"SOME EFFECTS OF AERATION ON ANAEROBIC DIGESTION"

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SUMMARY

The anaerobic contact process over the year has been found effective for the treatment of meat work waste water. The process is made possible by separating the sludge solids, after which necessary amounts of the concentrated sludge are returned to the digester. Sludge recirculation prolongs solid retention time in the digester. Unfortunately, however, sludge separation by gravitational sedimentation is almost impossible because the sludge tends to rise with the continuous gassing. Therefore treatment of the sludge suspension prior to sedimentation is necessary for effective solid separation, and vacuum and aeration degasification are two common methods used for sludge suspension pretreatment.

In the present study, it was found that the rates of aeration of 0.75 to 1.0 VVM (0.12 to 0.16 cu.ft. of air per gallon of mixed liquor per minute) were optimal for aeration degasification. These aeration rates were not only found sufficient to separate the gases from the sludge solids but also to stop gas production during gravitational sedimentation. They also gave better physical flocculation, improving the maximum reduction of primary particles in the effluent by up to 55 per cent.

In aeration degasification, the air exerts toxic effects on the anaerobic bacteria, and this toxicity has discouraged many people from using aeration degasification for the pretreatment of sludge suspension before sedimentation. The results from this study indicate that with the aeration rate of 0.12 cu.ft. (per gallon per minute) for 15 minutes, the reduction of the daily gas produced was only 5%. The overall reduction of gas was 9.3 litres (per kg. MLSS.kg.COD Loaded) per day for every 10 mg/litre of oxygen absorbed (calculated from sulphite oxidation data in a similar system).

Aeration was not found to affect the gas compositions, which were 65-70 per cent methane and 35-30 per cent carbon dioxide. However, aeration affected the pattern of gas formation; after the sludge suspension was aerated, a lag was observed

of one hour for aeration at 0.12 cu.ft. of air (per gallon per minute) over 15 minutes.

After 22.5 hours digestion of aerated sludge suspension, increases in effluent COD and volatile fatty acids were found. There was an increase in COD by 5.6 ppm for every 10 mg/litre of oxygen absorbed into the sludge suspension. Total volatile acids increased by 15 per cent (for the sparging of 0.12 cu.ft. of air per gallon per minute over 15 minutes).

The effects of air or oxygen on the performance of the anaerobic sludge culture were different from those of the chemical inhibitors such as hemiacetyl of starch and chloral (HSC) and carbon tetrachloride (CCl_4). Oxygen had a direct action on the anaerobes which were probably killed or inactivated, depending upon their sensitivity to air. In contrast, the chemical inhibitors (HSC and CCl_4) selectively inhibited methane bacteria.

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I INTRODUCTION

Anaerobic treatment is a process which has been used extensively for the stabilization of strong biologically degradable organic waste materials. This process is commonly used for stabilization of raw sewage sludge or the sludge produced from aerobic treatment processes. Anaerobic digestion has also been modified and applied to the treatment of some strong industrial wastes, such as meat works wastes. One such process is similar to the activated sludge process and is commonly known as the anaerobic contact process.

An essential feature of the anaerobic contact system is that an appreciable amount of the sludge biomass cells in the effluent is concentrated and recycled to the head of the system where it is mixed with the incoming waste water. In this way, Kirsch and Sykes (2) reported, a high level of cells is retained in the system, and the hydraulic retention time can be shortened to the economical level of approximately 6-12 hours. This system is similar to aerobic activated sludge process and has been often referred to as the anaerobic activated sludge process. The system can be shown diagrammatically as in Figure 1.

The application of anaerobic contact process to the treatment of different types of industrial wastes has been summarized by Kirsch and Sykes (2) as shown in Table I.

The anaerobic contact process has been studied in some detail by the meat-packing industry. The first study was undertaken just on a pilot-scale basis at the Geo. A. Hormell & Co. plant, Minn., under the direction of W.J. Fullen (3) in 1948. The results from the primary study were promising, so the development on pilot-scale was continued by Schroepfer and co-workers (4) (5) (6).

