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EVALUATION OF CLAY MATERIALS AS ANAEROBIC FLUIDIZED BED SUPPORTS: SOLID WASTES AND DOMESTIC SEWAGE TREATMENT

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ABSTRACT: This work describes a study of the effects of some support materials on anaerobic domestic sewage treatment. Clays generally yield very good results. Sepiolite reaches the highest purification value and in a fluidized bed digester has a twenty-times higher speed, six-times smaller HRT and a purification, that is only slightly smaller than that for the stirred digester without sepiolite. These experimental data can lead to an important economic saving in the process to enable its industrial use.

INTRODUCTION

The physical and chemical characteristics of the support media in anaerobic digesters have been identified as important factors affecting both the rate of biofilm development and the reactor performance. (Murray and van der Berg 1981).

Of all the possible support materials clays offer very promising results as a consequence of their physical-chemistry properties, especially clay-bacteria interaction and the flocculating properties of some of them (Pérez Rodríguez *et al.* 1989a and b, Lebrato 1990, Madsen and Schlundt 1989).

The attached microorganisms grow and proliferate in the support and may manufacture extracellular polymeric substances which form a structural matrix around the cell yielding a structured mesh or biofilm (Stronach *et al.* 1986).

Of the high-speed digesters the fluidized bed reactors have yielded the most promising results. The bacteria in fluidized bed system are attached to small-diameter media which may consist of various materials. The high vertical velocity of the water stream to be treated expands the bed to a point beyond which the net downward gravitational force is equal to the frictional drag. The large contact surface permits optimum bacterial growth (Henze and Harremöes 1982).

The most recent research has shown that the treatment of domestic sewage by the anaerobic digestion technology reduces environmental pollution and generates energy in the form of biogas as well as producing a quick-acting, non-toxic fertilizer (Traverso and Cecchi 1988, Cecchi *et al.* 1988, Barrosa and Sant'Anne 1989).

In this work the best clay support to treat domestic sewage anaerobically in a fluidized bed has been determined.

MATERIALS AND METHODS

Solid wastes and domestic sewage (SWDS) from the University dining room was used. Solid wastes were crushed and diluted to 50 % with domestic sewage.

Support materials

- Sepiolite from Vallecas (Spain) supplied by Tolsa.
- Vermiculite from Santa Olalla deposit in Huelva (Spain).
- Bentonite from Gador (Spain) supplied by Minas de Gador.
- Talc from Fuengirola (Spain) supplied by Malaguena de Talcos.
- Nontronite from Hagen-Hagen (source clays, Minerals Repository Columbia, Missouri).
- Diatomeaceous earth from Sanlucar de Barrameda (Spain).

Analysis

The chemical oxygen demand (COD) was determined by the standard method for water and wastewater (APHA, AWWA, WPCF 1985), by oxidation of organic matter with dichromate and set-back valoration with ferrous sulphate.

Before and after the anaerobic digestion of the SWDS the supports were studied by scanning electron microscopy (SEM) in an ISI apparatus, model SS 40 and the dispersion energy of the X-rays was measured by a Kevex analyser, model 8000. The observed bacteria were fixed in osmium oxide and glutaraldehyde in buffer solutions of sodium cacodilate followed by dehydration with acetone-water solutions of various concentrations.

Experimental procedure

The experimental procedure consisted of several steps:

(1) Adapted biomass culture.

The biomass containing the methanogenic flora was obtained from an anaerobic reactor that processes pigsty wastewater. The feed was modified by adding the domestic sewage slowly to the pig manure until the total feed change was attained.

(2) The best support materials reported in an earlier paper for a synthetic culture (Pérez Rodrígez *et al.*, in press) were evaluated with SWDS in a battery of 35 batch microdigesters with orbital stirring and thermostated at 36° ± 1 °C.

(3) Once the best support was obtained, the SWDS was treated in a digester with and without a support. The reactors used were one-litre magnetically stirred reactors in a 36 ± 1 °C thermostatic water bath.

