Wastewater treatment optimization with micronutrients

By Derk Z. Maat

Municipalities and industries have used biological wastewater treatment plants for many years. All are faced with the challenge of treating, separating and disposing of biosolids. A significant portion of operating costs for a wastewater treatment plant is related to providing aeration for various activated sludge processes and to dewatering, handling and disposing of biosolids.

The activated sludge process requires aeration to stimulate aerobic bacteria to feed on the organic content in the wastewater.

Biological decomposition of organic waste

The breakdown of dissolved and solid organic wastes is accomplished in a wastewater treatment plant (WWTP) by a wide variety of bacteria that are naturally present. Different groups of bacteria have unique growth requirements and different macro-and micronutrient needs. They often compete for the same growth substrate and organic feed materials. At times, the availability of specific micronutrients (vitamins and/or minerals) is the limiting factor for bacterial growth. For this reason, the input of select micronutrients can cause significant, beneficial changes to the nature and efficiency of dominant bacterial populations.

Dissolved and solid organic waste in wastewater treatment plants is degraded by bacteria that are generally classified by their ability to survive and multiply in the presence, or absence, of oxygen. Aerobic bacteria function in the presence of oxygen; anaerobic bacteria function in the absence of oxygen. Facultative bacteria are able to function in either presence or absence. All biological WWTPs include one or more of the three main bacterial groups.

Typically, the rate-limiting step in removing organic solids from wastewater is hydrolysis. A major contributing factor to this problem is that hydrolyzing bacteria are not functioning at full capacity due to micronutrient limitations.

Activated sludge

Many WWTPs employ an activated sludge process as a key treatment step. The activated sludge process requires aeration to stimulate aerobic bacteria to feed on the organic content in the wastewater. Typically in an activated sludge processes, 50% to 75% of the acetic acid generated by the acidifying bacteria is converted to new aerobic biosolids, which must be processed and disposed of.

To process, dewater and dispose of biosolids is a challenge for all aerobic wastewater plants and represents up to 40% of all operating costs. In addition, the energy cost to operate aeration equipment for this process can represent up to 30% of plant operating costs.

Anaerobic and facultative processes

Anaerobic processes utilize bacteria that degrade dissolved organic material in the absence of oxygen. Facultative bacteria use either dissolved oxygen, or oxygen obtained from sulfate or nitrate ions. This allows them to live under aerobic, anoxic, or anaerobic conditions. Anaerobic and facultative bacteria generate much fewer biosolids from acetic acid than aerobic bacteria. They convert a much larger proportion of organic compounds to gases, rather than to new biosolids. In the anaerobic process, methane producing bacteria and sulfate reducing bacteria compete for available dissolved organic compounds, producing hydrogen sulfide and/or methane and carbon dioxide.

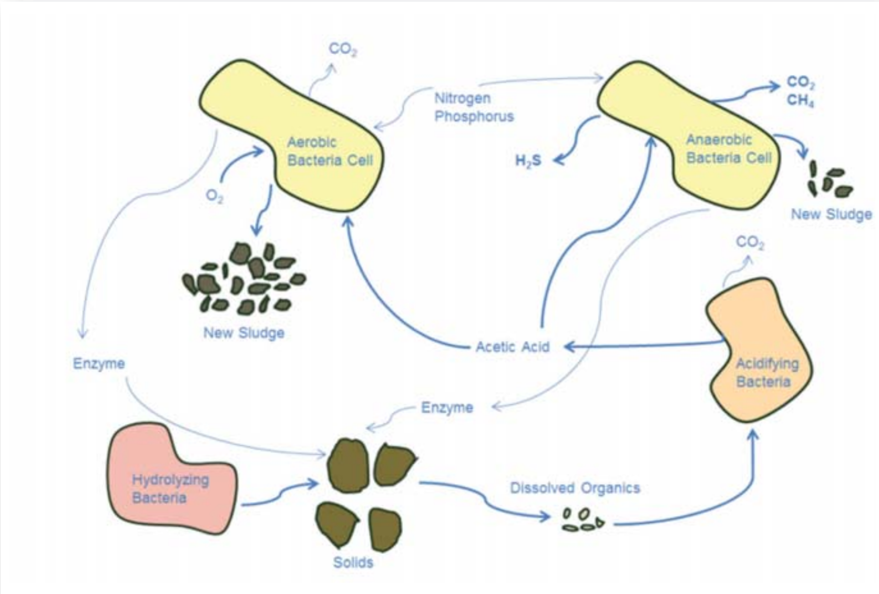
The generation of hydrogen sulfide (a noxious gas) and ammonia by certain anaerobes causes odour and has the potential to cause problems for adjacent property owners, discomfort for operators and corrosion issues with plant equipment. Management of odours is a challenge faced by most WWTPs.

