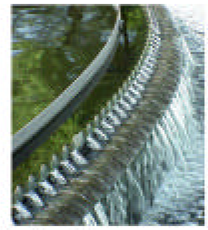
Environmental Leverage Inc.

Turning Liabilities into Leverage

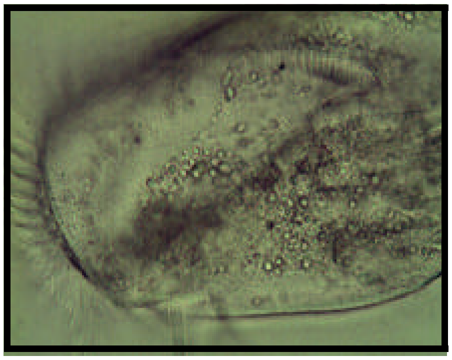


May 2009

The Wastewater Insight

The wastewater insight

MYSTERY BUG OF THE MONTH



We started this month out with a new

Mystery Bug of the month!

Check out our website for more photos of our new mystery bug!!!! WWW.EnvironmentalLeverage.com

Inside this issue:

Ferric, Alum or Lime-Why they are used in plants and how they can impact your process?

Many plants add Alum, lime, or iron salts to the wastewater to remove phosphorus by sedimentation or clarification. This process can reduce the concentration of phosphate by more than 95 percent.

Some plants use lime or Ferric sulfate for pH adjustment and some plants use Ferric as a "micronutrient" addition. The problems associated with the use of chemicals are their affinity to bind phosphorus. How much phosphorus is removed due to interaction with these chemicals, versus how much is needed by the bacteria as a nutrient source and how much interference the chemicals have on the impact of the biological process.

Very few plants have a tertiary clarifier for nutrient removal. Many plants add these chemicals directly to the secondary clarifier. The problem with this is over addition of chemicals that are returned in the RAS back to the front of the plant, causing an actual nutrient deficiency in the plant.

Requirements for chemical usage for Phosphorus removal:

Chemical treatment for phosphorus removal involves the addition of metal salts that react with soluble phosphate and form solid precipitates that are removed by solids separation processes such as clarification and filtration. Phosphate precipitation is achieved by the addition of metal salts that form sparingly soluble phosphate compounds. The common metals used are aluminum, iron and calcium. These salts are most commonly employed in the forms of lime ($Ca(OH)_2$), alum ($Al_2(SO_4)_3$), sodium aluminate ($NaAlO_2$), ferric chloride ($FeCl_3$), ferric sulfate ($Fe_2(SO_4)_3$), ferrous sulfate ($FeSO_4$), and ferrous chloride ($FeCl_2$). Simplified versions of chemical precipitation reactions are shown as follows for illustrative purposes (Tchobanoglous et al., 2003).

Phosphate precipitation with aluminum:

$Al_2(SO_4)_3 . 18H_2O + 2H_3(PO_4) = 2Al(PO_4) + 3H_2SO_4 + 18H_2O$ (1)

Phosphate precipitation with iron:

$FeCl_3 + H_3(PO_4) = Fe(PO_4) + 3HCl_3$ (2)

Phosphate precipitation with calcium:

$10Ca(OH)_2 + 6H_3(PO_4) = Ca_{10}(PO_4)_6(OH)_2 + 18H_2O$ (3)

Equations 1 and 2 suggest that one mole of aluminum or iron will precipitate one mole of phosphate, but the reactions are much more complex than that. Along with these reactions, complex aluminum hydroxide and ferric hydroxide compounds are formed. Thus the precipitation reaction is not stoichiometric. Where the final phosphate concentration is high, the reaction is closer to the 1:1 stoichiometric ratio, but when low final effluent phosphorus concentrations are required (< 1.0 mg/L) there are more competitive reactions with the hydroxide formations and the molar ratio metal salt to phosphorus removal substantially increases.

