



## Terra Systems Microbubbler Oxygen System

Terra Systems Microbubbler Oxygen System is an oxygen-generating system, which adds oxygen to the groundwater for enhanced aerobic bioremediation at sites typically contaminated with petroleum hydrocarbons (BTEX, PAHs, TPH), fuel oxygenates and related compounds (MTBE, TBA). The Basic Microbubbler unit provides the necessary supplemental supply of oxygen for the aerobic microorganisms in the aquifer at the rate of 24 pounds of oxygen per day (8,723 lbs/year) in the form of a 2-micron bubble.

### Key Communication Points

- The Microbubbler produces oxygen on a continuous basis to promote the aerobic biodegradation in groundwater for in situ bioremediation.
- Dissolved oxygen concentrations of up to 40-50 parts per million(ppm) can be achieved through pure oxygen injection, which contrasts to dissolved oxygen concentration limits of approximately 8-10 ppm when the saturated zone is aerated using atmospheric air, which contains approximately 21% oxygen. (USEPA, 2004)
- Pure oxygen is most commonly introduced
- Proven effective for the remediation of hydrocarbon contaminants like petroleum hydrocarbons (BTEX, PAHs, TPH), fuel oxygenates and related compounds (MTBE, TBA).
- Suitable for sites with low to moderate levels of contamination
- Minimal maintenance
- Safe – low pressure operation; eliminates hazardous handling and storage.
- Ease of installation – plugs directly into a 120 V outlet (requires access to electricity)
- Reliable – eliminates irregular deliveries of purchased oxygen
- Continuous release of oxygen to the aquifer
- Low cost of oxygen delivered to the groundwater.
- Injected directly into the aquifer via a proprietary microbubbler sparger



Photo of the proprietary sparger being inserted into the injection well.

130 Hickman Road – Suite 1 – Claymont – Delaware – 19703

For More Information Call Michael Free at 302-798-9553 or Email: [mfree@terrasystems.net](mailto:mfree@terrasystems.net)



## How it Works

Aerobic bioremediation requires the addition of oxygen to the aquifer in order for the aerobic microorganisms to breakdown hydrocarbon contaminants like petroleum hydrocarbons (BTEX, PAHs, TPH), fuel oxygenates and related compounds (MTBE, TBA). The Basic Microbubbler unit provides oxygen to the water continuously.

The oxygen flow rate for the Microbubbler Oxygen Generator is 12 scf/hr or 0.996 lbs per hour. Operating 24 hours per day, the unit will supply approximately 23.9 lbs. of oxygen per day or 8,723 lbs. per year. This results in the delivery of low cost oxygen to the groundwater.

By comparison a gas infusion unit such as an iSOC unit provides approximately 0.063 lbs. per day of oxygen per well (according to the literature a 40 c.f. cylinder will last for ~50 days) . On an annual basis, that is 23 lbs. per year of oxygen.

The stoichiometry of hydrocarbon degradation is 3 lbs. of oxygen per 1 lb. of hydrocarbon degraded. There are 3 basic forms of oxygen that can be delivered to the subsurface:

- gaseous (air, pure oxygen and ozone)
- liquid (hydrogen peroxide)
- and solid (metal peroxides)

The Microbubbler Oxygen System specifications are as follows:

### **Oxygen Generator**

#### Product Characteristics

Standard Product Flow: 12 SCF/hr.<sup>1</sup>  
Standard Product Pressure: 0 – 15 psig  
Minimum Product Purity: 90%  
Product Dew Point: -100° F

#### Ambient Operating Conditions

Locate the oxygen generator in a well-ventilated area that is protected from weather elements and remains between 40° F and 112° F.

Photo of the inside of the trailer with three microbubbler systems installed.



<sup>1</sup> SCF (Standard cubic foot) gas measured at 1 atmosphere and 70° F.



