Overview

Constructed wetlands designed for treating wastewater can be cost-effective for removal of suspended solids (SS), biological oxygen demand (BOD_5), fecal coliform bacteria, and heavy metals. However, in organically enriched wastewater, oxidative treatment processes, such as nitrification, are often rate-limited due to chronically low dissolved oxygen (DO) concentrations.

TVA has developed and patented (U.S. Patent No. 5,863,433) a novel subsurface-flow constructed wetland system—ReCip—in which vastly improved wastewater treatment is possible.

ReCip improvements are brought about by coupling anaerobic and aerobic environments within and between wetland cells via reciprocation—adjacent wetland cells are alternately drained and

filled on a defined and recurrent basis. This sequential fill-and-drain technique provides control of microbially mediated processes, such as nitrification and denitrification. A continuum of redox-specific reactions can be controlled via the ReCip system design and operation. Factors influencing efficacy include the backfill substrate size and composition and the frequency, depth, and duration of reciprocation.

Conventional Wetlands Systems

In both temperate and tropical regions of the world, constructed wetlands are being designed, installed, and evaluated as sustainable natural systems for treating municipal, industrial, and agricultural wastewaters. Popularity of constructed wetlands is based on treatment versatility, aesthetics, and relatively low capital and operating costs. They are viewed as having considerable potential, especially in rural areas where it is not economical or practical to construct and operate highly engineered wastewater treatment systems.

Despite their popularity, many constructed wetland treatment systems are failing with respect to their ability to remove ammonia (NH_4), certain heavy metals, and recalcitrant organic compounds. Microbial treatment processes, requiring moderate DO concentrations, are often rate-limited due to high microbial community respiration rates and the resulting chronically low-DO concentrations. Furthermore, in many situations, degradation of aqueous contaminants requires sequential treatments in aerobic and anaerobic environments.

Conventional wastewater treatment wetlands are of two types: (1) free-water, surface-flow in which water remains on the surface and is exposed to the atmosphere and (2) subsurface-flow in which water is maintained below the surface of a 30–150-cm-deep porous substrate, such as gravel. TVA's new patented ReCip system is a subsurface-flow wetland.

In wetland environments, DO is derived from both biological and physical processes. DO may be photosynthetically derived from submerged aquatic plants, attached algae, and phytoplankton.

Emergent aquatic plants are also able to transport atmospheric oxygen to the root zone.

Air-to-water diffusion is another source of DO, providing limited transport of atmospheric oxygen at the air-water interface. In most instances, these combined sources of oxygen in conventional constructed wetlands are not sufficient to meet the aerobic respiratory demands of organically enriched wetlands, and as a result, ammonia and other reduced compounds tend to accumulate to potentially toxic levels.

TVA's Patented ReCip Wetlands

However, the problems mentioned above, which are associated with conventional constructed wetlands, are eliminated using ReCip. By operating two adjoining

subsurface-flow wetlands in tandem, it is possible to utilize the concept of reciprocation, whereby adjacent cells are alternately drained and filled on a recurrent basis. Anaerobic water drained from one cell is stored in the contiguous cell, and vise-versa. During the drain cycle, thin water films surrounding the dewatered substrate and attached biofilms are rapidly oxygenated to saturation values.

ReCip also provides cyclical and uniform distribution of nutrient-laden water to the substrate biofilms during the fill and drain cycles. Even during prolonged drain cycles, the substrate remains moist, and gas exchange at the air-biofilm layer promotes rapid oxidation of organic matter, ammonia, and other reduced compounds. During the fill cycle, anoxic and/or anaerobic water fills the void spaces between the substrate, and the biofilms are bathed in oxygen-deficient water. Under these conditions, denitrification, sulfate reduction, and methanogenesis occur. Sulfate reduction provides excellent metals removal, generation of additional alkalinity, and buffering of pH.

The ReCip combination of sequential aerobic-anaerobic environments can provide excellent treatment with respect to nitrification-denitrification, heavy metals removal, biological phosphorus removal, and remediation of toxic compounds requiring oxidation and subsequent reduction.

Costs

TVA's ReCip wetlands system for treating domestic, industrial, or animal wastes will cost significantly less to build and maintain than other conventional technology systems. Please call the number below, and let us show you how ReCip can reduce your treatment costs.

For more information, contact:

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