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1. **ABSTRACT**For many developing countries like south Sudan (central Equatorial state) solid waste management remains a serious under-researched, problem. A case study of solid waste management undertaken in Juba city council and communities within Juba County. Solid waste management practices were to be investigated through interviews, **Questionnaires and Surveys, Observations, Focus Groups and documentary.** The main focus will be on the availability of funding, recycling programs and waste collection services to determine whether they contributed either positively and negatively to indiscriminate burning and disposal in public places. These elevated levels of toxic metals are of significant concern as the dumps are both nearby to water bodies, and have no restrictions, such as fence, to prevent public access. Appropriate funding for solid waste programs, including waste collection and disposal facilities, recycling and training programs are highly recommended to safeguard community health.
2. **INTRODUCTION**

Poor sanitation and unsafe disposal of solid wastes threaten the well-being of humans living in poor, remote and marginalized communities across the globe, including first nations (state/county) communities (owusu, 2010; zagozewski et al., 2011).

Improper disposal of municipal solid waste pollutes the air, water and land resources, and therefore threatens the wellbeing of people, animals and plant species, as well as water. As safe and potable drinking water becomes widely scarce, environmental contaminations attributed to poor sanitation and improper disposal of wastes render water sources unhealthy for people in many areas of both developing and developed countries across the world (Ritter et al., 2002; Reddy & nandini, 2011; haribhau, 2012).

Developed countries are typically more progressive than developing counties in terms of human development indices and environmental performances; however, living conditions in indigenous communities in some developed countries are often on par with developing countries (cooke et al., 2007; wong, 2012).

The poor living conditions are evident in the cases of many indigenous communities, such as first nations (state/county) (status and non-status Indians), metis and inuit in canada (cooke et al., 2004; palmater, 2012); aboriginal and torres strait islander peoples in Australia (tilbury, 2015; Doyle, 2015); the Māori people in new Zealand (sibley et al., 2011); and American Indians and Alaska natives in the united states (gone & Trimble, 2012). Thus, the overall picture of conditions in developed countries may not totally reflect local realities among indigenous populations. Research (e.g., Altman, 2007; Adelson, 2005; Cooke et al., 2004; Cooke et al., 2007; Sibley et al., 2011; and Doyle, 2015) indicates the poor wellbeing of indigenous peoples in some developed countries and the existence of significant gaps in wellbeing between indigenous and non-indigenous populations.

Improper solid waste management raises serious public health and environmental concerns (owusu, 2010). Of major concern are the practices of unsafe solid waste disposal, such as open dumping and open air burning, which has been found to have severe health and environmental consequences (ogwueleka, 2009). Children and adults are exposed to physical injuries and infections from sharps and other hazardous materials present in the waste stream (Rushton, 2003).

Most solid waste disposal sites on state/county reserves are unregulated waste dumpsites rather than sanitary landfills meeting government standards (Bhardwaj et al., 2006). Thus, the public health and environmental safety and social acceptability of solid waste management practices in many state/county communities across south Sudan becomes a serious issue (Bhardwaj et al., 2006). many of the designated waste disposal facilities located on state/county reserves, have turned into potential hazardous areas filled with all sorts of waste materials (Bhardwaj et al., 2006) with limited or no options for waste diversion and pollution prevention. Therefore, the need to research waste related problems and solutions from community perspectives becomes imperative, in order to protect environmental and community health.

1. **BACK GROUND INFORMATION**

The management of solid waste continues to be a major challenge in urban areas throughout the world particularly in the rapidly growing cities of the developing world (Foo, 1997). A high rate of population growth and increasing per capita income have resulted in the generation of an enormous volume of solid waste, which poses a serious threat to environmental quality and human health (Snigdha, 2003). Access to sanitation services and clean adequate water are therefore regarded as crucial to the health and wellbeing of people.

As more cities become industrialized, the congenital problem of waste management comes along with it. Technological and economic advancement has made the types and kinds of Solid Waste very diverse and their management much more complex. The complex nature of disease outbreaks; cases of cholera as well as other diarrheal diseases in recent times corroborate this fact.

Furthermore, the changing economic trends and rapid urbanization complicate solid waste management (SWM) in developing countries. Consequently, solid waste is not only increasing in composition but also changing in quantity from a few kilograms to tonnage proportions recently (Bartone, 1993). In South Sudan, the government started privatizing Solid Waste Collection (SWC) in order to meet the collection demand of the enormous waste being generated. Even though the government privatized SWC, the public sector still collected half of the city waste.

Moreover, in Juba, the collection systems differed from the high-income to low-income residents. Low-income groups cannot afford to pay for proper garbage disposal and they tend to dump domestic garbage near their houses, in rivers, into sewage drains, and at other illegal sites. On the other hand, high-income groups tend to pay waste collection fees. According to Boadi and Kuitunen (2003), in 1998, 80 percent of waste was from the low-income residents, 17 percent came from middle-income residents, and three percent of waste was from high income groups. Most of the waste generated from the low-income residents in Juba is not effectively collected.

1. **LITERATURE REVIEW**

This section provides a general overview on solid wastes, integrated solid waste management and solid waste management options including source reduction, recycling, composting, and landfilling. Topics covered are related to management practices for different kinds of solid wastes.

* 1. **SOLID WASTES**

Solid wastes are commonly referred to as trash, garbage or refuse. according to the European union (EU) landfill directive, municipal solid wastes (MSW) includes “waste from households, as well as other wastes which, because of its nature or composition, is similar to waste from households” (European union, 1999). Many jurisdictions handle hazardous wastes, medical wastes, end-of-life vehicles, contaminated soil and agricultural wastes as separate waste streams. In south Sudan, however, non-hazardous wastes materials from households, commercial and institutional activities, construction and demolition works, are classified as municipal wastes. (MSW)

As discussed by Kipperberg (2007), virtually all human activities produce waste materials that are unsanitary or unsafe. Traditionally, waste materials have been set on fire, buried or disposed on land, and sometimes dumped in the lakes, rivers, oceans and other water bodies (kipperberg, 2007). Today, these traditional methods of waste management threaten environmental quality and human health due to changes in waste composition (kipperberg, 2007).

