Vermifiltration: Relying on nature's environmental engineers

The disruptive technology of vermifiltration offers a revolutionary approach to wastewater treatment by relying on tiger worms to treat biodegradable effluent and remove nutrients. Kevin Jeffrey of Wastewater Wizard Ltd explains how.

Biological wastewater treatment systems have come a long way in the past 100 years, but one technology is pioneering a revolutionary new approach. Vermifiltration technology, which involves using worms to treat wastewater, has been designed around the lifecycle of worms. Typically, *Eisenia fetida*, commonly known as the tiger worm, is the key player in this process.

Tiger worms are found throughout the world in and around compost heaps. As nature's environmental engineers, they feed on the natural waste, digesting up to their entire body weight every day.

Disruptive technology is an apt description of this unconventional approach. Gone are the days when designers and operators spend their lives managing conditions in a plant, allowing the beneficial organisms to dominate while controlling the undesirable ones. In contrast, vermifiltration makes high energy-consuming treatment plants redundant, along with their associated complex control systems, selectors, anoxic zones, and sludge management regimes.

Although the origins of vermifiltration remain unclear, several companies around the world have been championing it, and countless academic studies have verified its capabilities. Recently, the UK-based Wastewater Wizard Ltd brought vermifiltration into the limelight by showcasing the Commercial Wizard system at Aquatech 2015, a leading trade show held in Amsterdam, Netherlands on November 3-6.

The Commercial Wizard is a single cell unit that treats wastewater simply without any primary tanks, final tanks, blowers, or any sophisticated control systems beyond the single treatment cell. Wastewater is distributed over the surface of the vermifilter. It percolates down through the many layers, and once it exits the structure, up to 95 percent biological oxygen demand (BOD) and suspended solids are removed. Tiger worms breathe air, but unlike humans they breathe through their skin. Their burrowing activity within the vermifilter ensures that it is naturally aerated, so plants do not need any form of residual aeration, which keeps the energy bills down to a minimum. The vermifilter's only high-tech requirement is the pump station, which distributes wastewater over the surface.

The Commercial Wizard is a multi-layered unit. Starting from the bottom up, the underdrain consists of layers of graded aggregate that support the upper layers made from coconut coir. Tiger worms live in the upper layers. They are surface dwellers and are found in the top 30 centimeters of the system; the coir acts like a simple filter by trapping the solids and organic fraction. The worms feast on this food source, or–to be more specific–they feed on the microorganisms that are found on this material. Once the wastewater passes though the vermifilter, which is approximately one meter deep, the final effluent is ready for discharge.

If the effluent is discharged directly into a watercourse, then the 95-percent BOD and suspended solids removal rates are sufficient. Many commercial enterprises discharge to the sewer, so the standards are much lower and do not require such an effective treatment process.

Extensive scientific research has been carried out and is continuing into the technology, particularly in China, India, and Australia. One leading academic in this field is Professor Rajiv Sinha, who has conducted extensive research on these systems for many years at Griffith University in Australia. His review paper "Vermiculture Technology: Reviving the dreams of Sir Charles Darwin for scientific use of earthworms in sustainable development programs" is often quoted by his peers in academic journals.

The primary mechanism to treat the wastewater is carried out by the worm as it acts an aerator, grinder, crusher, and chemical degrader. However, the worm's role is just one part of the story. The worm is the primary organism living synergistically within a complex community of microorganisms. While the worm is primarily responsible for treating the effluent, the attached growth makes an important contribution by providing an array of traditional nitrifiers. This combination ensures that removal rates are achievable for BOD, and solids are approximately 95 percent; chemical oxygen demand (COD) is 70 percent; and nitrogen and phosphorus are 60 to 70 percent.

The use of coir in the Wizard system is vital, and the worms thrive in this media. Working with Edinburgh University in Scotland, Wastewater Wizard calculated that the coir provides approximately 10,000 square meters per cubic meters (m^2/m^3) of surface area. The coir also provides the surface area for the attached growth. The lightweight material is advantageous during the construction phase given its ease in handling.

Early fascination inspires R&D

Wastewater Wizard's Managing Director Kevin Jeffrey's first involvement using worms dates back to the 1990s. He explains, "I was part of a UK research team, which studied the effects of using tiger worms to treat sewage sludge. Originally focusing on using a traditional wormery, the project developed a unit that could treat liquid humus sludge."

The project proved a success, validating the technology, but as what happens at the conclusion of many research projects, the people and companies moved on, leaving the project report and findings on the shelf. However, Jeffrey's fascination for this worm developed from there. "Let's face it, if it were not for microorganisms, wastewater treatment (as we know it) would not function in the way it does today," he says. "This project got me thinking if microorganisms can treat the biodegradable soup of sewage, could tiger worms do the same and, if so, do it better? Roll on several years, a lot of research and development, and the resounding answer is most definitely yes!"

