Solar Aquatics: sewage treatment in a greenhouse (1073 words)

by Doug Linzey (2 December 1996)

According to the map, we had arrived at Beaverbank Villa, close to the height of land north of Halifax that separates the Atlantic and Fundy watersheds. The view is panoramic from up here, some of Metro's higher buildings visible some 40 km away. The site where we stand was a US radar base built in the 1950s. Now a private community owned by the Stevens Group, the Scotia Nursing Homes complex comprises a nursing home, an adult residential centre for mentally challenged, mentally disabled and elderly people, and a number of residential rental units. More than 600 people live and work in this relatively isolated community.

Eleven of us are here to unearth the mysteries of a large greenhouse that dominates the southern slope immediately below the complex. Our tour guide is Albert Andrews. Albert's company, Applied Environmental Systems of Halifax, built the greenhouse and the Solar Aquatics system, or "living machine," that resides within.

The Living Machine is an engineered ecosystem of plants, algae, snails, micro-organisms and fish that uses sewage as a nutrient source. It duplicates, under controlled conditions, the natural water purification of streams and wetlands. It's housed indoors in a greenhouse to control the process and allow it to operate year-round. This one facility of some 7,000 square feet provides tertiary treatment to all of Beaverbank Villa's domestic wastewater. That means that what comes out the other end meets US EPA drinking water standards.

We started our tour at the front end, where 30-40,000 gallons per day of raw sewage exit the town's collection pipes into an underground tank. A simple bar screen deflects inorganic solids from the stream. At this point the sewage is agitated to break up organic solids, fine air bubbles are introduced, and bacteria are added to begin the biological breakdown. A pump lifts the sewage to a raised distribution box in the greenhouse.

In this greenhouse, green is the operative word. On entering the head end, we encounter 28 cylindrical tanks, or "solar silos," each one overflowing with plants, mostly water hyacinth and willow at the head end, mint and creeping primrose farther into the process. Six feet tall and about the same in diameter, the silos are transparent, made of heavy clear plastic film supported by wire mesh. Twenty percent of the total sewage flow moves through these tanks in four parallel lines. The other 80 percent goes directly to the solar pond, a large, four-foot-deep open concrete tank located beyond the solar silos.

The sewage decants by gravity from the surface of one silo into the bottom of the next, through a pipe. A lot goes on inside these biological reactors. We see masses of intertwining roots, algae, snails, and bubbles. The roots act as attachment points for what we can't see -- millions of bacteria and zooplankton that lunch on the nutrients of the sewage stream. That's the main purpose of the plants -- to establish as much surface area for bacterial contact as possible. The other element needed to break down the sewage at this point is oxygen. Hence the bubbles; the silos and pond are aerated to promote thorough mixing and to supply sufficient oxygen to the bacteria. The silos act as incubators for bacteria, so that by the time the streams enter the solar pond, huge quantities of bacteria are ready to go to work on the fresh sewage.

As in any ecosystem, biodiversity is key. With sufficient diversity of bacteria, flora and aquatic fauna, this controlled ecosystem is more stable and can treat a wider range of contaminants than either a purely natural system or a standard engineered biological treatment plant. It's fast, too, attaining tertiary treatment standards within two or three days' retention.

In the pond, we see more species of plants, many of them non-aquatic, exotics and natives alike perching on floating rafts or hanging from ropes, their roots in the water. Trees, shrubs, houseplants -- they're all welcome here. By this time next year, there may be some fish, too. A series of baffles forces the water to flow as it would in a stream.

By permit, final effluent must meet stringent standards for bod (biological oxygen demand), tss (total suspended solids), and other such pollutants as fecal coliform and ammonia. Effluent from the pond can still contain significant amounts of compounds of sulphur, phosphorus and nitrogen susceptible to breakdown by anaerobic bacteria. After settling and filtering out most of the few remaining solids, the water enters a six-foot-deep marsh made of gravel (on which we walk) and plants such as rushes, sedges, grasses, iris, and lily. Again, the plant roots provide attachment points for bacteria. The leaves and flowers take up phosphorus and nitrogen. Waste products such as hydrogen sulphide and nitrogen gas are released harmlessly to the atmosphere.