The data obtained by Fullen (3) and Schroepfer et al. (4) (5) (6) were later applied to the design and operation of the full-scale treatment plants for meat packing wastes at the Wilson and Hormel plants at Albert Lea and Austin, Minnesota. Later a similar plant was built to treat the wastes from the Agar Packing Co., in Momence, Illinois.

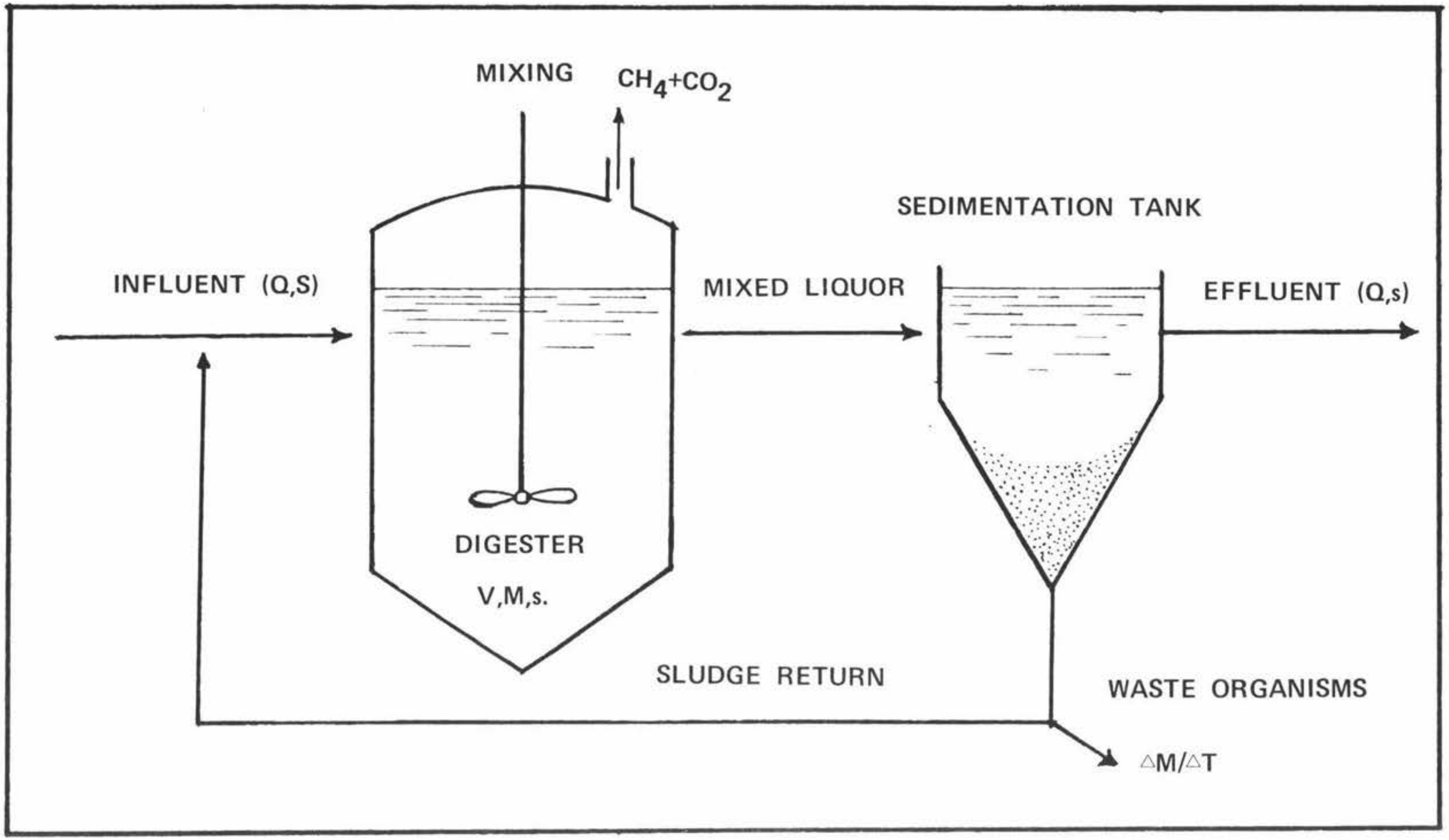

FIGURE 1. A SCHEMATIC DIAGRAM OF ANAEROBIC CONTACT PROCESS
[After McCarty, P.L. (1).]

