implementing organisation:

Opening minds and closing loops – productive sanitation initiatives in Burkina Faso and Niger

This paper shows how two agriculture funded sanitation projects in rural Niger and Burkina Faso have introduced sanitized urine and faeces as new fertilizers for improved local nutrient management, food security and health.

Authors: L. Dagerskog, M. Bonzi

Abstract

The link between food production and sanitation is at the centre of two agriculture funded sanitation projects in Burkina Faso and Niger. Productive sanitation is used to increase food security, based on the fact that urine and faeces from a family of ten contain nutrients equivalent to approximately 100 kg of chemical fertilizer, locally worth ~80 US$. Urine contains the main part of these nutrients and is relatively easy to collect and reuse. The agriculture extension officers have a key role in supervising participative tests with urine as a fertilizer that help create demand for sanitation. Farmers are trained on how to produce liquid and solid fertilizers from urine and faeces, by eliminating the dangers and capturing the resources via the good use of simple urinals and "productive toilets". The article describes the arguments and methodology used in the projects and perspectives for up scaling in Burkina Faso and Niger.

Introduction

By emphasising the strong link between sanitation and agriculture, the Regional Centre for low cost Water and Sanitation (Centre Régional pour l'Eau Potable et l'Assainissement à faible coût, CREPA) has obtained funds from the agriculture sector with the main objective to improve food production in rural areas via the promotion of sanitized urine and faeces as fertilizers. The two main productive sanitation projects at the moment are the ECOSAN_UE$_2$ project in province of Kourittenga, Burkina Faso, and the PS-Aguié project in the province of Aguié, Niger (see boxes at the end of the article). Urine is central in both projects, since it is relatively easy and cheap to collect and represents a substantial and often neglected source of nutrients. This article develops the arguments used to involve the agriculture stakeholders and the methodology and current results of the two projects.

Nutrient management and the link to sanitation

The big picture

On a global level, the price hike of chemical fertilizers in 2008 and the emerging "peak phosphorous" and "peak oil" indicate that the era of cheap chemical fertilizers is coming to an end (see Cordell, 2010 for details). Since there is no substitute for phosphorous in food production, our societies will need to improve nutrient management on all steps along the productive cycle.

The agriculture sector is trying to reduce nutrient losses from soils as well as recycling animal manure and plant residues, but relatively little effort has been made to recycle the nutrients present in the food taken away from the field for human consumption, and subsequently excreted

Key actions for introducing sanitized urine and faeces as fertilizers:

- Illustrative examples of the quantity of fertilizer in human excreta and results of reuse
- Simple urinals for "liquid fertilizer" production and composting/dry latrines for "solid fertilizer" production
- Involve the agriculture extension officers
- Participative evaluation of urine as a fertilizer to create demand for productive sanitation
- Sensitization on dangers and resources in excreta – and how to eliminate dangers and maintain the **resources**
- Follow up on the whole productive sanitation chain i.e. collection, sanitization and reuse.

as urine and faeces. The global phosphorous flow analysis by Cordell et al. (2009) estimates that only 10% of phosphorous in human excreta is recycled to arable soil, while 50% ends up in water and 40% under-ground or on non-arable soil. These losses are equivalent to around 20% of the annual phosphorous mined (Cordell et al. 2009).

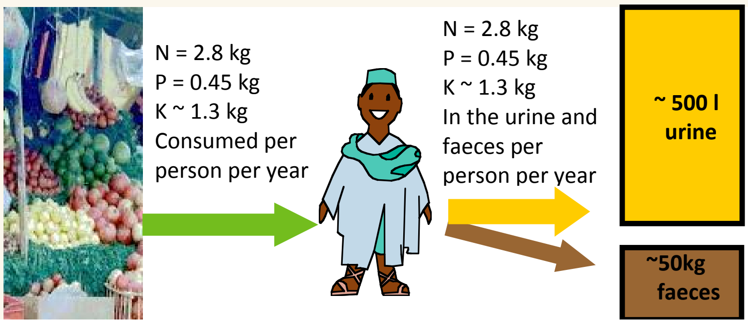

Figure 1. The average annual fertilizer production per person

In Burkina Faso and Niger chemical fertilizers are out of reach for most farmers, while a growing population increases the pressure on arable land. Table 1 shows the difficult soil fertility and sanitary situation in these two countries with low chemical fertilizer use, high nutrient losses from agricultural land, a high percentage of open defecation in rural areas and a high number of child deaths per year due to diarrhoea.

