Water & wastewater

A new wastewater treatment technology for developing countries

Economic growth does not always bring with it immediate sanitary improvements and waterborne illnesses are still far too common. Not only that, but traditional wastewater treatment facilities have high operational costs and are big users of energy. Here, Mark Fosshage, President & CEO, World Water Works explains how a new biological treatment technology using algae promises to reduce total energy consumption by 90%.

In spite of the impressive growth by former third world countries such as India, problems posed by waterborne pathogens still cause about 80% of illnesses. A huge part of this effort is the development of wastewater treatment facilities. Long bedeviled by poor access to the energy needed to operate wastewater treatment systems, only 20% of communities in India had access to wastewater treatment in the past.

New technology

Now, a new technology developed by Aquanos Energy Ltd, and further enhanced by World Water Works, is now available and promises to produce a high quality effluent at a fraction of the total energy consumption of conventional wastewater treatment plants.

The new technology captures and harnesses the symbiotic relationship between bacteria and algae. This natural process results in a 90% reduction in plant energy, reduces a wastewater treatment system's operational costs by 40-60%, and reduces capital expenditures. Its manufacturers claim that it is far more sustainable than other biological wastewater treatment systems that use microorganisms to treat wastewater, so it is ideal for use in India and other energy-constrained countries.

The process has been proven in a demonstration project and is now being launched to the municipal market in India and Africa. Further enhancements are already on the horizon, including an enhanced nutrients removal system and resource harvesting of the algae for use as a fertilizer and other useful products.

Biological wastewater treatment

In most conventional intensive wastewater treatment operations, organic material and nitrogenous compounds are degraded by aerobic microorganisms (bacteria), which require large amounts of oxygen for their biochemical activity. Supplying this oxygen usually requires mechanical devices, like surface aerators and air compressors and blowers to introduce air into the reactors. These devices use huge amounts of electrical power. About 60% of the energy consumed by treating water comes from blowing oxygen into the wastewater. The associated power costs impose a significant (sometimes insurmountable) financial burden on communities, making wastewater treatment effectively impossible for many communities in India and Africa.

Several years ago, engineers at Aquanos began looking for a better, more sustainable method, and one that would extend the benefits of advanced wastewater treatment to countries that lacked affordable energy alternatives. They noted that water is the single largest factor in world energy consumption, including water treatment, supply, purification, and wastewater. It is also the major cause of disease in these countries, and they knew it was possible to solve that problem. But perhaps most importantly, they wanted to find a way to change the way wastewater is viewed. Rather than thinking of wastewater as simply dirty water, the Aquanos team saw wastewater as a resource from which nutrients could be derived or converted to energy and products.

Recognizing that eliminating the need to blow air into the wastewater would significantly reduce energy needs, they examined a few

Figure 1. The use of algae in the purification process conserves energy.

alternatives, eventually alighting on the plan to use algae, an aquatic plant that consumes CO_2 from water and produces oxygen. Bacteria supplies carbon dioxide to the algae, algae provides oxygen to the bacteria, and both remove impurities from wastewater (Figure 1).

Production of oxygen by algae is not a new idea – it has been used extensively in wastewater treatment, either in conventional waste stabilization ponds or the more engineered high-rate algae ponds. However, these lagoon-based algae wastewater treatment systems require large areas of land because the algae ponds have to be very shallow so they receive enough sunlight. Such systems are also not highly-controllable systems, resulting in inconsistent effluent quality.

Mixing the oxygen-producing algae with the oxygen-consuming bacteria in a single environment turns out to create conditions that are not optimal for either type of organism. For example, the presence of large numbers of microorganisms creates high turbidity, which turns water brown, thus obscuring the sunlight the algae need to grow. Because of these issues, many systems that started out using algae to produce oxygen had moved into forced aeration – with its high energy use.

Separating oxygen

Aquanos engineers devised a novel approach that uses algae to produce the oxygen required for aerobic wastewater treatment, which then takes place on a fixed-film system. The unique aspect of the new patent pending approach is that it uses two separate reactors to separate the oxygen production capabilities of algae from the bacterial oxidation of both organic and nitrogenous compounds that occur on an attached-growth aerobic system.