However, as raw materials become increasingly scarce and expensive to extract, secondary benefits may be derived from waste materials to conserve resources and prevent environmental pollution kipperberg,2007).By virtue of responsibilities, solid waste management in south Sudan is shared among the various levels of government, i.e. state government, local governments and private companies. Solid waste management encompasses series of activities, which begin from the point of waste generation to final disposal. In state communities across south Sudan, however, there have been widespread public concerns about waste related problems over the past ten years (bharadwaj et al., 2006). Waste dumpsites on most state/ county community reserves have been reported as lacking environmental protection measures such as cover materials, engineered liners or a leachate collection system and are usually sited without geological considerations (Zagozewski et al., 2011).

Open air burning of all kinds of waste materials, ranging from plastic to kitchen wastes, are typically done by residents of these communities on a routine basis to reduce the volume of the waste stockpiles with the prospect that out of sight is out of mind (bharadwaj et al., 2006).

However, burning of waste materials results in release of noxious substances, such as dioxin and furan, into the environment and may lead to severe human health complications including respiratory disorders and cancer (scheinberg et al., 2010). More so, leachates from waste disposal sites are sources of ground and surface water contamination that can severely impact drinking water quality (Christensen et al., 1998). Research has linked exposure to water pollution from waste disposal sites to human health problems, such as developmental deformities, birth defects and cancer (kjeldsen et al., 2002). Sayville and Rockford in the United States are well-documented cases where groundwater contaminations were attributed to leachate from waste disposal sites (Shuster, 1976a; Shuster, 1976b).

Physical and chemical analysis of soil, groundwater and ash samples collected from waste disposal sites in selected state/county communities in south Sudan yielded results for parameters that exceed the south Sudanese drinking water quality. Hence, in order to prevent environmental pollution and human health problems from poor waste handling, appropriate systems to manage solid waste materials on state/ county reserves emerge as matters of high importance.

* 1. **SOLID WASTE MANAGEMENT IN SOUTH SUDAN STATE/COUNTY COMMUNITIES**

In 2010, a report presented on land management and environmental protection on reserves by the office of the land and environmental conservation in the republic of south Sudan recognizes environmentally unsafe waste disposal on county reserves as a significant risk which should be treated as a matter of urgency (oag, 2009). Efforts by some county and state communities to implement sound waste management programs are constrained by factors such as remoteness, funding, jurisdiction and staffing (Bhardwaj et al, 2006). Band offices, tribal councils and aboriginal organizations are faced with the challenge of balancing infrastructural needs to provide vital community services including medical care, housing, schools, sanitation and water supply against solid waste management (Bharadwaj et al., 2006).

The government holds the charter of responsibilities for state and county matters, including fiduciaries and land management (Bharadwaj et al., 2008). Amidst other specialized duties, the minister of land and environment takes charge of waste disposal in state/county communities, in pursuant to the *south Sudan reserve waste disposal regulations* (Bharadwaj et al., 2008). in some instances, the duties of setting up solid waste disposal facilities have been transferred to some state/county communities for other communities outside the state/county land management regime, for example the *south Sudan reserve waste disposal regulations* requires any individual, community or organization who intends to set up waste disposal facilities on state/county reserves to obtain permit from (department of justice, 2015). But they issued only a few permits across south Sudan and do not adequately conduct environmental monitoring of licensed waste disposal facilities on reserves (Bharadwaj et al., 2008). Department of justice also does not provide incentives to encourage such activities (Bharadwaj et al., 2008; oag, 2009).

In what seems to be one of the few research studies on waste management in state/county level Zagozewksi et al. (2011) discovered that community members, especially the elders, are concerned about them human and environmental health implications of poor waste disposal. However, these communities do not possess the required technical and financial capabilities to deal with the problems (Zagozewksi et al., 2011). Funding provided by government is neither sufficient for basic infrastructure nor for provision of environmentally sound waste management facilities (Bharadwaj et al., 2008).

This problem of inadequate funding amongst other constraints leaves a huge disparity between environmental protection regulations on state/county reserves and off-reserve communities (oag, 2009). Hence, waste disposal is not regulated in most state/county communities across south Sudan and the impacts on domestic water supply and air quality are ignored (oag, 2009). in order to address the numerous problems posed by solid waste management practices, many jurisdictions now focus on the implementation of solid waste management initiatives such as integrated solid waste management, which normally includes waste diversion (recycling and composting) and waster education programs and policies(kipperberg,2007).

* 1. **THE CONCEPT OF INTEGRATED SOLID WASTE MANAGEMENT**

Municipal solid waste management (MSWM) presents great environmental challenges with regards to the composition, generation, collection, transportation, treatment and safe disposal of waste materials (Nordone et al., 1999; Liamsanguan & gheewala, 2008; maintained that MSWM is a key aspect in the development of a sustainable city. thus, the failure of municipalities to manage wastes materials properly leads to serious environmental problems and may sometimes be attributed to lack of financial resources (Guerrero et al., 2013) and absence of well-articulated regulatory regimes (Pokhrel and viraraghavan, 2005).

In the past Ten years, a consumption-driven urban society have emerged due to increase in population, leading to a rapid increase in the quantities of waste generation both organic and inorganic wastes which are toxic to human health and the environment. Therefore, conventional solid waste management practices, which focus solely on waste disposal, are no longer appropriate to handle the ever-growing waste stream (zaman & Lehmann, 2011; United Nations, 2011; menikpura et. al, 2013). Alternative solid waste management innovations e.g. reuse, recycling and composting, are still not enough to address the environmental problems associated with MSWM and to maximize economic and social benefits from the waste management sector (Nordone et al., 1999; rabl & spadaro, 2002).

Public health concern, environmental protection, resource management, scarcity of land for the construction of waste disposal facilities, institutional issues and public awareness are some of the major drivers of the modern day waste management practices, according to Wilson (2007). In south Sudan, for instance, better environmental awareness and public outcry on the health and environmental implications of waste incinerations, especially in off-reserve communities, are lacking (Sawell et. al, 1996). There are very few recycling facilities that handle a minimum quantity of solid wastes such as plastic and glass bottles that was adopted by the water and distilling factories in south Sudan as one of many environmental friendly options for solid waste management although it has not been extended to many state/county communities where wastes are poorly managed (zagozewski et al., 2011).

