EFFECT OF THREE LEVELS OF AERATION ON THE AEROBIC FERMENTATION OF DILUTED SHEEP MANURE

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ABSTRACT

To study the effect of aeration on the batch digestion of the sheep manure, three columns were done from a PVC tube of diameter of 25 cm and each column is of height of 50 cm and its capacity is 24 liter. Three levels of aeration were investigated. These levels are: 1.8, 3.6 and 5.4 W. Firstly, the columns were loaded intermittently with equal quantities of the effluent of an anaerobic digester operating on diluted and smashed sheep manure. Then the columns were emptied and filled with a mixture of its emptied media and diluted smash sheep manure for a batch aerobic digestion which lasted for 28 days. TS of the new media was 5.5% and its pH was 8.2. TS and pH were measured intermittently and ambient temperature was recorded.

The experiment concluded to that:

1- The mean recorded ambient temperature was 29.5^{o}C.

2- Diluted sheep manure needs a high rate of aeration to degrade which may make the process of digesting sheep manure uneconomic. Reduction in TS was: 15.4, 5.6 and 2% for the aeration levels: 5.4, 3.6 and 1.8 W respectively.

3- Aerobic degradation of TS of sheep manure can be represented by a linear function with a high correlation coefficient.

4- Under the three treatments, the pH decreased through the first four days of the digestion while it increased – generally – from the sixteenth day till the end of the experiment.

The study ended to that sheep manure needs a high rate of aeration to be degrade and may, economically, the aerobic digestion of sheep manure be not efficient.

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INTRODUCTION

Under aerobic conditions, organic matter is oxidized by bacteria so a continuous removal of the organic matter from the waste takes place. This removal is a function of bacterial metabolism. The oxygen is supplied either from the atmosphere by means of surface aeration or from algae as a result of the photosynthesis process. Some of the removed organic matter is synthesized into cell protoplasm and the remainder of the organic matter is oxidized to form energy for this synthesis (**Merkel**, **1981**). Typical disadvantages of anaerobic digestion such as: very slow growth of methanogenic bacteria, low limit of ultimate biosolids removal, poor process stability, and requirements for further treatment of decanted supernatant, have caused the present widespread attention to the aerobic digestion, **Mohsen and Abbas (2006).** Anaerobic treatment has many advantages including minimum odor, a good quality effluent and eliminating many pathogens present in agricultural wastes. **(Zhu, 2010).** Aerobic digestion stabilizes the animal waste and convert it into a liquid that can be spread on the land, (**Merkel**, **1981**).

This research aims to investigate the effect of three levels of aeration on the digestion of diluted sheep manure.

REVIEW OF LITERATURE

Attar *et al., (2005)* Treated sewage sludge aerobically under aeration rates of 2.14, 3.00, 3.86 and 4.71 volume of air per volume of sludge per hours under 55^{o}C and different detention times and mechanical stirring. range of TS in sludge was 1.5-2.0 percent. For aeration rate 4.7 l/l.h, the percentage of removed TS increases from zero to 19, 28 and 39 percent during 5, 10 and 16 days of detention time respectively. pH of sludge were increased from around 6.90 to around 8.40 in all treatments. **Zhang *et al., (2004)*** Digested pig slurries of TS concentrations of 0.5, 1.0, 2.0 and 4% under a stirred batch system for 30 days. The digestion was carried out under 3 levels of aeration which are: +35mV oxidation-reduction potential, 1.0 and 3. mg [O_2] l^{-1}. TS removal efficiencies were 44.9, 50.3 and 56.4 for the three levels respectively. **Okamoto *et al., (1995)*** Digested aerobically cattle slurry of TS of 2.05% for 28 days. The reduction in TS was 22% and pH of the slurry rose from 7.39 to 8.03.

Ghaly and Ben-Hassan (1993), studied cheese whey yeast ermentation. Under aerobic fermentation, TS removal efficiency ranged from 25.20-69.33%. **Selvamurgan *et al.*, (2010),** treated coffee wastewater (results during coffee processing industry) aerobically under a batch system for 8 days. The removal efficiency of TS was 49.3%.

