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INCORPORATING ANAEROBIC DIGESTION TECHNOLOGY INTO DESIGN OF ANIMAL FARMS: A STRATEGY FOR WASTE MANAGEMENT, ALTERNATIVE ENERGY GENERATION AND BIOFERTILIZER PRODUCTION

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Abstract
As the demand for various animal products is increasing, the population of farm animals are also on the increase. This growth is also attended by the corresponding increase in waste generation, which if not properly managed will constitute major environmental crises. While there are conventional methods of disposing these wastes, sustainable production will have to explore technologies that will help recover useful resources such as biogas and biofertilizers from these wastes. The review presented herein explored the potential of incorporating anaerobic digestion technology into the design of animal farms for the purpose of managing the farm waste while recovering clean fuel called biogas and nutrient rich biofertilizer.
Keywords: Animal farm design, Biofertilizer, Biogas, Resource recovery, Waste management

INTRODUCTION

Animal production has seen significant growth in Nigeria and across the globe in recent time. This is not unconnected to the increased rate of consumption of various types of meat. For instance, it was reported that Nigeria recorded an annual chicken consumption of about 1.5 million tonnes, thirty percent of which are locally grown (Kelle and Eboatu, 2018). This is projected to significantly increase in the nearest future (Owamah, *et al*., 2020). According to Olajide and Akpan (2020), the common farm animals are Poultry birds such as Chicken, Turkey, Quail, Duck, Cattle, Small ruminants such as Goats, Sheep, Pigs, Rabbits, Donkeys, Camels and Horses. They stated that the distribution of these animals is region dependent. For instance, Donkeys, Camels, and Horses are mostly reared in parts of the north.

While the increase in animal production has significantly improved the meat available for human consumption, it is not without the attendant environmental pollution especially from the faeces and urine produced by the animals. Out of the estimated 998 million tonnes of agricultural waste produced annually, organic wastes constitute up to 80 percent of the total solid wastes generated of which animal manure production can amount up to 5.27kg/day/1000 kg live weight, on a wet weight basis (Agamuthu,

2009; Iorhemen *et al.*, 2016). According to the annual report of the Federal Ministry of Agriculture and Rural Development (Ojong and Anam, 2018), Nigeria produced 180 million poultry birds, 76 million goats, 43.4 million sheep, 18.4 million cattle, 7.5 million pigs, 1.4 million Equids (horses, donkeys, etc.). This statistic gives an idea of the quantity of waste that are generated annually. If there is no adequate system to manage this ever-increasing volume of animal waste, we will soon have an avoidable environmental crisis on our hands.

One of such technology receiving serious global attention now is anaerobic digestion (AD) of biodegradable waste. This system has been independently explored for the treatment of animal wastes (Alfa *et al.*, 2014a; Alfa *et al*., 2021; Owamah *et al.*, 2020; Samoraj, *et al.*, 2022). The objective of this review therefore is to

establish the strategic importance of incorporating AD technology into the design of animal farms to serve as a system of managing the farm waste, generating renewable and sustainable energy for the farm and production of biofertilizer for crop production.

Anaerobic Digestion of Animal Wastes and the Sustainable Development Goals

Anaerobic digestion (AD) is the controlled degradation of organic waste in the absence of oxygen and in the presence of anaerobic microorganisms which produces biogas (primarily composed of methane, carbon dioxide) and compost products suitable as soil amendments on farmlands (Ojolo *et al.*, 2007; Alfa *et al*., 2013). Biogas is a sustainable energy carrier which is mainly composed of methane (60%) and carbon dioxide (35–40%) (Abdeshahian *et al*., 2016). Among the raw substances, organic matters obtained from farm animal waste are pivotal sources for biogas production. There is therefore a consensus of opinions amongst various authors that AD has a suitable method for treatment of organic wastes which includes those from Farm animals (Abdeshahian *et al.*, 2016; Obi *et al*., 2016; Owamah *et al*., 2020; Alfa *et al*., 2021).

The need for adequate sanitation and energy especially in Nigeria where only 39.17% of the population has access to improved sanitation facilities, and only 71.38% have access to safe and clean water supply in Nigeria as at 2017 (Sachs *et al*., 2021) has made AD technology a welcomed development. This notwithstanding, the integration of this viable which will facilitate the achievement of the Sustainable Development Goals (SDGs) of the United Nations has not been fully explored in Nigeria. The incorporation of AD technology into the design of animal farms will facilitate the attainment of the following SDG 1 (No poverty), SDG 2 (zero hunger), SDG 3 (Good health and wellbeing), SDG 6 (Clean water and sanitation), SDG 7 (affordable and clean energy) and SDG 12 (Responsible consumption and production). This is because, the process will produce eco-friendly energy called biogas, utilizing the slurry (the digested waste) that is produced from the AD systems to fertilize, a community's crops and improve the composition of its soil, safer and cleaner environment which are instrumental to improved health amongst other benefits (Alfa *et al*., 2013, Sachs *et al.*, 2021). This will also address in part, the SDG 13 (Climate action) via the production of sustainable and renewable energy from the waste. A pictorial representation of the potential benefits of incorporating AD technology for management of wastes from animal farms is shown in Fig. 1:

