CHARACTERISTICS OF EFFLUENTS FROM A MEAT PROCESSING PLANT

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A study on the characteristics of effluents from a meat processing plant has been made at three stages : (*a*) the slaughter of animals (sheep and goat) ranged from 340 ± 10 per day and the treatment of effluents was through oxidation ponds, (*b*) the slaughter was 400 animals per day and the treatment plant (anaerobic digestion) had been commissioned, and (*c*) the slaughter was of the order of 700 animals per day. The treatment plant had been at work.

In the first stage, the effluents were being routed to oxidation ponds I and II one after the other with the total detention period of 19 days. The BOD by these lagoons had gone down by 50 per cent and the percentage total solids by 46 per cent.

In the second stage, the efficiency of the treatment plant was worked out to be 85 per cent. The solid content fall was only 37 per cent.

In the third stage, the Permanganate Value (PV), Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) had reduced by 82 per cent, 81 per cent and 82 per cent respectively. The decrease in coliform counts was about 80 per cent.

The BOD contribution has been worked out to be 555 gm/animal at the influent stage and 106 gm/animal at the effluent discharge stage.

INTRODUCTION

The Department of Defence Production has put up an accelerated freeze drying factory near Agra for the production of freeze dried mutton for supply to the armed forces. The number of animals (sheep/goats) slaughtered have varied from 150 to 700 per day during the last about two years. The factory complex consists of a modern slaughter house, facilities for the manufacture of slaughter house by-products, boning section, freeze drying establishment and packing of finished product.

The method of disposal of waste water from this plant has been of great concern from public health point of view and environmental pollution. Little information is available in literature on the volume and characteristics of the waste from a meat processing factory in India for lack of similar undertakings in the country. Wherever meat processing is being done, facilities for systematic treatment of effluents are non-existent.

The effluents are discharged into a stream which links river Jamuna at a distance of eight kilometres and passes through a number of villages during its course. Proper control on the characteristics of effluents was essential as per UP Effluent Board Regulations.

A treatment plant for the factory wastes was found indispensable for maintaining high hygienic standards in and around the meat processing factory. Lagooning was not considered suitable because the high organic load in the ponds disturbs[1-2] the symbiotic relationship between bacteria and algae. Moreover, when the effluents are very much depleted in oxygen, pink coloration[3] and putrified smell result in such type of ponds.

It has been suggested by Buswell[4] that organic industrial wastes, which have more than one per cent total solids can be economically and effectively treated by anaerobic digestion on a rough estimate basis. A treatment plant was erected to ensure that the characteristics of the effluents after treatment are well within the limits prescribed by UP Effluent Control Board. A check on the effluents is made regularly as per the Board regulations. The details of the treatment plant have been described and the plan view is given in Fig. 1.

