5 Results and Interpretation

5.1 Interpretation of Biogas Production

The bladder containing biogas was weighed; the difference in mass loaded and empty mass gave the mass of biogas produced after each day. Figure 3 shows the superimposed curves of biogas production in mass and volume per day. The mass and volume production curves vary in a similar way. We notice that the first ten days the production of biogas was important and fast because: the medium was inoculated with microorganisms contained in cow dung; the diversity of the mixture and the abundance of the organic matter gradually consumed by the bacteria. After the first 15 days, production becomes irregular due to changes in ambient temperature. From the fortieth day, production becomes negligible.

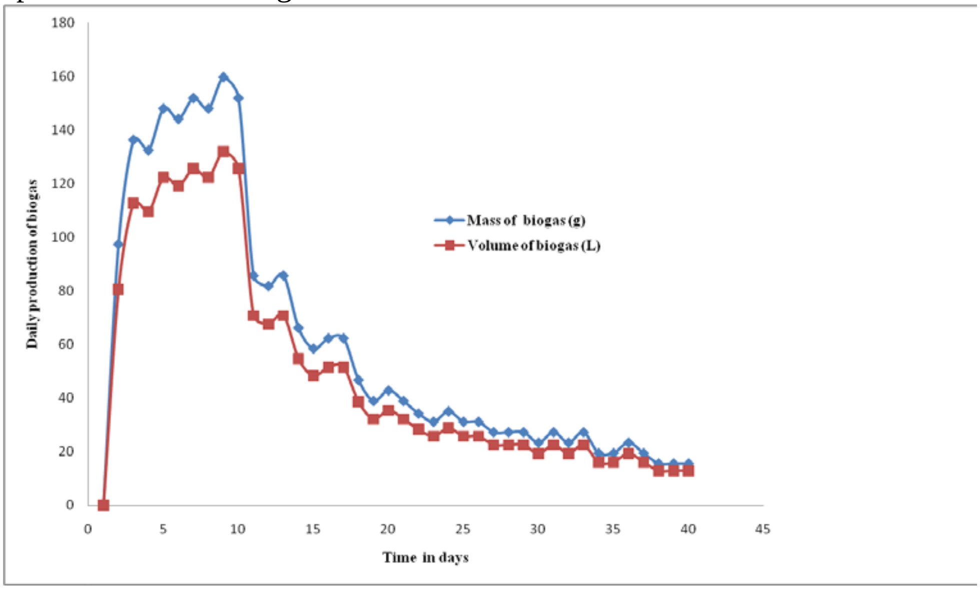


Fig.3: Kinetics of daily biogas production

5.2 Interpretation of Biogas Combustion

During combustion, we observed two main characteristics of this gas, the color of the flames and the deposit of carbon monoxide on the pot. Photo 11, shows that the flames produced by the biogas have a blue appearance. This color confirms the description relating to the combustion of methane. Moreover, it allows estimating that the combustion is complete. And therefore, there would be almost no carbon monoxide (CO). In addition, after a week of use of the pot for cooking with biogas, it is difficult to detect the black trace induced by CO on it.

Photo 11: Biogas combustion test

5.3 Interpretation of the Digestate Fertilizing Potential

5.3.1 Interpretation of Digestate Tests on Control Fields

The digestate is the residue of the methanation process after digestion of the organic matter by the microorganisms. It flows under the pressure of the gas and during a refueling of the biodigester in substrate. The observation of the digestate in the collection basin at rest, allowed seeing two large phases (photo 12): the liquid phase and the solid phase which was separated by decantation. The solid part was stripped of water to be dried, crushed and to obtain a biological fertilizer in the solid form. In addition, the liquid portion was stored in a closed bottle to prevent volatilization of nitrogen losses.

The mineralized sludge (photo 12) coming out of the experimental biodigester is recovered and dried in the shade to obtain fertilizer ready for spreading. This fertilizer provides the soil with nutrients and humus.

(a) (b) (c)

Photo 12: (a) Recovery of the Digestate; (b) Fresh solid digestate; (c) Dry solid digestate

The digestate thus dried was directly spread on the plot according to a test plan homogeneously followed by a mixture on the ground. The application of digestate on the test plot is shown in Photo 13.

