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PIGGERY WASTE MANAGEMENT: A CASE FOR ENVIRONMENTAL SUSTAINABILITY IN ENUGU STATE, NIGERIA

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Abstract
The study analyzed piggery waste management in Enugu state. Ninety respondents were selected through multistage sampling procedure. Frequency, mean and likert scale and logit regression were used for the analysis. Pig slurry and urinary excreta were the major wastes generated by the pig farmers and majority managed their piggery waste by open dumping/fly tipping, burning, stream/ riverbank dumping, utilization as fish feed, drying and selling as organic fertilizer, raw pig waste recycling into crop production, ESWAMA disposal and burying. Pig farmers generally had low awareness, poor attitude and wrong behavioural intentions considering use of improved piggery waste management options in the study area. Gender and education positively and significantly increases the use of eco-friendly waste management practices. The result of the likert scale rating shows that the key constraints to the use of eco-friendly piggery waste management were: time limit, absence of subsidy, poor waste chemical and trustworthy treatment facilities, lack of access to improved waste technologies, poor technical know-how for effective management techniques, insufficient land space to keep waste prior management, poor storage facility, availability of technology, lack of training programs, inadequate finance, inadequate profit, high labour cost, lack of access to loan, high cost of waste management technology.

Key Words: *Piggery, Waste management, Climate change, Enugu state*

Introduction

Pig manure, which includes faeces and urine contains: Water (about 90% by weight) and Organic matter (made up of complex carbohydrates) (Birchall *et al*., 2008). The three main types of pig manure are slurry, liquid manure and solid manure. Slurry is a mixture of urine, faeces and water; solid manure is faeces and litter scraped off the floor, and liquid manure is a combination of urine, faeces remaining after scraping and cleaning water (Vu *et al.*, 2007). Among the compounds making up liquid manure, there are compounds that mainly form the solid fraction e.g. organic compounds or phosphorus compounds, as well as constituents of the liquid fraction, such as nitrogen compounds and minerals in the form of oxides of sodium, potassium and magnesium (Lens and Hamelers, 2004). The content of these substances depends on the pig management and feeding procedures (Bertora *et al*., 2008).

Piggery effluent, manure and compost can be valuable sources of nutrients and

organic matter for improving soil properties and crop or pasture production. Good management is needed to gain the most advantage from these products while protecting the environment and preventing impacts to neighbours. Effective waste management can only be possible through a conscious desire by pig farmers to achieve and demonstrate sound environmental performance in controlling the different aspects and significant impacts of their activities and products and services on the environment (Lawal, 2003). Treatment technologies can play an important role in the management of livestock manure by providing a more flexible approach to land application and acreage limitations and solving specific problems such as odours, pathogens, water pollution, ammonia emissions, greenhouse gas emissions, phosphorus and heavy metal contamination of soils (Szogi and Vanotti, 2009).

There is rapid increase in the production of pigs, which has equally resulted into lots of wastes generation that is poorly managed. Presently, the possible impact of improper manure disposal on the environment represents one of the major challenges in the world agriculture (United States Department of Agriculture (USDA), Agricultural Research Service (ARS), 2012). In Enugu State, the problem of handling pig dung is recognized as a major issue in sustaining the growth of the pig industry (Okoli *et al*., 2006). Apart from foul odour, the hydrogen sulphide, ammonia and other gases emitted by stored pig manure diminish air quality (Spence *et al*., 2008). The bad odour can also lead to tension between pig producers and their neighbours, which can evoke legal action and risk possible shut down of production (Oseghale, 2010).

Manure generates heat as it decomposes, and can in fact ignite spontaneously should it be stored in a massive pile (Dermirbas, 2011). Once such a large pile of manure starts burning, it fouls the air over a very large area and requires considerable effort to extinguish, thus polluting the air with attendant greenhouse gas effect, thus leading to global warming and its attendant climate change. This calls for effective measures to contend systematically, the accretion of pig dung from large feedlots (Iregbu *et al*., 2014).

