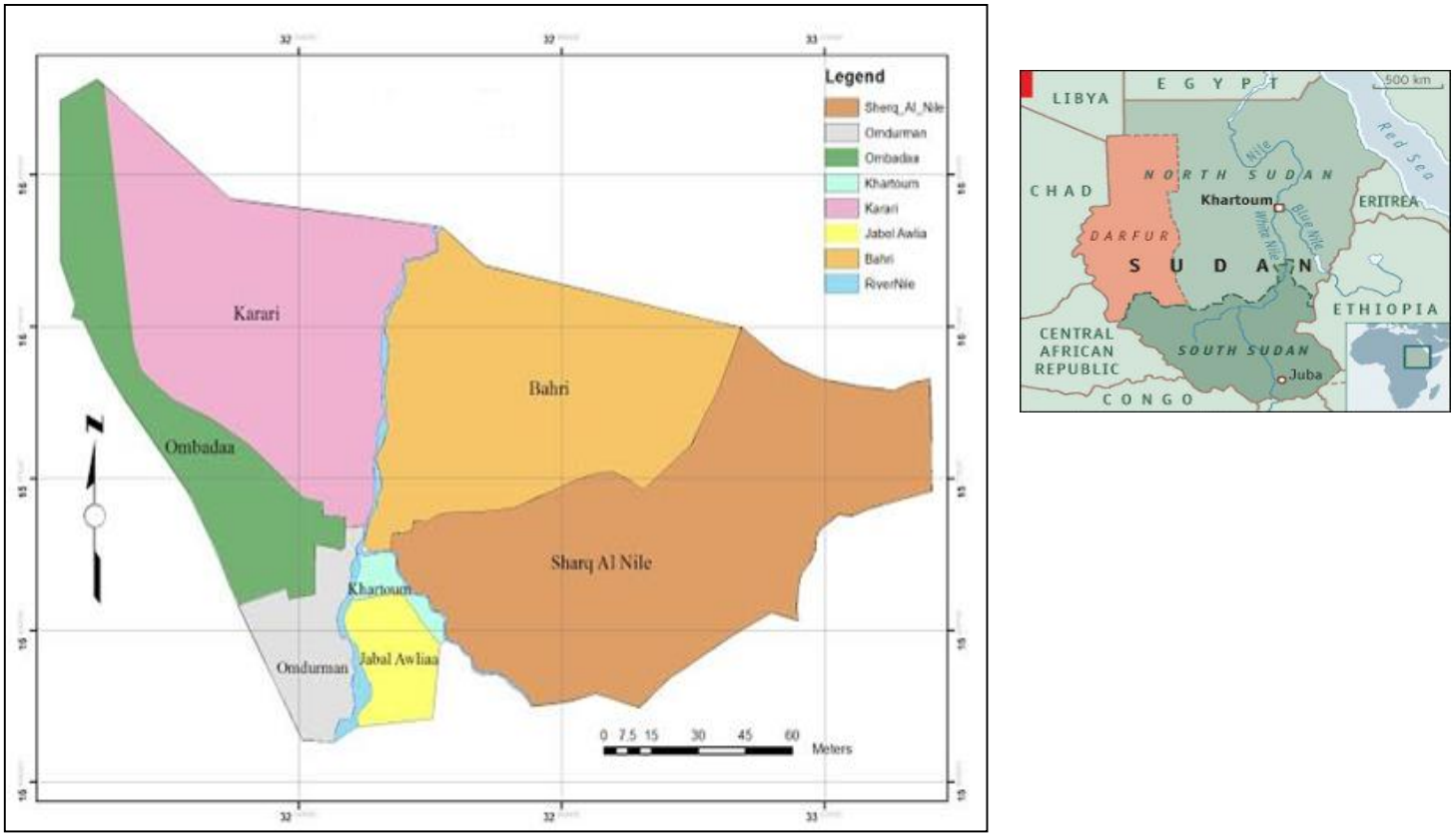

Fig 3.1: Khartoum State map

3.2 URBAN LOCAL BODIES

The Localities of Khartoum State (LKS), The Supervision Cooperation of Khartoum state and The Supreme Council for Environment and Urban Upgradingare the Urban Local Bodies of Khartoum city.

3.3 CLIMATE OF KHARTOUM

Khartoum is located at latitude 15.6N and longitude 32.3E at altitude of 380 metres above sea level. It was constructed at the joint of the White Nile and the Blue Nile. This location means that it lies at the fringes of the Sahara Desert. On the other hand it is quite remote from large water masses. The nearest is the Red Sea. This location makes Khartoum an ideal tropical and continental city(see Fig 3.2).

3. 4 THE SOIL AND GEOLOGY

The geology of Khartoum can be sub divided into six main units of increasing age comprising of Wind-blown sand, superficial gravels, Sediments of "clay" plains, Tertiary volcanic rocks, Nubian sandstone formation and Post-acrogenic igneous complexes. Figure 3.2 below shows the Geological Map Of Khartoum. and Figure 3.3 below showing Khartoum's general Soil Map.

3.5 WIND PATTREN

The wind regime is either southerly or northerly flow. The northerly flow prevails from October to the end of May. The general feature of this wind is its dryness. However one can distinguish two air masses.

In December to early march relatively cool air comes from Europe flowing over the hot soil and raises wide-spread dust storms.

In April and May extremely hot dry continental air mass originates over the Sahara and burns the area. Extremely high temperatures are observed during this period. Wind speed is moderate in general, however on the onset of the cold fronts gusty gale winds devastate the area.

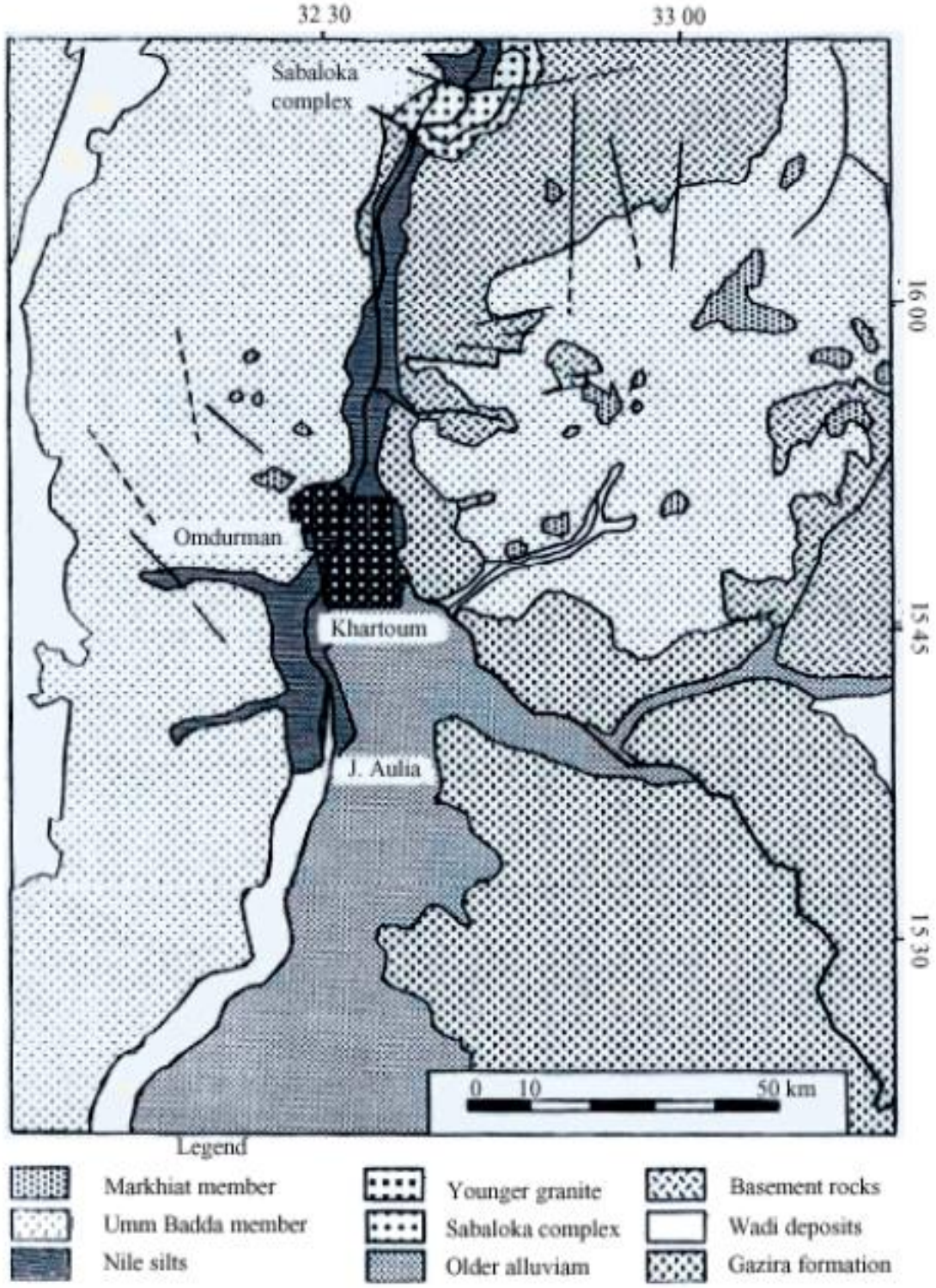

Fig 3.2: Khartoum Geological Map- Source: (UNESCO- Assess Of Water Supply Sources And Systems Of Potable Water in Khartoum Metropolitan In Relation to Liquid Waste Disposal- 2010)

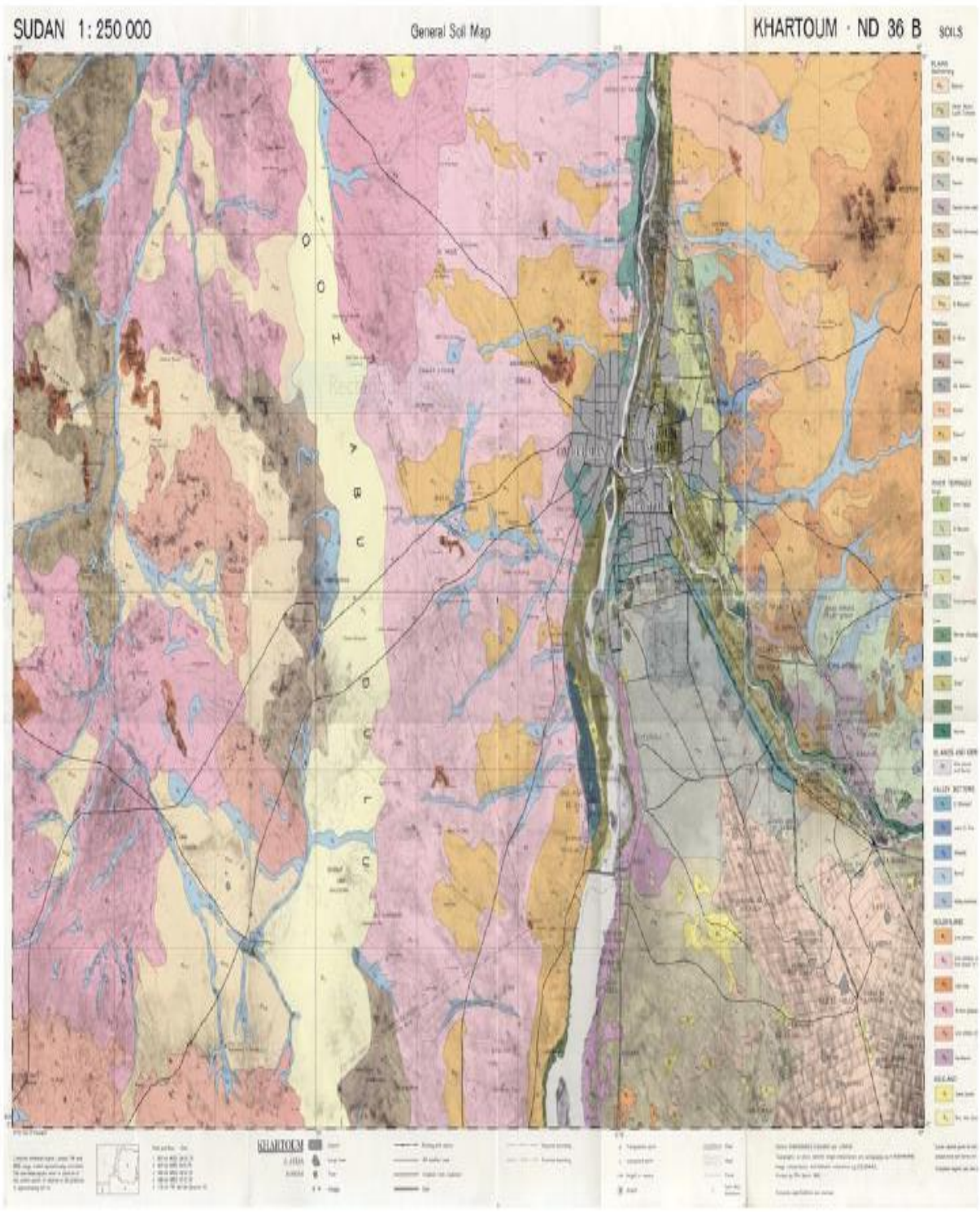

Fig 3.3: General Soil Map Of Khartoum - Source: (UNESCO- Assess Of Water Supply Sources And Systems Of Potable Water in Khartoum Metropolitan In Relation to Liquid Waste Disposal- 2010)

3.6 SOLAR RADIATION

As a tropical area Khartoum receives large amounts of solar radiation. The location at the fringes of the desert leaves the skies clear. The bright sun leaves sun rays coming directly without any interception loss.

