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Effect Estimation of Dry-Toilet Application for Rural Farmer Family in Burkina Faso

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Abstract: Water, sanitation and agriculture are important issues in Burkina Faso. In arid areas where water is significantly important resources, a dry-toilet-based resource recycling sanitation system seems more suitable than a conventional water-flush-toilet-based sanitation system. For designing that kind of sanitation system, the important factor is not only the treatment technology but also the material flow design of the total system. As a first step for designing the optimal material flow, this study carried out a household survey in the rural area of Burkina Faso, to reveal the current condition of water related material flow in and around a household. According to the results, the effect of the resource recycling sanitation system application was estimated as follows. Urine can replace almost half of chemical fertilizer. Graywater reuse allows this household to expand only 17 to 37 m^2 of vegetable garden however, it can irrigate through a year to the adjacent vegetable garden. This may enable a different schedule of cultivation to what is generally practiced with the farmer cultivating and selling produce strategically.

Key Words: Composting toilet, Urine reuse, Water reuse

1. Introduction

Burkina Faso, located in the Sub-Sahara, belongs to the semiarid area and the main soil type are Lixisols (FAO, 1991). It is possible to undertake agriculture but conditions are severe. A system that provides efficient usage of water and fertilizer is desired. On the other hand, the proportion of population using an improved sanitation facility was only 11% in 2008 (UN, 2010). The under-five mortality rate is 11th highest in the world; 169 per 1000 live birth and diarrhea occupies 19% of causes of these deaths (WHO, 2010). Water and sanitation are clearly urgent issues in Burkina Faso.

Direct disposal of human excreta or graywater causes deterioration of sanitary condition, though they have high potential as fertilizer or irrigation water. Water, sanitation and agriculture issues are closely related to each other in the living environment therefore the solution should be discussed those issues comprehensively.

Some of authors are proposing a comprehensive concept of sanitation system which recycles human excreta and wastewater with dry-toilet, which does not use flush water or expensive infrastructure, and has a simple graywater treatment facility such as slanted soil system (**Fig. 1**, Lopez *et al*., 2002). The main target is rural areas because only small increases in distribution of improved sanitation are observed there. It is however not easy to make rural people invest in sanitation system because of their low income. Especially for sanitation, the expected results of improved sanitation are improvement of public health however it takes time until general citizens can recognize the benefit of that improvement. Some other clear incentive is necessary.

One possibility is obtaining an income increase through a resource recycling system. In our concept, wastewater and excreta will have new values as irrigation water and fertilizer, and this will provide another value as agricultural products following cultivation. If farmers could sell the products and increase their income, it will be a great incentive for adoption.

To create an incentive as mentioned above, the current condition of water and material flows in a rural household including agricultural activity should be analyzed first. In this study, firstly water and material flow is described through a detailed interview survey on one rural household. Additional information about agricultural activity for vegetable cultivation is described following a field interview. The effect of application of the resource recycling sanitation system is evaluated.

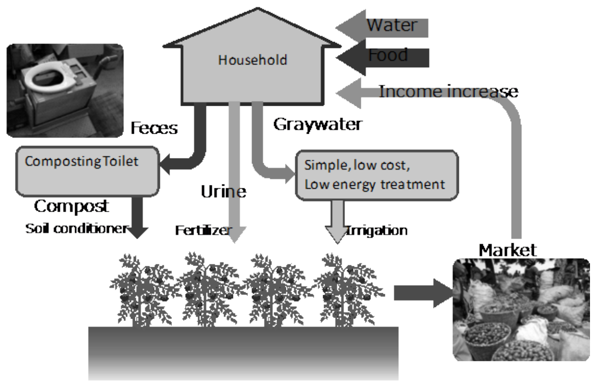

Fig. 1. Location of field.

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Fig. 2. Location of field.

Fig.3. Outside view of Mr. OP's resident.

Fig.4. Water storage crock.

2. Materials and Methods

2.1. Material flow survey

Field investigations were undertaken in the rural area of Ziniaré commune (**Fig. 2**) which is located about 35 km from the capital Ouagadougou. An interview survey was held for one agricultural household in Kologondiessé village on 12th and 17th September 2010. This household was chosen randomly from 20 households, those the village chief chose and allowed us to undertake an interview survey.

The content of the interview concerns water source, usage and discharge, agricultural activities and so on. The purpose of this research is to reveal whole material flow, therefore a nondirective interview was applied. To avoid misunderstanding, visual observation in the site was combined with interview.

2.2. Agricultural activity survey

An additional interview survey was held in four vegetable gardens in Ouagadougou on 24th and 30th March 2011. As indicated by Kedwide *et al*. (2009), many vegetable gardens are located along reservoirs. Three of four study sites are located along the Numèro Reservoir and one is located along a small reservoir (name unknown). Interview to farmers about their vegetable cultivation activity including selling activity was carried out.