MATERIALS AND METHODS

To study the effect of aeration on the digestion of sheep manure, three cylindrical columns were used. These columns were made from PVC tube of diameter of 25 cm. Each column is of 50 cm height and 24 liter capacity. To increase the efficiency of digesting the sheep manure, the effluent of an anaerobic digester (The digester was operating on diluted and smashed sheep manure. Manure of the digester was obtained from the farm of the animal production dept., fac. of agric., univ of Al-Azhar. The digester was in the stage of not producing a biogas, so its effluent contains aerobic and facultative bacteria) was transferred intermittently into each of the three columns. 1.5 liter of the effluent of the digester was transferred to each column at a time. This transfer was continued till about one third of each column was filled with media. The transfer of the digester effluent took about one month. Before the transfer of the effluent to the columns the following was carried out: one column was left without aeration (its aeration was due to ambient air). Another column was aerated using a compressor of power of 1.8 W. The third column was aerated using two compressors each of power of 1.8 W (its aeration is of power of 3.6 W). Each compressor transfers the ambient air into the bottom of the column through a hose of diameter of 7 mm. An air distributor was attached to the end of each hose. Time of aeration was 24 h per day. Total solids "TS" (the dry matter) of each column was measured intermittently. It was noticed that the reduction in TS is little for each of the three columns. After working for about one month on the effluent of the anaerobic digester, the media of the three columns were emptied and mixed. To the mixture of the media of the three columns, a diluted and smashed sheep manure was added (the manure was obtained from the previously mentioned source). Ratio of the sheep manure to the water was 1: 4 (by volume) and each of the three columns was filled with the new mixture and left for a batch digestion. TS of the new mixture was

5.5% and its pH was 8.2. To increase the aeration rate of the sheep manure, one of the three columns was equipped with one compressor and another one was equipped with two compressors and the third was equipped with three compressors. So three levels of aeration was obtained: 1.8, 3.6 and 5.4 W. TS and pH for three replicates for each column were measured intermittently and ambient temperature was recorded using a hygrothermograph. Each of the three columns was covered with a perforated plastic sheet to decrease the evaporating water (Fig.1 and plate 1).

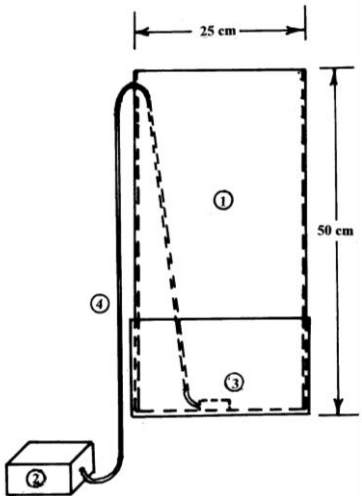

Fig.(1): The used column. 1- The column. 2- The compressor. 3- Air distributor. 4- Hose.

Plate (1): The used columns and compressors.

Before each measure of TS and pH, water was added to each column to compensate for the evaporating water. The batch digestion was continued for 28 days.

The reduction in TS "TSR" was calculated as:

$$TSR = \frac{TS_1 - TS_2}{TS_1}$$

Where: TS_1 concentration of TS at the begin of the batch experiment and TS_2 concentration of TS at the end of the batch experiment (after 28 days).

RESULTS AND DISSCTION

Mean recorded ambient temperature is was found to be 29.5 ^{o}C.

Table (1) shows initial, final and reduction in the concentrations of total solids "TS" for each of the three used levels of aeration for the batch digestion (lasted for 28 days).

Table (1): Initial and final TS concentration for the three levels of aeration.

Aeration level (W)	Initial TS (% w/w)	Final TS (% w/w)	Reduction in TS (%)
1.8	5.5	5.39	2%
3.6	5.5	5.19	5.6%
5.4	5.5	4.67	15.4%

Table 1 shows that sheep manure needs a high rate of aeration to be degrade**.** The only recognizable reduction in TS (15.4%) is for the aeration level of 5.4 W per 24.5 liter of diluted manure (time of aeration is 24 h per day). The relation between the level of aeration and the reduction in TS does not at all approach a linear one. Doubling the aeration level results in 2.8 times reduction in TS. When the aeration is three times, reduction in TS is 7.7 times. Economically, may the digestion of sheep manure be not efficient.

Figs. 2 through 4 show the relation between total solids concentration "TS" and time for each of the three used levels of aeration. The relation between TS concentration and time for the three levels of aeration can be

expressed by a linear function with R^2: 0.81 to 0.94%. As the aeration level increase, R2 increase. R^2 are 0.81, 0.89 and 0.94% for aeration levels 1.8, 3.6 and 5.4 W respectively.

Figs. 5 through 7 show the relation between pH and time for each of the three used levels of aeration. From these figures it can be noticed that:

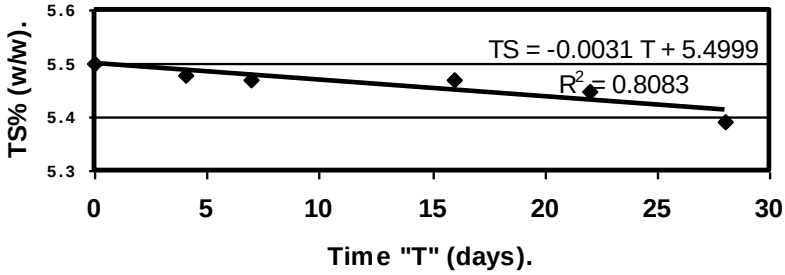

Fig. (2): The relation between total solids concentration and time for the 1.8 W aeration level.