The digester without support behaves as a stirred reactor, and with support material as a fluidized bed digester.

RESULTS AND DISCUSSION

In an earlier paper (Pérez Rodríguez *et al.*, in press) using synthetic feeding in batch microdigesters, the best purification results were found for the following supports: sepiolite, bentonite, nontronite, diatomeaceous earth, vermiculite and talc. In this paper these support materials were used for SWDS treatment. A control support-free reactor was prepared for comparison. The purification percentages are shown in Tab. 1. The digesters with supports yield better results than the control (40 %). The best purification was obtained for sepiolite (84 %), followed by bentonite (79 %) and nontronite and diatomeaceous earth (72 %). The lowest non-control value (52 %) was obtained when talc was used as a support.

As sepiolite yields the best results, it was chosen as the support material in a fluidized bed digester with SWDS as feed. In order to determine the influence of the support, other digesters without sepiolite were used.

Tab. 2 shows the experimental data for the two digesters with and without sepiolite. In the former the amount of higher organic matter treated daily is nearly twenty times that in the latter, 30.53 g/l versus 1.7 g/l.

TAB. 1. SUPPORT MATERIALS PERFORMANCE WITH DOMESTIC SEWAGE FEED.

	PURIFICATION (%)
Nontronite	72
Vermiculite	64
Bentonite	79
Diatomeaceous earth	72
Sepiolite	84
Talc	52
Control	40

TAB. 2. EXPERIMENTAL VALUES OF STIRRED AND FLUIDIZED BED DIGESTERS WITH DOMESTIC SEWAGE FEED.

	Stirred	Fluidized Bed
	(Without sepiolite)	(With sepiolite)
Higher organic matter (g/l COD)	1.7	30.53
HRT **minimum** (days)	6	1
Gas yield (1/day)	1.5	15
Purification (%)	90–72	70

The data show that the SWDS volume treated in the sepiolite digester was very much higher than when the clay is not present. The hydraulic retention time (HRT) is 6 times higher when sepiolite is present. Thus a smaller digester can be used.

Figure 1 shows the gas yield (l/day) versus the organic matter treated daily in a digester with and without sepiolite. In both cases the gas production increases to a maximum value. In the sepiolite-free digester this value is only 1.5 l/day for 1.7 g/l of organic matter treated, whereas in the presence of this mineral 15 l/day is obtained for 30.53 g/l of organic matter treated. Biogas production is ten times higher when sepiolite is present, because the optimum feeding is much higher due to the greater capacity for the development of bacteria and a better medium for anaerobic digestion.

The SEM study of the sepiolite after the anaerobic digestion of the SWDS in the fluidized bed reactor shows a high concentration of bacteria mixed with the mineral. Methanosarcina are depicted in photo 1 and bacilli and cocci in photo 2.

CONCLUSIONS

The use of a support benefits the process development. Clays offer good results for the purification of domestic sewage.

Sepiolite results in the best performance of the process 84 % versus 40 % for the control in purification. Followed by bentonite 79 % and nontronite 72 %.

When sepiolite is added to the digester as support material, the process velocity increases to nearly twenty times than when the support is not present and the purification is only slightly lower.

These experimental data can lead to an important economic saving in the process to enable its industrial application.

