

Current Status of Municipal Solid Waste Management in Juba City, South Sudan

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Abstract- Juba City, South Sudan, like any other developing countries in the world, has a problem of collecting solid waste. That is: one-third to two-thirds of the solid waste generated is not collected, therefore municipal solid waste management (MSWM) has become a complex developmental issue in Juba, the Republic of South Sudan due the economic activities. South Sudan is a developing country that just recovered from the decades' conflict situation from the North Sudan and experiencing alarming solid waste problems in the capital. The aim of this review paper is to assess the current status of MSWM in Juba city, in order to point out the current challenges and thereafter suggest some possible MSWM measures as solutions to the problems. Solid waste has been found not only to affect the environment and public health but it is noted to hinder efforts by several Governments especially in developing countries like South Sudan in the management of the environment, population growth, increased urbanization and more demand for goods and services have caused the persistent rise in the volumes of solid wastes generation in the developing countries. This has posed threats to the environment and socio-economic keys. It is challenging that the management of solid waste is rapidly becoming difficult as the dumping of uncollected wastes are found along the major roadside of Juba city. Therefore, Juba city faces serious environmental challenges concerning solid waste management due to rapid urban development and population increase. Open dumps have environmental safeguards; they can pose major public health threats and environmental effects in urban cities like Juba currently. However, the solution chosen for SWM in the development plan is the establishment of landfills on the outskirts of the city with recycling to reduce space for waste disposal. However, the problem of waste management is now beyond the capacity of Juba city Council due to abrupt population explosion and its related waste production, which requires significant resources of waste management, which are unavailable.

Index Terms- Solid waste management, Municipal solid waste, current status, Payams, Urbanization, Juba city council.

1. INTRODUCTION

Solid waste management has become a major challenging issue currently in Juba, South Sudan and facing almost all the developed

and the developing countries across the world (Gabriel 2015). The waste can also be called as any such material which must be disposed of and have no immediate economic demand after its usage. Generally, it is classified into three groups i.e. Liquid Waste, Gaseous Waste and Solid Waste. The solid waste consists of the material disposed of or thrown away as trash, garbage and rubbish from the homes or from any institution (Omofonmwan SI 2009). The management of waste should focus on how to find the value and redirect it back to the community. But unfortunately, our collecting and dumping process mix and crush everything together; and make separation an expensive and sometimes impossible task to properly manage wastes (Rabie 2006). The proper management of solid wastes generated from individual house, institutions such as hospitals, health centers; from public eating and drinking establishments (hotels, restaurants etc.); from business and working places is a very important part of environmental health service in a community. However, if these wastes are not disposed in a proper way, they create breeding places for insects such as flies, mosquitoes etc.; they provide food and harborages for rats. These insects and rats are health risk in that they are potential disease transmitters. In addition to health problems rats also imposes an economic problem (Sisay 2007). Several studies indicate that most of the solid waste is generated from the households (55% - 80%), market areas (10% - 30%), and institutions among others from the developing and developed countries. (Nagabooshnam 2011). Research has further indicated that wastes from these sources are highly heterogeneous in nature and have variable physical characteristics depending on their sources (Valkenburg 2008). Despite the present concern of governments, organizations and individuals about solid waste management in South Sudan and in Africa, it is still faced with more serious solid waste management problems with its associated negative health and environmental consequences. Therefore, the importance of a waste management system must always be the delivery of a discharging service which helps to maintain the safety and health of citizens and their environment (Cooper 1999).

Juba the capital city of the world's youngest Nations is very poor in term of solid waste management (Programme. 2007). South Sudan, a newly emerging and developing country, gained its independent from Sudan on 9th July 2011 after decades of civil war. South Sudan is surrounded by Ethiopia and Republic of Kenya in the East, Republic of Uganda and Congo (DRC) in the South, Central Africa Republic in the West and Sudan in the North. The

Republic of South Sudan is divided into several levels of government; the national government, the states, counties, payams and Bomas and municipalities in prominent cities. The Armed conflict broke out again in 2016, reversing much of the development progress including the waste management plans with the capital achieved by this new nation. The lack of infrastructure, low-level education for public awareness on the impact of waste on the health of the citizens and insecurity due to conflicts to access the landfill, contribute to the challenges of the local economy. The city Juba turned to commercial center right after the signing of Comprehensive Peace Agreement (CPA) in 2005. According to the report made by the United Nation (UN) estimates that the population living in Juba have reached over 1.5 million people because majority of people are foreigners who came to operate their businesses and more other local citizens left their own states, counties, payams to Juba to search for jobs and safety during the difficult times of the internal conflicts (Gabriel 2015).

However, the same situation relate to most of the South Asian cities facing the similar problems like urbanization, rural urban migration and the developments of industrialization and waste management technologies. As a result of all this population of cities' rapid increase. The constant increase in population has resulted in the generation of solid waste which is serious threat not only to the inhabitants of the areas but it is also a cause of environmental degradation, due to the poor management of solid waste, these cities are facing problems relating to public health and environmental pollution. Poor waste management is the result of poor Government Policies, lack of political will, lack of appropriate use of economic and human resources, and weak local institutions result in poor waste management especially in larger cities of developing countries. The local municipalities are trying their role to manage the solid waste but their hard work result into nothing due to the lack of resources, financial support, institutional and infrastructure facilities (Visvanathan C 2006). The conditions of waste management in the city of Juba South Sudan is worsening, well above the curve of these worrying global trends. Juba's population is continuing to grow rapidly – largely as a result of search for jobs as Juba is the headquarter of all the big organizations and in the past few years when there was insecurity in some counties due the civil war caused migration of many people for safety.

1.1. Overview on solid waste management

According to the UN estimates that in 2025, the world population will be 8 billion inhabitants, and around 2050, the total population will be around 9.5 billion, 50% more than the current one. 97% of this growth will be realized in Asia and Africa. The rising middle class in developing countries will shape both the economic and the political landscape. Nowadays, the total amount of waste generated per annum worldwide includes (municipal, industrial, hazardous) is more than 4 billion tons (Veolia 2009). Almost 45% of it is considered as municipal solid waste, while the rest is industrial waste, including hazardous ones. In addition, it has been estimated by UN that globally, urban household waste is going to increase by 44% from 2005 to 2025. As a global amount of the expected impacts, if present waste management trends are maintained, land filled food waste is predicted to increase the landfill share of global anthropogenic emissions from 8 to 10% (Adhikari 2006).

Recycling is one of the most important sectors in terms of employment creation and currently employs 12 million people in just three countries - Brazil, China and the United States. Generally, counting the casual sector, the number of individuals working in reusing is assessed to be more than 20 million people (Medina 2008). Waste management industry is one of the most dynamic ones on a global scale, with an annual revenue above 430 billion \$ and around 40 million workers (including informal recyclers), the industry covers a huge variety of operations for different waste streams and different phases of the waste life cycle. It is considered that the industry will further grow, especially in developing countries, and recycling business will be the foundation of it. Per capita waste generation increases with both the development level and the income level of the country (Wilson 2012).

