

Addressing salinity in tannery effluents and uses for land irrigation in Australia and India

Catherine A. Money

Leather Research Centre, CSIRO Textile and Fibre Technology, Clayton, Australia

Salinity in tannery effluents is a major problem in both Australia and India.

CLRI and CSIRO are collaborating in an Australian Centre for International Agricultural Research (ACIAR) Project, Salinity Reduction in Tannery Effluents in India and Australia. The aim of this project is to develop, evaluate and widely apply practical, viable systems to reduce salt use in hide and skin preservation and processing, in order to reduce the salinity of tannery effluent.

Tanners are closely involved with the Project and will trial and assess developments.

Tannery effluents vary greatly but they all contain sodium, chloride and sulfate ions. In addition they often contain calcium, magnesium, manganese, aluminium, bicarbonate, ammonia and low levels of chromium. Many tannery effluent components are also components of fertilisers including ammonium sulfate, lime, gypsum (calcium sulfate) and slow-release, high organic nitrogen products, present in the effluent as partially degraded hair. The effluent also contains topsoil, blood and dung that are washed out of the hides and skins. Some tannery effluents contain more sulfate than chloride as the effluent composition depends on the process.

Australian soils are commonly too acid, and are deficient in organic matter, nitrogen, sulfur and manganese. Many Indian soils are also deficient in sulfur: 20-40% of soils sampled in Erode and Dindigul by the Sulphur Institute were deficient.

THE EFFECTS OF SALINITY

High salinity or total dissolved salts in irrigation water causes high osmotic pressure. This results in reduced water availability to plants, and retarded plant growth of crops which are not salt tolerant.

In addition, high concentrations of sodium ions in irrigation water can adversely affect soil structure by causing dispersion of clay. However, the presence of calcium and magnesium ions in tannery effluent ameliorates this effect by stabilising the soils. This is taken into account in calculating the sodium hazard of water (SAR) where:

$$SAR = \frac{[Na^+]}{\sqrt{\frac{[Ca^{2+}] + [Mg^{2+}]}{2}}}$$

Problems with soil permeability can occur with a SAR above 6, depending on soil type and salinity. Nevertheless, increasing TDS inhibits clay dispersion and increases the acceptable SAR value, so that a SAR value of 12 can be acceptable for tannery effluents.

The Australian experience

Two Australian tanneries have been treating effluent by land irrigation for over twenty-five years and seven are doing so at present. This has provided tanneries with a cost effective effluent treatment when sewer disposal has not been an option.

Requirements for each irrigation system are site specific, and licence conditions vary greatly due to Australia's variable climate, soil types, local salinity issues and State regulations. It is always an advantage to have a large area of land to reduce application rates.

All systems use spray irrigation, but a range of effluent pre-treatments has been adopted. In some cases there is only liquor screening and mixing prior to irrigation, elsewhere there are physical-chemical treatments. In some cases biological treatments are used, either activated sludge or extended aeration.

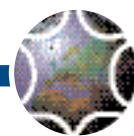
Sodium ions are commonly added to all wet blue processes, but in Australia, some tanneries have significantly lowered the total amount of salt discharged. This has been mainly by:

- processing green rather than salted hides—often assisted by short-term preservation with chemicals or chilling.
- reusing lime liquors
- the use of magnesium oxide for basification
- eliminating washing after tanning
- by Direct Chrome Liquor Recycling (DCLR). DCLR reduces the use of both sodium chloride and chrome powder, which commonly contains 30% sodium sulfate. It is important to note that total chrome precipitation from all spent chrome liquors results in far higher TDS levels.

Likewise, these practices also minimise TDS.

Practical benefits from land irrigation

Usually, tannery effluents can only be used to irrigate salt tolerant crops and pastures. However, experience has shown that irrigation with untreated tannery effluents can be beneficial to



soils although the nitrogen, BOD and TDS levels are high. Land which had little soil cover before irrigation is now covered with good soil, and prolific growth of kikuyu and couch grass throughout the year provides pasture for cattle. In these examples high TDS levels have not caused problems in the soil structure. Although there is some sodium chloride present, the TDS includes calcium, ammonia, sulfates, magnesium, proteins and, in some cases, manganese.

The impact on ground water and waterways of the leaching of TDS, particularly sodium and chloride, must be monitored. At one irrigation site where soils and local waterways have been monitored regularly, sodium and chloride levels in soils are not increasing. This indicates leaching from the surface soils. Calcium and sulfate levels in the irrigated soils are high compared to background levels, with calcium leaching from the soils at levels which can occur naturally. Calcium is beneficial as it protects the soils from the adverse effects of sodium and sulfate. The irrigation system is not measurably increasing salt levels in the waterways and soluble chromium is less than the detection limit. Ground water is not an issue for this tannery.

