BIOGAS FERTILIZER PROUCED FROM SHEEP AND CATTLE MANURES

M. A. Mosallam*

ABSTRACT

Fertilizer was produced under anaerobic fermentation from sheep and cattle manures using a conventional digester under semi-constant diurnal ambient temperature. Sheep manure from the lower layer of the bed (floor) of a sheep housing (1.55 % TS) was used in a digestion experiment that lasted for 8 days under mesophilic temperature (32.4^{o}C) and screaned sheep manure from the upper layer of the bed of the sheep housing (6.79 % TS), as used in a digestion experiment that lasted for 12 days under mesophilic temperature (32 ^{o}C). Cattle manure (8 % TS) was used in a digestion experiment that lasted for 69 days under psychrophilic temperature (19.2 ^{o}C). The results concluded that efficiency of anaerobic digestion in case of the lower layer of the bed of the sheep housing is greater than that of the upper layer as degradation in TS in case of cattle manure was 20 % and the long time of digestion (69 day) did not compensate for the decrease in temperature digestion (19.2 ^{o}C).

INTRODUCTION

Egypt produces 55.4 M ton / year of animal residues (**Helmy *et al.*, 2003)** which are a source of pollution. Treating these wastes anaerobicly, makes the waste odorless, destroys germs, lessens carbon to nitrogen ratio and results in an organic fertilizer of nutrients which are available for consumption by the plants (**Mosallam, 2009**). Fertilizer produced by anaerobic fermentation of manure has an an appropriate range of pH value making the manure more nutritive. Digester fertilizer is the product of biogas fermentation and consists of sludge and effluent. The effluent is a readily soluble fertilizer containing various water soluble nutrients.

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The sludge contains most of the main nutrient elements and organic materials, including humic acid, which improves the granular structure of the soil. Continuous, direct application of digester sludge not only increases the yield of crops, but also improves the soil and raises its fertility (**Biogas fertilizer system, 1981).**

This research aims to investigate the production of biogas fertilizer from sheep manure under a semi-constant ambient mesophilic temperature (32 ^{0}C) and the production of biogas fertilizer from cattle manure under a semi-constant ambient psychrophilic temperature (19 ^{0}C) using a conventional digester. Temperature is a very important factor affecting the fermentation rate of organic wastes. It directly affects the process by controlling microbial growth rates. Temperatures are characterized by the three zones of microbial activity, namely, psychrophilic, mesophilic, and thermophilic (**Merkel, 1981**). Merkel showed that total reduction of organic matter is the same for all 3 temperature zones, namely: 20, 30 and 50 ^{o}C, if sufficiently long retention times are permitted. Merkel added that when the digestion process is operating properly, the biochemical reactions will maintain the pH in the proper range. Experiments and analytical results have shown that about 30 to 50 % of the dry matter (TS) of the organic substances is degraded in the anaerobic fermentation process (**Biogas fertilizer system, 1981)** . Operating on cattle manure of 6.3% TS (total solids) under batch fermentation for 30 days and ambient diurnal temperature of mean of 27.5 ^{o}C, **Mosallam *et al., 1998,*** obtained a reduction in TS of 33% and lowest and highest pH of the substrate were 6.7 and 7.2. Using a cattle manure diluted with water at a ratio of (1 :1), **Ghazi *et al.*, (2010),** fermented the manure under a batch temperature controlled process (53 ^{0}C) with stirring (150 rpm) and for 10 days. Reduction in TS was 55% and lowest and highest pH were 6.7 and 7.8. Under anaerobic batch fermentation, temperature of 38 ^{o}C and time of 100 days, **Abdel-Hadi and Abdel-Azeem (2008)** obtained a reduction in OTS of 33% and lowest and highest pH values were 6.4 and 7.6. Working on a continuous mix anaerobic reactor and two diurnally cyclic temperature ranges (20-40 ^{o}C and 15-25 ^{o}C) and four levels of hydraulic retention times (25, 20, 15 and 10 d)on screened manure with TS of 6.4% , **Echiegu *et al.* (1992)** obtained a reduction in

TS within 18 to 40%. **Ghaly (1989)** worked on a dairy manure (6.6% TS) using a no-mix and a continuous stirred digesters at a 20-day hydraulic retention time and six temperature levels (20-45^{o}C) for the production of a fertilizer. Reduction in the TS obtained ranged from 18 to 28% and the sludge obtained from the bottom of the digester had high nitrogen and ash concentrations while the effluent had no offensive odor.