1.2. Sources of solid wastes and types

Municipal solid define waste as a general term, which involves all waste materials except hazardous waste, liquid waste and atmospheric emissions. Solid waste can be further subdivided into two common categories: private and commercial waste. The private category refers to the waste that's assigned as 'garbage'. The trash class can be depicted as the waste that's assembled by the community administrations. The commercial category contains industrial and agricultural customers. Badran, M. (Badran 2006) observed in the study that sought to characterize the amount and composition of solid waste in Vietnam that total wastes, food wastes and plastic wastes were the major types of wastes generated. This waste generation had a significant seasonal variation. also observed in a study on solid waste generation and composition in Gaborone, Botswana, noted that close to 45,000 tons of the annual amount of solid waste to landfill were paper, garden and wood waste, textile, food, metals, glass, electronic waste, plastics and fines (Nagabooshnam 2011).

Zurbrugg and Nze noted that family wastes are regularly produced from a few sources where variable human exercises are experienced. They argued that most solid waste from developing nations are produced from families (55–80%), taken after by commercial or market zones (10–30%) with changing amounts from roads, businesses, institutions among others.

1.3. Practices on solid waste management in the world

Currently, most countries especially the third world countries, solid waste management is one of the major challenging to the municipal authorities (Xiang 2019). The rapid and constant growth in urban population led to a dramatic increase in solid waste generations, with an important socioeconomic and environmental impact (Sharholy 2018). The significant effects are street littering, blockage drains and causing flooding, transmitting diseases through breeding from burning of waste, harming animals that unknowingly consume waste, hindering tourism's sector contributions to nation's collected socio-economic development. Furthermore, due to improper waste management system practice the organic contents of waste contaminates the soil and human health including animals' life are risk. Municipal solid waste which usually comprises of household waste, yards waste, packaging waste, including commercial and institutional waste is expected to double in next decade (European Parliament and Council, 2008), Waste management in the developing and

developed countries varies. For example, in Asia, a developing continent, most countries face severe problems in managing urban solid wastes. It is evaluated that Asia produces 0.5 million tons of wastes per day and cities and towns in Sri-Lanka produces nearly 3000 tons/day, with an yearly increment of 5%. Dumping of wastes on authorized as well as unauthorized sites is the common practice causing health problems to humans and misbalancing the ecosystems. However, European countries, North America and other developed countries have techniques for reducing the quantities of domestic waste and eventual disposal in landfills (AESSL. 2007). Municipal managers in the developed countries are looking to the development of sanitary landfills around the outside of their cities as a first solution. Landfills however, require the acquisition of large areas as well as good day-to-day operation in order to minimize potential negative environmental impacts. The other option is mass burn incineration similar to systems found in OECD countries (Rand 2000). In the developing world, poor management, outdated collection and transportation methods, scavenging and a shortage of proper disposal sites, complicates waste management services. The uncollected waste creates problems at the community level- blockage drains, releasing vulgar odors and toxic gases, and spreading diseases (Sersgeldin 1994).

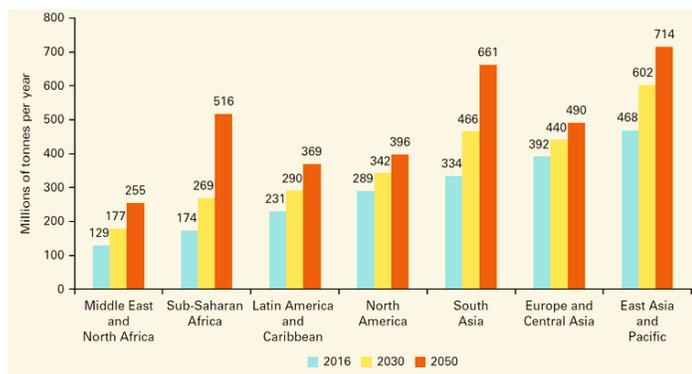


Fig 1. Global waste generation in developed and developing countries. Source, on internet.

A study conducted in Ghana shows high rate of urbanization in African countries indicates a rapid accumulation of solid waste. Social and economic development that most African countries have witnessed since the 1960s have also contributed to an increase in the waste generations per capita (Owusu 2012). It was observed that in South Sudan and Zambia as an example, there was no separation of the various types of solid waste, the waste components are just mixed and dumped in areas that are not designated for waste disposal (Yamba 2004). The best way of managing solid wastes is the internalization of costs (by levying charges for the use of the services). This is especially beneficial when a command and control policy is not effective. Government intervention is necessary for this. However, the major problem for solid waste management is the internalization of costs of waste disposal from households (Monyoncho 2013). According to Lusaka city council (2004) solid waste management is the responsibility of Lusaka city council (LCC) waste management unit, similarly to Juba, the waste management is in the responsibilities of Juba city council. The waste management unit (WMU) has partnered with Community Based Enterprises (CBES) and were responsible for the day-to-day management of the waste system in peri-urban areas. Based on Monyoncho, G. O noted that

there is need of adequate reserves to fund awareness campaigns to empower waste minimization at source together with minimal workforce hinder municipalities' endeavors to attain their vision (Monyoncho 2013). Moreover, the study done in Khulna, Bangladesh local governments are responsible for the collection and disposal of the wastes generated within their jurisdiction, as well as for the operation and maintenance of their equipment. In any case, local governments usually need the specialist and assets to supply a satisfactory and financially practical benefit. Effective and efficient solid waste management depends upon a fair distribution of responsibilities, authority, and revenue between the national government and all the local governments (JOHN April, 2017).

2. Background information of Juba city, South Sudan

Juba is the capital city of the Republic of South Sudan is selected for the present study which is the seat of the government of Central Equatoria state, headquarters of Juba County and where Juba City Council or Municipality lies. Juba city is found on scope 4⁰51'N and longitude 31⁰36'E and 518 meters over sea level. Juba city lies on the western bank of the White Nile. The city council or municipality comprises of three Payams (Districts) namely; Juba Payam, Munuki Payam and Kator Payam.

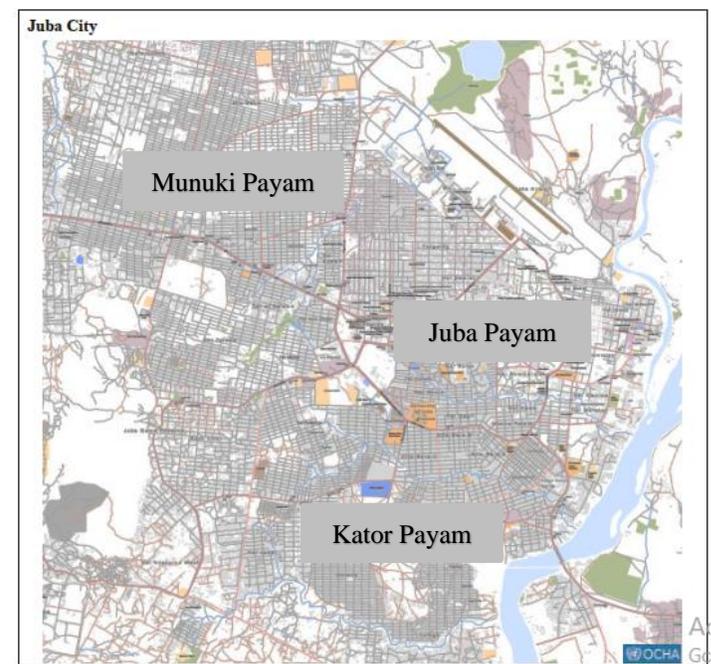


Fig 2. The study targeted the three Payams of Juba city.

