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Research Article

Biochemical Values of Pig Dung Collected from Different Locations in Imo State, Southeastern Nigeria

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Abstract

Background and Objective: Pigs generates a large number of dungs that could be detrimental to the environment if not properly managed. This study attempt to determine the proximate and mineral compositions in freshly voided pig dung collected from smallholder farms in Imo state, Nigeria for possible use as animal feed. **Materials and Methods:** Early morning dung were collected from six farms, two from each of the three agro-ecological zones of the state and sundried. The samples were analyzed for their proximate and mineral concentration. **Results:** The result revealed that pig dungs are good source of dry matter (87.97%), fibre (23.33%), total ash (23.24%) and mineral (potassium, iron, phosphorus). **Conclusion:** This study revealed that pig dung is a good source of nutrients and could be used as animal feed. The use of pig dungs in animal feed and fertilizer for agricultural soil will lead the development of sustainable environmentally friendly animal and crop farming systems.

Key words: Pig dung, minerals, heavy metals, fertilizer, smallholder farms, Nigeria

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Animal dung is persistent and unavoidable pollutants generated by housed animals in intensive animal production locations worldwide. However, livestock producers and animal scientists tend to think of livestock mainly as sources of meat, milk and egg, but in practice, they produce dung than anything else[1]. Animal dung, however, contains nutrients which have been used as feed raw materials for livestock, fertilizer for agricultural soils and biomass for fuel generation[2-4]. Mclaughlin *et al.*[5] quantified the savings that could be achieved through the utilization dung as fertilizer as opposed to inorganic fertilizers and demonstrated that greatest impact on reducing economical and energy requirements are made only when maximizing the of dung nutrient. There however remain the problems arising from the use of dung as fertilizer such odor complaints and cost of handling and application compares to inorganic fertilizer.

The current world population of pigs runs in to billions, with countries like the USA have pig farms of 4000-5000 sow unit that account for more than 10 million pigs slaughtered annually in that country[6]. Asian countries such as Vietnam with a population of 19 million pigs at the turn of the century has also witnessed a commensurate increase in pork demand over the years and expansions are expected through an increase in a number of pigs per farming units[7]. In sub-saharan Africa and particularly Nigeria, pig production has increased in tempo in recent times in response to the animal protein needs of a growing population and urbanization[8,9]. Pig production is increasing popular in southern Nigeria because of the inherent ability of the animal to convert cheap agro-industrial by-products or wastes into relatively cheaper animal protein[10,11]. For example, in Ifo Local Government Area of Ogun state in southwest Nigeria, 22 cooperative societies hosting about 3000 farmers and more than 2000 attendant have created what could be termed the largest pin farm in sub-saharan Africa[12]. Throughout the southern states of Nigeria, the challenge of handling pig dung has become recognized as a major production issue mitigating against the sustained growth of the industry[9,13].

Pig production could be a major contributor to environmental issues, either at the global level as greenhouse gasses emission units or at the local level as eutrophication, acidification and bad odor emission locations[12,14,15]. The direct impacts of dung handing are associated with water pollution by excessive nitrates, phosphorus, organic matter, microorganisms and heavy metals release into the environment[16,17], air pollution by ammonia, nitrous oxide and methane[13,18] and soil pollution by excessive accumulation of phosphorus or trace elements[2]. These releases to the environment may constitute important threats to biodiversity, ecosystem stability and human activities such as fisheries development and tourism[9,19]. Their reduction would therefore, significantly contribute to sustainable livestock farming.

Environmental problems arising from poor animal wastes management have been the subject of numerous research efforts in many industrialized countries. In such countries, waste management is a critical component of the livestock production system, especially at intensive industrial levels[7]. These management systems are engineered to reduce the impact of most of the environmental issues associated with large-scale farming that may lead to public health and environmental concerns[13]. Solutions and innovations currently applied to pig dung management in these countries include disposing of manure with effluent water through cemented drainage gutters from where they enter into sectioned covered pits, where they undergo both aerobic and anaerobic decomposition from where they are eventually evacuated to crop farms[7]. In some cases, the pig waste is flushed into an anaerobic lagoon, from where the waste water could be applied to crop farms[2]. However, environmental concerns ensure when more nutrients are applied to the soils than the crops can assimilate, especially because pig dung contains relatively high concentrations of phosphorus and other chemicals that may precipitate heavy metals[2,9,20]. Animal dung has also been applied to environmental oil spill cleanup operations as reported by Udebuani *et al.*[21] for pig poultry and cattle dung, biofuel heating[22], paper making, insects repulsion, brick making and firing of pottery[23].

