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The Management of Manure Production Units at the College of Zoo-Technology and Ecology in Chihuahua, Mexico

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Abstract: Residues management environmental problematic is complex, due to the lack of environmental education and participation capacity in the community and government. The hardly livestock activities planification contribute to the excretes accumulation leading to the environment degradation and putting the public health and livestock at risk. The first objective was to propose a manure management plan at the animal production unit's in the Facultad de Zootecnia y Ecologia. A second objective was to evaluate the biogas production from a manure mixture (pig, chicken, rabbit and cattle) produced in an anaerobic reactor and a third objective assess whether to implement a production scale biogas digester that support the provision of energy demands in production units. To accomplish the first objective a diagnostic was conducted on the recollection, disposition and use common practices of the mixture and its implications in two neighboring urban communities. In order to identify the impact an inquiry was applied in houses randomly selected within a 50, 100 and 200 m distance from the production units, Microsoft Excel and SAS 8.0 Proc Jeans XP were used to perform statistical analysis. To evaluate the mixture biogas generation rate and methane composition, an ascendant flow bioreactor was operated (UASB) with 5l capacity using mesophilic temperatures between neutral pH ranges with an organic charge (OC) of 1.9 kg SV $m^3 d^{-1}$. The methane content estimation CH_4 ($_g$), biogas was analyzed using the gas chromatography technique. The benefit of implementing large scale digesters were evaluated based on production of CH_4 in applying the efficiencies of total excreta estimated based on the number of animals recorded and their excretion rates, calculated based on rates of consumption and digestibility of the species involved To minimize identified problems training is suggested from the standpoint of environmental hygiene to operating personnel and implement biotechnologies to re evaluate the excreta. Production efficiencies of biogas and CH_4 obtained were 20.5 l and 13.5 l per kg of VS respectively and estimated production of 204 thousand 113 L Ch_4 ($_g$) in addressing the total (105.8 t/month) of sewage generated, so the installation of a bigger digester is a viable alternative to support the energy demands of the production units.

Key words: Manure · Biogas · Chihuahua · Mexico

INTRODUCTION

The administration of livestock activities has undergone dramatic changes motivated by a growing population, rising incomes as well as progressive and dynamic urbanization. This has caused serious pollution problems, especially when large numbers of animals are concentrated in areas close to water resources and populated centers such as cities [1-3]. Farming practices are hampered by poor technological implementation to treat solid and liquid wastes that accumulate under intensive production systems. In Mexico, ranching has been one of the main industries in sustaining the rural economy [4] and about four decades ago, Mexico became not only self-sufficient in basic foodstuffs but also a net exporter of agricultural products. Yet, its current profitability has been diminished due to the detriment of border states like Chihuahua, which suffer adverse conditions of severe drought [5], high production costs [3], the inaccessibility of agricultural loans [6], remote distances from production input centers and other negative factors.

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Clearly, intensive production systems represent an alternative to increasing production with lesser resources. Yet, the inadequate management of waste further generates deterioration of natural resources which threatens public health and zoo-sanitary aspects [7]. This is why management plans and shared actions are required to achieve an environmental balance to use waste products such as fuel and biosolids for commercial demand [8]. The livestock units at the College of Zoo-technology and Ecology of the Autonomous University of Chihuahua, are permanently hosting small herds of livestock (pig, rabbit, poultry and cattle), which are located in a socio-cultural context. The objectives of this study were: (1) identify and implement actions to reduce problems caused by the accumulation of feces in pens and surrounding areas (2) estímate the efficiency of an anaerobic process to take advantage of excreta by obtaining fuel methane (CH4g) and (3) assess the appropriateness of implementing a large-scale digester in the production units. The importance of this study is that an average cow produces about 5kg of manure on a dry basis and generates biogas $0.374m^3$ per kg [9], as in the faculty runs a monthly average of 200 animals it could generate a profitable biotechnology for alternative energy sources that support the energy demands in production units.

MATERIALS AND METHODS

A study of the production units at the College of Zoo-technology and Ecology located in the state of Chihuahua, Mexico was conducted. The college is located within the urban area of Chihuahua City.

