Food Waste: Waste or Resource? Current Practices and Status

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Abstract- Waste management has become a global concern for both developed and developing countries. Food waste (FW) causes tremendous environmental, economic, and great social influence, thus studies on food waste are essential and meanwhile very complex according to Food and Agriculture Organization of the United Nation. Countries have adopted different methods and technologies for both treatment and disposal of food waste from landfilling, composting, incineration and anaerobic digestion (AD). However, recently the first three methods have been questioned in terms of their environmental sustainability. This paper attempts to study AD of FW as a sustainable technology for treatment of FW and resource recovery in China and its current status and achievements in terms of answering environmental and economic challenges. It also intends to explore FW status in Lesotho as one of the developing countries with waste management difficulties and how it can also adopt the use of this technology to manage environmental pollution and waste of resources. Recently, China has also been exploring Life Circle Assessment (LCA) of FW as an alternative and more sustainable tool for evaluating and assessing environmental, social and economic impacts of waste treatment technologies. It's becoming more popular as it's proven through research to capture the cause-effect relationships between resource consumption and the environmental impacts of a specific service or manufacturing procedure. Adopting FW treatment technologies that allows FW to be used as energy substitute could be beneficial to all. Sensitizing communities on the importance of waste separation from source and the possible derived benefits and the negative impacts of not sustainably managing and treating waste is of great importance.

Index Terms- Food Waste, Anaerobic Digestion, Life Circle Assessment, Lesotho

I. Introduction

FW is one of the largest and most important components of municipal solid waste. This includes household FW, food-processing waste, and canteen and restaurant waste which are being generated at an amazingly high rate. The mounting of FW has gradually become a global concern [1]. It is estimated that the amount of FW will dramatically increase from 2.78 to 4.16 billion tons in Asian countries by 2025 [2].This is more evident in countries like China where the growth rate of FW has increased more than 10% with the acceleration of industrial development and urbanization processes [3].Sustainable management of increasing amounts of this waste has therefore become a major social, economic and environmental concern. Improper FW management leads to substantial negative environmental impacts such as air, soil, water pollution, and health safety issues [4]. Landfill space is also becoming very scare and countries are therefore looking for more alternative methods of dealing with the ever increasing amounts of FW [5]. Food safety issues frequently occur due to incomplete FW management systems. Its disposal is attracting widespread attention in many countries and has become a major environmental concern and one of the major components of waste around the globe [6, 7].

Some define FW as a left-over organic matter from restaurants, hotels and households [8] which is a useful source of fertilizer and biofuel [9]. A nutrient with high levels of carbohydrates, lipids, proteins, and other organic molecules which can support abundant populations of microorganisms [10]. AD, landfill, incineration, and composting are the most commonly used treatment technologies for FW. However, high organic matter and the water content in FW [11], are the main causes for harmful elements in landfills. Currently, the need for alternative and energetically more efficient ways of treating FW seems to be a global goal. AD of FW has demonstrated to be one of the most advantageous technologies to maximize the substrate and energy recovery [11].

II. Anaerobic Digestion of Food Waste in China

Anaerobic treatment provides a method of reducing pollution from agricultural and industrial operations while at the same time it balances the operations usage of fossil fuels [5]. AD is considered one of the oldest and well-studied sustainable biological treatment technologies for stabilization and reduction of organic wastes, including fruit and vegetable processing wastes, packinghouse wastes, industrial organic wastes, and agricultural wastes, especially the sewage sludge [12]. It is one of the most efficient waste and waste-water treatment technologies. It has been widely used for the treatment of municipal sludge and limited application in the treatment of organic industrial wastes [5].

Anaerobic fermentation produces methane as the main product and fertilizers as the byproduct. However, the disadvantages of the technology include high cost, strict start-up condition and long time for fermentation [13, 14].