Environmental problems arising from intensive piggery production in Nigeria has however, received limited research attention in the area[9,24], even there are increasing environmental and health concerns[9,12]. At piggery locations in southeast Nigeria, fouled odors and pollutant gasses emitted from dirty pens and heaped pig manure diminish air quality[9,13,15,25]. The disagreeable odors emanating from farms have been reported to cause tensions between pig producers and their neighbors and could in extreme cases evoke litigations and risks of possible shot down of production[9,26].

Pig dung is basically a cellulosic biomass material, being the undigested residue of feeding largely herbivorous matter to pigs. The concentrations of specific materials that make up the dung are influenced by the nature of feed offered to the animals. Okoli *et al.*[8] reported that in southeast Nigeria pig farmers feed preferentially palm kernel cake, brewers spent grain, local fish wastes and soybean meal amongst other ingredients to their pigs, with PKC constituting the bulk of the feed because it is cheap and readily available[27]. Recent reports by Okata *et al.*[28] also showed high variability in the proximate compositions of common feed raw materials from different locations in Nigeria indicating that dung voided by animals consuming these materials may also vary in their biochemical compositions. Similarly, there may be variations in the formulations of feeds fed to animals at different locations due to variations in locally available raw materials, thus, making for variations in biochemical compositions of dung.

Imperative to proper management of animal dung as animal feed and fertilizer for agricultural soil is the understating of their chemical constituents responsible for their environmental effects. Again, further processing of pig into organic fertilizer or animal feed requires an understanding of its nutrient and anti-nutrient constituents. There is, therefore, the need to characterize the actual biochemical compositions of pig dung produced at any given location in order to generate the much needed local data for their management. This study was therefore, designed to determine the proximate compositions and concentrations of different classes of minerals in pig dung collected from different locations in Imo state, southeast Nigeria so as to properly situate their use in animal feed and fertilizer for agricultural soil.

MATERIALS AND METHODS

Study area: The study was carried out in Imo state, one of the southeastern states of Nigeria during late rainy season months of July-September, 2017. The state lies between latitude 05°30" and 05°56" north of the equator and between longitude 05°37" and 07°26" east of the Greenwich meridian and occupies a land area[29] of 13, 032 km^2 (Fig. 1). The climate falls under type AW in the Koppen-Geiger classification of wet and dry climate and zone B of the Nigerian eco-climatologically zones[30]. Given the close relationship between climate and vegetation, the location of the study area coincides with the rain-forest belt. It receives an annual rainfall range from 2000-2484 mm, with an average daily temperature of 26°C. The soils are derived from coastal plain sands. This type of soil has good drainage and is well aerated, causing it to dry out quickly[31].

In addition, the agricultural land has humus soil in long-existing fallows showing a good area for agricultural practice. The study area has a moderate to high population density, with average population density being about 104 people[32] per 1 km. Imo state is politically divided into three senatorial zones, namely Owerri, Orlu and Okigwe and further

