Strategy of Oxygen Supplementation in
Water Bodies with Low Dissolved Oxygen Levels

Using

ECO$_2$ SuperOxygenation

“Speece Cone” Technology
**Technical Approach**

ECO₂ SuperOxygenation Technology was invented by Dr. Richard Speece more than twenty years ago to supplement lakes and reservoirs with additional dissolved oxygen to avoid problems of oxygen depletion in the hypolimnion during the stagnation of the summer months.

Anaerobic conditions in water bodies are the cause of a number of negative environmental consequences including the release of phosphorous, iron and manganese from the bottom sediments to the surrounding water as well as the formation of malodorous and corrosive hydrogen sulfide. These negative environmental impacts only occur under anaerobic conditions. The preferred method and the technical approach of the ECO₂ SuperOxygenation technology to prevent these issues from occurring, is to supplement dissolved oxygen directly into the water bodies to maintain an aerobic cap over the sediments.

The oxidation of H₂S, iron and manganese is both a biological and chemical process that is influenced by several water quality variables. Typically, in clean lake water, it takes on average 24 - 48 hrs to oxidize H₂S, iron and manganese. Therefore, the aerobic zone has to represent at least 48 hours of hydraulic retention time surrounding the intake structure. This zone will be impacted by the release rate of the lakes, i.e. the higher the release rate is, the larger the zone needs to be.

The other factor that needs to be taken into account for the system design is the amount of oxygen that needs to be supplemented to maintain the aerobic zone. The total oxygen demand in the hypolimnion is a function of the SOD (sediment oxygen demand) + HOD (Hypolimnion oxygen demand). The drop in D.O. resulting from stratification is the best measure of the total oxygen demand, representing both SOD and HOD.

It is important to apply a safety factor to the oxygen supply in recognition of the rapid changes in the release rate of the lakes and the changes in oxygen demand due the variables that influence the oxidation process.
**Hypolimnetic Oxygenation**

Rather than destratifying the lake by trying to add a sufficient amount of oxygen from the surface to the hypolimnion, the ECO₂ System takes a side stream out of the hypolimnion, raises its D.O. level in the ECO₂ Speee Cone, and discharges the oxygenated water **horizontally** over the sediment back into the hypolimnion where it will remain to prevent the production of hydrogen sulfide and the release of phosphorous, iron and manganese into solution. This technical approach efficiently adds oxygen via liquid to liquid phase mixing only to the hypolimnion where it is needed. The ECO₂ SuperOxygenation System achieves an average oxygen absorption efficiency of 95%. It dissolves the oxygen into the water before it is discharged into the hypolimnion, so all of the dissolved oxygen is readily available at the water sediment interface, preventing P, Fe and Mn release and H₂S production.

Traditional aeration systems are inefficient and waste oxygen either by undissolved oxygen bustling to the surface or by mixing the entire water column in order to distribute dissolved oxygen. Diffusers bubble air or oxygen through the water column in hopes that a small portion dissolves and stays in the hypolimnion. The absorption efficiency is low and dependent on the depth of the lake which constantly fluctuates. Any oxygen that is dissolved outside the hypolimnion is wasted.

Technologies that mix the entire water column to drive oxygen to the hypolimnion have to move large amounts of water using significant amounts of energy. The majority of oxygen transferred using this method does not become introduced to the hypolimnion or remain in the hypolimnion where it is needed and is therefore wasted.

It is critical to maintain existing stratification while supplementing dissolved oxygen into the hypolimnion to maintain water temperatures. ECO₂ allows for the existing stratification in the lake to be maintained. ECO₂’s system accomplishes this by withdrawing a sidestream from the hypolimnion, raising the dissolved oxygen and discharging the oxygenated water directly back into the hypolimnion.

This method ensures that the sidestream has the same water temperature and therefore the same density as the hypolimnion ensuring residence of the oxygenated water in the hypolimnion. The thermal stratification creates a natural barrier that prevents the oxygenated water from leaving the hypolimnion, keeping it near the sediment where it is needed.
Artificial destratification, caused by traditional aeration equipment, increases the temperature in the bottom waters. Higher temperatures degrade cold water fishery habitat and warm discharges from destratiﬁed reservoirs may negatively impact downstream fish habitats. In drinking water reservoirs, a homogenized water column precludes the optimization of raw water quality by selective depth withdrawal.