Safe recycling of urine and faeces can help improve both food production and health, but the farmers are rarely aware of the possibilities of how to "eliminate the danger" and "use the resources" in human excreta.

Table 1. Challenges with soil fertility and sanitation in Burkina Faso and Niger

	Burkina Faso	Niger
Chemical fertilizer use 1996-2002[1] (kg NPK*/ha/yr)	5.9	0.9
Estimated nutrient balance 2002-2004[2] (kg NPK*/ha/yr)	- 43	- 56
Open defecation in rural areas in 2006[3] (%)	83	92
Annual child deaths due to diarrhoea[4]	24 300	26 400

* NPK = $N+P_2O_5+K_2O$
[1] Morris et al (2007)
[2] Henau and Baanante (2006)
[3] UNICEF/WHO (2008)
[4] UNICEF/WHO (2009)

The fertilizer value of human excreta

To capture the attention of agriculture stakeholders it is important show that human excreta contain a substantial amount of plant nutrients. According to Jönsson et al. (2004) the amount of nitrogen and phosphorous in human excreta can be calculated from protein consumption. There is an equilibrium over the human body - what comes in sooner or later also comes out, except during growth when a minor part of consumed plant nutrients is incorporated in growing body tissue. Dagerskog (2007) used the method proposed by Jönsson et al. (2004) and statistics on protein consumption (FAOSTAT, 2005) to estimate the human fertilizer production for the ten countries in West Africa concerned by CREPA's ECOSAN program: Benin, Burkina Faso, Congo, Côte d'Ivoire, Guinea, Guinea Bissau, Mali, Niger, Senegal and Togo. An average person in these countries excretes annually 2.8 kg of nitrogen (N), 0.45 kg of phosphorous (P) and approximately 1.3 kg of potassium (K) with the urine and faeces (Figure 1).

This regional average was used to illustrate the value of human excreta in Burkina Faso. The annual quantity of N and P in urine and faeces from a family of ten persons corresponds roughly to the quanitity of N and P in 50 kg of urea and 50 kg of NPK(14-23-14) which are the two most common chemical fertilizers in Burkina Faso (Table 2).

The local market price of 50 kg of Urea and 50 kg of NPK in Burkina Faso is about 80 US$ (SOGEDIF, Feb. 2010). The total Burkinabè population of ~15,6 million inhabitants then excrete the equivalent of 125 million US$ worth of fertilizers per year. In addition, urine and faeces are complete fertilizers, containing the main plant nutrients (N, P, K) as well as the important trace elements and organic matter.

Table 2. The annual quantity of nutrients in the excreta from 10 persons compared with chemical fertilizer

Fertilizer	N (kg)	P (kg)	K (kg)
Urine et faeces from 10 persons in one year	**28**	**4.5**	**13**
50 kg of urea and 50 kg of NPK(14-23-14)	**30**	**4.9**	**7**

Comparing urine and faeces as fertilizers

The distribution of plant nutrients between urine and faeces depends mainly on the digestibility of the food. In general the absolute majority of N and K are excreted with the urine while P is more evenly distributed between urine and faeces (see Jönsson et al. 2004 for details). Faeces, rich in phosphorous and organic material, are a suitable base fertilizer while the nitrogen rich urine is a suitable cover fertilizer.

The baseline study for the project in Aguié, Niger, showed that defecation is mostly done in the fields around the villages, while the shower/ablution area is the preferred place for urinating (CREPA, 2009). In this situation, a better urine management would make the greatest difference to the local nutrient recycling. However this does not mean that open defecation should be encouraged for any reason. While defecating in the fields can bring the nutrients in faeces back into the productive cycle, it is a health hazard and a sub-optimal way of recycling as it is not applied at the place, time and dose to optimize plant growth.