MATERIALS AND METHODS

Digester used:

A cylindrical steel container (1 mm thickness) of height equal to its diameter (45 cm) was equipped to act as an Indian digester for the anaerobic digestion experiments, Fig.(1). Capacity of the digester is about 70 liters. The digester was equipped with two steel pipes (5 cm diameter) to act as influent and effluent pipes. Also the digester was equipped with a manual agitator; on its blades attached sponge strips to act as bacteria carriers. For insulation, the digester was wrapped with a fiberglass. The digester was placed on a wooden sheet on the floor of a room. The digester was operated under ambient diurnal temperature.

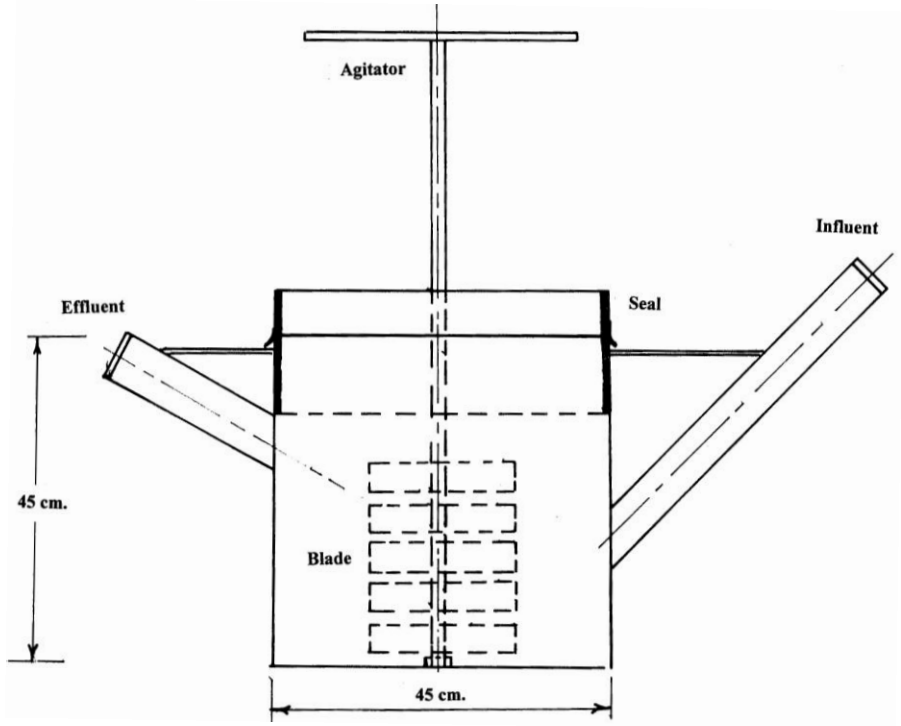


Fig.(1): The used digester, (Drawn to scale).

Sheep manure digested:

Manure under sheep (kept inside housing) makes a layer (Bed). This bed is composed of two different sub-layers: a lower one which is solid such that a vertical blow of a share of an axe not can break it. The hard solidification of this layer is due to walk of sheep on its manure for a long time. The upper sub-layer, of the sheep bed, is pulverized and of noticeably low density. When the sheep lay down its manure (to form the Bed), the manure comes out of the sheep in the shape of separate oval masses (in Arabic called Zebl زبل). Due to walk of sheep on this "Zebl", the Zebl it smashs into very small particles. So lower sub-l layer of sheep manure is composed mainly of compressed very small particles, while upper sub-layer of sheep manure is composed of a mixture of very small particles and "Zebl". Some of this "Zebl" was put into a beaker and water was added. The beaker was left open to air and water was added into it intermittently to compensate lost water due to evaporation. It took more than two weeks for "Zebl" to dissolve in water. An experiment was tried using sheep manure as a substrate as follows: The digester was loaded with a media of lower sub-layer of sheep manure (brought from Animal Production Farm, Fac. of Ag. Univ. of Al-Azhar, Cairo) mixed with water with a mass ratio of 1 : 1. The media was left inside the digester for about ten days. After these ten days, it was noticed that hydrolysis of media is slow and the media is very thick in a way which handicaps intermittent loading and corresponding effluent of the digester, and so the experiment was stopped. In another preliminary experiment, the digester was loaded with a media of lower sub-layer of sheep manure mixed with water with a mass ratio of 1 : 3 (manure to water). The media clogged influent and effluent pipes of the digester and the experiment was terminated.

