ESTABLISHMENT OF A BIOGAS PRODUCTION SYSTEM FOR THE USE OF THE INHABITANTS – FIANARANTSOA PROVINCE - MADAGASCAR

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ABSTRACT

For several years, the methanization of fermentable waste for the production of biogas has been chosen by several countries as a complementary source of energy. Given its methane content of around 60%, the biogas thus produced can be used either in combustion in a gas engine, or as cooking gas for domestic needs, and sometimes to produce electricity in cogeneration. The scale-up of a pilot biogas production facility, carried out a few years earlier to contribute to the energy needs of the inhabitants of an urban district. A forecast study based on availability of fermentable material in Fianarantsoa District - Madagascar

Keyword: *Biogas, charcoal, methanization, bio-waste, digester, Fianarantsoa, Madagascar*

1. INTRODUCTION

In Madagascar, more than 90% of households use charcoal or firewood for cooking. Thus, a Malagasy household, composed of 8 people on average, consumes at least 2.5 bags of charcoal per month (each bag weighing, on average, 70 kg). Therefore, concerning the forest, 0.5 m^3 of wood, representing the equivalent of 1.2 ha [1]. This paper reviews the annual consumption of charcoal in Fianarantsoa district – Madagascar.

2. METHODS

Methanization of fermentable waste for the production of biogas subdivided into six stages (Figure 1), composed by cylindrical digester 2 m in diameter, 3 m deep, offering a useful volume of 8 m^3. The first load of the digester approached an average quantity of 500 kg of cow dung previously mixed in the preparation tank.
The methanization lasts on average 15 days. The first gas sampling was not undertaken until the end of the 15 days of anaerobic digestion.
The time required for the digester cover to rise 1m under the pressure of the gas produced. Each daily sample was sent directly to the end-use stations. In other words, no gas storage tank was planned [2].

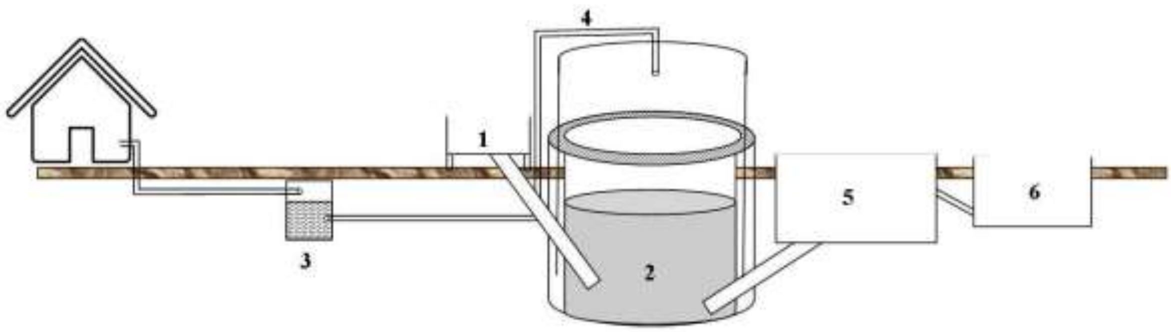

Fig- 1: General diagram of the installation

1 **Preparation tank:**

Beef dung is used, which is kneaded with water until there is a sufficiently liquid effluent in the preparation tank. The $9m^3$-volume digester is filled to 3/4 with the effluents prepared in the preparation tank.

2 **Digester**:

The digester is a cylindrical-shaped pit with a cemented and concreted wall and bottom. A second external wall, also cemented and concreted, surrounds the internal wall of the digester, thus leaving a space necessary to allow the sliding of the metal cover when the gas pressure is sufficient.

3 **Purifier**:

It is a parallelepiped shaped pit, also cemented and concreted, and filled with water to allow purification of the gas. This purifier therefore has an inlet and an outlet for purified gases (CO_2, H_20, H_2S, etc.)

4 **Connection pipes to appliances using the gas produced.**

We used galvanized pipes with valves, and connected directly to the gas utilization devices. The gas produced during the two years of testing was routed to two final devices. A first connection was intended to supply a battery of stoves used by the 8 technical staff of the Chemistry Laboratory for cooking their midday meal. A second connection made it possible to power the few bunsen burners in the laboratory during the students' practical work sessions.

5 **Residue collection tank:**

As the anaerobic digestion continues, the digestates are pushed more and more by the quantity of gases produced and delivered to the residue collection tank (digestate and luxiviat). The digestate settles at the bottom of the tank while the luxiviat flows into a collection tank located just nearby. Subsequently, the digestate was either transformed into briquette fuel by our students, or used as fertilizer for fertilizing flower beds by the university gardener. As for luxiviats, they were used for watering flower beds at the University of Fianarantsoa, or used by neighboring farmers as additional nutrients for farmed fish.

This device was operational for 2 years and had provided satisfactory results until its final shutdown due to lack of funding. In view of the results obtained during this pilot phase, some individuals from the outlying villages also attempted the production of biogas for their personal needs. Unfortunately, their initiatives are quickly encountered problems in the supply of raw materials and in regulating the quantity of gas produced.

