

ONSITE WATER TREATMENT

The Journal for Decentralized Wastewater Treatment Solutions



Two Continents, One Solution

An Integrated Living Machine serves as an educational tool for the study of wastewater reuse system surcharges and operation requirements in Ghana and North Carolina.

By Carol Brzozowski

In the developing West African country of Ghana, a Charlottesville, VA, company, is donating a decentralized wetland-based wastewater treatment system in an effort to address challenges in the developing country where source water used to irrigate crops is extremely polluted.

If the mission in Ghana is successful, the company would commence operations in Africa, with funding for system installations coming from third-party sources, from multilateral agencies, or in the form of micro-credit, whereby farmers would finance the systems on their own. Worrell Water Technologies has an eye to expanding its Living Machine system to Africa through designing a simplified version of the system for use there, says Will Kirksey, M.S., P.E., vice president of engineering for the company.

Imitating Nature

The Living Machine is an ecological wastewater treatment system that imitates processes found in wetland environments. The technology augments natural and biochemical processes with mechanical and computer systems in treating wastewater while reducing energy consumption by an estimated 10% to 25% of an equivalent activated sludge system. The systems are frequently integrated into wastewater reuse systems that minimize energy use, wastewater surcharges, and operation requirements while eliminating sludge disposal costs and reducing labor costs.

“It offers a lot more efficiency in the wastewater treatment process using anaerobic and aerobic bacteria without having to force air into the process,” he says. “The tidal action within the pump naturally draws air into the wetland cells. Water goes out and air comes in, so we don’t have to force the air with blowers and pumps like a lot of activated sludge systems do.”

Because the system is smaller than other constructed wetland systems, it has a reduced footprint, Kirksey adds. Energy and maintenance costs are also reduced through its design, he says. An environmental benefit of the system is “it does not have significant quantities of greenhouse gas emissions,” Kirksey notes.

Additionally, the system serves another purpose in that treated effluent is being used to grow useful crops, such as bamboo for building material and flowers for commercial sale, thus creating opportunity for an income stream, Kirksey points out.

Two Configurations, One Result

The Living Machine system can be configured in two separate layouts: the Tidal Flow Wetland Living Machine and the Hybrid Wetland Living Machine. In the Tidal Flow Wetland Living Machine system, influent feeds into a buried primary tank made of concrete or plastic, which features equalization. Solids settle in the tank and filtered effluent flows on to the tidal wetland.

The tidal wetland is located in a greenhouse, a building, or outdoors. Four to six tidal wetland cells are connected in a series by integral pump stations in addition to a control system. Each cell has a watertight basin with a bottom drain system covered by engineered media fill and vegetation on top. Pumps in each basin fill and drain each wetland cell in an ongoing cycle, providing the needed oxygen for treatment without mechanical aeration. “Ponding” is eliminated because there are no free water surfaces, which also prevents the potential for mosquito breeding. Effluent may flow through an optional disinfection system located in a greenhouse, a mechanical room, or underground. The system may include additional disinfection through ultraviolet, ozone, or chlorination technologies.

The reuse system has a pressure tank for non-potable reuse, such as a water supply source for toilet flushing, landscape irrigation, and surface or subsurface disposal.

The wetland vegetation, especially the root zone, enhances treatment by promoting a complex and stable ecosystem. Depending on site requirements or preferences, the system can be operated with simple controls or through a computer-based system, and either control system can be tied into an alarm for critical conditions or augmented by remote monitoring and operation. The system is designed for nitrogen, advanced biochemical oxygen demand (BOD), and total suspended solids (TSS) removal. The design can be tailored to the amount of nitrogen removal required, and effluent total nitrogen can be as low as 10 milligrams per liter.

The second configuration—the Hybrid Wetland Living Machine—combines two complimentary wetland technologies: horizontal subsurface flow wetland cells coupled to tidal flow wetlands with a hydraulic control and pump structure and a control system.