The climate of South Sudan is tropical in nature and is characterized by a rainy season followed by a dry period. May is the wettest month with marginally lower temperatures, higher humidity and more noteworthy cloud scope. Normal temperatures for South Sudan run between 20 to 30°C in July and 23 to 37°C in March (weather-and-climate.com) Due to many years of civil war (1955-1972 and 1983-2005) in South Sudan (the then Southern Sudan), basic sanitation infrastructure for solid waste management was not given importance as a result, Juba city is lacking facilities to manage solid waste. Due to need of rubbish collection administrations, most individuals utilize roadsides, open spaces, football areas, waterway banks, waste channels and indeed graveyards as dumping destinations. A few

wastes are burned in residential regions, on the roads, etc. leading to air pollution with likely potential health hazards. The circumstance was made worse by the return of displaced people from the neighboring nations and IDPs from Sudan as well as from Ethiopia, Kenya and Uganda when the country got independence in 2011 that brought relative peace and financial boom within the nation.



Fig 3. Map of South Sudan showing location of case study Juba city.

Trash is collected in parts of Juba at a charges but the service is unpredictable with 95% of Juba's home have no access to the waste collection benefit. Cholera and other waterborne diseases are common in Juba and South Sudan at large with major cholera outbreaks in 2006, 2007, 2008 and 2014 and the latest in 2015, with over 1,597 cases including more than 45 death.

2.1. Summary of MSWM practice in Juba city

The increase in the rate of MSW generation in African countries like South Sudan has been worsened by an increase in urbanization, rapid population growth, rural-urban migration and industrial growth. MSWM in Juba is based on waste collection, transportation and disposal at a dumping site originally in line with the South Sudan Development Plan (Rehabilitation 2012). The solution prefer for SWM in the development plan is the improvement of landfills on the outskirts of Juba city with recycling to reduce space for waste disposal. However, the problem of waste management is now beyond the capacity of Juba City Council due to abrupt population explosion and its related waste production which requires significant resources of waste management which are unavailable (Rehabilitation 2012).

However, a solid waste dumping site was identified in 2007, located at Rejaf Payam of the Juba-Yei road about 13Km from Juba town. The dumping location is worked by Juba Municipality (City Council) with JICA as the counseling operators. Uncontrolled dumping begun in 2006 along the most street with genuine controlled dumping method as of September 2012 and is embraced by JICA. Dumping is carried on daily basis, organized in cells and covered with soil. A wheel loader or bulldozer is found on site depending on

availability. Sources of solid waste to the dumping site are Juba payam, Munuki payam and Kator payam which make up Juba Municipality plus some parts of Rejaf payam with a total population of approximately 0.8 to one million.



Fig 4. Open random dumping of waste in Juba

Total area of the dumping location is 25,000m² (500m*500m) and volume of every day waste transfer in tones is around 500 tones (approx. 60 to 70 trucks * 8 tones).Waste pickers come to the dumping site daily in search of plastics such as PET bottles, nylon sacks and tyres and metal scraps like aluminum cans, etc. which they sell to recycling companies once a lot to be taken to Uganda. Most waste pickers are local people, who live on the edges of Juba city in Durupi, Lokwilili, etc. while others come from Terekaka Province. The waste pickers extend from children to grown-ups (both genders). A few are indeed lactating moms. In any case, these waste pickers are casual scavengers who need defensive equipment; as a result, they are powerless to assortment of wellbeing dangers related with waste picking exercises (Programme 2013).

There are around 15 companies operating in Juba specialized in recycling and mainly dealing with four types of recyclables. These includes:

1. Scrap metals: most targeted, collected and sold in Kenya or Uganda or Kenya
2. Blow/hard plastic: widely targeted, shredded and sold in Uganda or Kenya
3. Small-scale recycling initiatives where bottled water companies shred their defect plastic bottles and export to Uganda or Kenya

4. Aluminum and especially beverage cans are collected, melted and formed into gate decorations or simply compressed together and sold in Uganda or Kenya for melting.

However, by then, the two main companies where the Philing Environmental and Southern Express. The Southern Express for the case was registered in 2006 and is one of the companies contracted in 2008 for garbage collection and disposal with 12 trucks and one loader but currently most of the equipment are broken down hence limited their efficiency of work to deliver the services to the communities (Ministry of Health 2012).

The stakeholder's gathering was proposed to include the National Service of Environment, Service of Fund, Service of Physical Framework, significant state services, City Chamber and other local governments, Commerce sector, NGOs, CBOs, UN and universal advancement organizations (Progamme 2013). However, Juba City Committee, health officers from the three payams (Juba, Munuki and Kator), Juba County, Rejaf Payam, UNEP and JICA are improving waste management within the city but it is still at the beginning of the process. JICA and UNEP are providing the technical assistance in MSWM at present with funding from USAID, UK, etc.

However, so many challenges exist in Juba city regarding to recycling and solid waste management in Juba and South Sudan at large, which can be categorized into the following categories (Charles Mahmoud Sebit Many October. 2017)).

Awareness and education

- Lack of awareness for recycling among government officials and other key stakeholders.
- Negative attitude and stigma towards waste collection and recycling by the population due to local norms and culture.
- Lack of health and environmental education in the community.
- Lack of skilled personnel able to work in SWM or recycling.
- Language barrier among stakeholders making cooperation difficult.

Technical issues

- Lack of (access to) recycling equipment in Juba or South Sudan.
- Waste workers lack technical skills related to recycling processes and equipment.
- Lack of infrastructure and power to operate recycling equipment.

Policies

- No clear or adequate policies on SWM and recycling.
- Lack of clear regulations on SWM.
- National, state and local authorities unable to enforce policies and regulations.
- Inefficient SWM system.

Co-ordination

- Lack of co-ordination among key stakeholders.
- Public health officers not involved in waste management

Funding

- Lack of government funding and financial resources in SWM sector.

- Lack of private sector interest and funding in recycling business.
- High operational costs and expensive SWM and recycling equipment.
- Private investment deterred by insecurity

Market for recyclables

- No demand for recyclables items in Juba, South Sudan.
- Transportation within South Sudan and to Kenya or Uganda is difficult and expensive.
- Low earnings from recyclables.
- Low quantity of segregated solid waste to be recycled.