The potential negative impact of poorly managed waste materials on public health and the environment on state/county reserves have not been scientifically observed by the local government (Bharadwaj et al., 2008). In similar contexts, Hoornweg & Bhada-tata (2012) found that implementing safe waste disposal strategies are lesser burdens for communities than to ameliorate the impacts of poorly managed waste. generally speaking, MSW are heterogeneous mixtures of different kinds of materials, such as papers, metals, food scraps, glass, electronics etc., comprising of inorganic and organic wastes with different degrees of management sophistication.

On this note, liamsanguan and gheewala (2008) argued that there is no such waste treatment technology that can exclusively handle all waste fractions. Hence, a mix of various waste treatment technologies and management strategies (such as waste reduction, reuse, recycling, composting, incineration and landfilling) needs to be adapted for an effective and efficient MSWM (mcdougall et al., 2008; menikpura et al. 2013). This new waste management approach that combines various waste management strategies is termed integrated solid waste management (ISWM).

According to clift et al., (2000), ISWM ensures that waste materials are managed in the most environmentally appropriate manner and that valuable resources or energy are recovered. koroneos and nanaki (2012) claimed that an advancement of the ISWM system could trigger improved technologies, policies and programs required to manage MSW in an environmentally sound manner. In a publication titled *shanghai manual – a guide for sustainable urban development in the 21st century*, the United Nations affirmed the importance of ISWM: “ISWM appreciates local needs and conditions and then selecting and combining the most appropriate waste management activities for those condition” (United Nations, 2011. p7). In addition, strange (2002) agreed that decisions making in ISWM are based on best options for waste management and cost transparency.

ISWM generally appreciates the need for collaboration between stakeholders based on the 4rs (reduce, recovery, re-use, and recycle) principles that makes up the waste management hierarchy (hoornweg and bhada-tata, 2012). The 4r options were developed to fundamentally complement traditional waste disposal options (i.e. landfilling and incineration), since the later provide more socially and environmentally acceptable functions. it is however noteworthy that final disposal cannot be totally neglected in any solid waste management scheme, because it is difficult, if not impossible, to achieve waste diversion (e.g. recycling) without waste residues. As opposed to waste disposal options, there are many environmental benefits derived from waste diversion which include, but are not limited to, pollution prevention, greenhouse gas emission reduction, energy savings and resources conservation (mohareb et al., 2004).

* + 1. **INTEGRATED SOLID WASTE MANAGEMENT FRAMEWORK.**

According to Hoornweg & Bhada-tata (2012), a comprehensive ISWM plan should include: a well-defined objective and follow-up policies, community profiling, waste composition and generation inventories, identification of waste management options for different waste streams, evaluation of applicable options with consideration of technical, environmental, social and economic issues, monitoring and control measures, institutional and regulatory framework, fiscal assessment, source of funding, public consultation and implementation plan. The ISWM model established by *waste advisers on urban environment and development*, defined the involvement of stakeholders in waste management, an enabling environment and the ISWM elements as a three dimensional system that needs to be considered when developing a solid waste management plan (Guerrero et al, 2013). The major stakeholders identified in previous literatures include: government at all levels (Shekdar, 2009), community members, community-based organizations (cbos), non-governmental organizations (Ngo) (Vande klunder & Anschütz, 2001; Sujauddin et al., 2008), donor agencies, private sectors, service users (Van de klunder & Anschütz, 2001), government ministries of health and environment (Geng et al., 2009) as well as waste management related businesses (tai et al., 2011).

The integrated solid waste management ISWM) model (adapted from van de klunder & Anschütz, 2001). The ISWM model is based on the principles of equity, effectiveness, efficiency and sustainability (van de Klunder & Anschütz, 2001). Studies related to the elements of ISWM have identified size of household, education and household income as some of the factors that influence waste generation (Sajjaudin et al., 2008). According to ekere et al., (2009), waste utilization and separation behavior are a factor of gender, peer pressure, land area and house location. pay as you throw policies (Scheinberg, 2011), as well as the support provided to the private sector and house owners, impact public participation in waste separation activities (Guerrero et al, 2013).

* + - * Stakeholders participation
      * Ngos
      * Government
      * Private sector service users
      * Donors
      * Volunteers
      * ISWM elements
    1. **SUSTAINABILITY**Collection and transportation of waste materials are greatly affected by the bin collection system (Hazra & goel, 2009), infrastructural problems (moghadam et al., 2009) including bad roads, and inadequate waste equipment (henry et al. 2006).

To this end, sharholy et al. (2008) suggested an organized informal sector and incentives for small businesses interest in waste reduction, recycling and collection as ways to promote economically reasonable waste collection systems. As for waste treatment, technical-know-how or skilled man-power capacities is an essential factor (Chung and lo, 2008).

In a study of waste disposal practices in third world communities, Tadessa et al., (2008) found that the availability of waste disposal facilities affected waste disposal decisions by households. In addition, limited supply of waste bins/bags and long distance to the available ones increased the chances of open dumping of wastes (Tadessa et al., 2008).

Safe disposal of waste in a sanitary landfill is also hindered by inadequate funds and legislations (Pokhrel and Viraraghavan, 2005). To this end, Asese et al (2009) suggested that a proper legislative framework would foster the development of environmentally safe waste management systems such ISWM, whilst other scholars have indicated the potential of negative effects from poor solid waste management legislation (Seng et al., 2010; Mrryan and hamdi, 2006). At the level of waste diversion and reduction, Gonzalez-torre and Adenso-diaz (2005) emphasized that improved community interest in recycling is a result of social influences and regulatory factors. In order to further increase recycling rates, however, there is often the need to improve marketability and professionalism in the recycling industry, according to Minghua and his colleagues (2009).

Furthermore, authors have identified that funding and incentive for recycling initiatives (henry et al., 2006), encouraging the informal sector (Matete and trois, 2008) and the establishment of drop-off and buy-back are imperative to foster an increase in recycling rates (Guerrero et al, 2013). In addition to stakeholders’ involvement and the elements of waste management, ISWM is also influenced by a third pillar, which is the aspects that facilitate or hinder the performance of the overall system (Van de klunder & anschütz, 2001). These aspects are grouped into environmental, socio-cultural, economical, technical, institutional and regulatory considerations (Van de klunder & anschütz, 2001).