3.7 RAINFALL

Khartoum practices monsoonal regime of rain activity. The Inter-tropical Convergence Zone is the main regulator of the rain-producing system. The ITCZ reaches Khartoum in June and retreats in October. In between these two months the humid south-westerly winds prevail. The over-head sun triggers convection and scattered convective clouds are frequently observed in the afternoon period. Some of these clouds mature into thunderstorms. Rain showers are common in the afternoon.

In the middle of this period, i.e. in July, August and September, organized cloud systems giving strong rain activity late in the night and early morning hours. The average annual rainfall at Khartoum is about 120 mm. However extremely large amounts can pour down in one day. In August 1988, 216 mm came down in a single day. Below is the precipitation Chart of Khartoum for 2015.

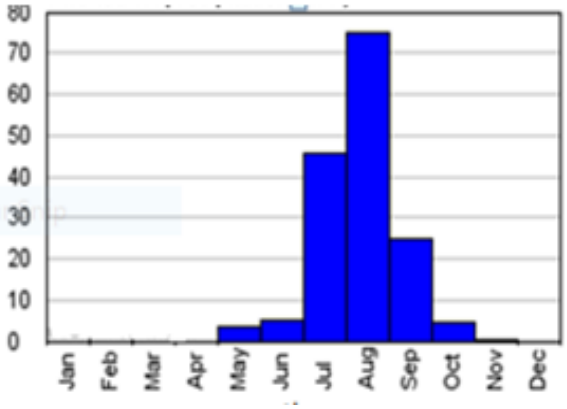

Fig 3.4: Precipitation of Khartoum in 2015, source:(Authority of Meteorological Khartoum State)

3.8 TEMPERATURE

The Sun moves over Khartoum twice a year(May and in August) with May as the hottest month of the year when the maximum temperature fluctuates around 45°C. The temperature can stay above 30°C for several days keeping the minimum temperature above 30°C. As the monsoons advances, the cloud cover cuts off the coming solar radiation. This makes the temperature drop significantly during the monsoon period, Jul, Aug and Sep.

In October the temperatures rise again as a result of the retreat of the cloud activities. The minimum temperature during the peak of the monsoon drops also due to rainfall. January and September are the coolest months of the year. On some occasions the cold fronts stay late and cold spells can be observed in early February. Below figure3.7 of temperature for Khartoum in 2015 by Khartoum State in Front of Climate Change.

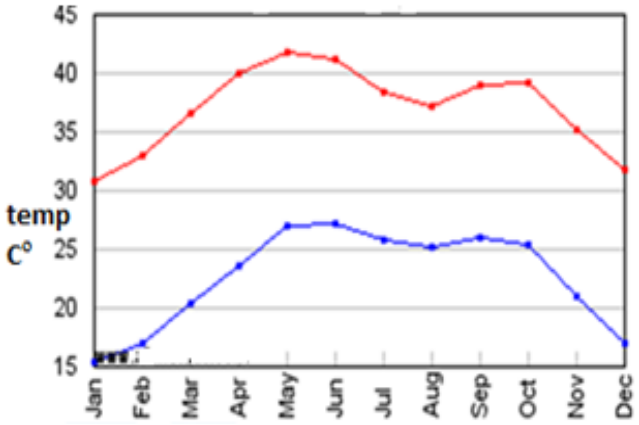

Fig 3.5: Khartoum temperatures, source:(Authority of Meteorological Khartoum State)

3.9 DUST STORMS

There are three types of dust storms on Khartoum area. The first one is associated with the intrusion of the cold air on the rear of a cold front. This come from the north , affects a wide area and can persist for many hours.

The second type occurs on the advance of the rainy season. Wide-spread rainfall on central Sudan creates local high pressure and pushes cool air northwards causing dust storms that persist for several hours. The third type is the wind. These dust-laden winds occur on the collapse of thunder clouds causing gusty winds. They approach Khartoum from the east and persist for few hours mainly in the afternoon and night.

3.10 POPULATION ESTIMATION FOR KHARTOUM

3.10.1 Population growth rate:

For Sudan the estimate of population growth rate using following equation

$$p_t = p_0 e^{rt}$$

p_t: present population , p_0: population before t year , r: population growth rate ,

t: time in year. Population Growth Rate For 2015 in table 3.1

Table3.1: Population Growth Rate For 2015 By As Central Bureau Statistics

State	Population growth rate
Khartoum	2.7
Nahrelnile	2.4
South Darfor	2.5
west Darfor	3.4
North darfor	3.4
Red Sea	6.7

3.10.2 Population Density:

Expressed of the population density is usually the population per unit of area.

Population Density= Total population÷Total land area

For 2016, the Population density; 7,385,158÷2253913=3.27 which presently stands at 3.27 persons per square kilometer of land area.

Table 3.2: Population Mode Of Living

Sex	Total	Urban		Rural	
	Population	Population	%	Population	%
Total	5,1811,85	4,1947,19	80.96	986,466	19.04
Male	2,725,183	2,219,025	52.90	506,158	51.31
Female	2,456,002	1,9756,94	47.10	480,308	48.69

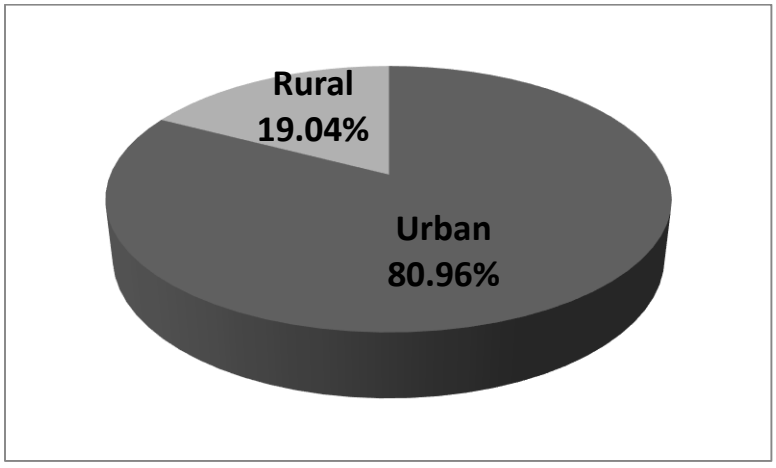

Fig 3.6: Mode Of Living

According to studies made by Sudan's Central Bureau of Statistics in 2015 the was projected to increase from 5,515,257 in 2009 to 7,993,851 in 2018. The following are Census data for the Various localities in Khartoum state.

Table 3.3: Population Estimation and Forecasting.

Year	Population
2009	5,515,257
2010	5,758,234
2011	6,006,885
2012	6,267,930
2013	6,534,795
2014	6,809,046
2015	7,095,148
2016	7,385,158
2017	7,687,547
2018	7,993,851

Table3.4: The Total Of Households According To The Locality

Locality	Total No. of House holds	Urban	Rural
Khartoum	**871,142**	**693,974**	**177.168**
Karari	117.127	103.942	13.185
Ombaddaa	162.162	137.213	24.952
Omdurman	84.956	55.894	29.062
Bahri	101.158	75.461	25.697
Shareq_Alneel	145.177	88.405	56.772
Al Khartoum	105.566	105.566	0
Jabal_Awliya	154.993	127.493	27.500

Table3.5: Population By Mode Of Living (Total) For 2008 By Central Bureau Statistic

Sector	Total	Urban	Rural
Khartoum	**5,274,321**	**4,272,728**	**1,001,593**
Karari	**714,079**	**642,418**	**71,661**
Alreef Alshimali	71,284	0	71,284
Kararri	404,608	404,231	377
Althawraa	238,187	238,187	0
Ombaddaa	**988,163**	**862,666**	**125,497**
Alameer	178,850	178,850	0
Alssalam	366,344	348,379	17,965
Albooghaa	335,437	335,437	0
AlreefAlgharbi	107,532	0	107,532
Omdurman	**513,088**	**344,575**	**168,513**
Wadnoobawi	56,805	56,805	0
Hai_Alaraab	38,979	38,979	0
Almoaradaa	31,255	31,255	0
Abuangaa	53,209	53,209	0
Alfitiahaab	59,921	59,921	0
Abu_saeed	104,406	104,406	0
AlreefAljanoobi	168,513	0	168,513
Bahri	**608,817**	**465,999**	**142,818**
Aljaili	69,377	0	69,377
Alsilait	73,441	0	73,441
Bahri shimal	287,837	287,837	0
Bahri	178,162	178,162	0
Shareq_Alneel	**868,147**	**546,212**	**321,935**
Alhaj Yoosof	265,666	265,666	0
Shareq Alneel	280,546	280,546	0
Wadi Soba	33,903	0	89,596
Abudlaig	20,721	0	33,903
Wad Abusalih	33,920	0	33,920
Alisailaat	70,720	0	20,721
Omdawaanban	73,075	0	70,720
Alailafoon		0	73,075
Khartoum	**639,598**	**639,598**	**0**
Alkhartoum	78,736	78,736	0
shimal	41,930	41,930	0
Gharb	72,235	72,235	0
Wasaat	159,717	159,717	0
Shareq AND	212,103	212,103	0
Alshagaraa	74,877	74,877	
Jabal_awliya	**942,429**	**771,260**	**171,169**
Alazhari	248,766	248,766	0
Alnaasr	244,837	244,837	0
Alkalakla	245,462	245,462	0
Jabaal Awliya	203,364	32,195	171,169

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CHAPTER 4

EXISTING INFRASTRUCTURE

4.1 GENERAL

Khartoum is located between latitudes 15- 26º and 15- 45º" N and longitudes 32- 25º and 32- 40' E, at an altitude of 40- 56 m above the level of the sea. The terrain is generally flat or gently sloping, only interrupted by occasional hills of rock outcrops while the sand dunes offer a slightly undulating topography. The flat landscape is broken by terraces and floors of wades and the Nile valleys. The White Nile has lower slope than Blue Nile.

The hydrological system, although dominated by the three Niles, has local drainage systems (which run after occasional rains and which are most important in the west and the east of Niles. Some of those West Nile manage to achieve while in the east they are slightly wider disorganized washes, and most of them do not reach the river because the terrain is sloping and covered by sand formations in the heart of Greater Khartoum Toti Island, formed depositional silt, clay and sand.

4.2 OPEN DEFECATION

The rate of open defecation decreased from 244 million in 1990 to 1.04 billionin 2001 representing to 24% and 15 % respectively. Table 4.1 shows the open defecation and improved sanitation percentages for all of the Sudanese states.

Table 4.1: Population Practicing Open Defecation or Using Improved Sanitation Facilities. 2015

STATES	% Population open defecation	% Population using improved sanitation facilities
Red Sea	59.7	24.1
West Darfour	49.1	22.7
Kassala	46.4	22.1
South Kordofan	46.4	16.9
Sinnar	45.1	17.3
Gadarif	44.2	28.4
South Darfour	39.1	4.9
Gezira	35.6	34.4
White Nile	34.0	20.2
North Darfour	33.6	18.4
Blue Nile	30.1	5.3
North Kordufan	20.8	20.3

STATES	% Population open defecation	% Population using improved sanitation facilities
River Nile	20.4	42.4
Northern	6.1	73.5
Khartoum	6.0	51.3
Rural	**42.2**	**17.9**
Urban	**8.2**	**46.9**

4.3 WATER SUPPLY

Daily average water consumption in Khartoum state at per capita for first , second and third residential classes estimated are estimated at 250 ,200 and 115 litters , respectively.

This givesan average daily consumption of 150 liters per capita in Khartoum , as the World Health Organization estimates the minimum daily need of the individual for all uses 280 liters , of which about 50 liters constitutes drinking water and household uses.

4.3.1 Water supply Sources

4.3.1.1 Nile River (White Nile and Blue Nile).

Water from these rivers are characterized by good quality and annual constant discharge and therefore they represent Reliable source for water production in Khartoum state.
Table 4.2 shows the Production of Water from Treatment Plants In the Last Five Years.

Khartoum state water corporation has established 11 water treatment plants in Nile River and Tributaries, from 1924 up 2010 to run with advance increase in population in the state.

Table 4.2 and 4.3 below show The Production from treatment plants and Coordinates Of Water Treatment Plant and Figure 4.1 shows the locations of the available Water Treatment Plants in Khartoum State .

Table 4.2: The Produced Water From Treatment Plants In the Last Five Years.

