



Reedbeds: Secondary and tertiary performance for tannery and other industrial effluents

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The high productivity and nutrient removal capability of natural wetlands has created substantial interest in their potential use for improving wastewater quality. Constructed wetlands, also known as root zone treatment system or reedbeds, is an engineered mimic of a natural wetland.

Reedbeds can be built with a great degree of control with well-defined composites of substrate, type of vegetation and flow pattern, the pollutants being removed through a combination of physical, chemical and biological processes. In general applications, reedbeds have several advantages over conventional secondary and advanced wastewater treatment systems, which include:

- Low to moderate cost of construction (depending on site conditions)
- Negligible maintenance costs
- Negligible energy requirements
- No need for skilled personnel for operation and maintenance of the system
- Flexibility in handling variations in loading rates
- Aesthetic appeal

A disadvantage can be the requirement of a relatively large area for construction. However, in the case of treating tannery effluent, compared with the land requirements for conventional secondary treatment and sludge drying the land requirements can be similar. In addition, as it is possible to integrate constructed wetlands with the landscape, reedbeds can be an attractive option for waste treatment.

The removal mechanisms of pollutants

The mechanisms of removal of pollutants in a constructed wetland are physical, chemical, and biological.

Settleable and suspended solids are removed primarily in a mechanical pre-treatment unit, which is installed before the constructed wetlands. Any remaining suspended solids are degraded biologically by bacteria attached to the plant and segment surfaces.

The oxygen requirements for the process are met by:

- Diffusion through sediment
- Water atmosphere interface
- Photosynthetic oxygen production in the water column
- Oxygen leakage from macrophytes roots

The plant uptake of phosphorous can also be significant, but this is often present in association with aluminium, iron, calcium and clay minerals in the sediments. Nitrogen removal in a



The reedbed at the Aravind Eye Hospital, Pondichery, Tamil Nadu, India, has a capacity of 540 m³/day. The untreated effluent has a BOD of around 100 mg/l and treatment achieves an outlet with a BOD less than 10 mg/l.

wetland is done by nitrifying bacteria in aerobic zones to nitrates, which get converted into nitrogen gas by the denitrifying bacteria in anoxic zones.

Pathogens are removed by sedimentation and filtration and natural die off in the unfavourable environment. Some plants secrete antibiotics through the roots, which also destroy pathogens.

The removal mechanisms commonly believed to be occurring for different pollutants are summarised in *Panel 1*.

The performance of reedbed systems for tanneries

Under the South East Asia regional programme of UNIDO, four pilot-cum-demonstration units treating tannery

Panel 1: Removal mechanism within reedbeds

Component	Removal Mechanism
Suspended Solids	Sedimentation/Filtration
BOD	Microbial Degradation
Nitrogen	Ammonification-Nitrification-Denitrification/Plant Uptake/Ammonia Volatilisation
Phosphorus	Soil absorption/Plant uptake
Pathogens	Sedimentation/Filtration/ Natural Die-off/Antibiotics secreted by the macrophytes

**Panel 2: Details of the four reedbed applications**

Project	Objective	Type of effluent	Flow pattern	Type of feeding	Media used
PKL Chennai	1) Evaluation of unit as a tertiary treatment unit, mainly colour & COD removal	Wet blue to finish	Horizontal	Continuous	Pebbles
	2) As a replacement of biological treatment for BOD/COD removal	Wet blue to finish	Horizontal	Continuous	Pebbles
Sidco Ranipet	Evaluation of the system as a tertiary treatment, mainly colour removal	Wet blue to finish	Vertical	Fill & draw	Sand
Ranitec Ranipet	Evaluation of the system as a tertiary treatment, mainly colour & COD	Raw to finish (EI)	Horizontal	Continuous	Sand
Vishtec Melvisharam	As a replacement of biological treatment, BOD/ COD removal	Raw to finish (EI)	Horizontal	Continuous	Sand

Panel 3

Item 3/1: Performance of a reedbed system in a CETP as a secondary treatment system (monitoring results for two years, average of more than 900 samples)

Parameter	Mean Influent Value	Mean Effluent Value
pH	8.4	7.5
COD mg/l	1436	304
BOD₅, 20°C mg/l	660	113

Item 3/2: Performance of a reedbed system in a tannery as a secondary treatment system (monitoring results for three years, average of more than 1,400 samples)

Parameter	Mean Influent Value	Mean Effluent Value
pH	8.1	7.4
COD mg/l	1751	579
BOD₅, 20°C mg/l	776	117

Item 3/3: Performance of a reedbed system in a CETP as a tertiary treatment system – fill and draw system (monitoring results for three years, average of more than 1,050 samples)

Parameter	Mean Influent Value	Mean Effluent Value
pH	7.3	7.6
COD mg/l	345	228
BOD₅, 20°C mg/l	27	13
Colour Pt-Co units	765	85

Item 3/4: Performance of a reedbed system in a CETP as a tertiary treatment system (monitoring results for three years, average of more than 350 samples)

Parameter	Mean Influent Value	Mean Effluent Value
pH	7.1	7.0
COD mg/l	304	165
BOD₅, 20°C mg/l	24	9
Colour Pt-Co units	675	115

wastewater have been installed and the plants have been monitored for a fairly long period. The performance of the systems was evaluated as a secondary treatment system and also as a polishing unit to remove residual colour, and BOD/COD remaining after secondary treated effluent. The salient details of the units are given in *Panel 2*.

