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REACHING THE UNREACHED: CHALLENGES FOR THE 21ST CENTURY

Pre-treatment of agro-industrial wastewaters

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ANAEROBIC DIGESTION IS one of the oldest biological processes which in the past has mainly been used for the stabilisation of sewage sludge. Some basic characteristics of the process have made it attractive for the treatment of industrial, agricultural and municipal wastewaters. These characteristics are: low energy requirements, low sludge production, low nutrients requirements, high degree of organic matter degradation, ability to handle high organic loads and the production of useful end products, i.e. methane, which can be used for the recovery of energy.

The two-phase concept

The microbiological activities in the process are carried out solely by bacteria. The main groups of bacteria involved are the acidogenic and the methanogenic. They play the leading role in the two respective biochemical stages involved in the process, acidification (acid fermentation) and methanisation (methane fermentation). These bacterial groups have different physiology, different demands with respect to environmental conditions (pH, temperature, nutrients, etc.) and different reactions to changes of these conditions. Acidogenic bacteria are facultative, fast growing and insensitive to environmental changes. On the other hand, methanogenic bacteria are obligate anaerobes and although they are present in great numbers, they are very slow growing, difficult to cultivate and they do not tolerate changes in their environmental conditions. Therefore, when uniform conditions are applied i.e. in a single phase process, optimum conditions cannot be achieved for both acidogens and methanogens[(1)].

Pohland and Ghosh[(2)] originally implemented phase separation for the provision of optimum conditions for both groups which led to an increase of the turnover rates. Additionally, the separation would make easy the control of the loading rate of the methane phase and would therefore increase the stability of the system by preventing inhibition of methane production and unnecessary accumulation of VFA. Finally, the disposal of sludge produced during the acidification phase would not result to the loss of methane producing bacteria.

The conclusions that can be drawn from laboratory and full-scale applications of two-phase processes are generally that the overall efficiency is either similar or better than the single phase process and the performance of the methanogenic reactor is significantly improved[(3)].

Laboratory investigations of pre-acidification

A great deal of research has been made on two-phase digestion and experience so far shows that design parameters differ, depending on the particular characteristics of the waste to be treated. Thus, there are not any standardised criteria and conditions, applicable to all cases of two-phase processes. Extensive experimental work has taken place using a number of wastewaters with different origins, e.g. wastewaters from instant coffee production, slaughterhouse, brewery, dairy and soft drinks. A lot of work was carried out in the Environmental Engineering Laboratory at the University of Newcastle upon Tyne, U.K. The aim was to investigate the performance and efficiency of two-phase systems; and for the first stage, also known as pre-acidification, to set the respective design criteria for each waste.

The results of the investigations collectively imply that optimum pH for acidogenic activity in the pre-acidification reactor has a value of 6.0-7.0 and the optimum temperature in the mesophilic range is 37°C and in the thermophilic range it is around 55°C. These though are general guidelines and one should give great consideration to parameters such as the nature of the waste water. However when the above parameters were continuously controlled and maintained at the above values, acidified COD of at least 40 per cent was obtained at HRT as low as 6 hours.

Although determinant parameters such as pH, temperature, HRT and nutrients ought to be controlled in order to optimise the process, it has been observed that for some wastewaters (e.g. soft drinks) even under minimum control, pre-acidification can occur at a satisfactory degree giving appropriate feedstock for the methanisation phase[(4)].

Referring to observations made by Alexiou (5), although mesophilic and thermophilic ranges are generally considered to be the optimum for the efficiency of the acidification reactor, the efficiency in the reactor does not decrease significantly at the highest psychrophilic temperatures. This eliminates the need for heating and makes the process attractive for applications in the developing world as a low-cost pre-treatment option. It is also stated[(5)] that complete phase separation might exceed the needs or even affect the overall efficiency of the treatment. The application of a pre-acidification reactor, preferably operated below or close to optimum environmental requirements for acidogenesis, followed by a single phase anaerobic reactor, may be a viable option.

Guidelines for the full-scale applications of the pre-acidifcation process

The following guidelines should be kept in mind for the successful application of pre-acidification process as a low-cost and efficient pre-treatment method:[6]

- The proposed for treatment waste should be fully characterised in relation to its biodegradability prior to treatment, since the efficiency of the process is highly dependent on the type of waste.
- Capital and operational costs should be kept to a minimum. This would require a thorough study prior to the design of the reactor so that the design criteria do not exceed the necessary (e.g. oversizing). Additionally the operation of the reactor should be as simple as possible.
- Adequate degree of acidification can take place in a balancing tank when one is used. In cases where a balancing tank is not required, the use of a pre-acidification reactor might be essential and could be justified by improvement of other process in terms of treatment and cost.
- The reactor should be maintained under anaerobic conditions and if a balancing tank is used, it should be covered to avoid odour problems.
- Any loss of biomass from the pre-acidification reactor would enter the single-phase reactor where it would be used for further degradation of organic matter. Therefore no settling tank would be required.
- The presence of methanogenic bacteria in the pre-acidification reactor does not aggravate the process since it only supports further degradation of organic matter. However, methane should be removed from the reactor to avoid any dangerous complications due to its explosive characteristics.

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