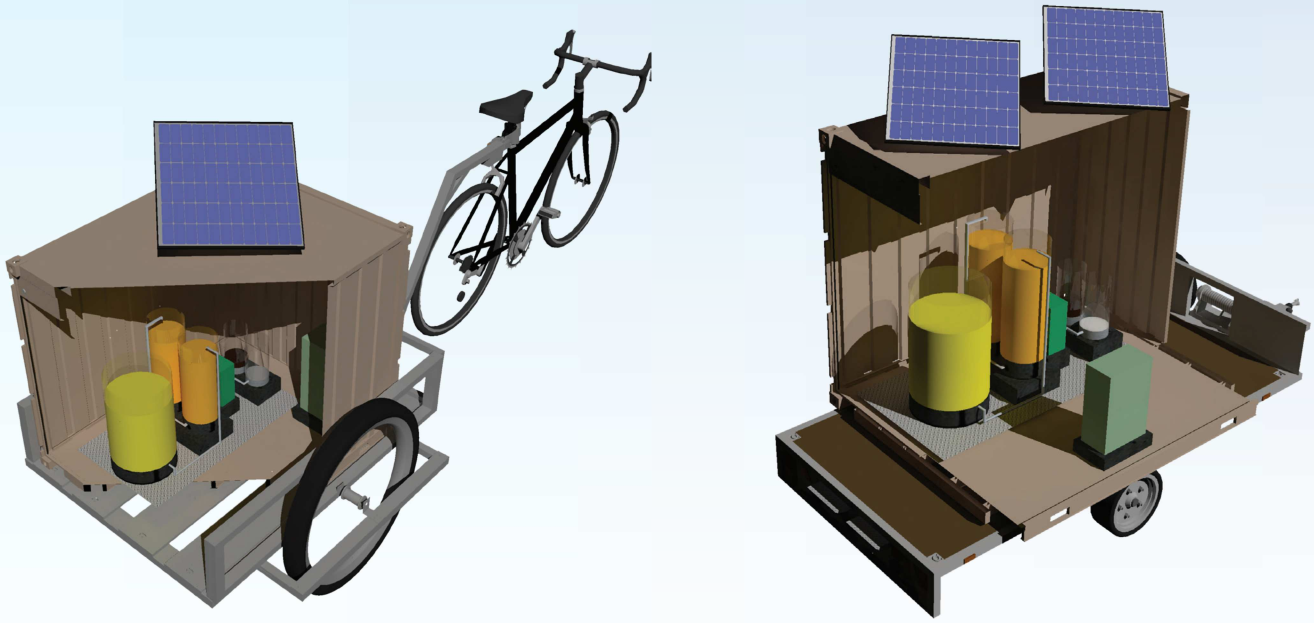
Draft concept note

Urine nitrification and distillation for recovery as fertiliser:

Development of an autonomous mobile nitrification reactor in order to reduce transport costs



August 2015

Abstract

The French company Ecosec, and the Dutch NGO SNV, will work in partnership to optimise the process of urine valorisation developed by the Swiss Institute of Aquatic Sciences (EAWAG). The improvements to the process proposed in this document are crucial to making this process commercially viable. These improvements focus on the automation and remote management of the existing treatment unit in order to make the reactor mobile and have a self-contained power supply.

The urine treatment plant would produce in situ a fertiliser containing all the nutrients contained in urine and therefore drastically reduce the volumes for transportation. The proposed research team aim to create and test a mobile reactor that will move it from one urine storage tank to another, instead of the more costly approach of moving the urine to the reactor as has been done in a previous VUNA Project. This new approach, having the reactor on a trailer would consistently reduce the final price of the concentrated fertilizer.

The project will be separated in two phases:

- Development and testing of a small-scale autonomous reactor placed on a trailer going from one ecosan toilet to the other in centre town, in France (Montpellier)
- Construction of a bigger reactor on a trailer in Burkina Faso (Ouagadougou) going from one ecosan toilet to the other, followed by agronomic tests and a larger-scale economic survey.

