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Solid and Liquid Waste in Manjai-Kotu: A Potential Source of Energy for Agriculture and Households in the Serekunda Area (The Gambia)

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Abstract: Due to rapid population growth and economic activity, disposal of solid and liquid waste has become a major problem in and around Serekunda (Gambia). The solid waste collected in the Kanifing Municipal Council, which is the most densely populated municipality in the Gambia, is dumped openly on the Kotu landfill site. The only technique used to dispose of this waste at the site is open burning. As for the liquid waste collected in households and industries, it is discharged in open air at several sites and in rivers. All of this constitutes a significant environmental and health hazard. They are sources of air, soil and groundwater pollution, and acute respiratory infections (AIRs). Despite this, no recycling technique for this waste, which is concerned with the environment and human well-being, has been developed by the Gambian Government so far. However, this waste can be renewed and used as energy in several areas, including agriculture and households. This study, carried out as part of the research themes of the West African Institute for Research and Development (WARDI), aims to identify technologies that can be used to recycle waste for irrigation, compost, and energy.

Keywords: Waste, Fertilization, Energy, Pollution, Kotu stream, WARDI, Gambia

Introduction

The collection and disposal of solid waste is one of the main problems of the urban environment in most countries of the world (Abdel-Shafy et al., 2018; Ferronato et al, 2019), but which are particularly difficult in Africa where most cities lack regular waste collection and disposal services (Scarlat et al., 2015). It is also the biggest challenge for authorities in small and large cities in developing countries. Improved living conditions, employment status, population growth, average family size, and rapid urbanization explain the amount and composition of solid waste generated (Sankoh et al., 2012). A significant increase in per capita waste generation rates is expected from 1.2 kg per person per day to 1.42 kg per person per day until 2025 (Hoornweg et al, 2012). For liquid waste, as disposal costs increase, there is a greater focus on recovering and recycling valuable chemicals from these streams (Kentish et al, 2001).

In the Gambia, the disposal of solid and liquid waste is a major concern for both the government and the people. In the Serekunda area and its surroundings, the Manjai-Kotu landfill site is the only solid waste landfill site. This is an open dump. Some of this waste comes from households, and another from the Serekunda market, which is the main market for vegetables and condiments in the region. The waste is first thrown openly into the streets, before being sent to the landfill. Once at the landfill site, these wastes consisting of plastics, rubbers, wood, metals, paper, condiment residues and vegetables, among others, are incinerated in the open. Open dumping and open burning are the main waste treatment and final disposal systems implemented, mainly visible in low-income countries (Ferronato et al, 2019). However, estimates indicate that in The Gambia, solid waste from urban areas will increase from 211,000 t produced in 2012, of which 84,000 t collected, to 471,000 t produced in 2025, of which 282,000 t will be collected (Scarlat et al. 2015). Liquid waste is mainly from households and industries. These are wastewater and domestic, and food, agricultural, and agri-food waste. This liquid waste is discharged into several open sites and into rivers; there is no treatment plant for this waste. As a result, this waste is not treated or reused.

All this constitutes a danger to the environment, health and make people vulnerable (Gutberlet et al, 2017; Ferronato et al, 2019). They are sources of air pollution (dioxins and heavy vices), soil and groundwater, acute respiratory infections (AIRs) and methane emissions. Groundwater pollution and human health risks from leachate leaks have become a global environmental problem, and the damage and influence of bacteria in leachate has received increased attention. People living on the periphery of landfill sites also face odour, but also smoke inhalation problems. Some studies have shown that the local population in the vicinity of solid waste management facilities has low birth weight, various birth defects and certain types of cancers (Lesley, 2003).

However, many recycling techniques can be used to reduce the amount of solid and liquid waste, reuse and recycle it (Kentish et al, 2001; Riber et al., 2009; Chandak, 2010; Mugodo et al., 2017; Abdel-Shafy et al, 2018). The objective of this study is to identify technologies that can be used to recycle solid and liquid waste for energy production in and around the Serekunda area (Gambia).

This study is part of the research themes of the team of the West African Institute of Research and Development (WARDI). WARDI is a research institute composed of researchers and technicians with different skills in the field of renewable energy, fighting land degradation, measuring forest carbon stock, and seeking to mitigate greenhouse gas (GHG) emissions, focusing on agriculture and climate change, and mapping vegetation cover in West Africa. It is committed to supporting and disseminating renewable energy technologies and research to help governments develop strategies and achieve the United Nations Sustainable Development Goals (SDGs). Since its inception, its members have been committed to conducting research and identifying issues that contribute to environmental degradation in West Africa and influence the achievement of the SDGs.

The data used in this study come from literature, field observations, semi-structured household interviews, and experiences and achievements of WARDI members in the field of renewable energy. After a brief presentation of the renewable energy sector in The Gambia, we will discuss successively the importance of waste recycling for energy production in the Serekunda area, the recycling technology that we propose, the recycling process and possible uses.

