Acceptability and market potential of forage plants grown in treatment wetlands

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Abstract

Cities, as engines of economic growth and social development require large quantities of natural resources to meet the inhabitants' nutritional, economic and social needs. Good infrastructure and reliable service provision are key to sustain the cities development. In this regard, they enhance investment opportunities and service access to vulnerable urban population. The treatment of faecal sludge in planted drying beds with Echinochloa pyramidalis (Lam.) Hitchc. & Chase offer many advantages like for the stabilisation of sludge and an good level of solid-liquid separation (Kengne, 2008, Abiola, 2009 unpublished data) but also by promoting its byproducts in various sectors such as agriculture, livestock or energy. Sanitation by the filters planted is the best strategy for sustainable management of sludge and an alternative choice for achieving the Millennium Development Objective for developing countries. This ecotechnology allows the production of nutrients to support agricultural production and improve livestock productivity while protecting the health of populations. Recent studies have shown that *Echinochloa pyramidalis* who has served to treat faecal sludge on planted drying beds, could be valued as forage for domestic ruminants (Kengne, 2008). For the first time, in Senegal and worldwide, the forage plant Echinochloa pyramidalis was used for the treatment of faecal sludge on full scale planted drying beds. This study was conducted at the Treatment Plant of Cambérène (Dakar) to investigated the start-up process of planted drying beds dewatering FS such as: i) the planting mode, ii) Growth characteristics and acclimatization iii) nutrients recovery potentials based. However, because of the dangerous nature of faecal sludge (viruses, parasites, bacteria ...), the total acceptability of byproducts requires the study of its safety and profitability for all stakeholders. The main objective of the present work is to evaluate the safety, nutritional value of Echinochloa pyramidalis, its potential economic and financial, the social acceptability of its use as forage supply by farmers and consumers. This researches also aims to establish how optimize the system of planted drying beds.

For this, the study will be divided into two parts: one part experimental and other part socio-economic.

Keywords

Echinochloa pyramidalis, planted drying beds, acceptability, market potential, livestock

INTRODUCTION

The management of sludge, the poor relation of political and layout planning of sanitation systems in most African cities, is a central component of sanitation and environmental protection and public health. Management involves many stakeholders and includes the emptying at homes, transport by special trucks, sludge treatment and recovery for farmers (dry sludge), farmers (forage) or industries (methane). Given the resources and relatively small capacity of African

states taken individually, developing a sustainable strategy for the management of sludge involving production of affordable nutrients to support agricultural production and livestock productivity while preserving the health of populations and of environment, remains the best alternative. For this treatment technologies should be little or no mechanization, weakly dependent on artificial energy and chemicals and allow the recovering of byproducts (Koné and Strauss, 2004) while combining the economic feasibility and social acceptability.

The drying planted beds, new technology to treat sludge appear to be the best system suited to the realities of African poverty, food crisis, financial crisis, urbanization, population growth exponential. In fact, it perfectly combines durability, efficiency and effectiveness through its technical advantages, financial and environmental.

In recent years, much interest has been exhibited in the use of sludge drying beds vegetated with emergent macrophytes as a cost-effective and technically feasible approach for sludge dewatering, stabilisation and humification (Kim and Smith, 1997, Kottatep *et al*., 2005, Nielsen, 2005) (Figure 1). Sludges are applied on the beds, thus allowing the solid phase to be retained on the surface of the filtering matrix where it undergoes mineralization, while the liquid phase drains out of the system for further treatment. The system relies on emergent macrophytes which play an important role in the dewatering of the sludge, thus allowing long term functioning without desludging (Kadlec and Knight, 1996; Randall, 2003; Rulkens, 2004).

