# FORTIFIED EXCRETA PELLETS FOR AGRICULTURE

**J Nikiema**, **O Cofie, R Impraim, P Drechsel**

International Water Management Institute - West Africa Office, www.iwmi.org
PMB CT 112, Cantonments, Accra, Ghana
Tel: (+233) 302 784 753/754
Fax: (+233) 302 784 752
Email: J.Nikiema@cgiar.org

## Abstract

This paper describes the pelletization process of fecal sludge-based fertilizers. The equipment used for the process was fabricated locally in Ghana. Each fertilizer product was individually used for the production of cylindrical pellets. From the current study, the binding material type (cassava starch, either pregelatinized or pretreated by gamma irradiation, or kaolin clay) and concentration (0 to 10 % in mass) as well as moisture content (20-47%) appeared to be the most critical factors during pellets production. It was noticed that the higher the binder concentration, the higher the stability of pellets. This study confirmed that cassava starch is a preferred binding material and that fixing its concentration at 1-3 % could be enough during the pelletization process. The pellets produced in this project had 7.5 to 7.7 mm in diameter, but their length distribution varied depending on the material used.

**Keywords**: Clay, compost, fecal sludge, irradiation, pellets, starch

## 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 (TTZ 2012). In Accra, for example, > 90% of all collected excreta are directly discharged into the ocean. On the other hand, farmers are keen to use the nutrient-rich product resulting in informal sludge markets which are also common in India and other developing countries (Cofie and Adamtey 2009).

While this practice fits some farming systems, it does not fit others and can in addition pose health threats. A solution to address both challenges is to sanitize the sludge and to sell it as dried and pathogen free organo-fertilizer. Initial market studies in Ghana revealed that there is a significant potential for such product (Ankrah and Sarpong 2012). To match the fertilizing requirements, which varied between farming systems, a solution was sought to influence the nutrient value of the final product and to support easier handling/transportation options. The IWMI project team responded to this need by exploring enrichment of fecal compost. Moreover, for SSA soils which have low water holding capacity and are subject to high seasonal torrential rain, leaching of nutrients following application of composts is often observed. High ambient temperatures also cause volatilization of mineral nitrogenous fertilizer and fast degradation of soil organic matter. Above all is the bulkiness of compost which makes it difficult for farmers to store and transport (Adeoye 2012).

Some 15 years ago, researchers from the University of Ibadan (Nigeria) introduced the idea of pelletization to address some of the previously mentioned issues for market waste compost. Doing so, they realized that a binding agent was to be added and they tested various materials such as clays (kaolin and bentonite) and pregelatinized cornstarch at concentrations of 2.5, 10 and 15 %. The pellets they produced had a diameter of 13 mm for a length of 25 mm. Parameters they studied included effects of type and concentration of binder on pellets' mechanical properties such as durability/friability, axial elastic recovery, brittle fracture index, crushing strength, etc. For most parameters, cornstarch used at a concentration of 15 % revealed to be the best additive.

The present research is built on the experience gained from Nigeria and aims at optimizing the pelletization of fecal-sludge based materials.

## Materials and methods

Organic materials included 1) raw dewatered fecal sludge (DFS) sanitized through Gamma radiation (I-DFS); 2) DFS compost (C-DFS); 3) DFS + sawdust (mass ratio: 1/3) co-compost (C-SDFS); 4) compost enriched with ammonium sulfate (EC-DFS). They were individually used for the production of cylindrical pellets (die hole diameter: 8 mm). Two binders, that is cassava starch and kaolin clay, were used. Cassava starch was pretreated through irradiation or pregelatinization. Irradiation consisted of subjecting each material (starch or DFS) to 20 kGy of gamma rays for 2 days. The equipment used for irradiation is available at the Biotechnology and Nuclear Agriculture Research Institute of Ghana. On the other hand, pregelatization consisted of mixing cassava starch, dispersed in limited amount of water, with hot water (80˚C). The amounts of water and starch involved in this process varied depending on the purpose of the research. Tested concentrations of binders ranged between 0 and 10 % in mass while the moisture content varied between 20 and 47%. The equipment used for the pelletization was fabricated in Ghana using locally available materials (including pumps) and local expertise.

Plate 1 presents different raw materials, the equipment used in the pellets production as well as typical pellets obtained in this study.


