



Assessment of Current Situation of Municipal Solid Waste (MSW) Management in Khartoum State

Amel Mohamed Mirgani¹, Hassan Ibrahim Ali Mofadel^{2*}, and Ahmed Hamad Elfaig³

¹Department of Environment Ecology, Faculty of Geographical and Environmental Sciences, University of Khartoum
P.O. Box 321, Khartoum 11115, Sudan.

²Kenana Sugar Company Limited, Business Development Department, P.O. Box 2632, Khartoum, Sudan.

³Department of Environment Ecology, Faculty of Geographical and Environmental Sciences, University of Khartoum
P.O. Box 321, Khartoum 11115, Sudan.

Corresponding author email: hassan.mofadel@kenana.com; hmofadel@gmail.com

ABSTRACT

Waste accumulation, disposal and treatment are serious problem worldwide, particularly in developing countries. In Sudan, the issue gets more challenging as there are no clear defined strategies for efficient and effective management of all types of waste. However, Municipal Solid Waste (MSW) imposes serious environmental risks on Sudanese communities and drains a considerable portion of the local economy. Unorganized MSW disposal system, increase in population leads stress on ecosystems and disturbs various nature cycles and human health. This study aims to shed light on the current situation of MSW management in Khartoum State and ensure that waste management practices and manual procedures are followed. The study covers the seven localities of Khartoum State namely Khartoum, Omdurman, Bahary, JabelAulia, Umbadda, Sharg ElNile, and Karary. The results show that the number of population in Khartoum State is 8,643,559 in 2020. Thus, distribution of population is varied within the localities and the highest number of population is 1,635,361 in Umbadda locality. The total average of generated waste in tons/cap/day for Khartoum State is 6,279,405 during the period from 2016 to 2020. The result indicated that highly significant positive correlation ($r = 0.943$) between number of population and the total generated waste during the period from 2016 to 2020, although in the localities there is a negative relation between number of population and the generated waste in 2019 ($r = -0.1848$). The classification of waste in Khartoum state during the period from 2013 to 2020 includes organic material 49.5%, dust and ash 13.4%, plastic 12.7%, paper and cardboard 11.8%, cotton and jute 4.6%, glass 3.5%, metals 1.7%, leather 0.4%, couch 0.3%, wood 0.2%, others 1.9%. The study identified three landfills in Khartoum State namely; AbuWlidat, Hattab and Tayba landfill as well as four transfer stations in Khartoum State, two in Omdurman city, one in Khartoum city -whereas the fourth one in Khartoum North city (Bahary) has been closed. Five new transfer stations are under construction namely; Soba and Alandlus (in Khartoum city) Wad-dafeeaa (in Khartoum North city) Abu-seid and Karary (in Omdurman city). The informative interview results concluded that lack of proper waste management practices in Khartoum State.

Keywords: Khartoum State; Transfer Station; Landfills; Municipal Solid Waste; Waste Management

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INTRODUCTION

Municipal Solid Waste Management (MSWM) service is provided to improve the sanitary environment and create working opportunities for poor people. Good MSWM service is the first step towards realizing a healthy population for the whole country, but it has been given a low priority in Sudan so far, this is reflected in the limited

financial resources appointed to solid waste management by the government, deficient in institutional organization and interest, there are no treatment plants, unsorted waste at collection stage, old machines and equipment and poor maintenance operations, in addition to the level of services offered for the protection of public health and

the environment and lack of urban planning. Municipal Solid Waste (MSW) is the abridgment of the waste generated from domestic, commercial, and construction activities by natural persons that is collected and treated by municipalities. Exponential growth of population and urbanization, and the development of social economy, coupled with the improvement of living standard, has resulted in increasing the amount of MSW generation throughout the world (Karak *et al.*, 2012).

A few decades ago, wastes were defined as useless, unwanted, unused, or discarded materials resulting from the normal community activities. Nowadays because of development in recycling and resource recovery technologies, the above definition is no longer completely correct. Some of what are known previously to be useless and unwanted are now processed into different valuable products. The types, composition and sources of solid waste such as garbage which generate from preparation, cooking and serving of foods; market waste, waste from handling, storage and sell of produce from restaurants, households, institutions and stores. Rubbish also another type of wastes which can be combustible, noncombustible, paper, carton, boxes, barrels, tree branches and wood furniture from markets and commercial activities. Ashes are a third type that generated from residuals of fire used for cooking and heating, from households and incinerators. The forth type of waste is a refuse that includes street refuse, sweeping, dirt and dead animals, from street side. Industrial waste is the fifth type of waste that includes food processing waste and scraps, from factories and power plants. The sixth type is waste from demolition and construction which includes plumbing parts, scraps, bricks and blocks. Special waste such as hazardous solids and liquids, explosives, radioactive materials, hospital wastes, from household, hospital, institutions also can be classified as types of wastes as well as sewage treatment residue such as solid from coarse screens, grits, sludge, from treatment plants and septic tanks (Ezugwu, 2015). Over 5000 years ago landfill site is existed. Archaeological evidence of landfills dates back to 3000 BC in Crete, where waste was deposited in pits that were subsequently covered up with earth when full (Encyclopedia, 2021).

