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Research on Landfill and Composting Guidelines in Kigali City, Rwanda Based on China's Experience

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Abstract. Due to the population growth and the improvement of life standards, there is a growing concern associated with waste generation in Kigali city. All collected waste goes to the only one landfill in Kigali and the waste composition is dominated by organic waste up to 68%. Some efforts were made to handle solid waste in Kigali City, but there are still some weaknesses related to waste disposal facilities. Most of data used in this paper are collected directly or indirectly from literature, government websites, and institution reports which are related to solid waste management and official media. This paper used a comparative analysis for Kigali city and China in order to propose guidelines that could be referred to improve the design of landfill and composting plants in Kigali city. This paper is proposing Kigali City to refer to Chinese standards on landfill and composting plants. China has important standards on liner system, leachate collection, cover standards, environmental monitoring standards that can be referred to in construction and monitoring the functionality of a landfill in Kigali city. The materials such as geotextile, Perforated HDPE pipe and others used in China should be tested if they are compatible with soil, weather, and other environment issues in Kigali City before using them. Composting is very necessary in Kigali City because 68% of solid waste generated is organic waste. MSW aerobic static composting standards in China such as moisture content, leachate collection, temperature could be followed in order to introduce the standards of composting in Kigali city, compost can be used in agriculture as 90% of Rwandans are formers.

Keywords: China'S Experience, Compost, Guidelines, Kigali, Landfill.

1. Introduction

Rwanda is a small country located at the east central Africa. Rwanda has a capital city called Kigali, covering an area of 730 km^2 in the central part of Rwanda, serves about 1,223,000 people and Kigali's population density is 1600 per km^2 Currently GDP per capita is 724$, a 3 fold increase from 2000 and the GDP target is $1,240 by 2017 [1-3].

Nduba dumpsite remains the current only facility in Kigali that deals with collected solid waste which receives about 400 tons per day of unsorted waste or 140,000 tons per year [4]. Solid wastes in Kigali City are mainly made by food remnants up to 68 %, the average waste generation is between 1800 and 2000 t per day [5, 6]. Organic solid waste should be composted for use in agriculture or kitchen gardening, which is mainly kitchen waste, plants, leaves [7, 8]. If a portion of the waste stream consists of organics or can be easily separated into organics and non-organics, composting may become a viable waste management strategy [9].

Kigali is facing significant challenges in relation to solid waste disposal. Waste generation is increasing, while a sizeable portion of it is disposed on improperly located and operated dumpsites and resulting in adverse impacts on environment and health [10]. Reports from various institutions claim that garbage management in Kigali has had diverse effects on both the natural environment and human society [4]. Deep seated fires, methane explosions, landslides and leachates threatening rivers and groundwater are some of the

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common problems of such basic dumpsite [11]. Launched in 2012, the Nduba dumpsite was established to avoid these potential disasters, poor sanitation practices and among other issues but it has problems of not being a sanitary landfill, with no proper engineered lining system to prevent leachate from contaminating the ground and no gas collection facilities.

Although many studies have been done regarding solid waste management systems in Kigali City (J BAZIMENYERA, Qiang Fu, Karangwa Antoine [5], Innocent Kahigana [12], REMA 2013 [13], and RURA 2009 [14]) there is no reported study which was focused on landfill and composting guidelines.

This paper referred to Chinese guidelines such as pollution Control on the Landfill Site of Municipal Solid Waste (GB16889) which was first released in 1997 and then amended in 2008; technical specification for operation, maintenance and safety of municipal solid waste composting plant (CJJ/T86-2000) for MSW composting [15]. These guidelines were issued by the Ministry of construction, the State Environmental Protection Administration, and the Ministry of Science and Technology.

Landfill and composting are promising for a developing country as Rwanda which is solid waste are increasing quickly and organic waste are dominating in solid waste composition. China has experience in landfill and composting, therefore, this paper is proposing Kigali City to refer to Chinese guidelines on landfill and composting. China has important standards on liner system, leachate collection, cover standards, environmental monitoring standards that can be referred in construction and monitoring the functionality of a landfill in Kigali city.

2. Current Situation of MSWM in Kigali City of Rwanda

2.1. Location

Rwanda has a capital called Kigali city, covering an area of 730 km^2 in the central part of Rwanda, serves about 1,223,000 people, Kigali's population density is 1600. Kigali City is built on interlocking hills, has an annual average temperature of about 20˚C [4].

