The evaluation of the impact of the first EcoSan project installed in Morocco.

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ABSTRACT

The first Ecological sanitation (EcoSan) pilot project was conducted in a rural village called 'Ait Daoud Ou Moussa' in Morocco (December 2009). The main Ecosan structures installed in this village are Urine-Diversion Dehydration Toilets (UDDT), Horizontal Constructed Wetlands (HCW) and Biogas toilets. The investigations were carried out in-situ to evaluate the impacts of EcoSan technologies use in this village. Indeed, qualitative and quantitative data were collected through field observation, an opinion poll survey, a group discussion and an interview with stakeholders in the field of sanitation. Around 15 % of the population of the village was investigated.

Results showed that after installing this project: over 95% of beneficiaries thought that their consciousness on environmental condition, their health and hygiene situation have been improved, because, it provides shelter to hide their privacy and safety in cold weather and during the night. In addition, they revealed that they have noticed the reduction of some foul odors, flies that once polluted their living environment and making it unhealthy and unsuitable. These new technologies can be used as an alternative for solving global sanitation problems in rural areas of low-income countries such as Morocco.

KEYWORDS:

Rural areas, EcoSan project, evaluation, impact, Morocco.

I. INTRODUCTION

In 2015, 4.9 billion people globally used an improved sanitation facility 'flush and discharge' or 'drop and store' but 2.4 billion did not open (practice open defecation) (UN,2016). These practices facilitate the spread of disease due to poor understandings of the health risks associated with human waste. Esrey et al., (1998); UN, (2016) indicated that when pathogen-infected faeces reach the wider environment, they quickly contaminate fluids (drinking and cooking water) and food (via human flies or human hands), thus a large number of people are exposed to infection and disease.

Moreover, it is estimated that a person produces 400–500 l of urine and 50 l of faeces a year. This relatively small amount of faeces is thus allowed to contaminate more than 35,000 l of water per person and year (UN-Habitat, 2003). Indeed, using pure water to flush excrement away appears to be an absurd alternative. In addition, the existing sanitation solutions are not affordable to the vast majority of the people, nor do they offer an approach ensuring sustainable society growth (Winblad & Simpson-He´bert, 2004).

According to Hutton, Haller and Bartram, (2007), for sub-Saharan Africa, one dollar is investing in the water sector would bring in $ 2.8 in net economic benefits versus $ 6.6 for a dollar invested in the sanitation sector. These are essentially gains in terms of time (90%), productivity (8%) and lower health expenditure (2%). Other studies show that the use of improved sanitation systems permitted the decline, eradication of highly contagious and deadly diseases such as diarrhea, cholera, dysentery, typhoid and hepatitis (Esrey et al., 1998; Martines, Simson-Hebert, 1993; Hutton, Haller et Bartram, 2007; UNICEF 2010).

The response to these challenges is so-called ''ecological sanitation'', which is based on the idea of preventing pollution rather than attempting to control it ex post factum; further sanitizing the urine and faeces and finally using safe products to improve the agricultural purposes (Winblad & Simpson-He´bert, 2004).

1. Ecosan system

Ecosan is based on preventing pollution, sanitising urine and faeces and recovering nutrients for food production (Werner C., 2009; Winblad U., Simpson-Hebert M., 2004) (figure 1). Indeed, Ecosan systems are sanitation systems designed to recover nutrients and organic matter found in excreta and wastewater for safe agricultural reuse (Andersson et al., 2016; Winblad, 1998). It aims to meet socio-economic and environmental needs in a given local context.

Ecosan focuses also on the harmless treatment of the waste and security of water resources. Water, nutrient, and biogas resulting from digestion process are recycled and the ecological loop of materials and energy is closed (Black,2001; Winblad and Hebert,2006). A number of guidelines on using human waste have been produced (Jonsson H. et al., 2004; WHO,2006). These systems may employ a range of different sanitation technologies and training strategies to promote use (Simha et al., 2017).