Equally, excessive build-up of animal manure due to haphazard dumping over a large area of land as organic manure tends to pollute the land, and result to eutrophication owing to excess accumulation of nitrogen and phosphorus, which will rather be toxic to plants (Iregbu *et al*., 2014). Furthermore, such spread of manure will contaminate surface water through run-off, and pollute ground water tables through seepage or infiltration, thus messing up the water in wells and boreholes that are meant for human consumption (Okoli *et al*., 2005; Appropriate Infrastructure Development Group (AIDG), 2008). Eco-friendly piggery waste management methods such as appropriate timing on land, utilization of waste as livestock or fish feed, biogas production, composting, prolysis and gasification have not gained prominence in Nigeria probably due to low technical capacity, high cost of waste management technology, and availability of technology.

However, from preliminary investigation, there are little or no information that studied piggery waste management systems in Enugu State. Ezeibe (2009) studied Profitability analysis of pig production under intensive

management system in Nsukka local government area of Enugu state, Nigeria**;** Ogbu (1998) performed a Feasibility study on the prospects of establishing a pig farm In Enugu-Ezike, Enugu state; Onyimonyi *et al*. (2013) investigated Pig farmers knowledge of the prevalence of mycotoxin in feedstuffs: A Case Study of Pig Farms in Nsukka Agricultural Zone of Enugu State – Nigeria are related studies in the area.

This study evaluated piggery waste management in Enugu State. Specifically, the study: identified and examined different pig waste management practices in the area; determined factors influencing use of eco-friendly pig waste management; and ascertained constraints facing piggery farmers in use of eco-friendly piggery waste management.

Methodology

Study Area

The study area was Enugu State, Nigeria with latitudes 5° 56′ N and 7° 05′ N of equator and longitudes 6° 53′ E and 7° 55′ E of Greenwich meridian (Enugu State Agricultural Development Project (ENADEP, 2009). The state is an interesting area for this study because of its location and considerable socioeconomic heterogeneity.