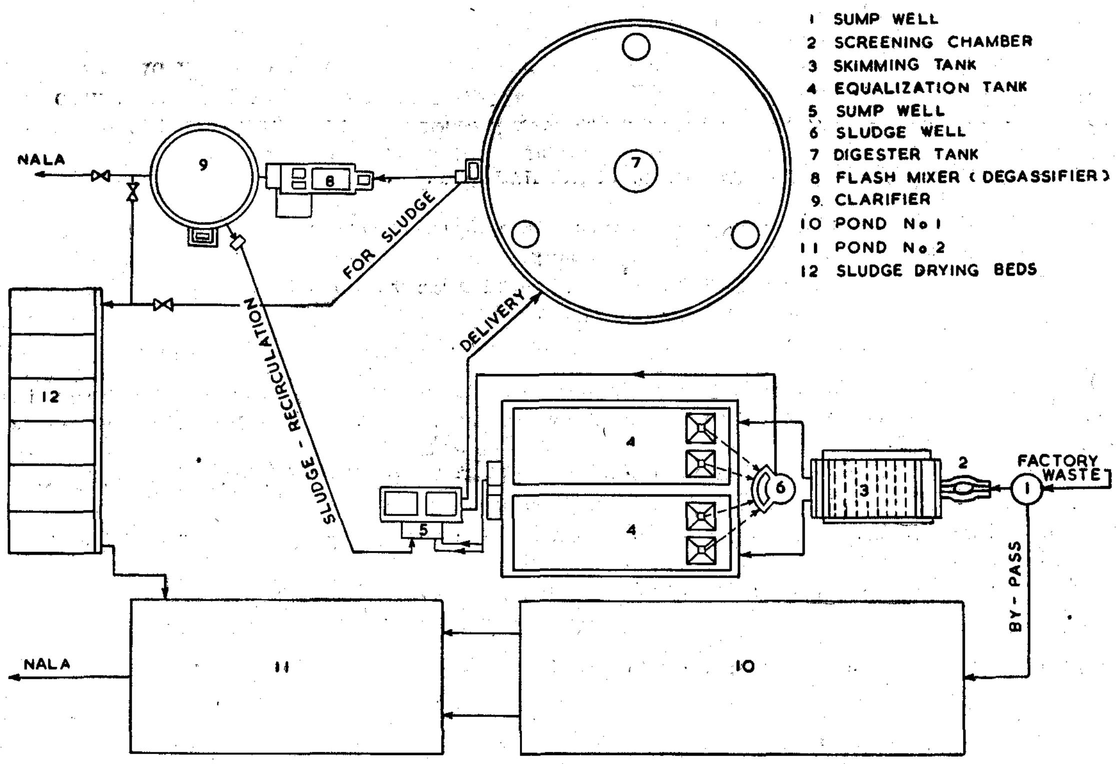

Fig. 1—Plan view of Effluent treatment plant.

Analysis has been carried out for assessing the quality and quantity of composite waste from the factory at different stages before and after the treatment and for finding the efficiency and adequacy of the treatment plant.

MANUFACTURING PROCESS

It is a mechanised plant where mutton is processed from live animal to the pre-cooked freeze dried product. Every effort is made to keep up the hygienic control of the plant.

The animals are selected as per Army Supply Corps (ASC) Specifications; these are stunned, guillotined and placed on a moving table where blood is allowed to flow out completely. The carcasses are then hooked on to a moving overhead conveyer, skinned, eviscerated and subjected to post mortem inspection. The fatty tissues are removed. The dressed carcasses are washed thoroughly and the extraneous water is removed. These are then stored overnight at +5°C to overcome rigormortis. The set carcasses are boned, the boned meat is taken in cooking forms and cooked by steam. The cooked meat is pressed into a compact mass by cooling at +5°C. The subsequent processes involved are slicing, deep freezing and freeze drying. The freeze dried product is packed in cans under nitrogen.

The fatty tissues are wet rendered to get edible fat. The entire viscera is washed and the small intestine is converted into casings on automatic mechanical stripping and cleaning machines. The washings from this process are passed on to a manure pump. The manure pump lifts the entire washings on to a vibrating screen, where oversize fleshings etc. are screened off. The effluent from here are sent to the treatment plant.

The heads, fore and hind limbs below the knee and hock joints, washed viscera, bones, blood, rejected organs and cracklings from the edible fat, are all sent to dry rendering plant. Meat-cum-bone meal and technical fat are the by-products obtained from this plant. The skin is fleshed, cleaned and salted.

DISPOSAL OF EFFLUENTS

The wastes from refrigeration plant, boning room, casing section, wet rendering process, dry rendering process, slaughter hall, stomach washing and animal pen washings are taken in the sump well and pumped into the treatment plant. A by-pass has been provided to route these effluents to two oxidation ponds. These ponds serve as a standby arrangement for discharge of effluents as and when the treatment plant gets out of order due to any mechanical/electrical defect.

The pumped effluents pass through bar-screens where big size particles are removed. They are then let into a skimming tank (9·1×3·0×1·2 m) where perforated plates are provided for aeration; a grease pipe has been provided to remove greasy material. The effluents then pass to a two-compartmental equalisation tank (18·2×12·1×1·5 m) through two 15 cm gate valves. The sludge is taken to the sludge well and the effluents from the equalisation tank flow to another sump.

