Bioaugmentation 101

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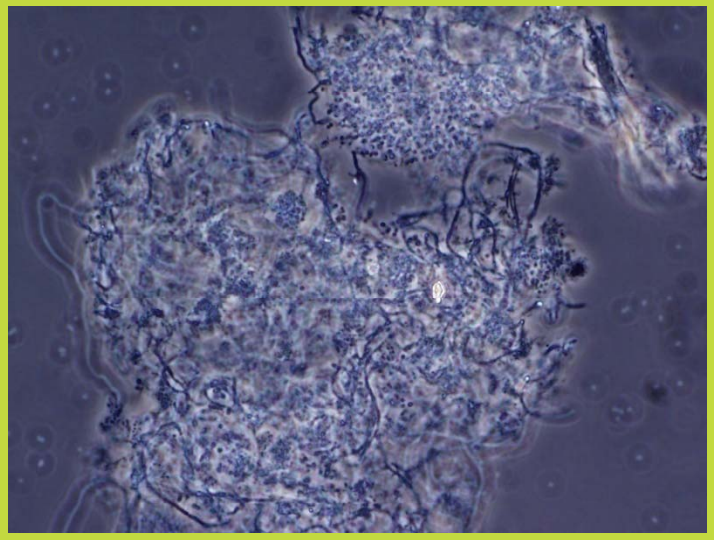
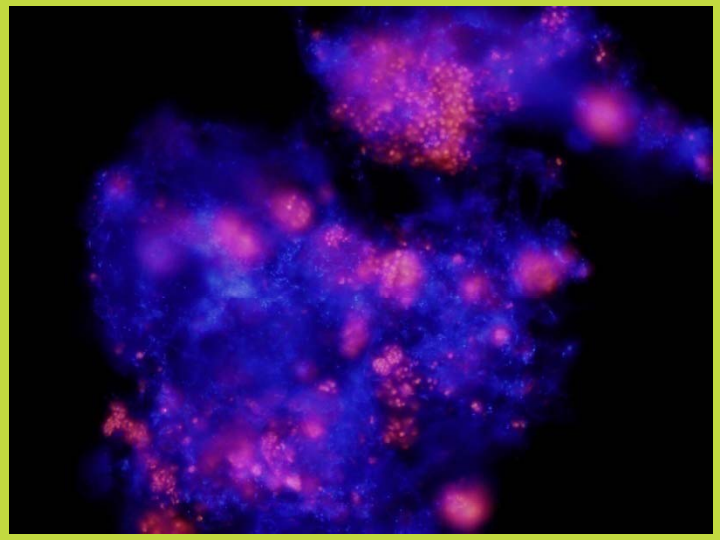
What is Bioaugmentation?

- It is the practice of enhancing the performance of an indigenous biomass through the addition of microbial strains with specific capabilities.





What Is Wastewater Bioaugmentation?

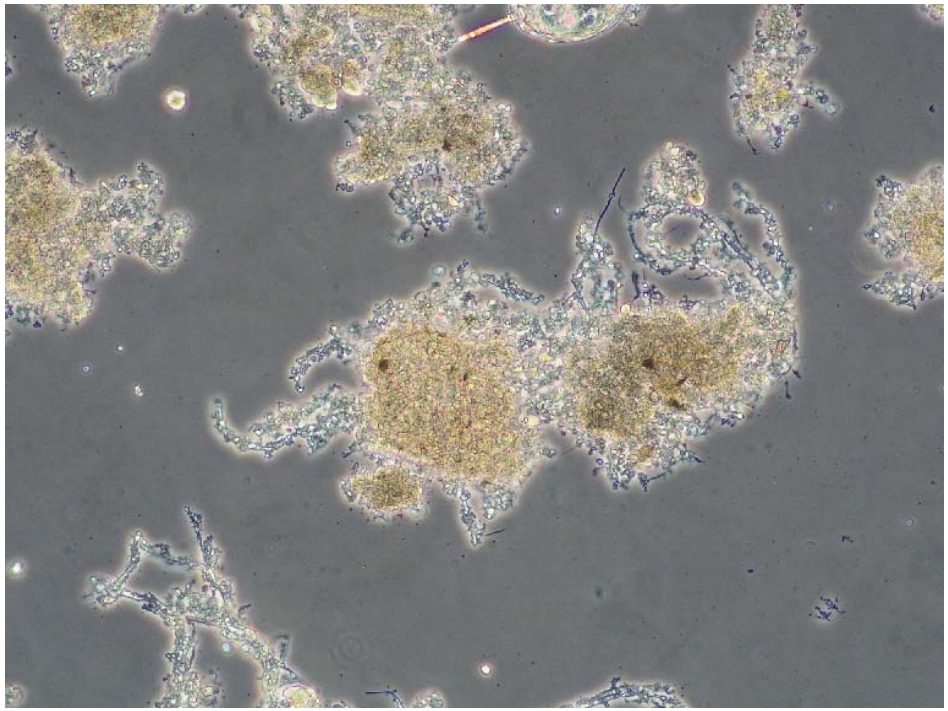
- It can enhance the ability of an indigenous biomass to respond to process fluctuations or to degrade certain components of the waste, resulting in improved treatment.
- **NO GEM's or GMO's**