TABLE I: Anaerobic Treatment Performance for Systems with Sludge Separation and Return Facilities

Waste	Detention Time (days)	Process Temp. (°F)	B.O.D. Raw Waste (mg/l)	B.O.D. Loading $\frac{lb.}{ft.^3 day.}$	Per cent BOD removal
Maize starch	3.3	73	6,280	0.110	88
Whiskey dist.	6.2	92	25,000	0.250	95
Cotton kiering	1.3	86	1,600	0.074	67
Citrus	1.3	92	4,600	0.214	87
Brewery	2.3	-	3,900	0.127	96
Starch-gluten	3.8	95	14,000*	0.100*	80*
Wine	2.0	92	23,400*	0.730*	85*
Yeast	2.0	92	11,900*	0.372*	65*
Molasses	3.8	92	32,800*	0.546*	69*
Meat packing	1.3	92	2,000	0.110	95*
Meat packing	0.5	92	1,380	0.156	91*
Fruit canning	0.18	83	800	0.18-0.43	50-70

* Volatile solids instead of B.O.D.

(AFTER: Kirsch and Sykes, (2).)

The Water Pollution Research Laboratory in England also carried out laboratory and pilot-scale investigations on the anaerobic digestion of meat wastes. This resulted in the construction of two anaerobic treatment plants; one in Northern Ireland and the other in Devon (7).

The major operating problem for this type of plant is solid separation. Gasing of the sludge solids during sedimentation often causes poor solid separation due to sludge rising. Degasification prior to sedimentation has been reported to improve sludge separation. However, the degasifiers must be taken care of; occasional failures of the degasifiers could result in the process washing-out. This problem is quite critical because the solid content will affect the overall efficiency of the process. According to Denmead (7) the suspended solid in the full-scale plants reported above could never be maintained above 10,000 mg/l. Perhaps due to this difficulty no full scale anaerobic contact process has been built since 1962 (7).

Even though the problem of solid separation is so critical for this type of waste treatment, not much study has been done to solve the problem. A review of all the possible methods of solid separation were reported by Steffen and Bedker (8). They include: vacuum degasification, degasification by aeration, and air flotation. Vacuum degasification has been successfully applied to the operation of the full-scale plant at Albert Lea, while aeration is used at Austin in place of vacuum degasification. For air flotation, the application to the full-scale plant has not been reported.

Among all the possible methods, Steffen and Bedker (8) concluded that vacuum degasification is the most economical and practical method of producing gravity separation of the anaerobic solids. From the economic point of view, vacuum degasification is not favorable and so aeration degasification is favoured in New Zealand (9). It has been adopted to solve solids separation problems of the anaerobic digester at the Moerewa Meat Packaging plant at Moerewa, New Zealand. Besides the cost, the performance is easily adjusted to variations in flow and the character of mixed liquor.

Under many circumstances aeration degasification should be considered as a substitute to vacuum degasification. However at present, very little information concerning its mechanism and design is available. So it is considered here that the study on aeration degasification is worthwhile to improve anaerobic contact process technology.

The objects of this study are therefore:

(1) To observe the flocculation characteristics in the aeration basin in terms of suspended solids removal, relating these to rates and times of aeration.

(2) To observe, and evaluate, gas formation characteristics; the rates of gas formation and the gas composition.

(3) To evaluate the process performance in terms of chemical oxygen demand reduction, and production of total volatile acids, as well as individual volatile fatty acids production.