Stakeholders' forum

- Lack of SWM and recycling stakeholder's forum that will coordinate among the different bodies (government, NGOs, CBOs, private sectors and funding institutions) involved in SWM.

Juba, where this study took place is the regional capital of South Sudan and the capital of Central Equatoria state. City authorities report that Juba legitimate occupies a total of 12 km area in diameter from the center of town (CIA 2010). Juba County, including the surrounding rural lands, encompasses generally 100 km in diameter. Juba it is likely one of the speediest developing cities within the world: (News report 2010). Roads are currently not in full good condition. But the United Nations, Chinese Companies and South Sudanese government are currently improving to repair the roads, constructing the roads and full repair is going on and expected to take some more years.

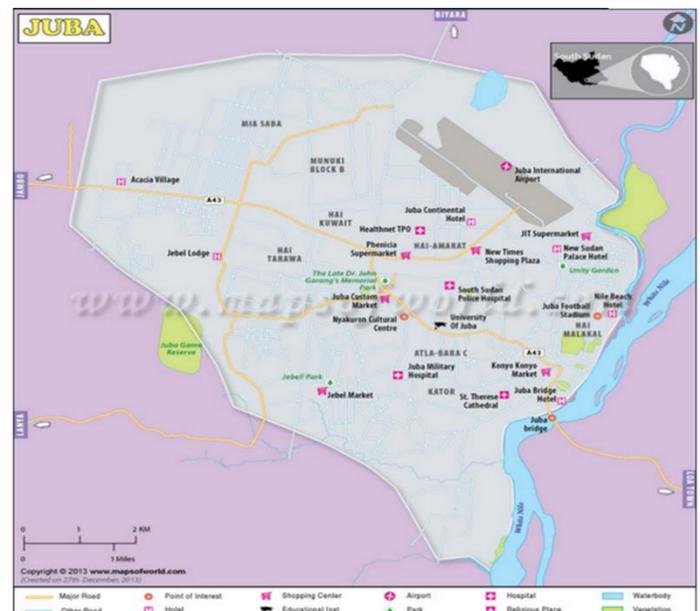


Fig 5. Main markets that generate wastes in Juba city, Source GoS 2013 Census

Juba have two main hospitals; Juba teaching hospital and military hospital and some more dispensaries and clinics as shown in the fig 5. There are four fundamental markets inside Juba, which incorporate Konyo-konyo and Custom as the main big markets, that produce expansive sum of wastes and other markets that generate waste like Suk Juba and Suk Jebel and other small markets. There is one slaughterhouse, which generates also waste

of different types and some primary and secondary schools and universities like University of Juba that generates wastes. Furthermore, there are also public institutions such as Churches, Mosques, gardens, prisons and stadium. The area also has international airport, which links it to other states within and international.

2.2. Status of municipal solid waste management in Juba city, South Sudan.

Solid waste management in Juba is under the responsibility of several stakeholders.; Comprises of; National ministry of environment, ministry of finance, ministry of physical infrastructure, relevant state ministries, city council and other local governments, business sector, NGOs, UN and international development agencies. The Ministry of Housing, Land and Public Utilities and the Ministry of Environment are both deeply involved in the topic. In Juba, these ministries are present at two different levels: Government of South Sudan (GOSS) and Central Equatoria state. Additionally, the sanitation office of Juba County is the one overseeing the on-going collection exercises inside the City Juba. As detailed from now on, both open and private partners are too included within the exercises of collection (Collivignarelli 2011).

The waste composition data for MSW produced the three (3) administrative (Payam) of Juba city council. Municipal Solid Waste core components are food waste, plastics (bag and bottle), metals, paper, aluminum, textiles, and garden waste. It contains blended composition of waste counting both degradable and non-degradable materials, and the wastes are usually collected without sorting. Compositing is one of the ways of reusing biodegradable wastes. Most of the non-degradable wastes are possibly recyclable materials, though the degradable materials can be composted. Plastics primarily come from water and natural product juice packs and containers (source Juba city council).

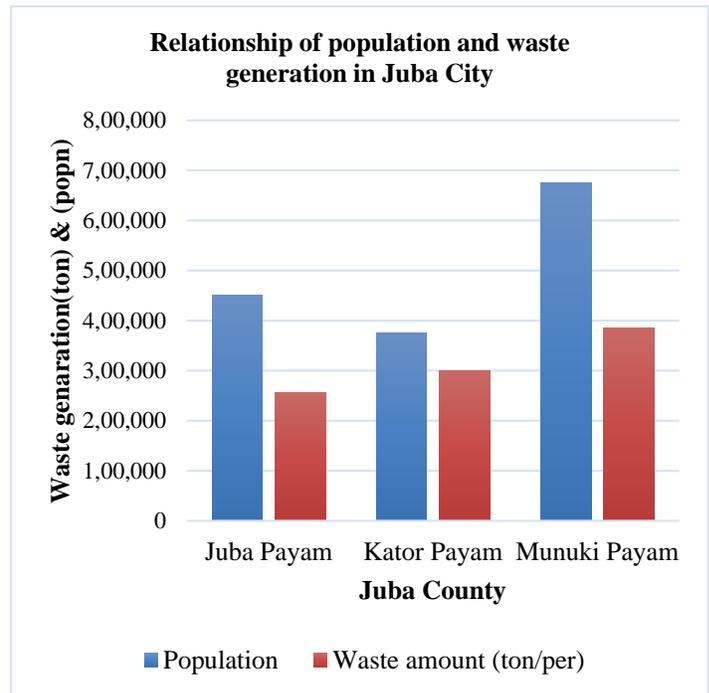


Fig 6. Residential waste generation in three Payams (t/d), 2018 data Source, Juba City Council.

The current formal framework of waste collection in place is only within the three Payams comprised inside Juba city (Juba, Munuki and Kator Payam). Within the other thirteen Payams, which form Juba County, an organized system is missing. Three different organizations are in charge of waste collection within the three Payams: They marked an assention with Central Equatoria state and Juba County. This understanding imposes rubbish collection expenses, as well as partitioning the town into three competence zones. Two private companies are responsible for the collection in Juba and Munuki Payams respectively, however the collection of waste in Kator Payam is under the responsibility of the Payam authorities. The collection service is usually limited to commercial areas and streets; only in Kator Payam the collection from residential areas is currently in place few years ago. The system of collection chosen is door-to-door; Systems of informal collection are also widespread: people owing a car collect waste from residential areas, under request, and usually dispose them in open plots or drainage channels in an uncontrolled way. This challenge is present in all the Payams of Juba.