* + 1. **ISWM AND CONVENTIONAL WASTE MANAGEMENT: A COMPARISON.**

In the united nation’s *declaration for better cities and better life*, many risks associated with conventional waste management (e.g. open dumping) were identified (united nations, 2011). In addition, the opportunities that emerged from the ISWM as a paradigm shift were explicitly stated (United Nations, 2011). The United Nations further highlighted that conventional waste management is characterized by a long list of problems including but not limited to:

* low efficiency, negative health and environmental impacts, and social problems due to lack of comprehensive approach to waste management,
* waste workers are exposed to various health hazard due to lack of safety measures,
* child labour is prevalent as witnessed in most low-income societies,
* consumption driven lifestyle encourages the waste of valuable resources from increased waste generation, community and private sector roles in the overall waste management process is undermined and no attention is paid to improve the system to accommodate newer waste stream and conserve resources (united nations, 2011).

In contrast, ISWM was presented as a combination of different waste management options with an effective pollution prevention plan. The advantages of ISWM over conventional waste management are that **ISWM**:

* minimizes environmental impacts, improves cost efficiency and social acceptability,
* facilitates recycling of useful resources,
* encourages stakeholder participation and introduction of innovative technologies
* accommodates plans for emerging waste stream such as e-waste, construction and demolition wastes and end-of-life vehicles,
* Enhances the safety of waste workers (United Nations, 2011).

**Table 1: Possible risk to health and communities from poor waste disposal**

|  |  |
| --- | --- |
| **Who is at risk?** | **Health and environmental impacts** |
| * Waste workers * Informal waste pickers * children * community members * Animals **source: united nations (2011)** | Health impacts to waste workers |
| Human immune deficiency virus, hepatitis, pulmonary disease, tetanus, respiratory problems, skin and stomach infections. |  |
| *Risk to communities* | |
| * Risk to children who live in houses close to waste dump sites exposed to toxics. * people living close to where waste is burned are exposed to air pollution which causes respiratory problems * Leachates from dumpsites could contaminate municipal domestic water sources waste dumps serve as breeding ground for disease vectors such as mosquito’s rats’ and dangerous animals could be attracted to waste dump sites.   indiscriminate waste dumping can cause blockage of drainage which leads to flooding and spread of diseases | |

* + 1. **MANAGEMENT OPTIONS FOR SOLID WASTES**

There are many options available for solid waste management including but not limited to waste diversion (recycling and composting) and disposal. Since it is impossible to completely divert waste materials through recycling, the remainder of the solid wastes materials generated from human activities ends up being subjected to disposal options, which include landfilling and thermal treatment. Maclaren (1995) and statistic south Sudan (2010) have identified landfilling as the most common and cheapest method of waste disposal. The popularity of landfilling as a waste disposal option in south Sudan has been attributed to the availability of a large area of unexploited

Most of the solid wastes are transported to waste management areas were landfilled, while the remaining was burned at incineration facilities. Waste collection, treatment and disposal are the responsibilities of municipal or local governments, while state governments set regulations. Since each state operates as an independent unit, regulations often vary among the states.

In general, the set regulatory guidelines and standards for environmental monitoring and also policies that can be adopted into provincial policies (Sewell et al., 1996). Examples are the waste diversion target and the national packaging protocol, as indicated by Sawell et al., (1996).

On the other hand, the federal government controls the movement of hazardous wastes and the release of toxic materials into the environment and related activities on federal lands, including state/county reserves because there are no waste diversion programs in most state/county reserves, a large fraction of the waste generated ends up being disposed in open dumps and/or burned in open places (Bharadwaj et al., 2006). The various options for solid waste management in south Sudan are highlighted in the subsections below.

* + 1. **WASTE DIVERSION AND REDUCTION.**

*“*The best way to change our garbage treatment is to change our garbage; first, by reducing the amount that goes into the landfill.” (Rathje, 1991, p. 130). Modern waste management strategies, such as ISWM, functions in accordance to the waste management hierarchy, also known as hierarchy emerged from Ontario pollution probe (an environmental NGO) literature in the 1970s (Hoornweg & Bhada-tata, 2012). The waste management hierarchy started as a 3rs (reduce reuse recycle) conceptual framework. Recently, a fourth ‘r’ was added to introduce material and energy ‘recovery’ into the scheme. The 3r principles form the basis of many European waste management frameworks, which outlines the need to manage wastes differently based on sources and characteristics (association of municipalities of Ontario [Amo], 2005). Grosse (2010) considered waste diversion as a shift in paradigm from unsafe waste disposal, such as open dumping, towards sustainable waste management options that reduce material wastage and minimize the impact of economic growth on natural resources. For example, the EU landfill directives targeted a 35% reduction, from the 1995 value, of organic wastes disposed at landfill by the year 2020 (Wilson, 2007).

Furthermore, Lehmann (2010) noted that landfill ban on certain waste streams have been implemented in several jurisdictions and the ‘zero waste’ concept has continued to garner momentum. Lehmann also contended that the ‘zero waste’ concept shifted focus from the general conception of waste as unavoidable and valueless to a waste prevention and resource recovery driven approach (Lehmann, 2010).

Bonam (2009) in understanding waste from a climate change perspectiveconsidered the waste hierarchy as a tool for waste diversion. The waste hierarchy takes cognizance of the various environmental, economic and social issues connected with waste management by way of prevention and minimization of waste materials. One of the management tools that the United Nations identified as a solution to the numerous problems associated with waste treatment and disposal is the adoption of the waste hierarchy (United Nations, 2011). The benefits of waste reduction as the most favorable option in the waste hierarchy are two-fold. On the one hand, pollution associated with the manufacturing processes is reduced (Hoornweg & Bhada-tata, 2012).

On the other hand, the emission associated with the processes that ‘diverted waste’ would have undergone is eliminated (Hoornweg & Bhada-tata, 2012). Waste hierarchy (adapted from Bonam, 2009)

Solid waste management plans have a higher chance of success, in terms of waste diversion from landfill and incinerators, if such plans follow the order of the waste hierarchy (Amo, 2005). for instance, the waste hierarchy incorporated into nova scotia’s solid waste resource management strategy distinguished the province as the only jurisdiction in Canada that achieved the 50% national waste diversion target set by the CCME over a period of ten years, between 1990 and 2000 (gape Atlantic, 2004). however, nova scotia’s approaches towards waste diversion came with cost implications, as an additional operating and amortized costs of $23.9 million were expended, according to an estimate by gpi atlantic (2004).