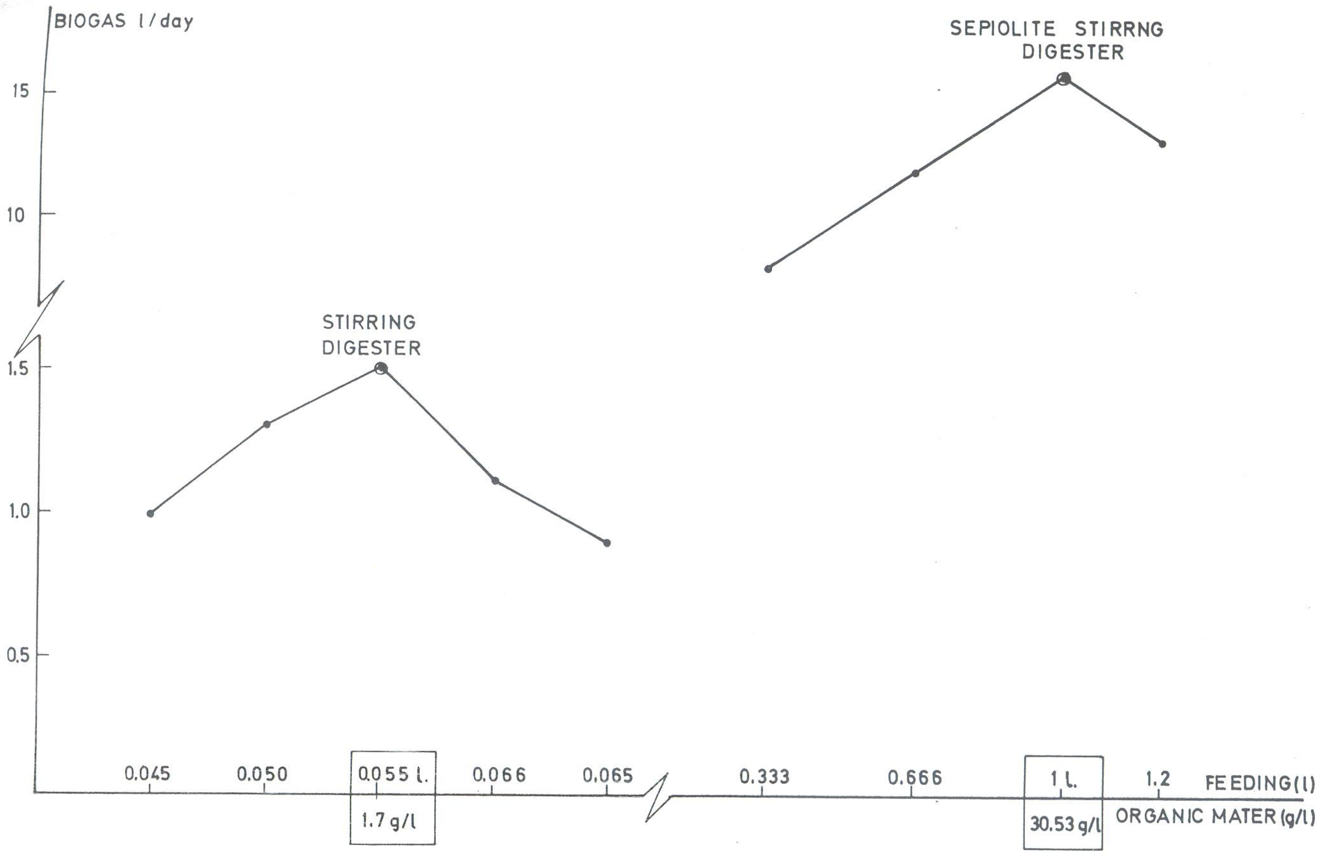
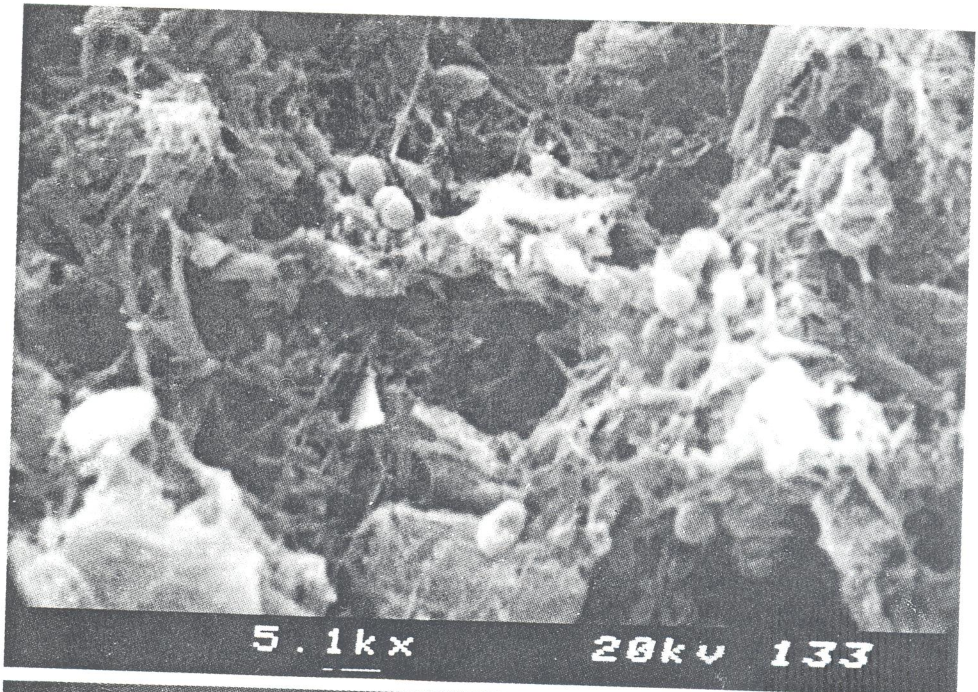


