



A salt-free process water recycling strategy for tanneries: Hybrid effluent treatment using reedbeds and membrane filtration

Wolfram Scholz, W2O Environment, UK

and

Richard Daniels, Greentech + Associates, UK

Tannery effluents contain many chemical constituents, in suspended, colloidal or dissolved form, which have to be treated to achieve local discharge standards. A conventional tannery effluent treatment plant may comprise of a primary, conventional biological and tertiary treatment, which allows an overall reduction of COD and BOD by up to 85-90%⁽¹⁾. But this form of effluent treatment is high in both capital and running costs and does not remove any salts. Moreover, it generates high amounts of sludge which often need to be disposed of at special landfill sites⁽²⁾.

Conventional effluent treatment is therefore not only expensive, but does not produce a truly high quality effluent. The final effluent quality does not allow for direct recycling in tannery processing due to its high salt concentrations and residual fractions of COD, BOD and suspended solids.

A new strategy to reduce the cost and environmental impact of tannery operations is to apply advanced biological treatment and polishing, in the form of membrane bio-reactors (MBR) and reverse osmosis (RO) respectively, to provide high quality water for recycling. However, the application of reedbed technology as a pre-treatment before MBR and RO treatment has great advantages: performance is improved, and overall operational cost reduced.

Reedbed technology

Reedbeds are already being successfully used for the secondary treatment of tannery effluents⁽¹⁰⁾. Over and above their low capital and running costs compared with the activated sludge process, they offer a considerable advantage to the combination of membrane bio-reactor and reverse osmosis.

Reedbeds can significantly reduce organic soluble fractions (COD and BOD) without producing any surplus sludge as this is fully broken down within the reedbed. Consequently, aeration, and hence energy requirements, and surplus sludge generation of the subsequent biological treatment can be much lower.

Membrane bio-reactor (MBR) technology

Membrane bio-reactors are an emerging technology with major potential in wastewater treatment. They provide a relatively compact alternative to conventional biological treatment options, producing a 'guaranteed' high quality effluent even at high and varying organic loading rates⁽³⁾.

The process is an extremely efficient combination of activated sludge treatment that employs membrane filtration to retain all the bio-mass in the bio-reactor. The technology ensures that much higher solids concentrations (up to 20 g/l as Mixed Liquor

Suspended Solids) can be accommodated than with conventional biological treatment⁽⁴⁾. This not only reduces the size of the plant but all of the suspended solids, and even large molecules, are also retained in the bio-reactor until they breakdown.

An increase in retention times (and higher operating temperatures) significantly reduces the volume of sludge produced⁽⁵⁾. This can be compared with the conventional biological processes, such as activated sludge treatment, which produce considerable volumes of sludge for disposal.

The MBR process is, therefore, well-suited for treating tannery effluents as these generally require long retention times for the effective biological treatment of less degradable pollutants. An effluent quality, which in many cases is far better than the required discharge standard, can be obtained by using MBR technology⁽⁶⁾.

Reverse osmosis (RO) technology

The treated effluent, however, still contains salts, and this reduces the feasibility of water re-use⁽⁷⁾. In this situation, a further polishing step using RO allows the desalinated water to be recycled back into the tannery process⁽⁶⁾. The use of ►

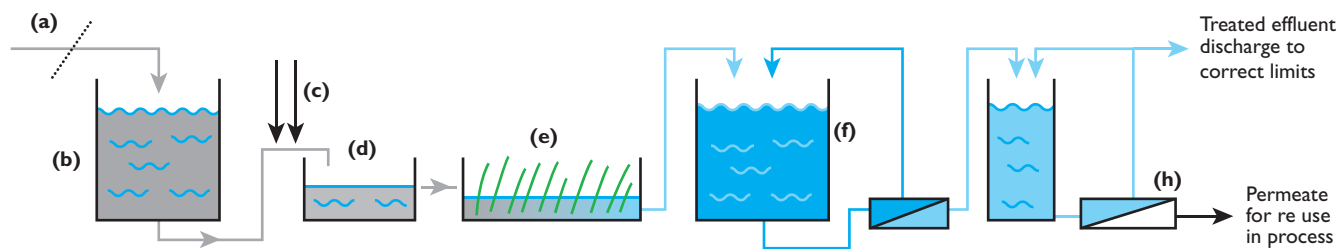
Panel 1: Example of a tannery effluent before and after reedbed treatment





HYBRID EFFLUENT TREATMENT USING REEDBEDS AND MEMBRANE FILTRATION

Panel 2: The hybrid scheme: reedbed, MBR and RO



- (a) Initial screening to remove gross solids.
- (b) Retention in an aerated balancing tank with a one-day capacity.
- (c) Continuous transfer and coagulation.
- (d) Removal of suspended solids using Dissolved Air Flotation. This combined physical/chemical treatment removes up to 95% of the suspended solids and around 60% COD. The primary sludge remains for disposal.
- (e) Continuous feed of the clarified effluent to a reedbed. A fast removal of the more easily biodegraded BOD/COD components, at short retention time of approximately half a day, can reduce the COD to around 80% of the original value and lower the suspended solids to a negligible level. There is no sludge for disposal.
- (f) Continuous feed of the 'hard COD' effluent to the membrane

bio-reactor. Due to the removal of COD through reedbed treatment the size of the MBR system can be significantly reduced. The lower feed to micro-organisms ratio also causes a decrease in the surplus sludge production⁽⁴⁾. The effluent feed from the reedbed can degrade more easily, as it is low in suspended solids, bacteria, turbidity and hard COD. The process is more efficient as a result of the increased retention time of the residual soluble components within the bio-reactor⁽⁵⁾.

