HORIZONTAL BIODIGESTOR BEHAVIOR AT POULTRY LITTER TREATMENT

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1 INTRODUCTION

At the beginning of XXI Century, the aviculture is facing a globalized market approach and a high commercial demand where the products as well as the production processes have to fit the acceptability standards of the client. Besides, there is the quest for the recognition of the sustainable development and of the environmental and social management programs, incorporated to the commercial product (Santos, 2004).

The growth of the industrialization process resulted in increased quantities of effluents with high organic contents that could lead to a potential increase of alternative energy sources. These effluents, which are capable of causing a great negative environmental impact, can become a considerable source of energy.

The poultry rearing is an activity demanding high consumption of energy for heating. That activity, however, holds the characteristic of producing residues with considerable energetic potential, such as the poultry litter that could contribute to the energetic balance of the activities developed within the rearing facilities (Santos, 2004).

The bio-digestion, or anaerobic digestion, is an excellent alternative for the adequate treatment of the poultry litter for biogas and fertilizer production. These two byproducts are highly valued as sources of energy and plant nutrition, substituting the inputs that otherwise would need to be bought by the producer. From that substitution, the producer would have a decrease in his production costs (Palhares, 2005).

The biogas produced from the bio-digestion of poultry litter can be used for the warming up of chicks, as well as in substitution of the electricity used, for example, in the illumination (lanterns), water heating (for sterilization of equipments, facilities washing, showers), stoves, and grain grinders (Palhares, 2005).

The pure bio-fertilizer contains a high concentration of nutrients, and can be used directly in the soil. It is also a great help when used as an additive in the preparation of nutrient solutions for organic-inorganic hydroponics, promoting an enormous increase in the productivity of the hydroponics crops. Once diluted, it constitutes a great foliar fertilizer and, in that form it is generally known as diluted bio-fertilizer.

Before the economical and environmental dependence in which the aviculture is set nowadays, this research work aimed at verifying the behavior of the anaerobic bio-digestion in the treatment of poultry litter in a continuous flow horizontal bioreactor, under laboratory scale.

2 MATERIAL AND METHODS

The experiment was carried out at the Sanitation Laboratory of the Western Paraná State University (UNIOESTE), Cascavel Campus, Paraná State, Brazil. The continuous flow bioreactor, measuring 60 cm in length x 20 cm in width x 30 cm in height, was built with glass, for a useful volume of 30 L. The bioreactor was maintained at 30±1ºC temperature and hydraulically connected to a gasometer, forming one single atmosphere. For the gasometer assembly, a 20 L capacity tube partially filled with a saline solution (3% H_2SO_4 and 25% NaCl) to avoid reaction of the CO_2 from the biogas with the solution was used. A thermometer and a water column manometer were connected to the gasometer to correct the volume of the biogas produced at Normal Conditions of Temperature and Pressure (NCTP). Once the gasometer is pressurized with biogas, the solution is forced to flow, measuring the volume of the biogas produced.

To start the bio-digestion process, 30% of the bioreactor volume was inoculated with sludge from the anaerobic lagoon of a starch effluents treatment system, and 70% of its volume was filled with poultry litter diluted in deionized water, at a proportion of 8% total solids (TS). The daily feeding of the bioreactor was performed with 1

L of poultry litter diluted in deionized water, for an organic load of 1.87 g volatile solids (VS) $L_{bioreactor}^{-1}$ day^{-1}. The bioreactor was allowed to stabilize for a period equal to the Hydraulic Retention Time (HRT) of 29 days, and after stabilization 30 days were evaluated as replications of the anaerobic bio-digestion with poultry litter for that HRT.

The bioreactor evaluations were daily performed by physical analyses of TS, VS and biogas production (APHA, 1995). For monitoring the biological process of the bioreactor, the pH and the VA/TA ratio, between results of chemical analyses of Volatile Acidity (VA) and Total Alkalinity (TA), were weekly monitored. The physicochemical parameters were determined following the methodologies described by Silva (1977).

The control graphs were mounted using the MINITAB 15 software, employing the following expressions for calculation of the upper and lower limits:

$MAi = | X_i – X_{i-1} |$ (2)

$UCL = X + ((3 * AM) / d2)$

$MCL = X$

$LCL = X – ((3 * AM) / d2)$

In which:

X is the mean of individual values;

MA is the moving average range of two successive observations to estimate the variability of the process;

d2 is the factor for the median line;

UCL is the upper limit of statistic control;

MCL is the median limit of statistic control; and

LCL is the lower limit of statistic control.

3 RESULTS AND DISCUSSION

On Table 1, the values on biogas production and on removal of the organic matter, resulting from the anaerobic bio-digestion of poultry litter in a continuous flow horizontal bioreactor, are presented. The mean production of biogas was 0.56 L and the mean TS and VS removal were 77.5% and 88.8%, respectively. According to the Anderson Darling test (p-value), data on the analyzed variables were normally distributed, at 5% level of significance.

