

Lagooning: a solution for tannery effluent

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The simplest method of purifying a wastewater is to discharge it into a pond and to let nature do its work. Sunlight, heat, oxygen from air, bacteria, algae, and above all time are needed. Generally known as the lagoon process, the technique was adopted in the USA, Canada and Europe many years ago but is most commonly used in areas where the climate is warm to hot.

There are variations within the process and it can be easily applied to tannery effluents, although there are technical limitations and constraints. There is a general adverse reaction to the process because it can be a major source of odour and, if poorly adapted to effluent characteristics, can be a source of pollution.



This is an example of an anaerobic lagoon before cleaning out. In this situation the tannery effluent receives bar screening, before it discharges into a section within the first lagoon for mixing and settling over a period of approximately two days. The creation of several sections within this first lagoon means that sludge from primary interaction between the tannery waste streams can be removed on a regular basis. After this simple but effective treatment, the effluent flows slowly from each lagoon in series, being held in this main section for a period of 6-10 days.

During this holding period the COD has been reduced by around 50%. In this example the initial working depth of the basins was 3.0 m and the construction ensured that no leakage occurred into ground waters.

Various types of Lagoons

ANAEROBIC SYSTEMS

In these lagoons an anaerobic environment is allowed to naturally develop and is then maintained. Volatile fatty acids are formed through breakdown of the biodegradable pollution input in these ponds, ultimately producing carbon dioxide and methane.

In general, the depth of the holding basin of the effluent is up to four metres, allowing a load of 600 to 1,000 kg of BOD₅ per 10,000 m². Unless contained within an impermeable membrane or other secure containment construction, there is a danger of polluting the aquifer. In addition, there are problems with odour that confine the technique to areas of low population density. The fermentation process is greatly influenced by heat and the efficiency of BOD₅ reduction can double between winter and summer in cold countries. For these reasons the technique is normally limited to countries where weather conditions are favourable and energy considered expensive.

Australian experiments involved construction of an anaerobic lagoon with a holding capacity of 42,000 m³. This was for a sheepskin tannery wastewater, being two metres deep and a dwell time of seventy days. In India many anaerobic systems have been

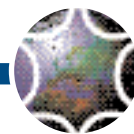
set up as a step before conventional biological treatment, such as activated sludge treatment. In this event the retention times are 7-8 days. Some investigations were made to reduce the retention time by using lamps during the night to increase the solar action on bacterial growth. However, this technology did not prove to be effective in reducing the retention time.

Based on findings from a mixed vegetable and chrome tannery processing bovine hides, it can be estimated that primary physical-chemical treatment followed by 7-8 days anaerobic treatment can remove approximately 50% of the COD.

AEROBIC LAGOONS

This type of system relies on the natural absorption of oxygen from air. The algae, which develop on the surface of these lagoons, are an essential component in the conversion of dissolved salts and in the production of oxygen available to aerobic bacteria.

To maintain photosynthetic activity the basins are more shallow than used in anaerobic lagoons. With depths between 0.6 m to 1.2 m they require large land areas and maximum loadings should not exceed 50-60 kg BOD₅/ha/day. Moreover, the high production of algae results in considerable organic material and this can only be eliminated by recycling. This requires multiple basins or physical-chemical treatment such as filtration, flocculation or flotation.



AERATED SYSTEMS

In these applications mechanical aerators are installed within the basins to generate aerobic conditions and ensure that all or part of the solids within the effluent are maintained in suspension. A considerable amount of solids is generated in this process, so a zone or area must be provided separate from the main lagoon to settle these solids.

Power balances show that levels needed for stirring are far higher than those needed for providing oxygen. For a fully mixed aerobic system the power required is about 8-10 watts per m³.

FACULTATIVE SYSTEMS

The facultative lagoon relies upon aerobic processing of the surface layer and anaerobic fermentation in the lower layers of effluent and sludge deposits. This can develop naturally but can include the use of low powered stirring to both ensure mixing and assist the absorption of oxygen in the surface layers.