The Role of Bacteria

- Microorganisms serve as the primary biological catalyst in the oxidation process referred to as decomposition.
- The natural cycling of elements depends largely upon bacterial activities.
  - carbon, nitrogen, phosphorus, sulfur, etc.

Development Method

- Selection
- Enrichment
- Blending



Fundamentals of New Strain Development

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1. Collect microbes from natural sources

2. Isolate the different types, select the most effective ones, and train them to do it better

5. Solve customer problems

3. Fermentation

4. Formulate

What are bioaugmentation products?

- Bacteria – the primary workers, typically formulated as consortia.
- Fungi* – Have been found to degrade some recalcitrant compounds, excellent for producing for certain enzymes
- Nutrients- nitrogen, phosphorus, minerals

Beneficial Microorganisms Versus Enzymes

Microorganisms are enzyme factories that...

- provide a continuous supply of complete enzyme systems
- are highly efficient - only the enzymes that are needed to degrade a compound are generated by the cell.

Raw enzymes are...

- Proteins...finite, no replication;
- Fast starting, function as a catalyst; and
- Very task specific. [Lock & Key]

What are the Target applications?

- **Organics - Process stabilization**
  - **Defined or undefined or toxic loadings.**
  - **Resistance to upset.**
  - **Statistically significant reductions in effluent organics and variability.**
  - **Increased removal of specific toxic organics.**
  - **Nitrification – ammonia, nitrite.**
  - **Denitrification**
  - **Odor Control**

Target Applications / Customer Benefits

- **BOD / COD Removal**
  - **Upset Recovery / System Start-up**
  - **System Stability – resistance to shocks!**
  - **Statistically significant reductions**
- **Increased removal of Specific Organic Compounds**
  - **Grease, surfactants, alcohols, Phenol etc.**
- **Improved Settling –** Fewer TSS violations, less polymer
- **Sludge Reduction –** less frequent or NO dredging
- **Odor Control – fewer complaints**
- **Nitrification –** permit compliance

Nitrification

- **Pre-Qualify**
  - Sludge Age - not too old, they must be wasting properly
  - Effluent BOD less than 15 ppm
  - Available Alkalinity (7.1ppm/ppm NH_3-N)
  - Dissolved oxygen greater than 2.0 ppm
  - pH optimum is near 7.8. If less than 6.7, consider temporary increase to 7.5 to speed recovery.
  - Absence of metals
  - Presence of ortho-phosphate

Nitrification example

Example: nitrification recovery at a chemical plant.

- Vital stats:
  - Flow = 2.0 mgd.
  - Sludge age = 30 days.
  - Influent ammonia-N range 200-800 ppm.
  - Plant designed primarily for Nitrogen removal.
  - Aeration pH at 6.1 – 6.5.
  - Nitrification upset, effluent NH_4-N = 400 ppm.

How did Bioaugmentation help?

- In this case:
  - Increased mixed liquor pH to mid-7s during recovery only, due to an alkalinity deficit that would have allowed pH inhibition preventing recovery.
  - Dosed equivalent of 110 lbs of a nitrifier concentrate over a 10-day period.