In a final treatment stage, the effluent passes through an ultraviolet purifier, which ensures that any surviving pathogens are destroyed before the water is released to a watercourse just outside the greenhouse.

The Solar Aquatics process does not produce much sludge -- most of the organic solids wind up as food for plants and creatures. Sludge goes into a combination outdoor marsh and composting facility just outside the greenhouse, along with copious amounts of harvested foliage during the summer. Typically, compost from a Solar Aquatics facility would be used for fertilizing non-edible crops.

This part of Nova Scotia is cold in winter, and some oil will be burned to keep the inside temperature above 10 degrees C. The process also needs electricity to operate pumps, aerators, some lighting, and miscellaneous equipment. On the whole, though, this facility is pretty easy on resources. It has few moving parts to break down, and despite its complexity, pretty well runs itself.

This would not be an unpleasant place to work, although opportunities for employment are slim. One half-time person can do the job. During summer, the main work is trimming excess growth from the plants. Regular daily tests (for tss, bod, fecal coliform, etc.) take little time. It doesn't smell bad, and it would be a joy for many of us to be around all that plant life every day.

In fact, this kind of sewage treatment plant should be a welcome addition to any community's back yard. We were impressed, coming away from this visit with a newfound respect for the power of life to address one of our most pressing problems in a humane and elegant way.

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Notes

Using greenhouses to enhance the

growth of bacteria, algae, plants and aquatic animals, wastewater flows through a

series of clear-sided tanks, engineering streams, and constructed marshes where

contaminants are metabolized or bound up.

Wastewater flows through an initial "blending tank", into a set of "solar silos", on to a

"solar pond", a "marsh", various filters, and a special unit for ultraviolet disinfection.

.At the end of the greenhouse is an ecologically engineered marsh where the final part

of the process takes place.

The system is based on using natural ecosystems to remove contaminants and

nutrients from the water.No chemicals are used in the process. This visually

attractive, odour free facility is located in the heart of the village, along the shore of

the river.

The Solar Aquatics process combines ecological engineering principles with standard

wastewater treatment concepts. By combining the biological components that work in

natural water purification processes with proven wastewater treatment practices, the

Solar Aquatics process provides an enhancement on natural and conventional

treatment processes.

The Solar Aquatics process uses fixed film substrate in the forms of plant roots and

Solar Tank surfaces. The process also uses suspended growth biomass within the

wastewater moving through the system. The process further combines an element of

activated sludge by recycling a portion of secondary sludge to the headworks

Blending Tank for reseeding bacteria.

The Solar Aquatics System is made up of three main processing sections:

 Headworks for blending and flow equalizations.

 Greenhouse System for biological processing and removal of contaminants.

 Solids Processing for stabilization and composting of sludge and vegetative

 waste.

The system utilizes a diverse combination of biological components to speed the

removal of organic material and nutrients by bacterial degradation. Algae, bacteria,

other micro-organisms, higher plants, snails, and other aquatic animals make up the

ecosystem food chain involved in the natural purification of wastewater.

The apparatus used within the Greenhouse System that provides the habitat for these

living machines includes:

 Solar Tanks. Translucent cylindrical tanks which optimize photosynthetic

 reactions and biological activity within the system.

 Solar Ponds. Artificially constructed ponds partitioned to provide slow moving

 streams to replicate a natural environment.

 Wetland or Marsh. Artificially constructed wetland where final polishing and

 purification are accomplished. In some applications, outdoor wetlands may also

 be used.

The treatment process occurs in stages, with detention time varying depending upon

the strength of the wastewater and the degree of purification required. Tertiary

quality treatment typically requires up to 4 days.

1. Blending, Breakdown of FOG's and Initiation of Biological Treatment Process.

Raw wastewater from the collection system enters the Blending Tank and is mixed by

fine bubble aeration. The naturally occuring bacteria, in the presence of air, begin to

break down soluble organic chemicals into carbon dioxide and water. The process

also degrades fats, proteins and starches into compounds that can be metabolized by

organisms down stream. The system does not use a primary clarification step for

wastewater, but keeps solids in suspension to make them available to be broken

down biologically.

