



The effects of salinity on the treatment of tannery effluents and sludges

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Anaerobic systems

Within the biological treatment of tannery effluent, the general approach uses aerobic bacteria maintained in suspension to digest nutrients within the effluent. Soluble effluent components that have a high oxygen demand, are converted into a fine suspension of bacterial clusters and these are removed as solids.

However, systems that rely on anaerobic bacterial action can also be usefully employed to remove components that otherwise would produce a high oxygen demand in the effluent. There are three methods that need brief review:

ANAEROBIC LAGOONING METHODS

These systems can work well in warm climates, but are not as common as aerobic systems. This is because the systems generally take longer to digest effluent components, but also because of the high level of odour that can be generated. In their most simple form, the construction can comprise of simple settling pits that receive wastewaters. Sunlight, warmth, bacteria and algae break down the effluent, but considerable time is normally required. The pits tend to be deep, typically 3 - 4 metres so that the surface area is relatively small compared with the volume. The technique is known as lagooning, and can perhaps be likened to a fermentation of the effluent.

THE UPFLOW ANAEROBIC SLUDGE BLANKET SYSTEM

In practice there is an upward flow of effluent for treatment through a heavy layer of anaerobic sludge held in a containment vessel. The sludge floats on top of a reservoir of effluent feed, and as digestion occurs and the COD is reduced, there is an evolution of methane gas.

This technique was investigated and developed by Central Leather Research Institute, (India) in association with TNO Institute of the Netherlands many years ago. It has been applied on a pilot scale for treating tannery effluent, but this application has not progressed mainly due to products within the effluent that caused inhibition of the anaerobic bacteria. If the effluent is diluted using domestic sewage the process becomes more reliable. However, a major installation in Kanpur is said to suffer from inhibitions due to an increase in tannery discharges in proportion to domestic sewage, and high levels of sulphide/sulfate, and probably chromium compounds. The technique has been under consideration/construction for many years for treating effluent from the Korangi Tannery Cluster, Karachi, Pakistan.

THE NITRIFICATION/DENITRIFICATION PROCESS FOR REMOVING NITROGEN FROM TANNERY EFFLUENTS

Within effluent treatment nitrogen in the ammoniacal state is oxidised by nitrosomonas bacteria into the nitrite state. This is subsequently converted by nitrobacteria into the nitrate form. Both of these bacteria are aerobic in nature, and at this stage there is a high oxygen demand. This is known as nitrification.

However, if this effluent is then transferred into anaerobic conditions, facultative bacteria utilise the oxygen associated with the nitrate, and nitrogen gas is evolved. This is known as denitrification.

Examples can be found in effluent treatment where the nitrification stage occurs naturally within the activated sludge treatment system. If some of the effluent is fed through a separate container where oxygen is absent, then denitrification occurs. In practice there is a continuous flow so the effluent passes through each stage several times. This process also occurs where there are 'dead' areas within aerobic systems, and even in anaerobic lagoons where there is limited contact with air.

Salinity and anaerobic methods of treatment

A simple, low cost, tannery effluent system was brought on line at a tannery. The treatment comprised 5 large settling sumps of size 22 x 22 metres, and an operational depth of 3 m. Each were linked together, with an effluent flow from the base of each sump into the top of the next in the series. The total retention time was 10 days.

The system was monitored very thoroughly, and reached a plateau in performance in a very short time. From a feed offer between 3200 and 2800 mg/l COD an average discharge value of 560 mg/l was reached in a little over 2 months. This represents a removal of COD of greater than 80%, whereas a removal of maximum 60% was anticipated after a period of around 6 months.

Although the tannery is well managed, there is not a high level of clean technology applied. According to practical experience and published information specific to the leather industry, it would be expected that the nitrogen content would be between 80 - 150 mg/l. However, analysis of the treated effluent showed a negligible nitrogen component.

Within lagoon applications this high removal of COD, the short time to reach optimum performance and the complete removal of nitrogen had not been experienced. However, there was one component where tannery practice was different from other tanneries in equatorial regions. There was a strong



emphasis on processing fresh hides. Salinity values from similar tanneries processing salted hides has been found to be approximately 10,000 mg/l as sodium chloride, but in this situation the salt content averaged 3,600 mg/l.

This indicates that relatively low salinity values may have attributed to the increased removal of COD and nitrogen from the effluent. Studies of tannery-related literature have provided no supportive information. In discussions, specialists in the field are not opposed to the concept of anaerobic systems working better under conditions of low salinity: all existing measures for performance are based on conditions where salinity values are two to three times higher than in this situation. Furthermore, in discussions with experts who have experience with the UASB, it is considered that in addition to inhibition by sulfate and chromium, salinity may have caused inhibitions.