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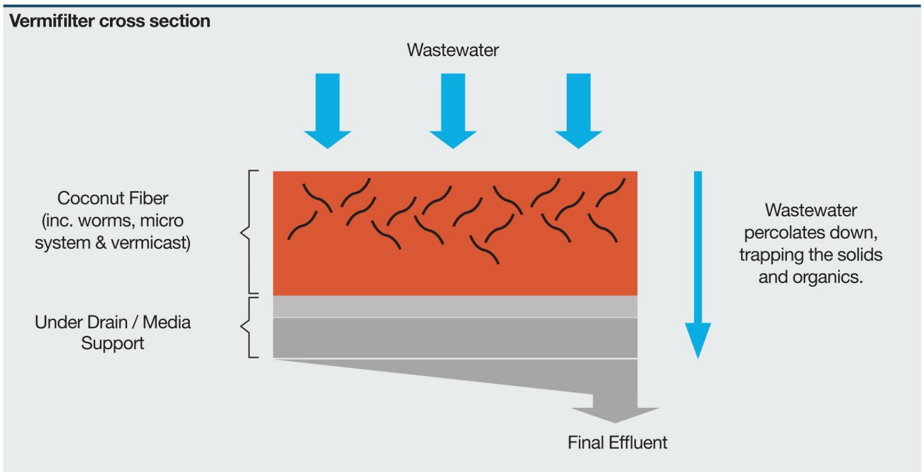
Loading rates for vermifilters are quite high at approximately 3- to 5-person equivalent per square meter (pe/m^2), which contributes to lowering the overall footprint of these systems. The compact footprint, in turn, reduces the regulatory compliance cost for companies allowing them to avoid high capital expenditures. Without costly sludge to treat and manage, the vermifilter's operational costs are lower. The worms secrete worm casts, which require periodic removal. Low-tech tools such as a pitchfork can be used to remove worm casts. Companies do not need to invest or spend large amounts of money in maintaining vermifilters or in having to up-skill their workforce to operate them.



Applications

Vermifiltration is versatile; it can be combined with additional technology to treat effluent for a variety of applications, including reuse in agriculture and industry. For irrigation, ultra-violet treatment can be used to disinfect the final effluent, or if a more stringent quality is required, it can be combined with conventional technology. If the client requires high-quality water, a membrane bioreactor (MBR) can be added to the treatment process. These options highlight the versatility of vermifiltration. Not only can systems be used outright for environmental compliance; but also they can achieve a very high quality effluent by using it at the front end to reduce the overall loading, and then couple it with a much smaller MBR. This approach reduces the overall cost for the treatment and makes high quality effluent reuse more affordable.

Vermifiltration is suitable for applications in which the wastewater is biodegradable, and such versatility has already allowed vermifiltration to find many uses around the world. In South America, the research of one pioneer in this technology, the late Dr. José Tohá Castellá at the University of Chile, has led to several spin-off companies, with one company aptly named Sistema Tohá. They have developed vermifiltration plants treating wastewater from distilleries, mining camps, abattoirs, towns, food processors, and agriculture. Here the world's largest treatment plant at El Melon treats sewage from the town's 15,000 inhabitants. In Chile's Antarctica base, a vermifiltration plant treats the station's wastewater in a heated building.

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Townships in New Zealand are turning to vermifiltration given its low capital and operational costs, which are a fraction of that of conventional biological systems. Farms in Centre Booth, Southland are already using vermifiltration to treat waste streams from dairy herds.

Recently, Wastewater Wizard helped postgraduate science students from Leiden University and Delft University of Technology, both in the Netherlands, in their research on the use of vermifiltration in the dairy industry for wastewater treatment and the reuse of worm casts. The casts have a high nutrient nitrogen-phosphorus-potassium (NPK) value and could be recycled on the farm to improve crop yield. A huge win-win scenario for the farmer, vermifiltration ensures environmental compliance, and it reduces the demand for manmade fertilizer, which uses dwindling supplies of phosphorus.


Tiger worms used in vermfiltration. Photo courtesy of Wastewater Wizard Ltd, ©Graeme Booth Photography.

In Australia, approximately 10,000 units are being used to treat sewage from single-family houses. Inventor Dean Cameron's former company (Dowmus) pioneered the technology, but there are now numerous companies creating similar systems.

In Europe while Wastewater Wizard is pioneering the technology, a European Union-funded project built a large-scale unit in Combaillaux, located in the south of France. Started as a research project, the plant treats the entire sewage from the town's 2,000 inhabitants and consistently outperforms the benchmarks set by Europe's Urban Wastewater Treatment Directive's standard of 25-milligrams per liter (mg/l)- BOD and 125 mg/l COD.

Through international trade shows such as Aquatech, Wastewater Wizard is reaching out to a wider global audience. The company is currently developing systems for residential developments in North America and dairies in the Middle East and Asia. In the Far East, vermifiltration technology helps clients comply with environmental regulations at a reduced treatment cost, provides local employment, and safeguards the local environment.

The famous English naturalist Charles Darwin spent many years studying the earthworm and concluded, "It may be doubted whether there are many other animals, which have played so important a part in the history of the world as have these lowly organised creatures." Industry is now waking up to the possibilities and benefits that these animals can deliver through vermifiltration technology and innovative applications.

Author's Note

Kevin Jeffrey is the managing director of Wastewater Wizard Ltd, based in the United Kingdom. Jeffrey's career spans more than 20 years primarily within the wastewater field, with highlights including managing wastewater labs through to design, commissioning, and operation of wastewater plants. A chartered chemist and member of the Royal Society of Chemistry, the author holds degrees in chemistry and a MSc in Marine Science.