Utilizing micronutrients to reduce wastewater treatment plant operating costs

Specific plant-based organic micronutrients have been demonstrated to stimulate many types of bacteria. The technology has been used worldwide to reduce energy costs associated with oxygen supply to the bacteria, decrease sludge generation, reduce odours and improve treatment efficiency. Micronutrients have been effectively applied in WWTPs that range in size from high-capacity municipal and industrial plants to very small, low-flow package ones, as well as many holding tank and waste storage/portable toilet applications.

Once these micronutrients are made available to the biological community in wastewater, metabolic rates of specific bacterial populations are dramatically increased.

The beneficial impact of micronutrients is most significant for facultative anaerobic populations. The micronutrients enable facultative anaerobes to actively break down organics in the non-aerated portions of WWTPs that are not typically designed to function as reactors, such as equalization or settling tanks. This makes the entire plant more efficient. As a result, a much greater proportion of acetic acid is converted by facultative anaerobes to atmospheric gases, instead of additional biosolids. This also results in a significantly lower oxygen demand in aerobic bioreactors because a significant portion of the acetic acid load is diverted from the pure aerobes to the facultative anaerobes.



Biological reactions in aerobic and anaerobic facultative environments.

The net effect is lower volumes of sludge/biosolids requiring processing and disposal, and a lower energy demand for aeration. Facilities using this approach have experienced a reduction in the volume of biosolids/sludge requiring disposal and in energy costs in excess of 25%. The net cost savings to

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	Location	Description	Reduction in Energy Consumption	Biosolids Reduction	Comments
1	Large food processor WWTP, Brampton Ontario	11,000 m^3/day activated sludge plant (three month detailed study comparing operating data pre and post treatment)	25%	26%	Significantly improved effluent quality, improved SVI
2	Municipal treatment plant, North Carolina	22,700 m^3/day conventional municipal wastewater treatment plant	Not available	34%	Significantly improved effluent quality, ammonia removal
3	Municipal WWTP, Prince Edward Island	3,000 m^3/day RBC plant with aerated lagoons	50%- (allowed for shut down of one of two blowers)	In excess of 50%	Inventory of accumulated biosolids completely removed; slime on RBC discs removed; much lower turbidity and TSS
4	Hog farm, Steinbeck, Manitoba	Long term hog waste storage lagoon (4,500 m^3 primary cell) – trial carried out for six weeks	Not available	21%	The operator estimated that the application recovered up to 946 m^3 of storage out of the 4,500 m^3 primary cell
5	Canadian Forces Base	Facultative sewage lagoon	Not available	82%	A measurement of the sludge blanket level before and after product application resulted in an overall sludge volume reduction of 82%
6	Everton, Ontario	RBC plant	Not available	Not measured	Significant removal of FOG and slime on biological contactors
7	Nairobi, Kenya	Oxidation ditch (significantly overloaded)	In excess of 50% (reduced operation of brush aerator to less than three hours per day)	Not Measured	Significant reduction in sludge depth, removal of all odours, significantly increased supernatant clarity

Treatment results at a range of wastewater treatment plants.

the treatment plant typically range from $1.50 to $2 for every $1 spent on organic micronutrients.

Inhibition of ammonia and hydrogen sulfide producing bacteria

The same organic micronutrients have been found to significantly reduce generation of ammonia and hydrogen sulfide gas by anaerobic bacteria. Studies have shown that the presence of micronutrients creates conditions that allow methane producing bacteria to compete with hydrogen sulfide producers for available carbon and other nutrients.

