38th WEDC International Conference, Loughborough University, UK, 2015

WATER, SANITATION AND HYGIENE SERVICES BEYOND 2015:
IMPROVING ACCESS AND SUSTAINABILITY

Biogas production in refugee camps: when sustainability increases safety and dignity

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BRIEFING PAPER 2116

This paper describes a project implemented by Action Contre la Faim (ACF, a French Non-Governmental organisation) in a set of refugee camps in the vicinity of Cox's Bazar, Bangladesh. The political situation of this population is quite complex and will not be discussed here but for the understanding of the reader we will present briefly the humanitarian context that can be summarised in a few words: WASH in these camps remains a challenge due to the lack of space available for the construction of new infrastructures. ACF tried several options for sanitation but none of them was fully satisfying until biogas reactors were tested and implemented. This technology is not often used in emergency situations such as refugee camps (Makhanu, Sibilike and Waswa, G.W., 2010), but in this case it helped to reduce the amount of sludge without using too much space in the camps as the reactors are buried underground.

Humanitarian context

ACF has been working in Cox's Bazar since 2008. Two sets of camps host Rohyingya refugees in the localities of Kutupalong and Teknaf. The first refugees arrived in the early 90's and since the influx of new comers has been almost continuous. The two sets of camps are each comprised of one official camp managed by the UNHCR and around it the unofficial so called "makeshift" camp. ACF is supporting the refugee population in sanitation and hygiene within the UNHCR camps of Kutupalong and Teknaf (where access to water is taken care of by the camp management) and is also supporting the unofficial Kutupalong camp in access to water, sanitation and hygiene. ACF is also running a nutrition treatment centre in the camp. The population in the Kutupalong official camp is 32,355 people and in the unofficial around 32,000.

The major challenge faced by ACF in the WaSH activities for both official and unofficial camps is the density of population and lack of space to construct new infrastructures. In both camps the density is higher than 100,000 persons / km² (106,666 in the makeshift camp). Such high density of population in refugee camps of the world is found only in the Gaza Strip and the occupied territories.

The camps are located in hilly areas and surrounded by many private lands and farms used by the local population. It is not possible to extend the limits of the camps. Water access is granted by series of bore holes spread throughout the camp. To construct new toilets keeping the security distance from the bore hole is almost impossible. The total annual production of human sludge in the camps is estimated to be 7,722 m3 per year. Pit latrines are normally filled in 2 to 6 months and due to space constraints it is not possible to dig new ones. Dislodging existing latrines is therefore a possible option. This option was tried by ACF since 2009, in both official and unofficial camps. As an example, in Teknaf camp, 25 dislodging ponds were constructed around the camp, downhill from the shelter area to make sure water points would not be contaminated by the percolation from the ponds. These ponds were supposed to receive the sludge from 955 toilets in the camp. Motorised pumps are used to pump the sludge from the pits to the pond. In Bangladesh people are using deported pits with manual flush and no urine diversion. Therefore the sludge is always liquid and easy to pump. Once pumped, the black water is stored in the pond and left to dry for about 15 days. Once dried up, the highly contaminated sludge cake is cut and buried on the ground outside of the camp. This system, very basic and rudimentary is working fine in the dry season. But during the heavy monsoon the daily accumulation of rain water in the pond makes the drying much longer and sometimes impossible. There is also an issue of security and olfactory nuisance for the surrounding population. The ponds had to be fenced and families were instructed to keep their children away to avoid accidents. After a year using this system, despite of some positive aspects (toilets were always dislodged and usable) it became obvious that the primary treatment of the sludge needed improvement as the capacity of the ponds (or the impossibility to construct more ponds due to lack of land) was not sufficient for the entire camp, especially in the rainy season.

ACF started then to consider the use of reed beds in order to increase the primary treatment capacity. A pilot installation was constructed in the official camp. A set of toilets was connected to a baffle reactor buried in the ground. The HRT was meant to be 5 days. The system however was too small for the number of latrines and the reed bed could not treat the effluent. All reeds dyed due to the concentration of the sludge. Again, there was no space available to construct a larger wetland.

