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Expert Insights from Linde.

Harnessing oxygen to boost biological treatment of wastewater in the Food & Beverage industry.

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Harnessing oxygen to boost biological treatment of wastewater.

All operators of medium to large-sized food and beverage (F&B) plants have to deal with effluent wastewater. Food processing plants, dairies, breweries and red meat and poultry producers in particular have to contend with high levels of soluble contaminants in their effluent, expressed as biochemical oxygen demand (BOD) and chemical oxygen demand (COD). Regulating the pH of alkaline wastewater often constitutes an additional challenge.

Many F&B processing plants own and operate their own wastewater treatment (WWT) facilities. Factors that prompt operators to choose an on-site option include the need to comply with environmental thresholds and secure operating licenses, and also to reduce trade effluent charges or tariffs by treating on site and then discharging to a municipal WWT plant. A rising number of operators go further to increase their sustainability performance by reusing or recycling water. In some instances, on-site plants can also help avoid costly investments in off-site facilities as overloaded local municipal plants often look at large wastewater customers to contribute towards much-needed upgrades.

Despite the many advantages of on-site facilities, they sometimes struggle to keep up with productivity increases and the resulting rise in effluent. The good news is that, as effluent water streams from the F&B industry grow, so too do the range and efficiency of treatment technologies available. In this article, we give an overview of the available options, highlighting in particular the advantages of using pure oxygen in the biological treatment of wastewater from F&B plants.

Anaerobic treatment.

Anaerobic fermentation processes such as anaerobic digestion are one option for treating F&B effluent wastewater. Unlike aerobic biological processes, they work in the absence of oxygen. The biological model is similar to the anaerobic environment that exists in the rumen chamber of a cow's stomach. Anaerobic digestion is undertaken by specialist bacteria and is split into four distinct stages. The first is hydrolysis, where complex molecules are broken down. This is followed by acidogenesis, where the simple molecules are converted into fatty acids, and acetogenesis, where the fatty acids are broken down to acetic acids and other fermentation compounds. The fourth and most important stage is methanogenesis, where the acetate compounds of fatty acids are converted to a mixture of methane and carbon dioxide gas (CO_2). Anaerobic digestion can be used to treat solids and high-strength biodegradable organic waste from the F&B industry such as sugar beet and brewing residues, sugary waste, fats, dairy, meat by-products and other solid food waste. Benefits include low power input and surplus energy. This can take the form of electricity generated directly from the combustion of raw biogas or bio-methane produced from raw biogas that can be fed into the national gas grid. On the downside, however, the anaerobic digestion process produces low-quality final effluent that needs a polishing stage, as well as odor problems which require remediation. It also carries the risk of sensitivity in the process itself due to influent characteristics and loading variation. For example, it requires a constant ratio of substrate to alkalinity in order to prevent the pH from dropping too low, and adequate mixing to continually release the biogas. Generally speaking, anaerobic processes are not well suited to biological nutrient removal, an increasingly important requirement for some operators.

The F&B industry – which includes cheese manufacturers, breweries, meat processing plants and dairies – produces effluent wastewater with high BOD and COD. Finding the best technology for treatment is crucial to keep up with regulatory and sustainability targets.

Membrane bioreactors.

A membrane bioreactor (MBR) is another biological effluent treatment option. These reactors can either be aerobic or anaerobic, with a membrane stage to separate the biomass or flocs (a loose mass of particles or clumps of bacteria forming a stable floc) from the final treated effluent. MBRs have a number of advantages. They enable a more compact plant footprint, produce final effluent of excellent quality, can be used for nutrient removal, produce less surplus solids, and provide polished effluent for potential downstream water recycling or reuse. With further treatment stages, the water can even reach potable quality. The main disadvantages of MBRs compared with conventional systems are related to cost as they can entail high CAPEX and higher energy costs due to the aeration needs.

Aerobic treatment.

The most universal and cost-effective aerobic process used to treat wastewater arising from the F&B sector is the activated sludge process (ASP), which harnesses naturally occurring biological processes present in bacteria. This process is capable of treating soluble and colloidal pollution (a two-phase system featuring continuous and dispersed particles common in raw waters). ASP converts this stream to oxidized by-products, generating new cellular biomass in the process. It requires energy for mixing and aeration and is therefore a net energy user. The ASP process is also very well suited to the treatment of nutrients such as phosphate and nitrogen compounds. **The resulting treated wastewater can be of extremely high quality and even reused if additional process steps, including UF, reverse osmosis, ozonation, UV and chlorination** are applied. The ASP process has many variants, and modern plants can be designed with a membrane stage to reduce the footprint and improve final effluent quality. The surplus activated sludge and primary solids from the pretreatment stage can be anaerobically digested to generate electrical energy from the raw biogas, or the biogas can be refined to produce bio-methane. Overall, the ASP is very flexible in terms of adaptability and resilience to substrate load variations. It can keep going even through periods of very low feed rate, but it must be supplied with dissolved oxygen and be kept agitated throughout. Advantages include the ability to treat an extensive range of aqueous wastewater types to a very high degree of quality, including biological nutrient removal. The main disadvantage is the relatively high power consumption needed for the aeration stage.