The effluents from this sump and the sludge from the clarifier and sludge well are pumped into the digester tank (24·3 m dia×4·2 m depth). The digester is provided with three mixers to agitate the contents in the tanks and facilitate digestion process. Effluents[5] in the digester undergo anaerobic digestion which occurs in two stages : (*i*) Acid production and (*ii*) Methane production. The sludge in the first phase is broken into organic acids, aldehydes, alcohols under anaerobic conditions by facultative bacteria. These serve as food source for methane bacteria which are obligate anaerobes. The destruction of organic acids, aldehydes and alcohols to CO_2 & CH_4 constitutes the second phase of anaerobic digestion. The *p*H of the digester is maintained optimum for the growth of these organisms.

The overflow from the digester is led into the degassifier (1·07×1·52 m) through 30·5 cm pipe. The gases are removed before the effluents enter the clarifier.

The circular clarifier is 9·1 m in diameter with 2·1 m side water depth. Effluents enter the circular feed well through a pipe running from the side of the tank. The effluents flow out radially towards the peripheral overflow weir. This allows the solids to settle during the time of flow from the influent to the effluent weir. The sludge settled at the bottom is pumped back to the digester tank along with the incoming waste.

The effluents from the clarifier are discharged into the stream directly or through pond II from its overflow. During the period the treatment plant had not been commissioned, the effluents were being routed directly to pond I and then to pond II.

The oxidation pond I (capacity 3629 cu.m) receives the overflow of raw effluents, whereas oxidation pond II (capacity 5077 cu. m.) receives effluents from pond I and from the clarifier.

RESULTS AND DISCUSSION

The samples were analysed for various physical and chemical characteristics by standard methods[6].

Initial studies were carried out when the animals were being slaughtered at the rate of 340±10 per day. The treatment plant had not been commissioned then. The waste was being routed to pond I and II and from the overflow to the stream. The effluents were mostly collected at peak periods. No composite lots were prepared. The results obtained are given in Table 1.

TABLE 1

ANALYSIS OF EFFLUENTS OF 340 SLAUGHTERED ANIMALS

(*i*) Total effluents discharged per day=0·45 million litres.

(*ii*) BOD Loading=180 lb/acres.

Characteristics	Untreated waste at peak periods	Oxidation pond II at overflow
*p*H	7·2—7·8	7·2—8·5
Temperature	27°—38°C	18·0—28·0°C
Total solids	2400±200 ppm	1900±100 ppm
Permanganate Value	380—540 ppm	120—170 ppm
BOD	618—814 ppm	160—200 ppm
COD	1300±5% ppm	650—680 ppm

The analysis of untreated waste at peak hours recorded herein did not reflect a general picture of the waste coming from the factory. The average BOD for the effluents (untreated) collected at different periods, including the peak ones, was 350 ppm (250 ppm for pond I and 180 ppm for pond II). The detention period in both the ponds then was of 19 days. The fall in BOD was 29 per cent in pond I and was 50 per cent in pond II.

The average figures for the total solids were: untreated waste 2400 ppm and pond II 1900 ppm. The water analysis of the factory was carried out frequently and the total solid contents therein were 1300 ppm. The total solids contributed from the waste worked out to be 1100 ppm in untreated waste and 600 ppm in pond II, overflow thereby showing a decrease of 46 per cent. The BOD loading rate was worked out to be 180 lb/acre.

The BOD and COD of the effluents collected from slaughter hall waste alone during that period were found to be 775 ppm and 1480 ppm which indicated that 48 per cent of the effluents from this source were bio-oxidisable.

A laboratory experiment on the effect of bleaching powder on the waste from pond I showed that it was quite effective—220 mg/lt of bleaching powder reduced BOD by 42 per cent.

Analysis of effluents was next carried out when the slaughtering of animals had increased to 400 per day. The treatment plant had been commissioned. Composite lots of the samples were made both from raw waste and from the primary clarifier at frequency of 15 minutes for 24 hours. These samples were stored at 3–4°C before being composited for analysis. The results are given in Table 2.

The BOD reduced from 440 ppm to 68 ppm after treatment (85 per cent). COD, which gave an overall index of total oxidisable matter, decreased from 1032 to 402 (61 per cent) which indicated that a considerable fraction was of non-bio-degradable organic matter and remained untreated during the biological treatment. The solid content went down from 1030 to 650 (reducing the total dissolved solids in water) i.e. by about 37 per cent.

