DESIGN OF SANITARY DISPOSAL OF POULTRY MANURE

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ABSTRACT

The physical and biological characteristics of the chicken manure from the University of Nigeria Poultry Farm are presented. Different methods of manure processing and disposal are reviewed. Stabilisation ponds are recommended as the most convenient and economical way of destroying poultry wastes. A design of a pond system for the Eastern Nigerian environment is presented.

1.   INTRODUCTION

Operation Feed the Nation will bring with it intensive poultry farming. Modern high density housing of the birds will create problems in collecting and disposing of their manure. Manure cannot be allowed to accumulate in the confinement area because of the health hazards of fly breeding, odours and potential water pollution. The problem is compounded by the nearness of some poultry farms to large human populations. It is important that some satisfactory method of disposal of poultry manure be developed. In order to design a system of handling, stabilising, utilising and disposing of the manure, some sanitary engineering properties relevant to the environment must be known. This paper presents the physical and biological characteristics of the chicken manure from the University of Nigeria poultry farm. Different methods of poultry manure processing and disposal are suggested.

2.   PHYSICAL AND BIOLOGICAL CHARACTERISTICS

The physical and biological properties in terms of the volumetric information, solids contents, BOD and COD values are given in Tables 1 and 2. BOD (Biochemical Oxygen Demand) is a bioassay involving the measurement of oxygen demand of micro-organisms in their aerobic degradation of organic matter present in a waste. COD measures the

TABLE 1: PHYSICAL PROPERTIES
Values for Egg Laying Chicken weighing 2.18 2. 36 kg (University of Nigeria Poultry Farm manure)

Wet manure per day (kg)	Average percent Solids in Wet manure	Average percent Volatile Solids content	Average Bulk Density (g/cm^3)
.16	72	30	.98

Oxygen required to stabilise the organic matter in a waste regardless of the biological assimilability of substances.

Fig. 1 shows the bulk density of chicken manure at various solids contents. Fig. 2 summarises the slump tests made to measure the fluidity of chicken manure. Fig. 3 shows the particles size distribution of chicken waste examined. The tests were carried out according to the Standard Methods [1]

3. CHEMICAL PROPERTIES

The obvious way of disposing of the chicken manure is to use it as a fertilizer. Table 3 presents the major elements (nitrogen, phosphorus and potassium) in chicken manure and

TABLE 2: MONTHLY AVERAGE VALUES OF BOD AND COD

(University of   Nigeria Poultry Farm Manure)

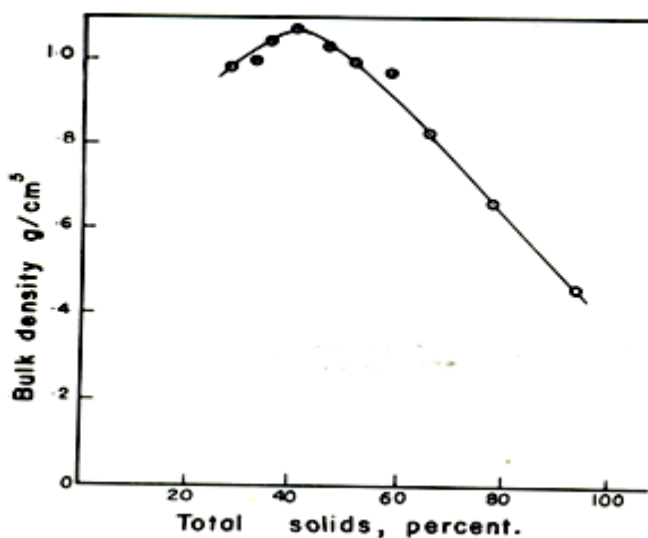| BOD mg O_2/mg Volatile matter	OCT.	NOV.	DEC.	JAN.	FEB.	MARCH	APRIL	AVERAGE
	.32	.30	.34	.42	.30	.40	.34	.35
COD mg O_2 volatile matter	.92	.95	.83	.72	.80	.68	.68	.80