Recently landfill was developed to accommodate specific untreated or treated waste based on a specific design and environmental precautions. Nevertheless most landfills in developing and under devolving countries not strictly follow good landfill practices and procedures (TagElsir *et al.*, 2015). It is known fact that urbanization, population growth, rapid increase in industrials manufacturing and modernization are solely responsible for high rate and successively increase of solid waste worldwide. However, improper waste management includes uncontrolled disposal process during waste streams is considered as a major problem

for municipal corporations and leads to pose a threat to public health and environment. TagElsir *et al.* (2015) stated that the average per capita of solid waste production at the level of Sudan in early 1990s estimated at 0.2 kg per day, which has doubled with the increase in urbanization, reaching more than 0.5 kg per day. This huge amount most probably transported and disposed without any treatment which include 60% in Khartoum State and only 10% in the rest of Sudan.

Sudan is one of the most growing populations in Africa with an average growth rate of 2% per annum. In recent years, urban areas in the Republic of the Sudan have been rapidly developing due to economic growth and the flow of refugees, and accordingly the urban population is increasing, it is important for the country now to manage and solve the problems associated with urbanization and population increase, environmental pollution, waste accumulation, dispose and treatment which make the citizens' lives less sanitary and sometimes unsafe (Elkheidir *et al.*, 2016). The generation of waste is not the contention but the disposal of generated waste, the threat posed by inappropriate disposal of wastes in the streets of the city could be readily observed and that are littered daily with waste.

Till present there is no actual data about the quantity of the waste generated from the different sectors, waste compositions and the percentage of waste collected from the waste generated in Sudan in general and in Khartoum State as the personnel in particular, all the data in this area is estimated. However the available data showing that the average per capita of solid waste production at the level of Sudan in early 1990s estimated at 0.2 kg per day, which has doubled with the increase in urbanization, reaching more than 0.5 kg per day, and only transported without safe treatment about 10% with exception of Khartoum State where the proportion of waste that is transported to and also without safe treatment about 60% (TagElsir *et al.*, 2015).

Thus Khartoum, the capital of Sudan has serious problem with solid waste management due to lack of comprehensive strategies and management plans. For instant thousands of tons are generated daily in Khartoum State but lacked proper collection, transportation, sorting, processing and disposal which are contributing to huge pressure to the landfills. The landfills on other hand also lack improper design and maintenance. Such inadequate waste collection and management systems resulted in serious urban environmental pollution and public health hazards. Therefore the main objective of this study is to shed light on waste management problems in Khartoum State including waste streams, started by collection and the current transfer stations as well as the landfills in the state with specific objectives include evaluate the current situation of solid waste management in Khartoum State and ensure that waste management practices and

manual procedures are followed.

METHODOLOGY

The study was conducted in Khartoum State during September to December 2021 to evaluate the waste management situation based on Khartoum State waste streams including the transfer stations and landfills systems. Secondary data was collected from Khartoum State Cleaning Corporation (KSCC) reports, published papers and other raw data available. Primary data was collected via Key informant interview in KSCC.

Study area

Khartoum is the capital of Sudan; is located at the confluence of the White Nile and the Blue Nile with area 20,000 km² in the middle of the populated areas in Sudan, with population of 8,643,559 which represent about 15% of country's population. Khartoum State comprises three cities namely Khartoum, Khartoum North (Al-Khartoum Bahary) and Omdurman and seven localities namely Khartoum, Bahary, Omdurman, Karary, Umbadda, JabalAulia, and Sharg EINile. Khartoum features is a hot desert climate, however, some districts are severely affected by flooding. It is a flat inland city, altitude about 400m above sea level (Mofadel *et al.*, 2016).

Data source and parameters

Data parameters include data from the period of 2016 until 2020 representing Khartoum State population, MSW generation amount-Unit Generation Rate (UGR) kg/cap/day, total MSW generated in million tons/day and MSW amount collected(tons/day) and collection coverage in percentage. The data obtained from KSCC and from the report of Baseline for Preparation of National Action Plan (NAP) for integrated Waste Management (IMW (Mofadel *et al.*, 2015).

Data analysis

The secondary data has been presented and compiled in tables and figures as well as comparison studies were done between different parameters such as relationships between the parameters using Microsoft Office Excel 2016.

RESULTS AND DISCUSSION

The study revealed that Municipal Solid Waste (MSW) stream (Figure1) in Khartoum State started from collection point at household, streets and commercial centres with no pre classification except by Nakasha,

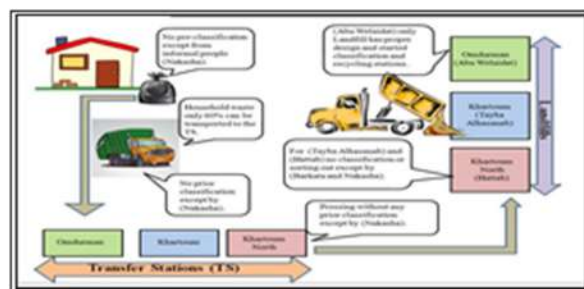


Figure 1: Municipal Solid Waste (MSW) stream in Khartoum State
Source: Mofadel *et al.* (2016).

then the tracks took the waste to the transfer stations where is pressing took place and the pressed waste transferred to the landfills. During this journey the sorting only been done by the informal sector in the tracks and at transfer stations by Nakasha and after dumping in the landfills by Barkata. In Hattab and Tayba landfills the sorting and classification process only been done by the informal sector, however, in Abu Wladat landfill formal sector (private company) did the recycling in the landfill, unfortunately due to the conflict of interest between them the landfill has been burned by Barkata and that resulted incomplete closure to the processing plant. This should be revised by the policy makers to see the appropriate way to incorporate them in the formal system based on win-win situation. The study revealed that in 2007, the cleaning and waste management responsibilities transferred from Khartoum State government level to the locality level without any technical studies and support in capabilities to enable them to perform the work inefficient manner. As a result, the percentage of transported waste has decreased. Therefore, 65% of the generated waste not been collected and transferred to the transfer stations, which distorts the city's landscape.

