

WASTE TO WEALTH - CONVERSION OF POULTRY LITTER FROM RAW FORM TO PELLETTED ORGANIC FERTILIZER.

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ABSTRACT

A review of the use of pelletized poultry litter for creation of wealth through use as organic fertilizer was done, using information from literature and data from field observation. Poultry wastes, which are a menace to the environment, are sources of wealth creation, especially for organic farming. There is an abundance of poultry wastes in Nigeria, as about 932.5 metric tonnes of poultry manure is produced annually from the well-established poultry houses which keep expanding at the rate of 8% per year. Also, global trend is shifting to organic fertilizer as the use of chemical fertilizer over the years has destroyed our soil. Organic fertilizer has much organic content, which can rejuvenate the already destroyed soil. Not only that, organic fertilizer is safe for human health. Pelletized poultry litter would compete successfully as a soil conditioner or soil amendment. It would also be priced competitively, as it provides a unique mixture of nutrients and conditioning properties. Consequently, there is more poultry farming profitability, efficient resources utilization and conservation of environment due to waste management.

Keywords: poultry, litter, pelletized, organic, fertilizer

INTRODUCTION

The poultry industry is recognized to be one of the main contributor to Nigeria's economy through food security, employment creation, and nutritional improvement. There is high demand for poultry products in form of meat and eggs, due to relatively low cholesterol content, which makes poultry business to be lucrative and high source of income (Ogundiran *et al.*, 2015). Despite these contributions, the poultry industry is facing a number of problems that require immediate solutions. There has been an increased concern for the disposal, utilization and management of poultry waste (especially poultry litter), due to the rapid growth and commercialization of the poultry industry. Poultry litter is bulk solid and biomass feedstock, which is a combination of accumulated poultry manure, feathers and bedding materials found in poultry houses (Bernhart, 2007). Materials contained in poultry litter include faeces, straw, sawdust, wood shavings, shredded paper and peanut or rice hulls.

Over 932.5 metric tonnes of commercial poultry manure are produced in Nigeria annually, which keep expanding at 8% yr⁻¹ (Adejinmi, 2000; Musa *et al.*, 2012).

Accumulation of poultry litter poses disposal and pollution problems. Uncontrolled decomposition of manure produces odorous gases which can cause

respiratory diseases in animals and humans (Schiffman and Williams, 2005). Ammonia volatilization from manure creates odour problems, and it may also contribute to atmospheric deposition and acid rain (Walker *et al.*, 2000a & b). Furthermore, greenhouse gases, such as carbon dioxide, methane and nitrous oxides which are implicated in ozone depletion and global warming are also released from manure handling and storage facilities. Improved manure handling and storage methods are needed to reduce the emission of these gases (Aneja *et al.*, 2006).

Some of the disposal means that have been employed for poultry waste includes: centralized anaerobic digestion, composting, direct combustion with combined heat and power, burial, rendering, incineration, feed for livestock, source of energy and fertilizer (Kelleher *et al.*, 2002; Bolan *et al.*, 2010). Most of the litter produced by the poultry industry is utilized around the places of production as a fertilizer, partly because of the expensive cost of transporting the low-density litter. Also, fresh poultry litter has high moisture content, bulky to haul, spread and have a repulsing odor (Bolan *et al.*, 2010). These make the material difficult to handle than commercial fertilizer, thus limiting their use.

However, poultry litter is an excellent fertilizer material because of its nutrient content, especially for nitrogen (N), phosphorus (P), and potassium (K). (Hochmuth *et al.*, 2009). Poultry litter has spectacular revitalizing qualities when applied to soil (Kelleher *et al.*, 2002; Khalid *et al.*, 2014a & b). Manures decompose (mineralize) in the soil releasing nutrients for crop uptake. In addition to supplying nutrients, poultry litter serves as a soil amendment, increasing the soil organic matter content. The added organic matter increases the moisture holding capacity of the soil, lowers soil bulk density, and improves overall soil structure, thus increasing the efficiency of the crop production. (Chan *et al.*, 2008; Hochmuth *et al.*, 2009; Harmel *et al.*, 2009; Bolan *et al.*, 2010; Kahlid *et al.*, 2014a & b). Beyond tackling disposal problems, application of poultry manure also improves the physical, chemical and biological fertility of soils (McGrath *et al.*, 2009).

