Sarnia • Lambton Environmental Association
Industries Working Together

Wetland Treatment of Wastewater

This monograph, one in a series of single issue documents that deal with our local environment, has been prepared by the Sarnia-Lambton Environmental Association in co-operation with the School Boards of Lambton Kent

Introduction

Wetlands may be defined as lands where the water is near the ground surface long enough each year to maintain saturated soil conditions. These areas are often called by such names as marshes, swamps, bogs, fens, wet meadows, sloughs and river-overflow lands. Vegetation that is characteristic of wetland systems includes cattails, rushes, water lilies and willows.

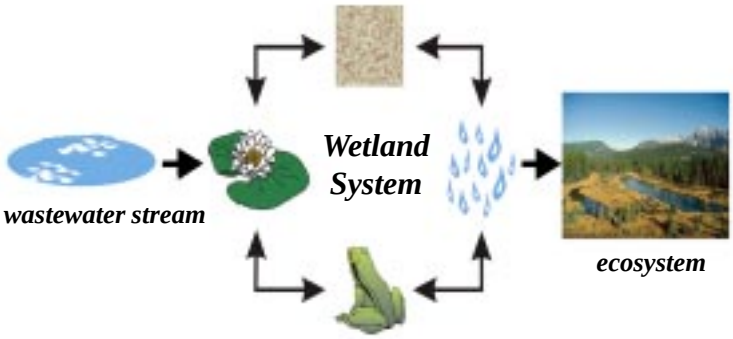
The productivity of many wetlands far exceeds that of the most fertile farm fields (which in many cases are former wetlands). Wetlands receive, hold and recycle nutrients continually washed from upland regions. These nutrients support an abundance of macro- and microscopic vegetation, which converts inorganic chemicals into the organic materials required - directly or indirectly - as food for animals, including man.

Hammer, page 10

Wetlands have received wastewater discharges from many different situations in the past, but only recently have they been recognized as potentially cost-efficient treatment systems. **They can effectively remove or convert large quantities of pollutants from point sources (municipal and industrial wastewaters) and non-point sources (mine, agricultural and urban runoff).**

Facts

A Wetland Scene at Lorne C. Henderson Conservation Area near Petrolia



The wetland system consists of plants, wildlife, substrate (soil), hydraulics (moving water) and a number of physical, chemical and biological processes. Contaminants in the wastewater are stored, degraded or transformed in the wetland.

Key Words

aerobic bacteria - require oxygen; *anaerobic bacteria* function in the absence of oxygen

hydrophilic - (water-loving) plants have adaptations that allow them to survive and thrive in water-saturated soils; decreased oxygen supply in these soils is the primary factor which limits the kinds of vegetation that will grow in wetlands

microbes - bacteria, protozoa, fungi, viruses, algae

surface flow wetland - wetland water is exposed to the atmosphere

subsurface flow wetland - plants are supported in sand/gravel; water levels are maintained below the surface of the soil; since the wastewater is not exposed to the air, odour and insect problems are controlled.