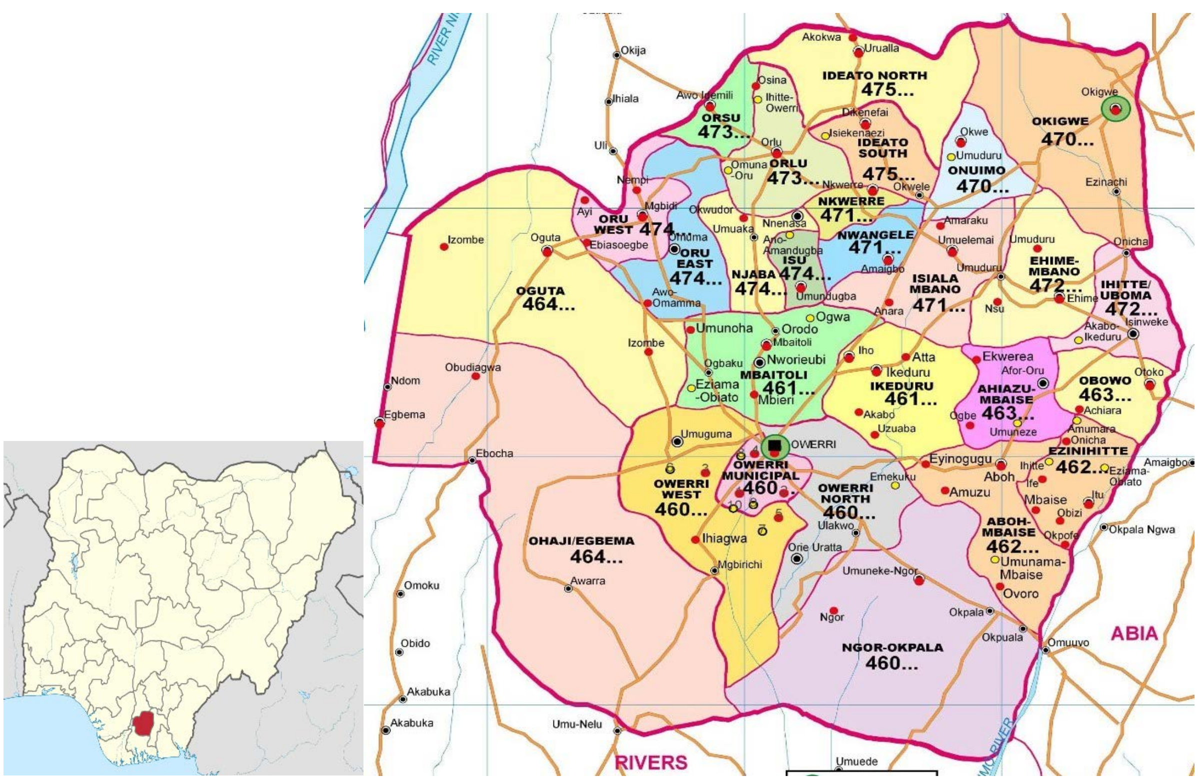

Fig. 1: Map of Nigeria showing Imo state
Source: Nigeria zip code map

divided into 27 Local Government Area (LGAs). These senatorial zones also correspond to the three agro-ecological zones of the state. Intensive farming of exotic poultry and pigs is popular although most of the farms are small and medium-scale, with few large-scale ones[33].

Collection of experimental materials: Fresh morning pig dung were collected from two medium-scale pig farms purposively selected from each of the three agro-ecological zones of Imo state during the late rainy season months of July-September, 2017. The farms were selected based on the willingness of the operators to participate in the study and also the farm containing more than 100 pigs of different ages. At each farm, early morning dung was collected directly from pens housing breeder and grower pigs and pooled to represent about 2 kg of dung on fresh weight bases. The dung samples were collected with the aid of a plastic scoop into properly labelled polyethylene bags and transported to the laboratory of the School of Agriculture and Agricultural Technology, Federal University of Technology Owerri, Nigeria for drying and analysis.

The samples were spread out on polyethylene sheets under the shed and allowed to dry with intermittent turning until they felt dry on touching. The samples from each agro-ecological zone were thereafter pooled and mixed thoroughly to give the representative sample for each zone. They were packed into properly labeled polyethylene bags until needed for laboratory analysis.

Proximate analyses: The dried pig dung were subjected to proximate analyses using the analytical methods described by AOAC[34] to determine the different proximate fractions such as moisture (MT), dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE), total ash (TA) and nitrogen free extract (NFE).