This paper examines the generation of wealth through the production of organic fertilizer from pelletized poultry litter. Pelletizing is the process of forcing materials through a specially design opening (Ugoamadi, 2012). It is the process of compressing or moulding a material into the shape of a pellet. A pellet is a small, compressed, hard chunk of mass. Pelletization of poultry litter makes it free of moisture and therefore lighter in weight easy to handle and suitable for use as fertilizer that can be applied mechanically by implanting or scattering (Mavaddati *et al.*, 2010; Zafari and Kianmehr, 2012).

THE MENACE OF POULTRY WASTE

Poultry production results in hatchery wastes, manure (bird faeces), litter (bedding materials such as straw, sawdust, wood shavings, shredded paper and peanut or rice hulls), and on-farm mortalities (Williams 2013). The processing of poultry results in additional waste materials, including offal (feathers, entrails and organs of slaughtered birds), processing wastewater and biosolids (Williams 2013). In Nigeria, over 932.5 metric tonnes of commercial poultry manure are produced in Nigeria annually, which keep expanding at 8% yr⁻¹ (Adejinmi, 2000; Musa *et al.*, 2012). This large chunk of wastes churned out from poultry houses encourages the growth of microbes, attracts houseflies, constituting health hazard to man and animals, and thus become a menace to the environment.

Furthermore, litter materials are usually needed beneath cages to reduce drudgery of routine cleaning. Poultry droppings readily produce maggots when not cleaned out or mixed with litter. Also, litter materials itself becomes wet and a nuisance when its moisture content exceeds 30%

and temperature is below 10°C (Adewunmi *et al.*, 2011).

Most of the waste produced by the poultry industry is dumped on sites around the places of production. Experiment of Vizzier *et al.*, 2009, shows that continuous dumping of poultry waste on land could lead to microbial build-up in the soil which could also lead to soil nutrient imbalance, eutrophication of surface water by phosphate and build-up of nitrate in the soil to 3 m depth or even up to the bedrock. This is capable of polluting the surface water, groundwater and air environment at high level and continuous dumping can lead to serious health challenge. Various challenges associated with indiscriminate poultry dumping has been reported to affect nitrates in groundwater which is hazardous to health if consumed (Powers and Angel, 2008). Uncontrolled dumping can also lead to air pollution as Ojolo *et al* (2007) reported that 57% of total nitrogen present in poultry waste is lost via volatilization within 14 days of dumping. This value may increase to over 65% of the total nitrogen before the waste is stabled. Ammonia volatilization is detrimental because it can cause suffocation, acid rain and greenhouse gas emission. It could also lead to eutrophication of rivers and algae bloom from phosphorus introduced into them from runoff. Phosphorus can pollute groundwater if the water table is shallow and the soil has very high hydraulic conductivity. Poultry waste dumping can also lead to influx of bacteria into shallow aquifer, cleaning up of which may not be possible in decades. Heavy metals like arsenic, copper and lead which are used as additives to poultry feed are very carcinogenic can be excreted with faeces and if dumped on land can pollute water bodies.

WASTE TO WEALTH OF POULTRY LITTER CONVERSION TO ORGANIC FERTILIZER PELLETS.

Environmental concerns of the use of chemical fertilizers has brought about a shift to the use of organic fertilizers. Chemical fertilizers grow plants but do nothing to sustain the soil because they do not replace many trace elements that are gradually depleted by repeated crop plantings, resulting in long-term damage to the soil. Also, the readily availability of nutrients from chemical fertilizers can lead to over fertilization. This not only can kill plants but upset the entire ecosystem. In addition, chemical fertilizers tend to leach, or filter away from the plants, requiring additional applications. Repeated applications may result in a toxic build-up of chemicals such as arsenic, cadmium, and uranium in the soil. These toxic chemicals can eventually make their way into your fruits and vegetables. Long-term use of chemical fertilizer can change the soil pH, upset beneficial microbial ecosystems, increase pests, and even contribute to the release of greenhouse gases. (Sabry, 2015)

On the other hand, in addition to releasing nutrients, as organic fertilizers break down, they improve the structure of the soil and increase its ability to hold water and nutrients. Over time, organic fertilizers will make the soil—and plants—healthy and strong. Since they are the ultimate slow-release fertilizers, it is very difficult to over fertilize crops. There is little to no risk of toxic build-ups of chemicals and salts that can be deadly to plants. Organic fertilizers are renewable, biodegradable, sustainable, and environmentally friendly (Sabry, 2015).