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The pH value is also an important factor for efficient removal of phosphorus using alum or other salts, as the solubility of their precipitates varies with pH. For alum, minimal solubilities occur in the pH range of 5.0 to 7.0 and for ferric in the range of 6.5 to 7.5. Iron and aluminum phosphate-containing sludge have been reported to be treated successfully in anaerobic digestion and sludge dewatering processes without phosphate release (Sedlak, 1991). The optimum pH for P removal using alum ranges from 5.5 to 6.5, but in typical wastewaters, it ranges from 6.0 to 9.0. Ferric chloride is most effective in removing P when the pH ranges from 4.5 to 5.0, with typical values of 7.0 to 9.0.

The addition of alum and ferric salts consumes alkalinity. Therefore, for some wastewaters, depending on their initial alkalinity, alkalinity addition may be necessary to offset the alkalinity consumption by the metal salts to maintain the pH level required for the wastewater treatment processes. An alternative for alum is polyaluminum chloride, which does not consume alkalinity, but is more expensive than alum.

For lime addition, Equation 3 shows that the calcium reacts with phosphate to form calcium apatite (Ca10(PO4)6(OH)2). The formation and precipitation of apatite requires a high pH, and thus the reaction of lime with the wastewater first includes a water softening step in which calcium carbonate is formed, producing large amounts of sludge. Because of scaling problems associated with using lime, the large amount of sludge production, and the impact on pH, lime addition is seldom used for phosphorus removal in wastewater treatment.

All of these chemicals generate large volumes of light inorganic sludge:

Each pound of liquid as alum produces 0.127 pounds of dry aluminum sludge, with a slight variation depending on the alum concentration

Each pound of liquid as ferric chloride produces 0.2677 pounds of dry iron oxide sludge, with the same slight variation

The lime will combine with the alum sulfates but will have varying degrees of solubility up to 2000 ppm so you may not see it as sludge. The lime combines with the chlorides to form a loosely bound salt, in itself a coagulant. Lime generates one pound of sludge per pound lime added.

Nutrient requirement for biological growth: Within a biological (Secondary) wastewater treatment system, heterotrophic bacteria (bacteria which utilize/degrade carbon molecules as a food substrate, i.e.; BOD) require a number of nutrients in their diet to maintain growth and reproduction. A typical bacteria cell contains:

Bacteria Cell

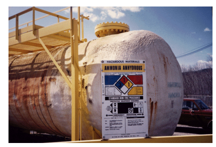
↓

80% Water | **20% Dry Matter**

↓

90% organic / 10% inorganic

organic ↓	**inorganic** ↓
53% carbon	50% P_2O_5
29% oxygen	15% SO_3
12% nitrogen	11% Na_2O
6% hydrogen	9% CaO
	8% MgO
	6% K_2O
	1% Fe_2O_3

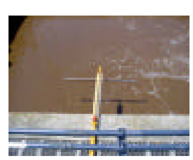


Therefore, it is obvious that the major nutrient requirements for a bacteria in addition to the carbon and water (H2O) are nitrogen (12% of the 90% organic = 10.8% of the total dry weight), and phosphorus (21.5% of 50% x 10% = 2.15% of the inorganic content). The other micronutrients are generally not a limiting factor as they are usually available in the trace amounts needed.

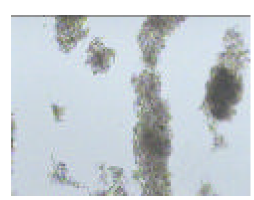
The general rule is that a system will need 5 parts of Nitrogen and 1 part of phosphorous for every 100 parts of BOD to be degraded. This is true for a conventional activated sludge system (such as a municipal sanitary WWTP), however, with a young sludge age (such as during a plant start-up or a BOD shock loading) the ratio would be 100 to 7 to 3 and for an extended aeration system (such as in an industrial treatment facility) the ratio would be closer to 100 to 3 to 0.5.

So, although permit requirements are tightening up, and excess ammonia and phosphorus are not good to be released into the environment, sufficient nutrients are required or you will grow filaments, and Zooglea; generate large amounts of sludge and increase your solids handling costs. There is a fine balance between too much and too little. Here are some plant examples where there was significant negative impact on the plant.