The media of the previous experiment (1: 3 manure to water, by mass) was more diluted with water such that its total solids (TS) was 1.55 % and an experiment was started on 5/8/2010 and ended on 13/8/2010 (lasted for 8 days). The digester was loaded intermittently at rate of about 17 d hydraulic retention time. In another experiment, upper sub-layer of

sheep manure was used after screening it by a sieve to separate "Zebl" from it. The sheep manure was diluted with water such that its TS was 6.76%. This experiment was started on 26/8/2010 and ended on 8/9/2010 (lasted for 12 days). The digester was loaded intermittently of rate of about 17 d hydraulic retention time.

Cattle manure digested:

Cattle manure used was brought farm of Fac. of Ag., Univ. of Al-Azhar, at Mostorod, Cairo.(مسطرد ، القاهرة) The manure was diluted with water at a ratio of 1 : 1 by volume. TS of the diluted manure was 8 %. The manure was digested under a batch process. This experiment was started on 26/1/2011 and ended on 17/3/2011 (lasted for 69 days).

Measurements of the effluent:

Total solids was measured by using a digital balance of 0.01g accuracy and drying the sample under 105 ^{o}C for 24 h. for each TS measurement, 3 replicates were used.

pH was measured using a digital pH meter of 0.01 accuracy.

Ambient temperature was recorded using a hygrothermograph.

Before and while taking a sample of effluent of the digester for measuring, media of the digester was kept under stirring by the manual agitator.

RESULTS AND DISCUSSION

Recorded temperature:

The graphs of the recorded ambient temperature obtained by the hygrothermograph, were either (like) straight ones (Fig.2) or the graph has a variation in temperature degrees ranging from about 2 to about 4^{o}C (Fig.3). This means that the ambient temperature under which the

digestion was taking place, was a (like) constant one. The room in which the digester was placed is designed to be a workshop. It exchanges the air with the outside through a (strip) of narrow windows near its ceiling. These windows are located at the top of one of its four walls. Each window has a glass sheet fixed at the bottom of the window and makes an angle of 45^{o} with. This design of the room explains the semi-constant temperature of its air.

Sheep manure of lower sub-layer of 1.55% total solids (TS);

The mean recorded temperature during the experiment period (8 days) was 32.4 ^{o}C.

Fig.(4) shows the relation between time total solids (TS%) for sheep manure 1.55% TS.

$$\text{The reduction in TS} = \frac{\text{initial TS} - \text{lowest measured TS value}}{\text{initial TS}}$$

The reduction in TS was found to be 29 %.

Fig.(5) shows the relation between time and pH for the same experiment. Values of the lowest and highest pH obtained during the experiment were 6.52 and 8.

Screened sheep manure of upper sub-layer of 6.79% total solids (TS);

The mean recorded temperature during the experiment period (12 days) was 32 ^{o}C.

Fig.(6) shows the relation between time total solids (TS%) for sheep manure 6.79% TS. The reduction in TS was found to be 17.2 %.

Fig.(7) shows the relation between time and pH for the same experiment. Values of the lowest and highest pH obtained during the experiment were 6.76 and 7.06.