Nevertheless, the benefits of implementing the waste hierarchy were proven to outweigh the costs (gpi Atlantic, 2004). For instance, the Nova Scotia wastes diversion strategy provided Nova Scotia’s residents with a net saving of about $31.2 million to $167.7 million (gape Atlantic, 2004). recycling and composting were the key approaches adopted by nova scotia to reach this milestone (gpi Atlantic, 2004), albeit through combined efforts of different stakeholders including municipalities, industries and the citizens (government of nova scotia, 1995; nova scotia environment, n. D). despite the waste diversion milestone achieved by nova scotia, gpi Atlantic (2004) noted that waste policy initiatives such as the extended producers responsibility (epr), hazardous waste monitoring, as well as source reduction may have led to a higher rate of waste reduction and diversion (gpi Atlantic, 2004).

* + 1. **SOURCE REDUCTION.**

Waste generation occurs throughout the entire life cycle of a product, from raw material extraction to the manufacture of final consumer product (Bonam, 2009). thus, source reduction is a waste minimization and pollution prevention strategy that entails design for environment (dfe) in the manufacturing context or an environmentally preferable purchasing (such as bulk purchase, material reuse- reusing bags for grocery shopping and buying refillables and products with less packaging) (kab, 2013). Source reduction strives to reduce the amount and toxicity of material reaching the waste stream (usepa, 2013b). according to the national recycling coalition (nrc) *measurement standards and reporting guidelines*, source reduction is defined as: any action that avoids the creation of waste by reducing at the source, including redesigning of products or packaging so that less material is used; making voluntary or imposed behavioral changes in the use of materials; or increasing durability or reusability of materials (nrc, 1989, p.18).

Source reduction influences the overall waste (or pollution prevention) hierarchy, in the sense that the amounts of waste materials to be recycled, combusted or landfilled are reduced (Bonam, 2009). Many programs and policies aimed at source reduction have been implemented in various jurisdictions. Examples of these programs and policies include: Epr or take back systems in Europe and japan, pay-as-you-throw or user fee, nova scotia’s solid waste resource management strategy, and polluter pay principle among others.

The polluter pay principle, for instance, places the responsibility of waste management on the generator of the waste. Hence, as polluters recognized the fact that certain waste materials are quite expensive to manage, several means to reduce waste output were devised. In contrast to source reduction, however, it is noteworthy that waste reduction is a broader term that encompasses all waste management strategies (source reduction, composting, recycling) to reduce waste that end up at waste disposal facilities.

* + 1. **RECYCLING.**

*“The main challenge of a modern industrial country is to break the historic link between waste creation and wealth creation.”* (Strange, 2002, p.1) recycling as an integrated waste management option is a key element of sustainable development because recycling is critical in the era of resources scarcity (strange, 2002). For The diversion of waste materials through recycling reduces air pollution (dioxin and furan from incinerators), water pollution (leachates from landfilling) and greenhouse gas emission. For example in Canada, landfills account for about 25% of methane emission (environment Canada, 2006).

The anaerobic breakdown of organic materials in landfill results in the release of certain type of saturated gases, known as landfill gas (lfg), into the environment (Ackerman, 2000). This highly saturated gas comprises of about 60% methane (ch4) and 40% carbon dioxide (co2), other constituents are also present in trace amounts (Spokas et al., 2006). Of the constituents of lfg, methane is the greatest environmental concern, because methane has a much higher global warming potential than carbon dioxide (Forster et al., 2007). However, methane can be captured from landfill and combusted to produce energy for electric power generation (Hoornweg & Bhada-tata, 2012).

The energy production processes produce carbon dioxide, which happens to be a gas of lesser global warming potential when compared with methane (Spokas et al., 2006). in contrast to the environmental consequences of waste disposal at landfills, recycling reduces greenhouse gas emission from waste materials disposal e.g. paper products by 7.37 mtce/tonne (metric tons of carbon equivalent per tonne of material) and aluminum by 3.9 mtce/tonne (mohareb et. al., 2004). Recycling is also of great economic benefits and creates green jobs. For examples the Canadian association of recycling industry (CARI) noted that the recycling industry in Canada creates more jobs and generates more revenue than other division of the waste industry (CARI, 2014). Recycling embodies a series of activities that convert valuable resources, which may have ended up as waste, into recyclables for raw materials production. Therefore, energy efficiency is increased and the need to further exploit resources for raw material is reduced.For instance, in the case of metal recycling, the energy efficiency is two to ten times more than extracting metals from ores (United Nations environmental programme [Unep], 2011).

in fact, the extraction of metals from ores accounts for about 7% of the world’s energy consumption and a major contributor to climate change due to emission of greenhouse gases during the primary production processes (Unep, 2011). Recycling metals compared to primary production saves a lot of energy, e.g. steel recycling saves up to 75% energy while aluminum and metals of the platinum group saves about 90% (Unep, 2011). About 16 to 18 million tonnes of scrap metals are  
recycled in Canada each year (CARI, 2014). The occupations involved in metal recycling activities include haulers, dismantlers, scrap dealers, shredder plant operators etc. (Unep, 2011). Effective recycling requires sorting of waste materials into fractions (Zickiene et al., 2005). Cleaner and high quality recyclable materials are recovered (upcycling) if waste materials are subjected to sorting at source (Zickiene et al., 2005). However, technologies, such as the material recovery facility (MRF), enhance the potentials for recovery of recyclable materials, which were not sorted *at* source. In general, recycling improves the availability of resources whilst reducing the overall environmental impact of material production (Unep, 2011).

In a book on the subject of solid waste management, strange (2002) discussed the reasons recycling activities often fail in the market: low cost-benefit; government failure inadequate policies, which encourages unsustainable practices-; and institutional failure. On the little downside, Bonam (2009) noted that since recycling does not provide 100% waste diversion, environmental impacts are inevitable, because the residue from recycling - though of minor fraction of the initial waste - ends up in landfill.

* + 1. **COMPOSTING AND ANAEROBIC DIGESTION.**

As discussed earlier above, organic waste at landfill contributes to greenhouse gas emissions. Food and yard waste are the major constituents of organic materials in MSW streams (otten, 2001). Organic wastes make up about 45% of MSW and responsible for leachate and landfill gas emission (otten, 2001). Thus, diverting organic waste from landfill, by way of composting or anaerobic digestion, will significantly reduce the environmental problems associated with leachates and landfill gas emission (otten, 2001). Swan (2002) defined the composting process as: the controlled biological decomposition and stabilization of organic substrate, under conditions that are predominantly aerobic and that allow the development of thermophilic temperatures as a result of biologically produced heat. It results in final product that has been sanitized and stabilized, is high in humic substances and can be beneficially applied to land, which is typically referred to compost (swan et al, 2002. p73).