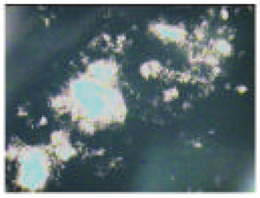
Here are three plants using alum or Ferric for phosphorus removal:

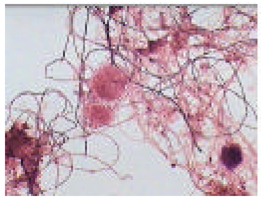


Municipality with Ferric added to the front of the aeration basin



Irregular shaped floc 100x due to over addition of ferric





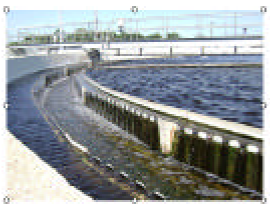
High India ink- high polysaccharide coating

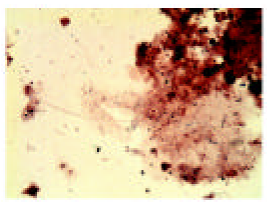
1000x Gram stain Zooglea present

Here is a food plant using Ferric for nutrient removal- too high phosphorus in the influent

Oxidation ditch at a Cheese plant

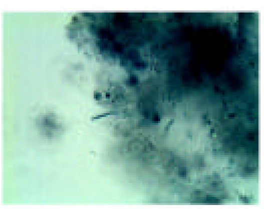
Digestor red due to overuse of Ferric

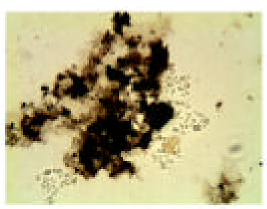




Here is a municipality using Alum for Phosphorus removal

Gram stain zooglea





Lactophenol cotton blue-zooglea

Neisser stain- Neisser positive Nutrient deficient cell clusters As well as alum visible

In addition to N and P, Trace metals or micronutrients are also required by the bacteria for cell growth, respiration and reproduction.

From: Activated Sludge Process Design and Control: Theory and Practice, W. Wesley Eckenfelder and Petr Grau, pages 146-7

"The biomass requires nitrogen and phosphorus in order to affect metabolism and removal of organics in the process. In addition to this, however, trace levels of other nutrients are required to assure good floc formation." **Note:** The section goes on to say that most trace elements are usually (but not always) present in sufficient quantities in the incoming wastewater.

Table 4.6 Trace Nutrient Requirements for Activated Sludge

Micronutrient	Requirement (mg/mg BOD)
Manganese	10 X 10^{-5}
Copper	15 X 10^{-5}
Zinc	16 X 10^{-5}
Molybdenum	43 X 10^{-5}
Selenium	14 X 10^{-10}
Magnesium	30 X 10^{-4}
Cobalt	13 X 10^{-5}
Calcium	62 X 10^{-4}
Sodium	5 X 10^{-5}
Potassium	45 X 10^{-4}
Iron	12 X 10^{-3}

From Wastewater Biology: The Life Processes, Water Environment Federation, page 120

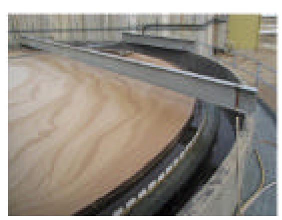
MINOR BIOELEMENTS. Several elements are required by organisms in minute quantities, and are termed the minor, or trace, bioelements. Zinc, manganese, cobalt, copper, and molybdenum are required by all organisms for various growth functions and play important roles in the activation and structural integrity of enzymes, energetic (energy conservation) pathways, and the formation of certain organic compounds, such as vitamins required for growth. Some organisms require other trace bioelements, such as tungsten or nickel.

The distribution of these metals into different chemical species (organic or inorganic, free-ion or chelated) determines their availability for the metabolic active microorganisms present within these granules

Here are two plants adding Ferric because a consultant said they needed "micronutrients" in their plant.