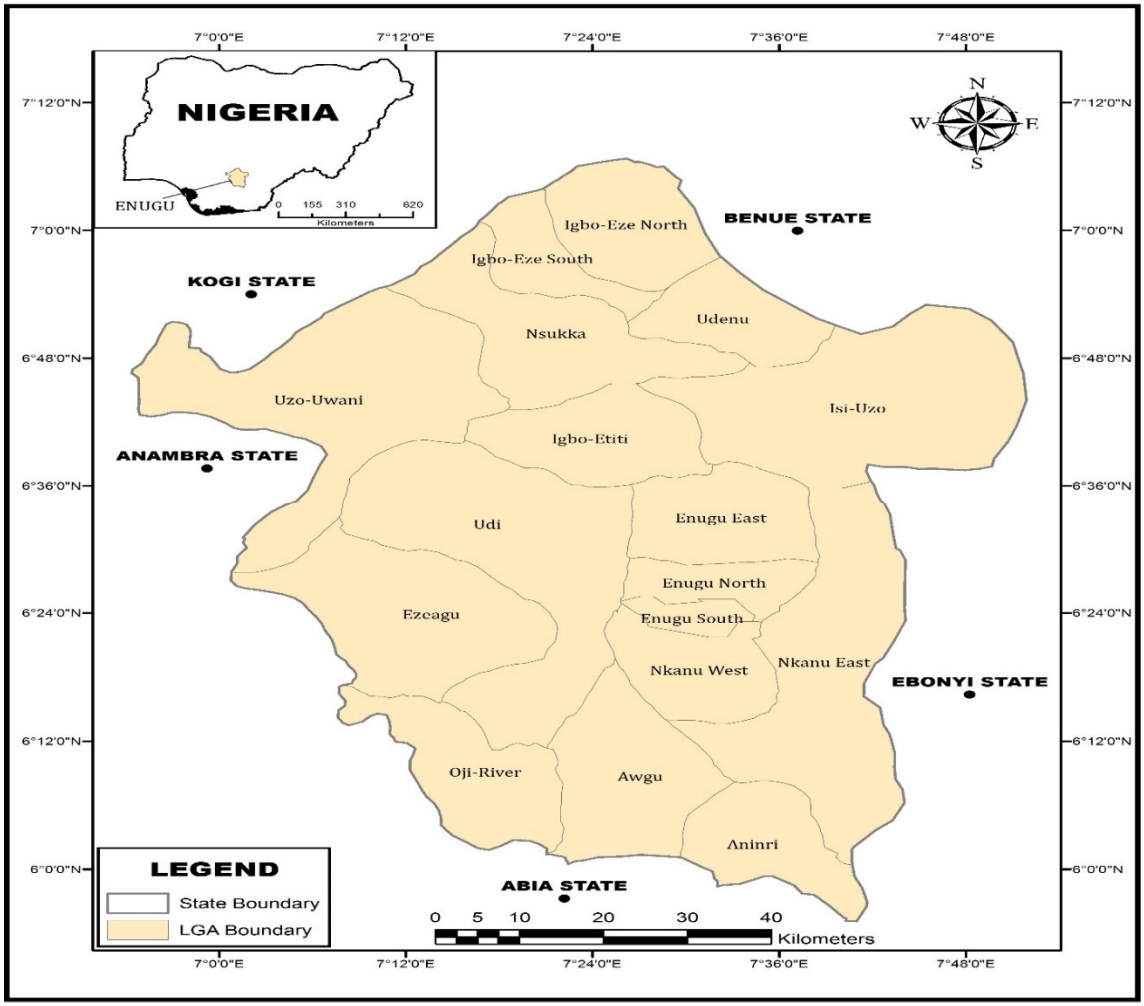

Fig. 1: Map of Enugu State, Nigeria showing the Local Government Areas of Enugu State

Multi-stage sampling procedure was used to select the respondents from a list of 246,542 registered farming households in Enugu State (GESS, 2013). The major animal production activities in the area are poultry and pig although other livestock like Goat, Sheep and Cattle are reared (Nwanta *et al*., 2011). One hundred and eighty (180) piggery farmers were selected for the study. Data for the study were collected by using a set of structured, pre-tested and validated questionnaire. Frequency, mean, Likert scale and Logit model were used in analysing the data. A four-point Likert type scale was used to identify constraints impeding the use of eco-friendly waste management practices, and is specified as follow; the option "Strongly Agree" was given the highest value of 4 and "Strongly disagree" was given a value of 1. The following scaling procedure was adopted: strongly agree (SA), agree (A), disagree (D), strongly disagree (SD).

Based on this, scores below 2.5 (MS<2.5) was taken as a weak factor and was not considered (rejected) while those with mean score of above 2.5 (MS>2.5) were taken as strong factors and considered (accepted).

Binary logit regression model was used to examine the factors influencing use of eco-friendly waste management among the farmers. The logit regression model is appropriate in analyzing the relationships involving binary dependent variable and a set of independent variables. The model is expressed as follows:

$$L_n Y_n(P_i/ 1-P_i) = \beta_0+\beta_1 X_1 +\beta_2 X_2 +\text{---------} +\beta_n X_n+ \mu \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.1)$$

Where:

Where Yi =A binary variable which is identified as 1 if farmer practices eco-friendly piggery wastes management (appropriate timing on land, utilization of waste as livestock or fish feed, biogas production, composting, prolysis and gasification) and 0; if otherwise.

Pi= the probability that piggery farm uses eco-friendly piggery wastes management

Ln.= Natural logarithm function.