According to Census 2008, population of the Khartoum State was 5.3 million as shown in (Figures 2 and 3). Almost 81% of the population lived in urban area in the state. The official projection by Sudan Central Bureau of Statistics indicated that Khartoum State population has increased to 7.4 million in 2016 and to 8.6 million in 2020. The major waste in Sudan is considered as municipal solid waste and it consists of 10 components as shown in (Figure 4). Thus, the trend of the waste components is showing the same since 2013 till 2020. As 30% of Khartoum State waste is recyclable materials, the policy should be no dumping or disposal into landfills, segregation and recycling should be practiced (Elsarraf *et al.*, 2017). The daily waste generation in Khartoum State is considered as the fast growing waste materials in Sudan, the unit generation rate (UGR) in 2016 is 0.78 kg/capita/day and waste amount generated is estimated as 5,752 million ton/day. MSW generation in 2020 is

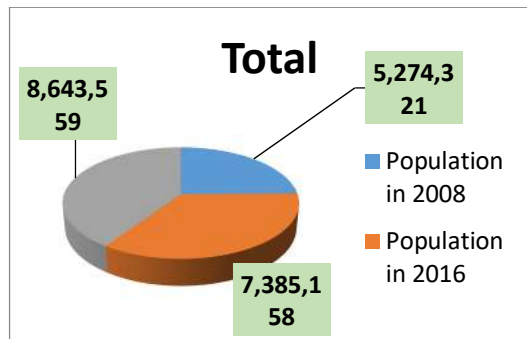


Figure 2: Population of Khartoum State for 2008, 2016 and 2020. **Source:** KSCC (2016).

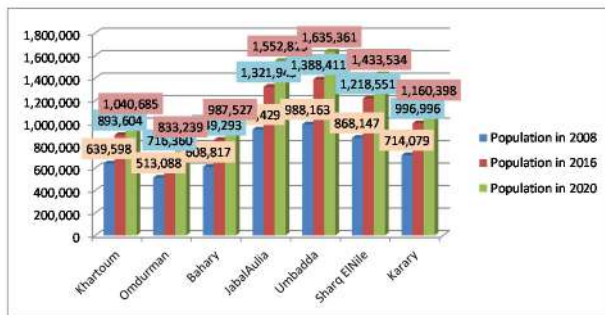


Figure 3: Population of Khartoum State and its Localities for 2008, 2016 and 2020 **Source:** KSCC (2016).

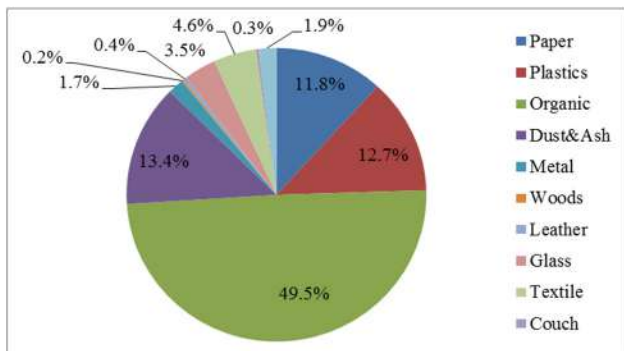


Figure 4: Waste composition analysis in Khartoum State **Source:** KSCC (2021),

Table1: The total population and generated MSW (millions per day, in tons) in 2016 and 2020.

Items	Population	UGR(kg/capita/day)	MSW generation (million ton/day)
Khartoum 2016	State 7,385,158	0.78	5,752
Khartoum 2020	State 8,643,559	0.82	7,087

Source: KSCC (2020)

increased to 7,087 million ton/day compared to 2016 as shown in (Table1).

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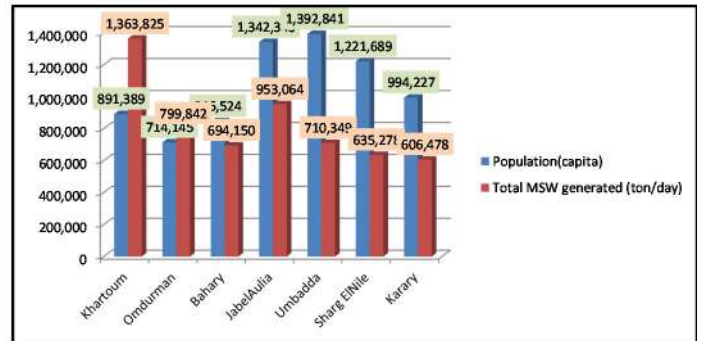


Figure 5: The total population and generated MSW (millions per day, in tons) by locality in 2016. **Source:** KSCC (2016),