Biogas reactor: pilot phase

Following the example set-up by the French NGO *Solidarites-International* in one neighbouring camp, ACF decided to convert its sludge management to biogas plants in 2013. Open dislodging ponds were not a sustainable solution with nuisances and risk of contaminating and accidents that increase the risk of having hazardous outbreak among refugees population. It was the first time that ACF tried a biogas reactor in a refugee camp. Normally biogas reactors are installed with the purpose or intention to produce gas in order to solve a fuel issue – lack of wood, high price of cooking gas, electricity production etc. In this regard, biogas reactors are optimized when connected to animal (such as pigs) farms that produce adequate manure for the optimal anaerobic fermentation. They can also take organic waste such as kitchen refuse. The fine tuning and optimization of the economic performance between the entrants and the final product is complex and often a break or a limit of success for small biogas production units (see Mang, H.-P. and Li, Z., 2010). In the case of Bangladesh refugee camps, our main objective was not the production of biogas but the treatment of several tons of human faecal sludge with a minimum of space and manipulation (transportation, discharging, etc.) involved in the process. If gas was produced on top of the pathogenic reduction and faeces isolation from the environment, it would be a nice added value and we could use it for cooking or lighting, but that was not the primary goal.

The main objective being to reduce the volume of sludge to manage and its contaminant potential, the focus was to develop a design that could fit within our constraints of an over-crowed camp and limited available space for construction.

In this regard, it was decided to develop small scale biogas that could be connected to 2 to 4 latrine blocks. The small dimension enabled flexibility in the implementation and the integration of this new structure without having to destroy existing shelters or WaSH facilities. Two different gas production capacities were chosen, 2m3 and 4m3, enough to create gas in sufficient capacity for cooking at least 4 meals a day for a dozen of families. Locations were also chosen in consideration of the possibility to connect additional latrines blocks to the biogas units after their completion. The pilot phase started in September 2013 and ended in November 2014. Five reactors were constructed and one renovated. The design selected is very basic yet efficient (for similar basic design see Tilley, E. Ulrich, L. Lüthi, C. Reymond, P. and Zurbrügg, C., 2014). A hydraulic chamber is collecting effluent from the 4 surrounding latrine blocks, directly from the latrine pipe. The fixed dome is buried underground. It is made of bricks and plastered with cement. The dome is connected to an outlet and inspection chamber that allows easy maintenance and emptying of remaining digestate. The gas expands out of the dome in a small pipe, directly connected to the cooking stove or the kitchen. During this pilot phase, no buffer balloon was installed but we consider it as an option for a scaling up phase. Small kitchens were installed and equipped with stoves. Because the gas is raw and used directly from the dome to the kitchen, it is not refined and contains some amount of sulphur which make it corrosive for the stove. Special non corrosive stoves had to be installed.

The Hydraulic Retention Time (HRT) in the dome is 25 days and the thermophilic temperature (above 50°C) is not met even during hottest summer days in Bangladesh. For this reason the digestate is collected and buried out of the camp, as it is still pathogenic. There is no plan at the moment to reuse it or to add secondary treatment such as sun drying, for the same reason as before: lack of space for drying beds. However, given the high added value of this digestate for fertilizing farms a potential agronomical use could be foreseen for future projects. ACF is planning to undertake bacteriological and chemical tests of the digestate during the first trimester of 2015. Results will have to comply with the national standards

(Bangladesh Environmental Conservation Rules 1997) for disposing of waste: BoD reduced to 40 mg/L; Coliforms under 1000 c/100 ml; Nitrates under 250 mg/L and Phosphates under 35 mg/L. If these values are met by the digestate, its use for secondary treatment or farming will be possible.