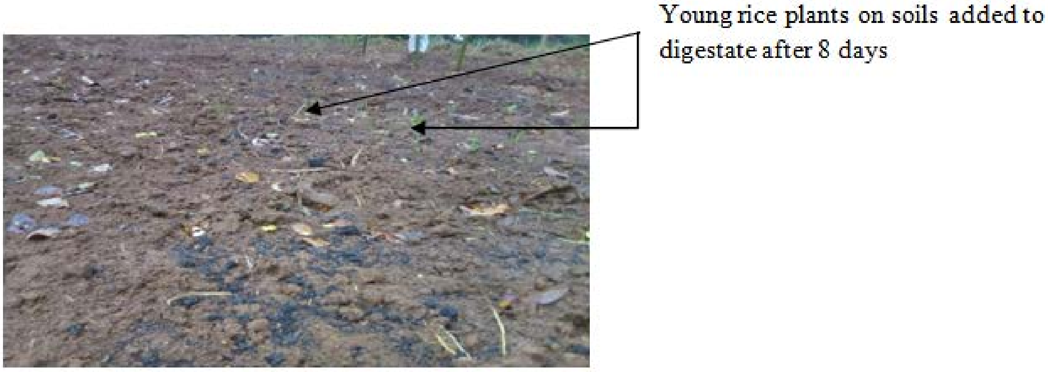
The darker part contains the spread digestate and the lighter part does not contain the digestate.

Photo 13: Spreading of digestate for nerica rice cultivation

5.3.2 Evaluation of the Fertilizing Potential of the Digestate

The rice seeds germinated rapidly, seven days after sowing we observed 9 seedlings on the plot not added to the digestate; while on the added plot we observed 26 young plants (photo 14). The difference is very significant which allowed us to see that the digestate is responsible for the germination of the rice seeds. After 70 days of experience, the calculation of the yield and a visual observation of the plants illustrated by (photo 14) (size, color and length of the plants) enabled to highlight the effectiveness of the fertilization by the digestate.

The following characteristics were highlighted:



(a) Rice plants after germination

(b) (c) (d)

Photo 14: (a) Rice plants after germination (b) rice fertilized with chemical fertilizer; (c) control (unfertilized) rice and (d) fertilized rice by digestate

1. Appearance and color of plants

After observation of the spaces, we find that the green color of the plants leaves added to the digestate and the chemical fertilizer is much more pronounced than that of the untreated plants leaves (photo 15). These differences in leaf color show a nitrogen contribution from digestate and chemical fertilizer treatments. The green color of the leaves is an indicator of a soil rich in nitrogen [32-33]. There was also a better development of the root system and plant stems growing on the plots together with digestate and chemical fertilizer. The development of roots and stems is an indicator of a soil rich in potassium [32-33].

2. Plant yield

Seed yield was evaluated as follows: The rice stalks were randomly sampled from the fertilized areas. By observation and by counting, we noticed that a rice stalk carried on average 11 panicles and a panicle carried on average 288 to 300 seeds of rice in parcels added to the digestate which allowed us to have a yield of 675906 seeds for a plot of 81 m^2 having 209 rice stalks. In a similar way, the crops of the chemical fertilizer added part gave us about 689700 rice seeds. We note from the calculation of the yields of different treatments, that there is no significant difference.

6 Evaluation of the Nutrients Contained in the Digestate

The evaluation of the nutrients contained in the digestate was carried out at the IRAD laboratory in Yaounde. Photo 15 shows filtration of the digestate to the filter paper and funnels. The filtrate is recovered in beakers.

Photo 15: Filtration device of the digestate

The liquid portion of the digestate thus obtained is labeled and then a mass spectrophotometer reading directly connected to a computer is performed (Photo 16).

Photo 16: Digestate analysis device

6.1 PH Evaluation

Table 1 shows the pH results over 35 days. The pH values vary very tiny and are between 6.60 and 8.44 while the recommended pH is between 6.5 and 8.5.