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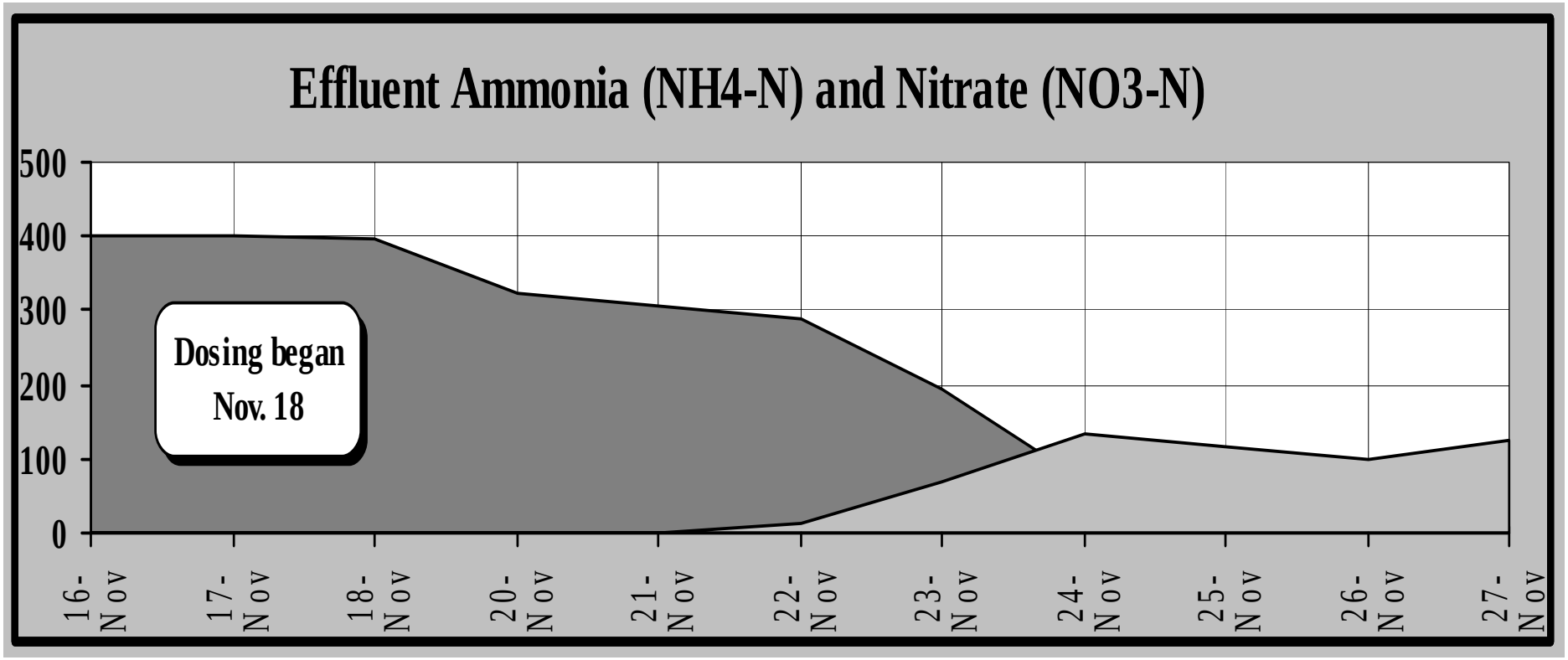
How Can Augmentation Be Used

- Results:
  - NH_4-N_{eff} from 397 to 10 ppm in less than 10 days; NO_3-N_e from 0 to a peak of 135, prior to recovery of denitrification.



Monitoring

- **Product Addition – 7-10 day programs**
  - Continue monitoring all relevant data.
  - Results normally begin in 3-6 days, but may be as quick as 2.
  - If no response is seen during a two-week program, toxic inhibition may be present. If this is possible recommend running a Nitrotox test.
  - Recovery is usually self-sustaining depending on the reason for the loss. Need for continuous addition is rare.

When do we use Bioaugmentation

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Steady state vs. Non-steady state

- No change in soluble BOD, TOC, COD
- Non-Inhibitory substrate
- DO at least 1.0 mg/L everywhere
- Excess Nutrients
- No Interfacial Tension Effects
- Normal range of pH or Temperature
- Excess Biomass
- Floc formers dominate

- Changing organic concentration
- Biomass Inhibition
- Low Oxygen
- Nutrient Deficiency
- Interfacial Tension Effects
- pH or
- Temperature Variance
- Enzymatic Inhibition
- Elevated Influent TSS
- Ionic Concentration varies

How are bioaugmentation products selected?

- Treatability studies.
  - Typically involve comparisons of non-augmented control reactors with augmented test reactors.
  - Nutrient amendments are used to eliminate any deficiencies in nitrogen (N) and phosphorous (P).

What type of toxic waste can be treated with Bioaugmentation?

- Examples of industries:
  - Centralized waste treatment
  - Citrus fruit processing – press liquors
  - Organic chemicals, synthetics
  - Pulp and paper – black liquor
  - Petrochemical
- Examples of specific organics:
  - Acetone, MEK
  - Acrylic acid
  - Ammonia, nitrite
  - Dimethylformamide
  - Furfural
  - Phenolics and related
  - Glycols

The natural solution for wastewater treatment

Biological organisms are key to a properly functioning wastewater treatment system. Bioaugmentation is the sustainable way to:

- **Lower operating costs**
- **Decrease polymer or chemical use**
- **Improve effluent quality**
- **Improve plant stability**

Final Thoughts

- There are no “superbugs”.
- There are process limitations that can be defined and addressed within the basic fundamentals of wastewater microbiology.
- Bioaugmentation is a sustainable, proven and viable technology