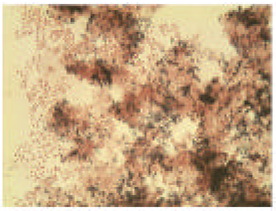
The result was the Ferric was binding up the phosphorus and the bacteria were nutrient deficient, so any minor benefit for trace elements was lost due to the impact on major nutrient requirement.

This first plant is a chemical plant that has added Ferric sulfate for over 10 years because a consultant told them they needed it to help with clarification as well as micronutrients for the bacteria.



Clarifier with foam carryover from Aeration basin,

and final effluent red from overdose of Ferric

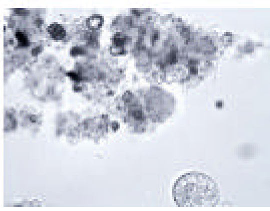


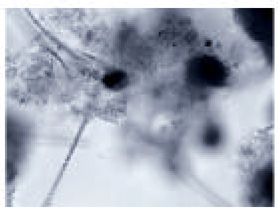
Gram stains showing large amounts of Zooglea

Neisser stains showing Neisser positive and nutrient deficient cell clusters.

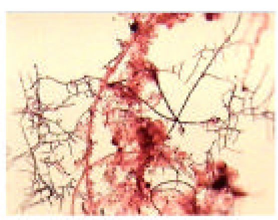
This plant turned off the ferric, and overnight achieved an instant increase in 26% BOD removal, decrease in foam and decrease in TSS in the final effluent.

Here is another plant that adds Ferric on a 100-5-1-.5 ratio of C:N:P:Fe based upon consultants recommendations. In reality, the bacteria were nutrient deficient and Zooglea was prevalent in spite of addition of phosphorus.





Here is a municipality that was not adding anything, but the local drinking water plant occasionally sends down backwash loaded in Ferric, as noted by the red color in the primary. Municipalities are normally not deficient in phosphorus, yet due to the Ferric, and this plant did not dewater every day, they were nutrient deficient.



Primary clarifier red from Ferric

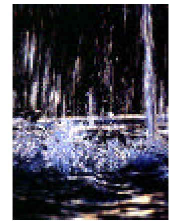
Gram Stain- Nocardia and high levels of zooglea

We changed their dewatering schedule to run the same days the drinking water backwash occurred to give the plant extra phosphorus from the digestor and dewatering and they did not have to purchase additional phosphorus for those few days of the month and now are doing fine.

Use your microscope and see what is going on at your plant if you do have to use inorganic salts for excess phosphorus removal. **See Biological Nutrient removal newsletter July 07 also**

If you are concerned about micronutrients, there are better ways to add trace elements, and minerals for bacterial growth. Kelp based micronutrients have been used for dozens of years in agriculture application as well as wastewater applications.

MicroClear M100 Micronutrient Formulation



Ok, I have heard a lot about micronutrients. What are they?

Research biologists have long known the importance of micronutrients, such as trace minerals, amino acids and vitamins, in the growth and reproduction of healthy cells. Micronutrients are a blend of trace minerals, amino acids and vitamins designed to improve performance of biological systems at the bacterial or cell level. Much of the work on micronutrients was pioneered in the agricultural industries of poultry, cattle and pig farming. This product is fed daily as a source of vitamins to the animals.

Under controlled conditions, researchers have been able to develop formulations that provide an optimum micronutrient balance to ensure rapid and healthy growth for bacteria in a biological wastewater setting. These micronutrients enhance biological growth and providing the critical building blocks necessary to maintaining a healthy floc-forming population. This product is a naturally occurring product, not a blend of chemicals.