A further series of experiments on effluents were carried out at a stage when the animals slaughtered per day had gone up to 700 and the treatment plant was in commission. The composite samples were collected as described earlier. The data obtained is given in Table 3.

The total solids in this case reduced from 1680 ppm to 600 ppm (reducing the total dissolved solids contributed by water) i.e. by about 64 per cent. The organic solids decreased from 1145 ppm to 260 ppm (77 per cent) and total suspended solids from 1010 to 90 (90 per cent). The PV, BOD and COD reduced by 82, 81 and 82 per cent respectively. The reduction in coliform was also about 80 per cent. There was also a small decrease (15 per cent) in total nitrogen. On comparing tables 2 and 3, no significant difference is noticed though the slaughter rate increased from 400 to 700 animals per day. This is due to the fact that the treatment plant was constructed to treat 1·2 million litres of effluents per day with proportionate increase in slaughter. The total volume of effluents passing daily into the treatment plant was 0·68 million litres with 700 animals slaughtered per day.

Table 2

Analysis of effluents of 400 slaughtered animals

Total effluents discharge per day—0·48 million litres.

Characteristics	Effluent analysis		Percentage reduction
	Untreated	Primary Clarifier	
*p*H	7.5	8.2	
Temperature	21—44°C	28—31°C	
Total dissolved solids	1930 ppm	1785 ppm	
Total suspended solids	400 ppm	165 ppm	58·7
Alkalinity	380 ppm	670 ppm	
BOD	440 ppm	68 ppm	85·0
COD	1032 ppm	402 ppm	61·0

TABLE 3

ANALYSIS OF EFFLUENTS OF 700 SLAUGHTERED ANIMALS

Total effluent discharge per day—0·68 million litres

Characteristics	Effluent analysis		Percentage reduction
	Untreated waste	Treated waste	
*p*H	7·4	7·6	
Temperature	30·5—38°C	29—32°C	
Total dissolved solids	1970 ppm	1810 ppm	
(*i*) Fixed	1640 ,,	1610 ,,	
(*ii*) Volatile	330 ,,	200 ,,	39·4
Total suspended solids	1010 ,,	90 ,,	91·0
(*i*) Fixed	195 ,,	30 ,,	84·6
(*ii*) Volatile	815 ,,	60 ,,	92·6
Permanganate value	288 ,,	52 ,,	82·0
BOD	571 ,,	109 ,,	81·0
COD	1380 ,,	248 ,,	82·0
Total Nitrogen	81·6 ,,	69·2 ,,	15·2
Coliform Bacteria	$5 \cdot 8 \times 10^4$	$1 \cdot 2 \times 10^4$	80·0

The BOD contributed per animal at the untreated stage was 555 gm and at the discharge end stage, 106 gm. The amount of water used per animal in the slaughter hall was found to be 550–600 litres.

The analysis of the treated effluents at the discharge point is carried out regularly and the data obtained was well within the standards prescribed by UP Effluent Control Board.

The minimum standards of purity laid down for factory effluents to be discharged into the stream are:

Total solids	< 2000 ppm	particle size	1/32 in dia.
BOD	< 200 ppm	*p*H	5 to 9
Turbidity	< 300 ppm	Colour	<400 μ *mho/cm*
Oil and grease	< 30 ppm	Electrical conductivity	<5000 μ *mho/cm*

Pink Colour Lagoons

Pink phenomenon was observed frequently during the year in pond I which served as a standby and received overflow of the raw waste in case of breakdown of the treatment plant. This may be due to low dissolved oxygen, high BOD, high sludge accumulation and depth of the pond causing anaerobic conditions. Putrified smell also dominated the area. The BOD reduction in this pond was from 350 to 250 ppm (about 29 per cent).

Pink colonies have been observed by different workers[3,7-9]. Different type of micro-organisms causing pink phenomenon have been identified. Certain workers have identified this due to pink algae viz., *merismopedia*[9]. Others have attributed it to the presence of photosynthetic sulphur bacteria.

Detailed studies of these pink phenomenon will be taken up separately.

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