

# Formulated Faecal Sludge and Compost Fertilizer Pellet for Crop Production: The Case Study of the Lavender Hill Faecal Treatment Plant

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**Abstract:** The application of excreta-based fertilizers has attracted attention due to the increasing prices of chemically produced fertilizers and low soil fertility problem of the agricultural land. This study was carried out to assess the efficacy of mixed dried Faecal Sludge (DFS) and municipal organic Compost pelletized on lettuce production. Faecal sludge was dried and mixed with compost produced from Accra Compost and Recycling Plant (ACRP). Analysis of the characteristics of Dry Faecal Sludge and Compost informed in the formulation of three (3) different composition in accordance with estimated variation on percentage nitrogen of 1.5%, 2.0% and 2.5%. The ratios were 1:3.3, 1:1.1 and 1:0.4 (w/w) of Dry Faecal Sludge and Compost respectively. The mixed formulation was pelletized using a pelletizer machine. Starch and clay were used as binding materials for pelletization. The pelletized treatment was used in the production of lettuce. Application of the pelletized treatments confirmed that, pelletize mix of Dry Faecal Sludge and Compost with starch as a binder is highly recommended as it had greater significant effect ( $p < 0.05$ ) on Lettuce Height, wet weight and number of leafs. M3 with ratio 1:0.4 (w/w) DM basis of faecal sludge and compost recorded the highest average dry weight of lettuce.

**Keywords:** Compost, Dried Faecal Sludge, Pelletization Binders, Fertilizer, Lettuce

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## 1. Introduction

In Ghana, as in most parts of Sub-Saharan Africa (SSA), human excreta from on-site sanitation systems are dumped in the environment without any appropriate treatment [1]. Waste management is a critical issue in Ghana's cities. Collection and disposal services are failing to cope with the increasing waste generation that comes with the highest urban growth rates in the world [2]. Excessive land application of raw sewage leads to water pollution through run-off, often culminating in fish kills, eutrophication, high ammonia losses to the atmosphere accompanied by serious odour problems causing a public nuisance. It is believed that poor sanitation costs Ghana about \$290 million per year according to a desk

study carried out by the Water and Sanitation Program [3, 12-13]. An average of 700 m<sup>3</sup> of FS from an average of 100 tankers is disposed off at Korle Gonno every day in the capital [4].

Mineral fertilizer use in Ghana is extremely low; application rate is estimated to be 7.42 kg per hectare per year which is one of the lowest in sub Saharan Africa [5] due to prohibitive cost as a result of privatization and removal of government subsidies. The high cost of chemical fertilizer and the current global shift toward organic farming have led to increase in the demand for organic-based fertilizers [6]. This situation therefore suggests the need to identify an alternative cheap source of nutrients for replenishing soil nutrients without necessarily resorting to the use of mineral

fertilizers [14].

Current studies reveal that an average of about 200 - 250 cesspit trucks dislodged at the new lavender Hill faecal treatment plant [7]. According to Gbenatey, [4] over 200,000 m<sup>3</sup> of FS was disposed into the marine environment in 2006. These foregoing acts pose an invisible and 'silent' danger of human food and water-borne disease outbreaks with serious economic implications. The figures presented represents a huge chunk of plant nutrients going waste and at the same time causing serious environmental pollution [4]. The foregoing arguments, evident in various studies conducted in Ghana suggest that FS is a very important raw material. Proper management of these FS can contribute positively to local resources.

The capital city of Accra generates approximately 0.72kg/person/day of solid waste and translates to 0.376kg/person/day of municipal organic waste [8]. The most widely used methods of solid waste disposal in the Metropolis is collected from home (57.4%) and by public dump (container) accounting to 32.9 percent. Liquid waste is mostly disposed into gutters (48.0%), through a drainage system into a gutter (26.6%) and through a sewerage system (7.8%).

The appropriate approach in curbing these problems could be the establishment of treatment plants and composting facilities. Composting is increasingly becoming a universal and popular option for environmentally sustainable means of recycling agricultural and municipal by-products [9].

In Ghana, commercial composting technology for conversion of large volume wastes into economically viable and safe products has not been fully developed. Currently Accra compost and recycling plant is the only commercial plant producing large quantities of organic compost.