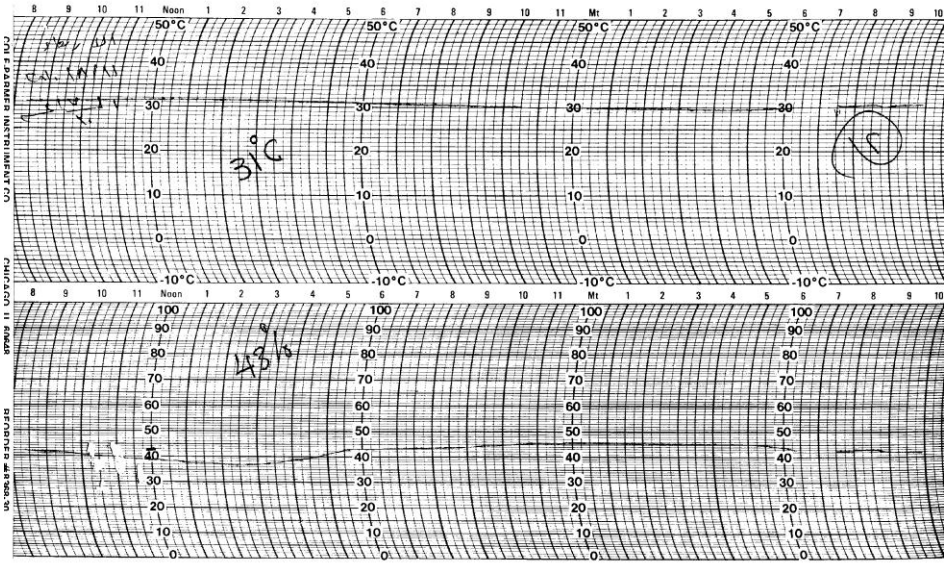


Fig.(2): Recorded temperature, straight curve.

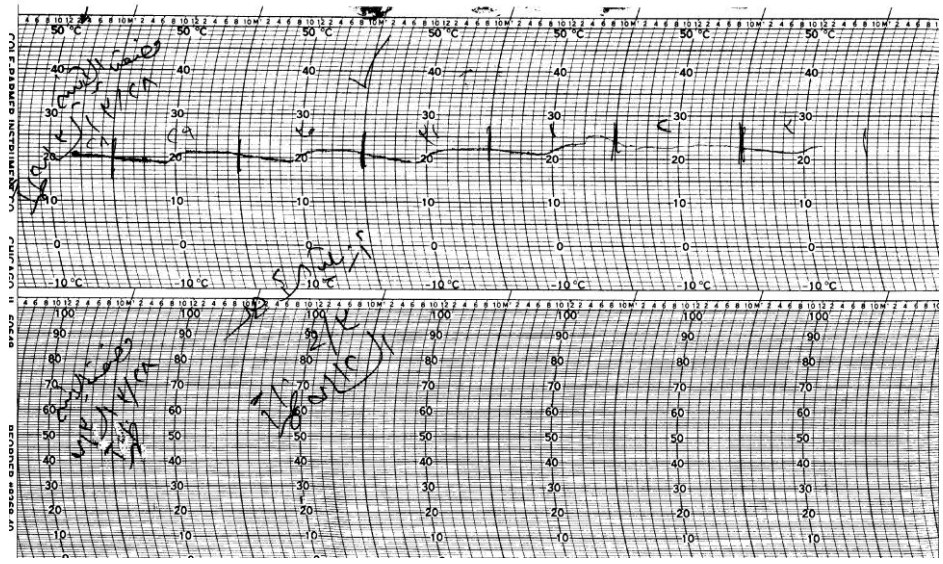


Fig.(3): Recorded temperature, fluctuate curve

FIg.(4): The relation between Time (day) and total solids (TS %) for 1.55% TS sheep manure.

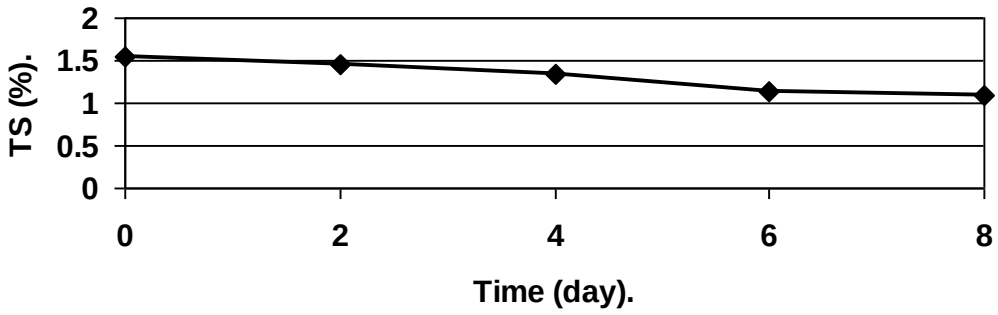


Fig.(5): The relation between time (day) and pH for 1.55 TS sheep manure.