In simple terms, composting is the microbial breakdown of organic waste, such as food and yard waste, in the presence of air and moisture to produce compost (city of Winnipeg, 2014). Carbon dioxide, heat, ammonia and water vapors are released as by-products of composting (Otten, 2001; Füleky & Benede, 2010). In the composting process, microorganisms utilize organic matter as substrate thereby breaking organics down into smaller compounds (Gajalakshmi & Abassi, 2008).

One of the problems associated with composting is that leachates and a negligible amount of methane is produced, however, such problems can be controlled by using the right proportion of feedstock, proper aeration and regular turning of compost piles (Elliot, 2008) [organic waste + oxygen + microbial activities = compost + carbon dioxide + water + heat] overall, the rate of composting is dependent on availability of substrate and other conditions such as carbon-nitrogen (c/n) ratio, oxygen, ph, temperature, moisture content and electrical conductivity (Gajalakshmi & Abassi, 2008).

Compost is used in organic farming, gardening, horticulture and landscaping, to enrich soil nutrient. As indicated by Mohareb et al. (2004), a 1985 study by brunt and his colleague indicated that one tone of organic MSW could produce between 0.3mt and 0.5mt of compost. The quality of compost varies with the design of composting facilities, source and proportion of feedstock, composting methods and duration of maturation (Hargreaves et al., 2008). MSW compost is usually characterized by low bulk density and high organic matter content (Soumare et al., 2003). Otten (2001) highlighted some advantages that composting:

* reduces waste at source to decrease the amount to be sent to landfill;
* Reduces pollution and other environmental effects of landfilling organic waste; 3) increases the life span of a landfill;
* results in an inert waste stream, which means less daily cover, equipment use and Manhour labour is reduced at landfill sites;
* is cost competitive and requires little monetary investment, as it is one of the least expensive way of handling organic fraction of MSW;
* serves as a useful technique in achieving waste diversion targets,
* Can be used in agriculture to improve soil nutrient and can be sold as fertilizer.

However, the use of compost on agricultural land is sometimes restricted due to the possibilities of metal contamination and elevated salt concentration, which can cause stunted growth in plants and destabilizes soil structure (Hargreaves et al., 2008). Nevertheless, metal contamination issues can be controlled by source separation and improved regulatory standards (Hargreaves et al., 2007). Judging by the increase in the number of composting facilities over a few years, Bonam (2009) admitted that Canadians are more likely to accept a composting facility compared to incinerators (Bonam, 2009). In addition, Tuomela et al. (2010) have described the rate of demand for compost in Canada as significantly high. Enhanced public education and awareness as well as source separation of organic waste can enhance composting (Otten, 2001). Access to curbside collection point is also a key determinant of public participation in composting (Elliot, 2008).

* + 1. **THERMAL TREATMENTS.**

Incineration, or established thermal treatment, is the controlled burning or combustion of waste materials at a very high temperature (in excess of about 1000oc) to reduce the volume and generate energy in the form of heat and carbon dioxide (Picher, 2014). MSW, hazardous wastes, such as waste from healthcare facilities, and bio-solids are the waste streams currently being incinerated in Canada (CCME, 2007a). Incineration is capable of reducing waste volume by up to 80% (i.e. final volume is only about 20% of initial volume), generating energy at the same time (Mohareb et al, 2004). The waste residues produced during the combustion process take the form of fly ashes or bottom ashes. Whilst fly ashes are the light particles emitted in the form of smoke, bottom ashes are the non-combustible waste materials (e.g. metals, glass) that remain after the burning process. The level of pollutant in fly ashes and bottom ashes may be dependent on the material composition of the waste stream as well as the completeness of the combustion.

For instance in Canada, there is a negative public perception about incineration due to the adverse environmental and health effect of emissions from incinerators (Mohareb et al., 2004). This perception may be long-lasting since pollution was the basis for the Ontario’s ban on incinerators in 1992 and 1996 (Mohareb et al., 2004). Some of the negative aspects, which hinders the development of incineration as a waste treatment option in Canada, were outlined by Mohareb et al. (2004) as follows:

* Incineration produces pollutants such as dioxin and furan, nox, carbon mono oxide, particulate matters, oxides of Sulphur, hydrogen halide and heavy metals.
* Nitrous oxide (n2o), a nox compound, contributes significantly to the ghg emission from high temperature incinerators.
* One of the power generating incinerators, located in Hamilton, was shut down due to pollution.
* Operating cost of MSW incineration is higher than conventional waste management options and is neither cost competitive with other waste treatment technologies.
* In urban area where MSW incineration was said to be cost effective, the emission control system that must be installed to meet regulatory standards is quite expensive.
* To address the negative environmental and public health effect of incineration, regulatory  
  standards have been set at provincial and national levels (CCME, 1989). Rather than controlled thermal treatment as in incineration, open air burning of waste materials is the prevalent waste disposal practices on state/county reserve across the country (Bharadwaj et al., 2006).

According to the environmental guideline on burning and incineration of solid waste, open burning is defined as the burning of waste where limited or no control of the combustion process can be exercised by the operator…on the ground or in burn boxes or burn barrel and often does not achieve the temperature or holding times needed for the complete combustion of the waste to occur. (Government of nunavut, 2012. p9). This is one of common waste disposal methods in south Sudan. Uncontrolled conditions of the open burning processes result in the release of potentially harmful pollutant (such as dioxin and furan) in form of gases and ashes into the environment (air, water and land) (Bhardwaj et al., 2008). Forest fires result from uncontrolled burning due to the release of hot sparks and ember (government of nunavut, 2012). Organic wastes that are not completely burned attract pest and other disease carrying organisms.

**4.4.0. LANDFILL.**

historically, landfills were initiated to off-set the negative effects of conventional waste management practices such as open air-burning, open dumping and disposal in water bodies. Today, landfilling -- which involves burial of waste on land -- is a more convenient and relatively cheap alternative for waste disposal but is not free from environmental consequences. A sanitary landfill on the other hand is an engineered method of waste disposal together with environmental protection measures (Unep, 2005). Sanitary landfilling involves compaction of waste, use of daily cover materials -- such as soil -- to eliminate environmental nuisances, bottom liners, and leachate collection systems, and in some cases, a landfill gas capture system (Unep, 2005).