Pure oxygen creates optimal aerobic conditions for successful biological treatment and faster degradation rates, and it supports biological nutrient removal.

Why oxygen-based aerobic treatment?

Oxygen is more effective than air in supporting the natural treatment of wastewater and can support higher concentrations of biomass within the process. It creates optimal aerobic conditions for successful biological treatment, faster degradation rates, and supports biological nutrient removal. By enabling the bacteria in the biotreatment process to break down soluble organic compounds more effectively, oxygen thus provides the conditions to effectively reduce the COD and BOD level of the effluent.

Operators of on-site industrial biological aerobic wastewater treatment plants are often challenged to increase capacity, manage foaming and odors, reduce sludge, avoid corrosion, and manage costs. Many of these problems can be fully solved or substantially reduced through the systematic addition of oxygen to the water treatment process.

The addition of pure oxygen to aerobic treatment processes can:

- cover scheduled aeration equipment maintenance
- provide additional capacity when existing aeration is limited
- bridge production peaks
- avoid process problems such as excessive foaming or the creation of aerosols and mists
- eliminate odors
- reduce surplus sludge volumes
- avoid corrosion in pressurized transfer pipes
- reduce CAPEX for mid- and long-term capacity increases
- secure additional oxygen demand during biological nitrogen removal


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Biological nutrient removal (BNR).

Demand for BNR is rising due to changes in environmental regulations. The process can remove nutrients without requiring the addition of chemicals. For example, phosphate is traditionally removed by a chemical precipitation reaction using lime and a coagulant, producing large quantities of sludge for disposal. BNR can be combined with all forms of ASP, aerobic MBR and potentially with anaerobic MBR, as a tertiary stage. The final effluent wastewater will be good enough for river discharge, aquifer recharge and, if MBR is used, for irrigation and as feedstock for a reverse osmosis plant to facilitate water reuse.

Trusted partner to the F&B industry.

Companies such as Linde can guide F&B customers through the various treatment options available to identify the process technologies or combinations best suited to their individual needs. The company provides a range of engineering and application processes for the treatment of drinking water, wastewater, process water and protected bodies of water (such as rivers and lakes). These application technologies combine state-of-the-art dosing and control equipment with industrial gases such as oxygen, carbon dioxide and ozone to boost capacity and resolve process challenges in a sustainable, cost-effective, and environmentally sound manner.

The SOLVOX® portfolio, designed to meet aeration and mixing needs, is compatible with existing equipment, making it an ideal complement to systems already in use. Linde technologies can handle temporary and permanent aeration needs and are suited to different WWT plant sizes and configurations, while ensuring high efficiency levels, easy installation and low maintenance costs.

For neutralization needs, Linde offers its SOLVOCARB® portfolio, a range of pH regulation and stabilization solutions to correct the pH of wastewater from F&B plants. This may be necessary to balance the effect of chemicals used for cleaning-in-place, manage pH during preliminary and primary treatment stages, and to ensure that the wastewater to be discharged complies with the set range. Many operators use mineral acids for these applications, but these are corrosive, dangerous to handle, and offer limited accuracy for final pH control.

Linde has a number of successful references for breweries, snack food producers, vegetable processing plants, dairies and other food-related production sites. These span greenfield builds, turnkey packages, retrofits and bespoke engineering projects for wastewater treatment plant upgrades, pH neutralization, re-mineralization, re-carbonation, pH adjustment, ozonation, oxygen mass transfer, process mixing, computational fluid dynamics (CFD) modeling and much more.

Visit www.linde-gas.com/watertreatment for more information on Linde's SOLVOX® and SOLVOCARB® portfolios and to get in contact with a Linde expert.

About the author.

Darren Gurney has 25 years of experience in the water treatment field and has developed several of Linde's WT technologies. Originally from the United Kingdom, he has an MSc degree in chemical engineering and has personally overseen hundreds of installations at wastewater treatment plants across industries as diverse as municipal, food and beverage, textiles, pharmaceuticals, fine and specialty chemicals, and pulp and paper.

"One of the things I value most is earning the trust of our customers. During the last 25 years I have had the privilege of serving more than 100 customers. Linde works hard to live up to the expectations of providing great service, on time and at a fair price. That is part of our DNA."

Darren Gurney, Sr. Process & Business Development Manager, Linde

Getting ahead through innovation.

With its innovative concepts, Linde is playing a pioneering role in the global market. As a technology leader, it is our task to constantly raise the bar. Traditionally driven by entrepreneurship, we are working steadily on new high-quality products and innovative processes.

Linde offers more. We create added value, clearly discernible competitive advantages, and greater profitability.
Each concept is tailored specifically to meet our customers' requirements – offering standardized as well as customized solutions. This applies to all industries and all companies regardless of their size.

If you want to keep pace with tomorrow's competition, you need a partner by your side for whom top quality, process optimization, and enhanced productivity are part of daily business. However, we define partnership not merely as being there for you but being with you. After all, joint activities form the core of commercial success.

Linde – ideas become solutions.

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