Energy in the Gambia

In The Gambia, the Renewable Energy Centre of the Gambia (GREC) has a mandate for renewable energy research, development and promotion of renewable energy and the environment. GREC is under the aegis of the State Department for Trade, Industry, and the Environment (DOSTIE) of the government. GREC serves as technical support to the State Department of Forests, Natural Resources and Environment.

Firewood is the key energy source available at the national level and affordable for households. Electricity generation and supply are limited to coastal urban areas and some rural growth centers. Despite official efforts to increase the viability and attractiveness of natural gas, it remains a relatively expensive and unpopular source of energy. Based on household activities alone, it has been estimated that, on average, firewood consumption per capita in The Gambia is equivalent to about 0.17 cubic meters of wood per year.

Importance of waste recycling for energy production in the Serekunda area

Due to poverty and lack of technology, the open dumping of waste is the option most used by people in the Serekunda area. The indiscriminate dumping of waste and its open incineration have a significant negative impact on environmental quality and public health. They promote the reproduction of disease vectors such as cockroaches, rats, flies, and mosquitoes; this amplifies certain diseases such as malaria and AIRs. To this is added the overflow of the landfill that pollutes the wells surrounding the site and the water table. In addition, during the rainy season, the rainwater filters through the waste deposited on the landfill causing liquid contact with the buried waste which removes hazardous chemicals for the drink. Moreover, the pollution or contamination of water caused by leachates is the most serious form of water pollution due to the discharge of Kotu; because there is no leachate treatment system and thick protective barriers to prevent it from coming into contact with groundwater and surface water. Leachate is a highly odorous black or brown liquid that typically contains heavy metals, such as lead, and volatile organic compounds or VOCs.

Since the site does not have a waste treatment method, it also emits tons of greenhouse gases into the atmosphere. Also, many people depend on the use of Liquefied Petroleum Gas (LPG) for their daily energy needs, but most people living along the landfill cannot afford it.

Therefore, recycling waste for energy production would make it possible to compensate for all these situations. In addition, most modelling studies estimate that electricity (per unit) generated from waste-to-energy (WtE) typically emits fewer health-related air pollutants (also fewer greenhouse gases), burning fossil fuels (e.g., coal) (Cole-Hunter et al., 2020). The benefits of recycling waste for energy production include increased agricultural productivity (Saidmamatov et al., 2021).

What technology is good for waste recycling and energy generation in the Serekunda area

There are many technologies for energy production while reducing the environmental and health risks faced by people living in the vicinity of the Manjai-Kotu open-pit landfill. These include incineration, biochemical conversion (anaerobic digestion), which can provide other benefits such as fertilizer, and collection of Landfill gas (Scarlat et al. 2015). According to the same source, in The Gambia, electricity generation from incineration of collected solid waste was estimated at 42 GWh in 2012 and 141 TWh in GWh in 2025. However, it should be emphasized that the technology to be used must be financially viable, technically feasible, socially, and legally acceptable and environmentally sound (Abdel-Shafy et al, 2018). It will depend on the structures related to the nature, quantity and quality of local waste produced.

Given all of that, the best technology we're advocating is anaerobic digestion for biogas production. This is the use of biogas plants or plants to generate electricity while generating compost for farmers (Figure 1). It is a technology that is growing as a solution to increase energy supply and mitigate climate change (Mugodo et al., 2017).