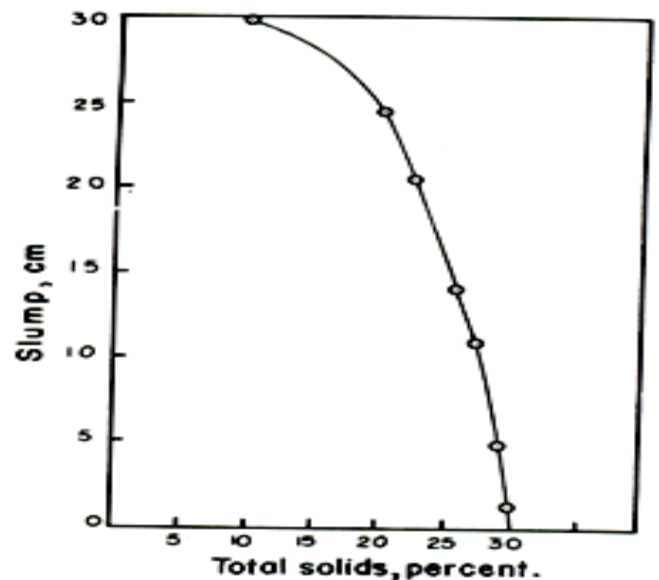*Fig. 1: Variation of Bulk density with Manure Solid Contents*

Fig.2: Slump Test Values.

commercial fertilizers as given by various researchers. It can be seen that there is a lot of variability in the chemical analysis. The major plant-food constituents of chicken manure compared well with those of low-grade fertilizers.

The pH of fresh manure ranges between 7.0 – 7.8.

4. MANURE PROCESSING

Manure processing is based on the need to stabilise organic waste material before disposal

4.1 PROCESSING SOLID MANURE

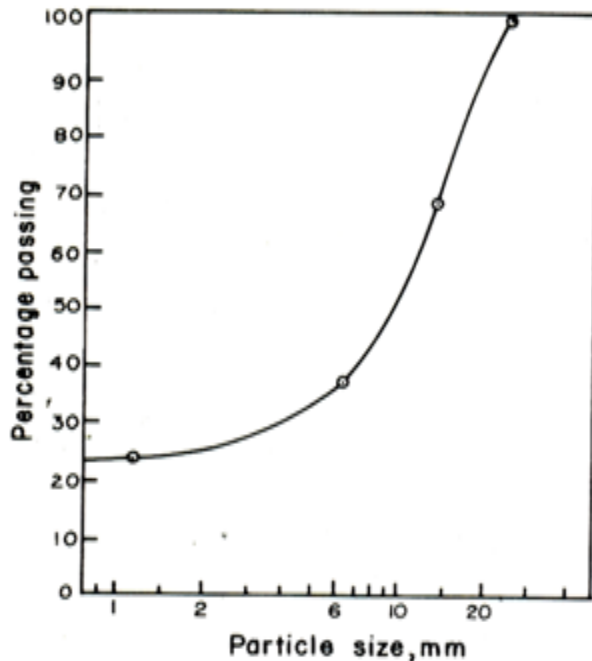By manure is stable and relatively odourless and breeds very few flies.

Fig. 3: Particle size distribution of wet screened chicken manure.

Drying has considerable potential in manure processing. Drying manure by artificial heat will be expensive. Sun drying should be a natural way of processing manure in the tropics. Hart [2] showed that spreading slurried manure thinly would dry it in one day without stirring and additional layers could be added each day. During the rainy season, drying will be difficult and the runoff contaminated with manure will pollute the water resource pool. Large land areas required may not be available.

Composting is another dry method of stabilising manure. Fresh manure is to partially dried first or a dry filler material is added. The C/N ratio is between 8 : 1 to 12 : 1 but good composting requires and initial C/N ratio of 20 : 1 to 30 : 1 [3]. Chicken manure is low in carbonaceous matter to compost well. It can be mixed with compost well. It can be mixed with carbonaceous material like grass or refuse. This is being done successfully at the University of Nigeria.

4.2 PROCESSING LIQUID CARRIED MANURE

The probable processing methods for liquid carried manure are digestion and anaerobic lagooning.

4.2.1 MANURE DIGESTION

Hart [4] in digestion tests of livestock wastes reached the following conclusions:

i. That chicken manure could be satisfactorily stabilised in high rate digesters equipped with adequate mixing at a loading of 1. 62kg per m^3 of digester capacity per day and at one month detention.

ii. That the destruction of volatile matter expected from digesting chicken manure closely approximates that of municipal sludge digestion (45% destruction as against 50% for municipal sludge digestion).

iii. That operational parameters of pH, alkalinity, volatile acids and the effect of temperature follow those expected from municipal sludge digestion.

These conclusions seem to show that digestion of chicken manure is feasible but the expensive equipment and skilled labour involved seem to forbid its application.

4.2.2 MANURE LAGOONS

Manure lagoons are anaerobic stabilisation ponds. They accept very high organic loading and are completely devoid of dissolve oxygen.

