ENVIRONMENTAL AND AGRONOMIC VALORIZATIONS OF THE BY-PRODUCTS OF RURAL BIOMETHANISATION APPLIED TO THE BOVINE BIOMASS

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Abstract - This work consists in studying of two possible valorizations of the rural biomethanisation applied to the bovine dejections, others than the valorization of energy. Thus, the follow-up of the adopted rural digester related to:  
- Analysis of certain environmental parameters (Suspended Matter: SM and Biological Demand of Oxygen: BDO₅), in order to establish the corresponding assessments of depollution.  
- An agronomic test of valorization of the residues of the rural biomethanisation: The bovine methacompost like substitute integral or partial of the peat and/or the compost and bovine juice of process as a fertilizer of the market-gardening seedlings.

The principal preliminary results rising from this work are the following:  
- The process of rural biomethanisation allowed an insufficient reduction of the load of pollution of SM and BDO₅ in the treated bovine effluent.  
- The use of the peat mixed with bovine methacompost as a substrate of culture gave an encouraging results with respect to the growth in height of the seedlings of pepper produced out of soil.  
- The bovine juice of process diluted with water at the rate of 75% showed an interesting power of fertilizing, all the more, the absence of fading observed with the concentrated fertigation.

Keywords - Rural digester, bovine dejections, assessment of depollution, substrate of growth, fertigation.

“1. INTRODUCTION”

Face to the very fluctuating economic situation of the energy and to reduce appreciably the local pollution and the greenhouse effect, the prospection and the development of new sources of energy were undertaken for a long time.

Many measures were taking by the public to protect the environment and the natural resources. Among the adopted solutions, the recourse to the use of renewable energies, which arouse an interest growth in particular those, was resulting from the biomass, and particularly, biogas coming from the biomethanisation of the agricultural effluents.

The biomethanisation having like principal vocation the production of biogas, showed lately other interests. It constitutes, today, one of sources of diversification for agriculture.

In the absence of Oxygen (O₂), bacteria degrade partially the Organic Matter (OM), which leads to the formation on the one hand, of a biogas mainly made up of the methane, and on the other hand, residues called digestates. These secondary By-products can be used in a solid state (Methacompost) like integral part of the substrates of culture or be spread, as they can be used directly in the liquid state (Juice of Process) like fertilizer of the arable lands, even, except soil.

The present study proposes to look further into the analysis of certain determining parameters on the environmental level (loads of pollution of SM and BDO₅ of the dejections before and after fermentation) and the agronomic use out of soil of the bovine biomass digested in the rural digester of farm (The use of the methacompost like a substrate of growth and the juice of process like a fertilizer).

“2. MATERIAL AND METHODS”

2.1. Experimental site

Work undertaken belongs to the experimentation of the biomethanisation of the bovine dungs on the level of the digester installed with the farm attached to the Agricultural Professional Center Training in Bovine Breeding (A.P.C.T.B.B) in Sidi Thabet, Tunisia. This rural digester of firm was built around the years
2000. It is of a buried pilot digester (Photograph 1) with manual uninterrupted alimentation and a capacity about 6 m³.

Photograph 1. Rural pilot digester of Sidi Thabet

The installation of biomethanisation considered is near the cattle shed, to facilitate the treatment of the bovine dejections.

2.2. Experimental material

It is the biomethanisation of the fresh dungs produced by the cows available (like substrate) and of the diluted black bovine dungs extracted from the septic tank (like inoculum). The characteristics of these two dungs are illustrated in table 1 hereafter.

Table 1. Physicochemical characteristics of the bovine imputes

<table>
<thead>
<tr>
<th>Nature of bovine dungs</th>
<th>% DM</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh dung</td>
<td>31.5</td>
<td>6.5</td>
</tr>
<tr>
<td>Black dung diluted</td>
<td>9.4</td>
<td>7.2</td>
</tr>
</tbody>
</table>

2.3. Different tests implemented

The environmental analyzes were carried out at the laboratory “Biogas” of the APCTBB.

2.3.1. Evaluation of the environmental performance of the digester

The environmental parameters in which were interested are relating to the polluting load (SM and BDO₅) of the digested matter coming from various mixtures.

For SM, they correspond to the whole of mineral and/or organic particles present in natural or polluted water. Their determination makes it possible to consider the bacterial biomass in the digester [5]. The analysis rests on the aim of quantifying all the matters being able to be decantable after elimination of the major part of water by filtration and evaporation in the drying oven with 105°C.

Concerning the BDO₅, this parameter constitutes a good indicator of the biodegradable OM content in water during processes of purification. The principle of the measurement of the BDO₅ rests on the quantification of O₂ consumed after incubation of the sample during five days.

2.3.2. Evaluation of the agronomic performance of the bovine methacompost

For the case of the methacompost, the evaluation in a direct way interests the appreciation of its maturity and its physical properties (different porosities). The indirect evaluation concerns particularly the follow-up of morphological parameters of the seedlings (germination, growth in height). These two valuations are necessary; in order to develop a suitable substrate allowing optimum conditions for the growth of the seedlings.