Water treatment Plants	design Production (MLD)	Actual of water in the day (MLD)	Efficiency of plant %
Bahri	300	220	71.9
Almanara	200	175	74.3
Soba	100	101	98.6
Al mugran	90	70	88.9
North bahri	50	43	55.6
Jabal awliaa	68	39	98.7
Saliha	15	14	98.3
Baat almal	27	17	75.2
Buri	16	15	94.7
TotI	4	4	100
Om katy	1	0.6	43.9
Total	**702.8**	**872,1**	**83.5%**

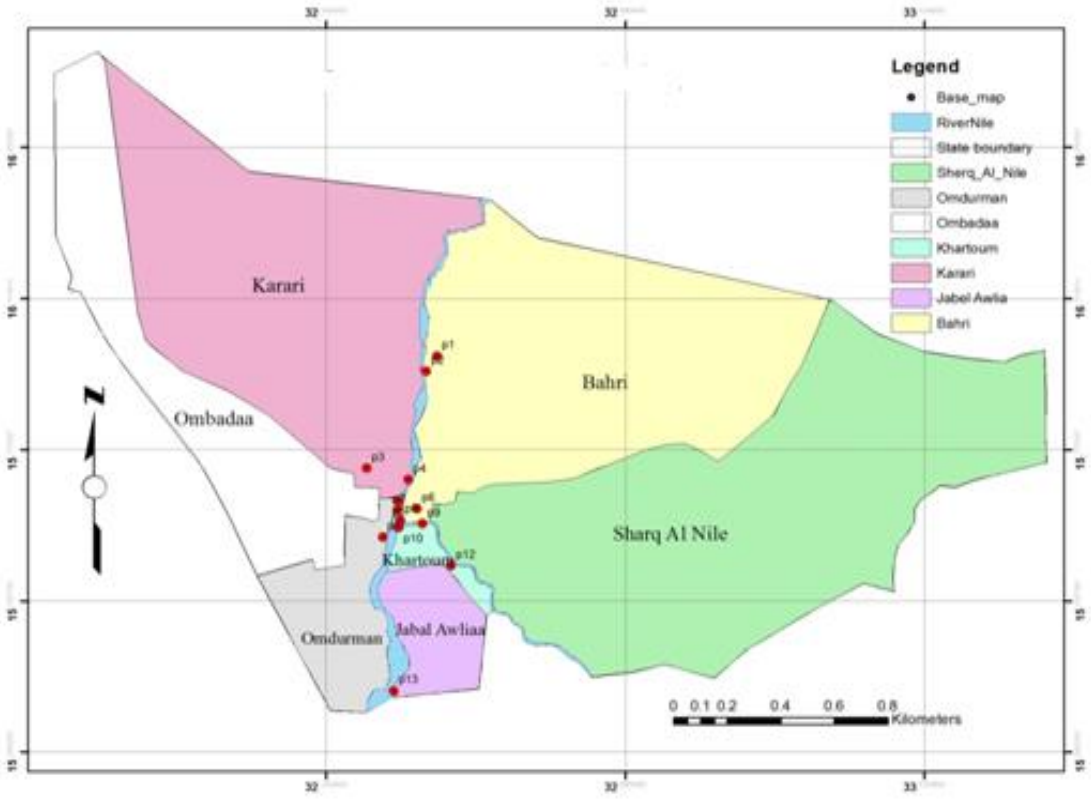

Fig 4.1: Water Treatment Plant - Source:(KSWC, GIS and Surveying Department)

Table 4.3: The Coordinates Of Water Treatment Plant

No.	Water treatment plants	Coordinates	
		Longitude(Degrees)	Latitude(Degrees)
P1	El thomanyat treatment plant	32.705326	15.979098
P2	North bahri treatment plant	32.560655	15.910569
P3	Karrari treatment plant	32.429308	15.661202
P4	Al manara treatment plant	32.532101	15.640262
P5	Al gamyir treatment plant	32.513065	15.585059
P6	Baatalmaal treatment plant	32.508794	15.560451
P7	Toti treatment plant	32.551460	15.562863
P8	Buri treatment plant	32.562188	15.526766
P9	Bahri treatment plant	32.510375	15.514562
P10	Al mogran treatment plant	32.516210	15.535416
P11	Abu saad treatment plant	32.479442	15.491006
P12	Soba treatment plant	32.626969	15.423667
P13	Jabalawliaa treatment plant	32.497410	15.113648

4.3.1.2 Seasonal Valleys.

There are a Number of valleys available in Khartoum state boundaries, but data is available on their annual discharges.

4.3.1.3Annual rainfall:

It range from 100 to 200mm.

4.3.1.4 Ground water basin.

Most of Khartoum state exists over the Nubian ground water basin which is characterized with good quality of ground water and salinity does not exceed 700 mg\l. Khartoum state water corporation has established around 1,900 wells varying from shallow to deep wells.The state depends on tube wells for domestic supply and also some of the rural areas for emergency supplies. In summer tube wells play very crutial role in the State. Tables 4.4 and 4.5 below show the Wells productions and Details. and in fig 4.2 below show the locations of tube wells.

Table 4.4: The Produced Water From Tube Wells In 2015

Locality	**Production of water in the day (MLD)**
Khartoum	119.907
Bahrii	75.028
Omdurman	111.198
Gabal owliaa	154. 419
Notth bahri	138.,646
Karrari	122.344
um badda	65.527
Total	**787.069**

Table 4.5: Tube Wells Details

Locality	**The wells connecting to network**	**Emergency wells**	**not working wells**	**Wells not connection to network**	**Private wells**	**Total**
Khartoum	67	3	1	3	14	84
Bahri	144	28	1	119	11	274
Omdurman	208	8	2	365	10	583
Jabal Awliaa	66	10	1	37	22	125
Notth bahri	64	17	4	13	18	95
Karrari	96	60	2	121	28	245
Om Badda	155	24	38	36	20	238
Total	**800**	**150**	**49**	**712**	**123**	**1644**

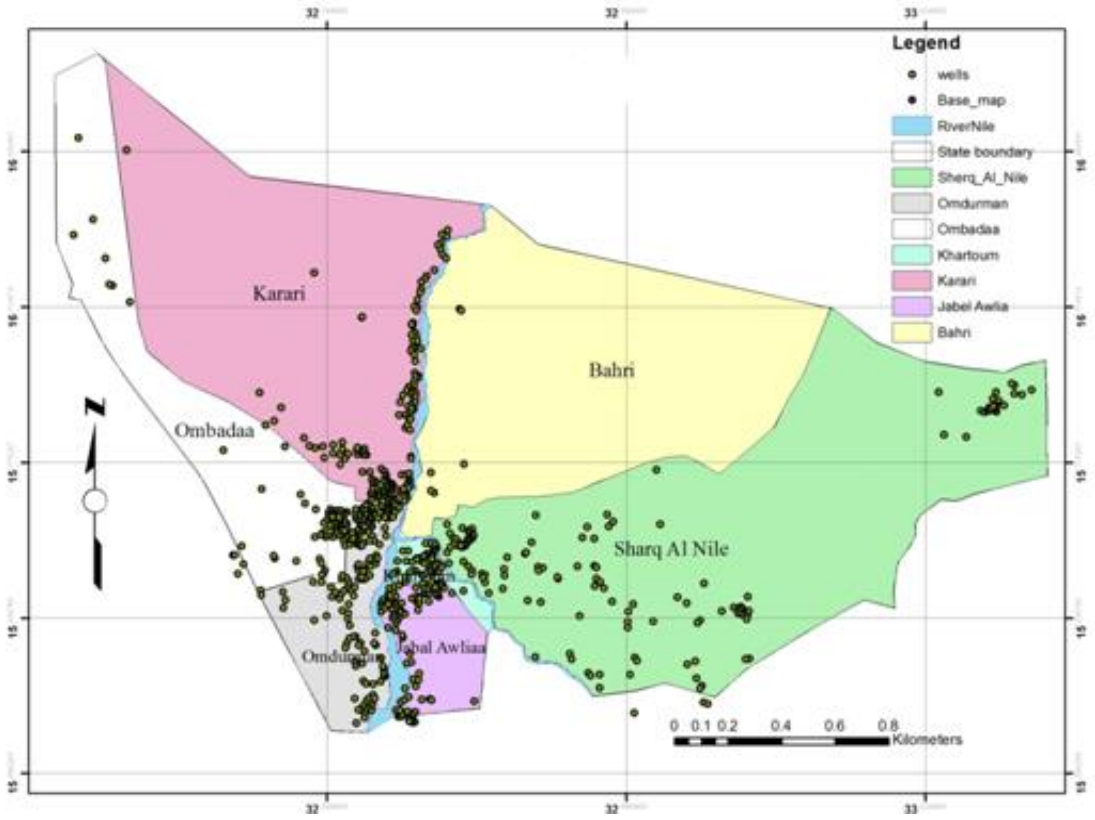

Fig 4.2: The Wells Tube - Source:(KSWC, GIS and Surveying Department)

4.3.2 Water Production

Table 4.6 bellows detailed the total production of water in Khartoum from the source: water treatment plants and tube wells these estimated by the Khartoum state water corporation since the year 2011.

Table 4.6: Water Production

Source	Production of water in the day (MLD)
Plants	702.9
Tube wells	787.1
Total	**1,450**

4.3.3Water Production Percentage

According to the total production of water supply in 2015 we can calculate the percentage of every source as shown in the Figure 4.3 below.

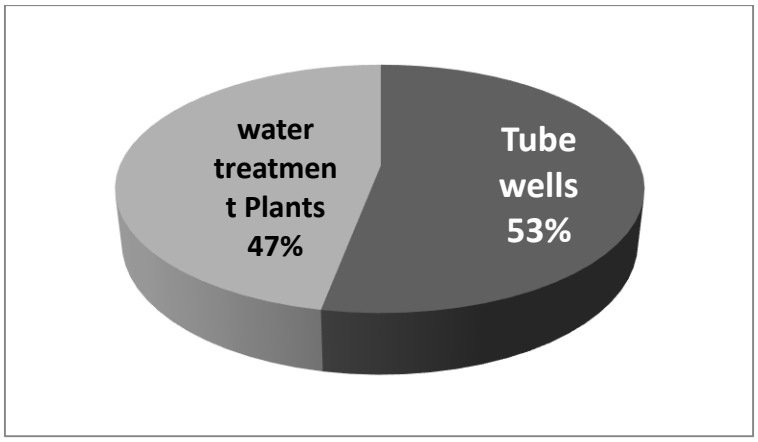

Fig 4.3: Water Production

4.3.4 The Demand , Production and Consumption

Khartoum has 7 states (Khartoum, Bahri, Omdurman, Jabal Awliaa , North Bahrii, Karrari and Om badda). Studies carried out by the Khartoum state water corporation in 2015 on the various state conditions and the tube wells ,provided estimates for the Demand , production and consumption of the water in Khartoum as well as forecasting for the future.

Table 4.7: Show The Demand , Production and Consumption In 2015.

Items	**Quantity (MLD)**
Demand	2,000
Production	1,500
Gap	500
Residential , industrial, government and service consumption	1,150
Losses networks and environmental uses (irrigation of trees and water features)	350
Total	**1,500**

Table 4.8: Show The Demand , Production And Consumption in 2018.

Items	Quantity (MLD)
Demand 2018	2,250
Production 2015	1,500
Additional production after the implementation of ambulatory plan	231
Expected production available in March 2016	1,731
The projected gaps for covering a mid-range plan	469

4.4 WASTEWATER

The sewage disposal system was started in Sudan in the early fifties of the last century. At that time, a British company, Marbles Ridgway, (consultant Howard Humphrey) built the sewerage network in Khartoum city. The network covered the area between the Blue Nile on the north side and on the south end bounded by railway station in addition to the areas of Khartoum.

In the early sixties UAE area was added to the network and the treatment plant at Algoaz was completed. The sanitary drainage services covered an area of about 15 square kilometers and network length of 250 kilometers of asbestos pipes. This enabled 80,000 inhabitants to use the system.

The sewerage network of Khartoum North industrial area was added in the early seventies with an area of 8.8 square kilometers. The quarters of Copper& Alwaha were added later to the network.

The current system has twenty pumping stations, of which sixteen pumps stations are serving Khartoum locality. The major pumping stations are pumps numbers 6, 20 and 21. All drainage is pumped to the collecting station pump no.30, which includes a second station known as Bittar pump station. All pumped wastewater in Khartoum is treated in Soba treatment plant which is a 100 meters away from pumping station no.30. The other four pumping stations are serving Bahri, and this sewage is treated in Alhaj yosif treatment plant.

4.4.2 Quantities of Waste Water:

The sanitary sewer system in Sudan began since the beginning of the twenty century. Khartoum produces more than 40,000 cubic meters / day of wastewater.

Currently there is no reliable treatment plant to treat the limited discharge and even less when the exhaust system of wastewater is expanded to cover the remaining area of the capital. There will be a big problem to deal with this increased flow to the sanitation situation in the State. The

total amount of production of sewage in Khartoum is bteween 30,000 and 40,000 cubic meters per day in the last five years.

According to the Khartoum state sewage company the existing sewer system coversonly about 5-7% of the state.

The daily water consumption in Khartoum estimates the average daily consumption per capita residential classes first, second and third estimated at 250, 200 and 115 liters, respectively. This means the average daily consumption of 190 liters per capita in Khartoum. (0.19) m3 / day. The amount of waste water is taken as 80% relative to the amount of water supplied.

Table 4.9: Quantity of waste water estimated in several localities in 2015 year.

Localities	Population in 2015	Water Supply (MLD)	Waste Water (MLD)
Khartoum	**5,274,321**	**1002.1**	**801.7**
Karari	714,079	135.6	108.5
Om Baddaa	988,163	187.8	150.2
Omdurman	513,088	97.5	78
Bahri	608,817	115.7	92.6
Shareq_Alneel	868,147	164.9	131.9
Khartoum	639,598	121.5	97.2
Jabal_awliya	942,429	179.1	143.3

4.4.3 Water Treatment Plant

There are four sewage treatment plants in Khartoum State , describing by geographic location to cover the network areas, including one well and one in the operation trial stage and the two don't working perfectly , as detailed below:

4.4.3.1 SOBASewageTreatment Plant.

Location at Khartoum around 15 KM south of Khartoum, Daily wastewater Flow is 35MLD.

4.4.3.2 New Soba SewageTreatment Plant.

It is located a kilometer south of the Old Soba plant which is currently out of order due to technical reasons.Rehabilitation of the station under a consultant is being carried out.