Regulations and monitoring for irrigation systems

Monitoring of irrigation is important to ensure sustainable systems. However, regulations for the utilisation of effluent by irrigation should be scientifically based.

Regulations for chromium, TDS, BOD and nitrogen levels should be considered in relation to tannery effluents and successful irrigation systems. Some have been operating for many years with effluents with TDS over 10,000 mg/l, and the following issues are being considered in Australia:

- It is acknowledged that effluent of high salinity can be used for irrigation sustainably, provided there is sufficient land for rest periods between applications
- The properties of partially degraded hair—a slow-release, high organic nitrogen product—are different to other organic wastes.

Experience from Michell Leather

A Michell Leather wet blue tannery produced 200 ton per week of full substance wet blue using environmentally friendly manufacturing. Effluent treatment comprises conventional primary effluent treatment and sludge thickening only. Biological treatment is not required as the effluent components causing the BOD provide crop nutrition. The techniques used at this location comprise:

- The clarified supernatant is sprayed onto the land for crop irrigation, and is invaluable in an area of low rainfall
- The thickened sludge is injected directly into the soil twice per year, before sowing oats.

Close monitoring and inspection schedules of the sites have been set up to avoid water logging and a build up of salinity, and close attention is given to avoid odour. Yields of oats and ryegrass have increased.

THE MICHELL APPROACH

- Purchased more land: Current area of land used for irrigation—120 hectares
- Farming approach rather than just dumping waste on land

- Process for low sodium and TDS in effluent
 - Green hides—no salt preservation
 - Direct chrome liquor recycle with minimal salt
- Effluent Treatment
 - Conventional primary treatment
 - Chrome recovery and reuse
- Clarified effluent irrigated to land
- Thickened sludge injected into soil
- Effluents matched to agronomic requirements
- Nutrient Management Plan.

Benefits

- Treats waste as resource to be reused
- Low energy input
- Capital outlay modest
- Potential returns from agricultural enterprises.

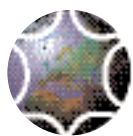
Drawbacks

- Water use needs to be well controlled to prevent water logging and odour in winter months
- Effluent and sludge must be kept aerobic and above pH 9.5 to avoid odours
- Difficult to match exactly NPK (Nitrogen, Phosphorous, Potassium) requirements for various crops with wastes. Phosphorous quite often has to be added
- Farming skills are required.

The Michell process achieved low sodium and chloride levels. Although the tannery is in an area where salinity of waterways and ground water is an issue, these sodium and chloride levels are sustainable. The nitrogen, phosphorous, calcium, magnesium, BOD and sulfur are beneficial, and the oil and grease and chromium are not a problem. The effluent composition is given in *Figure 1*:

Figure 1: Analysis of effluent used for irrigation

Parameter	Range as mg/l	
	Min value	Max value
BOD	3,000	4,000
TDS	10,000	15,000
Na	1,200	2,000
Ca	600	1,400
Mg	200	500
TKN	700	1,000
Total P	5	15
NO ₃	<1	
Oil & grease	700	3,000
Total Sulfur	1,200	2,000
Chloride	200	400
Chromium	0	5
E.C. Us/cm	12,000	17,000
pH	9.8	11.5
Volume m ³ /day	280	



The Indian Experience

Stringent regulations have been set in the State of Tamil Nadu in India for discharge from tanneries of TDS, 2,100 mg/L, BOD 30 mg/L, COD 150 mg/L, and Chromium 2 mg/L. Excepting for TDS, these regulations are now generally being met at considerable cost. However, a TDS discharge of 2,100 mg/L is extremely difficult to achieve.

Presidency Kid Leather has a modern, world-class tannery processing wet blue to finished leather. A reed bed is used to polish BOD and COD to meet regulations. The treated effluent TDS is 3,000 to 5,000 mg/L, being high in sulfate and low in chloride. Calcium from lime used in the effluent treatment is beneficial for irrigation, and the effluent is successfully used to irrigate Casuarina trees. When harvested, these are used as boiler fuel.

KSK Leathers provides an excellent example of new ideas and appropriate choice of technology for particular conditions. Effluent from their manufacture of finished leather from salted hides is used for irrigation. The treated effluent has a TDS which meets the regulation of 2,100mg/L in wet weather: sometimes it is higher, although always under 5,000 mg/L. The sludge from effluent treatment is dried and used as a fertiliser, where the value of sulfate is appreciated.

These examples of good practice could be used as a basis for reviewing the irrigation regulations. In addition to TDS, monitoring of the SAR, BOD and sulfate levels would allow greater understanding of the beneficial of using effluents for irrigation. In this event it may be advantageous to add other nutrients such as phosphorous.