The horizontal-flow effluent receives wastewater influent, providing initial treatment and flow equalization. Tidal cells recycle the water to “turbocharge” the horizontal wetland, enhancing nitrogen removal. The system can be utilized in its entirety, or the tidal flow component can be retrofitted to existing horizontal-flow wetlands or lagoon systems to improve overall treatment and nitrogen removal with layout and plant selection configured to meet site and aesthetic criteria, Worrell Water Technologies’ officials say.

The Hybrid Wetland Living Machine operates similarly to the Tidal Flow Wetland Living Machine, except it adds an additional treatment step between the primary tank and the tidal wetland. Located outdoors, a horizontal-flow wetland is aggregate filled with aquatic vegetation and initiates the BOD and TSS removal, as well as denitrification, with no visible surfacing water. The flow then goes to a tidal wetland.

Kirksey points out that government entities are often cautious in embracing new technology without assurances of its long-term effectiveness. He says Worrell Water Technologies is addressing that through extensive testing through which data are being gathered in an effort to demonstrate the systems’ effectiveness to regulators. To that end, a full-sized system has been installed at a

Charlottesville wastewater treatment plant, where it's been operative for more than a year while testing is being conducted.

An Education in Water Treatment

The Living Machine has been installed at a number of educational institutions throughout the United States, creating the setup for a living laboratory in which students learn about a natural approach to treating wastewater. "They can get close to it without any danger," Kirksey points out. "They don't have contact with a polluted water surface, because it's below the level of the aggregate media, which is put into the wetland cells."

Additionally, the system is attracting kudos through various awards it has received, from a 1996 EPA Environmental Merit Award to three American Institute of Architects Green Building Top Ten awards with respect to various installations nationwide.

At the Conserve School in Land O' Lakes, WI, a Living Machine system that has been in place since 2000 not only treats wastewater generated by the school community but also serves as a living laboratory and classroom experience for students at the private boarding high school. The school is located on 1,200 wooded acres in northern Wisconsin. The Conserve School has an environmental education program focused on environmental stewardship, ethics and leadership, and innovative uses of technology. There are about 130 students who live in dormitories on the campus, plus a faculty of 70 who not only generate wastewater but study it as well.

Dale Mattson oversees Living Machine operations at the Conserve School. When the school was under construction, part of what had to be done with the wastewater discharge involved constructing an extended treatment plant, he says. "[School officials] were looking at an activated sludge plant, and this would fit right in with the school as far as student studies," Mattson says, referring to the school's environmental education program.

Those programs have centered on the wastewater treatment process. Students have researched and written term papers on how everything in the Living Machine is treated and how the system operates. The laboratory room where the Living Machine system is located includes tables, microscopes, and whatever other laboratory equipment is necessary for the school's biology and chemistry programs.

"It's the same thing as activated sludge, except we have plants in there," says Mattson. "The plants remove phosphorous and nitrogen and also serve as media for microorganisms to attach to as a fixed media. It's aerated, and that serves like a resting place for them."

The system also includes extended filtration for the treated water that is discharged to the ground. "We don't disinfect—we let the ground do it for us," Mattson says. "The reason we do the extra filtration is because it is a drip aeration field and we do need to get any little particles that plug up that process out of the system by filtering anything out. That then eliminates the need for disinfection. But we do have to monitor the groundwater quality."

Mattson says the system has worked "fairly decent, pretty much similar to any other treatment plant." In terms of the water quality, Mattson notes that the BOD, as well as the TSS, is usually "non-detectable." Chloroform and nitrogen counts are also consistently low. The flow design is for 38,000 gallons per day.

Operation and maintenance is minimal, involving primarily preventative maintenance, Mattson notes. The most expensive part of the system is the aeration system, involving a three-phase blower, but Mattson notes they are energy efficient.