TABLE 1 **Descriptive statistics of the variables: biogas production, percent TS and percent VS removed**

HRT: 30 days	p-value	Minimum	Mean	Maximum	First Quartile	Median	Third Quartile	Standard deviation	CV %
L biogas	0.705	0.11	0.55	1.30	0.37	0.50	0.74	0.27	49.5
% TS removed	0.040	31.90	54.00	77.50	43.30	49.70	68.60	14.80	27.3
% VS removed	0.041	44.50	65.30	88.80	55.40	61.10	77.60	12.80	19.6

The anaerobic bio-digestion of poultry litter for the HRT (30 days) evaluated, yielded a mean biogas production by removal of organic mater of 0.017 L g $VS_{consumed}^{-1}$.

Using continuous flow bioreactors for the treatment of poultry litter from automatized production system, Augusto (2007) obtained a mean production of biogas by removal of organic matter of 0.029 L g $VS_{consumed}^{-1}$ and reductions of TS (72%) and VS (74%) with organic charge of 1.82 g VS $L_{bioreactor}^{-1}$ day^{-1}, as well as poultry litter from conventional production system, achieving mean biogas production by removal of organic matter of 0.013 L g $VS_{consumed}^{-1}$ and reductions of TS (78.7%) and VS (79.5%) with organic charge of 1.48 g VS $L_{bioreactor}^{-1}$ day^{-1}.

On Table 2, the pH and VA/TA ratio values, which are indexes indicating anaerobic bio-digestion stability, are presented. According to Silva (1977) with VA/TA values between 0.1 and 0.5, it is possible to state a better anaerobic behavior for the bioreactor. For values higher than those, the bioreactor may present instability signs.

TABLE 2 **VA/TA ratios.**

Date	01/10/2008	09/10/2008	16/10/2008	23/10/2008	28/10/2008
pH	8.30	8.20	8.33	8.32	8.02
VA / TA	0.32	0.30	0.33	0.25	0.25

Even with the bioreactor stabilized, variations in the byproducts yielded, originated from the bioreactor environmental conditions, will always occur. Through data and coefficient of variation displayed on Table 1, it is possible to verify the high variability of byproducts production and organic matter removal. Thus, the control of the process is important in order to achieve a higher conversion of the poultry litter into biogas and bio-fertilizer.

The use of statistical graphs of control is an efficient technique in detecting lack of control within the process, and its systematic use is an effective way to detect and to reduce the variability (Montgomey, 2008).

Analyzing the graphs of control processes of individual measurements of biogas production and solids removal, it is perceivable that the process is out of statistical control, since it displays extreme variations and deviations (more than six consecutive values below the median line).