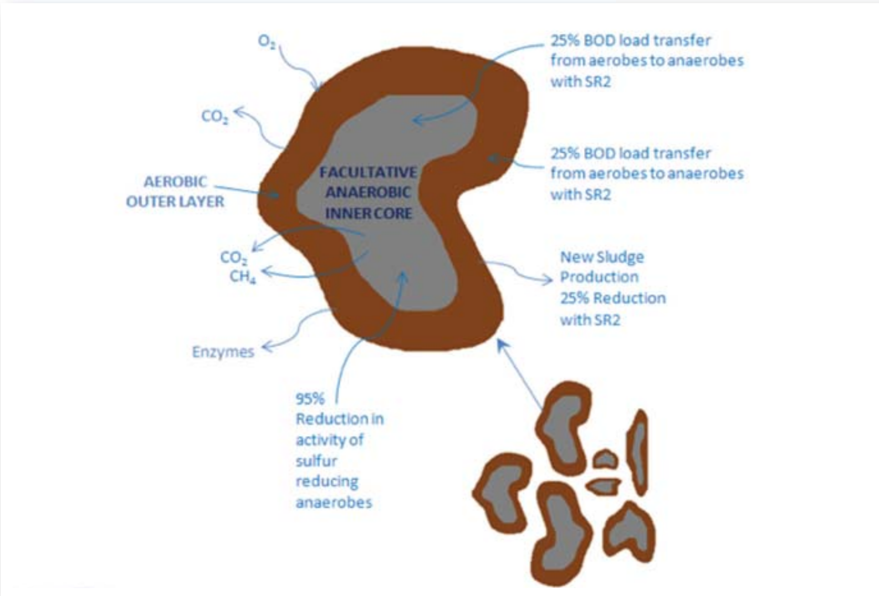
In addition, the micronutrients have been shown to block the activity of the enzyme urease. Its blockage prevents urea present in the wastewater from being converted to volatile ammonia. This effect has also been observed when the product has been added to hog farm waste, resulting in a 75% decrease in volatile ammonia in barn environments.

Conversion of holding tanks to biological treatment zones

Typically, the micronutrient is added as a liquid at the head works of a plant, in a wet well, equalization tank or anoxic biological nutrient removal reactor. Micronutrient addition has the effect of converting holding tanks (equalization tanks, primary clarifiers), where typically there is little bioactivity under normal conditions, into more active anoxic treatment zones. The micronutrients stimulate hydrolysis of organics in sections of the facility that do not typically undergo biological treatment.

Evidence of this phenomenon at treatment plants that use the product is the formation of fine bubbles at the surface of the wastewater in holding tanks and/or primary clarifiers. In addition, the presence of the micronutrient in wastewater prevents odour production at these locations and results in the removal, over time, of accumulated fats, oils and grease. Benefits also include improved effluent quality, including BOD, TSS, NH_3, P and turbidity.

Benefits have also been observed when the micronutrient has been applied to anoxic lagoons and/or holding ponds. In these cases, removal rates of accumulated biosolids have been significant and the clarity of the effluent has been improved. Sludge reduction rates have been observed to be in excess of 80% of accumulated sludge volumes over a period of time, in municipal applications, resulting in significant savings in dredging costs.



Impact of SciCorp BIOLOGIC® on biological reactions in flocs.

Impact of micronutrients on activated sludge

The activated sludge process is designed to promote formation of microbial flocs in aeration tanks to aerobically metabolize dissolved organics in wastewater. Bacteria in the outer portion of the floc are comprised of aerobic bacteria. However, the inner portion of the floc becomes a localized anoxic environment. This occurs as a result of oxygen being stripped from the wastewater by the outer aerobic zones of the floc as wastewater passes through it. Under typical conditions in an aeration tank, bacteria in the inner regions of the floc cannot efficiently contribute to breakdown of the organics.

However, this changes in cases where these organic micronutrients are present in the wastewater. Micronutrients are able to stimulate the facultative bacterial populations in the inner portions of the floc to more actively feed on the acetic acid. This results in a higher percentage of it being converted to methane and carbon dioxide instead of additional biosolids. As discussed earlier, this has the effect of reducing oxygen demand and reducing the amount of biosolids that are generated.

The activated sludge process is designed to promote formation of microbial flocs in aeration tanks to aerobically metabolize dissolved organics in wastewater.

Environmental considerations

The plant-based micronutrients described in this article are manufactured and sold by SciCorp International Corp. under the BIOLOGIC SR2 brand. BIOLOGIC SR2 has been tested and certified non-toxic by leading toxicity laboratories (Tox Monitor/BSR, Inc., Illinois). The product is certified within the EcoLogo program, North America's largest, most respected environmental standard and certification mark.

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