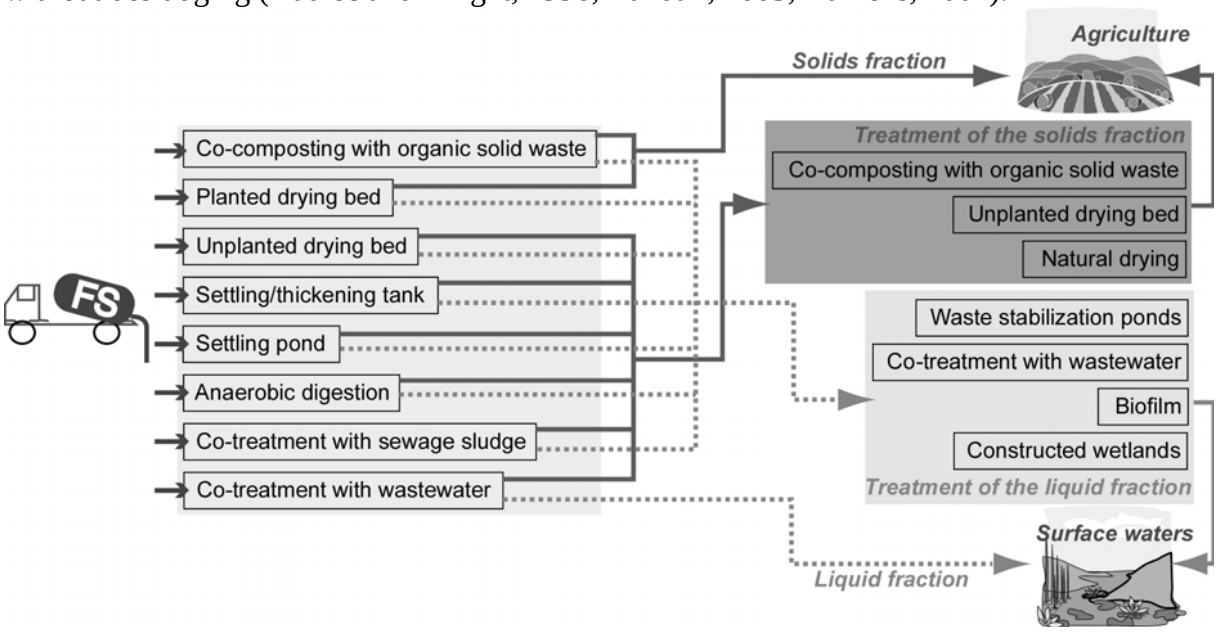


Figure. 1. Theoretical options for treating FS (Ingallinella et al., 2002).

Previous studies conducted by teams of Sandec (Eawag) in Yaounde (Cameroon) and Dakar (Senegal) on the potential of Echinochloa pyramidalis on drying beds have provided encouraging results (Kengne, 2008, Abiola, 2009). Results obtained showed that the system performed well for solid-liquid separation independently of the SLRs applied. Pollutant removal rates of the beds were more than 78 % for NH4+, 88 % for TS, 92 % for TSS and 98 % for COD. In Dakar, Abiola (2009) obtained reduction rates of 97%, 99%, 100%, 99%, 91% and 97% respectively for MS, SS, VSS, COD, NH4 + and PO 43 -. The sludges contained high levels of nutrients and relatively low C/N ratio. On an average basis, the contents of nitrogen and total P205 were in order of 2 %, while the exchangeable cations were in order of 1 % for CaO, 0.1 % for MgO, 0.03 % for K2O and 0.03 % for Na. The amount of humic substances of the sludges were relatively important, with carbon of free fulvic acid, that of humic acids extracted with pyrophosphate of sodium as well as that extracted with sodium hydroxide higher than 767, 19,000 and 27,000 mg/kg respectively. They could therefore be considered as good fertilizer reusable in agriculture

and should be manipulated with care since the sanitary quality of the biosolids still need to be investigated.
Vertical-flow constructed wetlands (VFCW) are nowadays recognized as cost-effective and technically feasible approach for sludge dewatering, stabilisation and humification (Koottatep *et al.*, 2005). This eco-technology has created substantial interest in its potential use for beneficial purposes. It is gradually gaining acceptance around the world with more knowledge being accumulated as far as its design, construction and operational functioning are concerned. Results showed that during the acclimatization phase, yound shoots of *Echinochloa pyramidalis* should be watered daily for the period of 2 months at least, with raw sludge displaying a solids content of TS <3 g / L. *Echinochloa pyramidalis* acclimatized very well to the different solid loading rates. Their density (footprint) increased from 10 shoots/m^2 during the early experimentation to 967 shoots /m^2 21 weeks later.
Our study suggests while treating the sludge, to provide food for livestock . *Echinochloa pyramidalis*, could greatly contribute to improving urban and peri urban livestock by providing quality food. Indeed, this aquatic plant known throughout Africa is particularly rich and it used as forage and hay (Adebowale, 1988). The surfaces covered by this plante are commonly used as grazing (Andersson et al. 2006).
Through this approach, the management of wastewater and excreta in developing countries could be a profitable business that would benefit cities, planners and people.