Anaerobic decomposition of organic waste disposed at landfill generates lfg and leachate (el-fadel et al., 1997; willumsen, 2001; butt et al., 2008). lfg and leachates are of environmental concern because lfg poses a risk of explosion, odour and global warming effects (Rajaram et al., 2011), whilst leachates have been attributed to water pollution (kjeldsen et. al, 2002). However, there is a great potential for electrical power generation from lfg, if appropriate measures are put in place to capture these gases (Rajaram et al., 2011). As aforementioned, landfilling is the most common waste disposal technique in south Sudan, partly due to availability of large area of underdeveloped land. Landfills are still very much in operation and still receive a substantial amount of solid wastes (Bonam, 2009). No matter the success rate of waste diversion programs, waste residues, which cannot undergo further treatment, are inevitable. Therefore, landfills cannot be avoided in the overall solid waste management processes (strange, 2002; Bonam, 2009).

**4.4.1. LEACHATES.**

Leachates from waste disposal sites are sources of ground and surface water contamination that can severely impact drinking water quality (Christensen et al., 1998; Ali and young, 2014). Leachate is formed when soluble materials in a waste pile comes in contact with water from various sources, mostly precipitation and initial water content of the waste, or as a by-product of anaerobic decomposition of organic waste (el-Fidel et al., 1997; renou et al., 2008). The composition of leachate is a reflection of the material content of the waste stream (Pichtel, 2014). Microbes such as bacteria and fungi are actively present in leachates due to it organic matter content (Pichtel, 2014). Once leachates flow to the bottom of a landfill, leachates either seeps through to the aquifer or is held in the vadose zone (el-fadel et al., 1997). Depending on the geological formation of the underlying layers and the lack of systems to prevent the release of leachate into the environment, researchers agreed that leachates contaminate ground water at landfill sites (el-fadel et al., 1997; Christensen et al., 2001; renou et al., 2008).

The volume of leachate is dependent, to a large extent, on the location of landfill and is a function of climatic conditions, presence of water, waste characteristics, as well as the nature of landfill surfaces and underlying soil (e-fidel et al., 1997; Christensen et al., 2001). Factors that affect the chemical composition of leachates includes: the age of landfill cell, weather, and moisture content (Pichtel, 2014).

The physical and chemical parameters of environmental concern in leachate include ph., biochemical oxygen demand, total dissolved solid, and total suspended solid, salinity and the presence of heavy metals (Pichtel, 2014). Thus, the removal of these parameters from leachates is essential prior to release into water channels (renou et al., 2008). Toxicity testing of landfill leachates has revealed their potential threat to living organisms and the environment and the need to include several physical and chemical parameters in the analysis of pollutant level (Bernard et al., 1996; Bernard et al., 1997

**4.4.2. WASTE MANAGEMENT AND HUMAN BEHAVIOR**

In the newfoundland and Labrador waste strategy, the provincial minister of environment noted that while the government is responsible for making laws that governs waste management within their territories and implement appropriate strategies to manage waste, the success of any waste management policy lies in the hands of the people who will require a change of attitude and behavior towards handling of waste (government of newfoundland and Labrador, 2002). Therefore, an effective waste management plan must consider the behaviors and attitudes of people within the affected areas (Valdivia, 2010). In order to study the best methods for waste diversion, Ferrara and missions (2005) considered the relationships between recycling and human behavior in households across Ontario, Canada and arrived at the following conclusions;

* Charging user fee reduces waste and increases recycling but illegal dumping may occur from inability to pay user fee.
* Increasing the number of garbage bag limit at curbside (i.e. free units) under the user fee program is counterproductive.
* Collecting garbage weekly or routinely for recycling increase recycling of some materials such as aluminum and glass, but has negligible impacts on paper and plastic recycling.
* Requiring compulsory recycling programs increase rate of recycling  
  allowing limited number of bags at curbsides has negative impact on recycling for some materials especially plastics and toxic chemicals.
* Curbside recycling increases the recycling rate of non-curb side materials such as toxic chemicals.
* Recycling intensity is unaffected by level of education attained, with the exception of postsecondary degree which increase the recycling intensity of newspaper, tin containers and toxic chemicals.
* As individual earnings increases, time becomes more valuable, thus recycling rate for materials like newspaper and toxic chemicals decreases.
* Impact of household size and age of household head on recycling is negligible, and
* Homeowners, as opposed to tenants, are strongly connected to their communities and pay attention to perceptions of other community members. Thus, they tend to recycle more. although the behavioral characteristics described by Ferrara and missions (2005) do not correspond to all waste stream and policies, nevertheless, the key findings could inform decisions about possible reactions towards the implementation of waste management programs. Otten (2001), on the other hand, suggested that appropriate public education increases publicparticipation in recycling. in fact, the high rate of organic waste diversion attained in guelph, ontario was attributed to compulsory source separation and public education (Otten, 2001)

**4.4.3. HAZARDOUS WASTES**

hazardous waste is any kind and form (solid, liquid, gaseous or sludge) of waste material, which as a result of its characteristic nature and quantity, has the potential to cause harm to human health and/or the environment, either alone or as a mix with other kinds of waste materials (lagrega et al., 2010). Hence, hazardous wastes usually require a special disposal method to eliminate environmental and public health risks. Hazardous wastes are characterized by ignitability, corrosiveness, reactivity and toxicity (lagrega et al., 2010).

Hazardous wastes emanate from a wide range of sources such as residues from automobile repair operations, household appliances, manufacturing processing plants and healthcare facilities, or obsolete materials such as waste lubricants and pesticides. As a result of the dangerous properties of hazardous waste materials, proper handling of materials during recycling and disposal operations must be ensured. In terms of hazardous waste regulation, the united nations and organization for economic co-operation and development treaties on the management and control of transboundary movement of hazardous wastes at the national level, managed under the environmental protection act of 1999 (Cepa 1999), which includes the following regulations;

* Export and import of hazardous waste and hazardous recyclable material
* Polychlorinated biphenyls (pcb) waste export regulations 3) interprovincial movement of hazardous waste regulations.
* Transportation of dangerous goods act. The municipal, provincial/territorial and federal government all play a role in hazardous waste management. Whilst the municipal governments are responsible for the various activities involved in hazardous waste management within their jurisdictions, provincial governments provide standards and play regulatory roles.