Mineral analysis: The samples were analyzed for their macro, micro and odorous minerals and heavy metal concentration. Mineral composition analysis was performed with an Atomic Absorption Spectrophotometer (AAS) (Bulk scientific, model 205) according to the method described by AOAC[34]. Briefly, 1 g of well blended sample was weighed into a porcelain crucible and pre ashed at 300°C and brought to 600°C and ashed for 2 h in a furnace, cooled and 25 mL of 3 M HCL was added, allowed to cool again. It was then filtered into a 100 mL volumetric flask and diluted to volume with deionized water. The sample was votexed for proper mixing, transferred to centrifuge tubes, centrifuged at 3000 rpm for 10 min and the supernatant decanted into clean vials for micro and macro-element determination using AAS. Phosphorus was determined by the titrimetric method.

Data analysis: Data generated were analyzed in order to establish the reference mean values of the different parameters in the study area. Differences between means where significant were separated using Duncan's multiple range test at 95% confidence intervals.

RESULTS

The proximate composition of pig dung collected from different zones of Imo state are shown in Table 1. The dry matter, moisture content, crude protein, crude fiber, ether extract and total ash and nitrogen free extract value were similar ($p>0.05$) among the dungs collected in different zones of Imo state. These parameters recorded low coefficient of variation across samples from different zones.

Table 2 showed the macro-mineral composition of pig dung samples from different zones of Imo state. Calcium, Sodium and Magnesium values were not significantly different ($p>0.05$) among the dungs collected in different zones of Imo state. The dung was high in potassium and phosphorus but the differences among the zone were similar ($p>0.05$). The CV values across the different zones were high.

Table 1: Proximate composition (%) of pig dung collected from different zones of Imo state, Nigeria

Parameters	Owerri zone	Okigwe zone	Orlu zone	Mean±SD	CV
Dry Matter (DM)	88.11	87.84	88.00	87.97±0.11	0.13
Moisture (MT)	11.89	12.16	12.00	12.02±0.11	0.92
Crude Protein (CP)	13.96	14.66	13.53	14.05±0.47	3.31
Crude Fiber (CF)	24.55	20.26	25.17	23.33±2.18	9.36
Ether Extract (EE)	8.82	9.50	6.48	8.27±1.29	15.65
Total Ash (TA)	23.00	24.04	22.67	23.24±0.58	2.51
Nitrogen Free Extract (NFE)	17.78	18.38	20.15	18.77±1.01	5.36

Means on the same row with different superscript are significantly different ($p<0.05$). CV: Coefficients of variation

Table 2: Macro-mineral composition of pig dung collected from different zones of Imo state

Parameters	Owerri zone	Okigwe zone	Orlu zone	Mean±SD	CV
Phosphorus (ppm)	2.60	2.60	2.00	2.40±0.28	11.79
Potassium (%)	8.82	9.50	6.48	8.27±1.29	15.64
Calcium (%)	0.04	0.05	0.04	0.03±0-01	10.88
Sodium (%)	0.01	0.09	0.04	0.07±0.03	70.71
Magnesium (%)	0.01	0.01	0.01	0.01±0.00	0.00

Means on the same row with different superscript are significantly different (p<0.05). CV: Coefficients of variation (%)

Table 3: Micro-mineral composition (mg/100 g) of pig dung collected from different zones of Imo state

Parameters	Owerri zone	Okigwe zone	Orlu zone	Mean±SD	CV
Iron	3051.55	1680.76	923.18	1885.16±880.84	46.72
Zinc	12.61	9.04	5.25	8.97±3.01	33.51
Manganese	10.95	6.57	2.83	6.79±3.32	48.92
Cobalt	10.95	6.57	2.83	6.79±3.32	48.92
Copper	6.47	1.26	0.47	2.73±2.66	97.38

Means on the same row with different superscript are significantly different (p<0.05). CV: Coefficients of variation (%)

Table 4: Heavy mineral composition (mg/100 g) of pig dung collected from different zones of Imo state

Parameters	Owerri zone	Okigwe zone	Orlu zone	Mean±SD	CV
Aluminum	28.86	18.57	11.47	19.63±7.14	36.36
Lead	1.54	1.23	0.08	0.96±0.63	66.11
Cadmium	1.69	0.76	0.47	0.97±0.52	53.18
Chromium	9.27	5.12	3.73	6.04±2.35	38.96
Silver	2.19	1.03	0.77	1.33±0.62	46.41

