Reservoir and dock water management – the role of aeration

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Oxygenation, aeration, and destratification mean different things to different people. Often used as interchangeable terms, arguably their meaning and use have become increasingly confused, particularly when referring to reservoir or dock water management. Frequently artificial mixing or oxygenation schemes are deployed with the aim of controlling algae, particularly the troublesome and potentially toxic blue-greens. In addition, a common objective is to prevent the release of metals, such as manganese that impart unacceptable taste and odour to drinking water. The problem however, is that many schemes have failed, fallen into disuse and certainly would appear to call into question many of the claims made by manufacturers of the kit. The reasons for failure can often be found in a lack of understanding of the root causes of the underlying problems and consequently inappropriate deployment of unsuitable techniques. What then are the differences between these three terms and when should they be used?

First of all it is essential to identify the cause of the problem we are trying to solve. In the case of manganese, it is relatively simple. When present in reservoir sediments for example, zero or low oxygen conditions immediately above the sediment cause conditions to arise that promote manganese release. Typically, this occurs with the onset of stratified water conditions (i.e. thermocline formation) where density differences caused by the sun's heat, effectively cut off bottom waters from the surface layers. Reverse these conditions by providing oxygen-rich waters throughout the water column and manganese will stay 'locked up' within the sediments. The same can be said for several other troublesome substances, including iron, phosphorus and ammonia, these latter two chemicals being key drivers for algal blooms.

One of the primary issues is understanding the microscopic interface between the sediment surface and the water column, the interstitial water. This very fine layer of surface sediments exerts a demand on oxygen in the overlying water, known as the sediment oxygen demand (SOD), similar to that created by the biochemical oxygen demand (BOD) in the water column. It must be satisfied, or like the water column, this interstitial layer will lose all of its oxygen, becoming anoxic. In doing so, a chemical micro-environment is created that facilitates release of the substances we want to lock away.

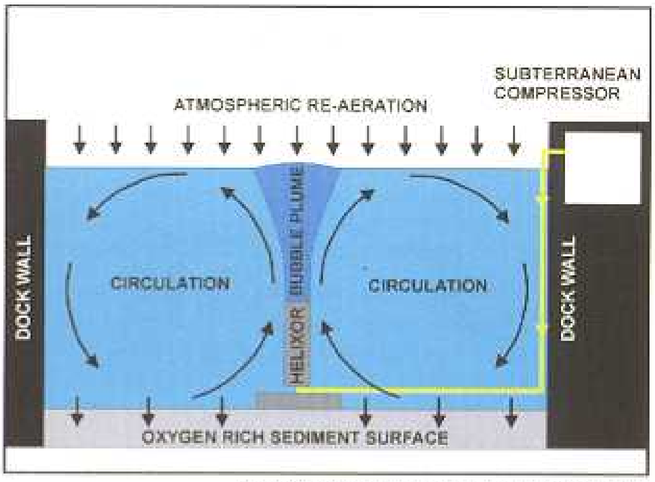
So, a primary objective in reservoir and dock basin management is to maintain oxygen within this surface sediment layer. Where the combined BOD and SOD can't be satisfied and oxygen levels cannot be maintained by natural wind action, some form of artificial intervention is required and this is where destratification, aeration and oxygenation come in.

In extreme cases such as the Manchester Ship Canal and the tidal Thames, the oxygen deficit is so high that only liquid oxygen injection will do. In Manchester, a £4.5 million scheme to maintain a minimum oxygen level of 4mg/l has been in operation for five years, preventing anoxic sediments from releasing nuisance substances and allowing the aquatic ecology to thrive.

However, in most cases, the oxygen deficit is not so severe as to require oxygenation, and the water column and sediment demands can be adequately satisfied by aeration. This can be achieved in one of two ways; either directly from diffusers or indirectly from the atmosphere using destratification systems.

The latter provide atmospheric oxygen utilising artificial mixing of the water column. Oxygen-enriched surface waters are circulated vertically to satisfy the sediment oxygen requirements. Sometimes destratification involves physical mixing using impellors etc, but more often compressed air is used to generate vertical mixing of the water column. A number of 'air-gun' type products and bubble curtain designs are available to achieve this, with varying levels of efficiency. Generally, the oxygen transfer directly from the compressed air itself is only in the order of 10 or 12%, the remainder being derived from atmospheric oxygen.

Hence with destratification, the mixing power generated is the key issue. For a system to operate effectively, the turnover rate must be sufficient to allow atmospheric oxygen to satisfy the combined water column and sediment oxygen demands. Crucially, it is the latter element that is often underestimated or overlooked in destratification installations. If the SOD is not satisfied, the system cannot possibly work. Salford Quays, using a 'Helixor' based approach, is a good example of effective destratification, the system being correctly sized to satisfy all water column and sediment oxygen demands. Similarly, the Roadford Reservoir destratification 'bubble curtain', after appropriate modification from the original underpowered design, has proved extremely effective in maintaining bottom water dissolved oxygen levels.