Table 1 : PH Results

Samples	E9 / 5 days	E10/10 days	E11/15 days	E12/ 20days	E13/25 days	E14/30 days	E15/35 days
PH	8.44	7.85	7.80	7.85	7.73	6.60	7.72

6.2 Nutrients Evaluation

Figure 4 shows the kinetics of concentration of the following elements: Ca^{2+}, Mg^{2+}, K^{+} and N. The graphs variation (Figure 14) allows to observe that the concentrations of calcium (Ca^{2+}), potassium (K^{+}), nitrogen (N) and magnesium (Mg^{2+}) are increasing as a function of time, moreover the presence of metals such as iron, zinc, copper, cadmium, lead, arsenic, manganese, selenium is zero after mass spectrometer analysis. . These results confirm that this fertilizer is not harmful to the environment, plants and soil.

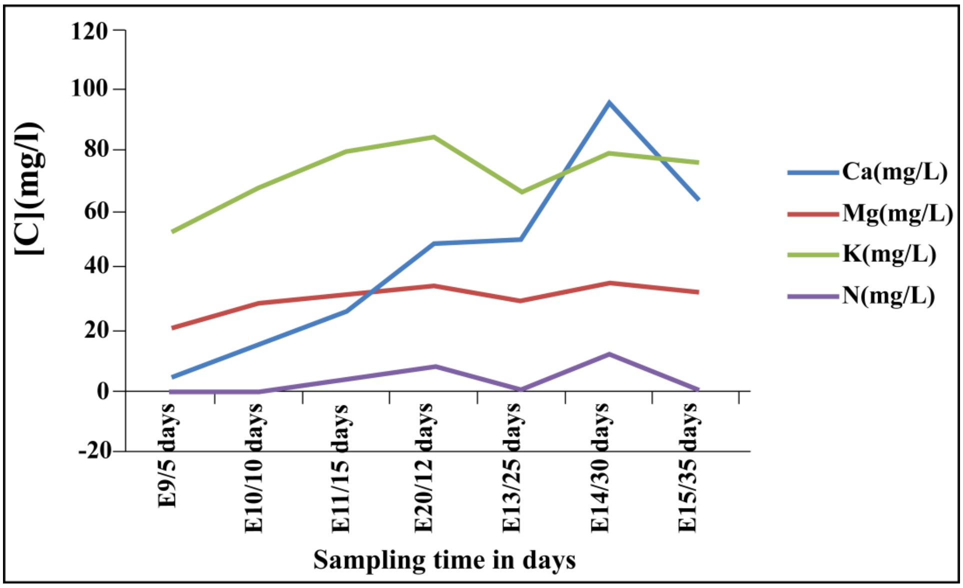


Fig. 4: Curves of calcium, nitrogen, potassium, magnesium concentrations as a function of time

Overall, we find on the basis of table 2 that the biogas yield is relatively low compared to the digestate yield for our mobile digester. For the simple reason that the anaerobic digestion test was experimental and that we have repeated our experiment over 40 days, however the quantities obtained can burn for one to two hours depending on the quality of the burner used.

The yield of digestate is close to half of the organic matter introduced into the biodigester, respecting the principle of what enters is substantially equal to what comes out.

Table 2: Yield of biogas and digestate

Substrate quantity	Quantity of biogas produced	Quantity of digestate produced	Biogas yield	Yield in digestate product
182Kg	2.28337Kg	80Kg	1.254%	43.24%

7 Conclusion

The aim of this work was to propose a mobile biodigester model that can produce biogas and digestate using kitchen waste. We have described the characteristics of the different products obtained. The biodigester is composed of a 220-liter barrel as a biogas enclosure to which we have incorporated accessories. This methanation device to operate is supplied with a three-quarter substrate. The substrate is prepared by harvesting the organic waste that has to be ground, weighed and combined with the cow dung then all is mixed with water. Once the methanation device refueled substrate, the enclosure is made anaerobic. After five days the bladder refueling valves are opened and the bladder can begin to take up the volume of biogas for 40 days. Every day, the weight of the product gas is weighed. The masses obtained enabled to establish the kinetics of biogas production. The physicochemical parameters of the digestate have been determined, and its fertilizing properties have been demonstrated. The digestate has been valued in agriculture in rice cultivation. The yield obtained was close to that of the control chemical fertilizers with yields of 675966 seeds in the surfaces treated with digestate and 689700 seeds in the surfaces treated with chemical fertilizer.

These results show that the production of biogas and digestate are valuable in energy, agriculture, refugee camps, probably in the restoration of abandoned mining sites and in the sanitation of prisons and villages.

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