The performances observed are given in *Panel 3*.

Tertiary treatment of tannery effluents: reedbeds compared to other systems

The performance of a reedbed used to improve tannery effluent after conventional secondary treatment over a five-month period is given in *Panel 4*.

It was considered best to compare this performance with other

Panel 4

Parameter	Influent	Final outflow	% reduction
pH	7.9	7.2	
TSS mg/l	45	25	44
COD mg/l	465	390	16
BOD mg/l	28	14	50
TDS mg/l	5550	5625	1.3


Panel 5: The percentage reduction using a reedbed as a tertiary treatment method compared to other systems

Parameter	Ozonation ⁽¹⁾	Activated carbon ⁽²⁾	Chemical oxidation ⁽³⁾	Reedbed
BOD	10-20	10-15	12-20	45-60
COD	5-10	8-10	4-15	10-15
TSS	---	50-60	---	40-50
Colour	15-20	20-25	20-25	10-15

1) Ozonisation: 30 minutes to 8 hours (16 trials)
 2) Activated carbon: Packed bed, contact time 30 minutes to 4 hours (16 trials)
 3) Sodium hypochlorite: 50 - 500 ppm (18 trials)
 3) Hydrogen peroxide: 100 - 500 ppm (12 trials)

Panel 6: Reedbeds for industrial waste water treatment

reedbeds have found many applications in industrial wastewater treatment. These include: food processing, petroleum refineries, textiles, pulp and paper, breweries & distilleries, coal mines, agro-industries, metal processing, tanneries, detergents and surfactants, and pharmaceuticals. reedbeds have also found application in treating leachates from toxic landfill sites, garbage dumps, etc. The performance of reedbeds in miscellaneous industries is given as Items 6/1, 6/2, and 6/3:

Item 6/1: Secondary treatment system in an oleoresin factory: (monitoring results for two years)

Parameter	Mean Influent Value	Mean Effluent Value
pH	7.5	8.0
COD mg/l	317	41
BOD₅, 20°C mg/l	43.0	9.0
SS mg/l	581	112

Item 6/2: Treatment system in an pharmaceutical factory (single stage reedbed: monitoring results for two years)

Parameter	Mean Influent Value	Mean Effluent Value
pH	4.9	6.72
COD mg/l	5860	252
BOD₅, 20°C mg/l	1413.0	90.0
SS mg/l	481	85
Oil and Grease	154	12

Item 6/3: Treatment system in an pharmaceutical factory (multi-stage reedbed: monitoring results for two years)

Parameter	Mean Influent Value	Mean Effluent Value
pH	4.9	6.72
COD mg/l	8860	296
BOD₅, 20°C mg/l	1650.0	68.0
SS mg/l	481	74
Oil and Grease	211	28.0

conventional tertiary systems. For this purpose the same effluent as fed into the reedbeds was collected and subjected to tertiary treatment using various methods. Several sets of experiments were repeated for each trial at various doses of chemicals, and the findings are given as *Panel 5*.

The reduction provided by the reedbed is not high, but when compared to the other conventional systems can be rated as quite good.

Conclusions from the investigation

- As a replacement of secondary biological treatment, based on operational times of two to three years, the results obtained are encouraging.
- As a tertiary treatment, the reedbed system with sieved sand (preferably of size 2 mm to 5 mm) as the medium, a retention time of 3 days, and continuous feeding is appropriate for obtaining 50-60% organic removal efficiency. This is better than any other common tertiary treatment system, with better colour and turbidity removal.
- The specific reduction of BOD₅ ranged from 23.47 g/m²/d to 62.12 g/m²/d with an average of 45.21 g/m²/d. The mean specific reduction of COD during the monitoring period was found to be 101 g/m²/d. The minimum specific reduction observed was 68.54 g/m²/d. The maximum specific reduction observed was 146.26 g/m²/d.
- Salinity may not be a problem for the survival of reeds or the operation of reedbeds.
- The prospects of wider application of the technology for treatment of various types of industrial effluents other than tanneries, particularly in countries where land is not very expensive and available in abundance, is indeed bright.

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