Living Machine® for Wastewater Treatment at the Marine and Environmental Research and Training Station (MERTS)

Clatsop Community College
Astoria, Oregon, USA

Overall Process Description

Overview

Living Machine® for wastewater treatment is a series of components through which the wastewater flows. The components included in this Living Machine are biological treatment reactors, a clarifier, a subsurface flow wetland and ultraviolet disinfection. Each component is designed for a specific treatment purpose. The later biological treatment reactors of the Living Machine® are ecologically diverse in order to enhance the treatment process, reduce sludge production and provide an aesthetic environment. This ecological diversity includes vegetation supported on the surface of the wastewater, aquatic insects, snails, aquatic worms and other flora and fauna. For this ecology to thrive, it requires light, and minimum temperatures above 45ºF. Therefore, in cold-winter climates, Living Machine systems are constructed in a greenhouse.

Living Machine at MERTS campus, Clatsop Community College, Astoria, Oregon

Influent and effluent from the Living Machine

Wastewater enters the Living Machine from three MERTS campus buildings. Full of organic matter and ammonia, high in BOD and solids, the water enters the treatment process.

Once complete, the water is clear, greatly reduced in BOD, cleared of ammonia, reduced in nitrates, and after disinfection with ultraviolet light, ready for reuse.

System Components

The purpose and main features of each component of the Living Machine system for MERTS are described in the following subsections. The Living Machine at MERTS is designed to handle a maximum flow rate of 2400 gpd. In addition, the MERTS Living Machine is designed to be part of an educational site for students studying ecology, wastewater, and environmental microbiology. For this reason, there are two parallel trains to allow students to conduct experiments within the facility.

Inside the Living Machine

Anaerobic Reactor

The raw wastewater from the current three facilities on the MERTS campus flows to two septic tanks. No aeration is provided in these reactors in order to create anaerobic conditions and to allow separation of solids from dissolved/suspended waste components. The primary purpose of the anaerobic reactor is to remove settleable solids and oil and grease. Also, a significant portion of the incoming organic material (BOD) is removed without using aeration. The quiescent (at rest) conditions in the anaerobic reactor allow solids in the influent wastewater to settle. These settled solids are stored for later removal. Oil and grease in the influent are retained in the anaerobic reactor, preventing them from being a nuisance in the downstream processes. Organic solids and oil and grease retained in the anaerobic reactor will partially degrade before removal, thereby reducing pumping and disposal requirements. The products of the anaerobic breakdown of organic wastes are also beneficial in the next step of the process, the Anoxic Reactor.

Anoxic Reactor

The anoxic reactor follows the anaerobic reactor; the environment is between anaerobic and fully aerobic in terms of the oxygen content in the wastewater. This condition is termed anoxic because there is no free oxygen (O_2) in the wastewater. Oxygen is present in the bound form of nitrate. The anoxic state is maintained by a short residence times that also prevents formation of anaerobic waste products. The purpose of this reactor is to "select" for the growth of floc-forming microorganisms, to convert nitrate to nitrogen gas (denitrification) and to remove some incoming BOD.

The anoxic reactor has attached growth media, on which some microorganisms responsible for denitrification grow and remain in the reactor. The nitrified wastewater from the final open aerobic reactor is recycled to the anoxic reactor for denitrification. Some of the biosolids settled from the clarifier are also recycled to maintain required microbial population for waste treatment.

The anoxic reactor is covered to help maintain anoxic conditions and to prevent the release of odorous gases into the greenhouse. Because the wastewater is not anaerobic, methane and hydrogen sulfide are not formed but some nuisance odor compounds may be. The gas space under the cover is connected to the gas space under the covered aerobic reactor allowing it to be vented through activated carbon "filters" venting the covered aerobic reactor.

Covered Aerobic Reactor

The covered aerobic reactor follows the anoxic reactor and is the first step in the fully aerobic portion of the Living Machine process. The purpose of this reactor is to remove a large fraction of the BOD in the effluent from the anoxic reactor and to strip odorous gases from the wastewater. Some conversion of organic and ammonia nitrogen to nitrate (nitrification) occurs in this reactor. This reactor will have attached growth media, to enhance the treatment performance of the reactor. The covered aerobic reactor will be aerated with fine bubbles diffusers to provide the required oxygen for treatment and to keep the contents mixed.

Venting of the gases from the covered aerobic reactor are passed through activated carbon "filters".

Flowers abound in the hydroponic tanks

Hydroponic reactors

The hydroponic reactors follow the covered aerobic reactor. The Living Machine for MERTS has three hydroponic reactors in series. These reactors reduce the BOD to very low levels and complete the nitrification process. The hydroponic reactors are aerated with fine bubble diffusers that provide the oxygen required for treatment and keep the tank contents mixed.

The surfaces of the wastewater in the hydroponic reactors are covered with vegetation supported on racks. The roots of the vegetation provide surfaces for the growth of attached microbial populations that assist in the wastewater treatment. The vegetation serves as habitat for beneficial insects and organisms that graze on microbial biomass. The grazing reduces the sludge volume generated and maintains the microbes at optimal growth rates. Also, the vegetation and racks reduce the surface turbulence in the reactor that dramatically reduces the formation of aerosols and volatilization of odorous compounds.

The vegetation used to cover the hydroponic reactors generally includes tropical, subtropical, and temperate species that Living Machines, Inc., has found to be effective in the treatment environment.

Clarifier

The clarifier follows the hydroponic reactors. The purpose of the clarifier is to separate the microbial solids from the treated wastewater stream using gravity separation. Some of the settled microbial solids are returned to the anoxic reactor to provide active microbial populations for the treatment process. The biosolids that are not recycled are wasted, and pumped to the biosolids holding tank for future disposal. The tank is covered with duckweed to prevent the growth of algae.

Constructed Wetlands

Effluent flows from the clarifier to the constructed wetland that acts as the final biological treatment unit before disinfection and re-use. Dissolved organic pollutants and suspended solids remaining in the clarifier effluent are further reduced in the wetland. Also, some additional denitrification takes place in the wetland.

The treatment zone of the marsh is planted with a variety of wetland species. The root and stone surface areas provide ideal sites for microbial treatment organisms. These organisms remove surface areas provide ideal sites for microbial treatment organisms. These organisms remove organic material and suspended solids from the clarifier effluent. Throughout the constructed marsh, anaerobic micro-sites also develop. These environments, coupled with the carbon produced by the wetland vegetation, allow additional denitrification to occur.

constructed wetlands are full of vegetation – lots of beautiful flowers all year round!

Ultraviolet disinfection

The final step in the Living Machine treatment process. This process uses ultraviolet light to inactivate pathogens remaining in the effluent wetland. Ultraviolet disinfection provides excellent pathogen inactivation without the use of toxic compounds and does not produce undesirable byproduct compounds in the treatment effluent.