Implementations of Actions for Waste Management: It was a monthly record of the practices that are usually done at the point of collection, disposal and reuse of wastes generated in the production units: *i.e*. number of animals, mortality rates, methods and frequency of cleaning, waste disposal rate and degree of utilization of excreta. In addition, we reviewed the status of animals in confinement areas, infrastructure and hygiene. Data collection covered the summer and winter seasons. To identify the discomforts that neighboring populations associated with farming in surrounding areas, a survey was conducted through random surveys of 1-6 houses per block, at distances of 50,100 y 200 m of the production units at Colonia Pavis Borunda y Zootecnia. The survey included perception of odors, confirming the existence of stinking waste sources not attributable to the production units. Data were analyzed with Excel®Microsoft Corp and with SAS 8.0® The SAS Institute through Proc Means for frequency table and mean values. It was also used to support the proposed actions aimed at minimizing the issues identified in the colonies under study.

Estimation of Efficiency to Produce Anaerobic Biogas: To assess the rate of degradation and biogas production of excreta, a mixture was prepared with equal portions of pig, bovine, rabbit and chicken. The content of total solids (TS), volatile solids (VS) and fixed solids (FS) was determined following the methodology described by APHA [10]. Was diluted 200 g of the mixture in 1:2 ratio to achieve an organic load (OL) of 1.9 kg de SVT^{-1} $m^3.d^{-1}$ and was fermented in a bio-digester of 5L, between 35 to 40°C, pH neutral and residence time (THR) of 38 days. Samples were collected daily in the reactor influent and effluent and pH analyzed, reactor temperature, ST, SV and fixed solids (FS), volume of biogas generated per day and its composition percentage of $CH_{4\,(g)}$ y $CO_{2\,(g)}$; for the latter, there were weekly analysis of the composition at the stage of beginning, middle and end of production of biogas with a gas chromatograph Perkin Elmen Mod Clarus 500 with thermal conductivity detector, where the gas separation was made in a column of 6ft x 1/8" packed with Porapak Q; quantiifcation of the concentrations of $CH_{4\,(g)}$ and $CO_{2\,(g)}$ of the analyzed samples was performed by relative response factors [11]. The pH variations in the bio digester were adjusted to near neutrality by the addition of acetic acid or sodium carbonate.

The degradation rate was evaluated based on total solids removed (TSR) obtained from the difference of the total SV (TSV) of the influent and effluent. The efficiency of biogas production and $CH_{4(g)}$ were estimated base on the amount added to the reactor TSV using the following equations:

Biogas efficiency = L biogas. day / TVS added

CH_4 efficiency = L biogas. day x % methane /TVS added

Validation of Desirability of Implementing a Larger Scale Digester: From the value of efficiencies of $CH_{4\,(g)}$, the amount that could be produced was estimated with total excreta(CE) generated during the study period, based on the number of registered animals and their excretion rates, calculated from consumption rates according to the stages of development and productivity of the species involved and their digestibility data reported [12, 13] according to the equation:

Biogas Total = Efficiency of $CH_{4\,(g)}$ *CE. * % SVT from the mixture

RESULTS AND DISCUSSION

Waste Management Actions: During the study period, the total of the 5,543 animals quantified were made up of 29.8% of chickens, 23.92% rabbits, 37.8% pigs and 8.5% of cattle (dairy and fattening) in different productive and physiological stages, respectively. Data analysis from the inspections on the daily activities of the excreta management showed that the main problems were located in poultry sheds where the dry cleaning techniques were done only weekly, for layers and breeders, it was yearly. There was a lack of sufficient infrastructure in place to minimize odors and dust particles suspended from manure accumulation. The practice of burning and open dumping of excreta as forms of waste disposal added to the equation as only part of cattle and poultry excreta are treated to produce compost or manure. For integrated management of livestock waste, the researchers [14] recommended the application of biotechnologies designed to minimize the amount of excreta by drying in order to minimize fly breeding and odor.

As for the discomfort perceived in the areas surrounding the production units at 50 m, 92% of the population surveyed in the Zootecnia colony and 48% of the Pavis Borunda colony, attributed the cause of odors to the production units. At further distances, social response decreased. Nonetheless, about 80% of the surveyed population in the furthest colony also perceived odors from the units at 200 m away attributed it odor generating sources outside the production units.