β_0= A constant

β_1- β_n= Logistic regression coefficient

X_1- X_n = Explanatory variables expressed as follows;

X_1= Age of pig farmer (years)

X_2=Gender of farmer (1=male; 0=female)

X_3=Marital status of farmer (1=married; 0=otherwise)

X_4=Household size (number)

X_5=Primary occupation (1=Farming; 0=otherwise)

$X_{6=}$ Distance of piggery farm to dumping site (1=near; 0=far)

X_7= Number of pigs (number)

$X_{8=}$ Farm manager's year of experience (years)

$X_{9=}$ Number of employees (number)

X_{10}= Pig management system adopted by the farmer (1=intensive; 0= otherwise)

X_{11}= Years spent in school (Years)

X_{12}=Member of a co-operative society (1: Yes; 0 =No)

X_{13}= Access to credit (1=Yes; 0=No)

μ = error term

Results and Discussion

Pig Waste Management Practices

The distribution of pig farmers according to their management methods of piggery waste is as shown in Table 1.

Table 1: Piggery waste management techniques employed by pig farmers

Pig waste management practices	Percentage (%)
Open dumping/fly tipping/bush dumping	14.4
Stream /riverbank dumping	5.6
Burying	2.2
Utilization of waste as fish feed	5.6
Drying and selling as organic fertilizer	23.4
Composting	1.1
Burning/ incineration	3.3
ESWAMA disposal	2.2
Raw pig waste recycling into crop production	42.2
Total	100.0

The pig waste management strategy of raw pig waste recycling into crop production process (42.2%) is the most practiced waste disposal strategy in the study area. This could become an environmental issue when the manure is applied to the land in excess of the receiving crop's threshold level and the ability to utilize the nutrients (Gregory *et al.*, 2008). Few proportion (2.2%) of pig farmers in the study area reported waste collection by ESWAMA.

Drying and selling as organic fertilizer (23.4%) is the second most practiced waste management strategy adapted by pig farmers in the study area. Drying the manure exposes it to the atmosphere thereby polluting the environment and releasing GHGs that causes climate change.

Managing pig waste through open dumping/indiscriminate dumping/ bush dumping (14.4%) is ranked as the third most employed management strategy/technique. All these constituted a significant proportion of pig waste pollution in the study area. This further confirmed earlier claims (O'Neill and Philips, 1992) that odours emanating from huge quantities of pig wastes that are continually being generated by the piggery farms often heighten the level of risk to human existence in the localities. This might have been mitigated if officials of the state's Ministry of Health and Environment ensured adequate monitoring and assessment of the activities of these pig farms towards ascertaining a minimal but safe compliance level.

Stream /riverbank dumping (5.6%) as practiced in the study area may be through flushing of pig wastes in form of slurry into nearby pits, streams and rivers that

causes damaging effects to both the human and aquatic lives and even water qualities in the downstream. Flushing may also cause a reduction in the quantity of dissolved oxygen and high water turbidity. This often threatens the natural habitats of many organisms in the nearby water masses. Biological effects include the release of untreated pathogenic microorganisms (faecal coliform) into the environment (Kelly, 1995). Also, few of the pig farmers in the study area utilized their pig waste as fish feed (5.6%). Biochar sequestration, vermicomposting, and anaerobic digestion were not practiced by any of the farmers in the study area.

Few (3.3%) of the pig farmers managed pig waste by burning/incineration or combustion however, Anon (2005) noted that burning of pig wastes could cause atmospheric pollution, which might pose some danger to human and livestock animals' lives. Burning is not an acceptable disposal method as it results to air pollution and negative climate change effect (Akinbile, 2012). Pyrolysis and gasification represent refined thermal treatment methods as alternatives to incineration.