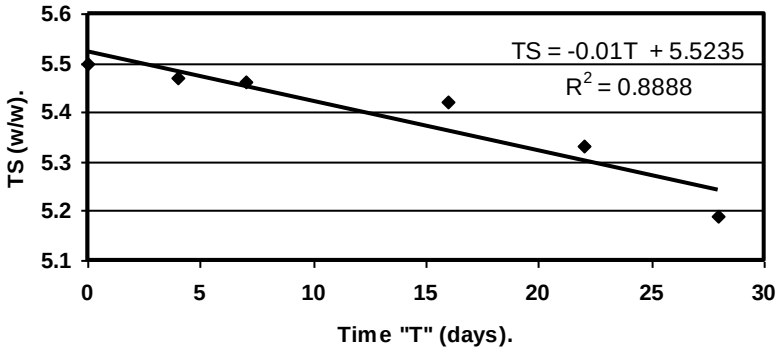

Fig. (3): The relation between total solids conceentration and time for 3.6 W aeration level.

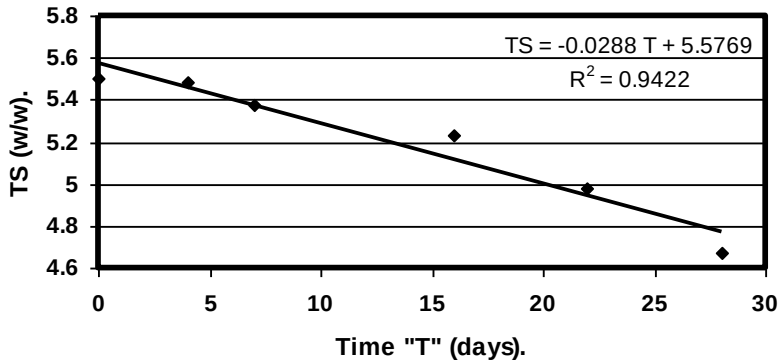

Fig. (4):The relation between total solids and time for 5.4 W aeration level.

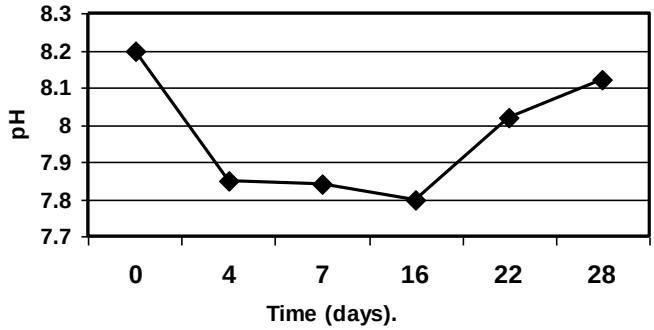

Fig. (5): The relation between pH and time for 1.8 W aeration level.

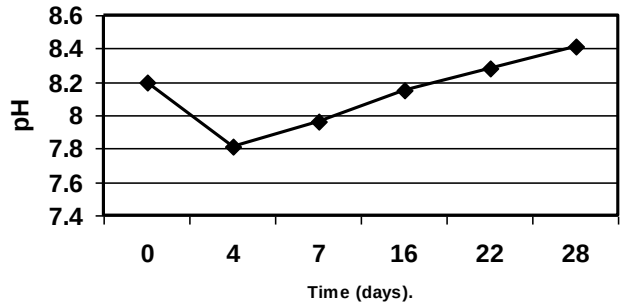

Fig. (6): The relation between pH and time for 3.6 W aeration time.

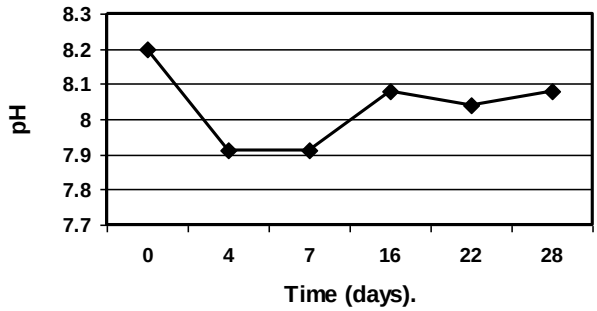

Fig. (7): The relation between pH and time for 5.4 W aeration level.

1- For the first four days of the batch digestion, the pH decrease for the three levels of aeration.

2- From the fourth to the sixteenth day of the digestion, the pH has not have the similar trend for each of the three levels of aeration. The pH either increases or decreases or remains constant.

3- From the sixteenth day till the end of the digestion, the pH, generally, increase.