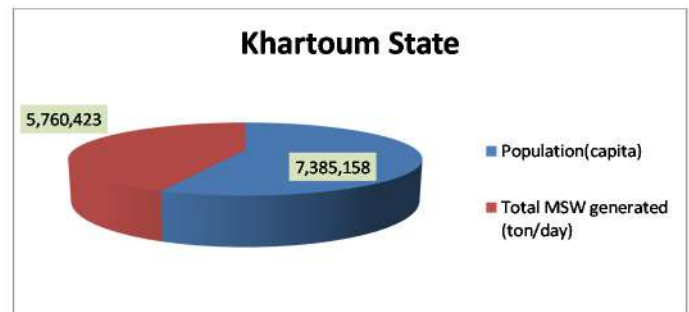


Figure 6: The total population and generated MSW (millions per day, in tons) in Khartoum State in 2016.



Figure 7: Waste management flow in 2016. **Source:** KSCC (2016).

The generated MSW amount is calculated by multiplying the unit generation rate (UGR) by the total population. The UGR refers to the amount of waste generates by person per day which indicated by (kg/cap/day). The total population, UGR and generated MSW for the seven localities in Khartoum State during 2016 to 2020 are presented in (Figures 5, 6, 7, 8, 9, 10, 11, 12 13, 14 and 15). The Correlation Coefficient between the number of population and the total MSW generated in 2016 shows insignificant negative relationship ($r=-0.173596$). Figure 7 described the total generated amount (5.8 million

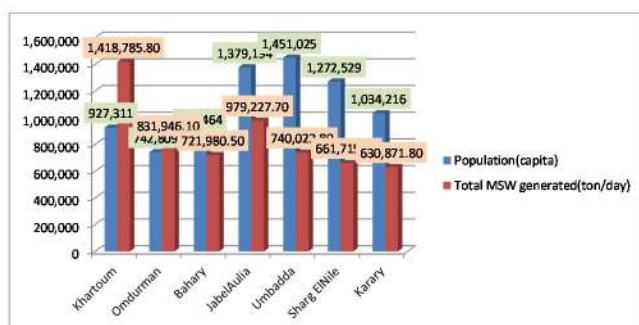


Figure 8: The total population and generated MSW (millions per day, in tons) by locality in 2017. **Source:** KSCC (2021).

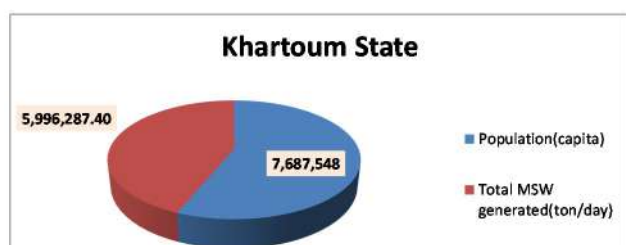


Figure 9: The total population and generated MSW (millions per day, in tons) in Khartoum State in 2017.

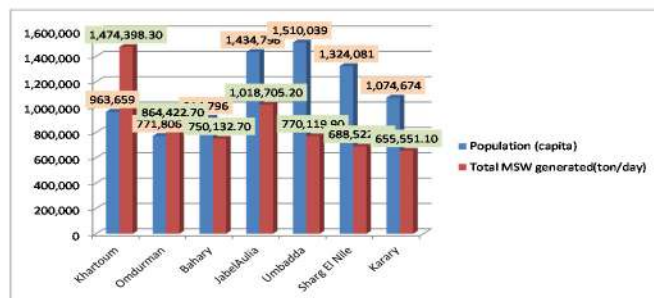


Figure 10: The total population and generated MSW (millions per day, in tons) by locality in 2018. **Source:** KSCC (2021).

ton/day) only 4.1 million ton/day of waste are collected by localities of which only 3.7 million ton/day are disposed at the landfills. The discrepancy between collection and disposal amount is considered to be caused by illegal dumping or fault records.

The Correlation Coefficient between the number of population and the total MSW generated in 2017 shows insignificant negative relationship ($r=-0.188564$).

The Correlation Coefficient between the number of population and the total MSW generated in 2020 shows insignificant negative relationship ($r=-0.200295$).

The result indicated that highly significant positive

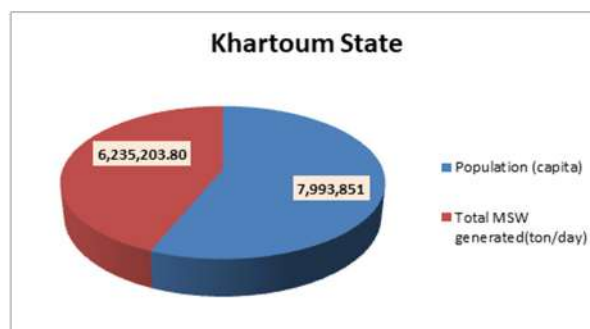


Figure 11: The total population and generated MSW (millions per day, in tons) in Khartoum State in 2018.