The evaluation of the maturity of the methacompost is carried out according to a biotest of germination of seeds of lettuce [1]. The aim of the biotest is to evaluate the maturity of the methacompost, to envisage the possible existence of some phytotoxic elements, while putting in consideration the photosensitivity of the seeds of lettuce employed like Plant-test [2].

The method followed consists in putting, under favorable conditions of germination, the seeds of lettuce. For that, one used small pots with transparent plastic, impermeable and hermetically closed. In each pot, 20 seeds of lettuce are putted and with three repetitions for the methacompost. The maturity can be evaluated, according to the percentage of germination, even, according to the energy of germination.

The determination of the rate and the energy of germination of the lettuce seedlings were carried out starting from regular counting of the germinated seedlings. The two parameters are estimated respectively by having recourse to the expressions hereafter:

\[
\text{Rate of Germination} (\%) = \left( \frac{\text{Germmed seeds}}{\text{Full number of seeds}} \right) \times 100
\]

\[
\text{Median Energy of Germination} = \text{Nure of days to reach 50% of the germinated seeds}
\]

The determination of the porosity of the studied substrates of growth is based on the control and the comprehension of the microscopic structures. On a microscopic scale, the substrate is in the form of a micro system with three phases; a solid phase composed by organic particles containing water, a liquid phase composed by absorbed water and a gaseous phase composed by the vacuum called lacunar space containing gases and steam.

The porosity of the substrates is defined as being the sum of the gaseous phase and the liquid
The total porosity (Pt) is determined by the relationship between the volume poured with the saturation of the total volume of the substrate (makes an attempt approximately one hour, then the addition of water, if it is required to have a good water saturation of the substrate). The porosity of aeration (Pa) is determined by the relationship between dried volume through the holes and the total volume (by letting water infiltrate during 10mn approximately). The porosity of retention (Pr) is determined by difference between Pt and Pa.

The total porosity of the substrates is generally higher than that of the soil, which is about 40 to 50% of the total volume [4]. The formulas used to calculate the three porosities and the standards adapted to the Tunisian context are presented hereafter. It should be noted that each elementary test of porosity was carried out with three repetitions.

\[
\Pr(\%) = \left(\frac{\text{Volume poured}}{\text{Total volume}}\right) \times 100 \\
\Pa(\%) = \left(\frac{\text{Recovered volume}}{\text{Total volume}}\right) \times 100 \\
\Pr(\%) = \text{Pt}(\%) - \text{Pa}(\%)
\]

The Tunisian norms require the following proportions of porosity to be applied: Pt ≥ 50%, Pa ≥ 20% and Pr ≥ 30%. These rules were inspired from thus of the Canadian standards [3], by supporting the retention on aeration, because of the dry climate of Tunisia.

About the evaluation of the agronomic value of the methacompost and its operating requirement like substrate of culture in a pure state or in mix, it appeared using a bearing test on the sowing of seeds of pepper. The methacompost used during this test was taken after 15 days of residence in the rural digester, and then dried only for a period of four days.

Three types of substrates were tested which are a pure peat (pilot), a pure methacompost and a mixture of 60% peat and 40% methacompost.

The follow-up related to the behavior of the pepper seedlings installed in alveolate plates (growth in height) interests the taking of the heights cumulated with regular intervals of four days.

2.3.3. Evaluation of the agronomic performance of the bovine juice of process

The fertilizing capacity of the juice of process is appreciated by using it to sprinkle seedlings of pepper already prepared in advance (sown in alveolate plates on the same support of reference which is the compost) while selecting seedlings having homogeneous heights which will be the support of the experimentation. Then, the fertigation every 48hours during 20 days of the seedlings selected with the solutions prepared, while taking the leveling cumulated with regular interval of 4 days.

The solutions employed are: water (pilot), juice of process concentrated, then respectively diluted, at a rate of 75% and 25%.

“3. RESULTS AND DISCUSSION”

3.1. Appreciation of the environmental interest of the biomethanisation

The increase of the assessment of depollution of SM and BDO5 (Figure 1) according to the concentration of DM introduced into the digester (from the first to the second mixture). The assessments of depollution obtained are regarded as insufficient and not satisfied as for SM, as for the BDO5 and deserve to be improved more especially for the case of the mixture initially introduced.

![Figure 1. Variation of assessment of depollution between two mixes](image)

3.2. Appreciation of the agronomic interest of the residues of biomethanisation

3.2.1. Appreciation of the maturity of the methacompost produced

The experimental results of germination of the seeds of lettuce on the methacompost tested are mentioned in table 2. The values obtained give a full satisfaction, since the rate of germination of the seeds of lettuce on methacompost is even higher than that obtained on sand. In the same way, the energy of germination is better (three instead of five days), which proves a suitable maturity of the substrate used. So the methacompost produces by the rural digester, considered well, could be useful like a substrate of culture.
Table 2. Results of the bio-test of germination

<table>
<thead>
<tr>
<th>Substrates</th>
<th>Rate of Germination (%)</th>
<th>Energy of Germination (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand (Pilot)</td>
<td>82</td>
<td>5</td>
</tr>
<tr>
<td>Methacompost</td>
<td>95</td>
<td>3</td>
</tr>
</tbody>
</table>

3.2.2. Appreciation of the porosity of the methacompost produced

The analysis of the physical parameters of the substrates is essential for the cultures out of soil, because the supports of culture have a direct influence on the rooting, therefore on the mineral-water nutrition, and consequently, on the metabolic activity of the whole plant. To guarantee a good production of the seedlings, especially the physical characters of the substrate of growth used must be satisfied, because they play a big role in the water supply of the plant and the operation of the roots: aeration and temperature. Primarily, the physical properties relate to the porosity of the substrate and the evaluation of the contents of water and of air available for the roots [6].