As a result of increased waste and a need for a more sustainable future, countries have revised and implemented frameworks for the appropriate management of such wastes and their possible future use. In July 2010, China issued a policy named Opinions on Strengthening Waste Cooking Oil and Food Waste Management", which clearly specifies the enhancement of FW management generated from restaurants and hotels putting more focus on waste reduction at source, centralized recycling and treatment. Since 2011, 83 pilot projects have been implemented in 81 cities with a total treatment capacity of 20,930 ton/day. The project was highly supported by Ministry of Finance, Agriculture and Housing and Urban-Rural Development. Among which, the utilization of biogas produced by AD of FW is over 70% [15]. However, the AD process of food waste in China is still in initial stage with noticeable problems such as low gas production efficiency, effective disposal of biogas residues and slurry and undesirable environmental emissions.

AD offers numerous significant advantages, such as low energy requirement and possible energy recovery. Compared to mesophilic digestion, thermophilic AD has killed pathogens, and improved post-treatment de-water degree of waste stabilization thorough destruction of virus and bacteria [16,17] AD is considered to be one of the most promising technologies for renewable energy production and even more efficient if there is pretreatment specifically adopted for FW. This will assist in adjusting the nutrient concentration of lipids resulting in higher biogas production and lower lipid limitation [18].

2.2 Life Circle Assessment of Food Waste in China

LCA is a technique used to assess environmental impacts with all the stages of a product's life. The LCA is widely accepted international tool to transpose life cycle perspective principles into a quantitative framework [19, 20]. It seeks to quantify all relevant emissions, consumed/depleted resources, and the related environmental and health impacts associated with the full waste management cycle [21]. The LCA results in complement techno-economic measurements and help decision makers to determine which strategy to use to achieve a high level of sustainability and identify the weak points and main areas that needs potential improvements [22, 23].

LCA of food carbon emissions from several stages such as raw material, production, consumption and disposition was explored by Wang and Qi [24]. They looked at the general LCA framework and methods of calculating carbon emissions from food, especially meat. Hu et al. [25] used LCA approach to analyze the carbon emission characteristics of food in China from 1996-2010, using brief statistics for energy/resource reuse in different parts of food supply chain, and concluded that diet structure, high amount of fertilizer application, as well as food waste are the three main causes for increased Greenhouse Gases (GHG) from food industries. Food waste percentages in China was studied, and both rough resources together with environmental influence was calculated [26].

Global food waste studies were summarized by Cheng et al. [27], who concluded that studies on whole food supply chain are not enough. On the other hand, Hao et al. [28] studied FW and brought forward the importance of LCA application on FW along with a complete life cycle inventory for food. Five treatment methods such as landfill, compost, AD, smashing, and integrated treatment for kitchen waste were compared. [29] AD can be quite beneficial for energy generation and emission reduction, especially when kitchen waste is mixed with other waste such as sludge.

Recently, Gao et al. [30] studied LCA of food waste and its application in China. It was found that FW management in China can improve LCA application in different aspects if more focus is put on: a) the early stages of the food cycle rather than just the kitchen waste; b) other environmental influences besides global warming potentials,; c) broader study of FW treatment by considering mixing it with other substrates using different methods; d) a local context with local data/inventory since the local context are substantially different, (for instance, rice from southern and northern parts of China requires different inputs/steps thus have different environmental profile); e) further more detailed studies to support an elevated food waste management, such as food waste profile can be developed.

III. Food waste management in Lesotho

Located in Southern Africa and entirely landlocked by South Africa, with the total length of 909 km, this mountainous country covers an area of around 30,355 km^2 [31]. It is divided into four agro-ecological zones, namely the mountains, foot-hills, lowlands and Orange-River-Valley as shown in Figure 1.