LITERATURE STUDIES

Literature studies into anaerobic inhibition within effluent treatment due to salinity shows that this is not a strongly researched area. No information was uncovered through archive investigations starting in the 1970s that related to tannery effluent treatment. However, inhibition effects have been found recently in the treatment of sludges, and some interesting observations have been found in other fields:

- [1] Inhibition effects on the breakdown of tannery sludges due to salinity have been reported, and a technique successfully developed to improve biodegrade via a washing process to reduce salinity. (*See this issue - 'Anaerobic digestion of tannery sludge: Reducing salinity to reduce sludge volume'*)
- [2] A system very similar to basic anaerobic lagooning is employed to remove nitrogen and selenium from contaminated agricultural drain waters. Known as the Algal-Bacterial Selenium Removal System, the process relies on nitrification/denitrification to remove the available oxygen from nitrates and nitrites, followed by bacterial utilisation of oxygen from selenates to selenite or to elemental selenium. This study refers to earlier work (2.i) where it was found that as salinity rises, there is an inhibition effect on bacteria—specifically *A. Veronii*—resulting in higher residual levels of nitrogen (*hence selenium*) in the treated water. In another study (2.ii) it was found that the nitrification/denitrification process of saline waste waters resulted in low treatment efficiencies because of loss of water from the cell structure of the organisms—hence reduced efficiency—in the presence of salt.
- [3] The recycling of wastewaters in the anaerobic digestion ➤

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THE EFFECTS OF SALINITY ON THE TREATMENT OF TANNERY EFFLUENTS AND SLUDGES

of beef cattle wastes was investigated. This resulted in a rise in pH and salinity (*unspecified*). As the rates of wastewater recycling increased, there was a significant reduction in the percentage of solids destruction and gas generation.

- [4] As part of a study of anaerobic sediments on the McMurdo Ice Shelf, it was revealed that methanogenesis is not inhibited by sulfate, but that chloride has a modulating role. This is believed to be due to the effects of osmotic stress action on the wider anaerobic bacterial community, as opposed to the direct effects on methanogenesis.
- [5] Following the commissioning of an activated sludge treatment system treating a blend of industrial saline effluent and domestic sewage, it was stated that nitrification is inhibited by salinity (*5.i*). It also states that rapid changes in salinity concentration caused more adverse effects than gradual change.

Salinity and aerobic methods of treatment

Where biological methods are applied, aerobic treatment is the norm for processing tannery wastewaters. This is usually the activated sludge treatment process, although there are other techniques that are mainly variations on rotating biological contactor discs and Pasveer ditch systems.

Due to the commonality of this treatment, it would be surprising if significant inhibition effects had not been recorded. From discussions with experts it is believed that aerobic bacteria can withstand concentrations of inorganic salts probably up to 15,000 mg/l. This is because of a shift within the treatment plant from a micro-species population as found in sewage-type treatment systems towards salt tolerant populations.

It is believed, however, that shock loading of salt will cause severe damage, and it is noted that the process has often been known to fail for unknown reasons where individual tanneries carry out their own treatment. It can be speculated that the individual system is more prone to salt damage than Common Effluent Treatment Plants, where dilution factors and buffering are considerably greater. In general, it is considered that where shock loadings have occurred, then recovery is possible, but it takes significant time.

One report [5] makes the observation that for the domestic/industrial treatment of saline waste—in the same order of salinity as tannery effluents—that the aerobic process does not appear to be inhibited. However, the energy input is approximately 20% greater than would be expected and this is attributed to the level of salinity.

Benefits from treating effluents with low salinity values

A considerable amount of analysis over a 1-year period have showed that the removal of COD using a simple anaerobic lagooning technique for low-saline tannery effluent is far more effective than similar systems of typical salinity. In addition, the removal of nitrogen is almost complete, and this is not found in comparative systems. The limited amount of information available supports these findings.

There are also implications regarding the volume and mass of deposited sludge. It appears that low salinity values favour methanogenic decomposition of solids, therefore, the volume

and mass of solids can be minimised. Within UASB technology, and the development of methods to biologically minimise sludge volumes, this implies scope to increase the generation of biogas as an energy source.

These findings infer that the use of salt within the tanning sector has restricted the range of technology available to effluent treatment. Aerobic treatment to reduce the COD and BOD levels has become the norm, and this is much more expensive in both equipment and operational costs than anaerobic technology. Opportunities may have been missed that would be of high value in warm climates.

In addition, an anaerobic phase is central to the removal on nitrogen in all tannery effluent treatment. If denitrification is inhibited by higher salinity, as suggested, then the efficiency everywhere—not just in warm climates—is affected. In this event, if salinity values in tannery effluent had been traditionally low, then all effluent treatment plants for nitrogen removal could have been smaller in size and more reliable.

There are also implications regarding residual sludges from tannery effluent treatment. If salinity is lower, then anaerobic sludge digestion may prove to be a very effective way to reduce mass and volume before land deposit, with the added benefit of increased bio-gas generation.

Aerobic technology is widely used but expensive. It is more salt tolerant than anaerobic technology, but shock dosing will inhibit activity and can take a long time to recover. There is evidence that if typical salinity levels were reduced, then energy costs could fall by approximately 20%. ☺

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