Few of the respondents (2.2%) also managed pig farm waste by burying. This may, however, lead to groundwater contamination (Carr, 1994) and thus constitutes a source of risk to human life. This serves as warning signals to the owners of close by residential houses in their efforts at properly locating their wells and boreholes. With respect to composting of pig waste, only one (1.1%) of the pig farmers in the study area reported composting pig manure. Compost application to soil allows the recycling of nutrients in the soil–plant system (Bernal *et al*., 2009a; Flotats *et al.*, 2011), increasing biomass production and soil fertility by improving the physicochemical and biological properties of the soil (Keener *et al.*, 2000; Loecke *et al.*, 2004; Cordovil *et al*., 2007; Bedada *et al.*, 2014) as well as nutrient availability. Simultaneously, composting provides an efficient and cost-effective way of recycling these materials (Arcadis, EUNOMIA Research and Consulting, 2010; Burgos *et al.*, 2006).

Factors Influencing the Use of Eco-friendly Waste Management Practices

The results of the binary logit regression model used in assessing the factors that influence the use of eco-friendly waste management practice are as shown in Table 2.

Table 2: Factors influencing the use of eco-friendly waste management practices

Variables	Coefficients	Std. Error	z-values
Gender	1.893467	.981927	1.93**
Age	1.699585	1.812536	0.94
Marital status	.5884742	.7732254	0.76
Household size	.0351742	.2153047	0.16
Primary occupation	-1.1611492	.5839043	-1.99**
Farm experience	.0108096	.1361598	0.08
Number of pigs	.0199229	.0197273	1.01
Distance to dump site	-1.7062327	.7281502	-2.34*
Management system	.7970862	1.692549	0.47
Years spent in school	1.04847	.5369866	1.95**
Number of employees	.3731622	.4497273	0.83
Member of cooperative	.6495391	1.168928	0.56
Access to credit	.0036317	.856488	0.00
_cons	-10.57557	6.576842	-1.61

Pseudo R^2= 0.6344
LR chi^2 (13) =72.81
Prob> chi = 0.0000
No. Observation=180
** denotes significance at 5% level

The R^2 value of 0.6344 means that, the independent variables were able to explain the total variation in the dependent variables by only 63.44%.

The results show that gender positively and significantly ($p < 0.05$) increase the likelihood of a piggery farmer been involved in eco-friendly waste management practices. This is in accordance with a*priori* expectations as this might be that males have better access to information and resources on improved technologies and techniques than the females. Studies have shown that, compared to men, women are less likely to adopt and use new technologies, have less confidence in their ability to use new technologies (Michie and Nelson, 2006; Reinen and Plomp, 1993; Shuttleworth, 1992).

The results also show that Years spent in school positively and significantly ($p < 0.05$) increase the likelihood of a piggery farmer been involved in eco-friendly waste management practices. However, this is not far-fetched as educated farmers who have adequate information at their disposal and may better process and utilize the information thereby increasing their adoption, technical efficiency and use of improved technologies (Panin and Brummer, 2000). Salequzzaman *et al.* (2001) argued that education is critical for promoting sustainable development and improving the capacity of people to address environment and development issues. The education program builds on the knowledge, values, skills, experiences and determination of human capacity needed to work on solving waste management issues at an individual and community level.

Distance to dumpsite had negative and significant ($p < 0.01$) effect on the use of eco-friendly waste management techniques. Thus, the farther the distance to dump site the less likelihood of practicing sustainable waste management

techniques. The possible reason could be that the farmers with a farther dumpsite are less disturbed by neighbours, local government council, environmental regulations, and standards as most of them chose a far bush as dumpsite. The far dumpsite still pollutes the air and releases GHGs thus causing climate change.

Primary occupation also had negative and significant ($p < 0.05$) effect on the use of eco-friendly waste management techniques. Therefore, being primarily a farmer has less likelihood of participating in eco-friendly waste management. The possible reason could be that, normally, farmers with other sources of income are more willing financially to participate in sustainable waste management. Another possible reason could be that the farmers will be more interested in drying the piggery waste for consequent use as organic fertilizer during crop production and thereby decline participation in eco-friendly waste management practices.

Constraints to Eco-friendly Management of Pig Waste

The results on constraints to the use of sustainable piggery waste management by the respondents were as shown in Table 3.