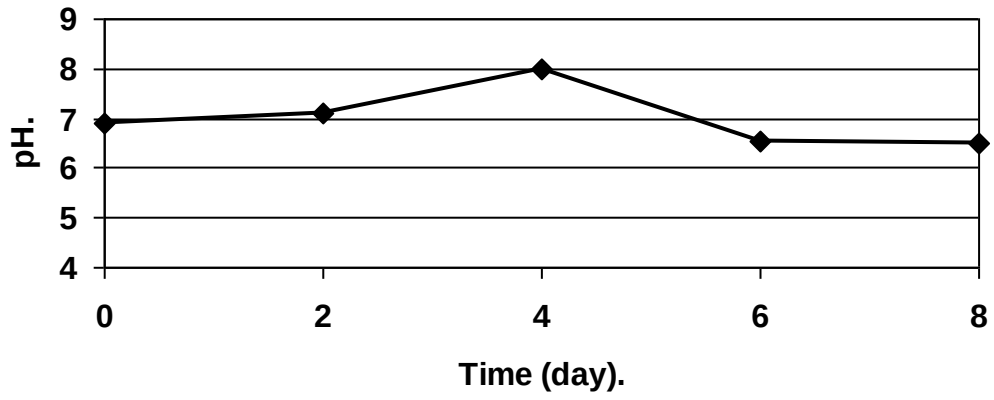


Fig.(6): The relation between time (day) and total solids (TS %) for 6.79 % TS sheep manure.

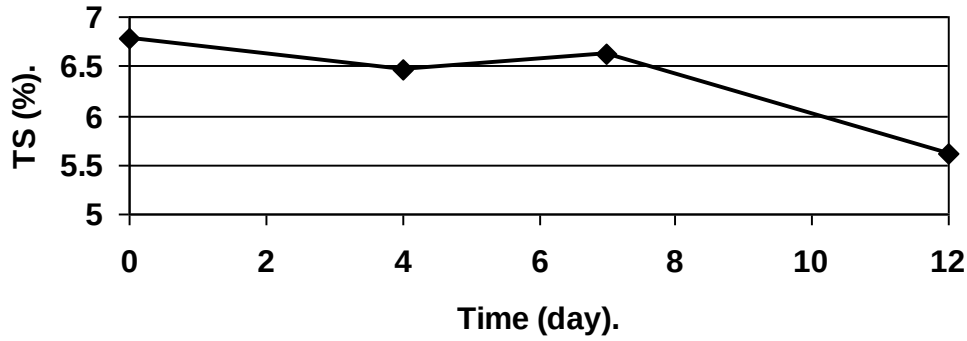
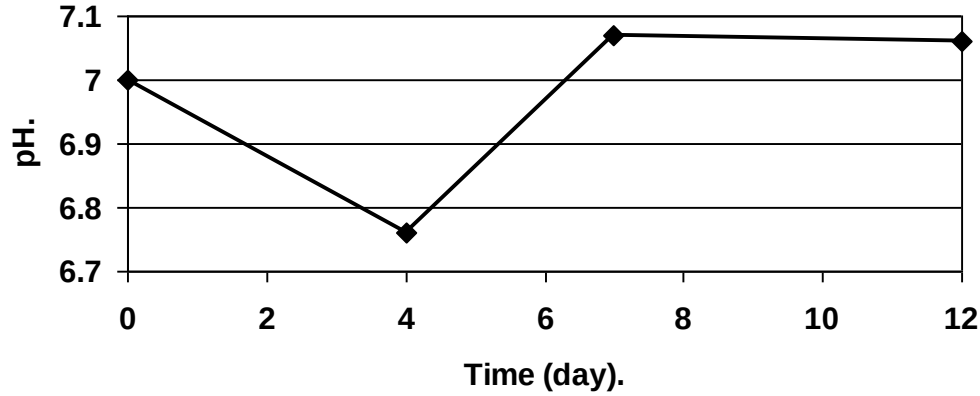


Fig.(7): The relation between Time (day) and pH for 6.79% Ts sheep manure.



Comparing the results of both TS concentrations shows that though temperatures of digestion of both concentrations is nearly the same and time of digestion in case of 6.79% TS is 1.5 as that of 1.55% TS, the reduction in TS in case of the lower TS concentration is 1.69 as that of the higher TS concentration. This means that lower sub-layer of sheep manure is more efficient for anaerobic fermentation.

