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The use of human waste for peri-urban agriculture in Northern Ghana

O.O. Cofie[1,*], G. Kranjac-Berisavljevic[2], and Pay Drechsel[1]

[1]International Water Management Institute, Sub-Regional Office, Accra, Ghana.
[2]Department of Agricultural Mechanization and Irrigation Technology, University for Development Studies, Tamale, Ghana.
*Corresponding author: o.cofie@cgiar.org

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Abstract

In Ghana, studies on the use of organic materials to increase soil productivity have focused on crop-residue management, use of green and animal manures, and legume cover cropping. Few studies have assessed the use of human waste for agriculture, even though this is widely practiced by farmers in the northern part of the country. This study was carried out to investigate the stakeholders in the use of faecal sludge (FS) for crop production in Tamale and Bolgatanga municipalities in the guinea savanna agroecological zone of Ghana. The aim was to determine the driving factors, constraints and potentials for this practice. Field survey and focus group discussions were carried out among 90 farmers who use FS, and officials of the Municipal Sanitation Unit were interviewed. Sixty-four percent of farmers interviewed used FS as a cost-effective way to improve soil fertility and increase yields of maize and sorghum. Sludge is discharged by spreading it on the soil surface, or it is stored and dried in pits during the dry season and incorporated into the soil at the onset of the rainy season. The high temperatures of the savanna climate and this long period of drying allow sludge to be handled easily. Although this treatment is perceived to reduce the number of pathogens in dried sludge, 22% of farmers complained of itching feet and foot rot after working with FS, which is done without wearing protective foot covering. This constraint is coupled with the foul smell, transport problem and public mockery associated with the use of human waste for agriculture. In spite of these problems, there is competition for FS among farmers, due to benefits derived from its use. Further investigation is required to ascertain the causes of itching feet and foot rot, and there is a need for education on proper handling and appropriate hygiene practices when working with FS. Information regarding optimal FS application rates is also required.

Key words: human waste, faecal sludge, peri-urban agriculture, Ghana

Introduction

Balancing food security and environmental health with increased demand for food and basic infrastructures is of paramount importance in the expanding cities of developing countries. Urbanization in Africa is of the order of 3.5%, three times the rate of rural population growth[1]. Agriculture within and close to the cities could play a major role towards achieving the UN Millennium Development Goal—to reduce the number of people suffering from hunger by half between 1990 and 2015. In addition to supplementing rural agriculture in food supply, agriculture in urban and peri-urban areas creates an avenue for recycling readily available urban wastes, thereby improving the productivity of farming systems as well as environmental health.

In Ghana, as is typical of developing countries, available sanitation facilities are overstretched and human waste management is poor[2]. Sewered excreta disposal systems are rare, due to high costs and scarce water resources. Most sanitation systems for human excreta are on-site facilities, including latrines, non-sewered public toilets and septic tanks. Human waste collected and transported by vacuum trucks to disposal and treatment sites from such on-site installations is commonly referred to as faecal sludge (FS)[3,4]. This type of sludge is highly variable compared to conventional wastewater from sewerage networks, in that it is subject to inconsistent storage duration, temperature and septic tank performance. Since less than 5% of the households in Ghana use sewerage networks, there is significant FS generation.

Although the use of wastewater in agriculture has been well documented in the literature[5–9], direct use of sludge from on-site sanitation systems has not received equal attention. Farmers in China, South-East Asia and parts of

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Africa have used human excreta to fertilize fields and replenish the soil organic fraction[10–13]. Human excreta, like animal manure, is a good soil conditioner and a renewable source of plant nutrients, such as nitrogen, phosphorus and potassium. On a daily basis, each person produces an average of 1.8 liters of excreta, consisting of about 30 g of carbon, 10–12 g of nitrogen, 2 g of phosphorus and 3 g of potassium[6]. The nutrient content of human waste excreted each year is approximately equal to that consumed and to that required for corresponding biomass production[14]. The benefits of using faecal biosolids in agriculture are similar to those for compost. They have been documented by the US Composting Council[15] to include:

- improvement in soil structure, porosity and density, thus creating a better plant root environment; increase in infiltration and permeability of heavy soils, thus reducing erosion and runoff; improvement in water-holding capacity, thus reducing water loss and leaching in sandy soils;
- supply of plant nutrients, as well as significant quantities of organic matter and beneficial microorganisms, to soil and growing media;
- improvement in cation exchange capacity of soils, thus enhancing their ability to hold nutrients for plant use, bind specific pollutants and stabilize pH;
- economic benefits derived from savings in fertilizer cost for the farmer.