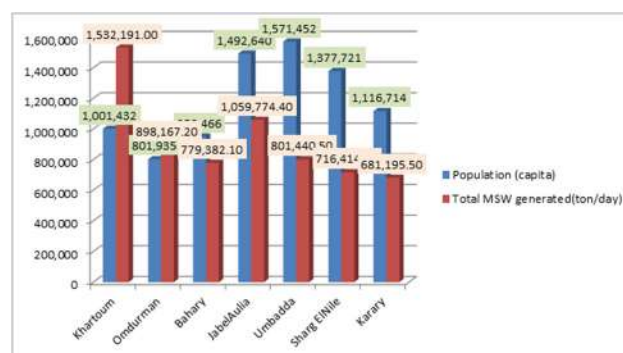


Figure 12: The total population and generated MSW (millions per day, in tons) by locality in 2019. **Source:** KSCC (2021).

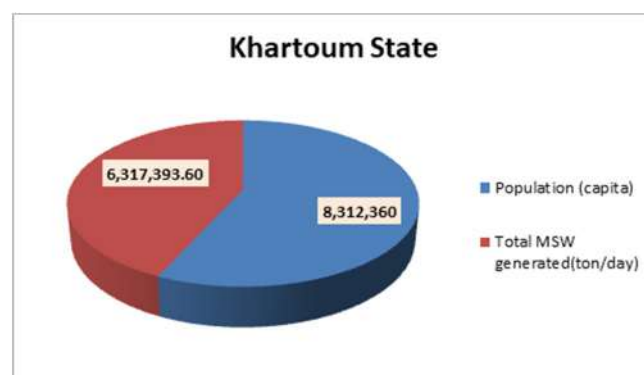


Figure 13: The total population and generated MSW (millions per day, in tons) in Khartoum State in 2019.

correlation ($r=0.943$) between number of population and the total MSW generated in Khartoum State was obtained during the period from 2016 to 2020 as shown in (Figure16). Although in the localities the results indicated a negative correlation coefficient ($r=-0.18481$ and -0.200295) in 2019 and 2020 respectively. The collection coverage rates in the different Khartoum State localities are calculated for years of 2016 until 2020 as shown in (Figures 17,18,19,20, and 21) respectively. Figures 22 and 23 showed that the total generated MSW in Khartoum State is estimated by 5.8 million ton per day whereas, the total collected amount only 3.6 million which

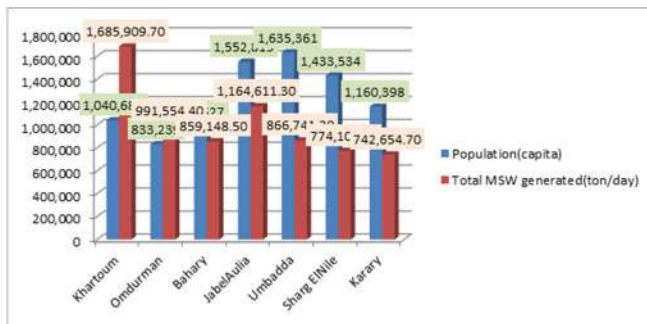


Figure 14: The total population and generated MSW (millions per day, in tons) by locality in 2020. **Source:** KSCC (2021).

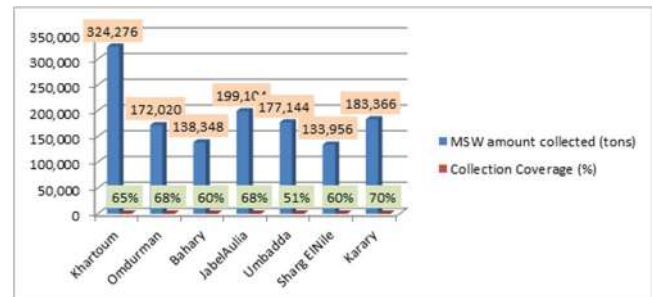


Figure 17: Collection Coverage by locality in 2016. **Source:** KSCC (2021).

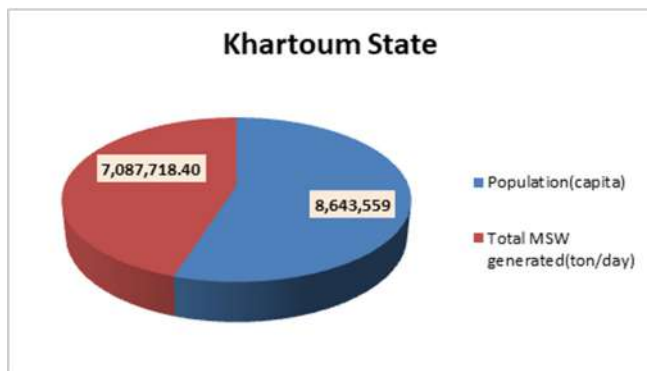


Figure 15: The total population and generated MSW (millions per day, in tons) in Khartoum State in 2020.

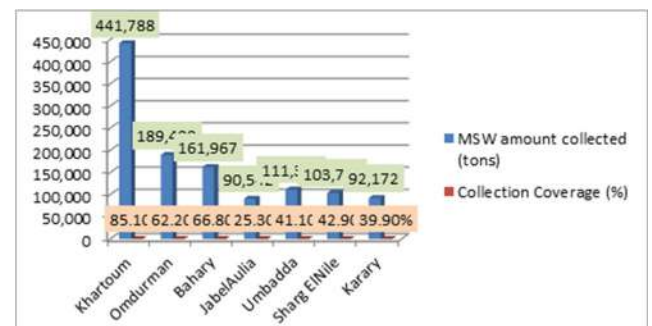


Figure 18: Collection Coverage by locality in 2017 **Source:** KSCC (2021).