**4.4.4. END-OF-LIFE VEHICLES (ELVS).**

By virtue of the toxic components of end-of-life vehicles (Elves), serious environmental and health consequences may arise if Elvs waste streams are not properly handled. Elvs include old and non-functional vehicles that are unable to pass safety tests or those condemned due to accident (sawyer‐Beaulieu & tam, 2006). Elves are complex units, which consist of so many parts including tires, glass, batteries, tires, metals, plastics etc. as indicated by Gerrard & kandlikar (2007), an average car is made up of ferrous material, which is a perfect candidate for recycling, accounting for about 68.3% of a vehicle’s weight. Other components are plastics, nonferrous metals, rubber, glass and fluids contributing to 9.1%, 7.8%, 1.6%, 2.9%, and 2.1% respectively (Gerrard & kandlikar, 2007).

The modern ways of recycling Elvs help to protect the environment and natural resources, and are socially and economically beneficial (Simic, 2013). Elvs management potentials are greatly influenced by the original vehicle producers and part manufacturers (Simic, 2013). therefore, in order to achieve high Elvs recycling rates, automobile products are now designed in such a way that parts can easily be recovered for reused or recycled at end-of-life (Eol) (simic,2013). Consequently, a large fraction of Elvs have high recovery and recycling potentials but south Sudan is still lagging behind in this aspect

**4.4.4.1 WASTE TIRE.**

Vehicles roll on tires that wear out overtime. Tires constitute about 3% of the overall weight of an Elv (cela, 2011). When a tire becomes obsolete, such tires are either discarded as waste tires or stored for recycling. Tires are made of hazardous substances and extremely difficult to recycle (Sienkiewicz et al, 2012). The vulcanization process in the manufacture of rubber results in a cross-link structure that makes it difficult to recover raw material, they are also non-biodegradable and requires extreme high temperatures to transform (Sienkiewicz et al, 2012). Typical tire consists mainly of rubber; other components include carbon black, steel belts and textiles. The presence of steel and textile constitutes a difficulty in the tire recycling process because these material need to be separated from the tire mass (Sienkiewicz et al, 2012).

On their own, tires may not constitute significant environmental hazards, but when burned, noxious substances are released into the environment. Toxins released from burning and decomposition of tires can pollute water, air and soil. If not properly disposed, tires can hold water, becoming a breeding ground for disease carrying vectors. (Amari et al., 1999).

Fore Instances in the province of Manitoba, joint efforts by industries, retailers, consumers, municipalities, recyclers and processors under the ‘tire stewardship’ program have achieved positive results with regards to collection and recycling of waste tires (tire stewardship Manitoba, 2015). When a consumer purchases a new tire, consumers in Manitoba (and across Canada) are charged an eco-fee for tire recycling at end-of-life (tire stewardship Manitoba, 2015) according to tire stewardship Manitoba (2015), there are over 1,400 tire collection points (including retail outlets, landfills and transfer stations) with about a million tires collected annually for recycling. However, collection points are often absent in remote areas and northern Manitoba state/county communities.

**5.0 CONCLUSION.**

Human ways of life have placed pressure on the environment and have caused imbalance in the eco systems by producing, consuming and wasting of natural resources. Most countries evidently have major effects on the environment due to Sewage generation with economic development since the natural resources are used, and waste and pollution are produced. Therefore, the concern towards the management of solid waste as an integral part for sustainable development has increased.

**5.1. RECOMMENDATION**

* Improve information at city level. Collect, document, and analyses local problems and good local practices, and analyses the waste stream and what is already happening to materials.
* Develop, disseminate, and use better financial tools, systems, and incentives that promote affordability, fairness, and burden-sharing.
* Strengthen institutions and focus on political commitment, not technology
* Build capacities for management, consultation, listening, and information exchange.

**REFERENCES**

1. Agenda 21. (1992).United Nations Conference on Environment and Development Rio de Jamarion,
2. Martin, O. A. (2011). Governance Crisis or Attitudinal Challenges? Generation, Collection, Storage and Transportation of Solid Waste in Ghana. Integrated Waste Management. In Tech 1, (978- 953-307-469-6)
3. MA E A, (2002) Privatization of Solid Waste Collection, the Tema Experience. Regional Workshop on Shared Management Responsibility of Waste in African Towns. McPhail, Alexander A. (1993).
4. Ministry of Environment and Forestry Notification. (2000), New Delhi. http://envfor.nic.in/legis/hsm/MSWMhr.html Accessed on 3rd June, 2012.
5. Misra, V. and S.D. Pandey. (2005). Hazardous waste, impact on health and environment for development of better waste management strategies in future in India. Envir. Int’l. 31(3): 417- 431.
6. NEHA (2005). Environmental and Health Impacts of Household Solid Waste Handling and Disposal Practices in Third World Cities: The Case of the Accra Metropolitan Area, Ghana.
7. Röhrs, L.H., Fourie, A.B., and Blight G.E. (1999). Landfill Bioreactors in developing Countries: A Balance between climate and waste composition – Barriers, Waste mechanics and landfill Design; Volume III; Proceedings Sardinia 1999, Seventh International Waste Management and Landfill Symposium; Pg 647 – 653
8. UNEP (2005) Selection, Design and Implementation of Economic Instruments in the Solid Waste Management Sector in Kenya: The Case of Plastic Bags, UNEP-ETB, Geneva. UN Summit on the Millennium Development Goals, (2010). World leaders gather to boost progress against poverty in New York. US EPA (1999). State and Local Solutions to Solid Management problems.
9. US EPA (2010). Waste-Resource Conservation-Common Waste & Materials Organic-OrganicMaterials.<http://www.epa.gov/osw/conserve/materials/organic/food/>
10. Whittington et al., (1993) Economic values and the Environment in the developing World: A Report Prepared for United Nations Environment Programme, Nairobi, Kenya. Whitworth, A. P. (2005). Part I.
11. Thermal Breakdown Characteristics of Municipal Solid Waste Components in Varying Oxygen Environments and Part II. Municipal Solid Waste Management in China.