

# VETIVER GRASS USED IN CONSTRUCTED WETLANDS TO RECOVER WATER FROM WASTEWATER

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## ENVIRONMENTAL POLLUTION FROM WASTEWATER EFFLUENTS <sup>1</sup>

Untreated or inadequately treated wastewater discharged into a receiving stream brings with it biodegradable organic material that diverse communities of microbes decompose. These reduction/oxidation processes consume dissolved oxygen in streams and *mineralize* organically bound nutrients that then become available to plants. The mineralized nutrients stimulate growth of algae at the base of the food web. Excessive microbial depletion of dissolved oxygen, or *eutrophication*, can impair the ability of streams, lakes or coastal waters to support aerobic forms of aquatic organisms.

Municipal wastewater effluents in many developing countries tend to be more concentrated than in industrialized countries because less water is used on average in household activities. Where the climate is seasonally dry or arid, the small amount of surface water restricts the capacity of the environment to dilute and assimilate wastewater-borne pollutants. In such cases the economic value of good quality water is highest, and the hazard of wastewater-borne pollution of surface and groundwater resources is magnified compared with regions with more rainfall. Ideally, wastewater treatment in water-scarce regions should be designed to protect the quality of the water resource by intercepting and fixing wastewater-borne pollutants, while restoring water quality to a level suitable for reuse.

## WATER RESOURCE RECOVERY <sup>1</sup>

A systems approach to water resource management recognizes that wastewater management is simply another component of water resource management, with an associated set of costs and benefits and definable linkages to the rest of the hydrological system. The most important linkages are the *amount* and *quality* of water that a city needs and the likely effects of the effluents on the quality of rest of the water resource.

Figure 1 shows that the amount of water available per person has been declining throughout the world as a result of expanding populations and environmental changes. Water scarcity has resulted in a series of problems: degradation and overuse of water resources and increasing competition and conflicts among user groups. These problems are provoking policy makers to reconsider wastewater disposal practices.

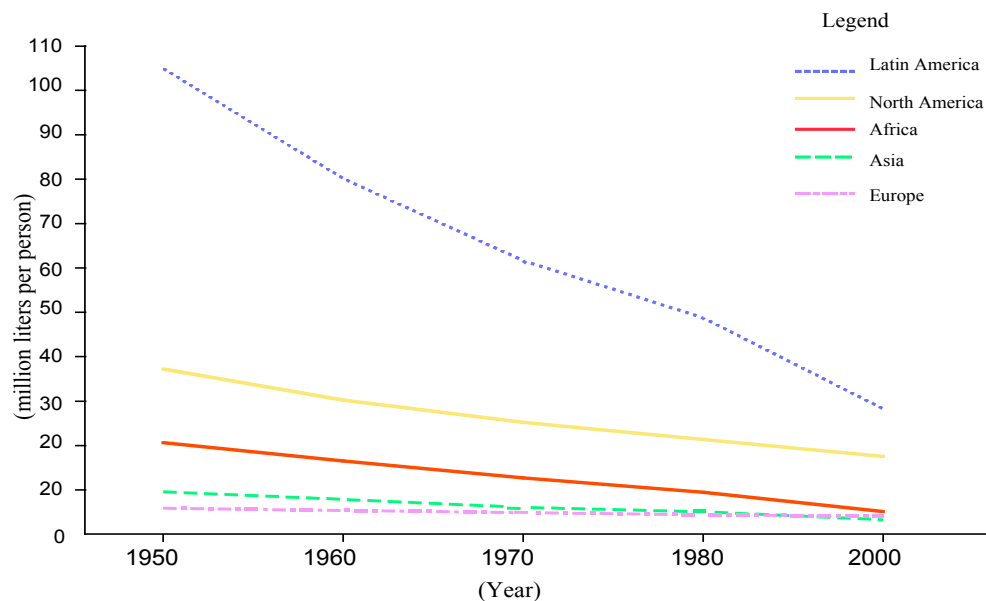


Figure 1 Water Availability per Person by Region From 1950-2000

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Worldwide, agriculture accounts for about 69 percent of water use, industry 23 percent and domestic consumption about eight percent. Water use patterns, however, vary from country to country and within single countries. Water demand for irrigated agriculture is particularly high in arid regions, such as the Middle East and North Africa, and there is increasing demand to satisfy urban needs.

Traditionally, urban water supply has followed a “flow through” model, importing high quality water and discharging low quality “used” water into the public domain, often to the detriment of the interests of downstream users, who typically bear the costs of environmental pollution. A more rational economic model would provide for reuse of a large fraction of the wastewater resource within the urban area while discharging insignificant amounts of pollutants into the general environment.

Where the development of additional supplies of high quality domestic water is very costly, wastewater is likely to be an economical source. Treated wastewater effluents can substitute for high quality water in applications that can accept a lower level of chemical and biological quality, such as irrigation of crops and parklands, flushing toilets and many industrial applications. Although an unconventional source, wastewater has characteristics that can be advantageous in an urban setting:

- it is a *renewable* resource whose availability mirrors water consumption; and
- it is located near the areas where it is needed, minimizing transport costs.

Reuse of treated wastewater effluents conserves water resources by reducing the net amount of water extracted from the primary source. In addition to providing health benefits planned reuse of treated wastewater can result in several economically important benefits, including:

- the value of the reclaimed water, equivalent to the opportunity cost of developing an alternative supply;
- the value of the water and nutrients to a crop production system;
- the value of avoiding or mitigating environmental damage to receiving water bodies.