- (g) Continuous outflow of the permeate from the bio-reactor filtration membrane to a holding tank.
- (h) Treatment by reverse osmosis. The size and treatment capacity of the RO plant can be designed to local standards.

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Panel 3: Reverse osmosis membrane plant for high quality water recycling



recycled water with a high and consistent quality saves costs in terms of the total volume of water consumed by the tannery, and it also minimises the volume of end-of-pipe effluent.

As a pre-treatment for RO, the membrane bio-reactor is ideal. This is because of the complete elimination of BOD and suspended solids. Small concentrations of these bio-components—as found with conventional treatment—cause bio-fouling of RO membranes, and suspended solids physically block the spacer of a spiral RO module⁽⁸⁾.

The mode of operation

This combination of reedbed and MBR/RO technology reduces the size/cost of the bio-reactor, increases the overall performance, and reduces the costs of advanced effluent treatment and recycling. A schematic of the treatment system is given as *Panel 2*, but there are several other details that should be taken into account:

- Energy saving mechanisms can be included in the plant design. The ultrafiltration membranes require cleaning, which is minimised thanks to the excellent pre-treatment. These membrane units can be shut down and flushed automatically as soon as the effluent volume drops, and aeration is provided by using variable speed blowers according to needs. The membrane use is efficient, achieving an extended life expectancy.
- Effluents following conventional effluent treatment are comparatively high in BOD/COD and often suspended solids. This means that these effluents need tertiary treatment by either sand filtration, activated carbon treatment, chemical dosing and settling, or combinations of these techniques before any RO treatment. But the effluent still remains high in complex components (*hard COD*) that can significantly increase the total dissolved solids. ➤

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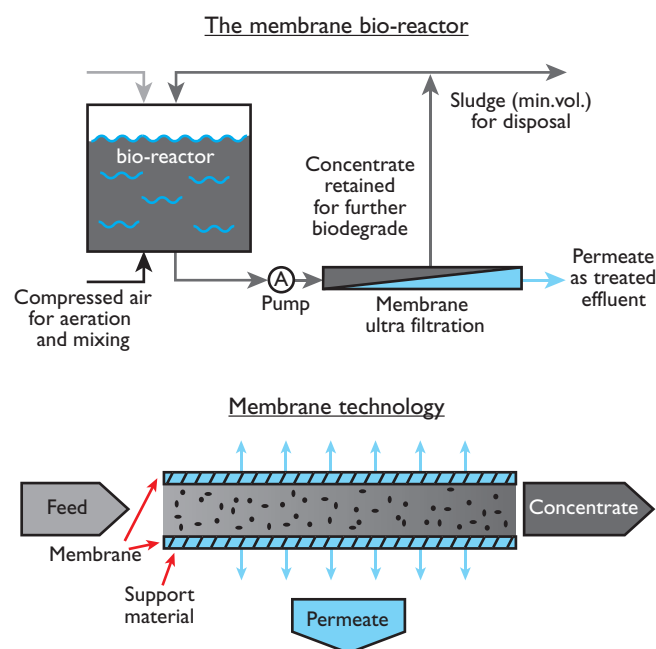
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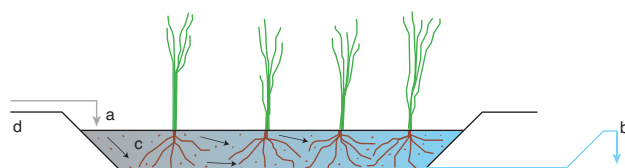
Panel 4:



Within the MBR, the bio-mass and large molecules are retained within the concentrate for further breakdown. This ensures that hard COD components are eliminated. The smaller molecules, such as water and sodium chloride, pass through the membrane filter as permeate.

RO only allows water to pass through the membrane as the permeate. Salt is thus retained in a solution of increasing strength as the concentrate.

Root-zone schematic



- a: in-feed
b: adjustable outflow to regulate effluent level in the medium
c: medium - washed gravel 5-10mm size
d: impervious layer to contain the waste water undergoing treatment

The effluent for treatment flows under the surface of the medium and through the root structure for bio-degrade. Design that takes into account both medium size and flow patterns within the reedbed ensures that effluents of very high COD/BOD can be treated after primary treatment.

- The bio-reactor treatment eliminates these components, so that the membrane load of organic compounds is reduced, leaving just the common salt component for treatment by RO. The efficiency of the RO treatment is raised by the elimination of these components, which would foul the membrane. It has been demonstrated⁽⁹⁾ that at the average salt concentrations of tannery effluents, up to 80% RO water recovery for recycling is feasible.
- Where there are limits set for chloride discharge from tanneries, the increasing salinity of the feed to the

ultrafiltration units within the RO plant can be monitored using a conductivity meter. This ensures that discharge at the maximum salinity as set by law is ensured. This then leaves the maximum volume of water available for recycling within the plant.

- If there is no limit for sewer, saline pipe, or marine discharge as an otherwise clean effluent, then the maximum recycling of water is possible.
- Where there is a need for zero discharge—such as in India—then the volume of saline effluent remaining for forced evaporation will be significantly reduced when compared with other methods.

The combination of reedbed, membrane bio-reactor, and reverse osmosis technologies offers a route for the recovery of high quality desalinated water at low costs. This concept can be adapted to local requirements and offers a treatment scheme that operates exactly at discharge consent.

Whereas effluent treatment represents a pure cost with no return, this hybrid scheme achieves cost savings resulting from a reduction in:

- fresh water consumption.
- the volumes of effluent discharged and sludge treatment and de-watering.
- solids disposal charges.

Where appropriate, the quality of the treated effluent can be carefully managed to maximise the discharge limits for salinity in a manner that is both legal and cost effective. 🌍

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