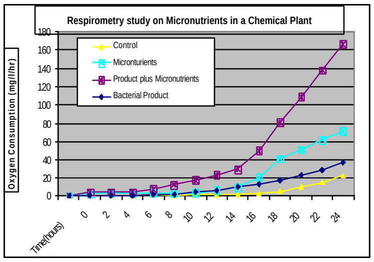
Basically, it is the equivalent of "Bug Vitamins". The formulation consists of three types of micronutrients: trace minerals, amino acids and vitamins. There are sixteen trace minerals, including calcium, iron, magnesium, manganese, cobalt, copper and zinc. The formulation also includes twenty amino acids, such as lysine, and thirteen vitamins, including folic acid.

Micronutrients are metallic cations or anions such as: Ag, B, Cr, Co, Cu, F, I, Mn, Mo, Se, Si, Sn, V, and Zn. Although their composition is small in relative quantity, (less than 1% of total microbial weight), micronutrients are indispensable for life and form bio-molecules that have specific cellular functions.

Analysis of Micronutrients	Specification
16 Trace Minerals	Present in trace amounts
Calcium	1.9%
Iron	.08%
Magnesium	.123%
Zinc	.0035%
Phosphorus	0.1 %
Vitamins	Present in trace amounts
A, B, D, E, K	
Folic Acid	0.3mg
Ascorbic Acid	150,000 mg
Niacin	2,500 mg

What exactly can Micronutrients do?

Research and field tests have shown that inadequate micronutrients can lead to poor settling or high effluent suspended solids due to unhealthy floc. Addition of micronutrients may also increase the biological degradation rate in many situations that will allow the biomass to respond more quickly to sudden increases in loads or toxic shocks. By maintaining adequate micronutrient levels, the system should also be more resilient to load swings or toxic shocks.

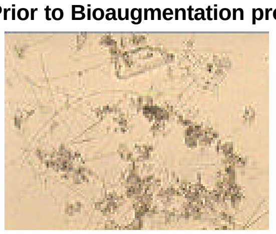


Literature has many references of the importance of trace metals and other micronutrients in the formation of biological floc to provide good settling.

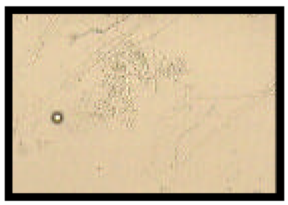
Examples of a plant prior to dual program ½ Bacteria,

½ Micronutrient addition

Prior to Bioaugmentation program changes

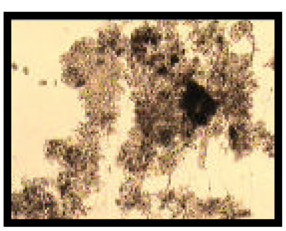


Smaller floc with lots of filaments
Photo taken at 100x bright field



Zooglea and spirillum
Photo taken at 400x bright field

After addition of MicroClear 118 and Micronutrients



Large compact floc structures

Significant increase in higher life forms, rotifers, less filaments and TSS

Both of these photos taken at 100x bright field

Let us know if you need help with your plant evaluation nutrient removal or nutrient addition.

Also see past issues on nutrients and micronutrients.

Upcoming training classes:

We still have a few spots in our one day Operator class and only 1 spot left in our Two day Filamentous ID Class. We are planning to hold another two day Filamentous ID class in July at Fox Metro since the June class is almost full.

Activated Sludge Process Control- May 7th 2009

Downers Grove Sanitary District
5003 Walnut Ave
Downers Grove, IL 60515

Filamentous Identification the Easy Way!

June 9-10th 2009

Village of Algonquin

125 Wilbrandt Street

Algonquin, IL 60102

This class was sold out, but we have a couple more spots now open due to people switching to the second class for timing purposes

Please let us know if you need the brochure for this. It was sent out previously.

New class added: Filamentous Identification the Easy Way!

2-Day Advanced class

July 28-29th 2009
Fox Metro WRD
682 State Route 31
Oswego, IL. 60543

Last Month's
MYSTERY BUG OF THE MONTH

Did you identify it correctly?

This was a stationary loricate rotifer- not very common

Mystery Bug of the month!

Check out our website for more photos of our new mystery bug!!!!
WWW.EnvironmentalLeverage.com

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