The main objective of the present work is through a transdisciplinary and participatory approach, the gender and the social equity, to assess the safety and nutritional value of Echinochloa pyramidalis from the drying beds, together with the social acceptability and the economic and financial potential. This study also aims to optimize the system of drying planted beds.

1. To fulfill this main objective, the following sub-objectives are defined:
2. Evaluating the social acceptability of forage plants
3. Analyze the effect of conditioning on the nutritional value and health (applying the method QMRA)on forage Echinochloa pyramidalis from drying beds planted and compare them to their natural ecosystem;
4. Evaluate ways to optimize the treatment of sludge from the beds planted at (Application of the material flow analysis)
5. Evaluating the social acceptability of forage plants
6. Analyze the effect of conditioning on the nutritional value and health (applying the method QMRA)on forage Echinochloa pyramidalis from drying beds planted and compare them to their natural ecosystem;
7. Evaluate ways to optimize the treatment of sludge from the beds planted (Application of the material flow analysis)

MATERIAL AND METHODS

Ecosystem approach to human health

In order to achieve the main objectives of this study, the methodology used is based on an approach called "ecosystem approach to human health" or EcoHealth approach. It moves beyond a focus on individual behaviour towards a wide range of social and environmental interventions (Figure 2). The health problem is related to all diseases related to waterborne diseases transmitted from faeces to humans through water and soil.

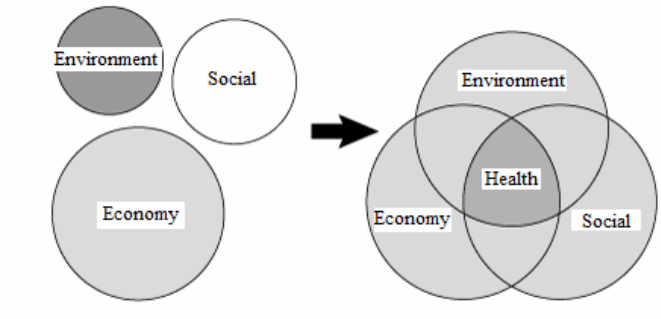


Figure. 2. Ecosystem approach t (CRDI).

Composition of the research team

In order to integrate transdisciplinarity and participation, the following team was composed:

- A veterinarian
- An economist
- A sociologist
- A technician

Two representatives of different organizations: farmers, consumers ... will participate in the development of surveys and interview guides, discussion of results. Wherever possible a man and a woman from each association for incorporating the gender

Workshop Information

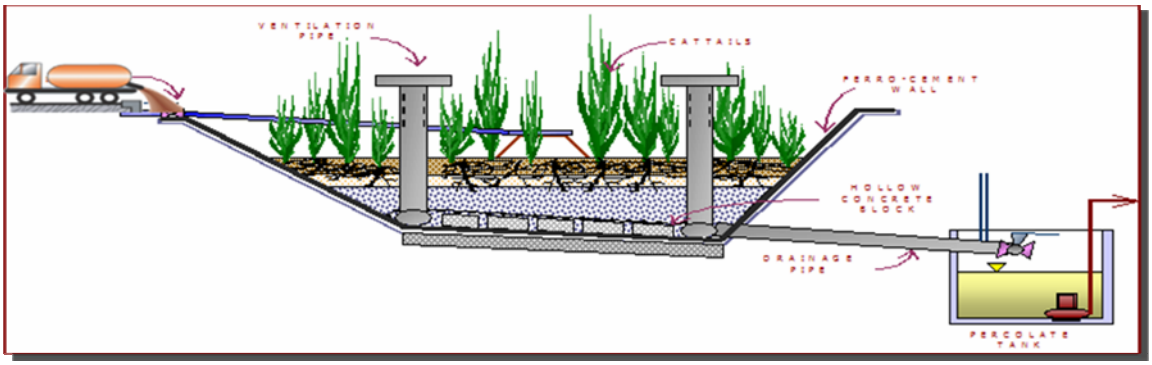
The study objectives and methodological approaches will be presented at the inception workshop that will bring together all stakeholders.