Cattle manure of 8% total solids (TS);

The mean recorded temperature during the experiment period (69 days) was 19.2 ^{o}C.

Fig.(8) shows the relation between time total solids (TS%) for cattle manure 8% TS. Fig.(8) shows that, with time, the TS does not gradually decrease. The explanation of this is as follows: when a sample of the effluent of the digester was taken out of the digester for analysis, the effluent pipe of the digester was cleaned of the dried manure at its top by inserting a stick inside it. Then agitator of the digester was kept turning at a relatively high speed. After some time of turning the agitator, a stick was inserted inside the effluent pipe and moved down and up to help in getting media of the digester out of it. Of course, the effluent pipe cleaning, in such a previously mentioned method, and speed of rotation of the agitator and time from the begin of turning of the agitator to time of taking of the sample from the digester and motion (up and down) while taking the sample out of the digester, all this differs from a sample to another leading to the non uniformity of decrease in TS.The reduction in TS was found to be 20 %.

Fig.(9) shows the relation between time and pH for the same experiment. Values of the lowest and highest pH obtained during the experiment were 6.3 and 7.6.

Though the time of digestion of the cattle manure was long, the reduction in TS was low. This means that the log time did not compensate for the psychrophilic temperature (19.2 ^{o}C). The pH of the manure remained nearly constant at the last 20 days of the experiment.

Fig(8): The relation between Ttme (T, day) and total solids (TS %) for cattle manure.

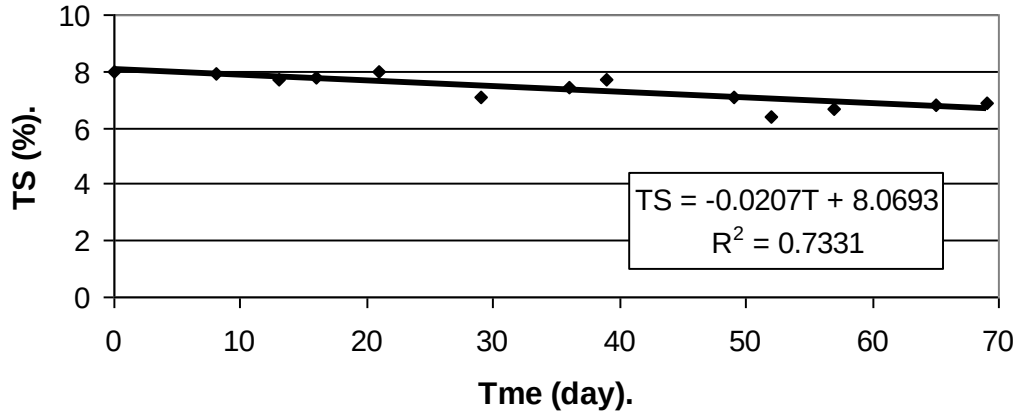
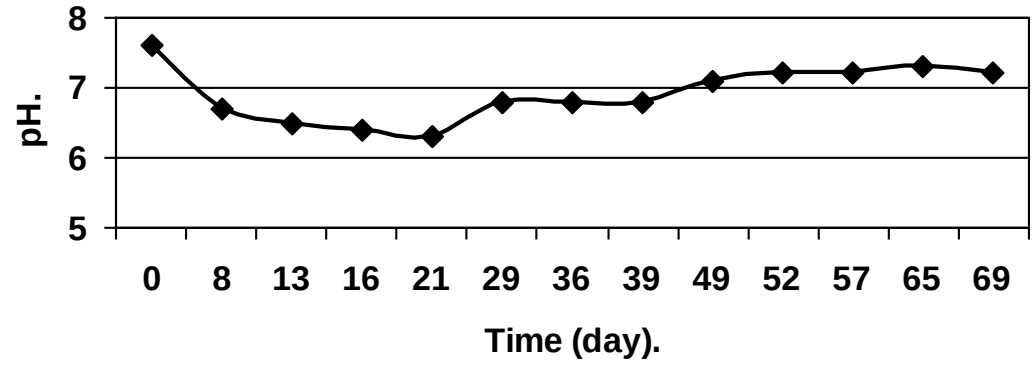


Fig.(9): The relation between Time (day) and pH for cattle manure.