**Reducing Algae Production is Shallow Water Bodies**

Algae growth in water bodies is stimulated by excessive nutrients (phosphorus, iron, and nitrogen) in the water. Excessive nutrients exist either due to surface agricultural runoff carrying fertilizers into the water body or internal nutrient recycling releasing nutrients into the water column from the sediments. Water bodies plagued with algae, where TMDL regulations and best water shed management practices are in place to reduce the amount of agricultural runoff, the root cause is often due to internal nutrient recycling. Internal nutrient recycling is caused by anoxic conditions in the water phase directly above the sediments. Iron and phosphorous are released from the sediment under anoxic conditions and re-circulated back into the water column where they serve as fertilizers to the algae.

The internal nutrient cycle can be stopped by maintaining aerobic conditions above the sediment. Creating an “aerobic cap” above the sediment will keep the nutrients (phosphorus & iron) bound in an insoluble form in the sediment. Aerobic conditions will therefore reduce the nutrients in the water, thus reducing algae growth. The added dissolved oxygen will also be available for biodegradation of the accumulated organic matter in the sediment, reducing sediment thickness. Over time, under aerobic conditions, the water bodies will be revitalized to before polluted condition. Aerobic conditions will also greatly enhance overall water quality and aquatic life production.
**ECO₂ System Design**

Eco Oxygen Technologies has designed several highly effective SuperOxygenation Systems for rivers, lakes and reservoirs. The ECO₂ SuperOxygenation technology is based upon the scientific principle of Henry’s Law. The Speece Cone is designed to provide enough inlet water velocity to break up the oxygen gas entering the cone. This action forms an intense bubble swarm which has an exceptionally large oxygen/water interface. As the bubble swarm grows, the cone’s diameter increases, thereby reducing the water velocity to a point lower than the buoyant velocity of the bubbles. This prevents the bubbles from escaping and holds them in suspension until they are dissolved.

The ECO₂ System has proven an average 95% efficiency for dissolving oxygen in water. Depending on the pressure in the system, D.O. levels can be increased to 40-150 mg/L or above. There are no internal baffles or static mixers that are prone to plugging, nor are there any moving parts in the cone that would require maintenance.

Conventional aeration systems elevate D.O., but at prohibitively high energy costs and with
limits to the D.O. boost that can be achieved. Typical aeration systems require 2,000 KWHR per ton of dissolved oxygen and realize 25% efficiencies. The ECO2 SuperOxygenation system achieves D.O. concentrations of 40 to 150 mg/l with avg. 95% oxygen absorption efficiency at 400 KWHR/ton of dissolved oxygen. With this system, it is possible to pull a small sidestream from a river or lake, SuperOxygenate it and dilute it back into the main river or lake to satisfy D.O. deficiencies without treating the entire body of water.

The ECO2 SuperOxygenation system can be installed in a small footprint, above or below water lines or even mounted on barges which can then be moved wherever and whenever needed. The flexibility and efficiency of the ECO2 system make it the technology of choice for meeting D.O. discharge requirements and aiding in the recovery of impaired rivers and lakes. The ECO2 SuperOxygenation system, a simple process with no chemicals and no moving parts other than standard industrial water pumps results in a robust, reliable, flexible, economically competitive and environmentally-friendly technology.

**Company Profile**

ECO2 SuperOxygenation systems for water and wastewater treatment are designed and produced by Eco Oxygen Technologies, LLC, headquartered in Indianapolis, Indiana. Founded in 2002, ECO2 built a business on being an environmentally friendly alternative to traditional aeration and chemical treatment for water and wastewater. Focusing on Dissolved Oxygen Supplementation through SuperOxygenation, we have helped cities across the country solve their needs in both municipal and industrial applications by providing custom designed and engineered systems.

The ECO2 patented design concept is based on the pioneering efforts of Dr. Richard Speece, the lead technologist and gas transfer expert who heads ECO2 research and development. Dr. Speece, Centennial Professor of Civil and Environmental Engineering at Vanderbilt University, invented the Speece Cone, a device originally used to add dissolved oxygen to the bottom of lakes to enhance downstream fisheries. The Speece Cone is designed to increase the solubility of oxygen in water, based on the scientific principle of Henry’s Law.

In addition to Dr. Richard Speece, Dr. George Tchobanoglous serves as a technical advisor and Board member for ECO2. A national authority on water quality management, Dr.
Tchobanoglous is a Professor Emeritus of Environmental Engineering in the Department of Civil and Environmental Engineering at the University of California at Davis. His principal research interests are in the areas of wastewater treatment, wastewater filtration, UV disinfection, aquatic wastewater management systems, solid waste management, and management for small systems.

*Example of a System Installed on Savannah Harbor, GA*