The facultative lagoon

In this form of treatment the following observations can be made:

1. Mineral and non-degradable organic matter settle on the basin bed where they may modify very slowly.
2. Biodegradable organic matter also settles out and decomposes through anaerobic fermentation. This breakdown produces:
 - carbon dioxide and methane
 - degradable soluble organic residue, which then collects in the surface layer of the basin
 - inert soluble organic residue, discharged as part of the treated effluent
 - insoluble inert residue that remains as a deposit
 - inert mineral and organic colloids that are partly absorbed into the biological floc and partially discharged as part of the treated effluent
 - the colloidal or soluble biodegradable matter used to form and grow new cells
 - the synthesis and subsequent organic activity within the system produce both carbon dioxide and organic matter, this either remains in suspension, eventually being discharged from the system or is deposited on the lagoon bed

In this example the effluent has received full mixing, chemical dosing and settling before feed into the lagoon. Containment is provided by a large concrete tank of 3.0 m depth.

In this example, the COD is said to be reduced by a further 15-20%. The next stage is conventional biological treatment using the activated sludge treatment process. This form of treatment is not uncommon in India, but requires an aeration treatment as an interim stage, as shown ➤, to flush off hydrogen sulfide.

Other variations include primary settling, followed by anaerobic treatment for a few days, followed by surface aeration, chemical dosing and settling, and the activated sludge treatment.



Biodegradable organic matter that settles out in the system is likely to break down into organic acids. These are—pH and temperature permitting—converted into methane, carbon dioxide and other gases.

Temperature is a particularly important factor as anaerobic fermentation is incomplete below 20°C, considerably slower below 12°C and stops completely below 4°C. Accordingly, there is an accumulation of organic matter during colder weather with increased fermentation in the summer. The oxygen requirement is thus greater in hot weather and this must be taken into account by increasing the stirring/aeration.

With time the accumulation of inert material slowly reduces the process efficiency, so the effective volume of the basin has to be over-sized. Great care must be taken when determining these dimensions as it is not simply a case of the retention time. The strength and biological characteristics of the effluent, the requirements for discharge, the annual temperature variations, and other climatic effects all need taking into account.

THE BOD₅ CONTRIBUTION FROM SUSPENDED SOLIDS

The by-products released as carbon dioxide, nitrates, sulfates and phosphates can serve as a basis for the photosynthetic action of algae thus assisting aerobic conditions.

Some of this algae and other biological flocs will be discharged from the system, and in this event causes problems as a secondary pollutant. Construction of a final settling/retention area can reduce this problem but a small quantity of solids will escape carrying their own BOD₅.

THE DEMAND FOR OXYGEN BY THE SYSTEM

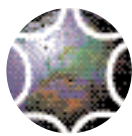
The oxygen demand corresponds in part to biosynthesis of the pollutants and to the demands of the bacterial mass. This mass may be in low concentration but is significant because of the high volume of the system. However, under hot conditions organic matter in suspension near to the inlet will mainly be broken down anaerobically and this can be taken into account.

Nevertheless, it is estimated that the oxygen demand during the warmer period is 30% higher than in winter. When considering equipment to provide aeration/oxygenation, allowance is needed for natural contributions caused by photosynthesis. Even the wind velocity needs taking into consideration and the general orientation of the lagoon.

CONSIDERING AERATORS

The best method of aeration is to install floating aerators on the lagoon. It should be noted that the cost of power consumption for one aerator in one year is generally the same as its purchase price. Hence, the overriding importance of selecting good quality equipment for highly efficient oxygenation.

Aerators can cause secondary pollution, like aerosols or foam formation. This can be combated by partly recycling treated effluent to the feed end of the lagoon head, although this problem should be addressed in the tannery by limiting the use of ➤



surface active agents.

Over and above the induction of oxygen into the system, aerators offer other significant advantages. They avoid preferential routing within the lagoon and help to homogenise the effluent. They also ensure that suspended matter is dispersed more evenly throughout the lagoon, so that on settling the anaerobic fermentation is more proportional to the area. Floating aerators are also easy to position at essential locations, although these are mainly at the head of the lagoon.