Kigali city has only one landfill located at North East of Kigali at Gasabo District, Nduba hill at Muremure cell at 10 Km from Kigali Center [13]. The dumpsite in Kigali receives about 400 tons per day of solid, not sorted waste or 140,000 tons per year. Even though, all waste collected in Kigali City are brought to Nduba landfill according to Kigali state of environment 2013 [16], a big part of Kigali city doesn't have collection system.

Kigali, which is very hilly, has changing wind directions throughout the day [17]. As the general annual trend of wind direction is from North and North-East to the South, the southern part of Kigali would expect to have highest concentration air pollution than other area in the entire city [18].

Rwandan soils are naturally fragile. They are generated by physicochemical alteration of basic schistose, quartzite, gneissic, granite and volcanic rocks that make up the superficial geology of the country [19]. Granitic and meta-sedimentary rocks underlie the City of Kigali; these include schists, sandstones and siltstones. Lateritic soils, rich in iron and aluminium, dominate the city's hillside surfaces while alluvial soils (fertile soil deposited in river valleys) and organic soils are found in the lowlands and wetlands. Inappropriate development on Kigali's hilly slopes has caused extensive soil erosion in some areas [1]. The City of Kigali has a hilly topography with soil permeability and stability of 0.01- 0.7 cm/min [20].

2.2. Data collection and methodology

Data of any kind involving solid waste is generally not widely valued, available or shared in Rwanda. In order to obtain the potential materials regarding solid waste, most data used in this paper are collected directly or indirectly from literature, government websites, reports and institutions which are related to solid waste management and official media. Kigali was expanded in 2007, so data for population, GDP per capita and solid waste generation starts from 2007.

This paper uses a comparative analysis for Kigali city and China in order to propose guidelines that could be referred to improve the design of plants and environmental monitoring. In order to profit from China's experience in MSWM and learn some lessons for Rwanda. This research uses a descriptive study to show the situation of MSWM in both countries Rwanda and China and then it will discuss some guidelines

on composting and landfill made by Rwandan government and Chinese government to conclude some recommendations for Rwanda.

3. Results and Discussion

3.1. Problem analysis

Rwanda is facing significant challenges in relation to solid waste management. Waste generation is increasing, while a sizeable portion of it is disposed on improperly located and operated dumpsites, resulting in adverse impacts on environment and health. Reports from various institutions claim that garbage management in Rwanda has had diverse effects on both the natural environment and human society [4]. While meeting demands for waste disposal, larger landfills can reduce the costs of land acquirement and environmental assessments, and can be equipped with better pollution control facilities [21].

Kigali city could learn from China technical standards pertaining to MSWM. Such as Pollution Control Standard for MSW Landfills (GB16889-1997) which was amended by the Ministry of Environmental Protection in July 2008. The new standard (GB 16889-2008) placed stricter regulations on the construction of landfill sites and established more rigorous pollution controls.

3.2. Waste increase

Kigali City's solid wastes are highly increasing in the quantity and quality as the number of population and economic activities are increasing while the land for disposal is becoming scarce. Composting and good landfill methodologies are the most viable alternatives for managing solid waste in Kigali City; however, no single method will control the waste problem as effectively as a comprehensive program that relies on a number of solutions for different situations and the direct involvement of citizens is essential.

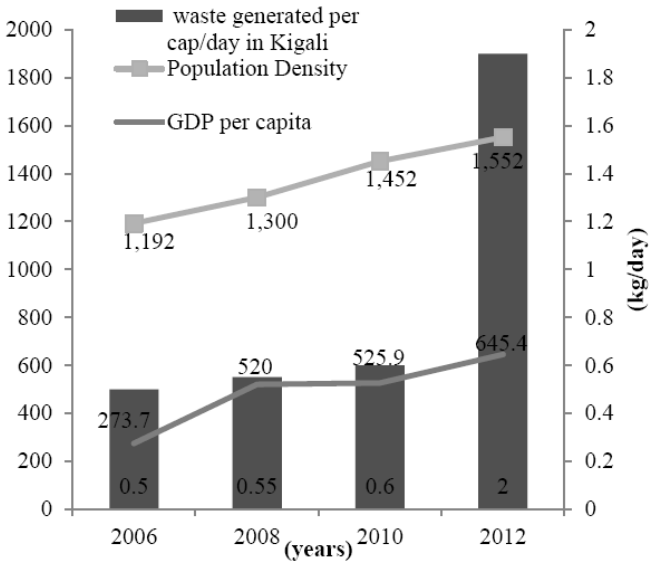

Fig. 1: Waste generation per capita, population density and GDP per capita per year in Kigali City.