3. Results and Discussion

3.1. Material flow survey

3.1.1. Overview of the household

The household consisted of 18 person including 3 babies. **Figure 3** shows outside view of their house. The interviewee was an adult male person. In this article, the pseudonym "Mr. OP" is used. The main income source of this household was selling vegetable and livestock and most of their food was supplied from their own farmland.

3.1.2. Water use

Water for use in the walled house area, called concession, was carried from a well with manual pump, which is about 150 m from the house. Water was carried in a 20 L plastic tank, and stored in ceramic crocks with a capacity of about 100 L (**Fig. 4**). This water was used for drinking, cooking, dish washing and bathing. The total amount of water use in a day by this household was 100 to 200 L. Therefore per capita use is estimated as 7 to 14 L/day; here we ignored the three babies as water consumers. This is smaller than reported amount in developing countries (FAO, 2010). One shallow well existed about 50 m from the house. Mr. OP's family used this water only for washing cloth, livestock and small vegetable garden. This shallow well dries up in the dry season, therefore, they have to go to the reservoir, about 4 km from the house, and wash clothes and give water to livestock there.

All wastewater generated in the concession was disposed to the ground directly. Because the ground in the concession was beard soil, disposed wastewater can be absorbed and dried easily. Possible materials contained in the graywater from this family were organic material from food residues and detergent for dish washing and bathing. Regarding organic material, most came from self produced crops and vegetables. The only thing they bought from market was seasoning such as salts and cooking oil. Regarding detergent, they used only natural soap made from the seeds of *Vitellaria paradoxa*. Synthetic detergents were not popular in this village.

The family generally urinated outside of the concession but sometimes urinated in the bathing area. They defecated outside or in the shared toilet, which was pit latrine, located about 70 m from the house. They were constructing their own new pit latrine, however the construction was stopped because of limited money.

3.1.3. Agriculture in the household

Mr. OP's family cultivated crops, such as millet, sorghum, and corn in the farmland around the concession. This was the main food for this family. Water supply for crops was only rainfall. No fertilizer was used except for compost made from agricultural waste.

The family also cultivated vegetables, such as tomato, onion, eggplant, green pepper in two vegetable gardens; a small one (6 m × 10 m approximately) near the shallow well, and a larger one in the reservoir side (area is unknown). They used chemical fertilizer for vegetable gardens; 300 kg/year of NPK fertilizer containing 15% of N, 6.5% of P and 12% of K respectively and 100 kg/year of urea fertilizer containing 46% of N. Both fertilizers were popular and sold in general stores. The price, Mr. OP bought was 17,500 FCFA/50 kg (approximately 3,500 JPY/50 kg) and 15,000 FCFA/50 kg (approximately 3,000 JPY/50 kg) respectively. There was no record of yield amount and price. Only for tomato and onion, which were main products, we could estimate by rough amount and price range of last year. Estimated annual sales value was 225,000 to 525,000 FCFA for tomato, and 150,000 to 550,000 FCFA for onion.

3.1.4. Material flow

Figures 5 and 6 show schematic views of the material flow of water and phosphorus respectively. Each flow value was estimated from interview and reference (Lopez, 2004). Although there are some unknown values, the following are shown; the volume of disposed water is comparable to that of irrigation water in a small vegetable garden, and phosphorus disposed as urine or feces is comparable to the total amount of provided phosphorus as fertilizer.

3.2. Agricultural activity survey

Table 1 shows characteristics of four vegetable gardens. In all sites, vegetables were cultivated with both chemical fertilizer and livestock waste. Cultivation season was from October or November to May or April in all sites. It almost corresponds to the dry season. Vegetables were bought by broker who came to buy, in all sites.

Table 2 shows one example of annual price fluctuation obtained by interview. Price rises at the beginning and the end of the dry season. It corresponds to the season vegetables cannot be harvested in the above mentioned schedule.

3.3. Effect estimation

3.3.1. Graywater reuse

All parts of graywater was disposed to the ground directly. If all of these graywater were reused for vegetable garden, available amount is 85 to 185 L/day, from which was deducted the estimated drinking amount of 1 L/person/day for 15

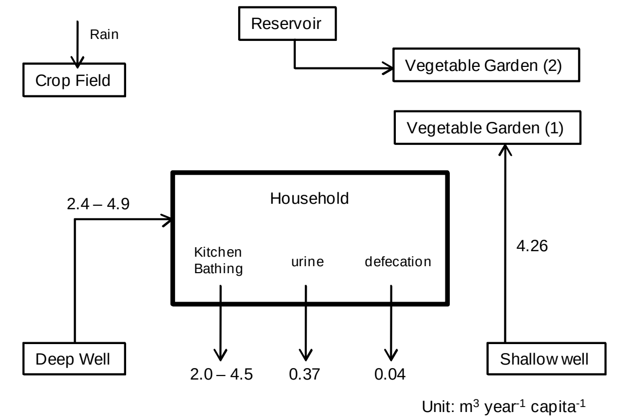

Fig. 5. Material flow in Mr. OP's household (water volume).