Considerable progress has been made in Tamil Nadu in reducing TDS discharge in tannery effluents. And it has been demonstrated in both Australia and India that a high TDS can be acceptable in tannery effluent, and that the use of wastewater can provide benefits in terms of land improvement and crops of commercial value. Moreover, calcium and magnesium can

Panel 1

Salinity, TDS and other values

There is often confusion between these values, and often the TDS is believed to be the same as the salt content.

Total Dissolved Solids (TDS): A measure of all soluble material in an effluent. Accordingly this covers components within an effluent that are both inorganic and organic. These products can be residual from process either as chemicals offered, extracted hide components, and inter-actions between these components. Both inorganic and organic components can be very stable, or may break down in time.

Chloride (Cl): Values generally relate to the common salt component within an effluent. As sodium chloride, this is always greater than the Cl value; for example, a Cl value of 1000 mg/l equals a sodium chloride content of 1648 mg/l.

Sodium (Na): Can be from many sources, so it may be different in proportion to the Cl value. A very common source in tannery effluent is sodium sulfate.

Sulfate (SO₄): Values are not simply related to sodium sulfate. Another common source is ammonium sulfate. Unlike chloride, sulfate is subject to change. In land applications it can be reduced to elemental sulfur.

Panel 2

Membranes and Salinity

Reverse Osmosis (RO) membranes are used to produce fresh water from salt water in many parts of the world. Conventional Crossflow RO membrane filters require that the inflow be largely free of suspended solids. The upper limit on TDS is around 30,000 mg/l but at this level only 35% water recovery can be expected and therefore the salts remain in 65% of the volume. Where the TDS concentration is lower in the initial offer 70% water recovery can be achieved. When the feed is seawater, great attention is paid to ensure that the feed to the membranes is clean to prevent their fouling.

Tannery liquors have some important components that make membrane concentration difficult. For example, very low levels of barium and strontium compounds form a hard scale in the dead zones of the membrane surface and reduce membrane performance. An Australian wet blue tannery has found that the barium and strontium levels in effluent after physical-chemical plus biological treatment is too high for Crossflow RO membrane filters. The scaling would be impossible to control. Barium was at 1mg/L and strontium 2.3mg/L and they apparently originated as contaminants in process chemicals.

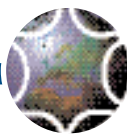
Membrane Bioreactors are being used commercially in tanneries to clarify tertiary treated effluents by removing activated sludge. Membranes are reported to be used to recycle sulfide solutions in crocodile tanneries, and in the removal of precipitated chromium flocs from treated tan liquors. These are limited, specific uses of membranes.

In Tamil Nadu, RO has been trialled by UNIDO on a small scale at a tannery. After physical-chemical plus biological treatment, the effluent was treated with a pressure filter, a photochemical oxidiser, an activated carbon filter, a water softener and two RO filters. The concentrate from such a process would be solar evaporated.

There were problems with the membranes in this well-managed UNIDO trial. To prove that removal of salts from tannery effluents by RO is a viable option for the industry, a full-scale plant would need to operate under commercial conditions for 2 years.

During drought, salinity of ground water increases, so large volumes of water are brought to the tannery by tanker. RO can provide usable water, which is an advantage, but to be sustainable, all the salts recovered should be utilised and this is very difficult.

This as an expensive system requiring excellent quality control and maintenance. Commercial viability will depend on the life of the membranes, the percentage recovery of fresh water and the disposal of the reject saline water. Sankar in 2000 reported that the financial viability of RO is yet to be demonstrated and determined that for a Central Effluent Treatment Plant (CETP), the incremental capital cost for the RO plant is 1.6 times the cost of the existing CETP. RO would not be cost effective for Individual Effluent Treatment Plants.



considerably offset the effect of a high sodium content in effluent on soil stability—and both can be found within tannery effluents.

The approach to reducing the salinity and TDS requires cleaner production technologies. Accordingly:

- Reduction in salt use for skin preservation by development and adoption of low or no salt methods will have the greatest impact on reducing salinity
- Within tanneries, process improvements can have significant impact on salinity. Reduction can be achieved to by improved pickle recycle and DCLR
- The economic viability of RO for concentration of salts from tannery effluent must be fully demonstrated before recommendation
- There is no viable system as yet available to remove TDS sufficiently from effluents to achieve regulations
- Further technology for reduction in salt use needs to be developed and adopted by industry
- Regulations for TDS discharge and irrigation of effluents need to be reviewed to enable beneficial use of wastewaters. 

Acknowledgement

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