(a)

(b)

(c)

(d)

(e)

Plate 1. a) Raw DFS; b) C-DFS; c) Grinded C-DFS; d) Locally constructed equipment; e) Typical pellets

After pelletization, pellets were dried and sieved using a grid having 5 mm in pore size. This allowed removal of fines from pellets. The amount of fine particles generated in the process can then be calculated as a percentage of the total feed, in mass. It serves as an indicator of the efficiency of the pelletizer as well as the appropriateness of its operating conditions. In a continuous process, these fine particles should be returned into the mixer (to be re-pelletized), which equivalently increases the volume of processed organic material, compared to the process inflow, this resulting in higher capital and operation costs.

A shaking test was performed to assess how successful pellets could be in maintaining their shape following shaking at 300 motions/min for a duration of 2 hours. This was meant to simulate handling challenges (e.g. transportation) the pellets might undergo from production to usage. Therefore, 120 g of pellets were placed into transparent glass bottle (height = 12.7 cm; diameter: 7.0 cm) to half fill it and shook. Following this shaking, the percentage of particles having more than 5 mm in length was used as an indicator of the stability of pellets.

## Results

<u>Moisture level</u>

From the study, the moisture content appeared to be a critical factor during pellets production. At moisture contents lower than the optimal value, it was visually noted that pellets coming out of the pelletizer were weak and easily break upon contact with the receiving container. Also, the pelletizer easily gets blocked with the feed material (due to its reduced fluidity) causing, at times, excessive heating of the pelletizer motor. On the other hand, at moisture content higher than the optimal value, formed pellets stuck together and excess water drained from the pelletizer.

Suitable moisture levels varied with the nature of the pelletized material as well as with the binder type and concentration. Under similar conditions (i.e. same binder type and concentration), lowest water requirements were for EC-DFS (e.g. 21-25% with starch) and highest requirements for C-SDFS (e.g. 38-42% with starch). The use of clay resulted in the need for higher amounts of water, compared to the use of cassava starch. Finally, in any case, lower amounts of water were required for higher binder concentration. Fig 1 illustrates these last 2 phenomena when C-SDFS was used.

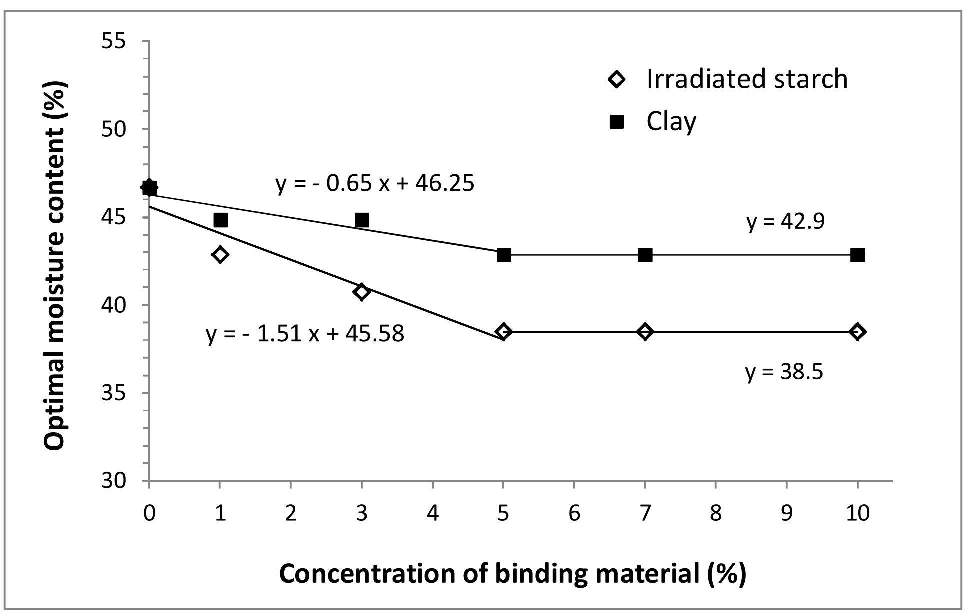


Fig 1: Optimal moisture content for C-SDFS

Efficiency of pellets' production

Fig 2 presents the percentage of fine (non-desired) particles, removed through sieving, obtained following variation in moisture content and irradiated starch concentration for a selected material (C-DFS). Overall, when starch was added (1-5%), the mass of marketable pellets corresponds to about 85-90% of the mass of material fed to the pelletizer. Fig 2 shows that the higher the binding material's concentration, the lower the levels of fines generated during the pelletization process. On the other hand, while moisture contents of 30.4 % and 33.3 % gave similar values, the lowest moisture level was detrimental (high levels of fines) especially when no binder was added during pelletization.