Provided that the pH is <6, BOD reduction in anaerobic ponds is a function of temperature and of BOD loading. The rate of sludge accumulation is small and desludging is required when the pond is half full.

For satisfactory performance, manure lagoons must meet three criteria:

i. Minimum of odour and the associated appearance of the lagoon;

TABLE 3: CHEMICAL ANALYSIS OF CHICKEN MANURE AND COMMERCIAL FERTILISERS

Values in % with respect to the solid content

Reference	Nitrogen as N	Phosphorus as P_2O_5	Potassium as K_2O
Facts about Chicken Manure U.C. Agro Ext. Serv. Leaflet (1962)	1.8-5.1	6.0-6.5	1.9-3.0
Ppoultry Manure, its nature, care and use .Conn. Agr. Expt. Sta. Bull. 272	2.5-5.9	3.7-6.6	1.7-3.3
Poultry Manure, its preservation, deodorisation and disinfection. Rutgers Agr. Expt. Sta. Bull. 707	4.1	3.7	2.3.
Animal manures, what are they worth today. Michigan Agr. Expt. Sta. Circ. Bull. 231	3.4	9	0.8
Soils. 1975 yearbook of Agriculture USDA	2.8	2.3	1.1
Poultry manure. WHO – Nig. 21/PHE/65	2.3	0.9	1.1
Commercial fertilizer Low value High value Concentrated value	2 4 4	8 16 24	2 8 12

ii. Fly,mosquitoes and other vectors must be controllable or must not occur;

iii. Pollution of the ground water table by infiltration must be prevented.

The release of objectionable odours from anaerobic ponds occurs when the volumetric loading is >400 of g $BOD/m^3 d$.

Occasionally the surface layers of an anaerobic lagoon assume a vivid pink colour imparted by a dense population of photosynthetic bacteria belonging to the family thiorhodaceae. These are purple sulphur bacteria utilize hydrogen sulphide as the electron donors in their photosynthesis. The purple sulphur and have been identified by Cooper [5] as thiopedia rosea or Chromatium Sp. the production of strong sulphide gases contribute to the malodours of the ponds. These purple sulphur bacteria utilise hydrogen sulphide as the electron donors in their photosynthesis. The purple sulphur bacteria are obligate phototrophs and store elemental sulphur internally and will produce sulphate with age. It is of interest to note that whenever the purple sulphur bacteria bloom odours have disappeared from the lagoons. These bacteria have become lagoon deodorisers.

Odour control may be achieved by inoculating the pond with a culture of sulphur bacteria or by raising the pH of the pond to about 8 so that most of the sulphides will exist as bisulphide ions.

One reason for processing manure is the hope of reducing fly production. Mosquito production in malaria endemic area may present serious health hazards. Weeds and floating debris provide quiet breeding places for flies and mosquitoes. For preventing or controlling the breeding of these vectors, weed growth must be prevented or controlled and the embankment slopes must be steep.

Hart and Turner [6] have evaluated the problem of ground water pollution and found that the biological sealing common

to ground water recharge and to septic tank leach field was not pronounced in their pilot

manure lagoons. The loss of solids via polluted water percolating from the lagoons was considerable. Even though bacteria are filtered off by passage of water through the soil. Virus, salt and taste producing organic material could as well pollute ground water supplies. Health hazards may be present where the water table is very close to the surface of the ground and where a large number of such lagoons are located in the same aquifer.

5. MANURE DISPOSAL

The ultimate disposal of most manure should be its return to the soil. Processing by drying reduces the weight and volume and concentrates the plant food constituents. Dry manure may be bagged and sold, but it is unlikely that the money realized will cover the costs of the sanitary manure management.

It is unlikely that the livestock farmer will be interested in composting operation in view of the labour and equipment required. For composting to succeed there must be a central body accepting and processing livestock and municipal wastes.

Digestion of manure on the farm has the same draw–back as composting , as digestion needs expensive and complicated equipment and skilled labour. Also the digested manure and the supernatant liquid must be handled before final disposal.

By the specialised system of poultry farming, manure is being produced every day but farms take manure seasonally so that manure utilisation does not synchronise with its production. So the final disposal of unused manure will be a constant worry to the livestock farmer. One of the reasons why manure lagooning is hereby recommended is that the farmer does not concern himself with disposal of the wastes. When the ponds are properly designed, the sludge accumulation is minimal and desludging may be necessary only every 3 – 5 years. Skilled labour and expensive equipment are not involved. They require a minimum of maintenance and can be applied to small farms. Adherence to good design, sound principles of construction and operation will minimise public health hazards posed by lagoons. Lagoon development should then be supervised by a sanitary engineer.