Preliminary results

From the pilot phase, preliminary conclusions are positive: there is gas production, there are no odours from the black water pit (slurry pit) and the latrines are kept functioning with no clogging. Most important, the impact in terms of soil occupation was minimized and the number of hazardous operations in dislodging is greatly reduced due to the direct connection between the toilets and the collection chamber. The frequency of dislodging diminished from 20% to 40% as follow:

- For a 2 m^3 reactor (connected to 4 toilets blocks with a total of 22 cubicles used by around 700 people): the 23.50m^3 of sludge dislodged every month from latrine block tanks became 3m^3 with the biogas installations, meaning a diminution of 87% of sludge managed each month.
- For a 4 m^3 reactor (with around 750 persons using the connected latrines): the 18.80m^3 of sludge dislodged every month from latrine block tanks became 1.5m3 with the biogas installations, meaning a diminution of 92% of sludge managed each month.

The gas production varies from 0.6L/s to 2.5L/s but needs more precise sampling to be considered as accurate. This value varies indeed on the time of the measurement and the number of people using the gas for cooking, as well as the number of users and frequency of use for the period.

Biogas in a refugee camp: pros and cons

In “traditional” refugee camps sanitation is managed with an emergency set up by humanitarian agencies and implementing partners trained and experienced to work in emergencies. In this context, the most efficient and the best value for money system is without any doubt the pit latrine, easy to implement, safe, cheap to construct and easily upgradable (VIP latrine, etc.). However, several limitations can be encountered when implementing emergency pit latrines – and recent humanitarian projects show various examples of these limitations (impossibility to dig pits after the earthquake in Port au Prince, high water table in the Rakhine State in Myanmar, etc.). Another point to be taken into consideration is that, according to UNHCR, the average stay duration in a refugee camp is 17 years. In Cox’s Bazar today, some new born babies are the 2nd generation to be born in the camp. With such long staying durations, more complex and more “development oriented” systems can be imagined in refugee camps, at least after a first period of emergency sanitation during the setting up of the camp, when influx of refugees is high and the demand for sanitation growing fast. Another common point of many refugee camps around the world is the high density of population. Even if Kutupalong in this regards is beating all records, it is a fact that refugee camps are often overcrowded due to lack of space to implement them and other land tenure related issues. Designing and constructing sustainable sanitation systems in such a context is challenging. Biogas reactors, once buried under the ground (or under a shelter or other building) are a good way to save space. Anaerobic digestion always requires less space than aerobic digestion.

Another interest of the biogas reactor is the reduction of operations involved in the dislodging and the fact that the dislodging is done at the reactor site and not in the latrine: latrines are often dirty after dislodging if dislodging is done through the defecation hole. The reduction of the number of operations involved in the dislodging and the transportation of sludge is a safety factor that should not be neglected. The reduction in volume of sludge is significant and also facilitates secondary treatment.

The gas obtained (CH_4 and CO_2, with low levels of H_2S and other gases, a mixture explosive and suffocating) can be used for cooking, lighting and with larger production units could be used for electricity production. Small basic systems such as the one implemented by ACF are facing a few limitations regarding their gas production. The quantity of gas produced is good but there is no buffer stock of gas and no regulation of the input: the flux is continuous and depends only on user’s use of the toilets. This is not optimal but so far we could not find a way to stock the sludge and discharge it on a regular basis in the reactor. The most important, in this context, is to avoid as much as possible manipulation of the sludge (for optimal use see Vögeli, Y., Lohri, C. R., Gallardo, A., Diener, S. and Zurbrügg, C., 2014).

There was, however, a specific limitation to the use of the gas for cooking: The idea of using biogas for cooking food was new to the Rohyingya population and some cultural questions were raised by the users. To overcome this issue, meetings were organised and an appropriate communication plan was established. Among other communication channels, Muslim religious leaders were targeted so they can spread the message of the compatibility between the use of biogas and the Muslim faith. After several discussions and on-site tests of the biogas reactor the leaders were convinced and passed the word to their constituencies. Satisfaction assessments done by ACF show that users are happy with the technology, mainly because the toilets are never clog or fill up.