Accra compost and recycling plant Near Medie Adjen Kotoku, Nsawam Rd receives 300 tonnage of organic solid waste daily. Approximately, 45-50 bags of organic fertilizer are produce from the plant daily. On the same premises of the plant is sited 1000m<sup>3</sup>/day of sewage treatment plant which produces about 10 tonnage of sewage sludge daily. The rich properties of sewage sludge can blend with the organic municipal solid waste complementing each other to produce quality organic fertilizer essential for improving soil fertility.

$$\%N \text{ on mix} = \frac{\text{Weight of Compost} \times \%N \text{ Compost} + \text{Wgt DFS} \times \%N \text{ DFS}}{\text{Weight Compost} + \text{Weight DFS}}$$

#### 2.4. Lettuce Response Trial

The different pelletized faecal- compost mixtures were tested on lettuce plant. The treatments tested consisted of pelletized (Soil only, Soil-Compost; Soil-DFS, DFS-Compost).

The experiment was arranged in a completely randomized design (CRD) with three (3) replicates consisting of 8 seedlings per box. The design consisted of five percentage concentrations of nitrogen on pelletized organic fertilizer (Compost, DFS, DFS-Compost formulation mix), (1, 1.5, 2, 2.5 and 3%) applied to the substrate at planting.

In view of this, the research is considered timely to access the potentials complementarities of each feed stock (compost and faecal sludge) to achieve desired nutrient blend for crop production.

## 2. Materials and Methods

### 2.1. Study Area

The research involved both field and laboratory studies. The field experiments were conducted at the Lavender Hill faecal treatment plant site at James Town; which is demarcated as a sanitary site by the Accra Metropolitan Assembly. The laboratory studies were conducted at the Center for Scientific and Industrial Research (CSIR) Water Research Institute Laboratory in Accra. The City of Accra shares boundaries with Ga West Municipal to the North, the West by Ga South Municipal, the South by the Gulf of Guinea, and the East by La Dadekotopon Municipal and it covers an estimated total land area of 139.674 Km<sup>2</sup>. It is important to note that Accra also serves as the national capital of Ghana (GSS, 2014).

### 2.2. Chemical Analysis of Raw Materials

Total organic carbon, nitrogen, phosphorus and potassium concentrations in the samples were determined using the procedure followed by [9]. The pelletizer machine used consists of a hopper, barrel which houses the screw conveyor (auger), the cutting knife and the die orifice. Power supply to the machine is from 2 kW, 1420 rpm three phase electric motor. Analyses were carried out with three replicates per sample, and the mean results per sample used for statistical data treatment.

### 2.3. Formulation Mix of Compost and DFS

Based on a preliminary analysis (Table 1) of quality characteristics of dry Faecal Sludge and Compost, three (3) different formulations of Mix were prepared accordance with estimated variation on Nitrogen percentage of 1.5, 2.0 and 2.5 using the formula below;

Fifty four experimental boxes of dimensions 30cm x 30cm x 20cm was made from five divisions of 150cm x 30cm width box prepared with 1½ inch polyline plywood. Approximately eight lettuces of average high 3.2cm seedlings were planted in each box. 0.025kg of each pelletized treatment was uniformly spread on each of the eighteen boxes. As a control for the experiment, 0.25kg of soil was used to fill two experimental boxes. Lettuce seedlings were watered three times daily (morning, afternoon and evening). Lettuce was grown for approximately four weeks before it reached maturation. Data was taken on the number of leaves, girth, height and yield of lettuce at one

week interval for the four weeks of lettuce planting in each experimental setup. The average number, girth, and height of lettuce leaves from each experimental box was determined by randomly selecting six samples for physical assessment of the various characteristics mentioned

### 2.5. Data Analyses

Data collected on number of leaves, plant height, girth, wet and dry weight were subjected to analysis of variance (ANOVA) using GenStat 9<sup>th</sup> Edition. Treatments means were compared using the least significant difference (LSD) at  $\alpha = 0.05$ .