Partners

The three main organisations in this research, Eawag, Ecosec and SNV, will work with specialised and complementary partners to execute this project. For the first phase, based in France, the partners are FabLab (remote control and unit automation) and the University of Montpellier (lab use and technical assistance). For the second phase in Burkina Faso, the local partners are IGEED (lab work), 2IE (expertise in ecosan toilets), INERA (urine agronomic field tests) and ONEA (public partner and lab work).

Location

The construction of the trailer, and the development and optimisation of the autonomous reactor, will be done in the laboratories of the University of Montpellier. The electronic development will take place within the FabLab of Montpellier. The small, autonomous, 50 litre reactor will be carried from one UDDT cabin to the other in the town centre.

The second phase of the project, in Burkina Faso, will take place in the peri-urban area of Ouagadougou. Construction and initial lab testing will take place in the IGEED lab, and nitrification and distillation tests will take place on the urban slum toilets which have been installed by SNV and 2iE. Agronomic tests of the fertilizer will take place in peri-urban areas where INERA is currently working.

Budget

In order to carry out the research work, a preliminary budget of USD$ 395,444 has been estimated.

The process

Figure 01 : from urine by nitrification and distillation (Complete Nutrient Recovery, VUNA Project, 2013)

Over several years, EAWAG have developed a process involving successive nitrification and distillation of urine. At the end of the process, a very small volume of liquid (less than 3% of the initial volume) of concentrated nutrients is recovered, drastically reducing fertilizer transport costs.

Nitrification is a biological process that is very sensitive to changes in process conditions (oxygen, pH, temperature, etc) so continuous monitoring is needed to ensure the effective running of the process. Indeed, a sudden change in one of these parameters can very quickly bring down the effectiveness of the treatment (conversion of ammonia nitrogen (NH4+) to nitrate (NO3-)).

Goals & Objectives

There are three fully operational processing units currently installed in Switzerland and South Africa, following the process shown in figure 1. The team has made several statements:

- On the VUNA project, transporting the urine to the reactor was costly and intense work
- By moving the reactor instead of the urine, overall transport costs could potentially be drastically reduced
- By moving the reactor, new participants could easily be added to a programme, and would only need to collect and store the urine.

To achieve this, the project has the following goals and objectives:

French component

1. Optimise EAWAG's reactor in the laboratory

- Improve construction, analysis and control of the biological process with low cost technology
- Simplify its management, using teleprocessing with simple technology (Arduino)

2. Making the reactor mobile and autonomous

- Construction of a trailer to make the reactor mobile, and link the reactor to a solar panel so it becomes autonomously powered
- Technical proof of the concept at a small scale, monitoring the process functioning as it is moved from one toilet to the next (5 toilets, each having 300 litres urine tank)

Burkina Faso component

3. Construction of the reactor in Ouagadougou

- Shipment of all the sensor, computers, technical parts, in order to save most of the initial investment
- Assess the scaling up of the project. How can we adapt the designs to make a bigger reactor (300 litres) and therefore more urine treatment (four schools, each with a 2m3 urine tank)

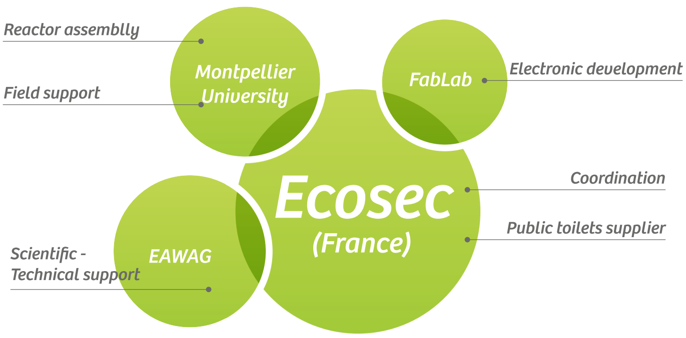
4. Monitoring the process and agricultural tests