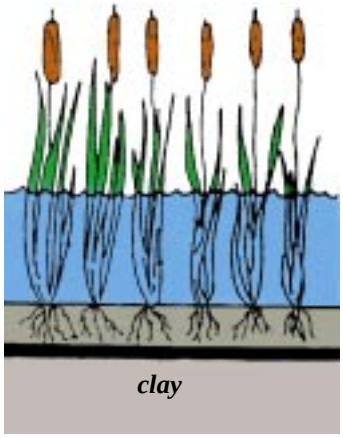
Treatment Wetlands

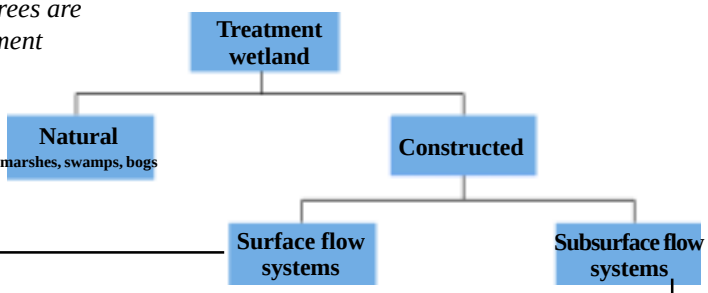
Wetlands are widely regarded as biological filters, providing protection for water resources such as streams, lakes, estuaries and groundwater. Although naturally occurring wetlands have always occurred as ecological buffers, research and development of wetland treatment technology is a relatively recent phenomenon. The goal of water and wastewater treatment is the removal of aqueous contaminants in order to decrease the possibility of detrimental impacts on humans and the rest of the ecosystem. *Kent, page 242*

Surface Flow System

A shallow layer of surface water flows over soils in which marsh plants, eg (cattails, bulrushes) grow. Submerged and aquatic vegetation, shrubs and trees are components of the treatment process.

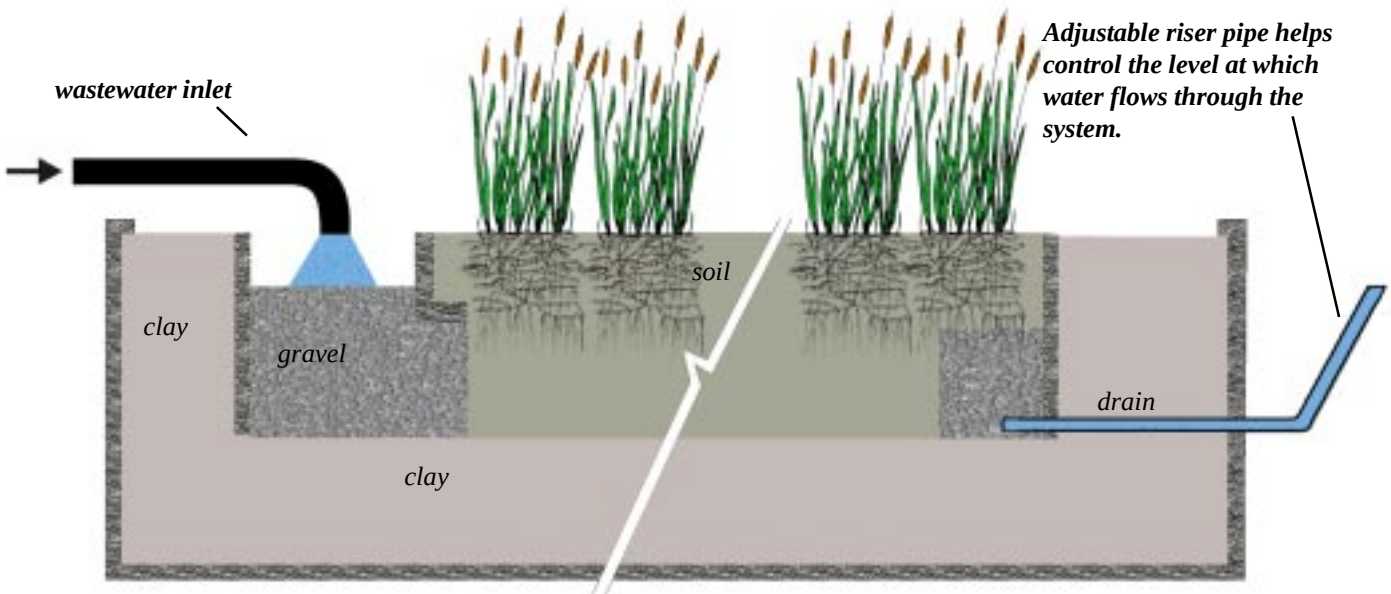
Constructed wetlands range from marshes in natural settings to those that involve extensive construction where much earth is moved and impermeable barriers are installed.