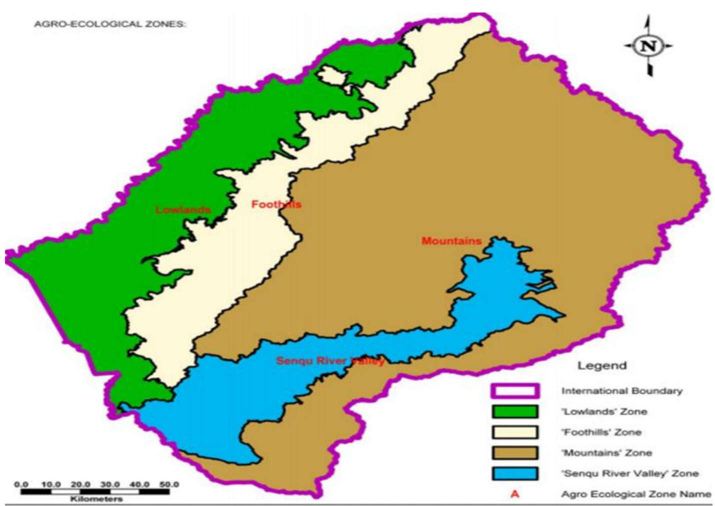

Figure 1 Ecological zones of Lesotho-[32]

Developing countries face problems of lacking effective waste management [33]. Lesotho is one of the developing countries that are unable to keep up with Municipal Solid Waste (MSW) generation rate, which results in unsustainable waste management [34]. The Nation is prone to air, land and water pollution due to unsustainable and illegal waste dumping [35]. Unmanaged organic waste emits large quantity of GHG [36]. Figure 2 shows organic waste being the major component of municipal solid waste in Lesotho with almost 60% generation. It implies that AD of FW could be a potential waste to energy treatment technology for the country. It is evident that FW management needs special and immediate attention for both public health and environment protection.

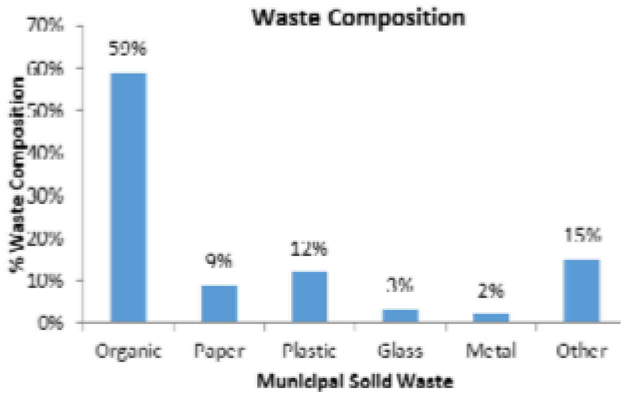

Figure 2 Composition of municipal solid waste in Lesotho [37]

According to United Nations Development Program (UNDP), MSW generation rate is estimated at 0.5 kg per capita per day which makes it 115,000 ton per annum for the city of Maseru (capital town) alone and expected to increase to 0.8 kg/capita/day by the year 2025, making the total MSW generation of about 279, 000 tons per annum [38]. The current waste status and future projections could predict waste management disaster especially with the current poor waste management infrastructure in the country. However, the high percentage of organic waste (59%) may also indicate a promising waste to energy potential for the country [39]. Therefore it could meet the need for balancing the energy environmental gap in the country. However, sustainable FW management is not practiced at all in Lesotho now. FW along with other wastes are disposed in dumping areas which cause both health and environmental issues. In Maseru, waste is being disposed in a dumping site at Ha-Ts'osane, a village in Maseru.

Through the years there has been a lot of environmental stress and community health risks caused by burning and unpleasant smell from the waste. Environmental, social and economic aspects of the various areas in Lesotho need to be considered for the introduction of AD technology for energy production. While rural areas in Lesotho may be compared with those in China and other Asian countries for application of this technology to generate energy from organic waste for lighting and cooking [40]. China's Ministry of Agriculture introduced new technologies to rural areas of the country, of which a domestic biogas plant forms the base, combined with other transformations that are dependent on local conditions, such as pig farming and the construction of solar-heated greenhouses [40]. Lesotho not being self-sufficient in energy production, the adoption and application of this technology used in China could boost the country's economy, assist those rural dwellers without access to electricity, decrease the demand for electricity and most importantly decrease the amounts of FW generated in the country. Figure 3 shows Access to electricity (% of population) in Lesotho. It was reported that only 29.73 % of the population had access to electricity in 2016 and 27.9% in the previous year according to the World Bank collection of development indicators.