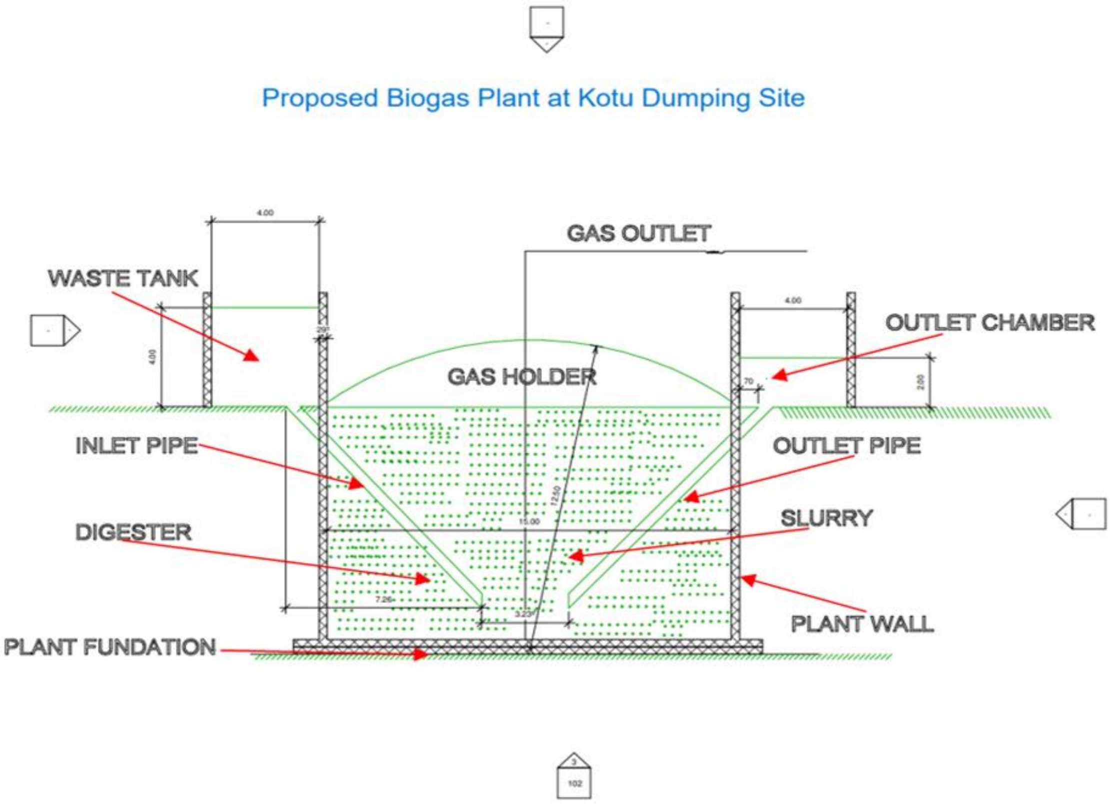

Figure 1. Biogas plant at the Manjai- Kotu dumping site

The biogas generated from the landfill is likely to have energy supply capacity for people living around the landfill and the entire Serekunda area. Thus, the construction of a huge anaerobiotic digester will generate a significant amount of biogas and biomethane that will be used for energy consumption, compost production for agriculture and even for transportation. The use of biogas plants to produce electricity will be another solution that will lead to the exploration and use of deep wells (drilling).

Biogas Waste Recycling Process

Biogas plants rely on anaerobic digestion, a fermentation process in which waste is digested by microbes to produce methane and biogas. Biogas is a combination of 55-77% methane (CH_4), 25-50% carbon dioxide (CO_2), <5% nitrogen (N_2), <1% hydrogen (H_2), <0.5% hydrogen sulphide (H_2S), <0.05% ammonia (NH_3) and <2% oxygen (O_2) (Everson et al, 2016). Both the energy content of the waste and the production of landfill gas depend on the composition of the waste. Thus, the waste collected and discharged on the site will be separated and sorted by the Kanifing Municipal Council service staff and a backup team at the landfill site before being put into the tank or the waste loader. Their physical characteristics will be considered when choosing the method of collection, transport, recoverable material, and energy transformation. The waste will then be mixed and pushed into the digester where the manure fermentation takes place. A reservoir above the mixed slurry acts as a gas refinery and outlet for the biogas produced.

Potential uses of biogas and biomethane energy in the Serekunda area

The energy from the site will be used for four purposes (Figure 2):

- For the operation of a generator supplying a medium-sized network.
- For cooking and heating.
- For the fertilization of land.
- For the operation of vehicles.

Figure 2. Kotu Dumping—Site proposed biogas plant

The biomethane generated from the plant will run a medium-scale generator that will provide electricity as an energy source for lighting. The electricity supply generated for a few people around the landfill is not that reliable and those who cannot afford it are without electricity. Electricity from the biogas plant will be relatively cheap and affordable for everyone.

Biogas can be used directly as natural gas for cooking. Some currently use GPL which is considered expensive and only a few wealthy can afford it. Biogas, on the other hand, is cheap and affordable. The biogas plant product from fermented waste can be removed from the outlet pipe to the outlet chamber and used as fertilizer for farmers who grow along Koto Creek and women's vegetable gardens.

Vehicles can also run on biomethane. There is a huge problem with fluctuating gasoline prices. Many transport vehicles (bush taxis) transporting people around the site to markets and other parts of Serekunda must pay the expensive price to travel a short distance because of the high cost of fuel. Biomethane can be used, which will radically change the cost of transportation while generating more revenue.

Conclusion

The objective of this contribution was to identify technologies that can be used to recycle waste from the Manjai - Kotu landfill for energy production in the Serekunda area. Sustainable management of solid and liquid waste is now an environmental and health concern in the study area. It is part of the research questions of WARDI members. At the end of this study, anaerobic digestion for biogas production appears to us to be the best solution at present for the disposal of solid and liquid waste and for the preservation of the environment. In a country like The Gambia, the use of this technology will be a clean energy innovation. Thus, to meet its main objective, which is research and development, WARDI plans to submit this project to donors to protect the environment, human health but above all to produce clean energy for the populations.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPHELS journal belongs to the authors

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