Aeration techniques applied in the treatment of Winery effluent

Winery effluent tends to be low in pH, low in nutrients and has a variable and often high organic load. The conductivity of the waste water is a function of chemicals used at the facility and this too is variable.

The National Water Act of 1999 (Currently under review) currently makes a distinction between discharge to a water resource and disposal via kikuyu irrigation.

For both disposal routes emphasis is placed on sustainable reuse of the water. Irrigation is therefore a primary objective in the treatment of waste water.

Removal of the waste water organic load is the most capital intensive. pH neutralization is relatively inexpensive and reduction of conductivity is best achieved by judicious use of chemicals. Best possible facility management can only partially reduce organic discharge.

Organic load in the waste water is analogous to sugar in coffee. It cannot be filtered out with conventional filtration. Like sugar it is biodegradable and can be removed successfully in a carefully designed biological environment. Typically cellar waste water has organic concentrations, measured in COD units, in excess of 5 g/l. This is many times more than the concentration of domestic sewage which usually has a COD concentration of less than 1 g/l.

Biological treatment has proved to be a viable and cost effective method to remove dissolved organic material from winery waste water. In the biological process, micro-organisms, mostly bacteria and collectively known as biomass, digest and absorb the dissolved organic material from the winery waste water. Dissolved organic material is effectively converted to biomass and the energy biomass requires to exist. Success of the treatment process hinges on the extent to which dissolved organic material is converted to biomass.

Biomass operates best in a pH neutral environment. Chemicals in the waste water can inhibit biomass growth. In spite of these obstacles, biomass is always committed to growth. The way in which biomass digests and absorbs dissolved organic material is complex. A sophisticated cyclic chemical reaction takes place involving the biomass, the dissolved organic material and an electron donor such as, but not limited to, an oxygen or nitrate molecule. The conversion of dissolved organic material to biomass is therefore directly proportional to the availability of an electron donor.

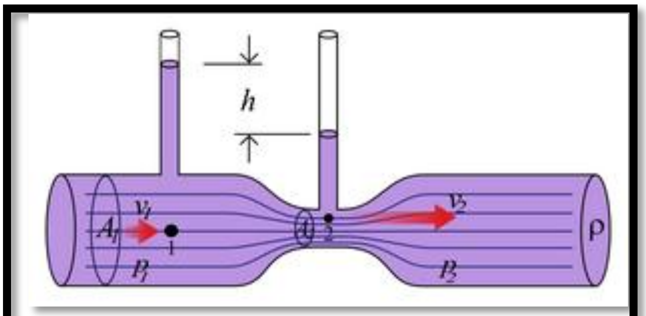
Because oxygen is readily available in air, the use of air as a supplier of an electron donor is the method of choice. There are numerous practical methods that have been developed to inject air into a body of water. In waste water treatment, the holding tank, into which air is injected and which contains waste water and biomass is known as a bioreactor. The ultimate objective of the air injection system is to get as much dissolved oxygen into as much contact with the biomass and dissolved organic material as possible.

In winery effluent treatment, several oxygen injection techniques are in use. The mostly widely techniques currently in use are;

- Venturi injection
- Surface aeration
- Fine bubble diffused aeration

Venturi injection requires a pump to move biomass through a specially constructed pipe that effects a gradual constriction immediately proceeded by a return to the original pipe diameter. At the constriction, the water pressure drops, creating a vacuum. By attaching an external tube to the constriction point, air will be drawn into the resulting vacuum. The combination of pipe, constriction throat and external tube is called a venturi.

This method of aeration has been popular because of its apparent simplicity. The rate at which dissolved oxygen can make contact with all areas of the bioreactor is dependent on the pump flow rate and the venturi size.



Section through a Venturi

Venturi aeration requires considerable pumping capacity to achieve optimal oxygen transfer.

Surface aeration is the method by which the surface of the bioreactor is agitated from a mechanical paddle arrangement. Surface aerators can be mounted on floating or fixed platforms. The resultant aeration zone created by surface aeration tends to be localized at the mechanical paddles.

Surface aeration is an economical method to aerate a large body of water such as a dam or pond. For a bioreactor using surface aeration, the geometry of the bioreactor is extremely important. To achieve good oxygen transfer the bioreactor needs to be cylindrical in shape with a slightly coned shaped base.

Fine bubble diffused aeration makes use of an air blower and diffuser dome arrangement. This method achieves a good oxygen transfer efficiency in almost any shaped bioreactor. Microscopic sized pores on the diffuser split the air supply into a multitude of minute gaseous streams.

When comparing different aeration techniques, oxygen transfer efficiency is an important yardstick. Aeration systems are usually rated by the mass of oxygen transferred per kilowatt hour. The more oxygen transferred per kilowatt hour, the more energy efficient the system. Because it is difficult to get dissolved oxygen into the bioreactor a lot of energy is lost in the process of oxygen transfer. Big bubbles do not necessarily translate to dissolved oxygen.

Aeration technique	Oxygen transfer rate ($KgO_2/kWhr$)
Venturi injection	< 1
Surface aeration	1.2 – 1.8
Fine bubble diffused aeration	2.0 – 2.8

As with all systems, different aeration techniques have advantages and disadvantages. The table below gives an indication of the practical aspects of each aeration technique.

Aeration technique	Legislative compliance	Capital costs	Bioreactor geometry	Mechanical maintenance
Venturi injection	Not easily achieved	Low	No restriction	Low
Surface aeration	Achieved	Medium to high	Limited	Low
Fine bubble diffused aeration	Achieved	Medium to high	Depth limit of 2m	Medium

There is not just one aeration system that can be used for all cellars. Each aeration system requires careful engineering considerations. The table below provides a rough placement guide for cellars.

Aeration technique	Cellar production (tons per annum)
Venturi injection	<100
Surface aeration	>1 000
Fine bubble diffused aeration	> 50

As mentioned above, the relationship between oxygen demand and dissolved organic material is linear. Not surprisingly the oxygen demand increases as cellar production increases. The table below shows typical peak oxygen requirements and compares the installed power requirements for each aeration technique.

Cellar production (tons per annum)	Oxygen requirement (kg O_2/d)	Venturi Injection (kW)	Surface Aeration (kW)	Diffused Aeration (kW)
100	20	2	-	-
1 000	130	13	6	3
5 000	500	51	21	14
15 000	1 400	144	60	41
25 000	1 750	181	75	50

When choosing an aeration system, it is important to know the oxygen demand. This information is usually calculated by the supplier of the aeration system. When comparing aeration systems it is therefore of great importance to know that each system delivers the same amount of oxygen.