4.3.4 Wad DEFIAASewageTreatment Plant.

It is located 7 kilometres north-east of Khartoum North Haj Youssef area , a working sludge system with a capacity of 17MLD and ended up working out and is in the stage of empirical operation.

4.4.3.5 Haj Yousif new Sewage Treatment Plant.

Located 1 kilometer north Wad Defiaa waste water treatment plant it stopped working for structural reasons . Sections of the Wad defiaa Waste Water Treatment Plant.

Fig 4.4: Wad defiaa Waste Water Treatment Plant

4.4.4 Wastewater Treatment Process:

The sewage treatment process is biological (stabilization ponds).

4.4.4.1 Soba Sewage Treatment Plant

Treatment method used is the lagoon method and two series we reconstructed. The treatment flow in one series is as follows: Anaerobic pond (2) → facultative lagoon (1) → maturation pond (1)

The laboratory monitoring and evaluation of this treatment and follow-up days to confirm the emerging design specifications mentioned.

Weather factors have a very important role in the digestion of organic matter and thus removing an estimated portion of the organic load of sewage water by microorganisms.

These factors are present in the sun and the air stream of light and temperature.
The table below showstempretures that affects Algae Cells where it has an important role in the growth of algal cells which saves a considerable amount of oxygen as they cleanses the water ponds.

Table 4.10: Whether Effecting On Algae Cells

Temperature	**32Cº**
High	Radiation
Medium	Wind
Non	Raining

4.4.4.1.1 General properties of pond.

Each pond from the plant playsa role depending on the type of bacteria and microorganisms in the water and the design of the station in the digestion of organic matter and sedimentation. The resulting disposal rate is 80-84 % of the organic load represented by the BOD and TSS.

4.4.4.1.2 The Efficiency

The focus is on standard tests of samples from the field and from the entrance to the final discharge point with surrounding proportioned grid for the organic load. The Table blow 4.11 shows the efficiency and the result of samples before and after treatment for 2015 by Khartoum waste water cooperation.

Table4.11: The Result of Samples before and after Treatment for Soba Treatment Plant

Test / Source / No	BOD (mg/L)		COD (mg/L)		TSS (mg/L)		PH		DO (mg/L)
	In	Out	In	Out	In	Out	In	Out	Out
1	450	63	560	133.3	360	160	7.15	8.32	1.9
2	460	116	480	160	320	20	7.46	8.23	3.1
3	260	33	400	266.6	240	80	6.71	8.32	3.3
4	370	58	480	160	240	200	7.21	8.29	2
5	1010	108	1515	266.67	1460	100	7.19	8.03	2.
6	400	88	800	266.67	380	100	6.78	8.40	2.5
7	520	220	560	346.67	280	180	7.20	8.00	2.1
Average	495.7	98	685	228.5	468.57	120	7.1	8.23	2.4
Actual Removal in %	**80.2**				**74.4**				

4.4.4.1.3 Reuse to Irrigate The Forest South Of The Belt.

According to the plan laid down in the re-use of treated water in the belt area to make the most of the composting material for this water , the water is subjected to additional processes for use in other purposes.

Table 4.12: Laboratory Monitoring For Soba Sewage Treatment Plant.

Test	Result
Chloride- CL^- (mg/L)	316.2
Sulphate- SO^-_4 (mg/L)	123.5
Ammonia - NH_3-N mg/L	12.08
(Nitriate – NO_3-N mg/L)	1.04
(Total Coli form TC/100)	1,500,000/100

4.4.4.1 Wad Defiaa Sewage Treatment Plant

Khartoum state waste water corporation makes follow-up patrol of the waters accumulated from industrial waste inside the station and around which contain a high proportions of persistent organic, non-organic, fat and heavy metal elements after they come out of different units (Primary, Secondary).

Table 4.13: Shows The Results Of Samples Taken For Wad DEFIAA Sewage Treatment Plant in March 2015.

Source	BOD	COD	TSS	PH	CU	MN	Pb	Fe
Inlet	2050	2160	380	5.52	0.035	0.108	0.05	4.8
Maturation	1550	1565	260	8.36	-	-	-	-
Outlet	360	650	280	8.25	N.D	N.D	0.023	1.11

4.4.5 EXISTING Water PUMP STATION.

In Khartoum sewerage system, there are four main pumping stations (PS.6, PS.20, PS.21, and PS30) from which all the sewage are pumped to their served areas and the other pumping stations. In Table 4.14 shows the Existing Sewage System's Pumping Stations and Flow Direction

The pumps (PS.1, PS. 2, PS. 3,PS. 4,PS. 5,PS. 7,PS. 10, PS.12, PS. x" friendship hall pump") pump the sewage to PS.6, The pumps (PS.8, PS.9, and PS.15) pump the sewage to PS.21. The pumps (PS.14, PS.15, and PS.6) pump the sewage to PS.20, The pumps(PS.20, PS.21) pump the sewage to PS. 30, PS.30 which has two pipelines through which the total sewage is pumped to PS.30 located at a distance of 100m away from the TP as shown in Figure4.5.

Table 4.14: Existing Sewage System's Pumping Stations and Flow Direction

NO	ITEM	Dia/m	Coordinates		Location
			E	N	
1	Lift station no 2	5.00	450525	1725801	University of Khartoum
2	Lift station no 3	5.00	449863	1725621	Industrial ministry
3	Lift station no 7	5.00	452622	1726040	Sahiroon hospital
4	Lift station no 8	5.00	450749	1723541	West of Dobaat club
5	Lift station no 10	5.00	447365	1724716	East of public police
6	Lift station no 14	5.00	451417	1722735	Elimarat road no 11
7	Lift station no 1	6.40	451573	1725723	Silah alasliha
8	Lift station no 15	6.40	451142	1721467	Elimarat road no 39
9	Lift station no 4	6.12	448862	1725425	North of parliament
10	Pump station no.9	6.00	448898	1723270	Industry area
11	Pump station no.6	10.00	449990	1724383	Musalimia pride
12	Pump station no.5	4.76	448104	1725216	Electricity
13	Pump station no.12	4.70	447130	17253335	Al mugran -road of fitihab
14	Pump station no.20	11*13	451905	1721071	Elimarate- road no 53
15	Pump station no.21	11*13	448030	1720825	Algooz East South Rumaila burial
16	Pump station no.30 SOBA	12*20	451618	1714794	Maaio - south of shop6
17	Pump station no.30 BITAR	5.3.5	451649	1714797	Maaio - south of shop6

Fig 4.5: Existing Sewage System's Pumping Stations and Flow Direction- Source(KSS, existing sewerage system in Khartoum city)

Each pumping station has its own manufacturer properties; the efficiency, velocity, head, power, and flow capacity are included in Table 4.15.

Table 4.15: Detailed of Pumping Stations

Number of pump station	Number of pumps	Power of pumps (kw)	Q High-Low (L/S)	Head High-Low (m)	Capacity %	Velocity (m/min)
Ps 1	1	30	76-72	26-25	65.60	1455
Ps 4	3	30	76-72	26-25	65.60	1455
Ps 5	1	30	137-101	18-14.84	78.70	1455
Ps 8	1	7.2	34.4-25.3	16-13.83	77.10	1460
Ps 9	1	54	113	33.5	78.30	1470
Ps 10	1	18.5	52.5	20	75.50	1460
P s15	1	54	112-104	35-33.5	92.00	1470
Ps 21	1	30	76-72	26-25	65.60	1455
Ps 30	1	75	175-140	16.6-13	79.40	1460
Ps 2	1	30	400	18	79.30	1455
Ps 3	1	30	76-72	26-25	65.60	1455
Ps 7	1	30	76-72	26-25	65.60	1455
Ps 20	2	140	-	-	-	-
Ps 30	2	185	-	-	-	-

4.5 SOLID WASTE

4.5.1 Composition of Solid Waste Typical Khartoum City

Board of Khartoum State cooperation estimated the amount of the solid waste in Khartoum state in 2012. Table4.16 below shows the Composition of Solid Waste Typical in Khartoum City.

Table4.16: Composition of Solid Waste Typical Khartoum City

Type of waste	Percent %
Plastic	12
Cardboard	11.80
Organic component	49.5
Paper	21.3
Metals	1.7
Timber	0.2
Glass	3.5
Total	**100**

4.5.2 Quantities of Solid Waste

The study found that 62% of respondents have small amount of SW, represented 20% mean elimination, while the remaining 18% is the great layout.

Table 4.17 shows the overall amount of SW, the size of the population and houses in seven communities.

In general, the results showed that all the state combined generates 4000 tons / day.

The results in Table 4.19 also show that the average estimated production and disposal per month of solid waste is 60.05 tons / month which is equivalent to 63.4%, within the range for low-income countries. In table 4.17 below the average quantity of SWin Seven Localities in Khartoum State are Road, Shops and Factory watse asre shown.

Table 4.17: Quantities of Solid Waste in Seven Localities in Khartoum State For 2015.

Locality	Population	No of house	Quantity (t/d)
Khartoum	760,000	190,000	970
Jabal Awliaa	942,426	115,000	723
Omdurman	270,000	46,000	1514
Ombaada	998,000	148,589	450
Karrari	850,000	117,164	340
Bahri	700,000	3111	590
Sharq Elnil	800,000	95,000	350
The solid waste from the road ,shops and factories			1200
Total			**5837**

4.5.3 Collection and Transportation of Solid Waste

Collection is done from door to door then by the locality vehicles to the transfer stations. Areas lacking containers alongfor waste collection and thus depend only on the vehicles (auto tipper, small truck, compactor or rear loader) , the area also lacks primary segregation and so it segregation is done at the landfill by manually**.**

4.5.4 Open Burning

The burning of waste in the streets , markets and neighborhoods with all its papers and plastics and dirt and residues , etc., and despite the stunning development in the process of waste sorting and disposal to recycle them and use them again all over the world , but has become the easiest thing to everyone , especially in the markets and neighborhoods is a waste incineration despite all kinds of health risks.

Fig 4.6: pen Burning in khartoum

4.5.5 Landfill

There are four landfills in Khartoum three of which are for waste in Omdurman , Bahri and Khartoum and only one hazardous waste landfill in Dongla street. There are also three transfer stations in Omdurman , Bahri and Khartoum whichreceive medical waste and solid waste in different quantities. Table 4.18 below shows the Quantities of solid waste in The Landfills and in Table 4.19 Details of the Landfill.

4.5.5.1 Abu Walidaat Landfill

It is Located in the karari locality 40 km from the centre of Khartoum, about 3 km from the nearest residential area (village area) and about 5 km from the city of conquest , recieving waste from the northern and western side of semi desert -free zone.

About 32-40 travels/day are made by 75,28 and 30 m^3 volumes of vehicle.

Omdurman landfill covers an area of more than 50,000 km^2 and receives waste more than 1,500 tons per day and receives municipal waste different their sectors (Omdurman , karari , Umbadda). The landfill has companion plant for waste recycling , contain unit washing and grinding plastic Unit compost Unit Paper and cardboard, recycling of waste associated with the start of maintenance work in the paper and cardboard recycling unit washing and grinding plastic unit closed compost plant.

4.5.5.2 Hataab Landfill (Bahri)

Located in the east of the Nile and the local is about 6 kilometers north of the village of Om sidr and 10 kilometers east of Alaliab area and 4.5 km west of the Main Street area of 6 km2 and the total quantity of waste more than 1,500 tons per day. the number of vehicle travels 12 travel/day, the volume of vehicle 75,23 and 18 m^3.

4.5.5.3 Taiba Landfill(Khartoum)

Located in the local jabalawliaa just 4 kilometers east of taiba Al_husnab village and 4 kilometers north of Asili village , 4 km from the Main Street area of the Faculty of 40 acres and the total quantity of waste around 1000 - 1,200 tons per day and receives waste Alklaclat sector east and west jabalawliaa , alnasr and Azhari . the number of vehicle travels 38 travel/day, the volume of vehicle 75,23 and 18 m^3.

Table 4.18: Quantities Of solid waste in The Landfills

Landfill	Quantity (t/d)
Hataab landfill	1,500
Taiba landfill	1,200
Omdurman Landfill (abo wilidat)	1,500
Total	**4200**

Table 4.19: Landfill Detailed

Landfills	Abu Walidaat	Hataab	Taiba
No of engineers	1	1	1
No of labours	2	3	2
No of site guides	2	2	1
No of drivers	13	7	8
No dozer vehicle	2	1	2
No Loader vehicle	2	1	1
No Excavator	2	2	1
No tippers	4	1	2
No of cells	3	2	2

4.5.5.4 Haskanita Hazardous Waste Landfill: It located in the local Ombdah area of landfill about 6 km is specially for hazardous wastes like (Chemicals expired -Asbestos). Table 4.20 Hazardous waste in Khartoum , in table 4.20 below show the Quantities Of Hazardous waste in Haskanita Hazardous WasteLandfill.

Table4.20: Quantities Of in Haskanita Hazardous WasteLandfill

Hazardous waste	Quantities
Waste of Fateh Tower	149 drum
Thermal naval station	30,000 litters

4.5.6Transfer Station:

A transfer station is a facility where collected waste can be stored temporarily transferred or smaller collection vehicle to larger transport vehicles for transport to the destination. Benefits transfer stations: the best transport routes for collection vehicles (usually paved - reduce damage to trucks and delay) Increased traffic control (avoid traffic jams , congestion to security), fewer truck on the roads of landfill haul Improved discharge efficiency (fewer trucks mean better traffic control), the cost of lower overall operating mail (reduction of no. of drivers / crew), in fig 4.6 m 4.7 and 4.8 show the transfer station and the landfills.
Khartoum has three transfer stations in Khartoum Bahri and Omdurman areas to transfer waste from small to large vehicles with waste compaction by hydraulic compactors to minimize the number of tracks and also the fuel to reduce the cost of transport, in table 4.21, 4.24 and 4.22 below the detailed of transfer station ,there distance from the localities and the distance from landfills.