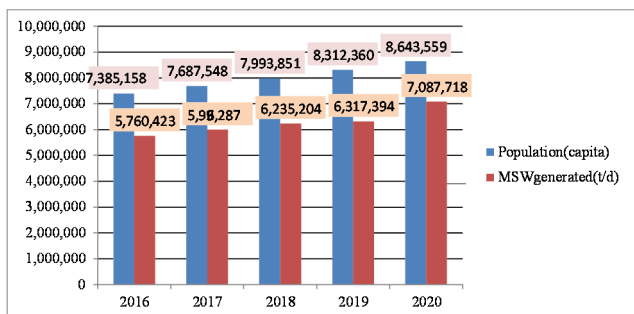


Figure 16: Khartoum State population and the MSW generated (million tons/day) from 2016-2020. **Source:** KSCC (2021).

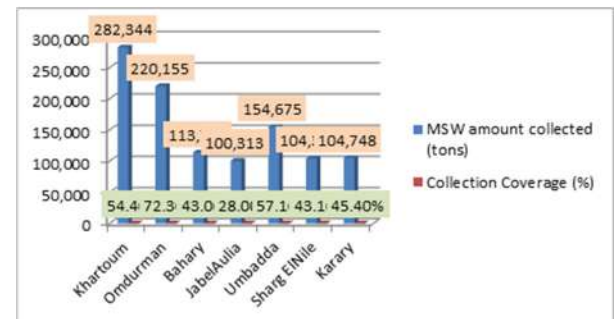


Figure 19: Collection Coverage by locality in 2018 **Source:** KSCC (2021).

represented only 63% of the total in 2016. The percentage of collected amount is decreased to 27.7% in 2020; despite the increased in the total generated waste (7.1 million ton perday). This indicated there is highly significant negative correlation ($r=-0.9194$) between the total generated MSW and the collected amount during the period from 2016 to 2020.

After collection the trucks took the waste to the transfer station where is pressing took place. The study identified four transfer stations in Khartoum State include Khartoum city transfer station, Omdurman city has two transfer stations, whereas the fourth one in Khartoum North city (Bahary) which has been closed. Five new transfer stations are under construction namely; Soba and Alandlus in (Khartoum city) Wad-dafeea in (Khartoum

North city) Abu-seid and Karary in (Omdurman city) as shown in (Table 2 and Figures 24, 25 and 26). Till yet only one transfer station is under operation as per the proposal and been closed due to the local community struggling for not to be in operation.

The waste after been pressed in transfer station is loaded in long vehicles and transferred to the landfills. Three landfills namely AbuWlalat in Karary locality, Hattab in Sharg El Nile locality and Tayba landfill in Jabal Aulia locality were established in Khartoum State. Table 3 shows the three landfills their locations, total areas and capacities, whereas (Table 3 and Figure 27) indicated the locations in a map using GIS.

The three existing landfills are open dump sites, without application of integrated waste management approach.

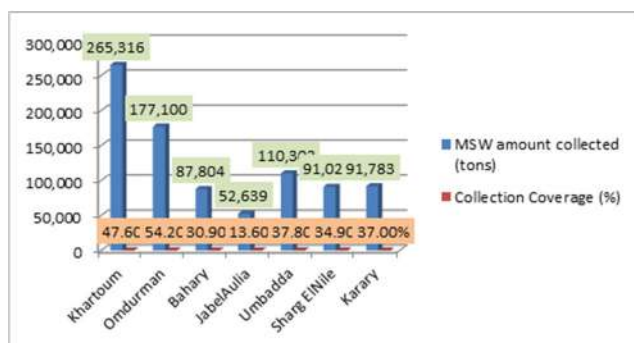


Figure 20: Collection Coverage by locality in 2019. **Source:** KSCC (2021).

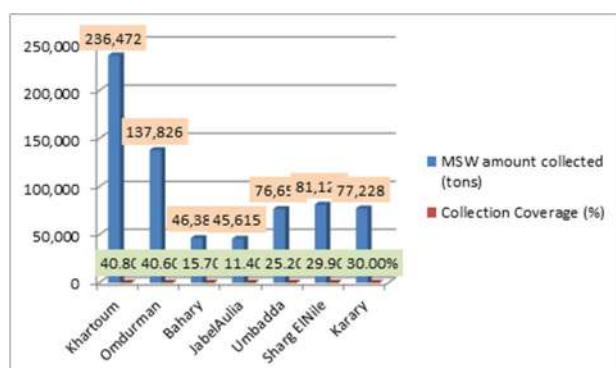


Figure 21: Collection Coverage by locality in 2020 **Source:** KSCC (2021).

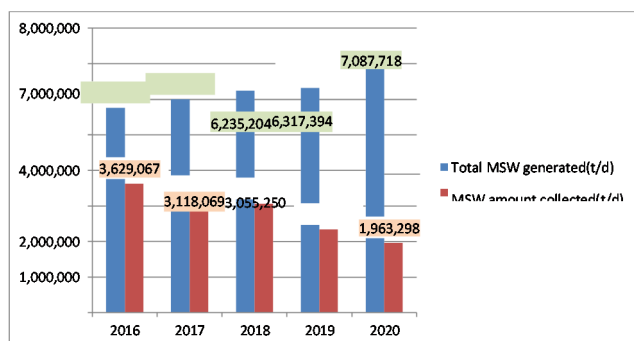


Figure 22: Khartoum State total MSW generated and the amount collected (million tons/day) from 2016-2020. **Source:** KSCC (2021).

