Efficiency, Safety, Cost Effective Solutions: gas molecules for wastewater treatment

How Oxygen, Ozone and Carbon Dioxide provide safer and more efficient alternatives for wastewater treatment

Whether it's treatment of effluent or wastewater, companies and municipalities can improve safety, cost efficiency and have a more sustainable solution. In comparison to the alternatives, these little gas molecules have the potential to deliver those improvements with the added bonus of flexibility in fitting the solution to the water treatment need. Let's look at each.

Oxygen (O_2) Enrichment: How it works and the resulting effect

Oxygen injection involves releasing oxygen at pressure into the wastewater, creating an oxygen enriched environment in the wastewater that is being treated. The gas-liquid transfer efficiency is then increased thanks to the greater difference of saturation and concentration in the liquid.

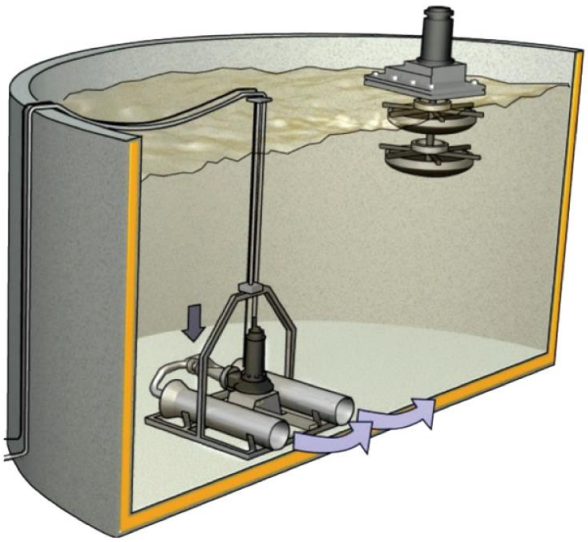
Oxygen is injected into the effluent using equipment specially made for the oxygen enrichment of effluent ponds. The equipment options are a combination of specifically designed in-line mixers and injectors, sized & positioned depending on the configuration of the treatment plant, plus the supply of O_2 via bulk storage or on-site equipment. Amounts, concentration and dispersion of oxygen being injected are controlled throughout the process by the various sized equipment.

Pure oxygen and oxygen enrichment are well-established approaches to biological treatment for municipal and industrial effluent. Pure oxygen injection results in improved mass transfer and enables a higher level of dissolved oxygen compared to traditional aeration. In fact pure oxygen solubility, at 20°C and 1 atm, is approximately 43 ppm compared to only 9 ppm for air under the same conditions[1]. That means if the oxygen dissolves that much faster compared to oxygen naturally present in the air, then the bacteria will break down much faster as well. Injection of pure oxygen means a more flexible treatment process, higher organic loading, along with potential process cost efficiencies and in most cases without additional capital costs.

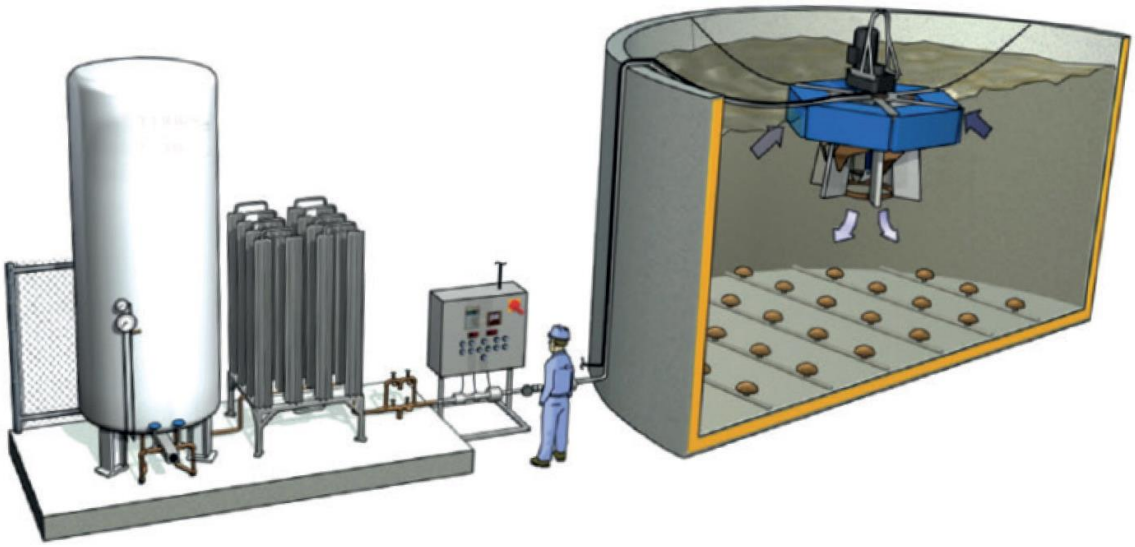
Use of oxygen injection provides a safer process compared to use of acids, as oxygen injection systems don't require any manual handling or personal contact with chemicals.