Kigali city has currently reached a density of 1600 population per km square from 1,192 in 2007 and Kigali is ranked as the first city in Africa which has the highest density. Rwanda is a developing country in 2007, GDP per capita was $273.7 and in the same year waste generation per day per capita was 0.5 Kg however in 2012 GDP reached $645.4 per capita and waste generated was times four more than in 2007 and reached 2kg per capita per day as shown Fig. 1. All these data prove the necessity of improving solid waste disposal because of increasing of solid waste linked with high population and economic development.

The average waste generation is between 1800 and 2000 t per day in Kigali but 400t are collected to Nduba landfill. Kigali City's population is expected to double by 2020 to 2 million inhabitants; currently the City of Kigali has 1,223,000 million inhabitants with annual growth of 4.0 percent. This growth goes with increasing demand for basic services and puts an unrelenting pressure on the environment in general.

3.3. Mixed waste

Solid wastes composition in Kigali City as shown in Fig. 2 are mainly made by food remnants up to 68 % and in China also organic waste takes 56% of waste generated as shown in Fig. 1. If organic waste is diverted for composting, it can be beneficial to agricultures as 90% of Rwanda are formers [22], [6].

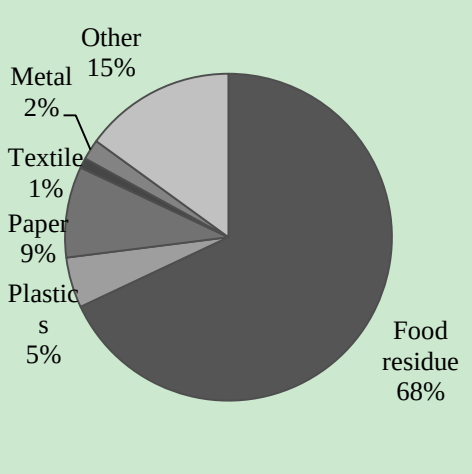

Fig. 1: Waste composition in Kigali City.

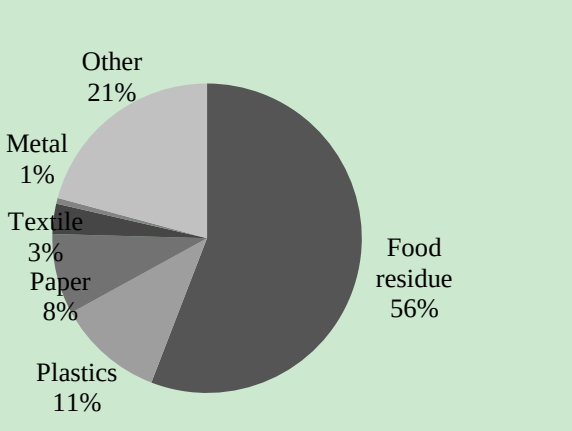

Fig. 2: Waste composition in China.

3.4. Comparision of technical requirements on Landfill between China and Kigali City.

Kigali city could learn from China how liner system and a barrier liner are accomplished, double liner and barrier layers are very necessary for a sanitary landfill. Chinese materials might not perform well in Rwanda because the soil, climate are not the same for both countries that is why some test are required such as soil test, geomembrane, geotextile and other materials.

Leachate facilities are very necessary for a sanitary landfill, if leachate is not collected, it can penetrate and pollute ground water. So, a strategic plan should be applied in Kigali City in order to collect well leachate, sand drainage layer is not enough that is why constructors of landfills in Kigali should refer to Chinese methods of using nonwoven geotextile, perforated HDPE pipe and other materials and test them before if they will perform well in Rwanda.

Pollution control is essential for a sanitary landfill; China has a Code for pollution control: GB16889-2008 that Rwanda can be referred to set pollution control in the landfill. China's code for pollution control is very detailed and easy to understand for a developing country as Rwanda.