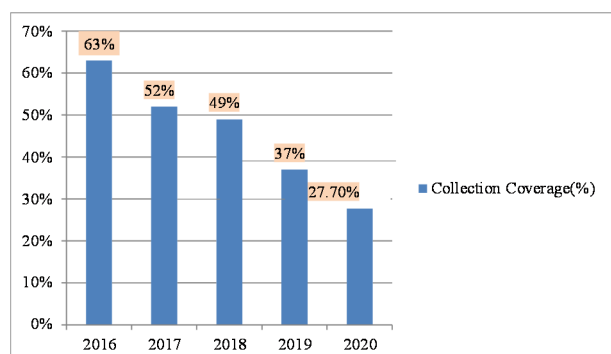


Figure 23: Collection Coverage (%) in Khartoum State from 2016-2020 **Source:** KSCC (2021).

Table 2: The transfer stations in Khartoum State

Working Transfer Station	
Item	Capacity ton per day
Khartoum transfer station	800
Omdurman transfer station	400
Umbadda transfer station	1200
New Transfer Station (under construction) Capacity ton per day	
Soba transfer station	1200
Wad Dafeaa transfer station	1600
AbuSeid transfer station	1200
Karary transfer station (completed)	1200
Alandalus transfer station	1600

Source: KSCC (2021)

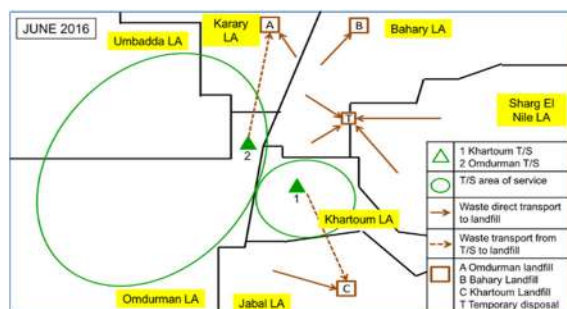


Figure 24: Situation of SWM transfer station in 2016 **Source:** Elkhidir *et al.* (2016) Khartoum TS=765 t/d Omdurman TS=830 t/d 28% of total generated MSW.

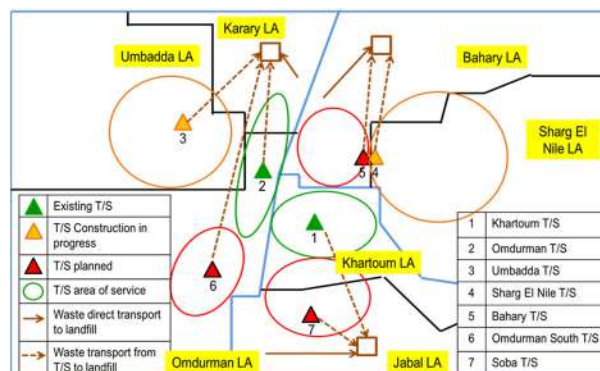


Figure 25: Waste transfer stations- proposed operations in 2020 **Source:** Elkhidir *et al.* (2016).



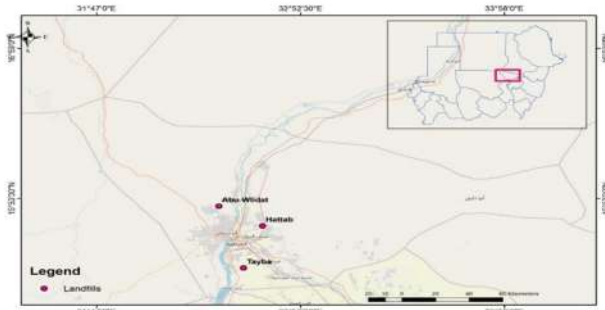
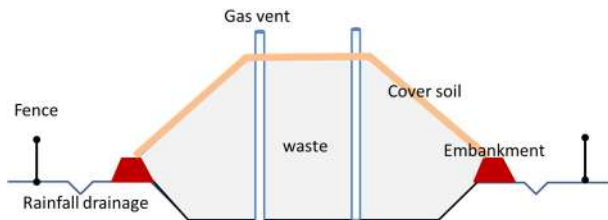
Figure 26: MSW pressing in transfer station **Source:** KSCC (2021).

The disposal is done in improper way which causes odour, visual offence and scattered waste around the area. As well as the negative role of the informal sector

Table 3: Landfills in Khartoum State

Land fill name	Location	Acres	Full Capacity/ton
Tayba Landfill	25 km from Khartoum center	41	1000tons
AbuWlidat Landfill	30 km North of Khartoum	80	1200tons
Hattab Landfill	25 km East of Khartoum	80	600tons

Source: KSCC (2021)

**Figure 27:** Landfills sites in Khartoum State Source: Researcher Captured using GIS (2022).**Figure 28:** Roadmap of developing sanitary landfill Source: Elkhidir *et al.* (2016).**Figure 29:** Image of (Level-2) landfill site Source: Elkhidir *et al.* (2016).

for in squeezing out the dumped waste for recycling material. However, the landfill should be designed in a sanitary manner to protect the public health and the environment. Since 2008, the government disposed solid waste as controlled dumping (Level 1) as shown in (Figure 28). Nowadays KSCC aims to operate the landfills as “Sanitary Landfill with bund and daily cover (Level 2)” by the Year 2021, however till now no development in the landfills sites has been noticed.