6. DESIGN OF A WASTE LAGOON FOR A POULTRY FARM

Based on the information obtained from the tests already described a design of an anaerobic chicken waste stabilisation pond for the Eastern Nigerian environment is presented:

DESIGN FORMULAE [7]

$A = Qt/D$

$\lambda v = L_i/t$

A = mid depth area, m^2

Q = volumetric flow rate m^3/d

t = detention time , d

D = pond depth , m

L_i = Influent BOD, mg/ρ

λv = Volumetric BOD loading, g/ m^3d

DESIGN CRITERIA FOR AN ANAEROBIC POND [7]

Provided pH is >6 and for temperatures greater than 20^0C, optimum detention time of 5 days achieves a BOD reduction of 70%. For no objectionable odour release λv should be less than 400 g BOD/ m^3d

Rang of Pond depth   2 – 4m

Length to breadth ratio 2 to 1

Embankment slope 1: 2 – 1 in 3

ANAEROBIC POND DESIGN

No. of birds   = 100,000

Wet manure per day   = .16 x 10^5 kg
Volume of manure/day = 16 x 10^6g ÷ .98 g/cm^3

Volume of manure/day = 16.3 x 10^6 cm^3 = 16.3 m^3

Volatile solids/ bird–day = .3 x .16 = .048 (Avg. % volatile solids content =30)

BOD/bird – day = 48 x .35 = 16 .8g (Avg. mg o_2/mg volatile matter = .35)

Total BOD output = 16.8 x 105 g/d

For no objectionable odour choose λV = 400g BOD/m^3d. pH7-8 and temperatures 25 – 29^{0}C and t = 5 days.

$\lambda V = L_i/t$

L_i = 400 x 5 = 2000 mg/ρ

Water needed to achieve Li = 2000 mg/ρ is 16.8 x $10^8 \div 2000$ = 8.4 x 10^5 ρ/d = 840 m^3/d.

Q = 840 + 16.3 = 956.3 m^3/d. say 860m^3/d

Choosing a depth of 4m

A = 860 x 5/4 = 1057 m^2

Mid depth Dimensions = 46.4m x 23.2m and taking a slope of 1:2

Allowing 1m freeboard

Surface Dimension = 58.4m x 35.2m

Bottom Dimensions = 38.4m x 15.2m

With a BOD reduction of 70% in the influent Effluent has BOD of .3 x 2000 = 600 mg/$_l$

From studies of the infiltration of sewage into soils [8] infiltration is estimated as 50 mm/day. Evaporation is estimated as 5mm/day from values for Enugu. Estimated water loss through 6 surfaces of the Pond = 43 m^3/d. A facultative pond is required to reduce the BOD to less than 60 mg/$_\rho$ (acceptable for sewage effluents). Effluent from the anaerobic pond = 860 – 43 = 817 m^3/d. This is then influent into the facultative pond.

FACULTATIVE POND DESIGN ADDITIONAL FORMULAE [7]

λs = 10 QL$_i$/A

$A = \frac{Q(L_i - L_e)}{18D(1.05)^{T-20}}$

T = Mean temperature of the coldest month, ^{0}C

L$_e$ = Effluent BOD, mg/ρ

λs = Surface BOD loading, kg/ha d (kilogram per hectare per day)

DESIGN CRITERIA

Rang of pond depth = 1 – 2m

Permissible Loading λs = 20T – 120

D = 1.5m, Li = 525 mg/$_\rho$, Le = 60mg/ρ,

T = 25^{0}C, Q = 817 m^3/d

$A = \frac{817(600 - 60)}{18 \times 1.5(1.05)^5}$

= 12765.6   say 12800 m^2

λs = 10 x 817 x 600/12800 = 383 kg/ha d

Check Permissible loading λs = 20T – 120 = (20x25) - 120 = 380 kg/ha d

Design is satisfactory.

Mid depth Dimensions = 160 x 80m

Choosing a slop of 1:3

Allowing 1m freeboard

Surface Dimensions = 170.5m x 90.5m

Bottom Dimension = 155.5m x 75.5m

PIPE DESIGN

Choose Asbestos cement soil pipe (easily available and has performed well from experience).