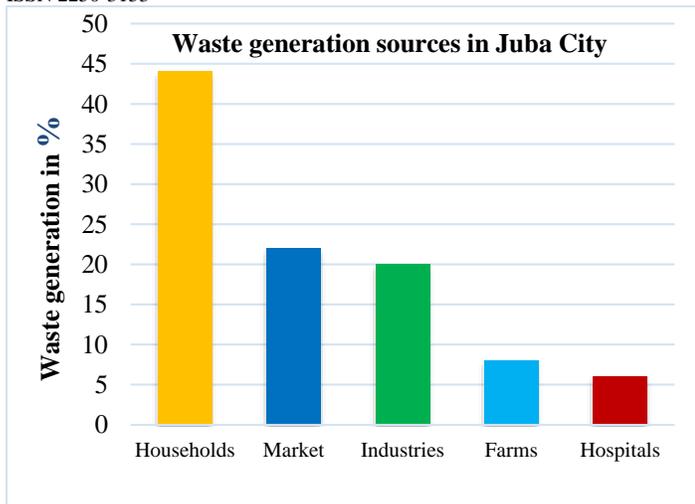


Fig.7. Juba municipal waste generations source, source Andrew Lako Kasmiro Gasim 2018.

No formal exercises of reusing are in place in Juba City. The most exercises of casual reuse and reusing regard plastic bottles, Aluminum and press. Used water plastic bottles are often collected along the streets by street children and then refilled with a local beverage or oil. Aluminum and press are reused at Konyo Konyo Market, the major market in Juba. Scrap Aluminium and iron are bought directly from householders or collected along the streets and then they are melted by using charcoal and molded to produce knives, pestles, spare-parts of cars or motorcycles and agricultural tools. At last, wastes collected by the formal framework are released in a dumping location situated around 20 km from Juba town. The site is neither provided with any measures for pollution control nor proper fenced. However, wastes are usually just disposed and accumulated on the ground. The site is a home for mosquitoes and flies and it is open to the access of animals, like goats, and scavengers looking for food. Over 480 people were reported to live close to the dumpsite, mainly making their lives from garbage. Also, waste coming from streams other than the municipal one (e.g. from the slaughterhouse or from health-care facilities) are usually disposed of at this site.

2.3. Stakeholders responsible for municipal waste management and collection in Juba

Solid waste in Juba city is managed by the department of Environment and sanitation of Juba city council, solid waste quantities, which are produced in Juba City, are large expanding with the developing prosperity and progressed standard of living. Municipal waste generation normal rate coming to 0.5720kg/per person/day (source Juba city chamber 2017), the population of Juba city is 1.500.000 Millions, such population produce roughly 950 tons of waste per day. Rain season is a higher waste generation rate. Solid waste generation changes per day in addition to the recurring seasonal variations. Collection recurrence too influences waste generations, in common, a more visit collection produces more MSW. Expanding the urbanization is one of the influences within the overall rate of solid waste production in South Sudan and many nations. The quantity of generated waste could be a financial indicator and a function of the degree of a nation's improvement. The distinction in waste generation between cities in developed nations (1.5–2 kg/person/day) and those in developing nations (generally less

than 1 kg/inhabitant/day) is essential. This critical distinction is due to utilization modes, as industrialized nations devour more items and utilize more bundling.

2.4. Solid waste collection, transportation, disposal and recycling in Juba

Juba city council, department of Environment and sanitation is a body in charge of management of all waste types within three Blocks (Payams) of Juba city but only the garbage collection just limited to the markets and business places, restaurants and road, main streets and in some areas like first- and second-class residential areas, the collection is just covering small region and the rest of private areas without collection administrations due to need of support, offices e.g.; tipper/compactor trucks to gather the garbage's, lack of private companies to take over private zones in rubbish collection. Juba city board office of Environment and sanitation has five zones all lies inside the region outline of Juba city administration overseen by a zonal facilitator alongside environmental officers and public health officers, rate collectors, bosses. Works on a centralized system where all the rubbish trucks are sent from head office to the zones no containers given by the city council. Collection and transportation are of critical significance in decreasing waste aggregation, Solid waste collection and transport are frequently conducted within the morning's hours. Lack of funding and inadequate maintenance causes a shortage of vehicles for waste collection, Juba city council ability to maintain waste collection is low and the provided vehicle/Compactors by the UNICEF in September 2016 and due to the outbreak of 2016 Civil war affected a lot the little available waste collections, some vehicles broken down and due to no good maintenance resulted to solid waste accumulations in the areas. Efficient solid waste collection depends on the proper selection of vehicles, which should be enforced with a consideration of road conditions, and availability of spare parts, servicing requirements, and transport distances. A serious concern is that most localities dispose of, and sometimes burn, their waste in random open dumps that do not support health and safety requirements. Local authorities use the burning method for volume reduction or for financial reasons. The budget for disposal is exceptionally little and does not cover advance treatment. Hence, regions perform waste disposal services according to the accessible assets from the collection fees. In turn, collection services deteriorate because the localities have highly limited financial resources (Andrew Lako Kasmiro Gasim 2019).The gathered information indicates that Juba does not employ and sorting or recycling processes for waste. Sorted recyclable wastes from family units are also uncollected. In addition, particular containers for waste isolation are unavailable. Individuals throw away materials as waste in any case of their conceivable benefits. These sorts of waste basically incorporate iron, aluminum, pipes, plastic sacks, magazines, and newspapers(Veolia 2009).



Fig. 8. Waste collection from roadside of Juba city.

2.5. Impact of solid waste on human health and environment

Unrestrained burning of solid waste and unsuitable incineration contributes significantly to urban air pollution. Greenhouse gases on the other hand are generated from the decomposition of organic wastes in landfills, and untreated leachates are known to pollute the surrounding soil and water bodies. Health and safety issues also arise from improper solid waste management. Insect and rodent vectors are attracted to the waste and can spread diseases such as cholera and dengue fever. In addition, hospital wastes are a source of defilement and contamination to both people and the natural environment as talked about in this paper. Improper disposal may be hazardous if it leads to contamination of water supplies or local sources used by nearby communities or wildlife. Sometimes exposed waste may become accessible to scavengers and children if a landfill is insecure. Medical wastes are potentially capable of causing disease and inhalation of vapors can cause: headaches; euphoria; light-headedness; dizziness, drowsiness; nausea vapor can irritate skin, eyes, and lungs over exposure can lead to unpredictable pulse, swooning, and in the long run passing on. Readily absorbed and can cause severe burning if brought into contact with skin/eyes/lungs inhalation results in chest pains, increased heart rate, coughing, nose and throat irritation, shakings, and eventually death. Moreover, can cause serious burning to skin, eyes or lungs if contact made can genuinely influence lungs and respiratory system in breathed in (aspiratory edema, lung irritation) possibly deadly ingestion causes sickness, vomiting, gastrointestinal disturbance and dying over exposure can lead to kidney and liver harm.