Results and project experiences

Introducing the new fertilizers - methodology

Both projects have followed a similar methodology when introducing sanitized urine and faeces as fertilizers. The methodology is based on how other new fertilizers are usually introduced, via practical participative tests:

- All concerned stakeholders are informed on the new fertilizers, showing the experience from CREPA's ECOSAN projects in West Africa and photos from other projects around the world.

Figure 2. Two bags of fertilizer were brought along for sensitization sessions in Niger to illustrate the annual amount of nutrients that are present in the excreta from one family

The population is sensitized on the amount of fertilizer they **produce (Figure 2) and the** local agriculture extension officers are trained.

- Urine collection starts via simple urinals (jerry can and a funnel) to enable tests with the locally produced "liquid fertilizer".
- Participative tests are done to demonstrate the virtue of urine as a nitrogen fertilizer (urine compared to urea) at farmer field schools and on individual fields.
- Participative evaluation of the test plots.
- Training of village facilitators and artisans.
- Sensitization in the villages using SARAR/PHAST tools for understanding the dangers as well as the resources in human excreta and on how good use of latrines and urinals can help

Table 3. The scale at local level of the two projects

	ECOSAN_UE2, Kourittenga, Burkina Faso	**PS-Aguié Aguié, Niger**
Number of villages involved:	30	11
Vegetable farmers :	366 farmers trained on urine application methods	25 farmers involved in participative tests, 22 others applied urine on own initiative
Cereal farmers:	1255 farmers tested urine in 30 farmer field schools, 500 have done tests on own initiative	122 farmers tested urine in eight farmer field schools, 65 have done tests on own initiative
Agriculture extension officers trained:	29	10
Surface fertilized:	A total of 5,7 ha for cereal tests in farmer field schools (half with urine) and 27 ha for individual tests (with and without urine).	A total of 0,7 ha for cereal tests in farmer field schools (half with urine)
Urine collected :	?	> 125 m3 during 2009
Households producing solid fertilizer via toilets:	318 (712 toilets still to construct)	150 (another 60 toilets under construction)
Households producing liquid fertilizer via urinals:	2000	1143

UDDT with adobe superstructure

Urine separation integrated on the slab

Urinal dug down for squatting

Figure 3. UDDT and urinal in Kourittenga, Burkina Faso

eliminate the dangers and capture the resources.

- Construction of fertilizer factories (latrines) that enable the production of "solid fertilizer" as well as "liquid fertilizer".
- Follow up on the whole productive sanitation chain i.e. collection, sanitization and reuse.
- Use inter-village visits to spread the message. In Niger the first pilot farmers were taken on a study trip to exchange and train with farmers in Burkina Faso. These first pilot villages were then visited by other villages in the province.

Scale

The two projects operate on a limited scale, but serves as references for further productive **sanitation initiatives in Burkina Faso and Niger. Table 3 provides a summary of the scale of the two projects.**

Production of liquid and solid fertilizer

In both projects urine collection was soon started using simple urinals. After the urine tests as fertilizer and sensitization sessions on the dangers and resources in excreta, the latrines were introduced. In Kourittenga it was decided to opt for the urine diverting dry toilet (UDDT), and build solid double vaults with cement bricks with a 180 US$ subsidy (Figure 3).

In Aguié, all pilot village households got the simple urinal, and were then offered a choice between a low cost UDDT (called "dry toilet" in Aguié) and a UD Fossa Alterna (called "composting toilet" in Aguié) (Figure 4). The dry toilet is built off the ground and faeces is sanitized by desiccation together with ash, while the composting toilet is a shallow pit toilet were sanitization is enhanced by composting through the addition of organic material and some ash after defecation. All toilets have two vaults/pits used alternately.