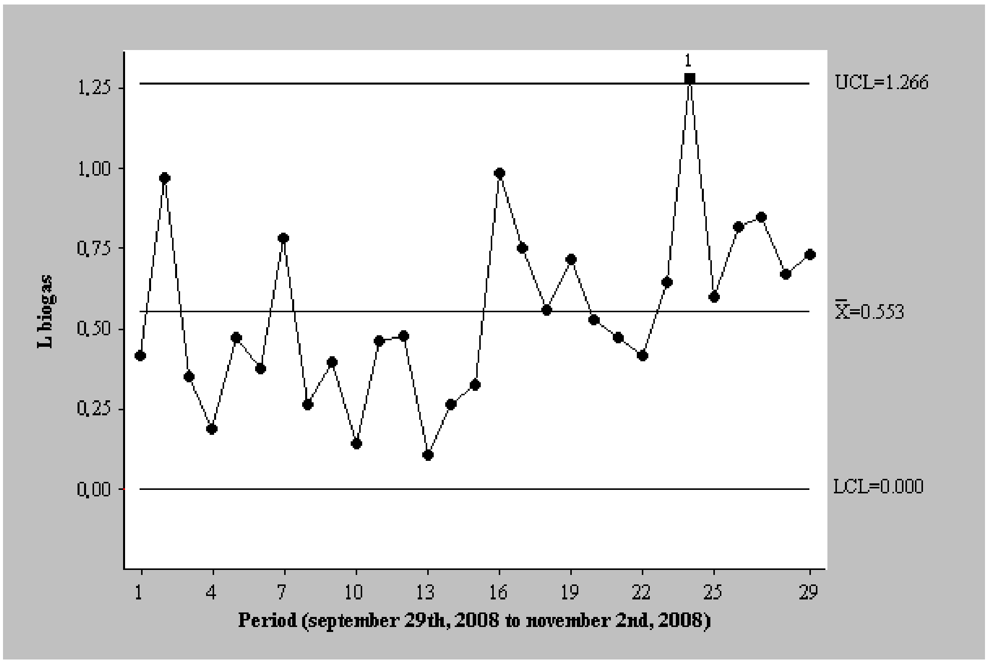

FIGURE 1 **Control Charts: L biogas**

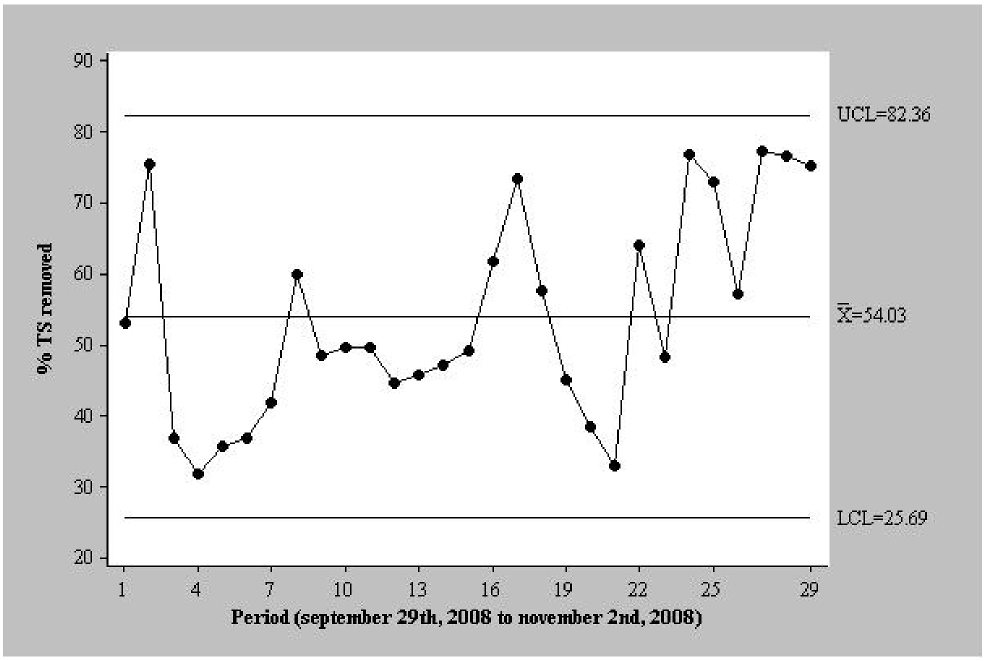

FIGURE 2 **Control Charts: Means of TS removed**

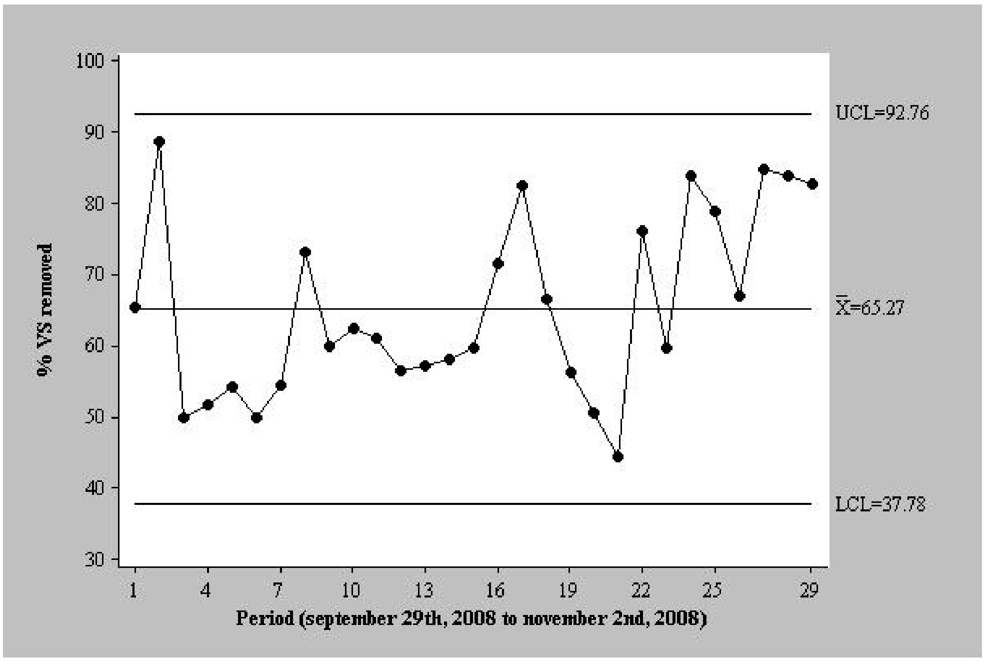

FIGURE 3 **Control Charts: Means of VS removed**

4 CONCLUSIONS

Stabilizing the bioreactor at the desired condition is extremely important to know the behavior of the anaerobic digestion and to take advantage of this technology with greater use of their byproducts. The pH and the VA/TA ratio are good indexes to verify if the bioreactor is actually acidifying or even if it supports a given organic charge.

The anaerobic bio-digestion, like other processes, is subjected to natural or sporadic variability of its byproducts. In the anaerobic bio-digestion, as production process, the statistical graphs of control processes are very useful, as in the verification of the instantaneous stability of the bioreactor by a sporadic value of gas production or if the bioreactor is actually producing byproducts with acceptable variations within a standard for its intended purpose .

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