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SECTION A 13

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Studies on the Anaerobic Digestion of Slaughterhouse Waste Waters.

This paper reports on the installation of an anaerobic contact system at a slaughterhouse in Newry, Northern Ireland and on the experimental work being carried out at that plant.

There are two basic problems for the designer of an anaerobic system:

(i) the amount of contact time to allow for anaerobic digestion and at what temperature in order to obtain an acceptable level of B.O.D. reduction.

(ii) how to overcome the physical problem of separating the suspended solids from the digester effluent which is actively gassing and returning these to the digester, in order to accumulate there the high concentration of solids upon which the efficiency of digestion depends.

In the case of the first problem Table I gives some indication of the range of choice of typical operating installations. At the lowest end of the complexity scale anaerobic lagoons, although apparently quite effective, are not an ideal choice from the point of view of proximity to a food processing factory, and because of their demand for considerable areas of land requiring special site facilities not always easily available in areas of concentrated population. At the other extreme an advanced design, operating at elevated temperatures of the order of 35°C., with efficient mixing, degasification and sludge separation systems, although conserving space and reducing unit construction costs to a minimum, are complex in operational control and have high running costs. It is likely that somewhere between these two extremes lie more economical designs modified only by certain important condition factors such as the temperature of the waste from the slaughterhouse, and its B.O.D. and suspended solids content.

Table 1.

Typical examples of treatment systems for slaughterhouse waste operating on an anaerobic digestion principle

Information source and location of plant	Basic design	Special facilities	Digestion time (based on total flow)	Digestion tempera-ture	Digester loadings lbs.B.O.D. per day/ cu.ft.	B.O.D.removal efficiency % (anaerobic digester only)
Steffen (1958) U.S.A.	Anaerobic contact	Digester contents mixed and heated, liquor degasified before separation	3 1/2 hours (approx.)	35°C	0,19	over 90 %
Hicks (1954)	Anaerobic contact	Digester contents mixed but not heated, liquor degasified before separation	2 1/2 - 3 days (approx.)	15 - 25°C	0,02-0,05	60 - 90 %
Dietz (1966)	Anaerobic lagoon	No mixing or heating no degasi-fication	14 - 16 days (approx.)	20 - 35°C (influent to lagoon) 5 - 30°C (effluent from lagoon)	0,015	80 - 85 %

The problem of separating the suspended solids in the effluent liquor from the digester has, in large-scale installations, been tackled by two basic methods, (a) vacuum degasification and (b) air-stripping or aeration. Although other methods such as pressure flotation, centrifugal separation and flocculation may prove useful, particularly as adjuncts to degasification, we have no knowledge of such method being applied on a practical scale. Vacuum degasification, although apparently extremely effective, is costly to install, maintain and operate. Air-stripping is probably less effective, but is relatively simple and cheap, although it suffers from the disadvantage that over-aeration of the liquor would disturb the oxidation-reduction potential of the system, and change the anaerobic character of the digestion. The amount of air which can be used to remove gas bubbles is therefore severely restricted. By whatever means it is achieved it is nevertheless necessary to maintain the liquor from the digester in a quiescent state for a period long enough to achieve efficient separation of suspended solids.

The design basis of the installation

Fig. 1 shows the flow plan of raw water treatment of the slaughterhouse, and the organisation of the various usages from the slaughterhouse to the sewage plant. A flow diagram of the sewage plant is shown in Fig. 2.

Two important design principles were established:

a) that it would be essential to take advantage of every possible device to maintain a high influent temperature to the anaerobic digester - other - wise it is not possible to obtain the digester temperature required without so much additional heating that the process become quite uneconomical.

b) that where possible waste should be saved in the solid form, e.g. stomach contents, blackscrapings, floor brushings, etc., thereby reducing the solids load in the sewage to a minimum. A natural extension of this is to pre-heat the sewage before it enters the sewage plant in order to remove as much fat and suspended solids as possible.