Table 2. Biogas reactor in a refugee camp: pros and cons (summary)

Pro	Con
Save space when buried underground	Need strict supervision to add adequate mixture every day in the reactor in addition to human sludge for C/N ratio to maximise gas production
Reduce manipulation of faeces	Require good communication marketing before construction and for the first months of use (gas produce with human waste)
Offer additional source of energy	Highly skilled masons are mandatory for the construction
Opens possibilities for valorisation of waste to fertiliser for agriculture	Strong supervision on the construction as system depends on materials used, ground work and precise finishing
	The methane gas produced by human waste is both an explosive and an asphyxiation hazard. Should be handled with care.

Conclusion

After the pilot phase, ACF completed a scale up process with an additional 22 reactors constructed. The results are encouraging since we observed strong ownership from households benefiting from the biogas for cooking and willingness to be involved in the maintenance of all facilities linked with the biogas. Those biogas reactors enabled the creation of social cohesion that did not exist among refugees used to humanitarian support since more than 20 years. ACF wants to scale up this approach including full control of the pathogenic waste. Total decontamination and valorisation of the final product, in regard of the impact of the biogas reactors on the communities, could be possible and will therefore increase community involvement and interest in improving their living conditions.

From the community feedback, having working latrines, no more odours and having the waste less exposed gives them more dignity while living in an overcrowded area with little perspective for future. From the technical side, the results obtained in the reduction of waste volume to manage are above expectations and encourage ACF to advocate for implementing more biogas facilities for this particular context of humanitarian support to refugee camps.

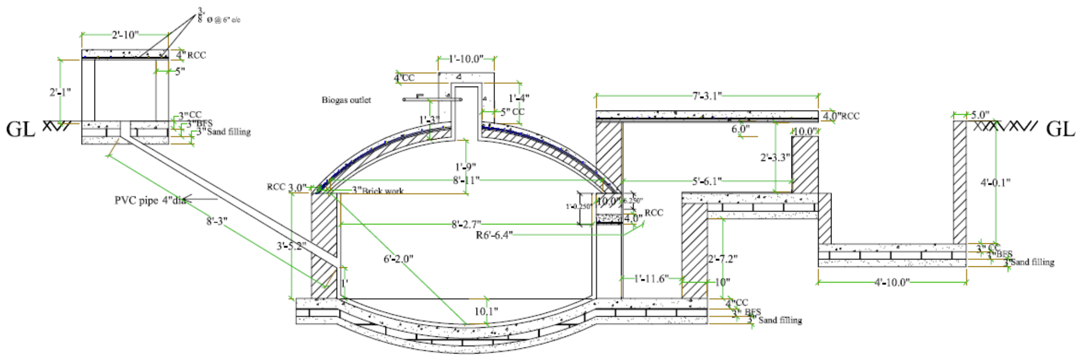

Figure 1. Biogas reactor

Source: ACF – Bangladesh

Acknowledgements

The authors would like to extend thanks to the refugee population of the official and non-official camps of Kutupalong as well as to all the stakeholders involved in the project.

References

Vögeli, Y., Lohri, C. R., Gallardo, A., Diener, S. and Zurbrügg, C. (2014). Anaerobic Digestion of Biowaste in Developing Countries. Practical Information and Case Studies. Eawag (Department Sandec), Dübendorf, CH.

Makhanu, Sibilike and Waswa, G.W. (2010), "Biosan latrines for refugee camps", Centre for Disaster Management and Humanitarian Assistance (CDMHA), Western University College of Science and Technology, Kakamega, Kenya

Mang, H.-P. and Li, Z. (2010). "Technology Review of Biogas Sanitation. Biogas Sanitation for Blackwater, Brown Water, or for Excreta Treatment and Reuse in Developing Countries". Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Eschborn,.

Tilley, E. Ulrich, L. Lüthi, C. Reymond, P. and Zurbrügg, C. (2014). "Compendium of Sanitation Systems and Technologies", Sandec, the Department of Water and Sanitation in Developing Countries of Eawag, the Swiss Federal Institute of Aquatic Science and Technology, Dübendorf, Switzerland.

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