In addition to these benefits, there are also potential health consequences associated with FS use. Excreted pathogens—bacteria, viruses, protozoa and helminths (worms)—can be transmitted to humans, thereby causing gastrointestinal and other infections. Two factors, pathogen survival and infective dose, determine whether excreted pathogens are capable of causing disease. The survival rate of pathogens excreted by humans and animals is determined by moisture, pH, temperature and UV light[16,17]. It has been found that worm eggs, such as *Ascaris*, are among the most resistant pathogens in the extra-intestinal environment. The dose required to create disease (infective dose) varies among organisms. For helminths, protozoa and viruses the infective dose is low ($<10^2$), while for bacteria it is medium ($<10^4$) to high ($>10^6$)[6]. While exposure to untreated excreta can cause infection in both field workers and consumers, the thermophilic composting or extended drying of FS can reduce or eliminate the risk of transmission[18].

Agricultural productivity in Ghana

Ghana is a low-income developing country in west Africa, located between latitude 4°44′N and 11°15′N, and within longitudes 3°15′W and 1°12′E, with a total land area of 238,539 km^2. It has a population of about 19 million, an annual population growth rate of 2.7% and population density of 79 persons/km^2 [19]. Urban population is 44% of the total. Administratively, Ghana is divided into ten regions. The Northern, Upper West and Upper East regions constitute the northern sector and form the interior savanna zone of the country.

The mainstay of Ghana's economy is subsistence agriculture. The overall growth rate in the agricultural sector is 2.8%. Ghana's Vision 2020, launched in 1995, targeted an expected annual growth rate of 5–6% for the agricultural sector[20]. However, the Ministry of Food and Agriculture has identified soil fertility decline and soil erosion as major constraints to the desired growth rate. Soils that support agriculture in Ghana developed on thoroughly weathered parent materials that have been leached over a long period of time[21]. As a result, their organic matter content is low. The two most commonly deficient nutrients are N and P, particularly in savanna soils[22]. The build-up of organic matter is further limited by regular burning of crop residues and removal of residues for fuel, animal feed or building purposes[23]. Food supply-and-demand analysis[24] indicates a deficit in the supply of all food items in Ghana. Strategies to increase crop production through the use of chemical fertilizer have been impeded by withdrawal of government subsidies on fertilizer and limited access to credit for farmers. Fertilizer imports declined from 45,000 tonnes in 1990 to 11,000 tonnes in 1994[25], and fertilizer use declined from 4.5 to 2.9 kg ha^{-1} between 1990 and 1996[23].

In Northern Ghana, farmers frequently resort to FS as an alternative to chemical fertilizer. Owusu-Bennoah and Visker[26] reported that 90% of collected night soil in Tamale municipality was used as fertilizer by farmers, although the extent of health and environmental risks involved is not yet documented. The municipal authority frowns at this practice even though no alternative sludge treatment is available. The objective of this study was to assess the farmers using FS as a soil modifier in Northern Ghana, to determine the driving factors, constraints and potentials associated with this practice.

Study Methods

This study was carried out in two municipalities of northern Ghana, Tamale and Bolgatanga, and involved selected farming communities within the municipalities.

Description of the study area

Tamale municipality is the largest in Northern Ghana, with an urban population of about 200,000. Characterized by distinct rainy and dry seasons, the area has a unimodal rainfall pattern with mean annual rainfall of 1000 mm, occurring mainly during August–September (Fig. 1) and a mean annual temperature of around 29°C[27]. In Tamale, where sanitary conditions are generally poor, the average volume of faecal sludge generated annually is 30,607 m^3 [28]. There is no functional treatment facility in the city and no single point for disposal of faecal sludge. Over ten disposal sites are in use around the city, on available land perceived

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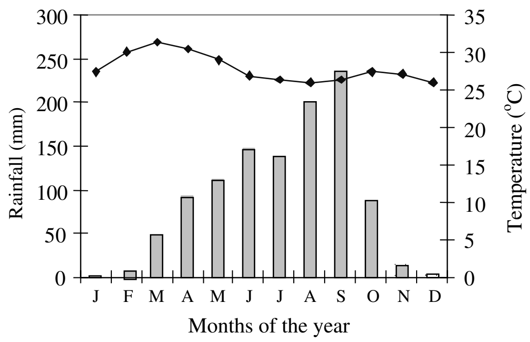

Figure 1. Variation in monthly rainfall (bars) and temperature (line) in Tamale (averages generated from 30 years of climatic data[27]).

