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Constructed Wetlands

Natural wetlands, permanently waterlogged areas populated by hydrophytic plants such as reeds, comprise a variety of sub-surface micro-habitats of differing oxygenation and redox potential, and support a diversity of microorganisms – bacteria, fungi, actinomycetes, protozoa – which degrade organic and inorganic substrates entering the system. Constructed wetland systems are increasingly being employed for treatment of wastewaters, sludges and industrial effluents as a cost-effective, low energy and robust alternative to traditional engineered biological treatment such as the activated sludge process. Constructed wetlands (CWs) are classified according to their mode of operation as surface flow, horizontal flow, vertical downflow or vertical upflow type. They have been used successfully in the treatment of domestic sewage, urban, highway and stormwater runoff, acid mine drainage, agricultural waste, industrial effluents, landfill leachate and meat processing effluent. BOD and solids reduction occurs through microbial activity and removal of nitrogen and phosphorus through the processes of denitrification, plant uptake and sorption.

- Artificial wetlands for wastewater treatment were pioneered in Germany and this natural treatment technology is now used all over the world, not only for domestic waste waters but also for industrial effluents.
- A lot of research has been done in the last twenty years and adequate design guidelines for the different kinds of constructed wetlands are available.
- The natural ability of soils to filter suspended solids mechanically and chemical reactions (precipitation) with sewage constituents are other forms of cleaning mechanisms, which interact. So pollutants are metabolized, settled and absorbed in sequential anaerobic and aerobic processes.

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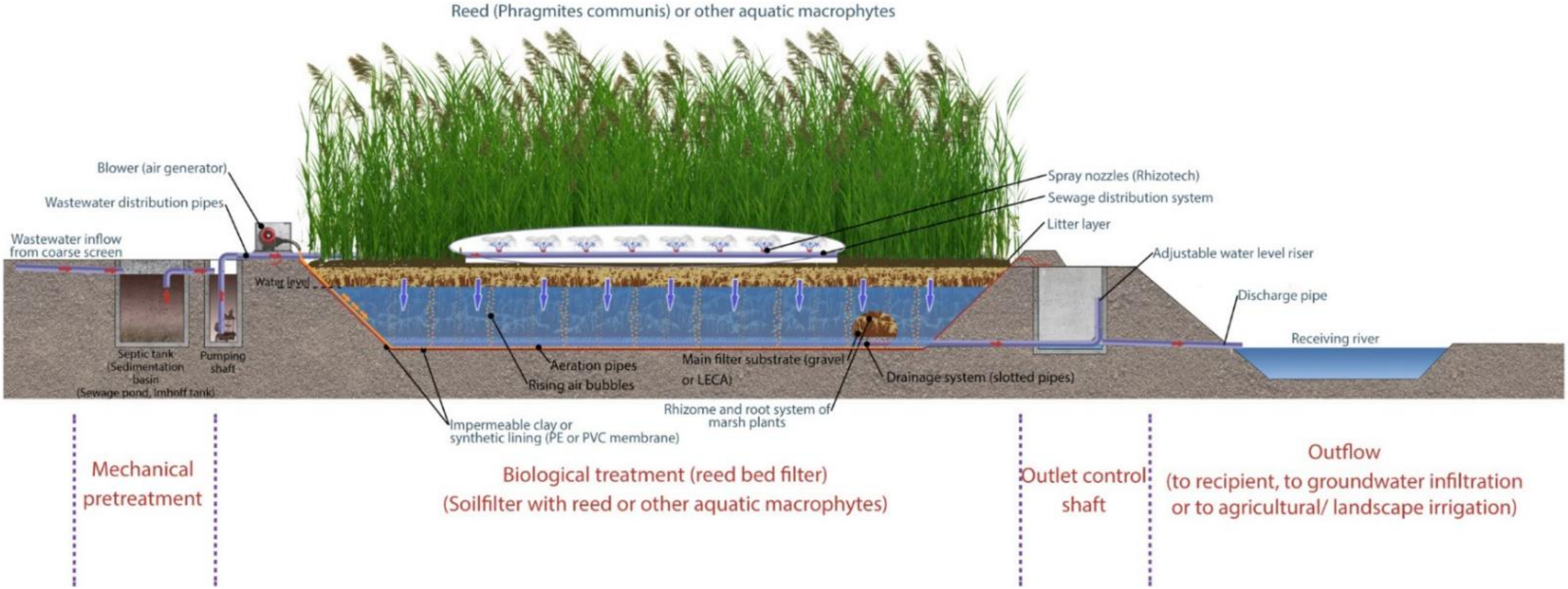
ARTIFICIALLY AERATED CONSTRUCTED WETLAND

(WATER SATURATED, PULSE-LOADED, VERTICAL SUBSURFACE FLOW)



Reed bed treatment system

The reed bed treatment system combines aerobic and anaerobic decomposition processes in a 1.0 m thick soil or substratum layer. The polyethylene lined and refilled basins are planted with helophytes like *Phragmites communis, Typha latifolia, Typha angustifolia* or other aquatic macrophytes.The wastewater percolates the filter substrate vertically to the bottom drains.

Besides the microbial and fungal decomposition of organic matter and pollutants in the rooted soil or substrate matrix, chemical and physical precipitation, adsorption and filter processes occur due to soil constituents like clay minerals and humus particles. This is most important for phosphate and ammonia binding. Some of the wastewater nitrogen is released out of the artificial ecosystem to the atmosphere as nitrogenous gases (denitrification).