Fig.1. ECOSAN - Closing the sanitation loop.

1.1 Some Ecosan systems

1.1.1 Eco-toilet

The adaptability and feasibility of diverting toilets as an alternative to conventional sanitation systems seems to be well established. This is evident through the huge number of installations of diverting toilets across the world (Prithvi S., Mahesh G., 2016). In this process, the relatively harmless urine is not contaminated by the faeces and can be used directly on crops as fertilizer. Containment and sanitization then form essential building blocks in the barrier against the spread of disease (Winblad & SimpsonHe´bert, 2004). After numerous years of research and field experience (Jonsson, Stintzing, Vinneras, & Salomon, 2004; Schonning & Stenstrom, 2004) the conclusion reached is that dry methods diverting urine and faeces kill pathogens more effectively than other commonly used methods.

1.1.2 Constructed wetlands (CWs)

Constructed wetlands (CWs) can represent a valid option as grey water treatment systems, due to their specific capabilities and the particular chemical characterization of the grey water itself (Olson, E., 1968); it is well known that the biodegradation rate is much higher for grey waters than for black or mixed waters (combination of black and grey). Several recent studies have demonstrated the good performances of horizontal submerged flow CWs applied for the treatment of segregated blacwater/greywater (bw/gw): the high quality of the final effluent is the most appropriate for reuse practices even at domestic level (Masi F. and Martinuzzi N., 2007; B. El Hamouri, 2007); also, the number of papers on bw/gw characterization is decidedly increasing nowadays (Nolde E., 2005). The segregation of bw/gw seems to be one of the best practices for minimizing treatment costs, when the final target is reuse of the wastewater itself.

1.1.3 Biodigester

As prices of conventional energy sources increase, the use of fuels derived from human waste (including biogas) will be a good alternative (Abbasi& Abbasi,2010; Defra,2010; Gasworld,2010; Guardian,2008; ter Heegde & Sonde,2007;Lohri et al., 2010; Thames Water,2009). According to Rodriguez and Preston (2007, p.2) using excrement to produce biogas can "play a pivotal role in integrated farming systems by reducing health risks, facilitating control of pollution and at the same time adding value to livestock excreta through the production of biogas and improved nutrient status of the effluent as fertilizer for ponds and crop land".

In areas where cultural taboos surrounding human excrement permit the resulting gas to be used as a cooking/lighting fuel, it can also help to address sanitation problems as well as household energy shortages (GTZ, 2010; Lohri et al., 2010; Santerre & Smith, 1982; Sinha & Kazaglis, 2010). In rural areas, anaerobic digestion has the added advantage of producing liquid or semi-solid slurry that can be used as a fertilizer for crops (Defra, 2009b; GTZ, 2010). According to Mae-Wan, 2008; Reddy et al., 1995 biogas slurry is usually a good source of major crop nutrients (nitrogen, potassium and phosphorus) as well as micronutrients and trace elements.

1.2 Sanitation in rural areas of Morocco

Since independence, the management of wastewater and excreta for African countries in general and for Morocco in particular, is a real public health problem.

The level of depollution of wastewater does not exceed 3%; this explains why almost the entire population directly releases domestic water into the wild. This insufficient management and treatment of wastewater and human excreta are threatening the quality of groundwater and watercourses already

scarce water resources, resulting in risks for human health and the environment (HCP, 2015; WHO/UNICEF, 2017).

With a view to improving the current situation, Morocco has drawn up a national rural sanitation plan (PNAR) whose main objective is to promote sanitation in rural communities. Most of the techniques recommended by this plan are part of ecological sanitation.

Promoting the EcoSan approach not only protects health and the environment through hygienization of human excreta but also improves the incomes of the populations.

The first EcoSan pilot project was carried out in a rural village called 'Ait Daoud Ou Moussa' in Morocco (December 2009). The main Ecosan structures installed in this village are Urine-Diversion Dehydration Toilets (UDDT), Horizontal Constructed Wetlands (HCW) and Biogas toilets (**fig.2**). Then, the main objectives of this study are**:**

- To evaluate the state of Ecosan installations;
- To assess the socio-economic and environmental impacts of the EcoSan structures in this village;
- To propose some solutions to improve the development of this new EcoSan approach in this village and in other rural areas of Morocco.