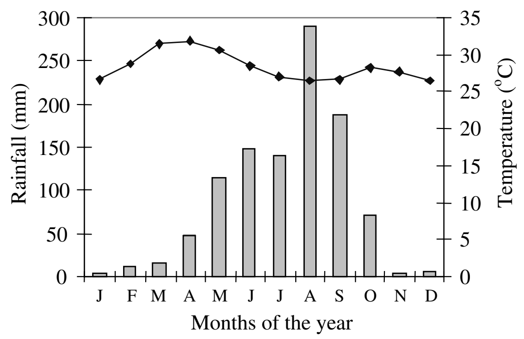

Figure 2. Variation in monthly rainfall (bars) and temperature (line) in Bolgatanga (averages generated from 10 years of climatic data[27]).

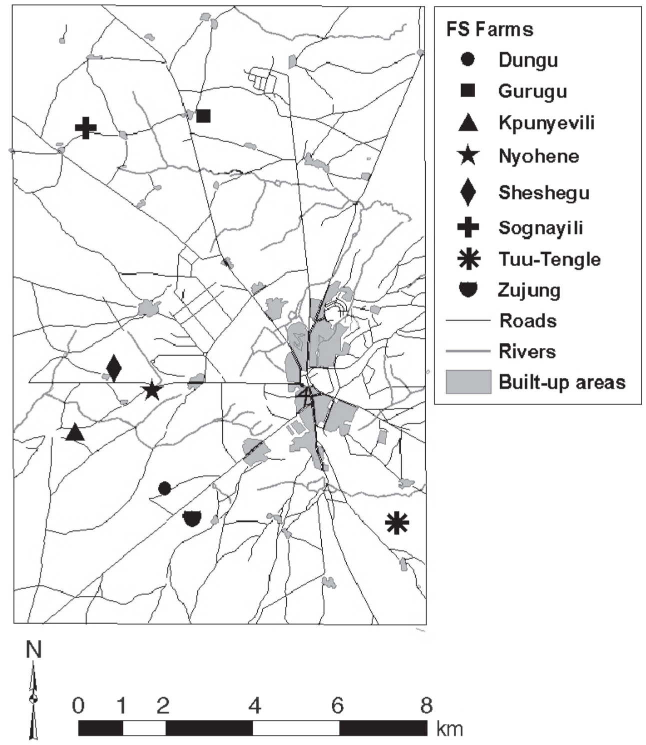

Figure 3. Locations of faecal sludge (FS) farming communities in Tamale municipality.

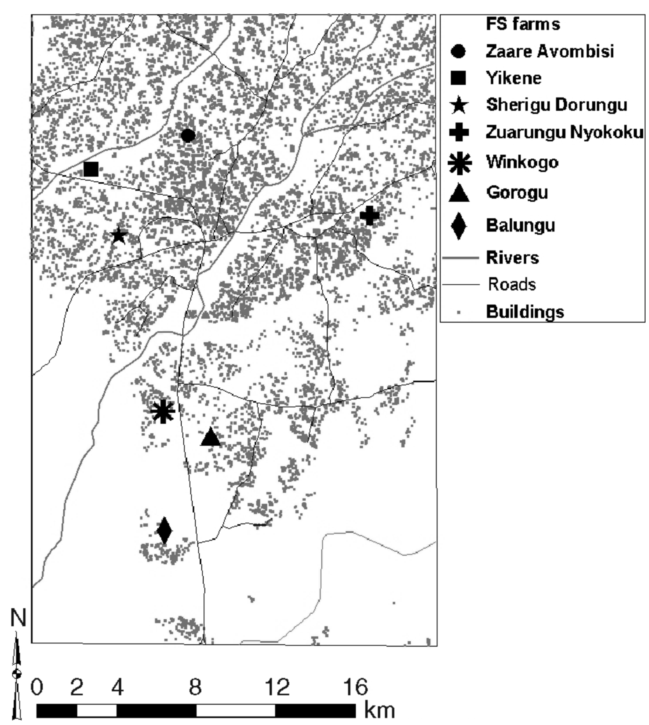

Figure 4. Locations of faecal sludge (FS) farming communities in Bolgatanga municipality.