Poultry litter has been used as organic fertilizer in its raw form, however, most of the litter produced by the poultry industry is utilized around the places of production, partly because of the expensive cost of transporting the low-density litter. Also, fresh poultry litter has high moisture content, bulky to haul, spread and have a repulsing odor (Bolan *et al.*, 2010). These make the material difficult to handle than chemical fertilizer, thus limiting their use. In order to move nutrients further away from the poultry farm environment and make poultry litter more competitive and appealing as fertilizers, value addition through pelletizing makes it free of moisture and therefore lighter in weight, easy to handle and suitable for use.

Although, the N-P-K levels of pelletized poultry litter are lower than typical chemical fertilizer found in the market, pelletized poultry litter would compete successfully as a soil conditioner or soil amendment. It would have to be priced competitively as it provides a unique mixture of nutrients and conditioning properties. Therefore, changing the image of fresh poultry litter into a desirable asset rather than an environmental liability would help to increase market opportunity. Also, proper product nutrient labelling would change the image of poultry litter from a waste product into a useful fertilizer and soil conditioner for home, small/ medium scale and commercial agricultural use.

Some markets already exist for organic residuals and others can likely be developed. If the final product can be labelled organic, the revenue potential would be greatly enhanced. The convenience of bagging/packaging the product correctly, being locally produced, and natural or organic, combined with the fact that it is pelletized, differentiates it sufficiently in the marketplace to attract competing product's customers (Wolfe *et al.*, 2007).

Animal manure has been used in agricultural production; horticulture (gardening, landscaping, nurseries, and top soil production), silviculture (Christmas trees, ornamentals) and for reclamation (landfill covers, mine reclamation) purposes. Direct

application of pelletized litter to the land is the most common use. However, opportunities to develop new uses for the product appear to exist. Furthermore, the ease of handling for the processor and consumer would be the largest benefit derived from pelletizing the litter. Pelletizing may not completely alleviate the odor problem but it would seriously reduce the odor after the product has been applied. Pelletizing also makes the product more stable as a soil conditioner compared to raw manure, because the pellets would have to be broken down by the elements before they could condition the soil.

POULTRY LITTER AS ASSET

For quick disposal to avoid loss of nutrient and environmental pollution, poultry litter can be utilized for land application to crops as manure, generation of energy (biogas, electricity), feed for fish and feedstuff for livestock. But, land application of poultry manure for crops has been the traditionally and most important use, which is not the best. This exercise is not only crude but dirty, odourful and has health risks.

Poultry manure is an excellent organic fertilizer, as it contains high nitrogen, phosphorus, potassium and other essential nutrients. In contrast to mineral fertilizer, it adds organic matter to soil which improves soil structures, nutrient retention, aeration, soil moisture holding capacity, and water infiltration (Deksissa *et al.*, 2015). Poultry manure consists of important plant nutrients including nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), sulphur (S), manganese (Mn), copper (Cu), zinc (Zn), chlorine (Cl), boron (B), iron (Fe) and molybdenum (Sistani *et al.*, 2003; Benhart, 2007). Poultry manure contains nutrient elements that can support crop production and enhance the physical and chemical properties of the soil. It increases the water holding capacity of the soil and improves lateral water movement, thus improving irrigation efficiency and decreasing the general draughtiness of sandy soils. Poultry manure application improves soil retention and uptake of plant nutrients. It increase the number and diversity of soil microorganisms, particularly in sandy conditions (Amanullah *et al.*, 2010). This effect enhances crop health by increasing water and nutrient availability, as well as suppressing harmful levels of parasitic nematodes, fungi and bacteria.

Deksissa *et al.* (2015) reported that pelletized poultry manure has significant positive effect on the crop biomass yield when applied at 1000-2500 kg/ha. As it is processed at 70°C, pelletized poultry manure has no risk for the potential contamination of ground water with faecal coliforms. They also reported that higher rate of pelletized poultry

manure in combination with mineral fertilizer may affect the receiving water quality via leaching for nitrate and runoff for phosphate, and therefore appropriate rate of application must be determined. The result of their field studies confirm that pelletized poultry manure can be an effective nutrient source for corn production.

