CHARACTERIZATION OF DAIRY FARM MANURE

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Abstract- The increasing quantity and volume of manure especially from the large and mechanized farms demand proper handling to reduce or eliminate threats to water, land and air resources. This paper presents the characterization of manure from a dairy farm. The physical, chemical and microbiological properties of the dairy cattle manure 'as excreted' for the lactating, dry and heifer cow was determined in accordance with recommended methods of manure analysis at the laboratory of the Niger State Water Board, Minna, Nigeria. The average age and weight of the young heifer is about 10 months and 200kg while those of the lactating are about 30 months and 800kg respectively. The lactating manure had the highest BOD_5 and COD values of 2.40mg/l and 7.20mg/l respectively compared to the dairy and heifer manures. Laboratory analysis of manure is an important management tool to use crop nutrients profitably and efficiently on the farm. Published estimates of average manure nutrients can be misleading for planning appropriate application rates as nutrient content of manure can vary from farm to farm and species to species hence, the need to determine the nutrient levels in manure is to take a representative sample for laboratory analysis as seasonal changes during the year. The farm managers can use the methods and results of this work for manure planning schemes. In-situ manure characterization is highly recommended to avoid the error arising from the decomposition of the manure while transporting the manure to the laboratory.

Keywords- Dairy Farm, Lactating, Heifer, Cow, Manure, Properties, Characterization, Land, Water And Air Resources

I. INTRODUCTION

Manure management is a critical concern in many parts of the world where the expanding livestock and poultry industry is concentrating[1,2,3,4]. Manure refers to combination of faeces and urine. Small amounts of spilled feed, water, soil, beddings, dust, hair and feathers are unavoidable in the production facility. Moffitt, [3] reported that these small additions must be considered to be a part of the manure and a part of the 'as excreted' characteristics presented.

Manure is often given descriptive names that reflect their moisture content (mc). Manure that have a mc of 95% or above are called liquid manure, those that have mc between 75% and 95% are called semi-solid (slurry) manure while those that have mc below 75% are solid manure.

The physical and chemical properties of dairy waste are affected by the physiology of the animal: size, sex, breed and activity of the animal; the feed; digestibility, protein and fibre content and the nature of other feed elements; the environment especially temperature and relative humidity; the feed quality and the spilled feed [5].

Animal manure contains a number of contaminants that can adversely affect surface and groundwater. In addition, certain constituents in manure can impact grazing animals, harm terrestrial plants and impair air quality. The principal constituents of animal manure that impact surface and groundwater is organic matter nutrients and faecal bacteria.

Manure may also increase the amount of suspended material in the water and affect the colour. The impact that these contaminants have on the aquatic environment is related to the amount and type of each pollutant entering the system and the characteristics of the receiving water. However, where manure is applied to agricultural land at acceptable rates, crops can receive adequate nutrients, soil erosion can be substantially reduced and the water holding capacity of the soil can be improved [3].

Livestock production facilities can be the source of gases, aerosols, vapours and dust that individually or in combination, can create such air quality problems as nuisance, odour, health problems for animals in confined housing units, 'greenhouse' effect, corrosion of materials, and the generation of deadly gases that can affect animals and humans [6].

Animal manure may contain pathogenic microorganisms. Transmissible livestock diseases from pathogens do threaten human. Examples include Salmonella, E. coli, Johne's, leptospirosis, listeriosis, TB, tetanus, anthrax among others. Dairy waste contains high concentrations of coliform bacteria (for example, E. coli) which are potentially hazardous to cattle and human health [7].

Manure is used as fuel, fertilizer, heat source, electricity (biogas), floor coating, mud-brick additive, art, fabric dye, bleaching fabrics, medicinal, insecticide and insulator [8].

Dairy farming is becoming very popular among farmers in Nigeria because it is highly lucrative. The corresponding increase in the quantity and volume of manure especially in mechanized farms demand proper handling to reduce or eliminate threats to water, land and air resources. Characterization of such manure is an essential component of manure management system that can improve farm profitability and the environment.