### ANAEROBIC INITIAL TREATMENT AND FINAL EFFLUENT POLISHING IN A “CONSTRUCTED WETLAND”

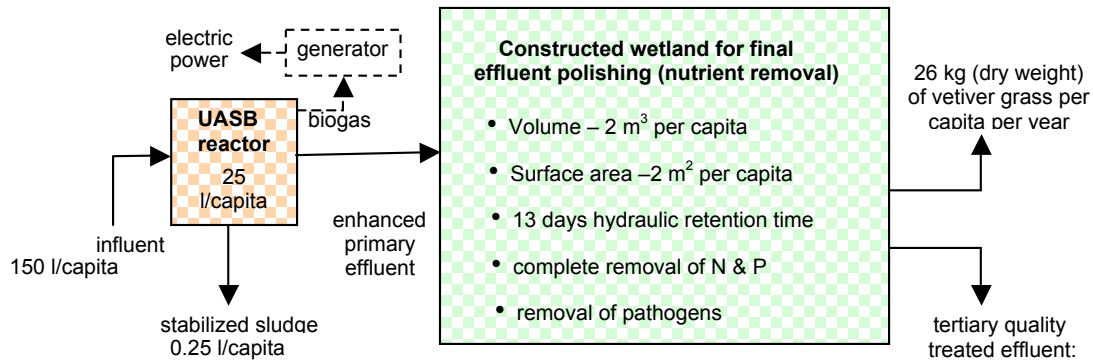
Where land is available at an affordable price and/or an advanced quality (tertiary) final effluent is desired because of the sensitivity of the receiving waters, anaerobic initial treatment may be sequenced with a constructed wetland to polish the effluent. A constructed wetland mimics a natural marsh, which is characterized by grasses, other emergent macrophytes and/or floating aquatic plants that together function as a “biological filter”. Quiescent hydraulic conditions foster sedimentation of residual suspended solids, bacterial action degrades oxygen consuming substances, while plant growth assimilates the mineralized nutrients ammonium ( $\text{NH}_4^{2+}$ ) and orthophosphate ( $\text{PO}_5^{4-}$ ) that are of concern in wastewater treatment.

Polishing of anaerobic effluents in wetlands takes advantage of treatment processes that are entirely passive, and only simple farm implements are needed to harvest the plant biomass that constitutes the sink. Constructed wetlands are simple to build, and may be operated by personnel with farming skills.<sup>1</sup> Like anaerobic reactors, the budget for operating constructed wetlands is consists primarily of labor costs.

Vetiver grass (*Vetiveria zizaniodes*) is a fast-growing, natural hydrophyte that is at home in a marsh environment. Vetiver grass grows rapidly in constructed wetlands and is an effective biological filter to polish pre-treated municipal wastewater effluents. The resulting high quality final effluent may be reused when less than potable quality water is acceptable, for example, for many industrial applications, flushing of toilets and horticulture irrigation. Reuse of treated effluent effectively prevents residual pollutants from reaching receiving water bodies, while conserving a significant fraction of the primary

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water resource for higher value uses. Figure 2 illustrates the input-output relationships of a constructed wetland based on vetiver production. For purposes of illustration the example assumes initial concentrations of N and P in the effluent are 45 and 4 mg/l respectively.



**Figure 2. Anaerobic/aerobic treatment plant and final effluent polishing in a constructed wetland**

Figure 3 shows vetiver grass that was grown hydroponically on a wastewater effluent in tropical Australia in an experiment to assess nutrient removal ability. The most common method of treating industrial wastewater in Queensland is by land irrigation of tropical and subtropical pasture plants. A series of research projects conducted at a gelatin factory and at an abattoir determined that vetiver grass was superior to pasture grasses used for wastewater disposal.<sup>3</sup> Vetiver grass has the potential to produce up to 132 tonnes per hectare per year (t/ha/year) of dry matter compared to 23 and 20 t/ha/year for Kikuyu and Rhodes grass respectively. This production level of vetiver can export up to 1,920 kg/ha/year of N (nitrogen) and 198 kg/ha/year of P (phosphorus), compared to 687 of N and 77 kg/ha/year of P for Kikuyu and 399 of N and 26 of P for Rhodes grass respectively. Vetiver growth can respond positively to a supply of N up to 6,000 kg/ha/year, and, to ensure this extraordinary growth and uptake of N, the P supply level should be at 250 kg/ha/year.<sup>2</sup>



**Figure 3.**  
 Root length of 780 mm after three months growth on effluent.  
 (Dr. Paul Truong)

Vetiver grass grown on wastewater effluent is soft and palatable forage for animals with high nutritional value. Such fodder has up to two percent N, which is equivalent to 12.5 percent crude protein, more than some tropical legumes.<sup>3</sup>

**Endnotes**

<sup>1</sup> Journey, W. K. and S. McNiven. 1996. "Anaerobic Enhanced Primary Treatment of Wastewater and Options for Post-Treatment". USAID Global Environment Bureau. Washington, DC.

<sup>3</sup> Truong, P., and R. Ash. (in draft). "The Use of Vetiver Grass Wetland for Sewerage Treatment in Australia". To be presented in Oct. 2003 at the Third International Conference on Vetiver in China.

<sup>4</sup> Dr. Paul Truong. 2002. Personal communication.