4- The 3.6 W aeration level resulted in the highest pH value at the end of the experiment (8.41) while values of the pH for the two other levels approached (8.12 and 8.08 for the first and third levels respectively).

SUMMARY

To study the effect of aeration on the batch digestion of the sheep manure, three columns were done from a PVC tube of diameter of 25 cm and each column is of height of 50 cm and its capacity is 24.5 liter. Three levels of aeration were investigated. These levels are: 1.8, 3.6 and 5.4 W. To accelerate the aerobic digestion process, each of the three columns was loaded, intermittently, with equal quantities of the effluent of an anaerobic digester operating on diluted and smashed sheep manure. When effluent of the digester became one third of the column volume, the columns were emptied from its media and these media were mixed and a diluted smashed sheep manure was added to the mixture and the columns were filled with the new media to start the batch

aerobic digestion. TS of the new media was 5.5 and its pH was 8.2. The digestion lasted for 28 days. TS and pH were measured intermittently and ambient temperature was recorded.

The experiment concluded to that:

1- The mean recorded ambient temperature was 29.5^{o}C.

2- Diluted sheep manure needs a high rate of aeration to degrade which may make the process of digesting sheep manure uneconomic. Reduction in TS was: 15.4, 5.6 and 2% for the aeration levels: 5.4, 3.6 and 1.8 W respectively.

3- Aerobic degradation of TS of sheep manure can be represented by a linear function with a high correlation coefficient.

4- Under the three treatments, the pH decreased through the first four days of the digestion while it increased – generally – from the sixteenth day till the end of the experiment. At the end of the experiment, the treatment 3.6 W recorded the highest value of pH (8.41) while the values of pH approached for the two other treatments (8.12 and 8.8 for the two treatments 1.8 and 5.4 respectively).

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الملخص العربى

أثر ثلاثة مستويات من التهوية الإصطناعية على التخمر الهوائى لروث الأغنام المخفف

محمود أحمد مسلم*

لدراسة أثر التهوية الإصطناعية على الهضم الهوائى بنظام الدفعة لروث الأغنام المخفف، تم عمل ثلاثة أعمدة من مواسير ال بى فى سى قطر ٢٥ سم و كل عامود بارتفاع ٥٠ سم و سعة العامود ٢٤ لتر. تم العمل على ثلاثة مستويات للتهوية للأعمدة الثلاثة. هذه المستويات هى: ١,٨، ٣,٦ و ٥,٤ وات. للإسراع بعملية الهضم الهوائى تم تزويد كل من الأعمدة الثلاثة، بشكل متقطع، بكميات متساوية من خرج هاضم لا هوائى يعمل على روث الأغنام المهروس المخفف. عندما بلغ حجم خارج الهاضم ثلث حجم العمود، تم تفريغ الأعمدة من بيئاتها و تم خلط البيئات معا و أضيف الى البيئة المخلوطة روث أغنام مهروس مخفف ثم ملأ كل من الأعمدة الثلاثة بالبيئة الجديدة وكانت نسبة المادة الصلبة الكلية للبيئة الجديدة ٥,٥% ورقم الأس الهيدروجينى ٨,٢ لكى يبدأ الهضم الهوائى بنظام الدفعة لمدة ٢٨ يوم. تم على فترات قياس المادة الصلبة الكلية و رقم الأس الهيدروجينى لكل عامود و سجلت درجة الحرارة المحيطة بالأعمدة.

توصلت التجربة للنتائج التالية:

١- درجة الحرارة المحيطة المتوسطة كانت ٢٩,٥ درجة سلزيوس.

٢- أن روث الأغنام المخفف يحتاج الى معدل عالى من التهوية لكى يمكن له أن يتحلل مما قد يجعل عملية تحلله الهوائى غير اقتصادية. كانت نسبة تحلل المادة الصلبة الكلية ١٥,٤ ، ٥,٦ و ٢% لكل من مستويات التهوية: ٥,٤ ، ٣,٦ و ١,٨ وات على الترتيب.

٣- يتبع التحلل الهوائى لروث الأغنام المخفف دالة خطية بمعامل ارتباط عالى.

٤- انخفض رقم الأس الهيدروجينى لروث المخفف تحت الثلاث معاملات خلال الأربعة أيام الأولى من الهضم بينما أخذ فى الارتفاع - بشكل عام – بدءا من اليوم السادس عشر و حتى نهاية التجربة . فى نهاية التجربة سجلت المعاملة ٣,٦ وات أعلى قيمة لرقم الأس الهيدروجينى (٨,٤١) بينما اقتربت قيم رقم الأس الهيدروجينى للمعاملتين الأخريين (٨,١٢ و ٨,٠٨ للمعاملتين ١,٨ و وات ٥,٤ على الترتيب).

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