Fig. 1: Biogas production versus organic matter treated daily.



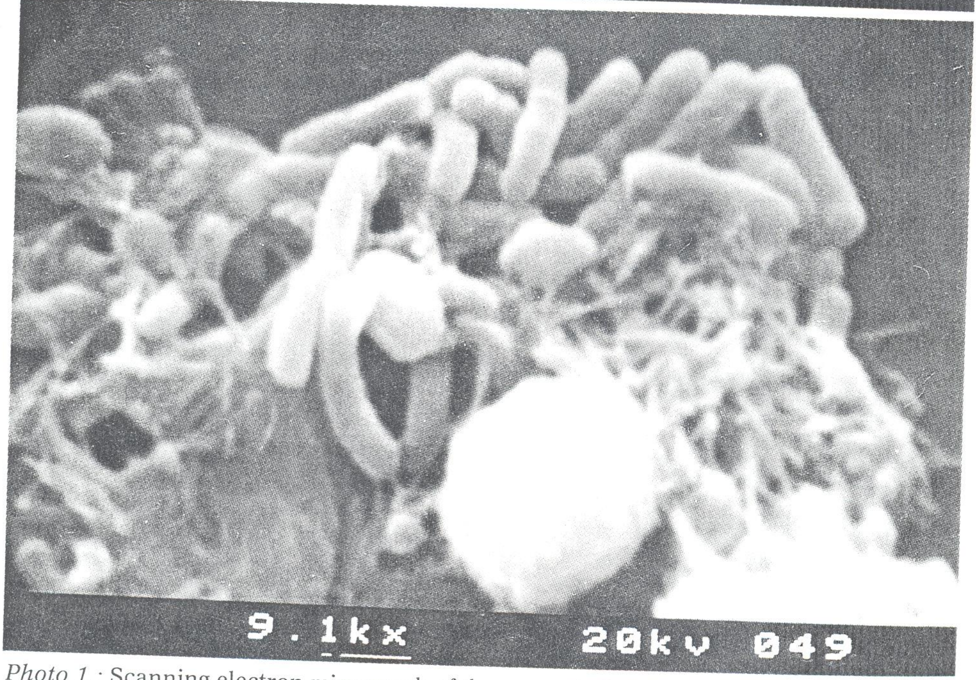


Photo 1.: Scanning electron micrograph of the support after anaerobic-digestion of domestic sewage (sepiolite fibres and Methanosarcina).

Photo 2.: Scanning electron micrograph of the support after anaerobic-digestion of domestic sewage (sepiolite fibres, bacilli and cocci).

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