Figure 3 Access to electricity in Lesotho (% of population) [41]

Lesotho Renewable Energy and Energy Access Project (LREEAP) which is funded by the World Bank, is one the project that the Government of Lesotho is preparing to scale up renewable energy-based off-grid electrification in order to increase access to electricity in rural and peri-urban areas of Lesotho. The project will be implemented over seven years under the Ministry of Energy and Meteorology (MEM). While electricity access is low in Lesotho, the country has potential to achieve universal access by 2030 using clean, renewable energy resources [42]. By using of sustainable technologies such as AD for treating food waste and recovering energy from biogas production, this could benefit the country and push it towards achieving sustainable development goal 7 (affordable and clean energy) and 11 (sustainable cities and communities).

3.1 Major challenges of waste management in Lesotho

According to Thamae et al. [43], poor waste management in the Lesotho is a result of lack of government attention on legislating efficient waste management guidelines leading to poor waste handlings. Greater portion of the waste therefore does not reach legal dumpsite and are largely and illegally deposited everywhere, along the roads and on illegal abandoned areas [36]. Proper solid waste management should be given priority for waste reduction, decreasing indiscriminate waste dumping and recovering some waste material to be recycled and collection of valuable material for energy generation [39]. Although, there are no formal waste treatments in Lesotho, there are waste recovery centers and some recycling private companies for waste exportation as well as individuals waste scavengers trying to earn a living [44]. If all of these are brought together and recognized by the government this could enhance the waste management system. In an interview I had with one of the civil servant from Mafeteng Urban Council in Lesotho, she mentioned that one of the main challenges facing the council now when it comes to waste management is the inadequate and unsustainable disposal of soiled food which could be poisonous to scavengers. Oil deposited in nearby dams also kill species living in water and makes it difficult for the water department to purify water for drinking purposes. Lack of financial and political support is also known challenges.

IV. Recommendations

Uncontrolled disposal of FW is likely to cause environmental pollution and waste of resources, which are very crucial issues in the world today [3]. The considerable contribution of food industry to the climate change cannot be ignored specially by the policy makers. According to Garnett, Hartmann and Ahring [45, 46], the GHG emissions from food supply chain are produced during all stages of the food production and consumption. Besides, for developed countries, food supply chain contributes between 15% and 28% to overall national emissions. All stakeholders within the food industry must responsibly consider this during the food supply chain. In recent years, this concern became a major driving force to reduce the volume of FW as well as evaluating it as a renewable feed-stock for the production of energy and chemicals.

FW involves a substantial amount of biomass material that makes it possible to use for the biofuels. As a result of high amount of organic material, the management of food wastes must focus on certain difficulties such as high water content, and fragile biological stability. Adopting FW treatment technologies that allows FW to be used as energy substitute could be beneficial to all. Sensitizing communities on the importance of waste separation from source and the possible derived benefits and the negative impacts of not sustainably managing and treating waste is of great importance. Millions of households in China are already using biogas. Livestock and poultry farm waste as well as household waste are the feed sources for the digesters. The biogas plants are mainly situated in farming communities where they serve a dual need: the reduction in organic waste and the supply of biogas as an energy source in areas where no energy was previously available. Lesotho being one of the African developing countries whose economy depends heavily on agriculture, theoretically, department of Agriculture can apply this example from rural China for improving farming communities in the rural areas for biogas and created fertilizer to supply nutrients and organics to the soil.

V. Conclusion

FW is considered a sustainable energy source due to its biomass features. Based on ongoing and previous literature, FW could be the answer to energy problems and not a problem on its own if well managed. Profoundly, it has been noted that the costs of managing waste are very high [47] but unsustainable management or no management at all can even be more costly. However, sustainable FW technologies should take center stage especially for countries like Lesotho where there are not even basic proper sanitary Landfills for general waste management regardless of the increasing amounts of municipal waste coupled with the low percentages of access to electricity. FW is an untapped resource and there are no LCA studies on FW reported in Lesotho by far. Therefore, it is crucial for future researchers to explore and unlock future potential of FW as well as assess and evaluate its environmental, social and economic impacts.

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