The sanitary landfill site required a suitable place with a sufficient area to accommodate the mechanisms. In open area not crowded with traffic and linked with asphalted road. The building should include administration office, access management facility (fence and gate), take all safety precautions, connected to a sewage system, supplying with drinking water, electricity network,

**Figure 30:** MSW treatment in the landfill Source: KSCC (2021).**Figure 31:** MSW poor management practices in some landfill site Source: KSCC (2021).

embankment, drainage facility and gas removal facility as proposed by Solid Waste Management Khartoum Master Plan2 in Khartoum State as shown in (Figure 29) (Elkhidir *et al.*,2016). At present, MSW generated from the state is disposed at three existing landfills. KSCC will construct a new landfill in Khartoum locality as replacement of existing Tayba landfill. Hattab landfill receives only municipal solid waste and Abu Wlidat landfill receives municipal solid waste additional to non-hazardous industrial solid waste as shown in Figure 30 (KSCC, 2021). Finally, the result of some landfill observations showed that poor management practices as shown in (Figure 31). Thus, Mofadel *et al.* (2016) stated that Sudan waste management lacks of holistic and detailed regulations and policies in the areas of waste management coupled with limited infrastructure and poor waste retain as the waste utilization is limited.

Conclusion

Information on the amount and composition of solid waste is important in management programmes and plans for waste handling collection, transportation, treatment and disposal. The composition of the waste will help to decide what will be the end use of the waste either to be used as source of energy, fertilizer; recycling (like paper, plastic and metals) or just it is a useless waste to be dump in a landfill.

This study revealed that the total amount of municipal solid waste MSW generated in Khartoum state in 2020 is estimated to be 7.1 million tons per day which is dominated by organic food waste 49.5%, dust and ash 13.4%, plastic 12.7% then paper and cardboard 11.8%. The total average of the waste generated in tons/cap /day for Khartoum State is 6.3 million, however, the collected amount is estimated to be 1.96 million tons/day as well as the percentage collection coverage is 27.7%. The results indicated that highly significant positive correlation ($r=0.943$) between number of population and the total MSW generated in Khartoum State was obtained during the period from 2016 to 2020. Although in the localities the results indicated a negative correlation coefficient ($r= -0.18481$ and -0.2002951) in 2019 and 2020 respectively which indicate there is relationship between the population in come and the generated waste. The result of key informant interview concluded that the government when applied waste management programme in AbuWlidat landfill in Omdurman city with private sector enterprise led to unsuccessful experience. However, such privatization of waste collection services will result in potential conflict between the formal and informal waste collectors. Nowadays all municipal solid waste are dumping in the landfills without any sorting, classification and recycling process except by Nakasha and Barkata which leads to social and environmental risk. A complete policy setup is crucially needed in order to speed up the integrated solid waste management in Khartoum State.

Recommendations

Khartoum State government with private sector enterprises and NGOs should design effective and efficient integrated MSW management programmes and plans including application of the common approaches.

The new approaches to SWM should be adopted by all localities in Khartoum State to achieve cost-effective SWM system; there should be focus on the 4Rs to create wealth from the waste and to reduce the final waste going into the landfills.

Khartoum State government should monitor the progress of MSW management system implemented by KSCC and LCAs and shall check the budget execution for proper use of SWM fee from residents to provide them with good SWM service to enhance satisfaction from the residents.

Monitoring while supporting private sector partnership due to the limitations of government finances and resources, to avert past deficiencies necessary policy measures must be made by the authorities to monitor and assess the performance of private sector partners. Government should sponsor public enlightenment and

environmental awareness programmes among citizens, workers and decision-makers on waste impacts and educate the public on ill-effects of improper handling of wastes.

Greater participation of local communities: as previously demonstrated, public awareness is a main key to the upgrade of waste management.

Establishment of proper landfill sites (Sanitary landfilling) should be adopted as final destination of these wastes to save our environment from further degradation and to protect public health.

Greater effort for community composting: composting is the best option for treating organic waste, especially in agricultural developing countries like Sudan, where the highest percentage of solid waste is of an organic nature.

Simple and dedicated programs for specific kinds of waste: for inorganic waste like plastic, glass, paper, and metal, localities should provide the tools for effective separation, storage, and transportation (such as the use of coded bins and appropriate trucks, etc.).

Empowerment of low-income communities for recycling: low-income communities, if properly trained, could recycle their own waste themselves in their areas, thereby allowing them to make extra income, besides improving the public perception of waste management.

Waste management as part of the initial infrastructure: for any type of construction, either residential or commercial, basic requirements should be enforced for the reduction and segregation of waste at the source (municipalities could consider measures such as the inclusion of separate containers for composting and recycling before approving a construction proposal for a new building).

Short-term and long-term planning: all municipal administrations should develop short-term and long-term waste management plans including visions, targets, responsibilities, timeframes, monitoring, and constant assessment.

More research and studies for a national plan: an effective national plan for sustainable solid waste management should be approached in collaboration with academic research institutions and universities from all over Sudan.

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