To minimize the socio-environmental problems identified, five actions are proposed. The first one is to intensify dry cleaning techniques in areas of higher ammonia accumulation and to add nitrogen balance in the diet. The second action is to improve the infrastructure in enclosed areas by opening spaces for increased ventilation and installing air extraction systems. The third action is to adapt a waste disposal site especially for feathers and carcasses, estimated at 276,598 kg year^{-1} before being taken to municipal confinement. The fourth action suggests that train workers handle the units with environmental-hygiene in mind and finally, the fifth action is to apply biotechnologies designed to generate self consumption products (compost and fuel).

Estimating the Efficiency Biogas Production: The characterization analysis reflects the mixture containing 15.53% of TS and 14.4% of VS, which was diluted by a ratio of 1:2 to obtain the 8% of fermentable content recommended in anaerobic process [15] and an Organic Charge (OC) of 1.9 kg of total volatile solids (SVT) m^{-3} d^{-1}. As to the behavior of parameters pH and temperature during the 38 d operation of the digester, Figure 1 shows variations in the influent and effluent pH near neutral ranges (6.6 to 7.2) recommended in the literature [16]. There were no significant differences of this parameter and that could be attributed to the buffering capacity of protein and fatty components in the different types of excreta, helping to neutralize acidic compounds generated in the microbial metabolism [17]. However, there were large fluctuations in temperature (Figure 2), which were attributed to the difficulty of maintaining mesophilic ranges recommended by Hansen *et al.* [18] during the winter season. Although no linear trend was obtained, the measurements of gas levels generated corresponded to days when the temperature reached or was above 30°C in the reactor; getting a peak production of 1.0 L at operation day 18 with an average of 0.19 L±0.2 L of biogas generated per day.