Both models were subsidized with around 50 US$ to cover the imported materials and mason fee for the vaults/pits. The composting toilet has been very popular – no roof is needed, no stairs and the anal wash water can enter the pit. A study by Djariri (2009) showed that it would be possible to decrease the subsidy part to 30 US$ with some technical modifications. This is approaching IFAD's aim of a maximum subsidy of 20 US$ per installation.

Storing large volumes of urine is expensive and can be difficult. In Aguié the farmers are advised to enrich their compost or "dirt pile" or apply the urine to the field even during the dry period (covered with soil) if they run out of storage possibilities.

Urine quality

In Niger the urine was sampled during four different occasions and analyzed with the results presented in Table 4 :

Urine can either be transferred from a pot to the jerry can or enter directly. Dug down it is adopted for the squatting position

The composting toilet with urine diversion

The dry toilet in local material except the slab and vent pipe.

Figure 4. Urinals and toilets in Aguié, Niger

Table 4. Results from analysing agronomic parameters in Aguié urine

Parameter (n=number of jerry cans analysed)	N (n=37)	P (n=33)	K (n=28)	Na (n=9)	Mg (n=3)	Ca (n=3)	pH (n=29)
Unit	**g/l**	**g/l**	**g/l**	**g/l**	**mg/l**	**mg/l**	
Average	6,0	0,8	0,9	3,1	20	36	8,8
Standard deviation	1,1	0,2	0,3	0,2	1,6	3,1	0,2

The urine is especially rich in nitrogen, and in the higher range of the 3-7 g N/l given as indicative values in Jönsson et al. (2004). It can also be noted that sodium concentration is much higher than magnesium and calcium. In irrigation water where the concentration of sodium salts is high relative to other types of salt, a sodic soil may develop, which is characterized by a poor soil structure: they have a low infiltration rate, they are poorly aerated and difficult to cultivate (FAO, 1985). Even though the salt concentration is quite high in urine, the total salt quantity applied per year is not high when compared to irrigation water. However salinity is complex and further research on urine use and salinity would be welcome to avoid long term problems.

Laminou (2009) followed the volume of urine generated from 10 men, 10 women and 10 children (ca. 10 years old) in two villages in Aguié. On average the men produced 1.7 l/day, the women 1.9 l/day and the children 0.9 l/day. With 50% of the population under 15 years, the average daily urine production would be about 1.35 litres per person. Using the concentrations in table gives that the average person in Aguié urinates annually ~ 3 kg N, 0.4 kg P and 0.45 kg K with the urine, which is higher than expected, except for potassium. It should be noted though that the study was made just after harvest time when people have plenty to eat.

Laminou (2009) also analyzed the sanitization of urine after 30 days of storage, and found no micro-organisms except for anaerobic sulphite reducers that were present in 3 out of 9 samples. *Clostridium Perfringens* is one bacteria of this type that can cause food poisoning. However, the infective dose is quite high and clostridium is frequently present in the intestines of both humans and animals and also widely distributed in the environment due to its spore forming capability (FDA, 2009).

Application of urine in agriculture

In Kourittenga, urine tests were done on a relatively large scale. To facilitate application, the furrows were opened and closed using animal traction and the urine was poured directly from the jerry cans (Figure 5).

In Aguié, the preferred application method has been with a bucket and cup. The urine in Aguié was dosed to give the same nitrogen quantity as the locally recommended dose for urea. With a urine concentration of about 5 g N/l and with urea containing 46% N, 10 grams of urea corresponds roughly to 1 litre of urine. After the application it is important to water down thoroughly, or wait to apply until after a rain. Some farmers have had problems with wilting plants after urine application, especially young tomato plants. A solution has been to avoid application during the hottest part of the day and to reinforce watering the two following days after application. For cereals, urine application has been made after a good rain when the soil is humid.
In both projects the local agriculture extension officers have been supervising the participative tests.