to be in a 'convenient' location. A sanitary landfill is currently under construction, but in the meantime FS is discharged onto open lands and nearby streams around the city. Eighty-three percent of the FS generated is collected and disposed of by the Municipal Sanitation Unit, while 17% is disposed of by individual households, particularly those using bucket-type toilet facilities. Toilet facilities are not adequate. A survey conducted in 100 households[29] revealed that 37% had household toilet facilities, such as water closets (15%), ventilated improved pit latrine (6%) and bucket latrines (16%). Fifty-one percent of the surveyed households used public toilets, while the rest (12%) had no confined toilet facilities.

Bolgatanga district has a population of about 228,000, of which 49,000 inhabit the city of Bolgatanga[19]. The rainfall average for 10 years (1993–2002) was 1012 mm per annum, with a peak usually in August (Fig. 2). The average annual temperature is about 28.4°C. The city of Bolgatanga has no treatment plant for processing human faeces. Faecal sludge is collected by the Municipal Sanitation Unit and deposited at a designated site, where it is available to farmers. It is estimated that 426 truckloads, 6.75 m^3 each, are deposited at the designated site annually, making a total of 2876 m^3 of collected sludge. Because a great proportion of human faeces is not collected, actual amounts of FS generated are much greater. However, according to Ghana Statistics Service[19], only 20% of households in Ghana lack access to toilet facilities, from 5% in the Greater Accra Region to 79% in Upper East Region where Bolgatanga is located.

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Box 1. Questionnaire

The use of human waste for peri-urban agriculture in Northern Ghana
Questionnaire No.: ...... Community: .... Interviewer: .... Date:.................

Particulars of respondents
Name: ....
Sex: ....
Age: ....
Are you a household head? Yes/No
How long have you been farming?....................
Household composition/size. Men: ....Women: ....Children: ....

Farming practices
What is the farming system? ....
What is the land tenure arrangement? ....
Which crops do you cultivate? indicate: Crop...................Plot size............................Yield/plot.............................
Who undertakes the following operations (by gender) and for how long?
(i) Land preparation..................; (ii) Planting...................; (iii) Weeding...................; (iv) Faecal sludge management ....; (v) Harvesting......................; (vi) Carting....................; (vii) Marketing................
What farmers' organizations exist in the community?..
Do you belong to any farmers' organization? Yes/No
If yes, which one and what is the nature of support you receive from them?..
What problems do you face in practicing agriculture in/around the municipality?..
Do you get support for peri-urban agriculture? Yes/No
If yes, indicate form of support for agriculture: Cash................; Inputs................; Others.......................
Do you use any of these inputs: fertilizer; manure; labor; water; compost; pesticide; farm residue; faecal sludge?
Are the inputs readily available? Yes/No
Do you encounter problems in obtaining them? Yes/No If yes, list: ....
What other employment opportunities exist apart from farming? ....
What proportion of farm yields contribute to household food security? ....
What is the contribution to cash security? ....
List other contributions from farm yields: ....

Faecal sludge (FS) utilization
Why do you use FS? ....
For how long have you been using FS in agriculture? ....
Which type of FS do you use: high strength (public toilet sludge); low strength (septage)?
What are the sources of FS? ....
Is the FS easily available? Yes/No
How long does it take you to receive your requirements of FS? ....
Do you get all your requirements? Yes/No
How much do you pay for FS? ....
How much FS do you apply in your farm? ....
How do you apply (use) the FS in your farm? ....
What has been your farm yield before FS use? (Quantify) ....
What is your current yield with the FS use? (Quantify)..
Are there any social constraints to the use of FS? Yes/No
If yes, name them. ....
Does the food produced using FS pose any health problems? Yes/No
What health hazards does the application of FS give? ....
What are the problems associated with the use of FS in agriculture? ....
What are the benefits you derived from the use of FS? (list) ....