The objective of this work is to determine the physical, chemical and microbiological properties of the 'as excreted' manure for the lactating, dry and

heifer of Holstein's dairy cattle of Maizube farms, Minna.

II. METHODOLOGY

2.1 Materials

The materials used are the 'as excreted' samples taken from the lactating, dry and heifer cattle pens of Maizube farms in Minna, Niger State, Nigeria. The farm is located along Latitude 9°32´N and on Longitude 6°12´E as shown in Plate 1[9].



Plate 1: Site for the Collection of Manure Samples in Minna, Niger State.

2.2 Instruments and Reagents.

The instruments needed include shovel, sealing machine, polythene bags, three 4-gallon containers, beakers, 2000mL volumetric flask, 1000mL volumetric flask, pipette, burette, Biochemical Oxygen Demand (BOD) / Chemical Oxygen Demand (COD) bottles, Conductivity/ temperature/ TDS Meter, pH meter, Corning 410 flame photometer, platinum crucible and DR/2000 spectrophotometer. The reagents are potassium iodide 10% w/v, 0.02N potassium permanganate solution, 0.02N Sodium thiosulfate, concentrated tetraoxosulfate (VI) acid (H_2SO_4), Hydrochloric acid ($HClO_4$) and Hydrogen fluoride (HF)

2.3 Sampling Methods

Five points of sample collection were marked out each in the lactating, dry and heifer pens. One points each near the four corners of the pen while the fifth point was at the centre of the pen. A shovel was used to collect the sample. The five samples collected in the lactating cattle pen were thoroughly mixed in a 4-gallon container, then scoped into a 500ml polythene bag and sealed with a sealing machine immediately. The sampling procedure was used in the dry and heifer cattle pens. These bags were labelled properly and then stored in a freezer at 4^0C in the Niger State Water Board laboratory for the analysis.

2.4 Personal Data on the Cattle.

Data relating to each cow (young and lactating cattle) were obtained from the observation room of the farm. The data obtained include the average age, weight and feed ration.

2.5 Analysis of manure samples.

The analysis of the manure samples was done in accordance with recommended methods of manure analysis [10,11].

The pH meter was set at zero and later dipped into the digested sample mixture and the pH reading taken. The temperature probe used and then the reading was taken and recorded in degree Celsius (^{0}C). An electronic balance of ±0.00g accuracy was used to determine the moisture contents. Percent moisture content is measured as the weight lost during drying and is expressed as a percentage of the as received samples: The dissolved Oxygen (DO) was determined using 60ml BOD Bottles. The BOD was determined using 60ml BOD Bottles after 5 days. In addition, COD, Potassium, Nitrate as Nitrogen and Phosphate as Phosphorus were determined. The manure was equally digested during the test.

III. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Young Heifer Data

The average age of the young heifer is about 10months while the average weight of the animal is about 200kg. Table 1 contained the feed ration for the young heifer in the farm.

Table 1: Heifer Feed Ration

Feed ration		Kg/cow/day
Concentrate:	Corn grain	4
Minerals:	Palm kernel	1.3
	Rice hull	1.6
	Premix	0.025
Roughage:	Corn silage	17.14

3.1.2 Lactating Cattle data

The average age of the cattle for the first lactation is 30months and for the second or more lactation is 48months. The average weight of the cattle is also about 800kg. Table 2 contained the feed ration for the cattle in the farm.

3.1.3 Manure characterization results

The results of the characterization of the manure samples for the lactating, dairy and heifer are as presented in Table 3.

