<u>THE OXYGEN CONTROLLED PACKAGE PLANT APPROACH</u> ©

Package treatment systems can present a difficult problem with regard to maintaining good settling activated sludge qualities while at the same time meeting the ever increasing demands from the EPA to lower nutrient levels in the discharge. Sporadic flows, feast or famine conditions can cause considerable problems.

The primary organisms responsible for good settling properties of activated sludge such as rotifers and free and stalked ciliates can become stressed if they are starved of nutrients or oxygen for extended period of time. Nutrient phosphate removal or "luxury" phosphate removal is predicated on the organisms health and stress free condition. If the organisms are not in a well-maintained condition, "luxury" phosphate removal may not be optimal.

Ammonia nitrogen removal is a constant headache if incomplete nitrification/ denitrification happens in the aeration basin. Research on our package plants has shown that optimal removal of nitrogen and ammonia is the key to all other nutrient removal such as carbonaceous BOD and phosphate. For this key to be properly used, oxygen must be controlled in the basin. A somewhat detailed discussion of nitrogen ammonia must be presented in order to fully appreciate the relationship of oxygen to ammonia nitrogen removal.

I. PACKAGE PLANTS AND NUTRIENT REMOVAL OF NITROGEN AMMONIA

As the number of wastewater discharges increase in particular receiving water the removal of nutrients such as nitrogen ammonia and phosphorus become more important. If these nutrients are present in large concentrations, oxygen can be stripped from the water and fish and aquatic life can be negatively impacted.

Operators of package type treatment systems need to understand that nitrification and denitrification are both necessary in order to remove ammonia nitrogen from these plants. Most operators, however, do not fully understand that nitrification happens when D.O. ranges between 1.0 – 4.0 PPM while denitrification happens at near 0 PPM D.O.

In the nitrification process "nitrosomonas" bacteria can convert nitrogen ammonia to nitrite ($NH4+ \rightarrow NO2-$). The nitrite is further converted to nitrate ($NH\ 2- \rightarrow NO3-$) by nitrobacter bacteria. This two step process happens in D.O. typically between 1.0 – 4.0 PPM and is called the nitrification process. The problem the operator now has is that the nitrate (NO3–) must be removed because the nitrate is still a nutrient. The biological solution is to turn the nitrate (NO3–) to nitrogen gas or nitrous oxide so it will be expelled into the air. This is also problematic because the bacteria strong enough to achieve this process which is called denitrification, are heterotrophic bacteria. These bacteria live in 0-PPM D. O. conditions. Some operators are convinced they can over aerate and strip the ammonia

out. At a pH > 10 this would be true, but the biological health of the basin would be compromised. The effluent could be raised to a pH > 10 and protect the basin but it would require chemicals and hardware to do this and the pH would have to be lowered after stripping and before discharging.

The stage is now set for frustration and anxiety. The operator must keep the treatment facility in aerated conditions in order to remove phosphorus and carbon based nutrient (BOD) but cannot effectively remove the ammonia nitrogen because the bacteria that will do this live at near 0-PPM D.O. These two D.O. conditions are opposite and worse, neither condition can be held for very long if nitrogen ammonia is to be removed. If denitrification happens in the clarifier and not the basin an upset condition could exist. Complete nitrification and denitrification must be accomplished in the aeration basin.

The best solution, which uses the process of nitrification/denitrification for these package plants, is to hold the O2 concentration between 1.0 – 4.0 PPM and then let it fall to near 0 PPM (.01 -. 1ppm). This can be accomplished by using a D.O. controller that can keep the oxygen cycling between these two conditions. However, only recently has the technology been available to do this, even though D.O. controllers have been around for over 50 years.

The old technology based probes are galvanic or polargraphic in their operation. Oxygen controllers that use the old type technology incorporated into the probes are not acceptable for this purpose. They consume oxygen and have to be constantly serviced and replaced. The consumption of oxygen by this type of probe requires an artificial flow when the air is turned off in order to obtain a reading. Other gases also poison the probes internally due to the fact that they will pass through the controller's membranes. This type of probe performs very poorly at the low D.O. required for waste treatment encountered in the activated sludge process.

The future of nutrient removal by controlling the oxygen levels to promote nitrification and denitrification will belong to non-consumptive, passive type probes which will not require flow or constant maintenance. Fluorescent probes will meet the criteria for nitrification/ denitrification ammonia removal while also treating BOD nutrients and phosphorus. Time clocks are hit or miss. A good bet would be to take odds that 90% of all package plants which service bedroom communities in the winter time are grossly over aerated at midnight and are starved for oxygen in the morning.

II. THE RETURN SLUDGE PROBLEM WITH CONTROLLERS

As one would predict, no solution comes without a price or other problems. Controllers using new fluorescent technologies are expensive.

There is also the return sludge problem. Most package plants will return sludge from the clarifier to the basin only when the aeration blower is being used. In the wintertime when the solubility of O2 is high due to temperature, the aeration basin can be satisfied in its oxygen demand using a controller. However, the return sludge did not return enough solids from the clarifier to effectively mix the solids from the clarifier to the aeration basin. In the summer this is not as much of a problem because the solubility of O2 is a lot lower and the controller has to work the aeration system a lot longer to get the O2 satisfied in the basin. This results in more time to return solids to the aeration basin.

One solution for these problems is a smaller dedicated blower to return sludge from the clarifier to the aeration basin independent of the status of aeration in the aeration basin. No package plant should be installed without this. State bureaucracies in the past have allowed this to happen at the expense of the operator and the environment.

Another solution is to use a time clock in parallel with the controller so that either the time clock or the controller can operate the aeration and sludge returns. The time clock can be set to provide a minimum of sludge return time while the controller can provide the control between low oxygen conditions and higher oxygen conditions for nitrification and denitrification for ammonia removal.

III. CONLUSIONS

In out test facility, which is a permitted facility, our research has shown that phosphorus and ammonia removal, as well as BOD can be accomplished with fluorescent based oxygen controllers while at the same time maintaining populations of good settling species such as rotifers, stalked and free ciliates.

By maintaining an oxygen concentration between low and high concentrations the bacteria responsible for removing ammonia nitrogen are optimized. These low and high conditions also maintain well-adjusted non-stressed populations of bacteria, which will remove carbonaceous BOD and 'luxury "removal of phosphorus. More importantly, the clarifier is not at risk of a denitrification condition. Proper placement of the probe at the front of the plant with independent sludge return control ability is an ideal solution for package plants.

The future of waste treatment lies in Fluorescent oxygen technology, which can be incorporated directly onto a fixed film stationary surface. Specific bacteria will be engineered and adapted for specialized treatment to support specific problem areas in large treatment systems or small ones.