A sanitary landfill should have a monitoring system of groundwater, landfill biogas, and leachate as it is mentioned in Chinese Code of monitoring: MOC/NCEC2001, CJJ/T 3037-1995 and GB/T18772-2008. Kigali city should refer to these codes in order to set adequate requirements of environmental monitoring.

A sanitary landfill has also a daily cover, intermediate cover and a top cover system but in Kigali's landfill, they try to put a daily cover only but also intermediate covers are also needed with adequate materials which are adaptable on Kigali city's environment. In Kigali sand, clay, gravel can be found easily but geomembrane and nonwoven geotex should be tested in order to know if they will not cause other problems.

3.5. Composting standards in China that could be referred to in Rwanda

According to Rwanda Environmental Management Agency, 50 % of wastes which goes to Nduba landfill are of good quality for composting, such as waste from purely residential neighborhoods, and wastes from special generators such as markets, restaurants, and slaughterhouses [23].

Temperature is a critical factor in determining the rate of decomposition that takes place in a composting pile. Composting temperatures largely depend on how the heat generated by the microorganisms is offset by the heat lost through controlled aeration, surface cooling, and moisture losses [24]. Kigali's average high temperature through the year is 26.89˚C and average low temperature through the year is 15.73˚C.

Composting should be considered as part of an integrated solid waste management strategy with appropriate processing technologies selected based on market opportunities, economic feasibility, and social acceptance.

Composting plant construction evaluation should address the following elements according to urban wastes for agricultural control standards in China GB8172 with life waste composting plant evaluation criteria CJJ / T 172-2011 and also MSW Composting plant technical evaluation CJ / T 3059 requirements [25].

A composting plant overall design in China has (unloading feed system; garbage sorting system; waste fermentation system; reprocessing facilities; ventilation dust and odor control system and leachate treatment facilities).

China's applicable standards compost 8 CJJ / T52 93 gives the static aerobic composting of municipal solid waste disposal requirements. MSW Aerobic Static Composting shall have relevant standards which are total nitrogen organic matter less than 8%, total phosphorus less than 0.2% and the total potassium less than 0.8%, ph value does not exceed the maximum.

The compost biological parameters control standards are compost products pathogen content should be less or even zero, moisture content should meet the following requirements should be 25% to 35% carbon-nitrogen ratio. To achieve this purpose, the stack body temperature should be maintained at 55°C, and hold duration of not less than 5 days.

The static aerobic composting of municipal solid waste could be used in Kigali city since 68% of Municipal solid waste is organic waste. The process could be successful because the compost can adapt to Kigali's temperature. The compost can be used in agriculture sector as a fertiliser since 90% of Rwandans are farmers.

4. Suggestion Guidelines on Landfill and Composting in Kigali City

In Kigali city, there is a gap in designing landfill and composting plants, also, pollution control should control the whole system of these plants. China has a lot of experience that Rwanda could learn.

On Landfill, there should be:

(1) Liner system: In Nduba landfill, there is no liner system; therefore, this paper is suggesting double liner and barrier liner systems because their materials are available in Rwanda.

(2) Leachate system: Sand drainage layer is not enough for Nduba landfill, so, test of some materials such as perforated HDPE pipe, woven geotextile and nonwoven geotextile should be performed in order to know if they can be adaptable in Rwanda to facilitate leachate extraction.

(3) Cover system design: Daily cover is not sufficient for Nduba landfill, there should be provision of an intermediate cover and top cover systems.

(4) Pollution Control: Pollution control such as Methane, leachate and groundwater monitors should be established in order to protect groundwater and surrounding environment of landfill.

On Composting plant, Kigali city could learn:

Design of composting plant should have (unloading feed system; garbage sorting system; waste fermentation system; reprocessing facilities; ventilation dust and odor control system; leachate treatment facilities and daily waste volume should be known).

5. Summary

Landfill and composting are promising for a developing country as Rwanda which is solid waste are increasing quickly and organic waste are dominating in solid waste composition. China has experience in landfill and composting, therefore, this paper is proposing Kigali City to refer to Chinese standards on landfill and composting. China has important standards on liner system, leachate collection, cover standards, environmental monitoring standards that can be referred to in construction and monitoring the functionality of a landfill in Kigali city. The materials such as geotextile, Perforated HDPE pipe and others used in China should be tested if they are compatible with soil, weather, and other environment issues in Kigali City before using them.

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