In this process, biological oxidation is achieved on an attached biomass, by recycling an oxygen-rich algae stream through a moving bed biofilm reactor (MBBR), resulting in a high quality effluent and a controllable process and one that requires a fraction of the energy required for aeration with mechanical aeration or blowers, and considerably less space than traditional extensive algae-based systems.

The algae-growing pond is shallow, so light can penetrate it. The retained microorganisms are in a different reactor close by, so there can be high concentrations of microorganisms without interfering with the algae. A pump transfers the highly oxygenated water into the fixed film reactor. Energy use could be further reduced if a solar pump was used to transfer the oxygenated water.

In addition, algae produced during this process can be used by local farms or urban developments as slow release nitrogen and phosphorus fertilizer. With additional treatment, the algal biomass could be used for the production of animal feed and possibly other high value algae-derived products.

This natural process results in a 90 percent reduction in plant energy, reduces a wastewater treatment system's operational costs by 40-60 percent, and significantly reduces capital expenditures. In some circumstances it will produce a net-positive energy balance. In addition, the method is considered a carbon sequestering technology, capturing greenhouse gases (CO_2) rather than releasing them to the atmosphere.

The process basics

In the process developed by Aquanos, wastewater is screened and de-gritted before being introduced into an anaerobic stage. Depending on the application, this may be anything from a simple lined earthen anaerobic lagoon to a fully engineered anaerobic sludge blanket reactor. This stage reduces organic loading, and serves as a sink for excess biomass.

Following the anaerobic stage, the wastewater is introduced into the MBBR, where aerobic chemical oxygen demand (COD) removal and nitrification take place. The active biomass is grown as a biofilm on small, cylindrical HDPE elements designed to maximize protected surface area and mass transfer of substrates and oxygen from the bulk liquid into the biofilm. MBBR provides a 'home' in which the bacteria can live and be concentrated and protected. The process is also very forgiving, handles load swings easily, and is simple to operate (Figure 2). The algae are harvested using an AHTO® (Algae Harvesting Technology Optimized) system.

The MBBR and AHTO® components for the Aquanos system were designed in close consultation with World Water Works, a global leader in MBBR and AHTO® that has installed numerous wastewater treatment plants using MBBR and AHTO® technologies. The two companies further enhanced and optimized the Aquanos process using World Water Works' proprietary MBBR and AHTO® technologies.

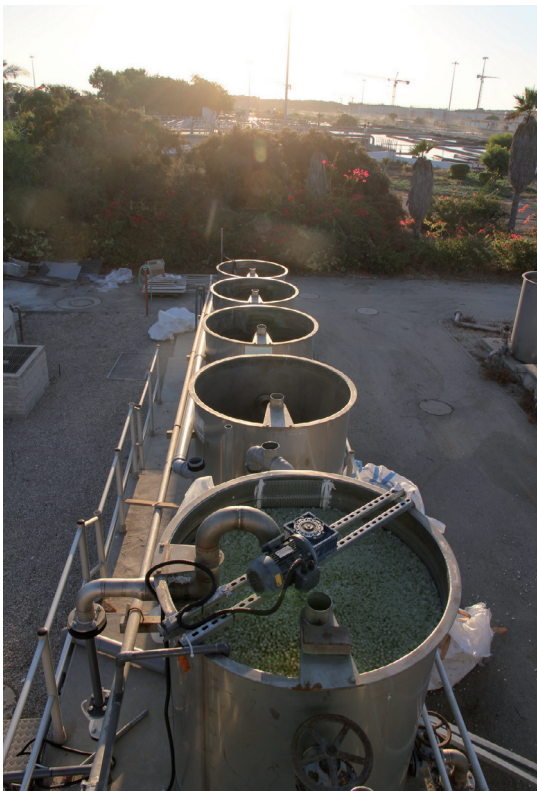

Figure 2. MBBR houses the bacteria where it is concentrated and protected.