Data collection

Field data were collected in 2002 through interviews and focus group discussions with farmers and Municipal Sanitation Unit officials. There was an initial reconnaissance survey within and around Tamale and Bolgatanga to identify communities using FS (Figs 3 and 4), to promote the study and to pre-test the questionnaire (Box 1). In all,

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90 farmers were interviewed. The questionnaire included a list of open-ended questions directed toward farmers, farm characteristics and FS utilization. Data collected were subjected to descriptive statistics using SPSS version 10.

Results and Discussion

General information on respondents

Of the 90 farmers interviewed, 43 were from five farming communities within the Tamale municipal area, while 47 belonged to six farming communities within Bolgantanga. More than half were between 50 and 69 years of age, and they averaged 25 years' farming experience. Ninety-four percent of respondents were male, and female respondents were mainly located in Bolgatanga. Prevailing cultural traditions in Northern Ghana do not favor female ownership of land, which leaves land ownership entirely in the hands of men.

Among surveyed farmers, 84% had acquired their land through inheritance, while the remaining 16% farmed land under hired or borrowed lease agreements, or communal tenure. Hired land indicates release of land by a landowner to another person for a token fee. Borrowed land means that the landowner (usually head of a household) has turned over use of a piece of land to another person without compensation. Both of these agreements may be revoked at any time. Communal tenure is a system of community land ownership that varies from place to place. In the study area, it involves leasing land to a group of individuals living within the same household. Eighty-four percent of surveyed farmers were heads of households, with an average household size of 13 members. Household size is a reflection of the traditional social structure in Northern Ghana, where it is common practice to find extended family members living together.

Farming is the primary source of income for 57% of farmers surveyed and average farm size is 1 ha. Farming systems are dominated by mixed cropping, mixed farming (crop and livestock production) and mono-cropping of cereals. In a few cases, cereals are rotated with legumes, but a majority (74%) of farmers surveyed grow maize, sorghum, millet and vegetables in mixed cropping systems. Both male and female members of households comprise the farm workforce, though their labors are allocated to different farm activities. Men are generally responsible for land preparation (93% of respondents), weeding (76%) and FS management (70%), while women are more involved in planting (50%) and marketing (64%) farm produce. Many farmers indicated that poor soil fertility, crop destruction by animals or bush fires, lack of funds and a shortage of farm land are critical problems (Fig. 5), and that use of FS is a cost-effective means to improve their farm productivity.

Utilization of faecal sludge for cereal production

All sampled farmers use FS for cultivation of cereals, mostly maize, sorghum and millet. Some use other sources

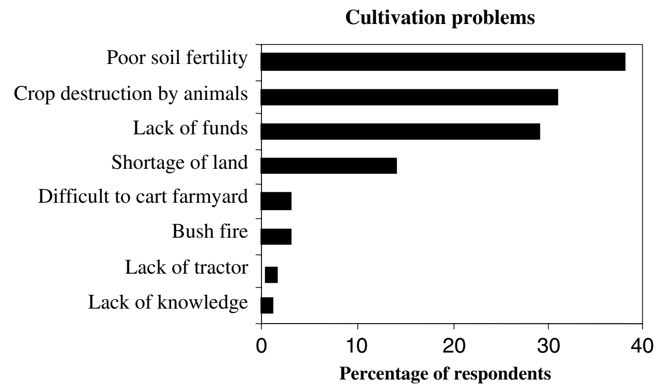

Figure 5. Farmers' description of cultivation problems in Northern Ghana.

of nutrients, such as farm residues (69%), chemical fertilizer (28%), farmyard manure (21%), household refuse (11%) and compost (6%). However, this was not on a regular basis, due to the cost of fertilizer (NPK fertilizer is about $US17 per 50 kg bag), possession of too few animals to generate manure, and the difficulty, as well as labor involved, in transporting and composting farmyard manure. All farmers indicated their preference for FS.