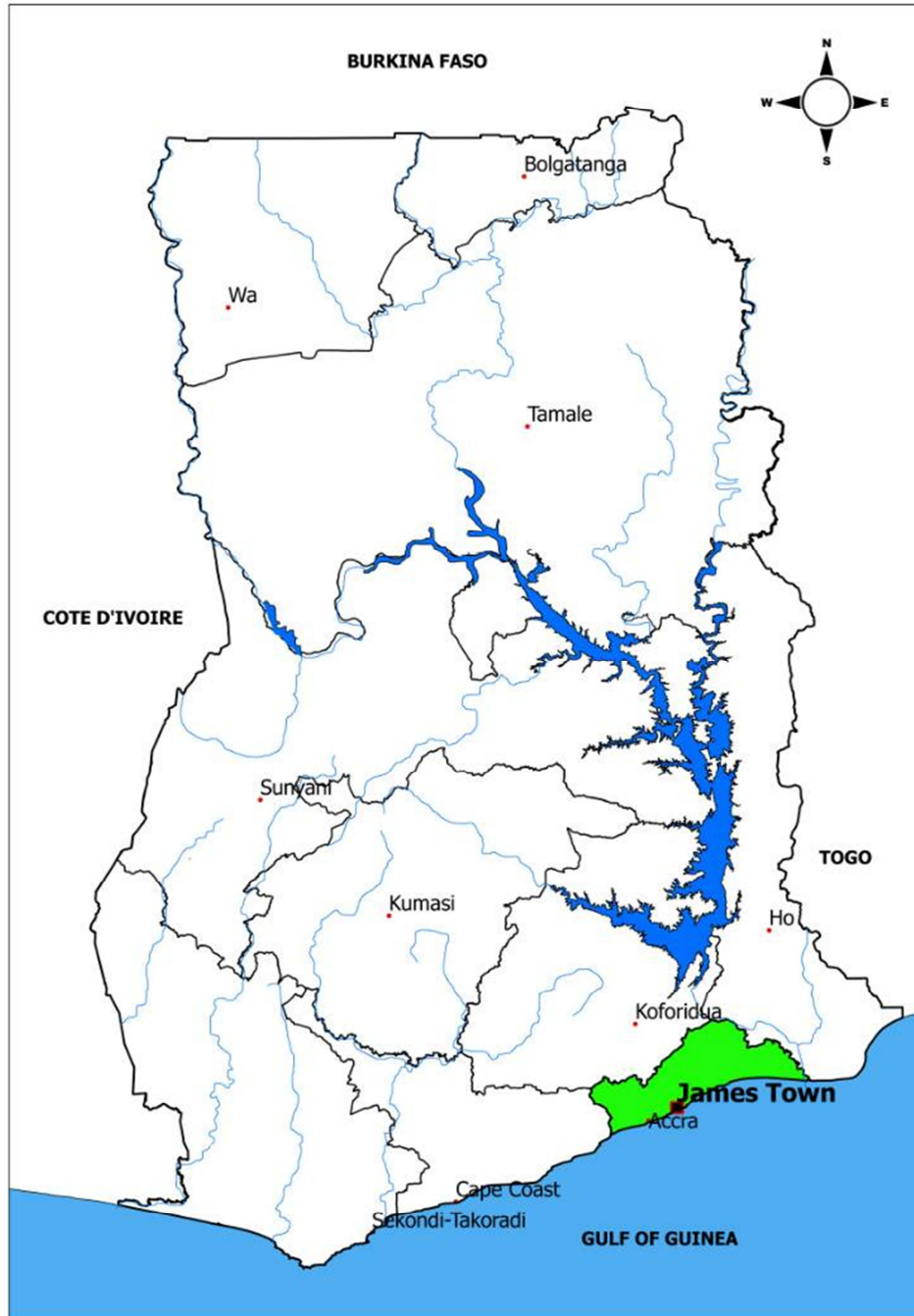


Figure 1. Study Area, James Town, Accra-Ghana.

## 3. Results

Table 1. Quality characteristics of compost and DFS.

Sample	N	P	K	Carbon
Compost	1.04±0.1	0.02±0.1	3.38±0.4	35.20±1.8
DFS	3.03±0.1	0.13±0.1	1.47±0.2	11.83±1.4

**Table 2.** Formulation mix composition.

Samples	Treatment	DFS	Compost	Ratio (w/w)	Composition
Unit	% N	g (%)	g (%)		
M0 (1)	-	-	-	-	Soil
M0 (2)	1.04	-	-	-	C
M0 (3)	3.01	-	-	-	DFS
M1	1.5	303 (23.3)	1000 (76.7)	1:3.3	DFS + C
M2	2.0	930 (48.2)	1000 (51.8)	1:1.1	DFS + C
M3	3.0	2808 (73.7)	1000 (26.3)	1:0.4	DFS + C

Values in parenthesis (), are the percentage weight composition of material used in the formulation of mixed Samples. M0 (1, 2, 3) represent soil, compost and dry faecal sludge respectively.