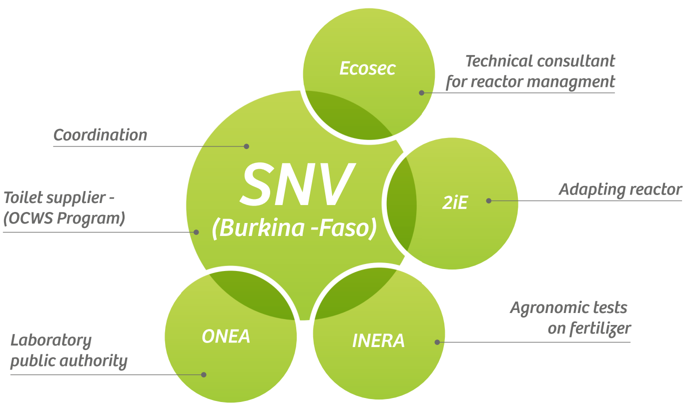
- Test the mobile autonomous reactor in several schools in urban Ouagadougou (one month at each 2m3 urine tank). Test ease of moving the reactor on a trailer from one place to the next. Test how easily we could add a new urine collecting location to the project
- Test liquid fertilizer efficacy when linked to a drip irrigation system, and its reception by local farmers

5. Economic evaluation: replicability and the potential to scale up

- Comparison between VUNA approach (urine to the reactor) and this approach (reactor to the urine) - benefit and limits of both pilots.
- Potential to scale up the project, lessons learnt and possible improvement of hardware and software.

Organisation





	2015				2016												2017			
Activity	sep	oct	nov	dec	jan	feb	ma	apr	may	jun	jul	aug	sept	oct	nov	dec	jan	feb	ma	apr
French Part																				
Preliminary Research	■																			
Reactor construction		■	■																	
Automation: Development /Implementation			■	■	■															
Remote management : Development / Implementation			■	■	■															
Construction of a trailer - autonomous source of energy			■	■																
Field test of the autonomous reactor					■	■	■													
Reactor Shipping to Ouagadoudou								■												
Burkina Faso Part																				
Trailer construction							■	■												
Reactor assembly on a trailer									■	■										
Lab tests of the reaetor (bigger size)										■	■									
Sites identification & operators training										■										
Experimentation follow-up											■	■	■	■	■	■				
Agronomie tests on concentrated urine															■	■	■	■		
Economie evaluation, Scaling-up potential																			■	
Deliverables																			■	■

Task

Coordinator	*PHASES*	*Sub-PHASES*	*Main Activities*	*Entity in Charge*
ECOSEC *(Montpellier, France)*	*Preliminary Research*	Choosing equipment	Research on low cost alternatives parts / Research on details for solutions to power the reactor with solar panels.	UM, EAWAG, Ecosec
	Prototype construction	Assembly	Assembling components of reactor, preferably with low cost elements	UM, EAWAG, Ecosec
		Setup	Starting-up, test and configure the reactor	UM, EAWAG, Ecosec
	Automation: Development / Implementation	Computer model	Optimize and configure the computer model developed by EAWAG	UM, EAWAG, Ecosec
		Control definition	Define parameters to monitor and control	UM, EAWAG, FabLab
		Choosing equipment	Define and install measuring equipments and controllers, with low cost technology (Arduino)	UM, EAWAG, FabLab
	Remote management : Development / Implementation	Choosing actions	Define measures and data needed to control - Develop an embedded bidirectional communication module	UM, FabLab, Ecosec
		Alerts & Interface	Create alert system, data backup platform & graphical interfaces for operators	FabLab, Ecosec
	Construction of a trailer - autonomous source of energy	Trailer construction	Design research and construction for a trailer and autonomous power source	UM, FabLab, Ecosec
		Follow-up	Carry out the small scale experiments with 5 public toilets	UM, Ecosec
	Economic evaluation, Replicability & scaling-up potential	Final reports	Findings of the project, market study for the reactor and the fertilizer	Ecosec
Reactor shipping to Ouagadougou		Preparation	Dismantling the reactor and prepare to move it to Burkina-Faso	Ecosec, SNV
SNV *(Ouagadougou, Burkina-Faso)*	*Reactor assembly on a trailer*	Reactor adapting	Adapting reactor for biggers size (300 liters)	SNV, 2iE, EAWAG, Ecosec
		Trailer building	Building trailer for reactor displacing	SNV, 2iE
	Testing portable reactor	Setup	Starting-up, test and configure the reactor	SNV, 2iE, Ecosec
		First tests	Testing moving reactor in different locations	SNV, 2iE
	Sites identification & operators training	Sites choosing	Adapting EcoSan facilities (schools, public toilets…) to place urine tanks	SNV, ONEA
		Operators training	Training operators (reactor moving & operating, urine treatment network establishing)	SNV, Ecosec
	Experimentation follow-up	Starting process	Organisation for urine treatment from site to site. Building capacity of the operator. Test with different set-up	SNV
		Follow-up	Reactor maintaining & displacing, bringing fertilizer to field sites	SNV
	Agronomic tests on concentrated urine	Preparation	Establish experimental protocol, choose techniques & pilot site	SNV, INERA
		Experience follow-up	Carry out the experiments	SNV, INERA
	Economic evaluation, Scaling-up potential	Final reports	Findings of the project, market study for the reactor and the fertilizer	SNV, Ecosec
	Deliverables		Making final reports & videos	SNV, Ecosec