Perhaps one of the biggest benefits of the system is the lack of odor, Mattson says. "It's not really smelly like most treatment plants," he points out. "In two of our treatment tanks, when the wastewater comes in from the septic tank, it's anaerobic. We introduce oxygen, which makes it aerobic. In the

meantime, there are gasses, but they go through a filter media, which is on top of one of the tanks. We have plants growing on the mulch on top of there, and that more or less traps all of the odors.”

The knowledge gained by studying the workings of the Living Machine system contributes to a body of knowledge useful in such areas as water conservation, biology, environmental work, and natural resource management, Mattson says. Additionally, graduate students from the University of North Carolina have studied a similar system located at the Guilford County Northern Middle and High Schools in Greensboro, NC. According to David Hicks, an independent operator employed by the school system to oversee the wastewater treatment operations, one of those students has even decided to use the Living Machine as the basis of a master’s degree program in engineering.

“We’re already seeing interest in that teaching portion of the system,” Hicks adds.

The Living Machine fits into the school district’s commitment to sustainable design and resource conservation. “This is their first experiment with this type of approach to building and utilities for their building, and it is unbelievably impressive,” says Hicks. “The Living Machine is a small part of what they’ve done to have low-impact construction for their schools. Aspects of that are being looked at for other construction projects that are going on in the school district as well.”

The Living Machine system is beneficial in many respects, Hicks notes. He observes it is a lower-energy-consumption treatment process than is typical for larger, more complex systems. “It’s certainly more rugged and easier to operate and to protect from shock loading than a small package plant-activated sludge system, which would be the worse situation from an operator’s standpoint,” he says. “It’s probably going to function with better overall nitrogen removal and especially nitrate reduction than most typical onsite systems, which is a big concern.”

“From the start, it’s operated without any events as far as the water quality. I wish I could say the same for equipment operations, but going through a de-bugging period is typical on any automated system,” he adds. “But the system has taken some shots and has filtered really good-quality effluent in the startup phase, so I’m super pleased about that.”

Worrell World Technologies has been responsive to problems in a quick fashion, Hicks notes. “Most of the startup problems have involved programming issues with the controller—there have been very few problems with the hydraulics and equipment,” he says. “But they made sure we had Internet connectivity on the project. When there are hardware-related issues, they come online and fix it. It’s a one-phone-call operation.”

Hicks says from an operation and maintenance standpoint, while the Living Machine is new technology for him, the closest system operationally to which he can compare it is a fixed media system, which he characterizes as “very rugged for shock loading.”

The system’s effluent is discharged to a standard no-traffic subsurface drip field. In the future, Hicks anticipates the effluent will be discharged into the school’s ball fields after logistical and final permitting issues are addressed. The installation of the subsurface drip was not completed until late last summer, when it was too late to get effective sprinkling going in the field, he says. Additionally, the state intended to conduct practical hydraulic testing of the field as it was installed before accepting final discharge rates for the fields, he adds.

“We’re anticipating sometime this summer coming up with the state’s test protocol in acceptable hydraulic loading for those fields so that there’s no public health issue there,” says Hicks.

Hicks says one developer investigating onsite wastewater treatment system options toured the system at the school to benchmark it as an optimal use for a community development but was surprised by the footprint, which Hicks says is appropriate for the school’s needs. “They had plenty of land, and functionally I don’t think it took tremendous investment for the grading and everything necessary to put the system in,” he adds.

In terms of cost-effectiveness in light of startup costs, operation and maintenance, and life cycle issues, Hicks says the system needs to generate some history before he can ascertain that, “but my gut feeling is that for electrical costs, I believe it is going to be much less expensive than more typical onsite systems. So far, I believe, in terms of my time invested per gallon of wastewater treated, it is going to require less onsite maintenance and observation than what I would have expected. All in all, it’s a pretty rugged system with minimal maintenance.

“It’s interesting to see new technology and applications marching on, and I’m eager to see if it lives up to everything it’s been touted to do—so far, it’s been impressive,” says Hicks. “We’ll know more in the next year and a half.”

Carol Brzozowski is a journalist in Coral Springs, FL.