Destratification schematic, using a Helixor system, as used in the enclosed basins at Salford Quays

These destratification systems differ fundamentally from direct aeration devices. Aeration systems are not as reliant on atmospheric oxygen, but in large part utilise oxygen directly from the compressed air itself. The various commercial products available, ranging from carborundum stones and micropore discs to diffuser hoses, basically operate on the same principle. The objective is to produce the smallest bubble size possible and maximise contact time to facilitate optimum oxygen transfer. Depending on the product and the depth of waterbody, laboratory based trials have shown oxygen transfer efficiencies can be as high as 47%, but figures around 10 to 15% are more typical in field conditions. Although there are many examples of this type of approach, for example Cardiff Bay, generally compressed air based diffusion alone is not sufficient to satisfy all oxygen demands. They are more appropriate for high density, maximum contact applications such as those required in secondary sewage treatment, where sewage derived water column BOD and ammonia reduction are often the primary targets.

To summarise, the key objective in preventing release of troublesome substances from sediments is to satisfy the sediment and water column oxygen demands. This is most commonly achieved using atmospheric oxygen via destratification, overcoming the layering effect of the thermocline. However, a common misconception is that the mixing effect afforded by destratification will also control algae. In some specific circumstances this may be true, for example in what are regarded as 'optically deep' reservoirs and lakes, where moving the algae into deep dark waters will prevent photosynthesise and result in cell death. However, sufficiently deep waters, particularly in docks and reservoirs are not the norm. Frequently inappropriate mixing will merely make matters worse, in effect maximising

A destratification system is in place at South West Water's Roadford Reservoir

algal productivity. The answer as to why this occurs requires a basic understanding of algal biology and habitat requirements, as distinct from the chemical environment surrounding the microscopic water/sediment interface layer discussed above.

It is true that some algal species, for example the blue green algae *Aphanizomenon*, can be controlled by artificial mixing. This is a raft forming species, often seen at the waters surface in defined colonies. Vigorous mixing in effect disrupts the colonies, eliminating the still, quiescent conditions that allow the algae to proliferate, replacing them with surrogate 'stormy' weather that does not allow this species of algae to prosper. By way of stark contrast other blue-green algae such as *Oscillatoria*, favour well mixed conditions, tending to appear in natural lake systems during the autumnal overturn, when the equinox gales induce natural stratification. These are precisely the conditions experienced by the algae during artificial mixing. In other words, by introducing artificial mixing the growth of certain species of blue-green algae will be promoted rather than controlled. Thus, alternative or additional control strategies for certain types of troublesome algal blooms need to be considered, catchment nutrient flux controls being the most obvious.

To conclude therefore, oxygenation, aeration and destratification all have a significant part to play in controlling the release of undesirable substances from sediment and in specific circumstances, the control of algae. However, before deployment, it is essential to understand the problem you are trying to cure. If bottom water anoxia is the problem, ensuring that the oxygen demands of the water column and sediment are known is essential in designing a system with sufficient oxygen delivery and/or mixing power to satisfy these demands. Otherwise, whatever method is chosen will be doomed to failure. Similarly, knowledge of the algal species you wish to control and their favoured growth requirements, together with a detailed understanding of the environmental drivers which cause the algae to bloom in the first place, are crucial in order to assess whether artificial mixing is appropriate. Failure to understand the basic biology and control mechanisms may mean that you merely turn your waterbody into a very effective algal growth vessel – a green laboratory of massive proportions.

For further information, contact APEM Aquatic Scientists on Tel: 0161 226 2922, E-mail: apem@apemltd.co.uk or visit: www.apemltd.co.uk

New Newton Gravity Aerator launched

Last year, Newton Industrial Group launched its brand new patented gravity aerator for reservoir aeration and de-stratification. It has the potential to aerate and de-stratify a large water body whilst using being energy efficient and easily maintained.

Like all good ideas, simplicity is the essence of the new aerator, which uses gravity as the driving force to efficiently oxygenate water. Its patented design reduces energy requirements by 50% compared to current aerators. Its capital cost is also lower and maintenance is reduced to a minimum.

The Newton Gravity Aerator is unique, as it utilises gravity as the driving force to force air bubbles into water and then thoroughly mix the air and water in a bubbly column. The aerated water is then discharged at any depth within a reservoir or lake. This action effectively de-stratifies the reservoir and ensures that anoxic conditions do not develop.

Each aerator is built on a floating platform and can be manoeuvred across the reservoir or travel automatically along a pre-defined path. Its manoeuvrability and the use of an energy-efficient, high flow pump results in the aerated water being spread widely across the whole reservoir.

For further information, contact Newton Industrial Group on Tel: 0151 632 4780 or visit: www.newtongroup.co.uk