Table 4.21: Detailed the Transfer Station

Transfer station	Quantities (ton/d)	Number of travel	Number of vehicles	Number containers	Number of Labors	The salary for any labor (pound/mounth)
Khartoum	467.5	300-350	8	5 - volume $7m^3$	25	1,000
Bahri	420-460	250-300	8-10	5 - volume $7m^3$	23	1,000
Omdurman	400-450	250-300	10-12	5-volume $7m^3$	30	1,000

Table 4.22: The Distance from Transfer Station to the Landfills

Transfer station	Landfill	Distance (Km)
Khartoum	Taiba	24
Bahri	Hattab	26
Omdurman	Abu wlidat	26
Khartoum	Abu wlidat	40

Fig 4.7: Khartoum landfill Site.

Fig 4.8: Khartoum Transfer Station.

Fig 4.9: Cemetery For The Burial Of Asbestos In Haskanita Landfill

4.6 BIO MEDICAL WASTE

Medical waste means all materials used for diagnosis or to patient care within the health facility or outside it, in the case of contaminated blood and body fluids directly or indirectly in the case of a patient infected with contagious or not infected with the intended disposal is among the hazardous medical waste must get rid of them by peaceful means through incinerators, ovens, sterilization and others with the exception of food and leaves consumed by patients during their care. The World Health Organization defines medical waste as the waste generated from operations to treat patients and handling within the health facilities, research centers,

departments, divided this waste to hazardous waste which constitutes about 10-25% of the total general medical waste.
It is considered hazardous waste if not addressed in a scientific manner and in conformity with the requirements of global and laws set by the World Health Organization and other international organizations . The medical waste in Sudan obsession I have a specialist environmental sanitation , civil society organizations and groups in the community and the ability of many of the decision makers at all levels of federal, state and local because of this waste can make Health and environmental damage . One of the problems facing the medical waste management there is no system of classification of waste in hospitals , helping to socialize with other medical waste from regular waste.

4.6.1 Quantities of Biomedical Waste

Statistical studies minutes to the subject of medical waste do not exist. But the organization «WHO» has developed several criteria to estimate the medical waste to developing countries, including (2-2.5)kg for each hospital bed, in a report issued by the Ministry of Health in 2010 was estimated number of beds in all hospitals of Khartoum state to 6757 beds for 2015. And thus it can be medical waste in Khartoum state estimate of about 17 tons/day for the year. From here it is clear that the hazardous waste from hospitals and health centers can be estimated at around 2.5 to 3 tons / day. In addition to medical waste, a dental surgeries of heavy metals, such as metals used remnants of the remnants of the dental filling and containing 49% mercury and silver remnants of the remnants of the output of the processing solutions radiographs and residues of solvents, sterilization and disinfectants and other metal.in Table 4.23 below show Survey for Khartoum Hospitals and Number of Beds and quantities of biomedical waste.

The water demand is based on Central Public Health Environmental Organization recommendation of 340 lcpd per bed up to 100 beds per hospital and 450 lcpc above that. 80% of water supplied is considered to waste water . biomedical generation (6.25 per bed).

Table 4.23: Survey for Khartoum Hospitals and Number of Beds

No	The hospitals	Beds	Waiting beds	Total Of Beds	biomedical waste Quantity (kg/bed)
1	Ibrahim malik	215	84	299	747.5
2	Academy	171	30	201	502.5
3	National Center	81	30	111	277.5
4	Gaafar ibnoof	193	0	193	482.5
5	Dental	71	22	93	232.5
6	Skin	35	0	35	87.5
7	The eyes	42	0	42	105
8	Sweden	67	0	67	167.5
9	Suaidi	32	1	33	82.5
10	Khartoum education	414	73	487	1217.5
11	Ibn sina	147	19	166	415
12	Al shaab	254	35	289	722.5
13	Alzara	152	0	152	380
14	Bashair	139	40	179	447.5
15	Turkey	149	26	175	437.5
16	Saudi	134	24	158	395
17	Children	225	65	290	725
18	Alwalidain	0	32	32	80
19	Hot area	60	32	92	230
20	Tigani almahi	87	14	101	252.5
21	Omdurman educational	489	82	571	1427.5
22	Childbirth	262	83	345	862.5
23	Abo anga	121	7	128	320
24	Chinese	183	0	183	457.5
25	Ombada-18	38	27	65	162.5
26	Exemplary Ombada	149	81	230	575
27	Alnaw	117	28	145	362.5
28	Albalak	132	29	161	402.5
29	Ahmed qasim	113	41	154	385
30	Heart	100	16	116	290
31	Haj alsafi	106	32	138	345

32	Ali abd alfatah	27	9	36	90
33	Ali basher	50	9	59	147.7
34	Taha bashar	389	93	481	1202.5
35	Bahrii educational	110	38	148	370
36	Jabail altina	25	20	45	112.5
37	Awad husain	20	20	40	100
38	Abo saad	33	17	50	125
39	Aslang	49	11	60	150
40	Al srorab	19	6	25	62.5
41	Om katti	6	7	13	32.5
42	Al fatih	25	33	58	145
43	Garii	26	22	48	120
44	Al kabashi	17	12	29	72.5
45	Jabal awliaa	52	39	91	227.5
46	Wad abo salih	12	14	26	65
47	Abo dalig	20	24	44	110
48	Om doan ban	32	40	72	180
Total		**5,390**	**1,367**	**6,757**	**16,892.5**

4.6.2 Collection And Segregation Of Biomedical Waste

BMW should not be mixed with any other type of waste , and must be separated at the generation point before storage or transport , should be placed on the container and according to schedule. Table 4.25 below showing type of container and treatment option during the color code.

Table 4.24: type of container and treatment option during the color code.

Color of bag	Container Type	Treatment
Yellow	Plastic bag	Incineration and deep burial
Red	Disinfected container/plastic bag	Autoclaving , Microwaving, And Chemical Treatment
Blue and White	Plastic bag, puncture, proof And Container	Autoclaving, Microwaving, Chemical Treatment and Destruction and shredding
Black	Plastic bag	Disposal in secured landfill

Fig 4.10: Segregation Of Solid Biomedical Waste In Khartoum Hospital

4.6.3 Transportation

Biomedical waste transported to hospital by wheeled trucks that are not used for other purposes , these trucks must not have sharp edges and should be cleaned daily , Biohazard symbol should be painted on the wagon , each health care should have a care health waste management plan , which should include collection points and waste transport routes , a time table of the frequency of collection should also be set up. almost of the hospitals in Khartoum transport there waste by Saudi company vehicles to treat it in Saudi company plant.

4.6.4 The Treatment and disposal

In the framework of implementing the company 's policy of strategic action to resolve environmental and medical waste problems partnerships and because of its detrimental effects on public health, the institute that has responsibility about treatment of the biomedical waste in Khartoum is Saudi company from Arabian Gulf they signed contract From 2014 with government of Republic Sudan to creates a site for treat the medical waste the of and Ministry of Health in Khartoum State and high council of environmental affairs have the Supervision and Inspection**.** Saudi Arabia (sepco Sudan) Company receives about 12ton/day the system of treatment plant is boiler1000kg/h and autoclaves, the boiler using for sterilization in temperature 160º and pressure 4.6 bar for 25 minutes. the cost of treatment for government hospitals 3.7 pound/ kg and for private hospitals 4.7 pound/kg**.** in Figure 4.10 below Saudi Arabia (sepco environment) Company autoclave and microwave

4.6.4.1Autoclaving: The autoclave technology its only available in The Royal Care International Hospital**,** in figure 4.11 below Royal Care Hospital Autoclave**.**

4.6.4.2Incineration: The incineration is available in some hospitals in Khartoum state by private way from this hospitals, aldaiat hospital in Omdurman, and of Chinese hospital incinerators. , in Figure 4.12 below show Incinerator Of Omdurman Hospitals

4.6.5 The Disposal

almost biomedical waste after treatment dispose the filling of land in municipal disposal site or hazardous depend waste disposal site waste type with standard disposal according to the site and the medical waste component.

Fig 4.11: Saudi Arabia (sepco environment) Company autoclave and microwave

Fig 4.12: Royal Care Hospital Autoclave

Fig 4.13: Incinerator Of Omdurman Hospitals

4.7 ELECTRONIC WASTE

Electronic items that could be classified potential of electronic waste , once they become useless or non-productive and / or outdated . Computers - desktop devices / laptops, servers , CPU and peripherals such as monitors , mouse , keyboard, webcam, printers , scanners , etc. , Photocopiers , projectors , plasma screens , LCD screens , table and pocket calculators, SIM cards. chargers and batteries , cordless electronic equipment and wire line, BTS , BSC and electronic equipment MSC , antennas, air conditioners , refrigerators , lighting equipment, Stations mobile charger , smoke detectors , fire alarms , control devices access and other products used for the collection, storage, processing, and communication of information by electronic equipment.ns.

Fig 4.14: Type Of Electronic Waste- source(http://www.govtech.com/products/5-Ways-to-Get-People-to-Recycle-More-Electronics.html)

4.7.1 The Amount and volume of E-waste

The success of the Communications and Information Technology, which is the hurry up electronic waste. udan mathematically we find that the number of computers in Sudan, about 100 million computers in 2020 , a total of computers in the period since the entry of the PC to the Sudan in 1967. Which showed the need for new hardware because of the transition from analogue to digital television, as well as the transition from the second generation networks for mobile communications to the third-generation networks (and in the near to fourth-generation) networks, as well as increased demand for equipment and devices, which enjoy higher speeds in the data processing - in sub-sector of computing and information - and sizes larger memory and smart phones and light display units (liquid crystal or thin-film technology). Because of this renaissance, it is bound to generate the end of the life span of the old devices and thus increase the accumulation of waste and dramatically so that their effects have emerged on the environment and human health. The volume of waste by statistical structural plan of Khartoum State in 2013 is estimated at 1,135 tons (including mobiles and computers), Number of working in the field of computers and accessories in Khartoum state companies 377 companies and 972 work name, It was classified into large, the ability of financial companies and medium and small businesses companies and business names , some with significant financial capability. It increased the amount of mobile phone is very high relative to the rates exceeded the reasonable limit, and has become the amount contained in the period (2010 -2015) 140,000,000 Telephone Based on information from traders and companies specialized in the field. The problem in the activity of contrabandtrade and the multiplicity of random ports and trade , and the activity of the mafia to get rid of containers of computer and electronic devices , which entered Sudan in large numbers exceed the estimated figure.Table 4.25 and Table 4.26 below show the Quantities Of Devices.

Now in the telecommunications sector, the number of subscribers to 27 million subscribers , and the majority are using smart devices and where the risk is the removable device's battery unquestionably and therefore, the number of batteries used for those phones amounting to many times the number of phones which threatens environmental disaster caused by poor disposal of waste on the grounds that the batteries phones are considered the most polluting soil and interact with a substance containing lithium , lead, which is one of the most dangerous materials polluting water and impact on humans.

The amount received from the electronic devices in the period from 2000 to 2015 according to testimony given to those companies .

Table4.25: Quantities Of Devices

Numbers	Classification	Quantities of Devices
18	Large companies	15,000,000
95	Medium companies	8,000,000
264	Small companies	900,000
972	Name work	2,350,000
-	Other companies	4,000,000
	Government institutions and companies	6,000,000
	Traders	1.350,000
	Companies non commercial	2,000,000
	Government institutions	8,000,000
	Different organizations	15,000,000

4.7.2 Treatment & Disposal

In Khartoum there are no politicians or institutions have responsibility for the E-waste management , and recycling and reuse doing inthe open markets by un safe way, and the disposal almost in landfill.

CHAPTER 5

ANALYSIS ON ELEMENTS OF CITY SANITATION PLAN

4.1 GENERAL

Based on the analysis of existing for all the elements of city sanitation plan in Khartoum that mentioned in chapter three refer some observation:

4.2 WATER SUPPLY

From the data collected from Khartoum state water corporation (KSWC) there are about 801.7MLD water supplied in the last five year, about 787MLD from tube wells source and 702 MLD from surface water (Nile river) come from water treatment plants, that mean 53% produce from tube wells and 47% from water treatment plants .

4.2 SEWAGE SYSTEM

The municipal sewage generated in Khartoum should be collected and ,conveyed and treated through network of sewerage provided with sewage treatment plant before disposing in the environment.

Based on data collected from Khartoum state sewage corporation (KSSC) the sewerage network of Khartoum Currently there is no reliable treatment plant to treat this limited discharge let alone when the sewerage system is expanded to cover the rest of the Capital City's area. There will be a big problems to treat this increasing in the flow with this situation of sanitation in Khartoum state, The total quantity of sewer generation in Khartoum is 801.7 MLD, the existing sewer system covers only 5-7% of the city.

In Khartoum there are only two sewage treatment plants are working now one in Khartoum and the other in north of Khartoum. The operation methods of this treatment plants are stabilization ponds method. The sewage treatment plants are SOBA sewage treatment plant and Wad Defiaa sewage treatment plant.

SOBA waste water treatment plant has daily sewage Flow 35 MLD and Wad Defiaa sewage treatment plant has a capacity of 17 MLD with total of treated sewage 52 MLD from total generation of 801.7 MLD.