Farmers use different types of sludge, depending on preference and availability. Generally, they prefer stabilized septage from septic tanks. However, as this is not readily available, only 32% of respondents use septage, while the remainder use either unstabilized public toilet sludge or a mixture of septage and public toilet sludge. Although some farmers have used FS for over 30 years, an average of 8 years was recorded. Half of the farmers learned to use FS from their neighbors, but about 10% discovered it through accidental deposition on their farmland by the waste management department. Forty-four percent of farmers indicated that the main reason for using FS is to improve the productive capacity of soil. Other reasons mentioned were to increase crop yield (20%) and to save the expense of inorganic fertilizer (7%). The decision to use FS is based on (often two- or threefold) higher yields of crops grown on FS-treated soils as compared to untreated soils. Moreover, the use of FS involves less labor than is required to collect and compost farmyard manure, and FS is free except for 'tips' given to the truck driver, about $US2 per load of discharged sludge. Twenty-nine percent of respondents did not indicate a reason for using FS.

Methods of cultivation with faecal sludge

Experience acquired over the years has led farmers in Tamale and Bolgatanga to devise specific methods for handling FS for crop production, methods that take advantage of the high temperatures of the savanna climate. They discharge FS on farms during the dry season by one of two means: surface spreading or the 'pit' method.

Table 1. Estimated amount of nutrients applied in faecal sludge by Tamale farmers[1].

Nutrient type	Nutrient concentration (kg)	
	Total ($kg\,m^{-3}$)	Amount applied ($kg\,ha^{-1}$)[2]
Nitrogen (N)	8.2	455
Phosphorus (P)	1.1	61
Potassium (K)	2.2	121
Carbon (C)	21.3	1183

[1] Calculated after Drangert[14], based on the nutrient concentration in human faeces per person-year.
[2] Approximately 56 m^3 of raw sludge is applied per ha in Tamale.

Surface spreading. This involves the discharge of faecal sludge at random points (accessible to the septic emptier) within farmers' fields in November. By the end of the season, the discharged FS becomes very dry and is redistributed evenly across fields before cultivation. As shown in Figure 1, the dry season lasts from November through March or April, when temperature and solar radiation are high and relative humidity is low (generally less than 50%, and as low as 5% in January). These conditions allow the sludge to be handled easily when incorporated into the soil. Moreover, health risks associated with the use of FS are reduced since most microorganisms contained in the sludge are killed by prolonged high temperature and low moisture. According to Feachem et al.[16], the survival time of pathogenic bacteria, viruses and protozoa in FS is less than 100 days, significantly less time than the dry season, which lasts between 120 and 150 days. However, helminths can survive for several months.

The 'pit' method. This method for FS application involves the use of large pits containing rice/maize straw or bran at the bottom. Faecal sludge is then poured into the pit, requiring several trips of the emptying truck. Bran and straw are placed between layers of discharged sludge until the pit is full. The pit is left open for several months to compost until the cropping season begins, when the mixture is applied evenly across the field.

The pit method is not as widely used as the surface spreading method because it requires more labor to gather the high quantities of crop residue used in the process. Moreover, more time is required to compost, dry and spread the FS across the farm.

The use of FS for cultivation in Northern Ghana is mostly restricted to cereals, such as maize, sorghum and millet. The harvested parts of these crops do not come into contact with FS-treated soil. Farmers have learned not to use FS for the production of legumes, such as groundnut, as it causes luxurious vegetative growth but poor pod yield.

Nutrients supplied through faecal sludge use in Tamale

Five trips of the suction truck are used to fertilize 1 acre of land (0.4 ha), an average of 55.63 m^3 FS per hectare.

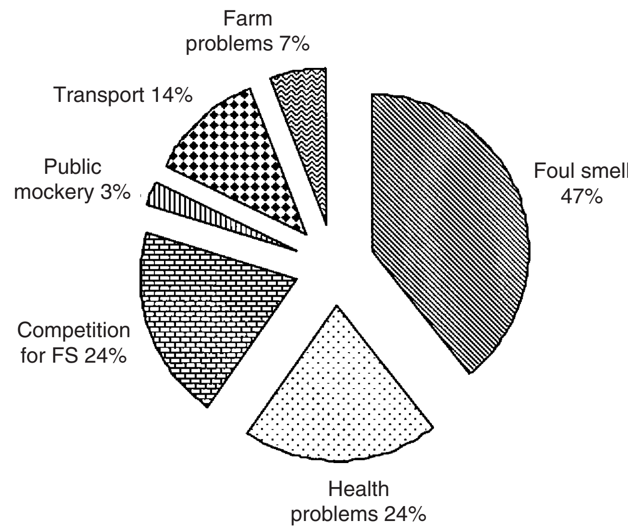

Figure 6. Farmers' description of problems associated with FS application in Tamale and Bolgatanga. The category 'Farm problems' (7%) includes increased weed infestation and labor requirements, the need for protective clothing and potential crop death with excess FS application.

