COMPOSTING OF FAECAL SLUDGE AS A SOIL CONDITIONER

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Background

Water For People commissioned a Decentralized Faecal Sludge Treatment Plant (DEFAST) in Kitgum Municipality in December 2016 which has a capacity to receive 8m^3/day of faecal sludge. The DEFAST has been designed with the aim to reduce the volume of the sludge and, at the same time, inactivate the pathogen agents present in the fecal sludge. The sludge is collected on daily basis by local entrepreneurs, commonly known as gulpers, from the several sites located in the Kitgum Municipality. Water For People, together with its partner UNICEF Uganda, sought to add value to the sludge by turning it into compost.

Introduction

Composting is turning manure and waste material into a soil conditioner and fertilizer enriched with nutrients. Faecal sludge (FS) as organic material is decomposed through a composting process to turn it to an organic soil conditioner. FS compost can be made in two ways:

1. Use of composting toilets or through the Fossa Alterna toilets
2. Decomposing of FS after it reaches the treatment plant. Water For People is currently piloting this method in Kitgum municipality at the DEFAST.

Uganda National Bureau of Standard (UNBS) for Organic Soil Conditioner

Organic fertilizer per UNBS definition is any product in solid or liquid form, of plant (except by-products from petroleum industries) or animal origin that has undergone substantial decomposition that can supply available nutrients to plants. This may be enriched by microbial inoculants and naturally occurring minerals but no chemical or inorganic fertilizer material has been added to the finished product to affect the nutrient content. The standards for organic fertilizer and soil conditioner are shown in Tables 1a, b and c.

Table 1a: UNBS Standards for Organic Fertilizer and Soil Conditioner: Nutrient Requirements

S/N	Characteristic	Limit	Test Method
i	NPK, %	5-7	ISO 11261 ISO 6598 ISO 5318
ii	C:N	12:1-15: 1	-
iii	Soluble salts (conductivity), mmhos/cm, max	5	ISO 11265
iv	Total Nitrogen, % m/m, min	1	ISO 11261
v	Organic Carbon, % m/m, min	12	ISO 10694
vi	Moisture Content (solid organic fertilizer), % m/m	30-35	ISO 11465
vii	pH	6.0-10.0	ISO 10390
viii	Stones >5mm size, % m/m, max	5	-
ix	Seed, number/kg, max	5	-

Source: UNBS (2017). Uganda Standard, Organic Fertilizer-Specification. First Edition 2017-06-20. 1584:2017.

Table 1b: UNBS Standards for Organic Fertilizer and Soil Conditioner: Microbiological Limits

Pathogen	Limit	Test method
Total coliforms, cfu/g	5 x 10^2	US ISO 4831
Salmonella	Absent	AOAC 967.26
Escherichia coli	Absent	US ISO 7251
Enterococci	Absent	US ISO 7899-2

Source: UNBS (2017). Uganda Standard, Organic Fertilizer-Specification. First Edition 2017-06-20. 1584:2017.

Table 1c: UNBS Standards for Organic Fertilizer and Soil Conditioner: Contaminant Limits

Heavy Metal	Limit mg/kg dry wt	Test method
Arsenic (As)	10	ISO 17318
Lead (Pb)	100	
Mercury (Hg)	2	
Cadmium (Cd)	5	
Chromium (Cr)	50	
Copper (Cu)	300	ISO 11047

Source: UNBS (2017). Uganda Standard, Organic Fertilizer-Specification. First Edition 2017-06-20. 1584:2017.

Faecal Sludge Composting Process

Previous FS Composting Process

After collections at the different sites, the sludge is transported in barrels to the DEFAST site. It is then discharged manually through coarse screens that remove the largest objects and the sludge flows to the drying beds where it dries up within few days. After this stage, the sludge would be removed from the beds, and sawdust added to the sludge. The mixture was then loaded into crates and bags with the addition of sawdust assumed to promote the composting process, which, in turn, would inhibit the pathogen activity and, consequently, provide a safe raw material for organic soil conditioner.

Unfortunately, the composting process did not perform accordingly (Figure 1). The raw material was too dry, and the sawdust was not the proper supporting material for dried sludge. The low moisture content and the poor porosity did not promote the composting process (Table 2a). Therefore, the organic load was not reduced, and the risks of pathogens outbreak (Table 2b) were still present even though the sludge looked composted. In addition, the blend of dried sludge and sawdust was not mixed after it was placed in the crates or the bags. This contributed to the creation of supplementary unfavorable conditions for organic matter degradation.

Figure 1: Previous composting conditions

Table 2a: Nutrient Content (per 100g of sludge tested) in Compost, Previous Composting Process

Test parameter	Crates	Compost Pellets
Moisture Content (%)	28.55	42.74
Dry Matter	71.45	57.26
Organic Matter	50.95	63.52
Inorganic Matter	49.05	36.48
pH	6.92	7.00
Nitrogen	1.23	1.18
Potassium	5.49	3.06
Phosphorus	1.29	1.24

Table 2b: Pathogenic Occurrence in Compost, Previous Composting Process

Sample Description	Thermal tolerant coliform count (cfu/g)	E. coli count (cfu/g)	Salmonella spp detection	Helminths count
Crates	Nil	Nil	Absent	4 (non-viable) and 2 (viable) Ascarid seen
Compost Pellets	129	115	Absent	No nematodes detected

New FS Composting Process

Water For People, in partnership with UNICEF Finland and their partners Korkia Ventures and Insights, developed a new process of composting the faecal sludge (Figure 2) that involved heaps instead of crates and sought to improve the degradation conditions, quality, and safety of compost. Details of the new composting process are as below.