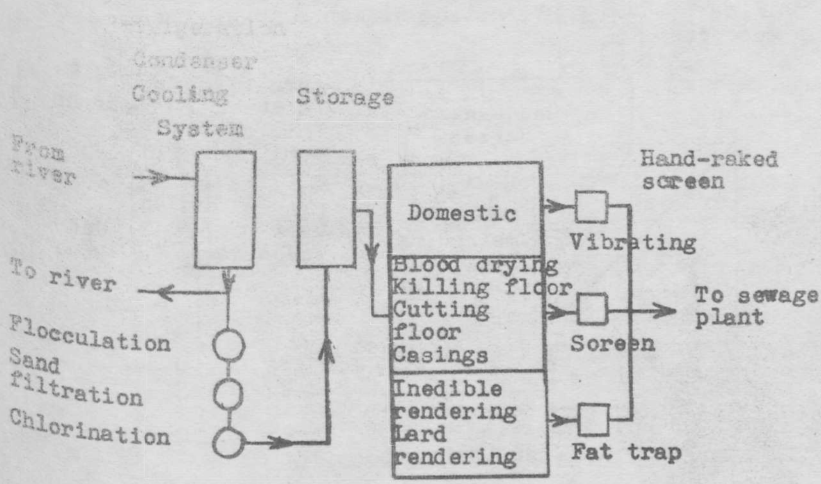

Fig. 1

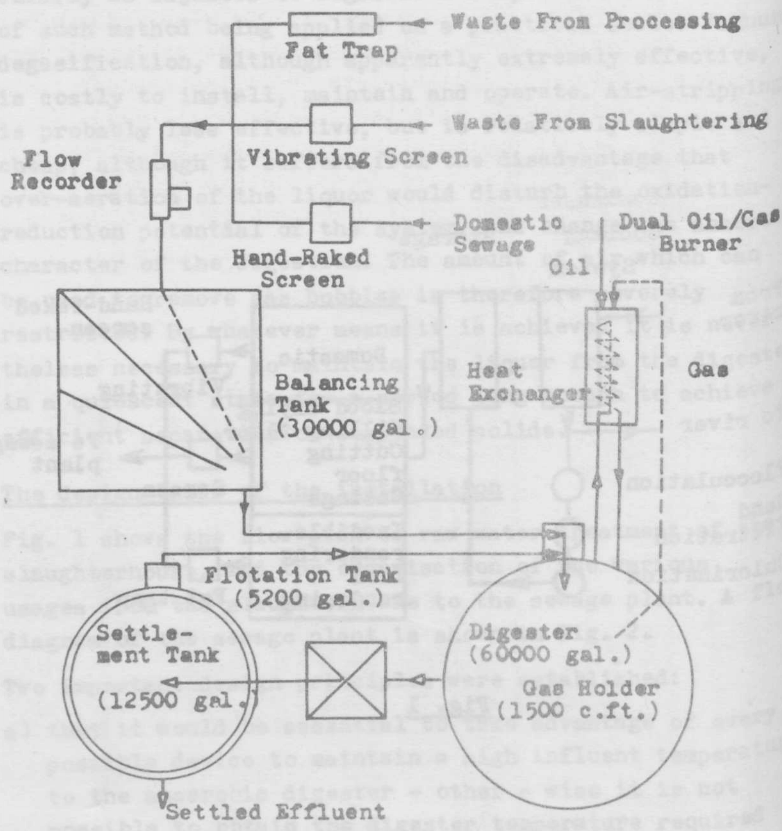
Waste From Processing
Fat Trap
Waste From Slaughtering
Vibrating Screen
Flow
Recorder
Domestic
Sewage
Hand-Raked
Screen
Dual Oil/Gas
Burner
Oil
Balancing
Tank
(30000 gal.)
Heat
Exchanger
Gas
Flotation Tank
(5200 gal.)
Settle-
ment Tank
(12500 gal.)
Digester
(60000 gal.)
Gas Holder
(1500 c.ft.)
Settled Effluent

Fig. 2

In the case of (a) above the raw water piped to the slaughterhouse is used first as cooling water in the condenser system of the refrigeration plant. This gives a valuable increase of temperature, so that the influent to the sewage plant is that much warmer.

The other point of note is that the sewerage in the slaughterhouse was planned to keep waters with high fat contents and waters with high blood and suspended solids content separate. The initial idea behind this was to curtail the detrimental effects of floor drainings, particularly blood, on the stability of the fat saved in the fat traps, but we have found additional benefits in connection with the control of the pH of the digester contents.

Additional design data is given in Table II.

Table II.

Additional design data for anaerobic contact system
(Design basis was for a total weekly kill of a maximum of 3000 pigs at not more than 600 per day, with a sewage waste volume of 50,000 gallons per day.

