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SUSTAINABLE VALORIZATION OF PIGGERY WASTES FOR RESOURCE EFFICIENCY AND GREENER ENVIRONMENT

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ABSTRACT

Valorization of piggery wastes samples from a commercial farm site and two institutional Research farms was done using five standard methods: biomethanation; feed recovery from the wastes by washing, sieving and sterilizing with steam; briquetting of the raw manure into solid fuels; activating the manure to adsorbent; and processing digester liquor and slurry into organic fertilizer. The study recovered 390± 45 kg dry matter feed/mT of the wastes with 9.32% Protein and other nutrients; recorded good yield of biogas and briquettes that burnt with energy of 65.43 MJ/g; activated carbon (AC) with good adsorbent property; stabilized sludge and liquor with high content of plant micro- and macro-nutrients useful as organic fertilizer all showed hope for sustainable management of piggery wastes.

INTRODUCTION

To those who eat pork, pig production represents the substantial percentages of the global meat products given as 37% in 2007 (FAOSTAT, 2009) and projected to be 31% in 2020 (Rosegrant *et al*, 2001). During pig production, pig manure was determined as the most significant negative impacts on the environment in terms of global warming, eutrophication and acidification (Jongbloed *et al*., 1999; Dalgaard, 2007; Gac *et al*., 2007). Biogas potentials from anaerobically digested pig manure have been studied extensively (Maraseni & Maroulis, 2008).

Folayanka *et al* (2012) and Ogunniyi *et al* (2012) studied biomethanation of piggery wastes into biogas and stabilized organic fertilizer and optimized the minimum digestion period that would destroy the pathogenic or hazardous microorganisms require a minimum of 75 days. Where large volume of such waste is produced daily, even though biogas production may be attractive the size of digester capacity required to handle such wastes will leave substantial volume of the biomass untreated. Other means of treatment such as briquetting into solid fuels will then be imperative.

Manure is a by-product containing many plant nutrients and organic matter. The slurry from its digestion and its mixture with other organic biomass has been known to provide useful organic fertilizer to farmers (Adewumi, 1995; Adewumi *et al*, 2005). Besides providing valuable macro- and micronutrients to the soil, manure supplies organic matter to improve the soil's physical and chemical properties.

The challenge of this study was the large volume of piggery wastes at Oke Aro Piggery Estate in Lagos State, Nigeria reputed to be the largest piggery farm estate in Africa with over 3,500 farms crowded on a 47 ha land space with average of 175 pigs per farm producing more than 890 mT of manure daily. Lack of waste management in the Estate resulted in the outbreak of swine fever recently. The paper reports the efforts taken at valorization of the manure in piggery farms in particular with a view to sustainable management of the daily volume of manure.

MATERIALS AND METHODS

Laboratory Modeling

Feed recovery: This was modeled by dissolving and washing known mass of the manure in water to recover the insoluble solids that is then sterilized and dried. The Proximate analyses of the recovered feeds were determined according to standard methods (Pearson, 1976; AOAC, 1990; Onwuka, 2005). The raw manure and dried recovered feed samples were cultured to confirm sterility and safety of reuse of the recovered feed. This was replicated several times.

Biogas production and organic fertilizer: The washed out liquor from feed recovery mixed with some of the raw manure was channeled into a biogas digester unit for biogas production for 30-40 days. Flame test was used as qualitative analysis of the biogas produced. The liquor from the biogas tank and the slurry were then processed into dry form and tested as *organic fertilizer* for its quality and content of macro- and micro-nutrients useful for plant growth.

Briquettes as solid fuel: The compression of known mass of the manure into *briquettes* and oven drying at 102^{O}C for 24 h was also modeled as a major method of recycling and valorization of the piggery wastes as cheap alternative to wood biomass. The produced briquettes then had their calorific values determined using standard methods.