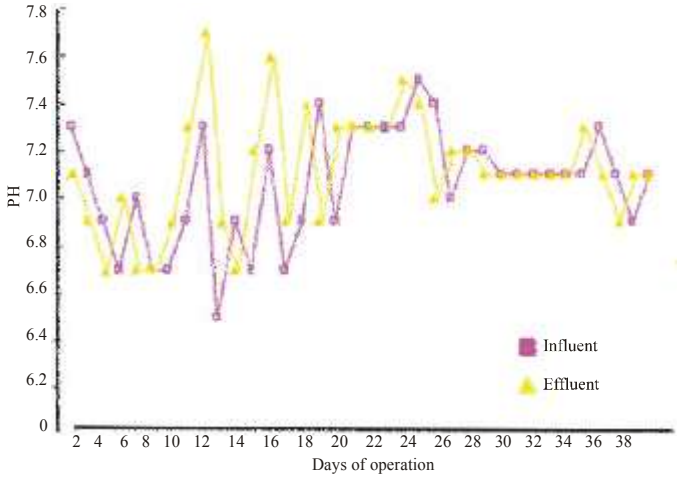

Fig. 1: Behavior of pH in the reactor influent and effluent

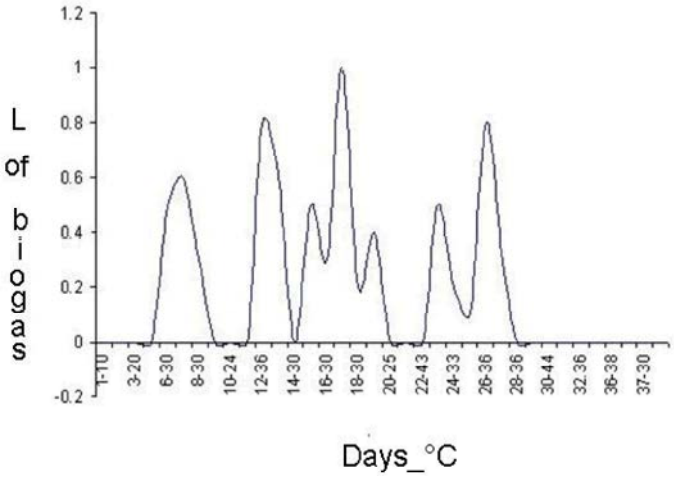

Fig. 2: Relationship between the values of temperature and biogas production

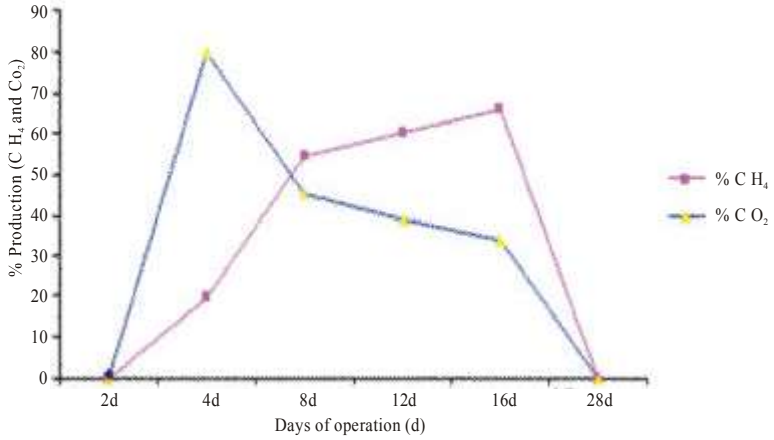

Fig. 3: Proportion of $CH_{4\,(g)\,and}$ $CO_{2\,(g)}$ of the generated biogas

Table 1: Mean values of solids content in influent and effluent

	% TS			%VS		
Day	I	E	%TRS	I	E	%VRS
2	7.97	0.14	7.8	6.42	0.16	6.2
5	5.07	0.27	4.7	3.66	0.16	3.5
8	4.97	0.36	4.6	3.69	0.32	3.3
11	6.67	0.44	6.2	4.65	0.26	4.3
15	7.71	0.62	7.0	6.31	0.58	5.7
17	6.20	0.96	5.2	4.60	0.44	4.2
21	5.31	0.81	4.4	4.06	1.08	2.9
25	5.48	0.72	4.7	5.22	0.74	4.4
28	4.68	1.66	3.0	3.64	1.06	2.5
32	4.17	1.05	3.1	2.95	1.3	1.6
34	7.03	0.78	6.2	5.91	0.62	5.2
Average ± SD	5.9± 1.2	0.7±0.4	5.2±1.5	4.6±1.2	0.6±0.4	4.0±1-4

I= influent E= effluent

The balance of the material content between the influent and effluent from the digester (Table 1) showed a 5.2% and 4.0% of TS and VS removed (RTS and RVS) respectively; corresponding to 88.1% of TS and 90% of VS from the degraded material in the reactor. Gas chromatography revealed an average composition of $CH_{4(g)}$ of 50.15±0.5% with maximum values of 65.94±0.9% at 26 days of operation at temperatures between 33-36°C (Figure 3). Under these conditions, the process efficiencies were: 20.5 L of biogas and 13.5 L of $CH_{4\,(g)}$ kg^{-1} VS added. These values were lower than those obtained in UASB type bi-reactors [19, 20], but the degradation rate obtained of 88.1% TS was higher or comparable to those identified in this study. As such, the process was considered profitable and could be improved by minimizing the irregularities attributed to temperature control.

Validation of the Desirability of Implementing a Larger Scale Digester: Considering the excreta amount (105.78 ton $month^{-1}$) generated on the excretion rate of the total animal species that were handled during the study, the efficiency values of the process and VS content of the mix (14.4%) provides 15.23 ton monthly of fermentable

material. Of this, 204,113 L of CH_4 could be obtained on a larger scale reactor, that could meet energy needs in the production units. This shows the advantage of implementing a productive scale bio digester to generate biogas that can help support their own energy demands of the production units and support in the task of training courses to students of ecology and to improve environmental internal and surrounding quality.

CONCLUSIONS

Depending of the rates of degradation, anaerobic process efficiencies and the amount of $CH_{4(g)}$ estimated to occur in dealing with the total sewage, the implementation of a productive-type digester, is a viable technology to support the demands of fuels in the production units of the Facultad also, contribute to the training of students of ecology with practices to improve the.

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