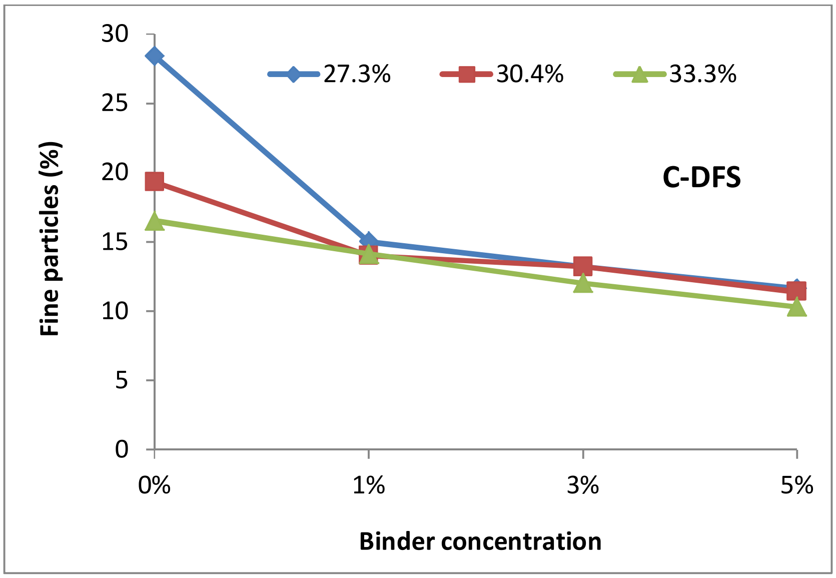


Fig 2: Influence of moisture content on formation of fine particles as a function of irradiated starch concentration for C-DFS

Dimensions of pellets

Pretreatment method applied to the starch, as well as the type of pelletized material, had a marked effect on pellet length distribution. In terms of pellets' length, C-DFS < I-DFS < EC-DFS. However, there was not much difference in the diameter of the various pellets (7.5 mm to 7.7 mm) because of the pelletizer uniform die hole (size: 8 mm). The little variation is the result of the contraction of the pellet which occurred as a result of drying.

Stability of pellets

For all materials, pellets produced with starch (1-5%) under suitable moisture content were proven to be of good stability, i.e. 90-95 % of the initial pellets' mass still being more than 5 mm of length after the shaking test. Higher binding material's concentrations led to higher stability.

## Conclusion

Various operating parameters are of significance for production of fecal sludge-based pellets. But most of them revolved around the binder type and concentration. Based on this study, it is possible to conclude that a starch concentration of 1-3 % could be enough during the pelletization process. This is significantly below the 15 % of pregelatinized cornstarch, recommended from anterior experiments in Nigeria for organic waste compost pelletization (particle diameter: 13 mm, length: 25 mm) (Adeoye 2012). This study confirms that it is possible to produce excreta based pellets in small and medium size enterprises with local machinery. Ongoing studies include testing of the produced pellets in a greenhouse to confirm their suitability for different soil types and crops. Recommendations would then be made for the production of fecal sludge pellets by entrepreneurs.

## References

Adeoye, G.O. 2012 Physico-biochemical analysis of selected binding materials. International Water Management Institute, Internal report, 29p.

Ankrah, A.D. & Owusu, S.E. 2012 A Market Survey for Scaling Up of Fortified Excreta Pellets for Agricultural Use in Ghana. Internal report, International Water Management Institute (IWMI).

Cofie, O., & Adamtey, N. 2009 Nutrient recovery from human excreta for urban and peri-urban agriculture. Paper contributed to the SuSanA Food Security Working Group Meeting during the WEDC International Conference held in Addis Ababa, Ethiopia, 15 April 2009. 12p.

TTZ. 2012 Evaluation of the existing water biotechnologies and water management strategies in the targeted countries. WATERBIOTECH (Project: Biotechnology for Africa's sustainable water supply
Funding Scheme: KBBE.2010.3.5-02), European Union - Grant Agreement number: 265972, 202p.

## Acknowledgements

This project was funded by the Bill and Melinda Gates foundation.