Evaluation of the dual digestion system: Part 1: Overview of the Milnerton experience

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Abstract

A number of advantages are claimed for dual digestion as a system for sewage sludge pasteurisation and stabilisation. In this paper, the first of a series of 4, an overview of a 4-year full-scale (45 m^3 aerobic reactor and 500 m^3 anaerobic digester) dual digestion research project is presented. The project was undertaken at Milnerton (Cape, South Africa) and its principal objective was to evaluate the claims made for the dual digestion system. In this paper the claims are stated; the layout and operation of the dual digestion system described; the main results obtained briefly discussed; and the claims evaluated with the aid of the results. It is concluded that most of the claims are valid, *inter alia,* the mesophilic anaerobic digester performance is not adversely affected by the first stage autothermal thermophilic aerobic reactor compared to conventional digestion. The 3 sequel papers focus attention on the aerobic reactor; its operation, performance, control, design and simulation of the temperature profile for both air and pure oxygen systems.

Introduction

Generally the treatment of sewage sludge involves the controlled degradation of the biodegradable organic material, called stabilisation, and further concentrating the sludge, called dewatering. The stabilised and concentrated sludge then needs to be disposed of, and to do this in an economically and environmentally acceptable manner is one of our society's great challenges. Most municipal sludge is disposed of by land application, land filling, lagooning, ocean disposal or incineration. Land application, which is the controlled spreading of sewage sludge into the soil surface, is, due to its economy and nutrient value to the soil, by far the most popular means of sludge disposal (Ekama, 1992). With the growing concern about the health risks posed by human pathogens when using sludge as a soil conditioner for agricultural purposes, disinfection or pasteurisation of the sludge as part of sludge treatment are now also required for certain uses (Dept. of National Health, 1991).

Processes other than conventional pasteurisation (heating sludge and maintaining it at 70° C for 30 min) are also capable of disinfection. Thermophilic aerobic digestion, for example, a system popular in West Germany, allows simultaneous stabilisation and pasteurisation of sludge. In this process, sludge temperatures in excess of 60° C can be maintained autothermally at 6 to 8 d retention times, thereby obviating the need for external heating of the sludge; the heat is generated autothermally from the biological oxidation reactions and the organic material destroyed by these reactions results in stabilisation of the sludge. This process requires a substantial input of energy for oxygenation and mixing. In South Africa mesophilic anaerobic digestion of sludge for stabilisation is popular, but this system does not sufficiently disinfect the sludge. Consequently, to change to thermophilic aerobic digestion would change the anaerobic digesters from an energy producing (through methane generation) stabilisation system, to an energy consuming (through oxygenation) stabilisation-pasteurisation system. An alternative system known as dual digestion overcomes this problem. It combines the advantage of autothermal aerobic digestion by providing pasteurisation and the advantage of anaerobic digestion by providing energy efficient stabilisation.

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Received 5 September 1991; accepted in revised form 29 October 1992.

The dual digestion system

The dual digestion system comprises an autothermal thermophilic aerobic reactor first stage and a mesophilic anaerobic digester second stage. The aerobic reactor is based on the principle that if the sludge mass is maintained under aerobic conditions by a supply of air or pure oxygen, and if heat losses from the reactor are minimised, then the waste heat from biological oxidation reactions in the sludge will cause the sludge temperature to rise into the thermophilic range (50 to 70°C). Due to the high rate of metabolism at the thermophilic temperatures, sufficient heat is generated biologically to sustain very short retention times. In combining a short retention time autothermal thermophilic aerobic reactor and a mesophilic anaerobic digester, a number of advantages are claimed to be obtained [Drnevich and Matsch, 1978; Appleton and Venosa, 1986; Water Research Commission (WRC), 1986], viz:

In the aerobic reactor:

(1) The thermophilic temperatures pasteurise the sludge making it safer for disposal
(2) The sludge is "pretreated" through partial solubilisation of particulate organic matter allowing short retention times (10 d) in the anaerobic digester
(3) Solubilisation produces alkalinity through ammonification of proteins lending greater pH stability to the anaerobic digester
(4) Very little sludge stabilisation takes place in the aerobic reactor - only to the degree that the heat generated biologically maintains thermophilic temperatures; final and