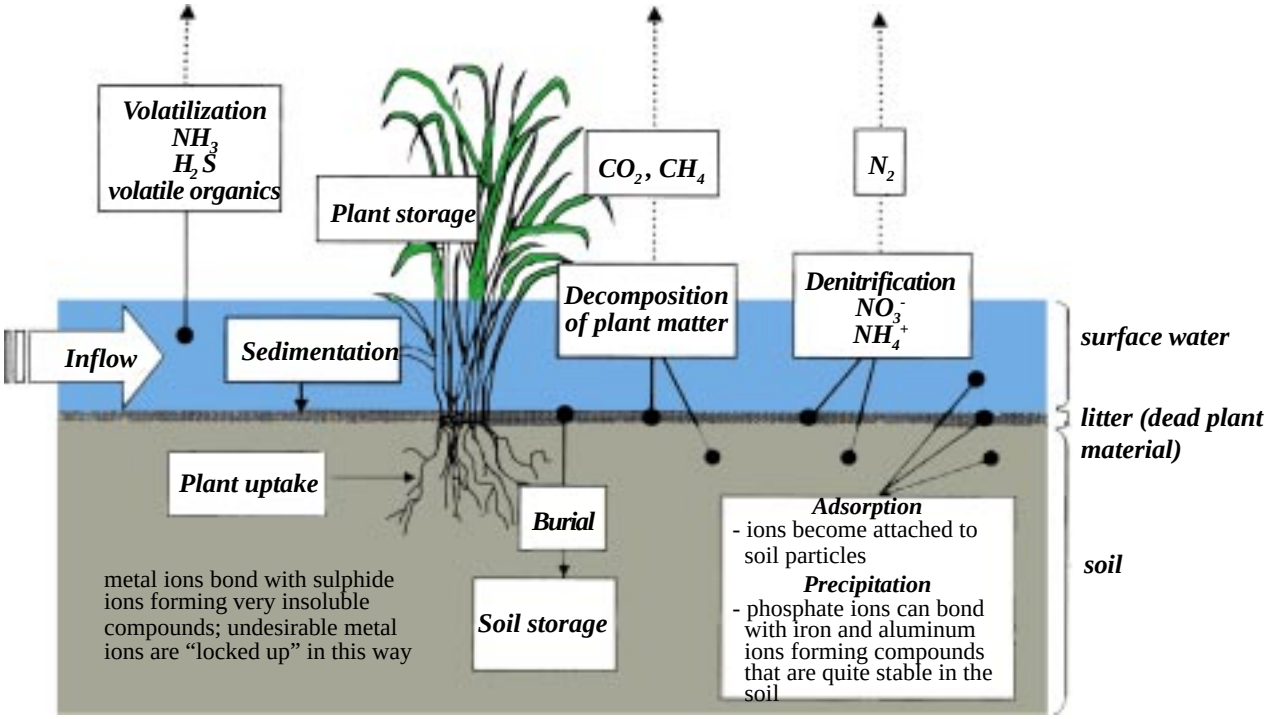
Subsurface Flow System

The absence of an open water surface decreases the possibilities of generating disagreeable odours; the propagation of insects is also controlled.



Microbes that treat the wastewater live on the gravel, soil and plant surfaces; the plants provide oxygen and food for the microbes. The removal of pollutants in wetlands is done mainly by microbes.

Contaminant Removal Mechanisms in Surface Flow Wetlands



adapted from Kent, page 245

Volatilization - *the diffusion of dissolved compounds from wetlands into the atmosphere*. Ammonia is volatilized from basic waters (pH > 8.5) - this action lowers the pH of the water. H_2S, a sulphur-containing gas is volatilized when anaerobic bacteria decompose matter.

Adsorption - *the attachment of ions (charged atoms, molecules) to soil particles*. Weak electrostatic forces bond ions to soil particles.

Precipitation - *the production of a solid within a liquid*. A number of metals and organic compounds can be immobilized in soils by reacting to form salts that do not readily dissolve.