Unit	Design data
Balancing tank	100 % equalisation
Digester mixing	with variable-speed paddle-type stirrer, peripheral speed 0,8 - 3,4 ft/sec.
B.O.D. loadings	0,10 lbs. B.O.D. per cu.ft. digester per day
Return sludge ratic	from 1 : 1 to 3,22 : 1
Retention times (based on total flow)	at 3,22 : 1 a) digester: 7,88 hours b) separator: 1,65 hours

Results

It is a well-known characteristic of slaughterhouse effluent that the volume of waste and its strength in terms of B.O.D. can vary enourmously from hour to hour throughout the working day. It is the function of the balancing tank to make the load fed to the digester more even over 24 hours and with 100 % equalisation this is easily done. It is also a fact, however, that there are considerable variations from day to day and we have recorded B.O.D. loads (lbs. per pig) as low as 0,7 and as high as 3,0 - very much dependent on the work programme involved. The digester system must be capable of responding to these variations without loss of efficiency over short periods.

We have found the installation described able to take an average loading of 0,1 lbs. B.O.D. per cu.ft. digester volume per day, with day to day fluctuations of the order of 0,06 to 0,16 lbs., and to maintain a B.O.D. reduction of 90 - 95 % at a digester temperature within the range 27,5 and 29,5°C. At temperatures lower than this the efficiency of B.O.D. removal is reduced, and Fig. 3 suggests that the above temperature range would be an optimum choice. This data relates to an average loading of 0,1 lbs. B.O.D. per cu.ft. and a retention time of 7,88 hours in the digester.

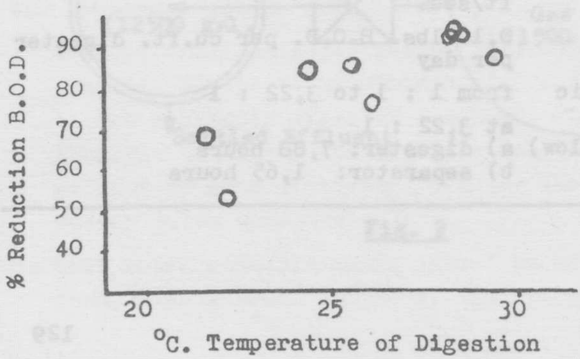

Fig. 3

The efficiency of the plant in terms of suspended solids separation has not been quite as good as is wished for. Although effective enough to maintain what would appear to be an adequate concentration of suspended solids in the digester (10,000 - 11,000 ppm) reductions of below 80 % are being recorded and rarely has it been found possible to achieve a reduction of over 85 %. This constitutes an excessive loss to the system and will have to be improved.

Typical performance data are given in Table III.

Table III.

Typical analytical data with a raw flow volume of the order of 55,000 - 60,000 gall/24 lbs. and a B.O.D. loading between 0,12 and 0,14 lbs. B.O.D. cu.ft. per day

	Raw feed				Effluent from anaerobic system				% reduction			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
B.O.D. (ppm)	2250	2225	2320	2040	230	140	120	140	90	94	95	93
Total solids (ppm)	4260	3784	4096	4660	2332	2060	2200	1840	45	46	46	61
Total volatile solids (ppm)	2928	2806	3028	2488	464	448	512	280	84	84	83	89
Suspended solids (ppm)	2130	2000	1570	2240	345	300	300	470	84	85	81	79

Under the above circumstances the digester sludge contents had total solids, volatile solids and suspended solids respectively within the ranges 10,000 - 12,000 ppm., 7000 - 9000 ppm. and 9000 - 11,000 ppm.

No trouble has been experienced with over- production of volatile acids in the digester, levels of less than 100 ppm being normally recorded.

Gas production of the order of 15 cu.ft. per lb. B.O.D. removed has been recorded. The heat balance (average composition 79 % methane, 20 % carbon dioxide) is such, however, that additional heating from oil burners has been necessary to maintain the temperature of the digester.

Conclusions

The anaerobic contact unit as presently designed operates quite successfully in terms of B.O.D. reduction and can achieve an efficiency of the order of 90 - 95 % without difficulty on digester loads of at least 0,10 lbs. B.O.D. cu. ft./day. The efficiency of solids´ separation still leaves a lot to be desired and work is in hand to test the effect of air-stripping in the flotation tank provided in the design. Initial trials indicate that air injection at a level up to 0,3 cu.ft. per gallon of liquor does not appear to alter the anaerobic character of the digestion.

The importance of temperature relationships on the economy of operation of the unit indicates that a full heat balance study of the system could yield useful information and work on this is now in progress.

From the point of view of hygiene an ecological study of the microbiological flora of the digester contents and also of the separated effluent is also intended.