Global planning

2016 / 2016 / 2017

oct. nov. dec. jan. feb. mar. ap. may jun. jul. aug. sept. oct. nov. dec. jan. feb. mar. ap.

- reactor setting up / lab test
- Test on public toilets
- Shipment
- Rector setting up
- Test on public toilets
- Agronomic tests
- Reporting / communication

STAFF Schedule - Budget

2016 / 2016 / 2017

oct. nov. dec. jan. feb. mar. ap. may jun. jul. aug. sept. oct. nov. dec. jan. feb. mar. ap.

1- Ecosec	Nb months	Cost MM (USD)	Total USD
Benjamin CLOUET - Project Direct.(20%)	2,50	5000	12 500
Vincent LE DAHERON - Project Manager (100%)	13,00	4000	52 000
Assistant (Intern)	4,00	1000	4 000
Bernard CAILLE - Electronics Technician (20%)	2,00	3000	6 000
3- UM			
Marc HERAN - Scient. Expert (30%)	2,00	5000	10 000
Assistant (Intern)	4,00	1000	4 000
4- FabLab			
Jean-P. CIVADE - Electronic Expert (30%)	2,89	5000	14 444
5- SNV	4,00	5000	20 000
Laurent STRAVATO - Project Direct. (25%)	13,50	3000	40 500
Savadogo Karim - WASH Expert (100%)	7,00	3000	21 000
Brigitte Ouédraogo (SNV) - Agronomic research (100%)	9,00	1000	9 000
Assistant			
6- 2iE			
Electromechanician	4,50	2000	9 000
7- INERA			
Agronomic specialist	4,00	2000	8 000
Total			**210 444**

Full time / Part time

NON Staff Schedule – Budget

2016 / 2016 / 2017

oct. nov. dec. jan. feb. mar. ap. may jun. jul. aug. sept. oct. nov. dec. jan. feb. mar. ap.

1- Travel and field mission expenses	PU	nb	Total
Benjamin CLOUET (Montpellier - Zurich)	1500	2	3000
Vincent LE DAHERON (Montpellier - Zurich)	1500	3	4500
Vincent LE DAHERON (Per diem + flight)	2000	7	14000
Savadogo Karim (Per diem + flight)	3000	1	3000
2- Reactor			
Construction	25 000	1	25000
Sensors / computers	25 000	1	25000
3- Consumables and fied expenses			
Laboratory consumables	7000	2	14000
Automation system	8000	1	8000
Communication system	8500	1	8500
Small Trailer construction	6000	1	6000
Experiment follow-up (France)	11000	1	11000
Reactor shipping (France - Burkina Faso)	8000	1	8000
Big Trailer construction	12000	1	12000
Solar panels and autonomous system	7000	1	7000
Experiment follow-up (Burkina Faso)	20000	1	20000
Agronomic experiments	6000	1	6000
Reporting / video	10000	1	10000
Total			**185 000**
Total USD			**395 444**