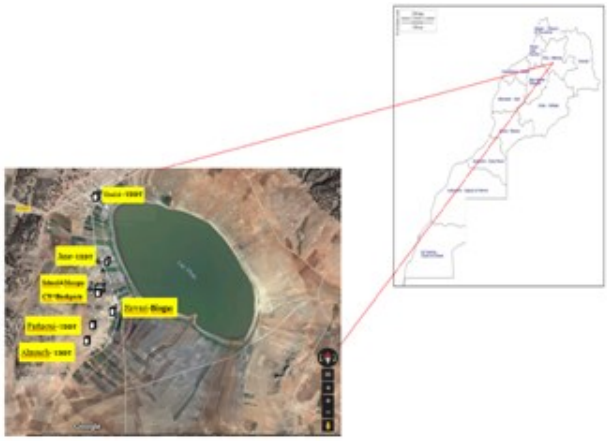

Fig.2: **Position of Ait Daoud Ou Moussa village in Morocco with the principal Ecosan structures.**

II. MATERIAL AND METHODS

In order to carry out this study, several materials including: a summary map of recognition of the place of study, a digital camera for shooting, data sheets of the EcoSan strusctures installed in this village, satellite image were used.

Various techniques and data were used in this study. The qualitative and quantitative data were collected through field observation, a questionnaire survey, a group discussion and interviews.

The main steps achieved could be summarized as follows:

- ✓ Preparation of the questionnaire:
  1 - Questionnaire for households beneficed of EcoSan structures;
  2 - Questionnaire for households none beneficed of EcoSan structures;
- ✓ A group discussion to collect general information about the village ;
- ✓ An interview with stakeholders in the field of sanitation;
- ✓ Visit the four families beneficed of EcoSan structures;
- ✓ Visit thirty families none beneficed of EcoSan structures and interviews with household head or his representative ;

About 15% of the village population has been concerned by the survey. The selection of these interviewees was based on the mass and the quality of information useful to provide this study.

The qualitative data made it possible to appreciate the importance of EcoSan structures in the protection of the environment and the promotion of sustainable development at this village. As for the quantitative data, they were collected at the level of the families and institutions benefiting of this project.

III. RESULTS

1. Sanitation system at Ait Daoud Ou Moussa

The sanitation system at Ait Daoud Ou Moussa is an autonomous system. 75% of the surveyed population has a toilet connected to a lost wells and gray water (shower, dishes, laundry) are released into nature without any treatment (figure2). While the remaining 25% do not have the financial possibility to dig the wells lost and defecates in the wild or in stables of cattle to hide the privacy. This village is fed by a network of fountain that is fed with a well managed by a village association. Unfortunately, this well is exposed to significant sources of pollution such as agricultural pollution and domestic pollution (lack of adequate sanitation). The average endowment of the population at the fountain is 12.5 liter / inhabitant.

Therefore, these practices generate an important source of waterborne diseases, especially for children and women taking contact with water, as well as groundwater and surface water pollution (Esrey et al., 1998; UN,2016) .

Photo 1. Environment and groundwater pollution

2. Socio-economic and environmental impacts of using ECOSAN structures

2.1 ECOSAN latrines (UDDT)

The Households surveyed with no toilet: more than 90% showed a real interest in taking ownership of a UDDT. Those who have lost wells: 80% want to convert to UDDT instead of the septic tank due to:

- Reduction of water consumption.
- Good waste management (urine, faeces ...) which facilitates the emptying of the faeces storage tanks and urine collection cans. Even people, who do not want to reuse the waste of these toilets, want to convert to the separation system given the ease of maintenance and emptying of pits, which is difficult in the case of the lost wells.
- Compatibility of the system with rocky soils.
- Reduction the flies and gastrointestinal diseases such as diarrhea, stomachache, etc. These results are consistent with those obtained by Jonsson,Stintzing, Vinneras, & Salomon, 2004; Schonning & Stenstrom,2004.