Activated carbon: Some of the briquettes were also carbonized at 400^{o}C and activated at about 600^{o}C in an alkaline medium to produce *active carbon* as an adsorbent for water and wastewater treatment. The adsorbent's quality was tested using the single methylene blue value method to evaluate both the interstitial surface area and activity (Adewumi, 2009).

RESULTS AND DISCUSSION

Feed Recovery Management Modeling

The laboratory study showed 560 kg ±0.04 kg Recovered Feed (RF) of wet sludge/mT of raw manure was recoverable which after sterilization and drying gave valorization of 400 ± 50 kg RF/mT manure. The sterilized recycled feed had no microbial count after sterilization with steam. The Proximate analysis result in Table 1 showed an average protein content of 8.64±

3.7 % while the mean non fat extract and crude extract was respectively 50.3± 9.6% and 10% except in three outliers. This will save the farmers a lot of fund and serve as a cheap source of feed if commercialized. Adding dried single cell algae that will be produced from the effluent of biogas digester and washings for feed recovery as protein source will enhance feed quality.

Table 1: Proximate analysis Results of Recovered Feed from piggery manure wastes

Samples	1	2	3	4	5	6	7	8	9	10	Mean, %
Content in %	Percentage of content in whole sample										
Ash	8.6	8.8	9.2	8.5	11.5	10.3	7.8	8.9	8.4	8.6	9.06± 0.6
Crude fiber	5.7	32.2	13.4	23.6	16.5	16.2	15.3	9.2	6.7	8.2	14.7± 9.0
Ether Extract	7.6	1.5	4.4	5.6	3.5	2.3	5.3	1.5	7.6	8.5	4.8± 3.04
Moisture	16.3	8.9	10.5	8.8	8.6	14.5	9.9	15.6	8.9	8.9	11.1± 2.5
Protein	14.1	6.6	12.3	10.5	12.8	7.7	7.9	6.8	6.8	7.7	8.64± 3.7
Non-Fat Extract	47.7	42.0	50.2	43.0	47.1	49.0	46.2	58	61.6	58.1	50.3± 9.6
Total (%)	100	100	100	100	100	100	100	100	100	100	100

The sludge's high moisture content (11.09±2.5 %) will be useful to engineers in designing the dryer unit for the extruded briquettes (Fig 1).

Fig 1: Extruded briquettes being air dried (Left picture) and activated in a furnace (central picture) for production of activate carbon (right picture).

Briquettes and activated carbon production from piggery wastes

The briquettes in Fig 1 and others produced in the laboratory had good fuel energy of 65.43 MJ/g that can serve as cheap source of fuel wood for the majority of households that depend on firewood presently. The low moisture of the dried briquettes makes transportation and storage easier. The experimental comparison of it with wood fuel showed it boils water faster and with less smoke than the conventional dry wood fuel. Production of this will not only create jobs but will also reduce deforestation and Green House Gas (GHG) effect on the environment. The activated carbon (AC) adsorbent produced had a carbon rating of 32 with surface area >980m^2/g. There is no known industry where AC is produced in Nigeria despite the very high demand for this engineering material by almost all industries (Adewumi, 2006; 2009).

Biogas and organic fertilizer production

The qualitative analysis of the biogas yield showed a gas that burns with blue flames and confirmed earlier studies (Adewumi, 1995; Folayanka *et al*, 2012). The biogas is planned to be used as a source of electricity generation. Liquor from the washing of the pig wastes for recovery of feed with some of the remaining wastes were digested into biogas and the effluent liquor and the slurry at the bottom of the digester can be used as liquid organic fertilizer or dried and used as granular organic fertilizer. These two can be packaged and sold to farmers as soil conditioner.

CONCLUSIONS

The results above showed that piggery wastes could be effectively managed by valorization into five useful products studied in this work. The outcome of the results is being used to develop processing plants for the production of these five valuable products for sustainable management of piggery wastes. The most promising of the five methods is briquetting which can process more than 80 % of the waste into solid biofuels. This work is useful to engineers who work in the area of environmental engineering

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