In the laboratories of every plant are monitoring to evaluate and get the efficiency of plant treatment.

4.3 SOLID WASTE

Based on data collected from The High Council for Environmental Affairs and Khartoum State Cleaning Cooperation, the city generate about 6,600 ton/day munciple solid waste and there is four landfills in Khartoum three of them for waste in Omdurman , Bahri and Khartoum and only one hazardous waste landfill in Dongla street. There are also three transfer station in Omdurman, Bahri and north Khartoum by quantities of solid waste 1500 tons/day, 1200 tons/day and 1500 tons/day respectively. The total generation of solid waste in the city 6,600 ton/day and the total solid waste reach for the landfills is 4,200 ton/day, in all landfills are receives medical waste respond with solid waste in different quantities. In city there are only one hazardous waste landfill it has quantity of 149 drum Waste of Fateh Tower and 30,000 litters fromThermal naval station.

Three are transfer station in Khartoum , Bahri and Omdurman sectors to transfer the waste from the small to big vehicles with compacting of the waste by hydraulic compactors to minimize the numbers of the tracks and also the fuel to reduce the cost of transportation.

4.4 BIOMEDICAL WASTE

The Ministry of Health of Khartoum state was estimate number of beds in all Khartoum hospitals in of Khartoum state 2010 the total number is 6,757 beds. And the total generation of the medical waste in Khartoum state is about (12.5 to 15) tons/day. The hazardous waste generated from the hospitals and health centres can be estimated at around 2.5 to 3 tons /day.

Saudi Arabia (sepco Sudan) Company is company has responsibility to treat the biomedical waste in the city, it receives about 12ton/day the system of treatment plant is boiler1000kg/h and autoclaves, the boiler using for sterilization in temperature 160º and pressure 4.6 bar for 25 minutes. the cost of treatment for government hospitals 3.7 pound/kg and for private hospitals 4.7 pound/kg**.** in Figure 4.11 below Saudi Arabia (sepco environment) Company autoclave and microwave

4.5 ELECTRONIC WASTE

Based on data collected from The High Council for Environmental Affairs classify the type and volume of electronic waste in Khartoum by statistical structural plan of Khartoum State in 2013 is estimated the generation of electronic waste is 1,135 tons/Year (included mobiles and computers). The computer companies and computer accessories in Khartoum are 1,349. The amount of mobile phone rates it increased between (2010 -2015) 140,000,000 Telephone/ year. the amount of electronic waste is increasing every year and there are no implementation for manage the E-waste for recycling, treatment and disposal.

CHAPTER 6

PROPOSED INTERVENTION

6.1 PROPSAL FOR IMPROVEMENT OF WATER SUPPLY

6.1.1 GENERAL

A proposal for improvement of water supply to improve supply level, reorganization of existing zone of water supply has been prepared by Khartoum water corporation 2015. This plan aims to provide a water supply in 2016 a suitable and stable for the citizens of the state by the end of March , and it complements the projects and the development of existing plants and increase efficiency and construction of and the construction of plants .
increase the number of subscribers from 800,000 to 850,000 households , increase of 50,000 subscribers.

6.1.2 Proposed Water re source Improvement

6.1.2.1Water Treatment Plant

The amount of water producing will increase with the increase the number of population , should use of information systems and modern technology in all activities and establish design of a modern water treatment plants. Designing and implementation of modern water systems in ways that lead to equitable distribution of water and reduce waste and improve investment in the field of water bottling and manufacture of imported raw materials. To covered the demand of water till 2018 proposed establish 90 water treatment plant to increase the supplying of water about 231MLD by cost reach to 490,239,62.

Table 6.1 Proposed Water Treatment Plant till 2018

The project	Production (MLD)	The Cost (Sudanese Pound)
Jabal Awliaa pipe line (630mm, 25.3 km length)	30	50,362,400
Shajara water treatment plant	15	31,200,000
Abo Saad water treatment plant	15	32,658,500
Bahri pipe line from Halfaiaa water treatment plant to Al-Kadaro (400mm, 12 km length)	36	67,159,320
Extension for Al-Mogran water treatment plant	45	21,560,000
Finish establish of Eed-Babeker water treatment plant and make pipe line from OM-Doom water treatment plant to : 1) Eed-Babeker (630mm, 14.3 km length) 2)Al-Fihaa (630mm, 10 km length)	50	229,299,40
Feeding Tube wells by solar energy	-	46,000,000
Total	**231**	**490,239,62**

6.1.2.2 Tube Wells

To covers the demand of water till 2018 proposed establish 90 tube wells to increase the supplying of water about 279MLD by cost reach to 25,600,000.Table 6.2 and6.3 below Proposed of Tube wells till 2018 and tanks.

Table 6.2: Proposed Tube wells till 2018

Localities	Tube wells		Cost (pounds)		Production (m^3/day)	
	normal	high	normal	high	normal	high
Khartoum	5	1	560,000	1,250,000	4,800	7,200
Jabal awliaa	5	-	-	1,250,000	4,800	-
Karari	6	-	-	1,500,000	5,760	-
Omdurman	5	2	1,120,000	1,250,000	4,800	14,400
ombadda	20	3	1,680,000	5,000,000	19,200	21,600
Bahrii	5	-	-	1,250,000	4,800	-
Sharq Al-nile	34	4	2,240,000	8,500,000	163,000	28,800
Total	80	10	5,600,000	20,000,000	207,360	72,00z0
	90		**25,600,000**		**279,360**	

Table 6.3: Proposed of Tanks

Localities	Number of tanks	Cost of tank (pound)	Total cost (pound)
Khartoum	-	-	-
Jabal awliaa	2	120,000	240,000
Karari	5	120,000	600,000
Omdurman	5	120,000	600,000
ombadaa	8	120,000	960,000
Bahrii	5	120,000	600,000
Sharq Al-nile	25	120,000	3,000,000
Total	**50**	**-**	**6,000,000**

6.2 PROPSAL FOR IMPROVEMENT OF SEWAGE

6.2.1 General

The Sewage generated in KS has manage it by proper strategies of collection , treatment (STPs), reusing and disposing.

6.2.2 Sewage Network

The sewerage network of Khartoum North industrial area was added in the early seventies with an area of 8.8 square kilometers. The quarters of Coppar & Alwaha cities were added later to the network. The current system has twenty pumping stations, of which sixteen pumps stations are serving Khartoum locality. The major pumping stations are pumps numbers 6, 20 and 21. All drainage is pumped to the collecting station pump no.30, which includes a second station known as Bitter pump station.

6.2.3 Pumping Stations

All pumped wastewater in Khartoum is treated in Soba treatment plant which is a 100 meters away from pumping station no. 30. The other four pumping stations are serving Bahri, and this sewage is treated in Alhaj yosif treatment plant. In 2007, divided Khartoum into four zones, in each zone determined the population and the population served, This divided these zones by showing by table 6.4 below the sewage system for any zones for 2040; the total pipes length with the total flow discharge. After doing so, an estimate of the construction cost for each zone was presented.

Table 6.4: Proposed of Sewage Zones to 2040

Zone (Area)	Z 1	Z 2	Z3	Z4	North
Total No. of population (2040)	660,000	1000,000	750,000	700,000	360,000
Total project Area kmP2P (Hectare)	30.5	42.20	35.5	33.00	17.0
Total length of pipes (km)	470	610	400	400	240
Total No. of manholes	10600	13500	9100	9200	5600
Total Length of pressure line (km)	-	-	-	-	8.5
Q - Average Total Flow (MLD)	120	180	135	120	65
Total No. of pump station (lift)	5	4	4	3	5
Treatment plant 1PstP phase mP3 P/d (Total 3phases)	40,000	60,000	40,000 (Exist)	40,000	40,000 (Exist)
Estimated project cost for 1PstP phase (U.S dollars)	90,000,000	120,000,000	100,000,000	80,000,000	40,000,000

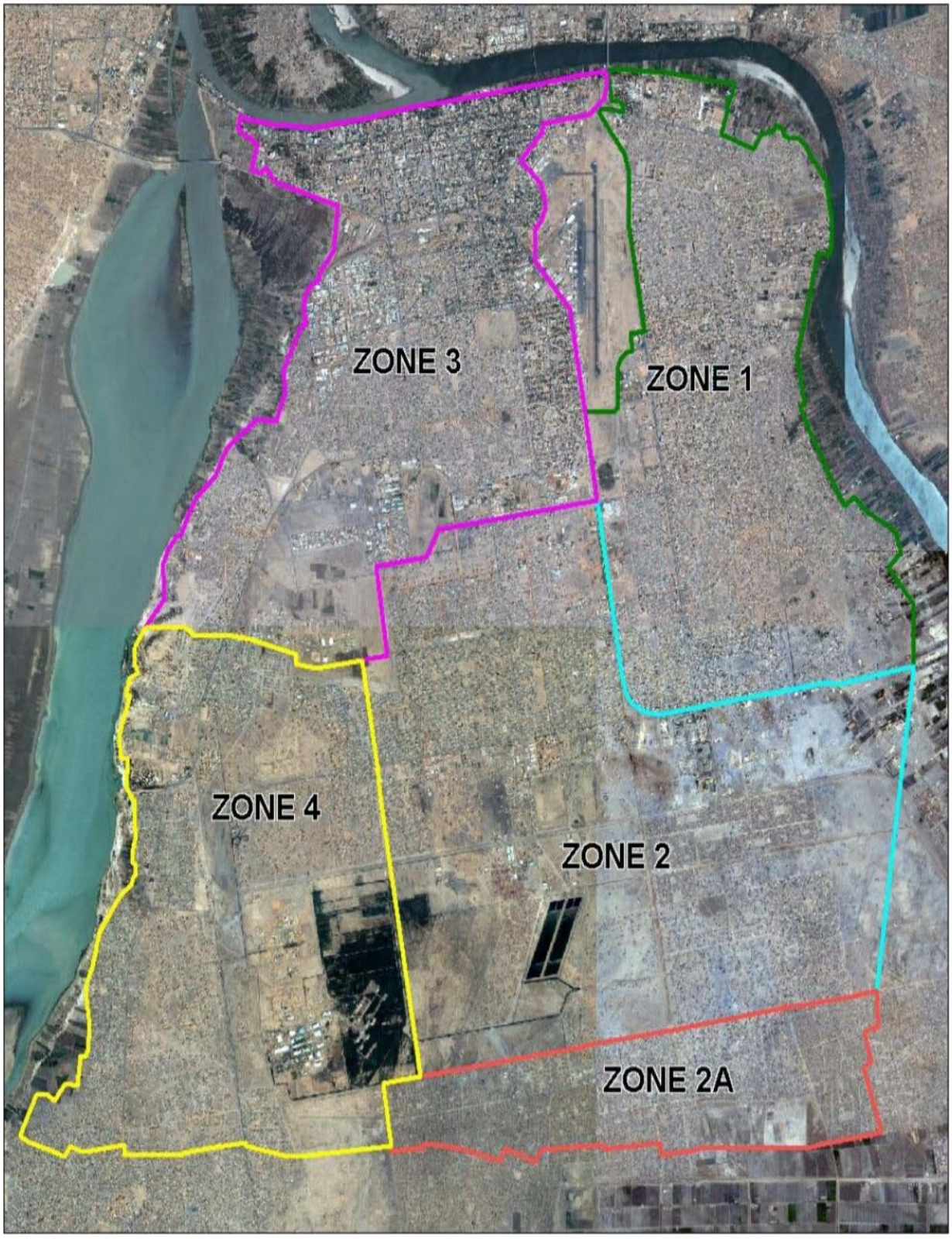

Fig 6.1: Proposed Sewage district - Source: (KSSC, existing sewerage system in Khartoum city)

6.3 PROPSAL FOR IMPROVEMENT OF SOLID WASTE

6.3.1 Calculation the quantities of solid waste

The SW generation per person= 385 g/c/d , assumed density of solid waste (300-560) kg/m^3 by average density=430 kg/m^3 in table 6.5 and 6.6 below proposed Solid waste generation waste in 2008 to localities and generation Solid waste up to 2018.

Table 6.5: Proposed of Solid waste generation waste to 2008 to localities

Localities	**Population in 2008**	**Solid waste generation (Metric Tone/day)**
Karari	714,079	275
Om Baddaa	988,163	380.4
Omdurman	513,088	197.5
Bahri	608,817	234.4
Shareq_Alneel	868,147	334.2
Khartoum	639,598	246.2
Jabal_awliya	942,429	362.8
Total	**5,274,321**	**2030.6**

Table 6.6: Proposed generation Solid waste up to 2018

Year	**Population of Khartoum**	**Solid waste generation (Metric Tone)**
2009	5,515,257	2123.4
2010	5,758,234	2216.9
2011	6,006,885	2312.7
2012	6,267,930	2413.2
2013	6,534,795	2515.9
2014	6,809,046	2621.5
2015	7,095,148	2731.6
2016	7,385,158	2843.3
2017	7,687,547	2959.7
2018	7,993,851	3077.6

6.3.2 Transfer Station

A proposal for improvement of Transfer Station to improve receiving of municipal solid waste by density of MSW 385 kg/m^3, Storage period 3days, No of effective operation 320 days , and additional space for movement. the full area proposed it has to divide to the three transfer stations according to the generation of solid waste and the volume of MSW. inTable 6.7 below Proposed Design for Transfer Station. Assuming the height of waste collection =7m

Table 6.7: Proposed Design for Transfer Station

Year	Solid waste generation (Metric Tone/day)	Capacity of receiving(Metric Tone/day)	Storage Volume (m^3)	Full Area Requirement (hectare)
2015	2731.6	3115.7	8092727.3	150.3
2016	2843.3	3243.1	8423636.4	156.4
2017	2959.7	3375.9	8768571.4	162.8
2018	3077.6	3510.4	9117922.1	169.3

6.3.3 Landfill Site

Landfill space requirement per year to cover the generation of solid waste up to 2018, the proposed area of landfills with waste having specific weight density of 710 kg/m^3(0.710 ton/day)and 4:1 ratio of waste to cover soil and height of 10 meters, by this information estimated in table 6.8 below the Proposed landfill area requirement up to 2018.