**Table 3.** Nutrient Composition of Binding Agents.

Binder Type	Carbon (%)	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Clay	2.66	0.23	0.03	0.02
Starch	49.4	4.25	0.04	0.22
LSD	0.16	0.03	0.01	0.03
P-Value	<0.001	<0.001	0.016	0.001

**Table 4.** Effect of pelletized treatment on lettuce (without binding agent).

Treatment	Height (cm)	No. of leaf	width (cm)	wet weight (g)	dry weight (g)
Soil	14a	10a	11.5a	23.75a	1.62a
Compost	14.67ab	11ab	11.67a	30.15bc	1.95a
DFS	16.17c	11ab	12a	33.57bc	1.87a
M1	14.67ab	12.33b	11.67a	28.88ab	1.7a
M2	14.83ab	12.67b	12a	36.1c	2.27a
M3	15.33bc	11.67ab	11.33a	44.19d	2.52a
LSD	1.292	1.922	2.789	6.254	1.651
P-Value	0.052	0.092	0.993	0.001	0.828

LSD for comparing means at the same level of treatment (5% level of significance): 2.782

For each variable, means followed by the same letter are not significantly different at  $p=0.05$  level and exhibits similar treatment effect

**Table 5.** Effect of Clay Pelletized treatment on lettuce.

Treatment	Height (cm)	No. of leaf	width (cm)	wet weight (g)	Dry weight (g)
Soil	14a	10ab	11.5a	23.7a	1.62a
C	15.33a	10.33ab	12.77a	37.7bc	2.17a
DFS	16.17a	12.33c	12.67a	26a	1.48a
M1	13.33a	9a	10.67a	31.6ab	1.93a
M2	16a	10.67abc	11.33a	29.4a	1.77a
M3	16.67a	11.33bc	13.33a	40.1c	2.37a
LDS	3.564	1.967	3.88	8.29	1.336
P-Value	0.329	0.045	0.657	0.006	0.697

LSD for comparing means at the same level of treatment (5% level of significance): 3.807

Values sharing similar letters in a column are in the same range and exhibits similar treatment effects

**Table 6.** Effect of Starch Pelletized treatment on lettuce production.

Treatment	Height (cm)	No. of leaf	width (cm)	wet weight (g)	Dry weight (g)
Soil	14a	10a	11.5ab	23.7a	1.62a
Compost	14.67ab	13.67d	11.33ab	37.8bc	2.48ab
DFS	19.33c	12.67bcd	13.67b	48.5c	2.72b
M1	13.17a	13cd	10.33a	28.4ab	1.81a
M2	16.17b	11ab	10a	26.4ab	1.77a
M3	15ab	11.33abc	11.33ab	34ab	2.07ab
LDS	2.033	11.33	2.525	12.13	0.884
P-Value	0.001	0.006	0.094	0.008	0.107

LSD for comparing means at the same level of treatment (5% level of significance): 5.780

Values sharing similar letters in a column are in the same range and exhibits similar treatment effects

## 4. Discussion

Quality characteristics (C, N, P, K) of compost and dry

faecal sludge samples were determined. Table1 present the chemical composition of raw materials used in the formulation mix. The values obtained differ slightly as those

obtained by Josiane [10], 2.1% of N, 2.4% of P and 0.5% of K. However nutrient composition of DFS was found to be higher than in compost except Potassium concentration.

#### 4.1. Binding Agents

Investigations revealed that cassava starch and clay were possible binding materials that can be used for pelletization [10]. The study consists of comparing the nutrient composition of binding agents and its impact on the feed stock (DFS and compost). According to [11], the higher the binder concentration, the higher the stability of pellets. Three percent of binding materials were added to the formulation mix before pelletization [11]. Table 3 shows quality composition of binding agents before pelletization process.

Starch used as a binding material seems to be high in the parameters analysed which relatively present higher values of concentrations. Starch analyzed contain 4.25% mean of nitrogen whereas clay contains 0.229%N. Mean Carbon Content in starch is apparently very high which is 49.4% and 2.66% in clay. Carbon and nitrogen concentrations showed significant difference ( $p < 0.001$ ) in the binder type. The rich property of nutrients in starch than in clay predicts increase nutrient concentrations in pellet formation with starch.