However, some of the commonly reported work-related health and harm issues in solid waste management and disposal includes;

- Infections from direct contact with contaminated material, dog and rodent bites, or eating of waste-fed animals;
- Puncture wounds leading to tetanus, hepatitis, and HIV infection;
- Injuries at dumps due to surface subsidence, underground fires, and slides;
- Headaches and nausea from anoxic conditions where disposal sites have high methane, carbon dioxide, and carbon monoxide concentrations; and

- Lead poisoning from burning of materials with lead containing batteries, paints, and fuses. The common illness within the consider area according to public health inspector in Juba city incorporates: diarrhea, jungle fever, viral illness, eye infections and skin infections. The major causes of these illnesses is poor environmental sanitation, inappropriate disposal of refuse and human farces, insufficient water supply, destitute lodging and terrible nourishment cleanliness (Cointreau 2006).

2.6. Current common environmental problems

Right now, world cities produce almost 1.3 billion tons of solid waste per year and this volume is anticipated to extend to 2.2 billion tones by 2025, more than multiplying in lower wage nations. This may influence health population due to be caused by vector borne illnesses and chance of fire close where family waste is kept, without satisfactory requirement of the existing environmental legislation and expanded public involvement, vital components of the integrated waste management (UNICEF 2009). There is inexhaustible discharge of vaporous, poisonous substances into Juba town environment as well as risking of wellbeing of scavengers as a result of burning of obsolete e-wastes. Due to contact with smokes from burning of solid wastes and gaseous emission from dumpsites, cases of several diseases have been recorded (Oyelola 2009). Solid wastes are dangerous in nature since they accumulate and contaminate the ground and surface water and are toxic and breeding grounds for insects and fly which in turn are the sources of several diseases. Further, percolation of leachate to ground water sources may cause severe health problems if used for drinking water purposes (Tchobanoglous 1993), (Beigl P. 2009). As such, environmental friendly strategies for administration of municipal solid waste management have ended up a worldwide challenge in confront of competition with constrained assets, quickly expanding population, urbanization and around the world industrialization (Katiyar R.B. 2013).

Government ought to strengthen waste collection and transfer frameworks in each state whereas reinforcing and upholding the fitting laws. To avoid genuine environmental disaster, priority ought to be given to waste management (Oyelola 2009). Open dumpsite approach as solid waste transfer strategy could be a primitive organize of solid waste management in numerous parts of the world. It is one of the foremost ineffectively rendered services by municipal specialists in developing nations, as the frameworks connected are informal, obsolete and in- proficient. Solid waste transfer destinations are found both within and on the outskirts of developing urban cities. With in-crease within the worldwide population and the rising request for nourishment and other fundamentals, there has been a rise within the sum of waste being produced every day by each house- hold. This waste is eventually thrown into municipal transfer destinations and due to destitute and incapable administration, the dumpsites turn to sources of natural and wellbeing dangers to individuals living in the vicinity of such dumps. One of the main aspects of concern is the pollution caused to the earth—be it land, air and water.

According to Nguyen, Solid waste disposal sites are found on the outskirts of urban areas. These zones gotten to be children's sources of defilement due to the increment and increasing of flies, mosquitoes, and rodents. They, in turn, are infection transmitters

that influence population's health, which has its natural protections in a developmental and imaginative state (Nguyen 2011). They said that, circumstance produces gastrointestinal, dermatological, respiratory, hereditary, and a few other kind of irresistible infections (A. 2013). The UNEPA expressed that wastes that are not overseen legitimately, particularly solid waste from family units and the community, are a genuine health risk and lead to the spread of irresistible illnesses.

The report further expressed that unattended wastes lying around draw in flies, rats, and other animals that, in turn, spread infections. Regularly, it is the wet waste that de-composes and discharges a terrible odor. The awful odor influences the individuals settled next to the dumpsite, which appears that the dumpsites have genuine impacts to individuals settled around or next to them ((UNEP) 2006). The group at risk from this destitute transfer of solid waste includes-the population in regions where there is no legitimate waste disposal strategy, particularly the pre-school children, waste laborers and specialists in offices producing poisonous and irresistible materials. Other high-risk group incorporates population living near to the waste dump (al. 2010). In specific, organic residential waste poses a genuine danger, since they mature making conditions favorable to the survival and development of microbial pathogens. Coordinate dealing with of solid waste can result in different sorts of irresistible and unremitting illnesses with the waste workers and rag pickers being the most vulnerable (Nwanta J. A. and Ezenduka 2010).

Open dumpsites are a major problem to the environment especially to the air that we inhale. Dumpsites emit horrible odors and smoke that cause illness to people living in, around, or closer to them (Marshall 1995). Agreeing to Medina, 2002 contamination, a major environmental impact of dumpsites, isn't straightforwardly exchanged from land to people, but within the case of cleans and direct contact with harmful materials. Pollutants deposited on land usually enter the human body through the medium of contaminated crops, animals, food products, or water. In addition, the dumpsite has smelly and un-slightly conditions. These conditions are worse within the summer since of extraordinary temperatures, which speed up the rate of bacterial activity on biodegradable natural fabric. Transfer sites can also make health at risks for the neighborhood (Boardi K. O. and Kuitunen 2005).

3. Public participation in solid waste management

In many parts of the world, communities continue to be looked at as passive recipients of government services, and are very often ignored even in local decision-making processes (TADESSE 2006). Eventually, this approach comes about within the individuals falling flat to know the role they can play within the prepare. In this manner, within the middle of several waste management and disposal strategies, interest may be a lost link/component in a conceivable formula for better solid waste management. Significant research endeavors have been coordinated to open cooperation even within the angles of reusing behavior like (BARR 2004). Be that as it may, such researches have had curiously discoveries develop in back of open interest in solid waste management. Research findings show that landfill space is now scarce and yet the communities also are less likely to accept landfills to be sited near their habitation for environmental, health and aesthetic reasons (BARR 2004). Since it may not be

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practical to utilize waste management strategies of an despotic nature, the interest of the individuals in solid waste management choices and practices gets to be unavoidable. Within the study on residential solid waste management in South Sudan, found out a few gaps within the solid waste management practices that would effectively point to public participation as the foremost conceivable solution. It was found out that systematic sorting of waste at the different stages right from the source to the disposal sites was lacking (JOARDAR 2000). It was also a major finding that in South Sudan, incineration has not appeared victory due to the different composition of the waste since it isn't sorted. Essential sorting should ideally be a role played by the public, at the source (of waste generation). Without waste sorting, it practically becomes difficult to manage the solid waste in a sustainable way. Other than, the way in which waste is disposed of particularly within the developing world may only suit participation of the public in order to switch the impacts of poor solid waste disposal (JOARDAR 2000). The most widely practiced municipal disposal method has been uncontrolled dumping, concentrated in low-lying fringe locations and leading to leachates percolation and pollution runoff and contamination of soil, ground water, canals, and river ways". Uncontrolled dumping when practiced aimlessly by the public, it imposes far-reaching impacts as Sauro focuses out. In any case, in itself, dumping isn't a feasible way of management of waste, it would really be a qualified damaging strategy, however it can be controlled and the impacts switched in case the public were included within the waste management and disposal structure. However, the process of public participation may sometimes be long and not cheap in terms of time. To a few individuals, it may not indeed be important. Nevertheless, it is nearly inconceivable to talk almost sustainable development and at the same time avoid the need to have the individuals included. This is because in present-day development practice, growing awareness of the importance of people's non-expert experiences and knowledge has continuously led to a terrible need for shared decision-making in various contexts (BARNES 2005). The input of the public isn't insignificant in any given sector since of their applied impact on the heading of improvement.