The first parameter for sizing an aerator is the stirring capacity. This power requirement is always greater than for oxygenation as the effluent needs distributing over the largest area possible. The oxygen requirement is based on summer workings because of the faster degradation rate and the lower dissolved oxygen levels and it is probable that the aerator contributes more than 1.6 kg oxygen/kWh. Taking these factors into full account, in practice tannery effluent requires a power input of between 3-4 watts per m³.

It is also recommended that floats supporting the aerators should be constructed from laminated polyester filled with polyurethane foam. The motors need to be fully waterproof and metal components exposed to liquid such as shaft and propeller should be in stainless steel. Bearings should be watertight and at a high level, as they must provide long service in adverse conditions and there is a clear preference for polypropylene or polyester mooring cables.

THE PRODUCTION OF SLUDGE

The sludge deposits within the facultative lagoon develop from suspended solids carried over from primary settling and as solids from the biological processes. In reducing the load of an effluent by 1 kg as BOD₅ it is generally accepted that less than 300 grams of solids on dry weight is formed.

If the load from one ton of bovine hide after primary settling is estimated at 40 kg of BOD₅ and 25 kg of suspended matter, the corresponding volume of solids will be 0.3 m³ per ton of processed hide. This takes into account the reduction in volume that results from anaerobic fermentation and is based on a sludge of 10% dry solid.

If the design depth of a basin is 2.5 m, the system needs cleaning when the sedimentary layer reaches one third of the volume, that is at height 0.8 m. In practice this means that a lagoon is normally cleaned out after five to ten years operation. Optimum conditions for this job occur after a lengthy period of hot weather when the sludge has stabilised. If it is planned to dry out the sludge *in situ* before removal it is best to have two parallel lagoons available so that one can function while the other is being cleaned.

FINAL SEDIMENTATION

The final settling zone has to be generous in size and avoid algae and colloidal matter being carried over in the effluent at the point of discharge. Good settling is needed and this requires a long time, the maximum sedimentation rate being provided by a standard of 0.20 m³/m²/h. An additional settling lagoon, or a nonaerated zone with retention time of at least two days, will enable 80% of the suspended solids remaining from treatment to settle.

THE REMOVAL OF NITROGEN

The system is not effective for the removal of nitrogen. The

reduction as total Kjeldahl nitrogen was monitored at 28% in primary treatment. However, the total removal—that is primary settling and the facultative lagoon—was limited to 10% in winter and 30% in summer. It appears that nitrogen can reappear in lagoons due to the effects of anaerobic fermentation.

THE REDUCTION OF THE MICROBIAL CONTENT

In general, a reduction of 90% of the total microbial load is observed. However, it should be noted that this reduction seems to be attributable to effluent dwell time rather than to the process itself. In studies no action faster than natural disappearance was observed.

ADVANTAGES AND LIMITATIONS

Facultative aerated lagoons offer considerable advantages within tannery effluent treatment if set up correctly.

When creating a facultative aerated lagoon, large site areas are required with guarantees of soil impermeability to protect ground waters. Secondary problems such as odour need taking into account and that the system needs cleaning out periodically. The process is sensitive to climatic variation. However, once established it remains very efficient and reliable.

The process can sustain heavy peak loads because of the very large buffer volume of the basins. And the process has the great advantage in that mass or toxic shocks can be absorbed. These events can be catastrophic within many treatment systems and are far from unknown in treating tannery effluents. Nevertheless, in these large capacity lagoon systems the recovery is wholly natural. Even deterioration in the course of time can be minimised by cleaning before deposits become too great and lagooning requires hardly any monitoring.

The quality of the final result is not as good as other techniques such as extended aeration or the activated sludge treatment system. However, the mature system will provide consistent results. If the limitations of the technique can be accepted then this process adapts well to the effluents produced from small- and medium-sized tanneries. ●

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