According to figure 2, we can note that the results obtained are far from being acceptable for Pt and Pa. Only the compost shows an acceptable Pr. Such results are in contradiction with the literature, which regards the peat as the ideal substrate for the breeding of the seedlings, especially from porosity point of view. Such a situation could be due particularly to the handling errors and/or the drying during the carrying out of the standard test of porosity.

Concerning the bovine methacompost, it meets the standards of Pt and Pr, however, its Pa is unacceptable. In front of such situation, this substrate can be considered as retaining and should be partially mixed with an aerator substrate. The optimal ratio of mixture remains to be determined.

Water can act directly by its reactions of degradation and hydrolysis. These last relatively reduce granulometric dimensions of the methacompost. The holding water capacity can increase and Pa can decrease when the granulometric components of the methacompost are fine.

The methacompost resulting from the biomethanisation of the bovine dungs can be only a partial substitute of the peat and/or the compost.

According to the raised results, this methanized residue is regarded as a retaining substrate which could be mixed with an aerator substrate (like the forestry compost) to make an adequate mixtures. It is advisable to continue this preliminary work to fix the ratio of mixture which could be applied.

Figure 2. Results raised from the standard test of porosity

3.2.3. Indirect evaluation of the methacompost produced

By comparison with other substrates of culture (pure or in mixture), the growth in height of the seedlings of pepper is almost identical for the subjects installed on peat and methacompost at the pure state (Figure 3). But, the seedlings installed on methacompost presented hails stems, sensitive and some were fading. The peat mixed with methacompost (at a rate of 60% peat and 40% methacompost) gives a faster growth and higher heights of the seedlings without presenting any vegetative anomalies.

These preliminary results are extremely interesting (being given the possibility of incorporation of the methacompost at the rate of 40% with the peat) and deserve other investigations before being applied.

Figure 3. Growth in height of the pepper seedlings installed on various substrates

3.2.4. Test of fertigation of the seedlings with the juice of process

The concentrated juice of process used for the fertigation of the seedlings of pepper allowed a considerable growth in height reaching 8cm in 20 days, but it is necessary to evoke that several seedlings finished by fading suddenly. The same observations were raised for fertigation with juice of process diluted at the rate of 25% water (Figure 4).
The solution 25% juice of process and 75% water allows a better growth without presence of anomalies.

![Figure 4. Test of growth of the pepper plants sprinkled with various solutions](image)

“4. CONCLUSION”

The animal manure is particularly interesting to be used, when they are produced in significant amounts and regularly and especially when they are treated biologically by biomethanisation before use.

The results obtained from this study referring to environmental and agronomic valorization of the bovine biomass treated in a rural digester supplied uninterrupted can be summarized in these points:

- The follow-ups as of SM and of the BDO5 showed that the biomethanisation allows a reduction of the load of pollution which takes more importance with the increase of the concentration in DM of the matter to be fermented, proving thus that the biomethanisation is a very beneficial process in terms of energy valorization and recycling of OM for the safeguarding of the environment. As the assessments of depollution obtained are considered relatively acceptable, these reductions need an improvement.

- The methacompost tested cannot be regarded as a good substrate of growth because of its insufficient porosity of aeration, which justifies its mixture, according to adequate proportions, with the peat which has a porosity of aeration normally more raised, for a correction of the physical balance of the substrates of growth conferred.

- The agronomic tests carried out showed that the use of the peat in mixture with methacompost at a rate of 40% like substrate of culture proves very encouraging and powerful with respect to the growth in height of the seedlings of pepper. The recourse to the methacompost like substitute partial of the peat or the compost in the confection of the substrates of growth could constitute an interesting alternative to limit the imports, and consequently, the hemorrhage of the currencies.

- The juice of process showed an interesting fertilizing power, in particular, that diluted to water at the rate of 75%. However, the results obtained are only preliminary and they deserve to be considered with prudence, because of certain vegetative anomalies raised in the case of the concentrated juices (from 75 to 100%).

“5. REFERENCES”


“6. THANKS”

The authors warmly thank the Agricultural Professional Training Center in Bovine Breeding (A.P.C.T.B.B) for Sidi Thabet, Tunisia for the gracious supply of the By-products of biomethanisation and the setting at our disposal of its rural digester of farm, its laboratory “Biogas” and a room to carry out the various agronomic tests.