Means on the same row with different superscript are significantly different (p<0.05). CV: Coefficients of variation (%)

Table 5: Odorous elements composition (%) of pig dung collected from different zones of Imo state

Parameters	Owerri zone	Okigwe zone	Orlu zone	Mean±SD	CV
Sulphur	0.44	0.63	0.35	0.47±0.12	24.65
Nitrogen	2.23	2.35	2.16	2.25±0.08	3.49
Carbon	18.00	18.71	17.52	18.08±0.49	2.70
Chloride	0.00	0.00	0.00	0.00±00	0.00

Means on the same row with different superscript are significantly different (p<0.05). CV: Coefficients of variation (%)

Table 3 shows the micro-mineral composition of pig dung samples from different zones of Imo state. The micro-mineral values had similar (p>0.05) values among the dungs collected in different zones of Imo state. The dung was high in potassium and phosphorus but the differences among the zone were similar (p>0.05). The CV values across the different zones were moderate to high.

Data on the heavy mineral and odorous elements composition of pig dung collected from different zones of Imo state are presented in Table 4 and 5, respectively. The heavy metal concentrations and odorous elements had similar (p>0.05) values among the dungs collected in different zones of Imo state. The CV values were moderate to high.

DISCUSSION

The dung samples were high in dry matter, crude protein, crude fiber and total ash indicating that when properly processed, the material could be useful as ruminant feed and organic fertilizer for crop farming. These parameters recorded low coefficient of variation across samples from different zones indicating that there mean values could be used as reference values for the state. These high values are probably a reflection of the high inclusion levels of gritty and oily palm kernel cake in pig feeds in the study area[8]. The percentage of crude protein result is similar to the 13.79% reported by Udebuani[16], while the ash value was much lower than the 35.30% and the ether extract and nitrogen free extract values higher than the 3.0 and 12.42% reported by the same author in the same study area.

The dung was high in potassium and phosphorus and low in the other minerals. However, the CV values across readings from different zones were high, especially for sodium indicating that with exception of magnesium, the means may not serve as reference values for the state. Okoli *et al.*[20] also reported a high level of potassium and phosphorus in pig dung from the study area, while Udebuani *et al.*[17] however, recorded much higher calcium, magnesium and phosphorus values than the present results.

The samples were generally much higher in iron content than the other micro-minerals. Specifically, all the minerals recorded very high CV across the different sample sources, indicating that the mean values should not be used as a reference for the study area. Udebuani[16] published a much higher zinc value (26.28 g kg^{-1}) but similar copper value in pig dung sampled at the study area.

The samples were high in aluminum and chromium but low in the other heavy metals. The moderate to high CV values were again an indication that these may not be regarded as reference values for the state. The lead and cadmium values recorded in this study were similar to the values reported by Udebuani *et al*.[17], while their aluminum value was much lower. The metal values were also relatively low when compared with heavy metals similar to the values in poultry dung by Okoli *et al*.[35]. The results also revealed that pig dungs collected in the different zones of Imo state were relatively high in carbon and similar to the value of 16.85 g kg^{-1} reported by Udebuani[16], while the nitrogen content was similar to the 2.06% by the same author, but much lower than the value of 4.5% reported by Okoli *et al*.[20]. The zero reading on chloride was probably due to loss of most of the element during storage.

CONCLUSION

This study showed that pig dung collected from different locations in Imo state is rich in beneficial nutrients. The moderate to very high CV across the different sample sources is a pointer that the mean values should not be used as a reference for the study area.

SIGNIFICANCE STATEMENT

This nutritional study showed that pig dungs are rich in essential nutrients that could be employed in reducing the high cost of inorganic fertilizer especially in developing like Nigeria. This study also demonstrated that pig dungs could be incorporated in animal feed as a source of fibre and ash. The high fibre and ash content in pig dungs has also positioned it as an important raw material with the ability for industrial application and commercialization.

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