2. Nitrification, first stage nitrogen and phosphorous removal, reduction of

suspended solids and BOD. From the Blending Tank water flows to the Greenhouse.

Higher plants on the surface of the Solar Tanks and Solar Ponds, with their root

masses reaching down into the water column, take nitrogen and phosphorous from

the waste stream to promote leaf and flower production. The extensive surface area

of the root systems filters solids from the wastewater and provides extensive

microsites for microbial attachment. Very large populations of micro-zooplankton

also inhabit the root mass. Bacteria, algae and higher plants metabolize components

of the waste stream. Organic nitrogen is mineralized into ammonia. Ammonia is

oxidized into nitrates. BOD is degraded. Nitrates, ammonia, and soluble

orthophosphates are taken up directly by green algae and higher plants. Snails,

zooplankton and other animals feed on solids.

3. Sludge Removal and Processing. Following treatment in the Solar Tanks and Solar

Ponds, residual biomass and recalcitrant solids are removed from the process stream

by clarification. A small amount of this "secondary sludge" is recycled into the

Blending Tank for microbial reseeding, with the balance to an aerobic digester for

thickening and further processing.

4. Denitrification, second stage nitrogen and phosphorous removal, and pathogen

reduction. The clarified process water passes through the stone substrata of the

marsh. Nitrate is reduced to nitrogen gas, and certain pathogenic bacteria are

destroyed by action of the marsh plants, which include bulrush, scirpus, cattail, iris

and other reeds. Phosphorous is taken up by marsh plants and absorbed on the

marsh substrate. The marsh provides the final stage of biological treatment.

 "Because the systems do not have the negative image of conventional systems, the

 projects can be located within communities close to the

 source of the waste-water," says Albert Andrews, president of Applied Environmental.

A conventional sewage lagoon system upgrade had been priced at almost a

half-million dollars.

The technology involves construction of a greenhouse with a number of

clear-sided tanks and artificial ponds inside. The sewage enters the system by gravity flow through

existing sewers , The

cost-effective process is visually attractive, self-contained and odour-free.

Scotia Nursing Homes sought and received assistance from the Canada-Nova Scotia

COOPERATION Agreement on Sustainable Economic Development (SEDA) to help fund the

construction of a 13 by 50 metre (42 x 165 ft.) Solar Aquatics demonstration facility.

The Solar Aquatics System, known as the "Greenhouse That Grows Clean Water", should provide

the equivalent performance of secondary and tertiary systems without the use of chemicals and with

substantially less residual sludge (which can later be recycled into a fertilizer). Although other

traditional systems use biology to some extent, they do not represent a complete engineered

ecosystem and do not use larger organisms such as algae, fish and snails. Solar Aquatics is also less

susceptible to toxic shock due to its reliance on biodiversity. There would still be hundreds of

back-up organisms should a toxic substance kill one of the "friendly bugs" in the process.

The system should be no more difficult to operate than a conventional sewage treatment facility.

Since it is less mechanically complex, it should require less repair and the organisms are expected to

continue feeding during mechanical breakdowns or power outages. The manufacturer warranties its

system and even offers long-term technical and operational support.

Solar Aquatics is capable of treating sewage flows in quantities that would satisfy most Nova Scotia

communities. A system is now being installed in Bear River, a village of 200 homes and businesses

in the Annapolis Valley, that currently uses septic systems that have been failing for years and

causing contamination of well water. Conventional systems exceeded their price limitations and

were unacceptable to the community. The attractive facility will be built in the centre of the village

on land donated by the Board of Trade and local property owners. With its central location, the

community should save both capital and operating costs associated with pumping sewage to remote

locations.

BENEFITS:

The Beaverbank and Bear River projects are the first commercial applications of the Solar

Aquatics technology in Canada. This innovative process is a practical, sustainable and

socially-acceptable alternative to current sewage treatment practices. With the assistance of SEDA,

the long-term savings - both economic and environmental - will help promote technologies such as

Solar Aquatics when many conventional systems in Nova Scotia require replacement in the future.