Sedimentation - *the settling action of a solid that is distributed throughout a liquid*. Slow moving water permits suspended solids to settle and become part of the wetland soil.

Decomposition - *the break-down of molecules into simpler molecules or atoms.* Microbes decompose plant matter (organic carbon); decomposition provides life-sustaining energy for microbes. Organic carbon is converted to carbon dioxide (CO_2) and methane (CH_4). Microbes remove a wide variety of organic carbon compounds including those found in municipal wastewater, food processing wastewater, pesticides, and petroleum products.

Denitrification - *the transformation of nitrate ions into nitrogen gas (N_2).* Microbes remove inorganic nitrogen that is contained in nitrate ions (NO_3^-) and in ammonium ions (NH_4^+) from wetland soils. Microbes transform ammonium ions to nitrate ions (nitrification); the nitrate ions then undergo denitrification.

adapted from Kent, page 245

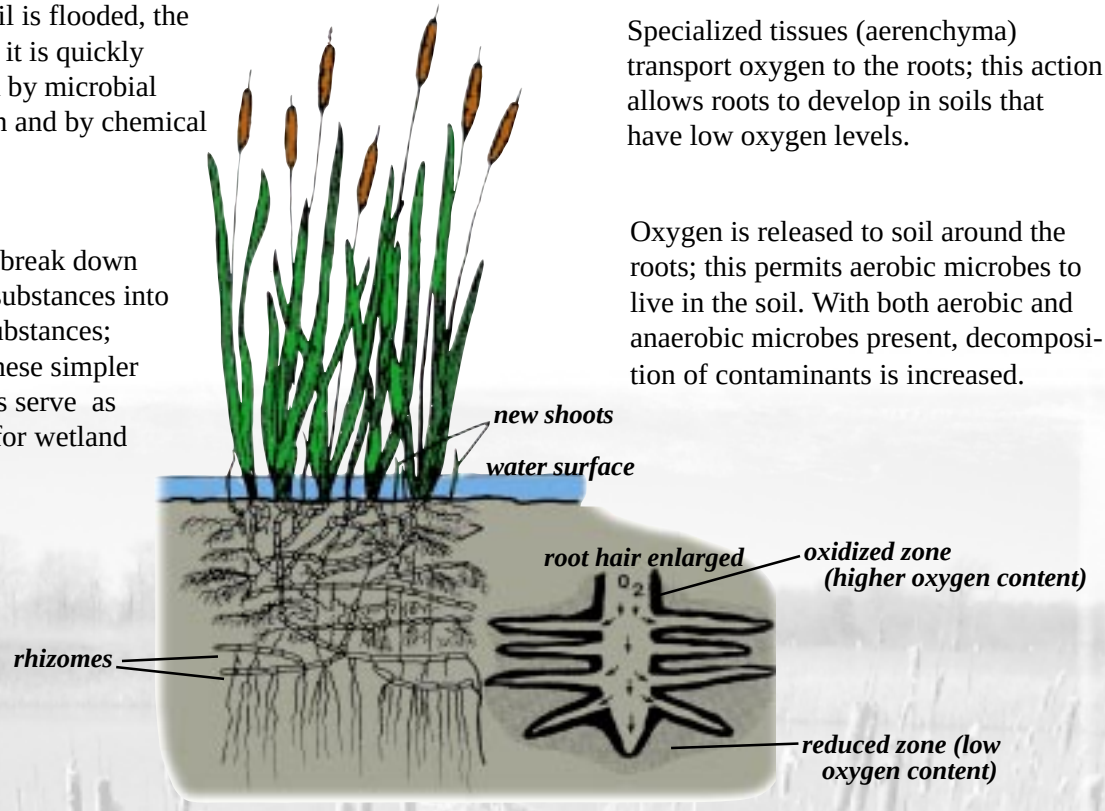
Hydrophilic (Water-Loving) Plants

Wetland soils are covered with water much of the time; many plants are unable to survive in such an environment. Plants (their roots included) cannot live without oxygen. **As soils become saturated with water, air is displaced from the spaces between soil particles; when oxygen is removed in this fashion, the roots of many plants die.** Hydrophilic plants are designed to survive and thrive in water-saturated soils. Hydrophilic plants include cattails, reeds, rushes, willows.