Regarding the EcoSan products, 60% of the surveyed populations are informed of their economic and ecological gain, of which 40% have shown that the experience of the reuse of urine in agriculture among families with UDDT is successful. However, none of these surveyed populations took the initiative to fertilize with the recovered excreta. In fact, their real concern is that they fear the bad reputation that this type of fertilizer can have on their production in the village and the "souks", as was the case with the reuse of chicken excrement in neighboring villages selling products with remarkable odors of chicken excrement. This phenomenon of fecophobia has been studied in detail by (Dellstrom Rosenquist, 2005). He suggested that, in contrast to how the promotion of sanitation is carried out today, marketing and use of a cognitive approach can greatly influence the degree of acceptance of sustainable solutions.

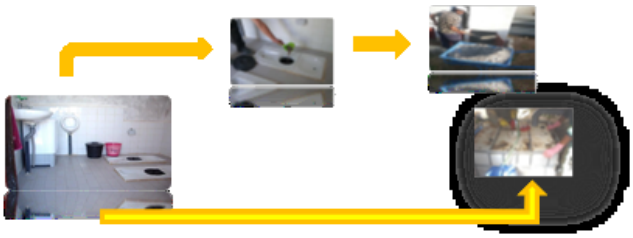

Fig. 2 UDDT installed at Ait Daoud Ou Moussa village

2.2 Constructed wetlands (CWs)

Several planted filters were set up at Ait Daoud Ou Moussa village in 2011. They are well accepted by users as it can produce useful plants, beautify the area and provide a pleasant landscape with ornamental plants (Photo2). It also provides habitat for birds, insects and other small animals. In addition, all users of these filters revealed that they have noticed the reduction of some foul odors, flies that once polluted their living environment and made it unhealthy and unsuitable.

Photo2. Planted reed and iris filter at J family in good working order shower + sink

According to Campos et al., (2002)**;** Rauch and Drewes, (2005) filtration involves pollutant removal mechanisms that include: biodegradation, straining, sedimentation, adsorption, nitrification and denitrification. Biodegradation is the primary removal mechanism of organic matter in both the solid and liquid phases performed by the active biomass attached to solid surfaces. The main advantages of planted filter are:

- Strong reduction of polluting organic matter and suspended solids.
- Very high decline of pathogens.
- Can be built and maintained with local materials and workers.
- No need for electrical energy if the topography allows it.
- Low operating costs.
- Simple system to understand and maintain by unskilled staff.
- The level of treatment allows reuse in irrigation and the production of exploitable plants.

2.3 Biogas toilet

The Biogas toilet installed in the village is an agricultural digester of the hemispherical dome digester type with a volume of 30 m^3 (Lukas Ulrich, 2012). It has a dual role:

First is the treatment of organic waste (manure) and wastewater of the toilet to produce a digestion that is comparable to chemical fertilizers. Second is the production of gas from the treatment of organic waste (almost 5h of production under optimal conditions) (Abarghaz, Y.,2009).\

The results of the survey revealed that the household benefited from this biogas is no longer fed by animal waste, but it is only fed by the toilet. This is due on the one hand to the reduction of the number of cattle, and on the other hand the unavailability of the person who will feed the biogas daily. The grandson of this family stated that: " *this biogas is no longer functional as before since it is unprofitable: requires daily maintenance and in addition one manure truck worth 700 MDH*". In addition, the digester is no longer valued but it is unloaded permanently on apple trees causing the death of these trees and bad smells. As a result, this biogas system is not accepted by the village population.

IV. DISCUSSION

1. On the environmental level

After installing the EcoSan latrines in the village, all beneficiaries revealed that they have noticed the reduction of some foul smells that once polluted their living environment and made it unhealthy and unsuitable.