#### 4.2. Pelletization Processes

Compost and DFS was mixed on a lined concrete floor (Figure 2) to ensure homogeneity. Application rates were conducted using the appropriate mass balance proportions for the Greenhouse experiment in 20 boxes (Dimensions, 30 cm X 30 cm): Factors of treatment included (Soil only, Soil-Compost; Soil-DFS and Treatments of Soil-Compost and DFS) on Lettuce (*Lactuca Sativa*). The mixture is manually placed in the hopper of the pelletizer (Figure 3); an auger helps to force the sample through a flat metal disc (die) with uniformly distributed holes of 5mm diameter. The pellets were cut with a stationary cutter and manually collected in a plate followed by sun-drying (Figure 4).



Figure 2. Mix sample preparation.



Figure 3. Pelletizing the mix sample.



Figure 4. stationary cutting with manual collection.

#### 4.3. Lettuce Production with Pellet without Binding Agents

There was no significant variation ( $p > 0.05$ ) on lettuce height, width, dry weight and number of leaf of pelletized treatment except lettuce wet weight which recorded high significant ( $P = 0.001$ ) difference (table 4). High wet weight of lettuce might have resulted from high water holding capacity of pellets in M3 which could as well be related to nutrient (N, P and K) uptake. Compost and DFS exhibited similar treatment effect on the wet weight with range value of 30.15-33.57g showing less similarity in M1 and M2. Again, Soil and M2 showed similar treatment effects according table 4. The highest value recorded with respect to wet weight was 44.19g indicating Mix 3. All growth parameters recorded for Soil (control) showed less values comparing with treatment samples, this generally suggest that, addition of pelletized treatments resulted in an increase in lettuce production in terms of height, number of leaf, width, wet and dry weight of lettuce.

#### 4.4. Lettuce Production with Clay Pelletized Treatment

From table 5, Using clay as a binding agent in the



pelletization of treatment showed significant variations in the wet weight and Number of leaf of lettuce as the p-values recorded was less than 0.05. The lettuce height, width and dry weight showed no significant ( $p > 0.05$ ) difference. The Soil (23.7g), DFS (26g) and M 2 (29.4g) showed similar treatment effects in terms of lettuce wet weight (table 5). M3 recorded the highest wet weight indicating value of 40.1g which translated into nutrient uptake, recording the highest width, height and dry weight of lettuce produced. This increase in could be as a result of the steady increase in nutrient composition in formulated mix sample. Compost and soil samples exhibited similar treatment effects in terms of number of leaves. There are similarities between M 1, 2, and 3 with respect to number of lettuce leaf.

#### 4.5. Lettuce Production with Starch Pelletized Treatment

From the variance table (table 6) most growth parameters showed significant difference ( $p < 0.05$ ) in the treatment on lettuce except lettuce width and dry weight. Pelletized dewatered faecal sludge with starch (DFS-Starch) recorded the highest lettuce height (19.33cm); wet weight (48.5g) and dry weight followed by formulation mix 3. Soil treatment and pelletized Mix1-starch showed similar treatment effect on lettuce height recording the lowest value. Pelletized compost with starch and Pelletized Mix3 with starch (M3-starch) recorded 14.67cm and 15cm respectively which showed similar treatment effect. Compost Pelletized-Starch recorded the highest number of leaf over the control (soil) treatment recording the lowest value indicating 13 and 10 respectively. Mix treatments (M, M2 and M3) were found to be in the same range showing similar effect on treatment.

## 5. Conclusion

The study has shown that application of pelletized treatment samples of dry faecal sludge and compost can promote vegetative growth. Mix 1, 2 and 3 recorded Total Nitrogen Content values of 1.53%, 2.13% and 2.50% respectively which shows that, blending dry faecal sludge (high nitrogen content) with Compost (low nitrogen content) proves a good approach, complementing the capacity of each growing media and becomes very essential for use by farmers as soil fertility improvement materials. The average pelletized treatment application has proven to be a better option over the control. Average dry weight of lettuce recorded the highest in M3 followed by compost, M2, DFS and control recording the least value. Average highest lettuce was recorded in Mix 2 and 3 with control recording the least value.

Application of these treatments showed a high average growth rate of lettuce produced with pelletized formulation mix 3 and DFS with starch as binding agent. Addition of starch as a binding material apparently increases the nutrient compositions of the feed stock.

From the study it can be concluded that, pelletized treatment increased the water holding capacity as well as the nutrients content of the soil which enhanced the growth of

the lettuce plant.

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