Table 3: Constraints of eco-friendly management of pig waste among farmers

Constraint factors	Mean	Standard deviation
Preference	2.1778	.64613
Poor technical know-how	3.8333*	.40364
Availability of technology	3.4000*	.63246
High cost of waste mgt. technology	3.6333*	.48459
Limited information on eco-friendly methods	3.8000*	.40224
Land tenure	2.4556	.95000

The results in Table 3 show that poor technical know-how (mean=3.8333) is a major constraint to eco-friendly pig waste management. Eco-friendly waste management institutions, companies and NGOs should organize campaigns and workshops to train piggery farmers on sustainable waste management methods.

Limited awareness about opportunities for eco-friendly waste methods (mean=3.8000) is also a major constraint in effective pig waste management. Arthur *et al*. (2011) acknowledged that lack of knowledge about the technology in Ghana greatly led to low uptake. Sensitization of locals on economic, social and environmental benefits of eco-friendly waste management is required from the government and private NGOs through awareness creation campaigns and seminars to enable them understand why eco-friendly piggery waste management should be a choice for everyone.

High cost of waste management technology (3.6333) as shown in Table 3 is a constraint to eco-friendly waste management. Income is another prime factor influencing adoption since it is only with sufficient cash that an individual will be at position to meet technology costs (*Mwirigi et al*., 2009). Eco-friendly waste management disseminating institutions and NGOs should review implementation strategies to produce low cost plants that are affordable to all. Government should also make available compost bins, subsidy schemes and low interest loans for eco-friendly waste management procedures.

The results also show that Availability of technology (3.4000) is a constraint to eco-friendly waste management methods. The government through Agricultural Development Projects (ADPs), Agricultural Development Institutions (ADIs), and NGOs should provide and made available sustainable waste management technologies such as Mini-anaerobic digesters, biochar sequestrate and vermicompost by granting subsidies and credit facilities to both the technology companies and farmers.

Conclusion

Pig slurry and urinary excreta were mostly generated by pig farmers and the majority of these pig farmers in view managed their piggery waste by open dumping/fly tipping, burning, stream/ riverbank dumping, utilization as fish feed, drying and selling as organic fertilizer, raw pig waste recycling into crop production, ESWAMA disposal and burying.

The factors influencing use of eco-friendly waste management practices as gender, years spent in school, primary occupation and distance to dumpsite. The key constraints to the use of eco-friendly management of piggery waste were: Poor technical know-how for effective management techniques, Availability of technology, High cost of waste management technology and Limited information about opportunities in eco-friendly piggery waste.

Recommendations

In Enugu state, there is a grave environmental risk associated with improper waste disposal. The government may consider integrating a farmer based friendly programme designed specifically to promote better piggery waste management for sustainable environmental condition by encouraging practice of waste reuse and recycling. However, such efforts need to be supported by the municipal authority and ESWAMA through campaigns on waste collection, sale of recyclables and reuse.

The government through ADPs and ADIs should offer a reliable and convenient recyclable waste collection service in order to encourage pig farmers to engage in waste separation practices. Considering the fact that 90% of the pig farm waste is recyclable waste, offering this service is justified. It is also essential to provide a convenient collection service free of charge in order to encourage more pig farmers to participate in the programme. Providing incentives such as discounted or free storage and compost bins will help to make waste separation practices attractive.

Waste management authorities and NGOs should offer trainings, workshops and awareness campaigns in order to improve environmental knowledge and encourage environmental enthusiasm amongst people. Farmers if well trained can ensure consistent maintenance and repair of the waste management facilities

Mini- anaerobic digesters, biochar sequestrate and vermicompost should be promoted and subsidized by the government and waste management NGOs. Successful deployment of these technologies to pig producers will result in increased disease free organic fertilizer and work friendly environment, reduced risk of environmental contamination, enhanced producer profit margins and increased urban property value.

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