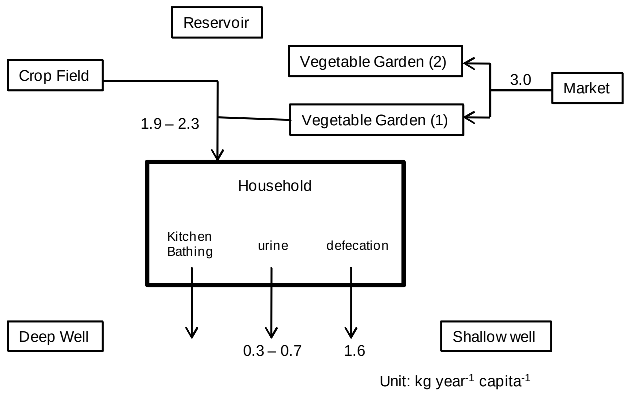

Fig. 6. Material flow in Mr. OP's household (Phosphorus).

Table 1. Material flow

	Water source	Chemical fertilizer	Manure	Pesticide	Vegetable
Site A	River	Use	livestock waste	Use	L, Cbg
Site B	shallow well	Use	Livestock waste + city waste	Use	T, L, B
Site C	shallow well	Use	Livestock waste	Use	L, Cbg, T, O, Crt, B
Site D	shallow well	Use	Livestock waste	Use	L, Cbg, O, Crt, E, S

L: Lettuce, Cbg: Cabbage, T: Tomato, B: Bronble
O: Onion, Crt: Carrot, E: Egg plant, S: Strawberry

Table 2. Example of annual fluctuation of vegetable price.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Price	cheap		well		Expensive		?	Expensive			well	cheap
Onion	4,000 - 10,000 FCFA/bag*							25,000-30,000 FCFA/bag*				
Tomato	3,500 FCFA/20L									10,000 FCFA/20L		
Lettuce	4,000 FCFA/area (1.5 × 10 m)									7,500 FCFA/area (1.5 × 10 m)		
Blonble	1,000 FCFA/area (1.5 × 10 m)									2,000 FCFA/area (1.5 × 10 m)		

* Farmers were using plastic bags for 50 kg of chemical fertilizer

Table 3. Current fertilizer use and potential of urine.

	N (kg/year)	P (kg/year)	K (kg/year)
Current use of chemical fertilizer			
NPK fertilizer ×300kg/year	45	20	37
UREA fertilizer ×100kg/year	46	0	0
Total	91	20	37
Urine contents			
Individual	3.2	0.29 – 0.73	0.99
Household total (15 person)	48	4.4 - 11	15
Percentage vs current use	53%	22～56%	40%

persons from total water use. Required amount of water for 1 m^2 vegetable garden was estimated as 5 L/day/m^2, with following to FAO manual (Brouwer and Heibloem, 1986) and assuming tomato cultivation under the dry season of Burkina Faso. This amount roughly corresponds to currently supplying amount (4.6 L/day/m^2) estimated from the interview result.

As a result, additionally available vegetable garden is estimated as 17 to 37 m^2. This area corresponds to only 1/3 to 1/2 of Mr. OP's smaller vegetable garden, however, he can irrigate through a year to the vegetable garden near his house. This gives a chance for Mr. OP to sell vegetables in a better price. Of course, some treatment should be done for graywater to avoid growth inhibition of vegetables and health risk for vegetable consumers. Slanted soil treatment system, which requires no energy consumption and low initial cost, is one of candidate technologies. Ushijima *et al*. (2011) reported that the slanted soil system achieved enough treatment performance to avoid above mentioned two problems. Therefore, the balance of initial cost of this system in Burkina Faso and expected income increase by graywater reuse is the key issue to be discussed in the future.

3.3.2. Urine utilization for vegetable garden

In this article, as a potential evaluation, nitrogen (N), phosphorus (P), potassium (K) amounts are compared between currently used chemical fertilizer and urine, which contains few pathogens in general. **Table 3** shows the results. Regarding to N and P, almost 1/2 can be replaced by urine. Regarding to P, 1/5 to 1/2 can be replaced by urine. A large part of P is discharged as feces (1.6 kg/year) (Lopez, 2004), therefore if feces is added in safe way such as compost, about 70% of P can be replaced by urine and feces in maximum.

4. Conclusion

Based on detailed interview, the effect of a resource recycling sanitation system application was estimated as follows. Urine can replace almost half of chemical fertilizer. Graywater reuse allows this household to expand vegetable garden only 17 to 37 m^2 however, it can irrigate through a year to the garden near from house. This may enable to cultivate in different schedule from general one, and farmer can cultivate and sell more strategically.

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