With this in mind, a respondent with UDDT stated: "In the past, I was having trouble finding a hidden place to put myself at ease to defecate, which is no longer the case today with the EcoSan latrine ". According to Jonssonet al., (2004); Schonning & Stenstrom, (2004), the adoption of Ecosan system no doubt allow the reduction of certain diseases due to hygiene and sanitation. So, if ecological sanitation could be scaled up, it would protect groundwater, streams and Dayet Ifrah Lake from pollution and pathogens. The ecosystem will be preserved intact as there will be no disturbance effect. In addition, eco-sanitation makes it possible to use urine and feacal matter as a high-value fertilizer and not to resort to chemical fertilizers that increasingly pollute the ecosystem and have negative effects on the health of the populations.

2. Socioeconomically

The conventional system ensures only the collection of these excrements in lost wells, but the gray water, from the kitchen, is discharged into the wild. Consequently, this system is a source of contamination of groundwater, streams and public places.

In contrast, Ecological structures are new models of sanitation facilities that people are increasingly accommodating. They are based on simple technologies, accessible to everyone and very easily achievable. Indeed, UDDT reduces the use of water by using ash instead of flushing. It ensures the separation of excrements (urine, feces and gray water), and treats them separately for healthy valorization in agriculture (liquid fertilizer and irrigation water). On the other hand, Constructed Wetlands are effective in treating greywater; it ensures a clean environment.

Some studies show that the interest of the use of improved sanitation systems is the decline, eradication of highly contagious and deadly diseases such as diarrhea, cholera, dysentery, typhoid and hepatitis (Esrey et al., 1998; Martines, Simson-Hebert, 1993; Hutton, Haller et Bartram, 2007; UNICEF, 2010). The generalization of this kind of sanitation in the village will lead to the reduction of household spending on the purchase of drugs parasitic diseases such as cholera, diarrhea, etc and travel to cities to be hospitalized. In addition, the rocky terrain makes digging lost wells difficult. However, the UDDT is built above the ground.

Ecosan systems, when properly managed and maintained, produce no flies, no other insects, and no foul odors because moisture levels are too low to generate flies. This situation is therefore a great advantage by providing ordinary pit toilets. On the sanitary level, EcoSan latrines help reduce infections related to waterborne diseases. Indeed, the water supply can of the washbasin ensures the availability of water for hand washing after the use of the toilet. Before the installation of the UDDT, the villagers used the buckets of water directly for washing, or pebbles without washing their hands, hence the possibility of faecal contamination. On the other hand, household members had difficulty taking a shower. The men go to the nearby centers (Azrou, Imouzzer) and the women and girls use the living room or the kitchen to take a shower. But now they have a shower that they use frequently and they can easily heat through the stove in cold weather.

After the installation of the demonstration trials in the village, which aims to study the effect of the excreta on crop yields; 30% of the surveyed population recognized the importance of fertilizers obtained from the EcoSan system. According to them, the products resulting from this system give more vitality to the plant species, accelerate their growth and improve their yield.

V. CONCLUSION

The generalization of this type of sanitation in this village and in others rural areas will allow one hand to protect groundwater and the environment in general against the anarchic proliferation of certain pathologies that ruin the populations on the physical, moral and financial levels. In addition, the generalization of EcoSan latrines in schools will increase the rate of girls' education.

The promotion of this sanitation system also responds to the process of fight against poverty or the achievement of sustainable development in Morocco in general and in the study environment in particular. Hence the importance of ensuring a combination of efforts, because we are aware that improving sanitation alone cannot make development but it contributes greatly to development.

It is therefore desirable to sensitize and train populations for cultural acceptability of the princi principle of excrement recycling in order to set up a a production collection system that is more viable at the socio-economic and environmental levels.

In conclusion, Developing cost effective technologies, improving infrastructure, raising awareness and breaking down cultural barriers will be required if the full potential of holistic approaches such as ecosan are to be realised (Haq G. and Cambridge H., 2012).

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