Adeli *et al.* (2016) reported that lint yield was greater in pelletized poultry litter than inorganic N fertilizer treatment by approximately 6% in 2012 and 21% in 2013 and averaged across years, lint yield was 5% greater with pelletized poultry litter than inorganic N fertilizer (1378 vs. 1303 kg ha⁻¹). They concluded that, applying pelletized poultry litter significantly enhanced soil fertility, improved soil aggregate stability, minimized postharvest residual NO₃-N concentration in the soil profile and may provide growers with an alternative nutrient management strategy for cotton.

PROCEDURES DEVELOPED FOR PELLETIZATION OF POULTRY LITTER

Poultry litter pelletizing process consists of multiple steps including feed material pre-treatment, pelletizing and post-treatment. The first step in the pelletizing process is the preparation of feedstock which includes drying of digested poultry litter, milling and then conditioning to appropriate moisture content for pelletizing. After several experimentations, the procedures developed in this research for obtaining efficient pellets from raw poultry litter are described below.

The moisture content of the litter can be considerably high and are usually up to 40 to 60% which should be reduced to 10 to 15%. The litter can be air- dried or dried mechanically using rotary drum dryer which is the most common equipment used for this purpose. Superheated steam dryers, flash dryers, spouted bed dryers and belt dryers can also be used. The raw litter is not left to over dry, as a small amount of moisture helps in binding process during pelletizing. The drying process is the most energy intensive process and accounts for about 70% of the total energy used in the pelletizing process.

Before feeding the dried litter into pellet mills, it is reduced to small particles of the order of not more than 3 mm. This is because, if the pellet size is too large or too small, it affects the quality of pellet and in turn increases the energy consumption. Therefore litter is milled for proper and consistent size. Size reduction is done by grinding using a hammer mill equipped with a screen of size 3.2 to 6.4 mm.

The next and the most important step is pelletizing where the poultry litter is compressed against a heated metal plate (known as die) using a roller or screw auger. The die consists of holes of fixed diameter through which the litter passes under high pressure. Due to the high pressure, frictional forces increase, leading to a considerable rise in temperature. High temperature causes the starch components present in the litter to soften which acts as a binding agent between the litter particles and fuse to form pellets.

Due to the friction generated in the die, excess heat is developed. Thus, the pellets are very soft and hot (about 70 to 90°C). Therefore, they are cooled and dried before storage or packaging. Additionally, the pellets may be passed through a vibrating screen to remove fine materials, this ensures that the pellets are clean and dust free. The packaging is done such that the pellets are protected from moisture.

AGRONOMIC RESULT

Agronomic response of Maize to raw and pelletized poultry litter.

Field experiments were conducted with the pellets produced from the procedure above. Raw and pelletized poultry litter was applied as organic fertilizer to maize and the effects of the pellet diameter on maize growth response was evaluated at 2 weeks, 4 weeks and 6 weeks after planting as shown in Table 1. It is observed that the pellets nutrients were released to the crop for growth, as seen in the plant height, faster than the raw litter. This implies a lesser immobilization period when the pellets is used.

Table 1. Effects of pellet diameter on maize growth response at 2, 4 and 6 weeks after planting

Pellet Diameter	Plant Height (cm)		
	2 weeks	4 weeks	6 weeks
Raw	36.2b	50.5ab	70.5ab
4 mm	39.8ab	39.9c	53.5c
6 mm	41.1ab	54.1ab	70.8ab
8 mm	45.3a	58.5a	76.3a
Control	46.2a	48.0bc	61.1bc

Note: Values with same letters are significantly differently by DMRT (P=0.05) within columns

CONCLUSION

It has been established that pelletized poultry litter has great potential to compete favourably well with chemical fertilizer as more concerns are being raised on soil nutrient depletion and contamination of water bodies through the use of chemical fertilizers. The market profitability of pelletized poultry litter is therefore on the rise as more and more growers turn to organic fertilizers for crop production.

ACKNOWLEDGEMENTS

We acknowledge the financial support of the Center of Excellence in Agricultural Development and Sustainable Environment (CEADESE), Abeokuta under the World Bank ACE project. Also, the effort of National Center for Agricultural Mechanization (NCAM), Ilorin towards the successful completion of this project.

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