### Control Power Requirements

120 V ~ ± 10%, 50/60 Hz, Single Phase, 4 A  
220 V ~ ± 10%, 50/60 Hz, Single Phase, 2 A  
Typical Power Consumption (at 90% purity): 350 W

### Physical Characteristics

Dimensions (W x D x H): 17.25 x 10 x 26.75 in.  
Weight: 55 lb.

### Physical Connections

Product Gas Outlet: ¼" NPT/B size oxygen adapter

### Sound Level

55 dba @ 1 meter, open field conditions

### Certifications and Approvals

NRTL certified compliance to UL 3101.1, CSA, CE Compliant

### Warranty

1 Year Parts and Factory Labor<sup>2</sup>

## **Micro-bubble Sparger**

Bubble size: 2 microns  
Flows of up to 10 lbs./hr.  
Construction material: Stainless Steel – porous  
Physical Connection: ¼ " NPT hex nipple

We recommend that no more than three micro bubble spargers be connected to one oxygen generator. The cost for this system is as follows:

Oxygen Generator Purchase	\$2,550 ea.
Micro-bubble sparger purchase	\$495 ea.
Oxygen Generator Monthly Rental	\$600 ea.
Micro-bubble sparger purchase	\$495 ea.

---

<sup>2</sup> An unprotected or inadequately ventilated environment or improper control power may cause damage to the oxygen generator not covered under warranty.



## MICROBUBBLER SYSTEM BENEFITS

The primary advantage of the TSI Microbubbler is the low cost of oxygen delivered to the groundwater. The oxygen flow rate for the Microbubbler Oxygen Generator is 12 scf/hr or 0.996 lbs per hour. Operating 24 hours per day, the unit will supply approximately 23.9 lbs. of oxygen per day or 8,723 lbs. per year.

The gas infusion unit (iSOC) provides approximately 0.063 lbs. per day of oxygen per well (according to the literature a 40 c.f. cylinder will last for ~50 days) . On an annual basis, that is 23 lbs. per year of oxygen. A rough cost comparison for one unit in one well is as follows:

Description	Microbubbler	iSOC
Capital Cost	\$3,000	\$4,500
Electricity	\$365	\$0
Cost of oxygen cylinder <sup>1</sup>	\$0	\$325
Cost of technician <sup>2</sup>	\$1,000	\$2,000
Cost per lb. of oxygen for 1st year	\$0.50 per lb	\$297 per lb
Cost per lb. of oxygen for 1st year	\$0.16 per lb	\$101 per lb

<sup>1</sup>Assumes 8 cylinders per year at a cost of \$25 per unit plus one time cylinder purchase of \$150.

<sup>2</sup>assumes \$250 per site visit to change oxygen cylinders 8 times per year for the iSOC system. Assumes \$250 per site visit to check Microbubbler system 4 times per year.

The transfer efficiency of the Microbubbler is dependent on groundwater temperature and head pressure. Even if we assume the worst case transfer efficiency (10%, i.e., lose 90% of oxygen through volatilization), the Microbubbler will deliver 872 lbs. of oxygen per year or 38 times more than the iSOC unit at 100% efficiency. The following are our assumptions regarding oxygen costs.

The stoichiometry of hydrocarbon degradation is 3 lbs. of oxygen per 1 lb. of hydrocarbon degraded. The key to cost effective bioremediation is delivering oxygen at the lowest cost as dictated by the site characteristics. When comparing costs, it helps to look at both the product (oxygen) cost and the delivery cost. The product cost increases with the complexity of the “carrier”, i.e. gaseous is the cheapest followed by liquid and then solid. The delivery cost which includes injection wells, recirculation systems, product emplacement, etc., will vary based on the site characteristics.

### Southeast Florida Site Using the Microbubbler

Photo of the site with I-95 behind the hill. The area is fenced off for security. You can see the hoses running from the trailer to the injection wells and the sparger being inserted into the well.



130 Hickman Road – Suite 1 – Claymont – Delaware – 19703

For More Information Call Michael Free at 302-798-9553 or Email: [mfree@terrasystems.net](mailto:mfree@terrasystems.net)