SUMMARY

Fertilizer was produced under anaerobic fermentation from sheep and cattle manures using a conventional (prototype) digester of 70 liters under semi-constant diurnal ambient temperature. Sheep manure from the lower layer of the bed (floor) of a sheep housing (1.55 % TS) was used in a digestion experiment that lasted for 8 days under mesophilic temperature (32.4^{o}C) and screaned sheep manure from the upper layer of the bed of a sheep housing (6.79 % TS) was used in a digestion experiment that lasted for 12 days under mesophilic temperature (32 ^{o}C). the two experiments were carried out under intermittent flow. Cattle manure (8 % TS) was used in a digestion experiment that lasted for 69 days under psychrophilic temperature (19.2 ^{o}C). The experiment was carried out under batch fermentation. Ambient temperature was recorded and TS and pH were measured for each experiment.

The results were as follows:

1- Efficiency of anaerobic digestion in case of the lower layer of the bed of the sheep housing is greater than that of the upper layer.

2- Degradation in TS in case of the lower layer was 29 % while was 17.2 % in case of upper layer. Lowest and highest values of pH were in case of the lower layer as 6.52 and 8 while they were 6.76 and 7.06 in case of the upper layer.

3- Degradation in TS in case of cattle manure was 20 % and the long time of digestion (69 day) did not compensate for the decrease in temperature digestion (19.2 ^{o}C). Lowest and highest values of pH were 6.3 and 7.6. It was noticed that the value of the pH was nearly constant (higher than 7) at the last 20 days of the digestion.

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الملخص العربى

إنتاج سماد البيوجاز من روث الأغنام و الماشية

محمود أحمد مسلم*

تم إنتاج السماد بعملية التخمر اللاهوائى لروث الأغنام و الماشية و ذلك باستخدام هاضم تقليدى سعة ٧٠ لتر تحت درجة حرارة يومية شبه ثابتة. تم استخدام روث أغنام من المرقد التحتى لأرضية حظيرة أغنام (مادة صلبة كلية ١.٥٥ %) فى تجربة تخمر مدتها ٨ يوم تحت درجة حرارة ميزوفيلية (٣٢.٤ درجة سلزيوس) و تم استخدام روث أغنام مصفى من (الزبل) من المرقد الفوقي لأرضية حظيرة أغنام (مادة صلبة كلية ٦.٧٩ %) فى تجربة تخمر مدتها ١٢ يوم تحت درجة حرارة ميزوفيلية ٣٢(درجة سلزيوس). كانت التجربتان بنظام السريان المتقطع.

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تم استخدام روث ماشية (٨ % مادة صلبة كلية) فى تجربة تخمر مدتها ٦٩ يوم تحت درجة حرارة سيكروفيلية (١٩.٢ درجة سلزيوس). كانت التجربة بنظام الدفعة. تم تسجيل درجة الحرارة المحيطة بالهاضم وقياس المادة الصلبة الكلية و رقم الأس الهيدروجينى لكل تجربة.

كانت النتائج المتحصل عليها كلآتى:

١- كفاءة الهضم اللاهوائى للمرقد التحتى لأرضية حظيرة الأغنام أعلى منها فى حالة المرقد الفوقى لأرضية حظيرة الأغنام.

٢- كان هضم المادة الصلبة الكلية فى حالة المرقد التحتى ٢٩% بينما كان في حالة المرقد الفوقى ١٧.٢ % وكانت القيم الدنيا و العليا لرقم الأس الهيدروجينى فى حالة المرقد التحتى ٦.٥٢ و ٨

بينما كانت ٦.٧٦ و ٧.٠٦ فى حالة المرقد الفوقى.

٣- كان هضم المادة الصلبة الكلية فى حالة روث الماشية ٢٠ % ولم تعوض طول مدة الهضم اللاهوائى (٦٩ يوم) انخفاض درجة حرارة الهضم (١٩.٢ درجة سلزيوس). وكانت القيم الدنيا و العليا لرقم الأس الهيدروجينى ٦.٣ و ٧.٦. لوحظ ثبات رقم الأس الهيدروجينى (أعلى من ٧) فى آخر ٢٠ يوم من عملية الهضم لروث الماشية.