Through this practice, significant amounts of plant nutrients, such as nitrogen (N), phosphorus (P) and potassium (K), are returned to the soil. In addition, the organic matter level of soil gradually increases. Based on the average concentration of nutrients in human excreta, as reported by Drangert[14], estimated amounts of N, P, K and carbon in applied sludge are presented in Table 1. This estimate does not account for nutrient loss during sludge storage in septic tanks or in the field. Considering the current FS application rate by farmers, about 550 ha of land can be fertilized annually using faecal sludge generated in the Tamale municipality alone. For Bolgatanga, the potential area covered is much lower, about 52 ha, under the same application rates. Optimal FS application rates have not been determined for Northern Ghana. This requires further research, to provide guidance for farmers and municipal authorities.

Problems associated with the use of faecal sludge: farmers' perspectives

During focal group discussions and interviews with farmers, the following issues were highlighted as the main constraints associated with use of FS for crop cultivation (Fig. 6):

- Bad odor. About half of respondents (47%) indicated that bad odor of FS is a major constraint to its use. Farmers are not allowed to use sludge in backyard gardens, particularly in highly populated areas.
- Competition for FS. Twenty-four percent of surveyed farmers complained of competition for FS. Some farmers must wait for 1–2 months from the time of request until FS is delivered to their farms.
- Increase in urban population. As agricultural lands become human settlements, FS users are pushed towards

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peri-urban areas. Moreover, suction truck drivers are reluctant to deliver faecal sludge to fields too distant from cities as it is not profitable. Fourteen percent of respondents indicated that transport is a problem.
- Negative attitude of other people towards the use of human waste. Landlords often do not allow use of FS on their land despite positive effects on soil fertility. This is probably due to concerns about weed build-up and odor.
- Weed infestation (2%). Due to its high fertilization effect, FS increases weed populations.
- Need for protective clothing and extra labor during FS application (4%).
- Death of the crop when FS is applied in excess (1%).
- Consumer shunning of crops produced using FS (4%). Some people believe that taste is diminished and there is a tendency for maize and millet to be reddish in color.
- Health problems associated with handling FS. Some 24% of farmers had experienced health problems during land preparation involving FS, which was done without protective foot covering. While 22% experienced itching feet and foot rot, 2% observed headache and catarrh. This observation was irrespective of the method of FS application. All farmers who had experienced itching feet were residents of three communities in Bolgatanga, while those complaining of foot rot belonged to three communities in Tamale. However, both groups comprised less than half of the surveyed farmers in either community. Itching feet and foot rot are probably due to excreted parasitic helminth worms capable of penetrating bare feet. This indicates that some microorganisms remain viable in spite of the long drying period.

Conclusions

For many years, farmers in the guinea savanna zone of Ghana have used FS in agriculture. Sludge discharged on farms during the dry season is incorporated into the soil at the start of the rainy season, after 3–4 months of drying. Constraints associated with this practice include competition for FS, foul smell of the sludge, lack of transport, excessive weed infestation and health issues, primarily itching feet and foot rot following FS application. Yet, these concerns do not hinder farmers from scouting for FS at the onset of the drying season. Farmers are motivated to use FS because it: (1) is an inexpensive alternative to fertilizer; (2) increases the productive capacity of the soil; (3) results in increased crop yields; and (4) improves household food security and earnings.

However, there is a need to educate farmers regarding modes of disease transmission and the proper handling of FS, using protective boots, nose pads and hand gloves. Information on simple cost-effective methods for decontaminating FS is also needed. Presently, farmers use an extended drying period to decontaminate FS, but the frequent occurrence of foot rot and other health problems suggests that some pathogens are not eradicated by this approach. In Ghana, further research is needed to assess: (1) the impact of FS use on agricultural productivity and crop quality, especially in comparison with manure and fertilizer; (2) optimal FS application rates; and (3) the long-term consequences of FS use on farmer/consumer health and the environment.

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