Visit and field observation

The visits will be made among various stakeholders and beneficiaries, to better identify problems and prepare solutions to overcome them.

Experimental study

A planted sludge drying beds can be define as an artificial system composed of selected media supporting emergent vegetation purposely constructed by humans for sludge dewatering (Kadlec and Knight, 1996). It is also called vertical-flow constructed wetlands for sludge treatment since the flow path for liquid is vertical (Figure 3).



Source: AIT- SANDEC

Figure 3: Planted drying bed (Sandec)

This study will carried out on the drying bed of Station of Cambérène of Dakar (Senegal). It is rectangular with a length of 16 m over a width of 8 m or an area of 128 m2. It is composed from bottom to top by: a clay layer whose function is to seal the base of the bed, 10 cm of coarse gravel of 20-60 mm in diameter, 10 cm of small crushed gravel of 5-20 mm in diameter, 10 cm of sand rolled very thin diameter less than 0.5 mm (Photo 1).

Photo 1: Planted drying bed at Cambérène (Abiola, 2009)

Macrophytes *Echinochloa pyramidalis*(Lam.) Hitchc. & Chase

Characteristics Echinochloa pyramidalis used in planted sludge drying beds

Echinochloa pyramidalis generally grows in swamps, on river banks, marshes or in open water, sometimes forming extensive meadows on flood plains (Hutchinson and Dalziel, 1972). It is found throughout tropical Africa where rainfall accumulates, but is also drought resistant (Photo 2).

E. pyramidalis has a great value as deferred feed for sheep, cattle, goats throughout tropical Africa. Indeed, no toxicity of this plant has been reported. Its nutritive value index ranged from 35.8 at 3 weeks to 23.4 at 12 weeks old (Adebowale, 1988).

Although extremely coarse, indigenous animals graze it readily to ground level at the end of the dry season. It makes useful hay and silage in South Africa. In certain region, *E. pyramidalis* constitutes an excellent dry-season grazing after old growth is burnt off.

The grain is used as human food in some parts of Africa. In Nigeria an impure salt or carbonate of soda is made by burning the grass (Chippendall & Crook, 1976).

Its dense, tangled, floating stems, rooting at the nods, provide efficient protection against wave action on the walls of earth dams or flood-induced erosion on river banks.

Experiments aiming at treating wastewater with species of *Echinochloa* sp. have been reported elsewhere (Ngoutane, 2003; Poach *et al.*, 2003).

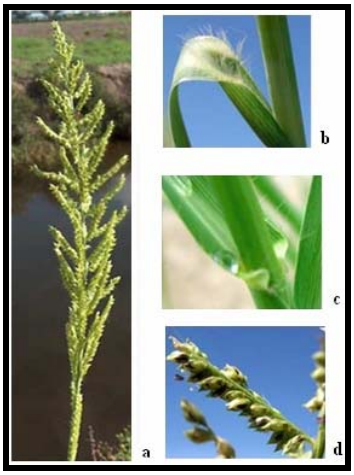


Photo 2: Echinochloa pyramidalis

The planting will be done with cuttings from 15 to 20 cm long with at least two internodes. Cuttings are placed in a hole of 5 cm depth with a density of 9 plants / m2. The period of acclimattion should last 1 to 2 months depending on the growth rate of regrowth. During this period, the cuttings are watered every day with tap water, the supernatant or raw sludge having a concentration of less than 3 g / l (Abiola, 2009). During the ramp-up, the maximum rated mass load will be 200 kg/m2/an. The nutritional and health values of Echinochloa pyramidalis will be assessed at the end of the acclimation phase, and once a month.