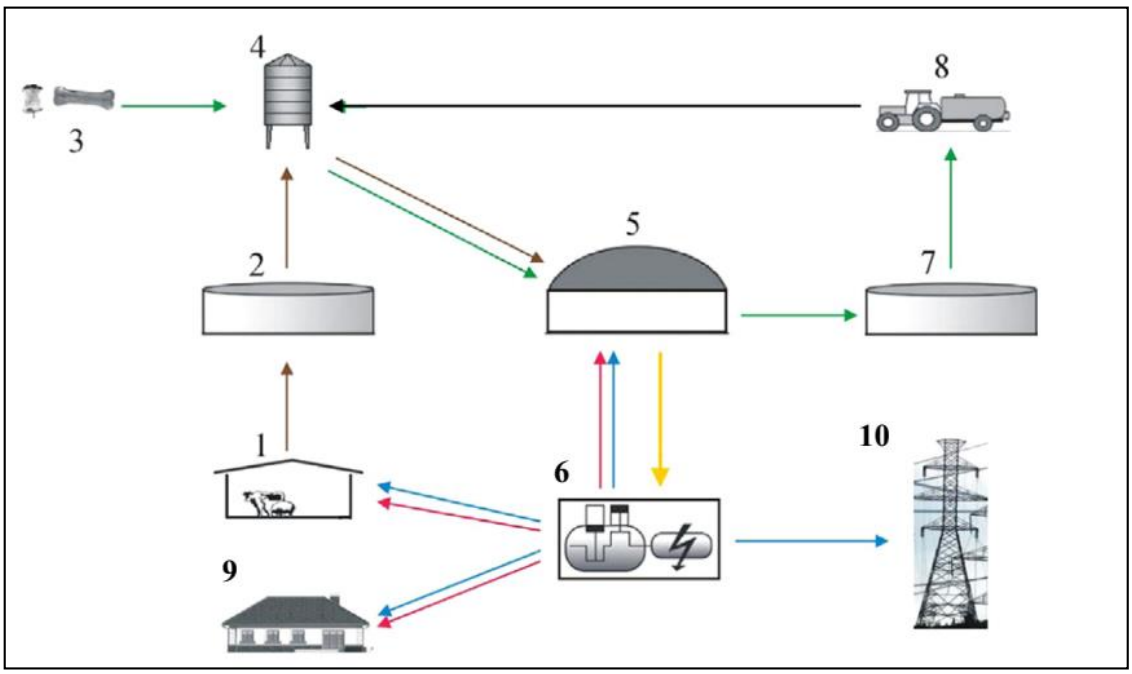


Fig. 1. Pictorial representation of a biogas plant utilizing wastes from an animal farm (Igliński *et al*., (2015); Abdeshahian*et al*., 2016).

(1) Animals (2) Preliminary tank (3) Slaughterhouse
(4) Mixing tank (5) Anaerobic Digester (6) Power and Heat co-generation
(7) Post-treatment tank (8) Collection of fertilizer (9) Offices
(10) Energy distribution grid

Application of Anaerobic Digestion Technology in Nigeria and Energy Production Potential

Various researchers have investigated the production of biogas and biofertilizer from the Anaerobic Digestion of a various animal manures. Some of the manures widely investigated especially in Nigeria are chicken droppings, cow dung, horse dung, pig manure amongst others (Ojolo *et al*., 2007; Alfa *et al*. 2013; Owamah *et al*., 2014; Alfa *et al*., 2014a; Alfa *et al*., 2014b; Alfa *et al*., 2016; Alfa *et al*., 2021; Owamah *et al*., 2020). These and other similar investigations carried out within and outside Nigeria have demonstrated that the inclusion of this waste management component into animal farms will not only ensure cleanness but will be a means of recovering energy and other resources from the waste materials. An estimate of potential biogas resources recoverable from the manures of selected farm animals is presented in Table 1. The information presented in Table 1 were based on aggregated findings from various research works carried out previously (Avcioğlu *et al*., 2012; Afazeli *et al.*, 2014; Alfa *et al*., 2014b; Alfa *et al*., 2016; Abdeshahian*et al*., 2016; Alfa *et al*., 2021; Owamah *et al*., 2020).

Table 1: Biogas production potentials of selected farm animal manures

S/N	Category	Animal	Average Body Weight (kg)	Manure (kg/day)	Total Solid (%)	Daily Biogas Production (m^3/kgVs/day)	Estimated Annual Production(m^3)
1	non-ruminant herbivore	Horse	454	25	25 – 30	0.18	8,202.65
2	Large Ruminant	Cattle	250	22.5	25 – 30	0.33	8,280.94
3	Small Ruminant	Sheep	40	1.6	18 – 25	0.35	1,098.65
4	Poultry	Chicken	1.5	0.045	10 – 29	0.019	2.03

Table 1 shows that there a huge resource locked within the supposed wastes from the animals. The application of appropriate technology such as AD therefore will help to recover these resources which can immensely contribute to the sustainability of the farm.

Conclusion

From the foregoing, it has been established that there is a need for inclusion of a sustainable system of managing animal wastes in such a way that energy and other resources can be recovered from them and one viable technology for doing this is Anaerobic digestion of the organic component. This will produce a clean fuel called biogas and nutrient rich organic biofertilizer. This will arguably contribute immensely towards sustainable animal production in Nigeria especially in this season of energy crisis.

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