Figure 5. Urine transport and application in Kourittenga

Figure 6. Individual test in Kourittenga on sorghum where organic matter (OM) has been used as base fertilizer and urine as an additional source of nitrogen (pile to the right)

Agronomic results with urine

During the tests, urine has been compared to urea as a nitrogen fertilizer, or complementing the farmer's traditional way of fertilizing using only organic matter. The test on **sorghum in Figure 6 is an example of an individual in Kourittenga who** tested the nitrogen effect of urine on sorghum.

The tests in the farmer field schools were monitored more closely, **and Table 5** summarizes millet results from four farmer field schools in Aguié in 2009. All test plots (T0-T3) of 200 m^2 had organic matter (OM) as base fertilizer at a dose of 20 ton/ha. T1 and T2 also had 50 kg/ha of Super Simple Phosphate (SSP) as extra base fertilizer. The N-application was either through 5 grams of urea (T1) or 0.5 litres of urine (T2 and T3) per plant, which with 10000 millet plants/ha gives around 25 kg N/ha.

Urine gave roughly 10-20 % more than urea. This is not surprising as urine, a part from nitrogen, also contains some phosphorous and potassium. Compared to the control with only organic matter, urine increased the yields in general by 40-50%. One 25-litre jerry can of urine gave around 2-3 kg extra grains in the Aguié conditions.

It is important that farmers see sanitized human excreta as something that complement rather than replaces existing fertilizers. Recycling human excreta helps reduce losses, but to increase fertility in degraded soils all available resources are needed: animal manure, crop and food residues, chemical fertilizers as well as human excreta.

Overcoming mental barriers

To consider human urine and faeces as potential resources requires a change of mindset. Such change does not come over night, and initial resistance is normal. Here are some experiences of how mental barriers were over come in the two projects:

- The farmers want to see to believe. It was important to quickly start with urine collection and testing.
- In Muslim societies urine is considered impure and something that one should never get in contact with. On the other hand, the importance of cleanliness in Islam provides a good argument for collecting and taking away urine from the compound. Men also squat when urinating, so the alternative to dig down the urinal was appreciated. When applying urine, gloves and mouth protection are used, and the same clothes are not used when praying. If urine touches the clothes or skin, the accepted solution is to wash well with water.
- The fields closest to the village has always given the best yields since animals and people relieve themselves there and no-one has ever hesitated to eat what is produced from these fields. The new way of recycling excreta is an improvement of what is already done.
- It is possible to eliminate the danger and keep the resources by simple storage for urine or drying/composting for faeces. After sanitization urine is called "liquid fertilizer" and faeces is called "solid fertilizer", which makes it easier to talk about.
- The urine odour is said to be the fertilizer - if it

Table 5. Millet harvests (kg/ha) at four farmer field schools in Aguié.

Village	Dan Bidé	Tsamiya Bakoye	Malloumey Saboua	Zabon Moussou
T0 (OM)	781	660	1244	1209
T1 (OM+SSP+Urea)	1160	893	1318	1000
T2 (OM+SSP+Urine)	1257	1072	1637	1111
T3 (OM + Urine)	1161	948	1773	1399
Surplus yield T2 compared to T1 (%)	8	20	24	11
Surplus yield T3 compared to T0 (%)	49	44	42	16

doesn't smell, it is no good! In Kourittenga, it is compared to the traditional spice soumbala, which is considered to be better the stronger odour it has.

- It is people behind desks who can be the real barriers. Farmers are often very pragmatic in their struggle to get a decent harvest. The productive sanitation approach that both improve the living conditions and food production has been received with open arms in the two projects.
- A much appreciated activity in Aguié was the “blind taste-tests” of vegetables and cereals fertilized with urine and urea. The results show a sweeter taste for urine fertilized vegetables, and in general a higher buying preference for the urine fertilized vegetables both based on taste and appearance (Saley, 2009).

Scaling up potential

In Burkina Faso, the use of excreta derived fertilizers could either be scaled up like other agriculture innovations, or it could go through the national sanitation program (PN-AEPA) that is about to roll out. The PN-AEPA includes the UDDT as a technical option, but it does not explicitly allocate resources for accompanying farmers with the recycling. Fortunately, in Burkina Faso it is the Ministry of Agriculture who is in charge of water and sanitation, so there are good opportunities for synergy between sanitation and agriculture programs, if the political will is there.