Table 6.8: Proposed landfill area requirement up to2018

Year	Population of Khartoum	Solid waste generation (Metric Tons/day)	Area (hectare)
2015	7,095,148	2731.6	17.6
2016	7,385,158	2843.3	18.3
2017	7,687,547	2959.7	19
2018	7,993,851	3077.6	19.8

To cover the landfill area in 2018 that 19.8 hectare that mentioned in Table 6.8 the area required for 2018 it will dived to three landfills that's according to the possibility of landfill extension and the generation of localities coved.

6.3 PROPSAL FOR IMPROVEMENT OF BIO-MEDICAL WASTE

6.3.1 GENERAL

The total generation of biomedical waste from several hospitals, clinics, nurse homes, is 16.9tonne according to surveying of 2015 from ministry of health. The Proposed of The Quantity, Number Of Beds, And Quantities Of Biomedical Waste show in Table 6.9.

Table 6.9: Proposed Quantity , Number Of Beds, And Quantities Of Biomedical Waste

Number Of Beds	Number of Hospitals and Clinic	Total Number Of Beds	Total Biomedical Waste Generation (Kg/day)	Water Demand (KLD)	Waste Water Generation (KLD)
Below 100	23	1155	184.8	392.7	314.16
100-499	25	5601	896.16	2520.45	2016.36
500 and above	-	-	-	-	-
Total	**48**	**6756**	**1080.96**		**2330.52**

6.3.2 Treatment and Disposal for BMW

Treatment and disposal of BMW that processes come after collection, handling, segregation, storage, and transportation using Technology Methods according to the type of BMW that mention detailed in chapter four.

CHAPTER 7

INSTITUITIONAL DEVELOPMENT

7.1 GENERAL

Institutional development is a process and content of change in institutions. Unfortunately there is no Target standard terms for this in development circles . Notice some of the differences between them which are drawn Foundation and capacity Between , development and construction. This usually reflects whether the focus of the particular area or subject to environmental or functional capabilities such as accounting policies and gold if the focus was on existing or new living organisms. When the focus is on the internal development of the individual organism , it can be used for medium-term institutional forces focus on a smaller scale destiny.

The terms process and content cover how change is achieved and what is to be achieved, respectively. How is the area of change management of organizational development. It concerns the processes through which the need for change is identified and accepted ownership, programs of change are designed and agreed commitment and implementation is organized. What relates to the change, which are to be made, such as redefinition of objectives, reorganization or new human resource policies. It the increasingly understood that institutional arrangements for CSP shall be critical to its success. The city Sanitation plan for Khartoum aims at a local body with the capacity to undertake envisaged functions related to improved urban sanitation services for all the key role of Khartoum municipality as the principal stakeholder in CSP is recognized.

7.2 WATER SUPPLY

The only institution Responsible for water in the state of Khartoum , is the State Water Corporation (SWC), which is working on the supervision of the Ministry of Planning and Public Utilities (The level of government) and other ministries are the Ministry of Irrigation and Power and the Ministry of Water Resources , Ministry of Health , Ministry of and Agriculture , Ministry of Environment and Natural Resources(Under the supervision of Irrigation and Water Resources), the Ministry of Public Cooperation and water (PWC) and the departments of groundwater .

7.2.1 Administrative issues

Potable water supply is the goal of the sectors of water , but there are many challenges , such as financial problems. Different payment depending on the residential area on the basis of change in the level of consumption , but the tariff does not cover operating and maintenance expenses , And a the collection system fees need to be developed.

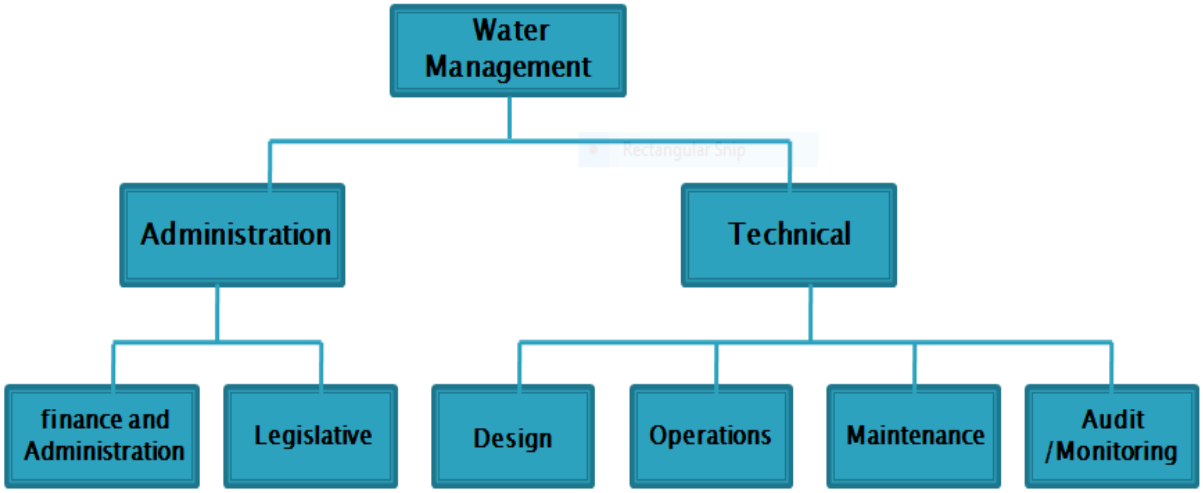

Fig 7.1 Management of Water Resources

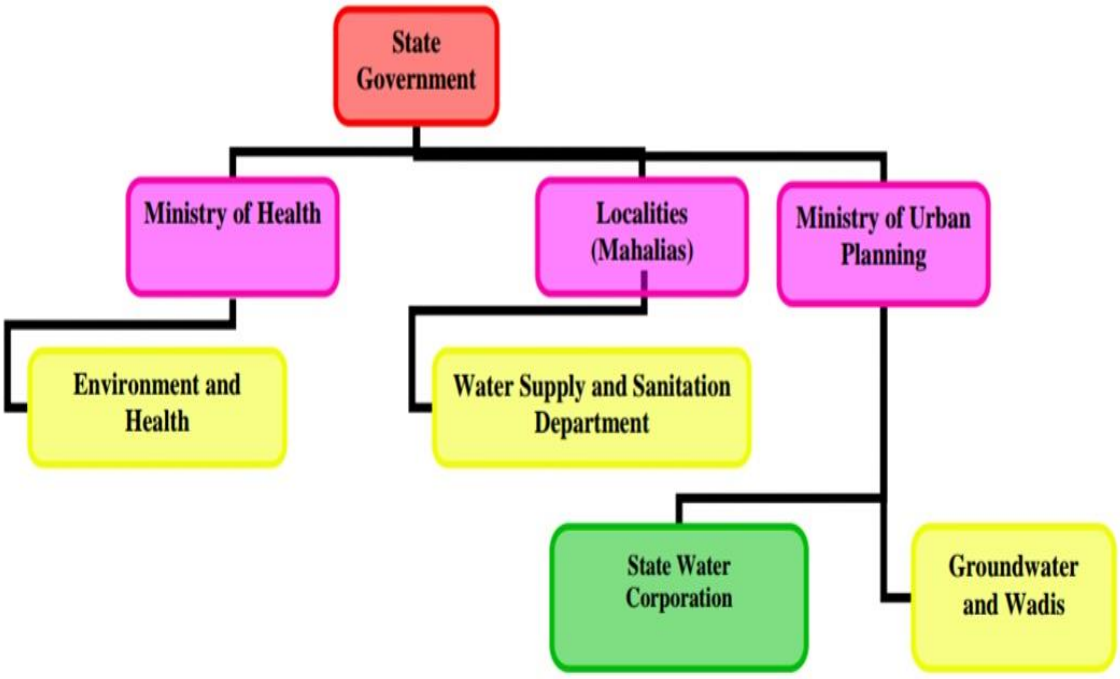

Fig 7.2 Water Supply Sector relationships and city roles

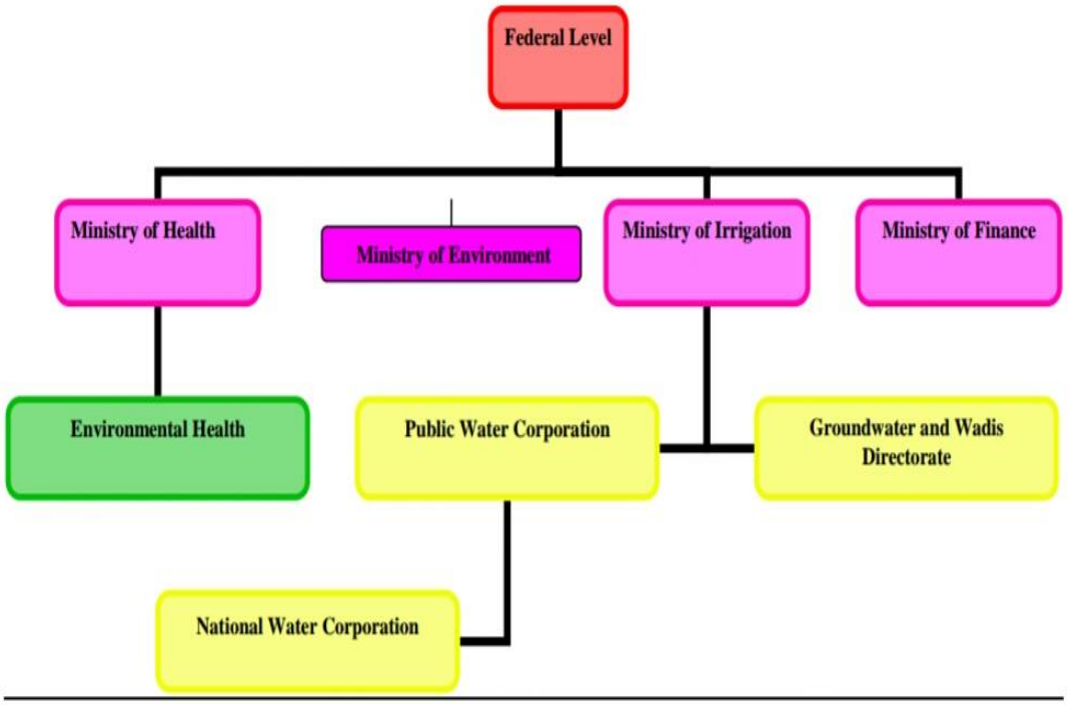

Fig7.3 Water Supply Sectors Relationships

7.3 WASTE WATER

7.3.1 Khartoum State Localities(KSL) and Khartoum State Water Corporation (SWSC)Roles

There responsible for water and environmental sanitation WES make the villages Communities project budget coordination details, the KSL make WES projects with implementation and monitoring for water supply and sanitation management .

7.3.2 The State Government Role

The state government is responsible for the management of water and sanitation , and the development of water supply and sewerage of the state ,State Government is responsible to oversee the SWSC to ensure good performance and good governance , should SWSC be responsible for oversight, the study projects and the acceptance of funding.

7.3.3Water and Environmental Sanitation Corporation (PWSC)Roles

PWSC it's that institute make required studies for the quantities of equipment, machinery and the purchase of this equipment. PWSC organize training programs in the health and sanitation

for all levels in Khartoum, drinking water supply , which is response about the monitoring of water supply and sanitation ,and improve the future planning and sustainability.

7.3.4 Private Sector Roles

You must employ activates sector and implement and manage the water supply and sanitation including designing and preparation to all construction activates of any digging, digging wells, water supply and construction of environmental sanitation, equipment installation, building materials, water supplies, develop the water and sanitation by adequacy .Detailed in Table 7.1 below institutions for the implementation of the CSP.

Table7.1 Institutions For Implementation

Institute	Description
Ministry of Irrigation and Water Resources	Overall leadership of water sector; Oversees policies, master plans and regulations for water resources management; Oversees the Water Corporation of Sudan. Water resources management
Ministry of Agriculture	Oversees Agricultural practices including irrigation.
Ministry of Cooperatives and Rural Development	Develops strategies for rural development, including organizing self-help programs.
KSSC	Oversees sewage disposal and treatment in urban areas.
Khartoum State Water Corporation (KSWC)	Water service to Khartoum and surrounding metro areas. Provides water service to urban and pri -urban areas in Sudan.

7.4 SOLID WASTE

7.4.1 Khartoum State Cleaning Cooperation Roles

The role of Khartoum State Cleaning Cooperation Roles is collect, transport, store, and dispose of solid waste. Implementation of designs landfills and intermediate stations , supervision , and the safe disposal of hazardous waste .

7.4.2 The High Council for Environmental Affairs

The role of the High Council for Environmental Affairs is supervisory role of the solid waste , where the Council acts on the inspection landfills and transfer stations and survey the amounts of solid waste and pollution monitoring and measurements of landfills and transfer stations .

7.5 BIOMEDICAL WASTE

7.5.1 Role of The Ministry Of Health And High Council for Environmental Affairs -Khartoum state

Responsibilities of both of the Ministry of Environment and The Supreme Council of the Urban Environment and upgradeare Supervisory role about the quality and quantities then the quality of treatment and disposal for biomedical waste.