Table 2: Lactating Cattle feed ration

Feed ration		Kg/cow/day
Concentrates:	Corn grain	8.9
	Groundnut cake	5.5
Minerals:	Cassava chips	0.1
	Lime stone	0.1
	Premix	0.1
	Bi-calcium phosphate	0.1
	Salt	0.1
Roughage:	Corn silage	19.1

Table 3: Manure characterization results

S/N	Parameters	Lactating	Dairy	Heifer
1	Time of collection of manure	8.20am	8.38am	8.55am
2	Appearance	Dark	Dark	Light Dark
3	pH	5.4	5.4	5.4
4	Temperature	25°C	25°C	25°C
5	Moisture content (%)wet basis	80.29%	80.98%	75.81%
6	Total solid TS (%)wet basis	19.71%	19.02%	24.19%
7	$B.O.D_5$ (mg/l)	2.40	1.81	1.91
8	C.O.D (mg/l)	7.20	7.00	6.71
9	Potassium (mg/l)	0.34	0.30	0.29
10	Nitrate as Nitrogen (mg/l)	1.43	1.31	1.24
11	Phosphorus (mg/l)	0.12	0.11	0.10

3.2 Discussion of results

3.2.1 Time of collection of manure

The time of collection of manure affects the manure characterization in many ways. At the time of collection, the cleaners had not touched the fresh manure excreted over-night by the cattle yet. The time duration between the actual excrement and sample collection could be a maximum of 12 hours. Within this time, many changes may have occurred and such manure is actually partially decomposed manure.

3.2.2 Appearance

It was observed that the colour of the heifer dung is slightly lighter than that of the lactating and dry cattle. This may be due to fact that the manures collected are half-decomposed manures as decomposition causes the manure to get darker in its colour.

The digestibility of the feed ration, the protein and fiber content, and the nature of the other feed elements also affect the physical composition and appearance of the manure.

3.2.3 Temperature and pH

The temperatures of all the samples were the same (25°C). This temperature measured reveals low biological activity in the manure sample.

The pH is the measure of acidity or alkalinity of the manure. A pH of 5.4 is acidic and thus manure can be used to correct a highly alkaline soil. For proper plant growth, a pH between 6 and 7.5 is appropriate.

Manure from dairy cattle in a confinement building will contain all the ingredients of the feed; some of them in their original form, others in chemically simpler forms thus affecting the pH of the manure.

3.2.4 Dry Matter and Moisture content (%) wet basis

The moisture contents of the lactating, dry and heifer cattle were 80.29%, 80.98%, 75.89% respectively. The moisture contents were on the high side because the manures were collected "as-excreted". But this correlates with the expected value from research carried out on dairy farm manures (Table 3).

When the animals are exposed to higher temperature it is observed that they tend to drink or consume much water to keep their chemical balance. In colder regions, the cattle pass out much of the excess body liquid as urine.

The manure handling system adopted in the farm is the use of bear floor without litter. If manures are to be used as organic manure for soil, the excess weight of water in the manure must be removed to reduce cost of transportation. Reduction of the moisture content to 50% will save thirty percent (30%) of the cost of transportation. The use of litter will reduce the moisture content but increase the bulk of the manure and thus the cost of movement.

A gravity flow system is advisable to use for removal of liquid and semi-liquid manure from livestock houses whereby manure is transferred hydraulically on a liquid "cushion".

3.2.5 BOD_5 and COD values (mg/L)

The BOD_5 of the manures were as expected in comparison with standard result from previous research (Table 3). The BOD_5 , COD, and TS are used to measure the polluting power of waste. A BOD of 20mg/l and COD of 30mg/l are standards that must be met if wastes must be disposed into the sewage ways. This shows that the manures would cause little pollution to sewage systems.

Most dairy rations include antibiotics for disease control. When large doses of these antibiotics are administered to the cattle, a sufficient portion may pass through the digestive tract to severely inhibit or at times limit biological treatment of the manure and thus affect the BOD and COD test results. This has a lowering effect on the BOD results.

3.2.6 Potassium, Nitrogen, Phosphorus (mg/L)

The average potassium, nitrogen and phosphorus contents of the lactating cattle were higher than the dry and heifer cattle. This is in agreement with the research results of Table 3.

The ratio of N: P: K from the manure analysis (6.4: 1: 3.4) is also in agreement with that of the research report (11: 1: 3). This may be due to the fact that lactating cattle often excrete under tension when they are removed from their sheds to the waiting room. The excrement under tension is not properly metabolized and thus much water and nutrient finds its way into the dung.