The ongoing EcoSan projects in Burkina Faso are still preparing the base, and the information and results are slowly reaching the top. To convince the decision makers there is still a lot of advocacy work needed, with precise and reliable data, as well as good economic arguments. Part of this work is being done within the project in Kourittenga.

In Aguié, Niger, the local partner project partner (PPILDA) will continue to support farmers and eventually extend the approach to the entire intervention zone (260 villages). On national scale in Niger the Rural Development Strategy (SDR) could be a suitable framework to take the approach further. The director of the SDR executive committee has shown interest but wishes to have more national research on hygienic and agronomic aspects.

From an agro-economic point of view, the subsidy of 180 US$ in the Burkina project or 50 US$ in the Niger project for a productive toilet can help a family to potentially collect around 80 US$ worth of fertilizer per year. This is a short pay back time, but the construction and good use of productive toilets require skill and knowledge. A large scale program that provides these new skills and follows up on the whole system will need a lot of time and resources. However, simple urine collection captures the majority of plant nutrients in human excreta and can be done to a much lower cost, and with less skills and follow up. An interesting approach would be to scale up urine recycling via the agriculture sector while sanitation programs promote faeces management. The agriculture extension officers already widely present in the rural areas could disseminate knowledge on urine reuse, and prepare the grounds for further sanitation interventions.

As an alternative to large national programs a recent example from Malawi (Bramley and Breslin, 2010) show that basic productive sanitation services also can be spread on grass root level via business opportunities for small scale entrepreneurs. There are signs of this dynamic in the two projects discussed in this article; In Kourittenga people have initiated urine collection on public places, and in Aguié an individual has already bought 140 jerry cans of urine from his neighbours to enrich his compost.

Conclusion

In the pilot villages in Kourittenga and Aguié, urine and faeces are now looked upon as potential liquid and solid fertilizers. An important reason has been the methodology of participative tests with urine. In rural areas food production is the main occupation and an effective entry door to create interest for sanitation, at least among the men. The women tend to be more interested by the comfort, hygiene and pride-side of productive sanitation. Already a simple urinal makes a difference, as the urine odour in the shower disappears with the collection.

On a global scale, with the absence of political awareness and will, the incentive to recycle human excreta will come with increasing fertilizer prices. In Burkina Faso and Niger were commercial fertilizers are beyond the purchase power of most farmers, there is already a strong recycling incentive. The important knowledge of urine collection and reuse can be spread by the local agriculture extension officers. They are in a good position to lead the yellow revolution!

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Name: Linus Dagerskog
Organisation: CREPA Headquarters
Town, Country: Ouagadougou, Burkina Faso
e-mail: linusdagerskog@yahoo.fr

Name: Moussa Bonzi
Organisation: CREPA Headquarters
Town, Country: Ouagadougou, Burkina Faso
e-mail: bouabonzi@yahoo.fr

The ECOSAN_UE$_2$ project in Burkina Faso is financed mainly with EU food security money (~1.5 million Euro, 2008-2011). CREPA together with the National Environment and Agriculture Research Institute (INERA) and the Ministry of Agriculture implement the project covering 30 villages in the Kourittenga province. Ecological sanitation is combined with soil and water conservation techniques to improve food production.

The International Fund for Agriculture Development (IFAD) granted a 200 000 US$ pilot project for CREPA, PPILDA (a 17 million US$ IFAD-funded rural development project run by the Ministry of Agriculture in Niger) and Stockholm Environment Institute (SEI) to test urine as a fertilizer in the Aguié province in Niger. The objective was to show the effectiveness of urine and to develop strategic tools as well as low cost appropriate technologies for an eventual up-scaling within the PPILDA rural development project and other IFAD funded projects. The PS-Aguié project was carried out during 16 months from Nov 2008-Feb 2010. See www.ecosanres.org/aguie for more information, fact sheets and tools.