4. Challenges of solid waste management in developing countries

Municipal solid waste management (MSWM) in developing nations can be depicted as lacking service scope, operational wasteful aspects of administrations, insufficient management of unsafe and wellbeing waste and environmental issues. The quantity of waste arising – solid, liquid and gaseous are generally considered to be growing across the globe as a result of increase in the world's population, increasing industrialization, expanding urbanization and rising benchmarks of living (USEPA 1993).

4.1. Inadequate service coverage

Solid waste collection schemes of cities in the developing countries generally serve only a limited part of the urban population. The majority of the people, especially in slum areas remain without waste collection services. These are as a rule the low-income workers living in destitute conditions in semi-urban areas. One of the most causes of insufficient collection services is

the lack of budgetary assets to manage with the expanding sum of produced waste created (Zurbrugg 2003).

4.2. Operational inefficiencies of services

Operational inefficiencies are due to inefficient organization structures, inefficient organizational strategies, or insufficient administration capacity of the institutions included as well as the utilize of improper technologies (Nze 1978). With respect to the specialized framework, frequently the “conventional” collection approach, as created and utilized within the industrialized nations, is connected in developing nations. The used vehicles are sophisticated, expensive and difficult to operate and maintain, thereby often inadequate for the conditions in developing countries. After a short time of operation usually only a small part of the vehicle fleet remains in operation. Transport also depends on operational vehicles, and visit breakdowns coupled with parts shortages can immobilize collection vehicles for amplified periods of time. For example, UNEP estimated that in the cities of West Africa (UNEP. 1996).

4.3. Inadequate management of hazardous wastes

Healthcare wastes are produced as a result of exercises related to the practice of pharmaceutical and deals of pharmaceuticals (Zurbrugg 2003). Nevertheless, a few of the health-care wastes coming from any specific clinic or institution are comparative in nature to residential solid wastes, and may be called “general health-care wastes”. The remaining wastes posture serious health dangers because of their physical, chemical or organic nature, and so are known as “hazardous healthcare wastes”. In many cases the most dangerous items in health care wastes are needles from syringes and drips, because the needles shield the virus from chemical disinfectants and a harsh external environment, and the sharp point allows easy access for the viruses into the blood stream of anyone who is pricked by the needle (WHO. 2004). The key to improving health care waste management is to provide better methods of storage and to train the staff to adopt safer working practices and segregate as hazardous healthcare wastes from the general health care wastes.

4.4. Inadequate management of human health risks issues

The decomposition of waste into constituent chemicals could be a common source of nearby natural contamination. This issue is particularly intense in developing countries where existing landfills don't meet worthy environmental benchmarks, due to restricted budgets, (UNEP. 1994). The issues related with fast urbanization once more compound the issue. As land gets to be rare, human settlements encroach upon landfill space, and local governments in a few cases encourage unused advancement specifically on best of working or as of late closed landfills. A major environmental concern is gas released by decomposing trash. Methane could be a by-product of the anaerobic respiration of microbes, and these microbes flourish in landfills with high sums of moisture. Methane concentrations can reach up to 50% of the composition of landfill gas at most extreme anaerobic deterioration (Cointreau and Levine, 1996).

5. Integrated strategies for solid waste management

Although solid waste is very challenging to manage and arrange of, it isn't continuously completely futile. Imaginative ways of managing with solid waste can be formulated to create solid waste valuable. The Centre for Ecological Technology (CET) which supports sustainable technologies in New England undertook such an effort, turning waste composting into a “way of doing business”(MAJERCAK 2002). Through collaboration with commercial transporters, commercial waste generators and, farmers, the project took off with the farmers being the composting agents who would then send the products to the market. Engaging in such a complex of collaboration, in itself presents an opportunity for constructing a collaboration that would beneficially take advantage of solid waste to make it productive. This would result into a double gain since composting can fit exceptionally well within the commercial center elements because it gives an opportunity for benefits both financially (salary to agriculturists) and ecologically (diminishing nursery gasses and lessening on leachates generation), from organic waste. Agriculturists too get enabled to manage their possess waste by utilizing it as fertilizers, subsequently minimizing on the utilize of synthetics or petroleum-based fertilizers(MAJERCAK 2002). Such an undertaking may not essentially be simple to begin and keep up, but it may definitely turn out to be beneficial.

In Africa, a very small volume of the generated solid waste is recycled or recovered as there is little “economic incentive and market for recycled materials (USEPA 2002). On one hand, (BOURNAY 2006) notes that wealthy nations proceed to send waste to Asia and Africa which turns out to extend the burden in those continents. This waste is in shape of obsolete things that not meet the buyer inclinations and measures within the wealthy nations, and or pointlessly excessive bundling of made items for send out. The defense of the rich countries is that the waste they send can be “recycled anyway”(BOURNAY 2006). On the other hand, many European nations have reusing plans for glass and paper, but the victory of such plans has moreover been decreased by the expanded generation of waste paper and glass and hence making the solid waste issue fair however to be mitigated (USEPA 2002). In addition, it moreover a few what sounds unreasonable to accept that there will be successful and productive reusing of waste in Africa, when really the most strategy of waste administration and transfer is landfilling.

Landfilling has become the immediate most possible way of managing solid waste in most African countries because of the high prevalence of indiscriminate waste dumping. The authorities that primarily bear the responsibility to clean up the cities, towns and residential areas find it easier and time saving to collect the waste and carry it to a landfill other than sorting the waste for reusing and less still for composting. Therefore, solid waste management challenges are worldwide albeit at different levels in the different parts of the world.

The United States Environmental Protection Agency(USEPA 1993), outlines and explains three main components in an integrated municipal waste management strategy- that is; waste prevention, recycling including composting and, combustion. In a review of these components,(USEPA 2002) categorically introduces and defines five main activities (in a hierarchy) classified under integrated solid waste management (waste

prevention, recycling, composting, combustion and landfilling), and the likeness is recognizable between the previous components and the afterward activities classified. This studies will discuss the following;

5.1. Waste prevention

Waste Prevention also known as source decrease within the plan, fabricate, buy, or utilize of materials and products to decrease the sum and/or harmfulness of disposed of waste. Waste anticipation too implies, in basic terms, “reducing waste by not producing it”(USEPA 2002). USEPA declares that since it decreases the sum of waste that a community must oversee, waste anticipation is the favored municipal solid waste management method. According to USEPA, source reduction includes reuse activities and “has come to be recognized as a commonsense approach with significant potential to utilize resources effectively, spare money, and decrease waste” and since of the different focal points it presents, many states within the United States of America (USA) have progressively locked in in imaginative wanders towards solid waste prevention((USEPA) 1998). Glass cycling and terrace composting are taken to be “forms of source lessening or waste anticipation since the materials are totally occupied from the transfer offices and municipal management or transportation” ((USEPA) 2002).