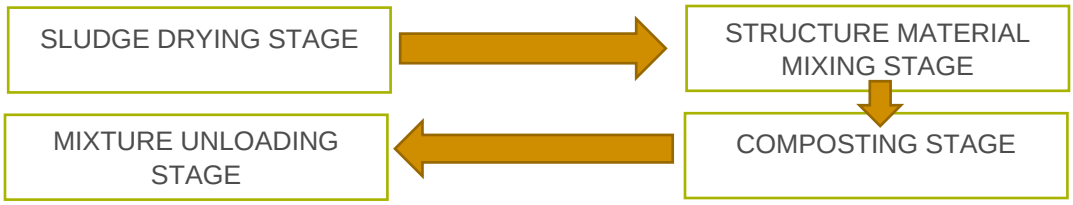

Figure 2: Schematic diagram of composting process

Composting Process Steps

1. Remove the sludge from the beds on daily basis (Figure 3) before it is too dry. Optimal Total Solids (TS) percentage is between 20 and 30.

Figure 3: Removing sludge from drying beds

2. Ensure that the structure support material is available. It is advisable to have 1 week storage that corresponds to 3 m^3. Straw, dry corn stalks, dry leaves, small branches or dried grass should be used as structure support material (Figure 4).

Figure 4: Preparing the structure support material

3. Thoroughly mix the sludge cake and the support material (Figure 5). The support material should be at least 2/3 in volume of the substrate. If the daily volume of sludge after drying to 20-30 % TS is 660 l/d, then minimum support material required is 440 l/d.

Figure 5: Mixing sludge with structure support material

4. Place the mixture in a heap and ensure that it is not too high (Figure 6). Many heaps can be made as the composting space allows.

Figure 6: Mixture heap (opted to remove the crates to allow for more heaps)

5. Water the pile on a regular basis, initially every second day. Mark the table (Table 3).

Table 3: Watering Recording Table

Heap No	Watering Day																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2																				
3																				
4																				
5																				
6																				

6. Measure the temperature on daily basis and record the temperature (Table 4). You will need a soil compost thermometer for this.

Table 4: Temperature Recording Table

Heap No	Daily temperature ^{0}C																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2																				
3																				
4																				
5																				
6																				

7. If the temperature does not increase within 2 days after the heaps is loaded, water every day.

8. Mix if the temperature rises above 65 °C.
9. Once temperature has risen to 65 °C, it will gradually decrease to the air temperature.
10. The compost is ready after a period of 20 days and this can be transported to the garden.

Nutrient Content and Pathogenic Occurrence Results

With the new FS compost process, tests were carried out to determine the nutrient content and pathogenic occurrence in the new heaps following the country standards as determined by Uganda National Bureau of Standards. The results were shown in Table 5.

Table 5: Nutrient Content and Pathogenic Occurrence Results Using New FS Compost Process

Parameter	Unit	Top Sample	Middle Sample	Bottom Sample	UNBS Standard	Comments
Total NPK	%	2.58	2.61	2.51	5-7	Low levels
C: N ratio	ratio	11.23	13.24	8.03	12-15	Falls within limits
Soluble salts (Conductivity)	mmhos /cm	12.5	11.6	14.9	5 (max)	Too high
Total Nitrogen	%	1.14	1.05	0.99	1	Falls within limits
Organic Carbon	%	12.34	13.58	10.26	12	Falls within limits
Moisture Content	%	37.3	26.6	79.9	30-35	High in the bottom sample
pH		6.1	6.2	6.2	6.0-10.0	Falls within limits
Stones >5mm	%	1.03	1.15	0.89	5 (max)	Falls within limits
Total Coliforms	cfu/g	7.60E+06	6.50E+06	4.90E+06	5.00E+02	All were non-viable nematodes detected
Salmonella	cfu/g	0	0	0	0	Good
E. coli	cfu/g	0	0	0	0	Good
Enterococci	cfu/g	0	0	0	0	Good
Helminth eggs	eggs/g	28	32	27	No limit	All were non-viable nematodes detected
Arsenic	mg/kg	0.07	0.06	0.12	10 (max)	Good
Lead	mg/kg	93.33	96.45	111.4	100 (max)	Falls within limits
Mercury	mg/kg	3.93	4.11	5.16	2 (max)	High
Cadmium	mg/kg	1.74	1.82	1.52	5 (max)	Falls within limits
Chromium	mg/kg	1.92	2.51	1.88	50 (max)	Falls within limits
Copper	mg/kg	110.74	123.5	156.9	300 (max)	Falls within limits

Health and Safety in Handling FS Compost

- Recommended immunization against Hepatitis A and B for site operator and any other employees working directly with the sludge
- The operator and employees should always have safety wear on such as gumboots, gloves, overalls, and nose masks
- The faecal sludge should be given some time to dry to TS 20-30% before the composting process is started to avoid working with wet conditions.
- There should be no shortcuts with the composting process to ensure a quality product.

Application of FS Compost Recommendations

Water For People is promoting the use of compost from faecal sludge for cereals, trees, grass for landscaping, legumes, and banana plantations. We are not recommending it for vegetables and low lying fruit trees until it has been approved by UNBS. We are also promoting it as a soil conditioner rather than a soil fertilizer.