Wetland Plants Have a Unique Ability to Transport Oxygen to Support Their Roots

Once a soil is flooded, the oxygen in it is quickly consumed by microbial respiration and by chemical oxidation.

Microbes break down complex substances into simpler substances; some of these simpler substances serve as nutrients for wetland plants.



Specialized tissues (aerenchyma) transport oxygen to the roots; this action allows roots to develop in soils that have low oxygen levels.

Oxygen is released to soil around the roots; this permits aerobic microbes to live in the soil. With both aerobic and anaerobic microbes present, decomposition of contaminants is increased.

Large populations of microbes around the root hairs bring about desirable modifications of metallic ions, nutrients and other compounds.

Plant surfaces (stems, leaves, roots) provide huge areas on which populations of microbes become attached.

Microbes - bacteria, fungi, algae, and protozoa alter substances (contaminants included); as a result the microbes obtain nutrients or energy to carry out their life processes. The effectiveness of wetlands that are designed for wastewater treatment is dependent on developing and maintaining environments that are supportive of large populations of microbes.

adapted from Hammer, pages 13 - 16

Other Functions and Values of Wetlands

• **Wildlife Habitat -** home of many species; the productivity of many wetlands far exceeds that of most fertile farm fields, which in many cases are former wetlands.

• **Flood Flow Alteration -** potential for reducing and delaying downstream peak flows; slowing the flow of floodwater is another beneficial function.

•**Groundwater Recharge -** if underlying materials are porous, wetlands act as groundwater recharging areas. Wetlands may also serve as discharge areas for surfacing groundwater; this helps to sustain base water flows in streams during dry seasons.

• **Recreation -** Sport and commercial hunters have been among the first to note the relationship between wetland destruction and declining populations of valuable species that are dependent upon certain types of wetland habitats.

• **Soil Stabilization -** Roots of wetland vegetation bind the underlying soils; upper parts of plants decrease the rate at which water flows through the wetland.

adapted from Kent, page 66

Wetland Experimentation at the University of Waterloo

Researchers are trying to better understand the factors that contribute to wetlands as treatment systems; a better understanding of these factors will permit improvements to wetland design, construction and operation. A long-range objective of the University's study is to gather sufficient information that will allow the behaviour of a system to be predicted over given periods of time.

The two wetland systems pictured are subsurface flow types, ie. water levels are maintained below the surface of the soil. Each of these two systems contains a vertical subsurface flow unit as well as one that is horizontal, one system contains plants, the other is unplanted. The purpose of this difference, is to determine the extent to which plants assist in removing contaminants.

Note, in each system, microorganisms actively break down contaminants. **A wastewater stream (containing contaminants) is directed into each of the vertical subsurface units**, the water flows through the horizontal unit to an exit.

Analysis of water as it exits indicates how each system affects contaminants which were present in the original wastewater stream. In this picture, a syphon is being used to obtain a water sample from one of dozens of sampling points that are distributed at various locations - e.g. at the corners, along the edges, at different depths throughout each system. Samples are collected at two week intervals; analysis of these include - determination of oxygen content, of nitrogen and pH. Data obtained from these studies indicate how each wetland will perform over time and to what extent it will affect contaminated water.

Resources

Hammer Donald A., 1989, CRC Press, Constructed Wetlands for Wastewater Treatment

Kent Donald M., 2001, CRC Press, Applied Wetlands Science and Technology

Canada, Ontario, Michigan DNR, 1995, St. Clair Remedial Action Plan, (RAP II)

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** references available in our resource centre*

** additional copies of this monograph are available from the Sarnia-Lambton Environmental Association or on-line at http:\\www.sarniaenvironment.com*

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