5.2. Recycling

Recycling includes the reuse of materials that are potential waste but are or maybe turned into important resources. The foremost imperative advantage with reusing is that it decreases the generation of greenhouse gasses since there's redirection of the waste from the landfills. Reusing too decreases the utilization of modern resources, in a way contributing to economic development. Materials like paper, glass, steel, plastic, and aluminum can be reused such that rather than arranging them of, they can be recaptured and subsequently reused.

5.3. Composting

Composting refers to the controlled aerobic biological decomposition of organic matter, such as food scraps and plant matter, into humus- a soil-like material. Compost acts as natural fertilizer by providing nutrients to the soil, increasing beneficial soil organisms, and suppressing certain plant diseases” (USEPA 2002).

6. Technologies for municipal solid waste management

MSW generation is speedily increasing in South Sudan states. These wastes need to be treated adequately to prevent environmental problems and enable a constant development of modern society. Currently, landfilling and composting are the only technologies primarily used for waste management in most developing countries (Dlamini, Simatele et al. 2019).

6.1. Vermicomposting

Vermicomposting of MSW was too proposed in a few nations. With an disturbing decrease within the availability of energy

resources, there's a recharged intrigued in inventive ways to change over the existing saves with more effective advances which will lead to a lower effect on the environment(Collivignarelli 2011). MSW is actually a resource with huge potential in terms of material and energy recovery. Thus, waste-to-energy (WtE) operations have the advantages of resource generation and the minimization of land-filled waste. Other commonly accessible advances for treatment of MSW are displayed.

6.2. Incineration

Thermal treatment utilizing incineration innovation has been recognized as an substitute appealing strategy for MSW disposal due to the essential preferences of sterile control, relative safeness, volume decrease (approximately 90%), mass lessening (around 70%) and energy recuperation (Gasim). As a result, burning of MSW has gotten an extraordinary bargain of consideration in nations with small landfill space. MSW incineration technology with direct gasification and melting has been taken as a wide-ranging technology offering high temperature, long time for gas transiting, nitrifications of various remains, no heavy metal and lower quantity of dioxin. Organic composition gasifying and mineral melting are combined to obtain fuel gas, metal and slag using this technology(Magram and Technology 2011). Incineration does have its problems and is consequently disapproved due to incomplete combustion of materials giving rise to harmful emissions, presence of chlorine leading to highly toxic dioxin and furan emissions, high working costs and utilize of supplementary powers to realize high combustion temperatures (Acanto). Products determined from MSW thermo-chemical transformation, such as syngas and bio-oil, may be specifically utilized as fuel, included to petroleum refinery stocks, upgraded utilizing catalysts to premium review fuel or utilized as chemical feedstock. Extraordinarily, generation of a fluid fuel product increments the ease of taking care of, capacity and transport and hence, the product does not ought to be utilized at or near the reusing plant (Nguyen 2011).

6.3. Landfilling

Landfilling has long been the most common disposal method for MSW, especially in developing countries, because of its simplicity, low investment and operational costs and easy operation. A typical landfill may be a source of three stages of waste products: solid (wastes), liquid (leachate) and gaseous (landfill gas), which may pose a threat to the individual elements of the environment ((UNEP) 2006)MSW landfills are also potential sources of offensive odors causing irritation, which may cause decreased quality of life and negative magnitudes on human health and wellbeing. The impacts of producing and treating landfill gas (LFG) and leachate have been the essential concerns of analysts as the major environmental issues related with MSW landfilling. Treatment of MSW by landfilling has been, and still is, connected with a danger of pollution (Patz, Graczyk et al. 2000). In case executed legitimately, selection of sanitary landfill can offer assistance in creating resources like landfill biogas, offering of processed deny as fertilizer as well as offering benefits of resource generation through CDM. Pyrolysis: Pyrolysis is considered as an inventive alternative for treating MSW. Pyrolysis

has been inspected as an alternative for MSW disposal that allows energy and resource recovery (Remigios and Journal 2016). Pyrolysis is the thermal debasement of waste within the nonappearance of oxygen.

7. Conclusion

Municipal solid waste management in Juba city is still in its earliest stages, missing fitting specialized solutions, adequate organizational capacity and participation among wide extend of stakeholders, in this manner, the management of solid waste in Juba town under the City Council need to improve and put more efforts to management. However, the challenges of MSWM in Juba are immense, ranging from lack of strategic planning, which is attributed to lack of capacity, being the overall challenge. Lack of capacity has resulted to a catch phrase, "Capacity Building", often used by aid agents in South Sudan in all different sectors. Dismissing the public in decision making or arranging adds to another challenge. The needs of the people are not understood, as a result, they will not be part of such programs. Regarding the cultural and socio-economic aspects, Juba municipality faces the challenge of behavior pattern and underlying attitude of the citizens not oriented towards waste conscious behavior, factors that are shaped by the local cultural context. Most of the inhabitants of Juba live in slum areas where SWM services are insufficient or totally missing. The challenge the MSWM faces is that no space among the densely packed settlement for refuse containers, narrow roadways, steep gradients and un-surfaced roads that standard collection vehicles cannot manage. The commitment of leaders at the municipal levels to actualize plans is disintegrated when discussions emerge about the obligation or jurisdiction of the waste sector driving to the disappointment of such projects.

Waste is dumped aimlessly which ends up blocking all the waterways and drainage system. This has driven to spread of infections and floods causing misfortune of lives. The quantity of solid waste tended to increase in level of income, activity, changes in eating habits and the widespread use of disposable containers and packages resulting in huge amounts of waste and geographic factors. It was realized, according to the assessment the public were aware of their actions pertaining to waste management since they are seeing the effect but the blame is pushed on the government as not doing its work. Final disposal of solid wastes is completely by improper methods, weakness of environmental awareness about solid waste, presence of health hazards and environmental problems due to the final disposal of solid waste, and finally regulations and law that recognize, so the following recommendations are suggested for consideration.

- (1) The public must be educated and aware on the impact of solid waste on human and environmental health through various means of communications.
- (2) The concept of waste management progression should be embraced, which aims at extricating the most extreme practical benefits from products and to create the least sum of waste through the "3Rs", Reduce, Reuse and Recycle.
- (3) Solid waste service revenues should not flow into the general municipal account so that it is not absorbed in the overall expenditures, instead the revenue should remain with waste sector

in an autonomous accounting procedure, that make it easier to improve and/ or extend services.

(4) A democratic public process of SWM policy formulation is essential to determine the actual needs of the citizens and therefore, to prioritize the limited municipal resources in a just manner.

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