For the past fifteen years, given the scarcity of trees at least 5 years old that can be exploited. Charcoal burners and firewood suppliers moved far from the city. For that, they have some problems for transporting their product especially during raining season.

3. RESULTS

Various tanks represent the bulk of the investment, offering excellent sealing and using a material more economical [3].In addition, the dimensions of the digester will be calculated taking into account the volume of the storage device in order to guarantee maximum security for the neighboring population, and in accordance with the number of households in the district and other uses of biogas. Also, the various organic waste collected daily from each household will be systematically added the organic residues rejected daily by the various market places distributed within each district of the arrondissement. An urban district of 2,000 households rejects an average quantity of domestic bio-waste of around 10 tonnes per day (table 1). In addition, the daily quantity of unsold residues from the markets is estimated at 65 tonnes. The collection of all these inputs will be ensured by a reduced number of people aboard a medium-tonnage vehicle, over a relatively limited route to the anaerobic digestion center, and planned to collect at least the tonnage necessary to supply the digester of the arrondissement. Where appropriate, the injection of human excreta into the process, as in several countries, will be gradually considered. Otherwise, the annual consumption of charcoal is estimated by 12,000 m^3 for 2,000 households, and it corresponds on 29,000 ha of deforestation.

Table -1: results of our investigations among urban and suburban households

Households	Number of people per household	Quantity of bio-waste rejected (Kg / J)	Cost of electricity per month in Ariary	Volume of charcoal per month (m^3)	Cost of charcoal per month in Ariary	Energy expenditure in relation to the average salary (%)
Urban households	8	8 to 10	40.000	0,6	45.000	42,5
	5	5 to 6	20.000	0,4	30.000	25
	2	1 to 2	6.000	0,2	15.000	10,5
Suburban households	8	10 to 12	40.000	0,5	37.500	51,66
	5	6 to 7	25.000	0,4	30.000	36,66
	2	1 to 2	6.000	0,1	7.500	9,00

In urban areas, the monthly salary considered is the minimum hiring salary of 200,000 Ariary. In suburban areas, as in general 60% on average of the inhabitants are farmers, our investigations estimate the monthly income of each household at 150,000 Ariary. After grinding and a long maceration of the bio-waste in the presence of water in order to optimize their biodegradation, the digester will receive a first load of organic inputs in an amount not exceeding 2/3 of the volume of the digester. Methanization will last 3 to 4 months, before the start of transfer of the biogas produced to the storage device. Taking into account the extreme danger of its storage as well as the very delicate handling of its distribution, requiring respectively maximum security of the surrounding inhabitants and that of the users, these two operations will be systematically entrusted to a subcontractor holding the appropriate devices and the staff well trained for these tasks. In suburban districts, crop residues from market gardens as well as slurry and other pet excreta can also contribute to the supply of a digester.

4. CONCLUSIONS

The treatment of bio-waste for the production of biogas will contribute to the gradual elimination of private and especially public landfills generally established at altitude, making the landscape ugly and causing inappropriate land use. Moreover, as the various organic acids generated by the biodegradation of bio-waste permanently soak landfill soils, the latter will very quickly become potential sources of contamination of various heavy metals in agricultural areas, the water table and all areas of landfill. Water is located below.

In fact, knowing that the soils of the Malagasy island are already particularly naturally enriched in various heavy metals [4], the remobilization of the latter by rainwater, to which are added those released from solid waste of various kinds, piled up pell- mixes in public landfills, will be widespread in such a restrictive environment. Their

inevitable accumulation in agricultural areas located at the bottom of the slope, as well as in alluvial plains, risks causing contamination of various heavy metals in market garden products.
To these various heavy metals will also be added various varieties of hydrocarbons, various endocrine disruptors and many chemical compounds released from the numerous solid and liquid garbage discharged daily [4].
Such heavy metal contamination of some market garden products grown in the vegetable gardens of the many valleys of the city of Antananarivo was demonstrated by ongoing investigations carried out by a researcher from the Geochemistry Team [5]
Moreover, knowing that open incineration remains the only solution adopted for the treatment of waste from public landfills in Madagascar as in almost all the countries of the south, such a practice will aggravate the generalized pollution of the air, already heavily loaded into landfill gas propagated by biodegradation of fermentable waste. Indeed, in addition to these landfill gases, incineration will also generate a strong dissemination of various varieties of volatile aromatic compounds and that of congeners such as polychlorinated dibenzodioxins and polychlorinated dibenzofurans forming during incineration [4], dangerously increasing the emergence of skin and respiratory diseases that are sometimes incurable within the local population.

5. PERSPECTIVES

- The team of the GEOCHIMED Doctoral School - the University of Fianarantsoa in partnership with researchers at the Faculty of Sciences – University of Fianarantsoa decided to transpose the pilot device started on 1997 in five districts of Fianarantsoa

- Specific investigations will also be carried out on the availability of raw materials, on the organization of the collection of bio-waste, as well as on the biogas distribution network, first of all to meet the domestic needs (cooking of food) of each household of the district chosen, and then to reinforce its public lighting network. The results obtained can be subsequently transposed to the scale of the other urban and suburban districts of Fianarantsoa province.

6. REFERENCES

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