Benefits of Oxygen Enrichment by injection (at a glance):

- Lower initial capital cost compared to an equivalent oxygen based system
- Less aerosols, VOCs and odours
- Reduced plant footprint of new secondary treatment facilities
- Less energy required per tonne of BOD removed
- Flexibility to cope with BOD variation
- Better mixing and increased dissolved oxygen
- Rapid and easy installation
- Increased BOD loading
- Increased sludge settleability



VentoxAL, Subsurface venturi/nozzle oxygen enrichment injection



TurboxAL: Floating oxygen injection mixer

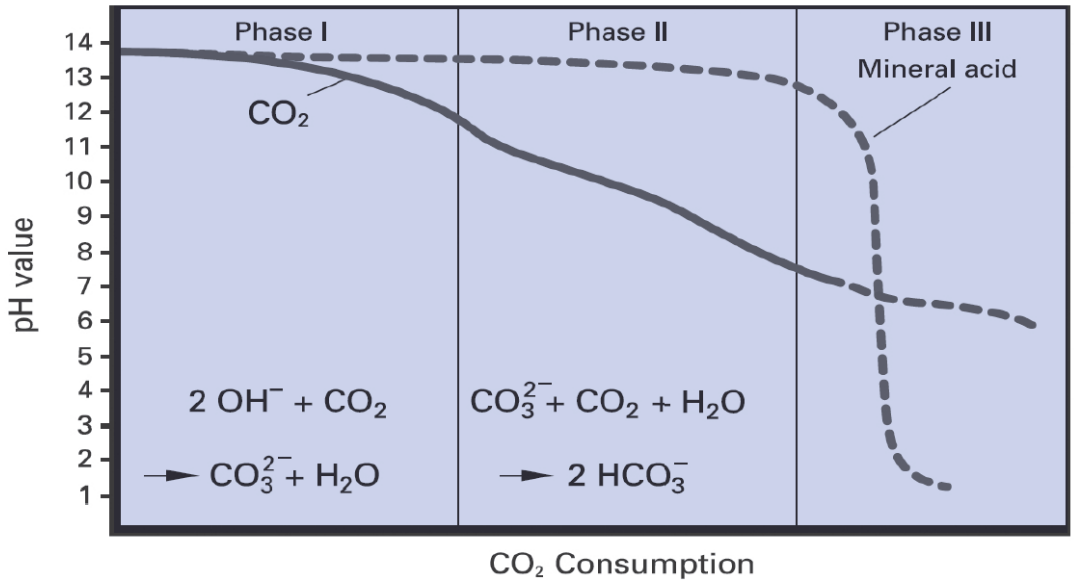
Carbon Dioxide (CO_2): How it works and the resulting effect

Using Carbon Dioxide at your site can offer measurable safety and cost advantages over other treatment systems that employ mineral acids. Carbon Dioxide is a safer alternative compared to

mineral acids, because of the supply method used which generally does not require handling, reducing the risk of accidental injury.