Nitrogen in the undigested protein is excreted in the solid dung. In the digested proteins, it is absorbed and later excreted in the urine except for the portion that is used to build flesh in the animal. Potassium is absorbed during digestion, but practically all is excreted. Part of the phosphorus content of the feed is absorbed, but most is excreted in the faeces

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Laboratory analysis of manure is an important management tool to use crop nutrients profitably and efficiently on the farm. Published estimates of average manure nutrients can be misleading for planning appropriate application rates.

The nutrient content of manure can vary from farm to farm and species to species. Animal manures can have very different properties, depending on the animal species, feed, bedding, and manure-storage practices. Therefore, the only reliable method to determine the nutrient levels in manure is to take a representative sample for laboratory analysis.

During application, seasonal changes during the year and depending on the manure handling system, one to several samples are required. Multiple samples will cost more but having more than one test result will mean a much higher level of accuracy for planning manure applications.

The analyses needed for developing a manure application plan are total nitrogen (N) phosphate (P_2O_5), and potash (K_2O). Analysis of dry matter, or solids content, is needed if results are reported on a dry matter basis and must be converted to an as-is or wet basis.

It is usually not necessary to analyze manure for other mineral constituents such as calcium (Ca), magnesium (Mg), zinc (Zn), sulfur (S), or boron (B). Most manure contains significant quantities of these minerals, and fields with manure histories are rarely deficient. Deficiencies are better managed using soil testing and plant analysis.

4.2 Recommendations

The farm managers can use the methods and results of this work for manure planning schemes.

The farm may need no commercial fertilizer if they use dairy manure properly. In this case, manure can supply all the nitrogen, phosphorus, potassium, and several other nutrients needed for forage production.

More than half the nutrients in dairy rations are excreted in manure. The key to managing manure is to treat it as a resource by recycling these nutrients to produce forage. For example, one dairy cow's manure can supply enough nitrogen for 1.5acres of silage corn.

In-situ manure characterization is highly recommended to avoid the error arising from the decomposition of the manure while transporting the manure to the laboratory.

If manures are to be used for organic fertilizer then it should be sample from the manure application equipment. This will give a more agitated manure sample and a closer revelation of what goes into the soil. Also, the use of manure for fertilizer will be recommended if it will be mixed with inorganic fertilizer to meet the requirement of the soil.

REFERENCES

[1]. Hart J., M. Gangwer, M. Graham and E. S. Marx., Nutrient management for Dairy Production. Oregon State University Extension Service 1997.

[2]. Peter, J. B. and S. M. Combs., Variability in Manure Analysis as Influenced by Sampling and management. New Horizon in soil science No.6-98. Dept of soil sci., University of Wisconsin-Madison, WI. 1998.

[3]. Moffitt, D., Handbook of Agricultural Engineering, (Vol.II). Published by American Society of Agricultural Engineering (ASAE). p174, 1999.

[4]. Dennis B., T. Wagar and M. Schmitt., Livestock manure sampling, Communication and Educational Technology Services, University of Minnesota Extension, 2002.

[5]. Ronald, E. and K. K. Prasanta., Animal Data Sheet, Washington State University Cooperative Extension, 1994.

[6]. USEPA (United States Environmental Protection Agency). Anthropogenic methane emissions in the United States; Estimates for 1990, Report to Congress Office of Air and Radiation, Washington, DC. 1993.

[7]. www.ext.vt.edu, 2000

[8]. www.photojournalistas.com, p.12002

[9]. Encarta, Microsoft Corporation, 2007, 1993-2006.

[10]. Scarf, H. One hundred years of the Kjeldahl method for nitrogen determination. Arch. Acker. Pflanzenbau Bodenk. 32:321-332, 1988.

[11]. Isaac, R. A. AOAC Method 985.01. Metals and other elements in plants. In: Official methods of analysis of AOAC international. 16th ed., P. Cunniff (ed.), Gaithersburg, Md: AOAC International, 1998.

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