Determination of nutritional value and safety of Echinochloa pyramidalis from planted drying beds

Safety of Echinochloa pyramidalis by the Quantitative microbial risk assessment (QMRA) uses the best measurements about microbes' behavior to identify where they can become a danger and estimate the risk (including the uncertainty in the risk) that they pose to human health.
QMRA has four stages, based on the National Accademy of Sciences framework for Quantitative Risk Analysis, but modifed to account for the properties of living organisms like BAC:

- **Hazard Identification**: Describe a microorganism and the disease it causes, including symptoms, severity, and death rates from the microbe. Identify sensative populations that are particularly prone to infection.
- **Dose-Response**: The relationship between the dose (number of microbes) received and the resulting health effects. Data sets from human and animal studies allow the construction of mathematical models to predict dose-reponse.
- **Exposure Assessment**: Describe the pathways that allow a microbe to reach people and cause infection (through the air, through drinking water, by touch, etc.). Determine the size and duration of exposure by each pathway. Estimate the number of people exposed and the categories of people effected.
- **Risk Characterization**: Integrate the information from steps 1, 2, and 3 into a single mathematical model to calculate risk -- the probability of an outcome like infection, illness or death. Since steps 1, 2 and 3 will not provide a single value, but a range of values for expsure, dose, and hazard, risk needs to be calculated for all values across those ranges.

Nutritional value of Echinochloa pyramidalis

The nutrient content of forages varies greatly depending on the type of forage, degree of maturity at cutting and capacity preservation. The nutritional value of food depends on its rich nutrients assimilated by the animal like energy, nitrogen, minerals and vitamins. For the first two, there are specific units of measurement for ruminants: UF Forage Unit, which quantifies the energy from food and food needs , the digestible protein in the intestine, which quantifies the contributions and nitrogen requirements. Maturity of the forage is one of the most important factors that determine proper harvest time. As forage plants or hays mature, the quality or feed value declines. Additionally, the acid detergent fi ber, which is an estimated
measure of digestibility, increases during the same period. Increased acid detergent fi ber means lower digestibility.

Socio-economic study

Socioeconomic environment refers to a wide range of interrelated and diverse aspects and variables relating to or involving a combination of social and economic factors. These aspects

and variables could, in general, be categorized into several categories including, economic, demographic, public services, fiscal and social. The social aspects may, for instance, involve community life as well as social and cultural attitude and values. Community services may meanwhile be concerned with housing and requirements for public services such as water, sanitation, communications, police and fire protection facilities, solid waste disposal as well as health and educational services. Similarly, economic factors may include general characteristics, structures and changes various economic activities and employment.

Evaluating the social acceptability of the use of Echinochloa pyramidalis by breeders and consumers

A mixed method was adopted, the method quantitative and qualitative. The data collection tools that we use are of two kinds: a questionnaire applied and interview guidelines distributed according to the importance of the role in society of breeders and consumers. Both tools will be developed just after an observation phase. With these tools will be added informal discussions.

Conduct a market research and assess the economic viability of the use of byproducts of planted drying beds

This activity will be done with the collaboration of the entire team. The test of acceptability, factor analysis and typological analysis will be performed.

Material flows analysis used in the treatment of wastewater and faecal sludge

Material Flow Analysis (MFA) is a quantitative procedure for determining the flow of materials and energy through the economy. It uses Input/Output methodologies, including both material and economic information. It is an accounting system that captures the mass balances in an economy, where inputs (extractions + imports) equal outputs (consumptions + exports + accumulation + wastes), and thus is based on the laws of Thermodynamics.
Material Flow Analysis recognizes that Material Throughput is required for all economic activities and asks whether the flow of materials is sustainable in terms of the environmental burden it creates.

RESULTS AND DISCUSSION

Expected results:

- Acceptability of byproducts and economic values
- Characterization of *Echinochloa pyramidalis* like forage

CONCLUSIONS

In semi-arid countries, livestock production relies mainly on natural pasture which is limited and increasingly decreasing due to climate change. Rain fed-fodder crops production is affected by the scarcity of rain. Nature pastures are reducing while cities' demand for dairy product is increasing.
This project aims at linking sanitation service and infrastructure provision to cities economic development agenda. It links to key MDGs targets: (i) sanitation improvement and (ii) food security in poor urban and peri-urban areas of developing countries. Hence, this project introduces a new paradigm: making excreta and wastewater management a profitable business for cities planners and stakeholders.

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