Manning's formula for gravity flow

$Q = \frac{1}{n}AR^{2/3}S^{1/2}$

Q = flow rate, in m^3/s

n = coefficient of roughness

A = cross sectional area of flow, m^2

R = hydraulic radius, m

S = slope of the hydraulic gradient, m/m

n for A.C pipe = .013   [9]

S = .02 m/m

Assuming cleaning out of manure takes 3 hours a day, Q = 25.5 m^3/hr. from Nomograph for Manning formula, diameter of pipe = 100 mm. The pond system is shown in Fig. 4.

COST ESTIMATE

The capital cost of the two lagoons is estimated at 60k/bird (based on ₦2.00 per m^3 for earthworks) and the operating expenses have been estimated at ₦ 1.12 ton wet manure or 5k/bird/ year (based on an operator per house of 14,000 birds).

7.   CONCLUSION

Manure management on concentrated poultry farm is a serious problem because of the fly breeding, odour and disease
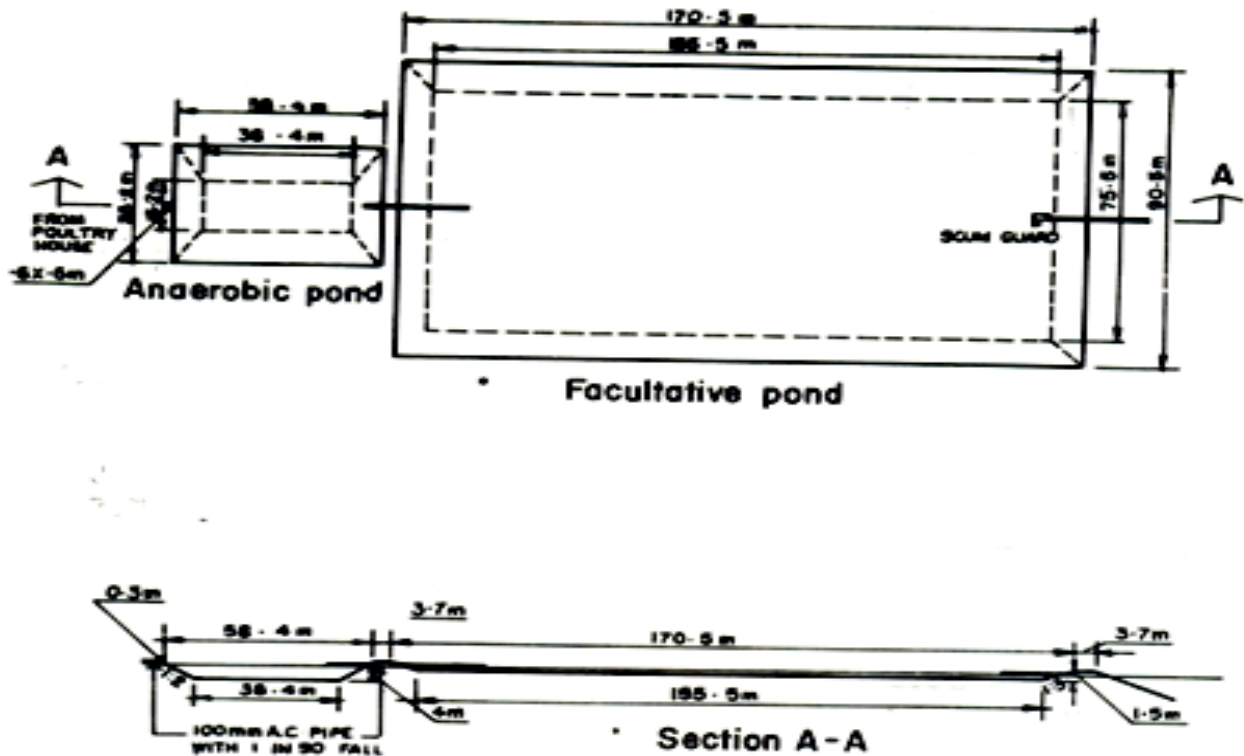
Fig.4: Stabilization Pond System.

hazards associated with fresh manure. The talents of sanitary engineers should be tapped to solve these problems.

For a successful and economical operation of a lagoon, there must be a steady and plentiful supply of water. This can prohibit the use of lagoons in some part of Nigeria where water is difficult to obtain especially during the dry season. There is a great need to use poultry manure as fertilizer in Nigeria. Land for drying manure has been estimated at 0.1 m^2/ bird [2]. Drying of manure is recommended to be undertaken by the farmer until he can find no more cheap land for the operation. As manure is produced daily and farms take manure

seasonally, lagoons can be used for the final disposal of the unused manure. Where a farmer has no land for drying manure or has no market the final disposal of the dried manure, lagooning of the manure is recommended.

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