Carbon dioxide is an inert gas used in several water and wastewater applications:

- Water de-hardening and Calco-carbonic equilibrium correction
- pH Control of alkaline effluents - CO2 is highly soluble (2 g/L at 15 ^{0}C and 1 atm) when in contact with water CO2 reacts quickly to release Carbonic acid, a weak acid that neutralises basic effluents with precision to desired pH [See Figure below]
- More efficient coagulation/ozonation - precisely controlled optimal pH range for specific coagulants avoiding formation of complex salts by coagulant overdosing
- Re-mineralisation



Reaction of CO2 in water compared to Mineral acids

With CO_2, the solution is as simple as it is a safer alternative to mineral acids. CO2 is stored on site and dissolved into water in a number of possible ways. Specially engineered solutions include:

- Static Mixer
- CS Nozzle (Venturi system)
- Bicone (see image below)
- Porous diffuser/sparger/pipeline injection

The supply of Carbon Dioxide can be automatically managed by the provider, thus eliminating stock monitoring and ordering requirements.

Benefits of Carbon Dioxide (at a glance):

- The supply of CO2 generally requires lower capital investment, is quick and easy to install and offers a safer solution with minimal physical handling requirements, compared to mineral acids.
- Low reaction time and precise pH control means operational ease of use, eliminating the prospect of over treating without the formation of undesirable secondary by-products
- No corrosive effect on infrastructure meaning increased asset life and reduced maintenance spend
- Reliable technology
- Maximises lifespan of equipment compared to exposure to corrosive acids

Bicone: Side stream oxygen injection cone

Ozone (O_3): How it works and the resulting effect

Ozone use in the water treatment process is a worldwide established solution and it provides a more effective, efficient and safer process than the use of chemicals. Ozone is a wide ranging disinfectant with less resistant microorganisms than chlorine based compounds and a powerful oxidant for refractory organic and inorganic matter. O_3 has, after fluorine, the second highest redox potential and is therefore an ideal oxidation and disinfection agent for the majority of water treatment processes and macro and micro pollutant removal. Furthermore, ozone decomposes partially into oxygen during the oxidation
process and belongs to the natural oxidants.

Ozone must be generated on-site through UV-light, or more commonly, by electrical voltage discharge. It reacts quickly in water, with both direct and indirect reaction mechanisms, by combining with multiple compounds and by partially forming highly reactive and short-lived free radicals. The rate of ozone dissolution in water depends on temperature, pH, and dissolved and suspended solids? Ozone then oxidizes the microorganism cell components by causing cell lysis and ultimately destroying the microorganisms.

Since the development of ozone generators and the wide use of oxygen as a feed gas for ozone generation, ozone can be produced with a better yield versus using air, with a lower energy consumption and an increased lifespan of the generator. Ozone yield is increased by up to 2 times by using pure oxygen versus air and operational and maintenance costs are estimated to be 10% lower with liquid oxygen supply[2]. The benefits of oxygen supply from ozone generation are straight forward, as oxygen concentration, humidity and purity of the inlet gas are predominantly the most important parameters to achieve higher efficiency.

Benefits of Ozone (at a glance):

- Disinfection and oxidation of refractory biochemical components and microbiological agents
- Reduced usage and handling of mineral acids
- Potential lower capital costs versus air supply
- Removal of colour and odours in the water with no final taste/odours in water
- Reduced formation of disinfection by-products
- Minimisation of microbial growth
- Helps preventing scaling and corrosion of pipes in heat exchangers
- Reduction of filamentous microorganisms
- Enhancement of coagulation/flocculation and reduction of excessive sludge

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Air Liquide Australia Limited has facilities and distributors all across Australia in both metro and regional areas. They service customers of all sizes across a broad range of industries, from gases for pubs and breweries to gases for food packaging, metal fabrication and wastewater treatment. With local experts, backed by global expertise, Air Liquide has been a key provider to the wastewater treatment industry in Australia for over 30 years.

** Following the acquisition of Airgas on 23 May 2016*

[1] Degremont, Water Treatment Handbook, Sixth Ed. Paris: Lavoisier Publishing; 1991. 510p

[2] Langlais, B., Reckhow, D. A., Brink, D.R., Ozone in Water Treatment- Application and Engineering-, 2nd Edition. Michigan: Lewis Publisher (1991)