7.5.2 Role of Saudi Company (Sepco)

The implementation of the partnership policy between the Saudi company (Sepco) with Sarmaj Company for Trading and Investment Co., Ltd. It was the first medical treatment plant for treat and dispose the biomedical waste in Khartoum in 2015, its Use of modern technologies in the medical waste treatment are also provided free training for sorting and collection of medical waste and its give hospitals bags sorting color and containers and boxes. strategies.

7.5 proposed Institutional arrangement

state governments have responsibilities to control of several waste in Khartoum apart of there responsibilities the urban development and manage the wastes as possible get benefits in the treatment processes to increase the economic. the following figure suggested the Institutional arrangement for Khartoum CSP. in figure 7.4 below proposed organgram for Institutional arrangement in Khartoum for CSP

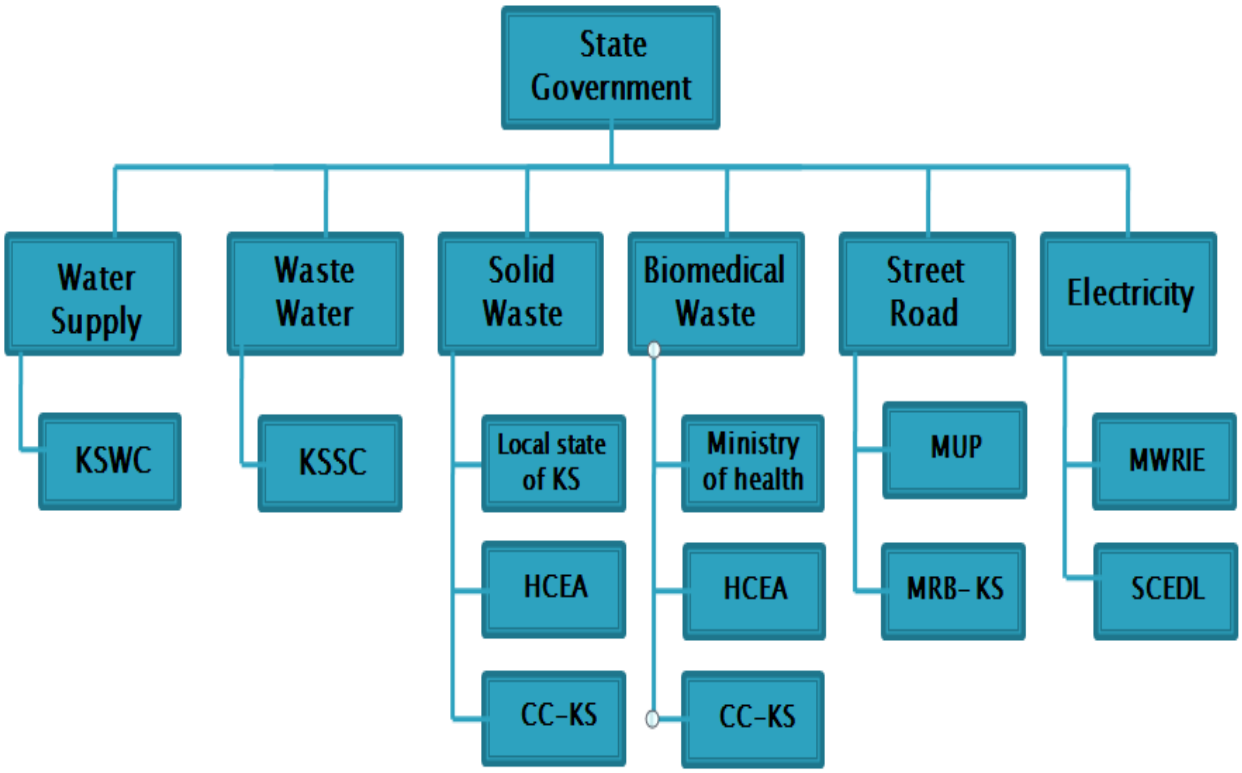

Fig 7.4 proposed organgramfor Institutional arrangement for Khartoum CSP

7.6 ELECTRONIC WASTE

7.6.1 Role of The Ministry of Environment and Forests and Urban Development

The Ministry of Environment and Forests and Urban Development is responsible about the management of electronic waste , response about the develop of management processes. till now there are no implement for any planning of E-waste management.

7.6.2 Role of High Council for Environmental Affairs

The role of the High Council for Environmental Affairs has supervisory role of the solid waste , where the Council acts on the inspection disposal sides and calculate the amount of E-waste in Khartoum state Coordinate with Ministry of Industrial.

CHAPTER 8
COST ESTIMATION

8.1 GENERAL

The financial sustainability of sanitation investments and transactions are often cited as key determinants for the provision of safe and reliable drinking water. Yet the concept of financial viability and how it translates into spending income needs are often misunderstood. The reason is that financial sustainability can be taken at different levels, especially if you made a distinction between short and long term. In Simplest area, utility that meets the daily cash requirements for operations and maintenance (O & M) and Fort Minor Capital expenditures could be considered viable financially viable in the short term. This could be yourself so much money these needs are sourced by external government transfers. What matters to the financial equation in this case is the predictability of the funding source, the source instead of; as it has been shown that in many parts of the developed world, public services can be viable financially supported by the long term capital and operating with direct subsidies largely by taxpayers.

8.2 SEWAGE SYSTEM DEVELOPMENT

The Sanitation in Khartoum is need improve in the, the disposal system for sewage only septic tanks and latrines. Only 5-7% of sewerage networked serve the households , and the households using septic tanks and latrines are 75%. The preliminary cost estimates done on analysis of existing sewage system with responsible of Khartoum state sanitary cooperation. In Table 8.2 below show Waste Water management development.

Table 8.1: Waste Water management development

Sr . No	Description	Total cost(Sudanese billion pound)	Proposed Cost (Sudanese Billion Pounds)
1	Laying sewer network	4,127	4,540
2	Pump stations, mechanical and electrical items	850	935
3	STP construction	1,192	1,312
4	O&M cost for STP and sewer network	183	201
Total project cost		**6,352**	**6,987**

8.3 SOLID WASTE

The Solid Waste in Khartoum is need improve in the collection, transportation, fee collection, storage area and disposal. in table 8.3 below show The municipal solid Waste management development**.**

Table 8.2: municipal solid Waste management development

Sr . No	Description	No of unit	Total cost (Sudanese billion pound)	Proposed Cost (Sudanese Billion Pounds)
Transportation				
1	Vehicles cost	300	2,680	2,710
2	The labours salaries	900	1	1
3	O&M Cost		3.0	3
Transfer station				
3	Vehicles cost	30	298	328
5	O&M Cost	-	11	12.1
Landfills				
6	Vehicles cost (tippers, Excavator, dozer, Loader)	22	276	304
	O&M Cost		2.3	3
Total			**3,271**	**35,99**

8.4 BIOMEDICAL WASTE

From 2014 Saudi Arabia (sepco Sudan) Company contracted with government of Sudan to treat the biomedical waste in Khartoum state it receive about 12ton/day the system of treatment plant is boiler1000kg/h and autoclaves, the boiler using for sterilization in temperature 160º and pressure 4.6 bar for 25 minutes. the cost of treatment for government hospitals 3.7 pound/kg, for private hospitals 4.7 pound/kg and 12 pound/bag for blood.

Table 8.3: Biomedical waste treatment for6757 beds

Sr .No	Description	Total Cost (Sudanese Billion Pounds)	Proposed Cost (Sudanese Billion Pounds)
1	Vehicles	212	233
2	Boilers	11	
	Autoclaves		12
	Shredders		
	Incinerations		
3	Building	11	12
4	O&M Cost	113	124
	Total	**347**	**382**

8.5 TOTAL COST

the total cost estimation for sanitation by calculate the cost of all elements of CSP in table 8.4 below shows the total cost of CPS elements.

Table 8.4: Total cost estimation of CPS

Sr .No	Elements	Total Cost (Sudanese Billion Pounds)	Proposed Cost (Sudanese Billion Pounds)
1	Sewerage system	6,352	6,987
2	Solid waste	3,271	3,599
3	Bio-Medical waste	347	382
Total		**9,970**	**10,968**

CHAPTER 9

RESOURCE MOBILZATION

9.1 STRATEGY FOR RESOURCE MOBLIZATION

The finance for sanitation for city dependent of The Ministry of Finance and National Economy of Khartoum State and subsides offered in various schemes . the collection of the proceeds performance of the localities offices in the several localities of KhartoumAnd all of localities offices are branches from The Local State Of Khartoumand there are supplying the revenue to The Local State Of Khartoum then to Ministry of Finance and National Economy. the resource mobilization strategy for city sanitation plan take out the source of sanitation finance and resource generation for sustaining sanitation plan.

Strategic intervention at city and ULB level following by :

9.1.1 City level Strategic intervention

a) KSWC is heavily subsidized by government, and water users pay little or nothing for access and consumption (USAID 2009).
b) Change funding from grants and subsidies with no or very low outcome to sanitation promotion and resource leveraging.
c) The Traffic policies fixation and review by ULB.

d) Develop guidance to support policy through the sewage services.
e) Make public private partnership frame work for sanitation in state.

9.1.2 ULB level Strategic intervention

a) Collecting the taxes, fees and improve the facility of collection.
b) Update and introduce of the taxes and fees of sanitation

c) Resource generation of waste at the request of local markets for products
d) Develop appropriate local strategies for mutual support of sewer service based on guidelines by the state government
e) Formulation of a strategy for resource mobilization to adopt with timetables and objectives clearly defined.

9.2 PUBLIC AWARNESS

9.2.1Specific IEC objectives for hygiene education and sanitation are set out in the section on animation

Prepare a national programme of communities on various aspects of hygiene, Animation has to be done for hygiene around the water points, environmental sanitation, control of used water and the construction of sanitary latrines. The animation programme will be developed by DGRH (sanitation, water points in rural areas) through its Animation Department; by the Ministry of Public Health (sanitation/health) through its Health Education Division and the USBs and health centres; and by the Ministry of Education (hygiene education) through primary and secondary school teachers, The Animation Department will be responsible for the production of training materials (graphic and audiovisual) needed for the programme, Introduce new concepts of community participation and cost sharing, Animation must explain the new strategy and define the precise role of all parties involved, The animation strategy integrates all aspects of water supply, hygiene, hygiene education, water use, and the protection of the environment. Animation actions on water and hygiene must be coordinated with the animation work of other interested or related ministries.

9.2.2Proposed IEC actions

The Animation Department will coordinate programmes, define themes and organize campaigns at national level, using different media, The department will provide support to projects and local animators and assist in the development of specific themes and training materials, Train village water committees in operation and maintenance, financial contributions, hygiene, Promote the involvement of women in organization, selection of technology, and maintenance. They also are the prime target group for hygiene education.

9.2.3Specific IEC activities listed

The training of seventy village teachers and 140 basic health officers in animation techniques, and the training of 30 animators in the project area. Under social mobilization, broadcasting about the well-diggers' association, promoting mobile plays, and designing posters, videos and radio programmes are listed. The second project in the water programme, , has two relevant components for IEC: Support to the Animation Department at DGRH, animation and health education, Specific objectives under this project include to raise to 50 percent the proportion of women who wash their hands before preparing food.

CHAPTER 10

CONCLUSIONS AND RECOMMENDATIONS

9.1 SEWAGE SYSTEM

The total quantity of sewer generation in Khartoum is from 801.7 MLD, the Sewage system in Khartoum is need improvement, the network system for sewage serve only from 5-7% from the city almost of them in the industrial area , it should establish sewage network to dispose the sewage by pump station to STPs by engineering design with institutes arrangement .

9.2 SOLID WASTE

The city generated solid waste more than 6,600 tons/day and only 4,200 ton/dayreach to the landfill and there is so many traders working in the recycling of waste so up less amount of received in landfills also fight open burning, the government not feedback any benefits from the biogases that emitted from landfillfor energy conversion , there is no composting for organic waste suggests to get benefits from the released gases from landfills and produce electricity and composite of organic materials to increase the Revenues . Also develop the process of waste collection by engineering design, there arevehicles delayed to collect the waste in the most of Khartoum localities.

9.3 BIOMEDICAL WASTE

Tthe city generated 17 ton/day and only 12 ton/day going for treatment and disposed in the landfills there are so many biomedical waste come as municipal solid waste, must set strict rules for hospitals and clinic for method disposal of BMW and put penalties and taxes and coercion on them to treat it.

9.4 Future Work

- Connecting the city by existing/ proposed sewer network transport the sewage to designed STPs.
- Stop dumping the recycling the sewage water in Nile river and Reuse in the green belt area and composite the sludge for agricultures.
- Improve collection technique of solid waste, segregation of the solid waste from the source, provide containers in the roads, markets and shops.
- Designing engineering landfills to protect the ground water and the air from the pollution, provide land covers, collection pipe system for the gases and leachate pipe collection.
- generate electricity from the emission gases from the landfills and composting the organic component.

- studying for the waste water generated from the hospital and existing/ proposal treatment unit.
- Strict implementation of biomedical waste management rules, it should made compulsory healthcare facilities.
- Put polices and institution arrange electronic waste management, reuse , recycling, treatment and disposal.
- Effort to increase the revenue generation by regulating fee and taxes.
- Mentoring and control the pollutions.
- proposal and implementation of air pollutions management, noise pollutions management and Radioactive pollution management
- development of environmental awareness and public participations.

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