Through intermittent loading of the reed beds a radical change of oxygen regime is achieved. After water saturation by feeding with the distribution system a drainage network at the base collects the purified water. The pore space of the substrate is refilled with air thus enabling aerobic decomposition processes.

Another part of oxygen transfer into the rhizosphere happens through a special helophyte tissue in the plant stems and roots (aerenchym) from the air.

Clogging effects of the filter substrates (soil, sand, gravel) are prevented by the continuous growth and decay of roots and rhizomes of the aquatic macrophytes and the thereby remaining soil macropores. In this manner, long-term water transport into the soil matrix is guaranteed.

The substrate, which is filled in the sealed earth basins, is a sitespecific mixture of selected components determined by aspects of hydraulic conductivity and physico- chemical properties. The soil and substratum mixture is a single case decision of planning further depending on the composition of sewage, whether municipal or industrial.

By means of high evapotranspiration of the marsh plants the wastewater tends to increase pollutant concentrations, thus improving the efficiency of the microbial degradation process. These artificial wetlands reduce both pollutant concentrations and the water volume. Their performance has to be described by - pollutant load parameters (kg BOD / [m^2 x d]), not just comparing (pollutant)concentrations (mg/l) between inlet and outlet.

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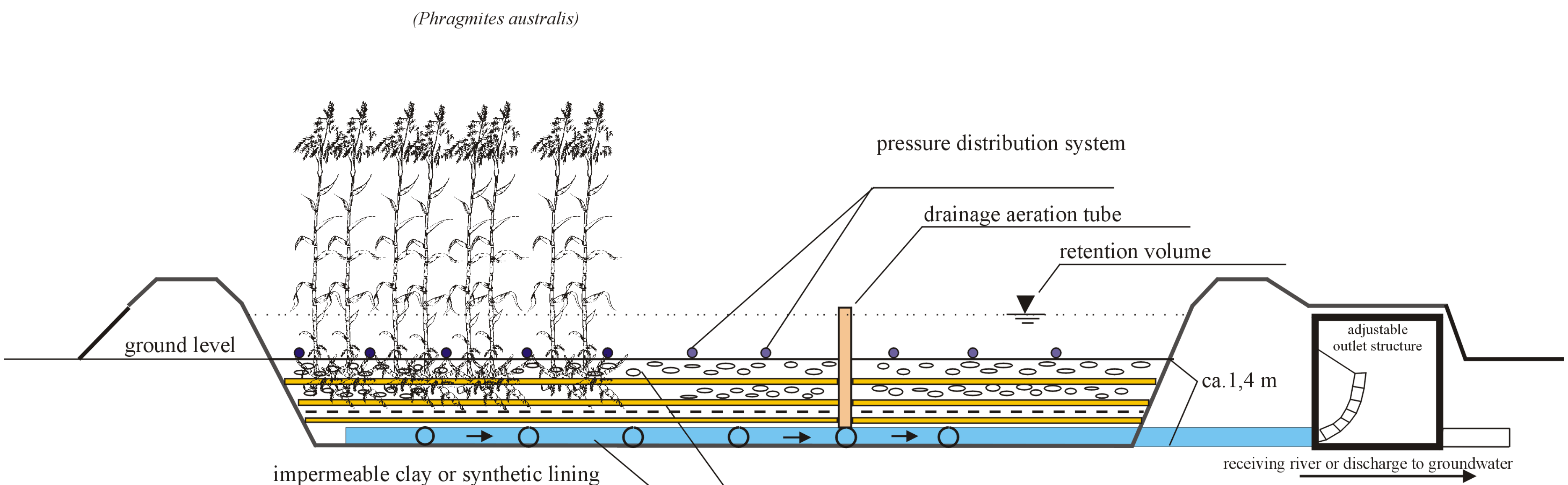
Vertical subsurface flow reed bed treatment system



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The design (length-width ratio, depth, hydraulic loading rate, hydraulic residence time, plant species, soil mixture and so on) depends on sitespecific facts (type of waste water, topography) and on degradation kinetics typical for reed bed treatment systems - in most cases a first order reaction.

The necessary area or volume is further calculated to meet the officially required discharge limits.

Besides proper construction and planting of these artificial wetlands, specialists should supervise the initial phase of the ecosystem development to avoid misfunctions of the total pollution control concept.

The main factors that typify the treatment characteristics are:

- hydraulic loading (m^3/[ha x d]) and hydraulic detention time
- oxygen supply
- temperature
- influent pollutant concentration
- development stage of the reed ecosystem

Cost effective in the long term

Although sometimes initial investment costs can be as high as those of the more conventional treatment methods, especially since specialist companies need to be contracted to design and to supervise the construction of the system, the subsequent running costs have found to be significantly lower and much less labour intensive.

An attraction for wildlife as well

From the nature conservation angle, reedbeds offer enormous ecological advantages over conventional purification systems. Experience has shown that even relatively small artificially created reedbeds of this type very quickly rival the “natural” reed systems as wildlife habitats. One system in Germany established to deal with the removal of pollutants from a large textile factory, for example, has since become the largest reed bed system in that region (18 ha) and as such attracts impressive numbers of birds e.g. reed warblers, gadwall and such visiting waders as green sandpiper, little ringed plover and greenshank.

Conclusion: a genuine win-win solution

Being able to use the natural properties of reed beds for municipal and industrial waste water management has opened up all sorts of possibilities for a modern natural treatment of polluted effluents. From an environmental stand point there is the added bonus of re-creating wildlife habitats in arid climate zones. In terms of socio-economic benefits the fact that, once installed, reed beds are very cheap to run and are readily adaptable to wide range of industrial waste products.

Our constructed wetland in Mahshahr (Iran)