



Bioremediation:

using bacteria or plants to remove or transform wastes

Organic matter

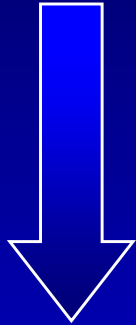


“mineralization” by
various heterotrophic
bacteria working
as a team

CO_2 , NH_3 , PO_4 , etc



“nitrification”
by two groups
of nitrifying bacteria
working as a team

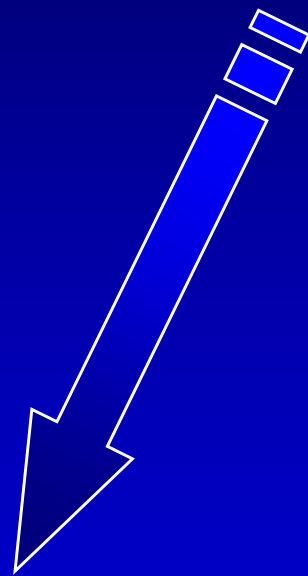


“denitrification”
by certain anaerobic
bacteria

Nitrogen-containing organic material



Mineralization



Carbon dioxide gas

ammonia

nitrate



Nitrogen gas

Intrinsic bioremediation

let nature work at her own pace

Engineered bioremediation

biostimulation: enhance environmental conditions to speed up the process

bioaugmentation: add bacteria to speed up the process

Bioaugmentation and probiotics

Probiotics

A live microbial additives that improve feed use, immune response, or alters the microbial environment to reduce pathogen abundance

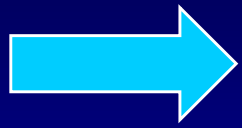
Mixed success, but generally accepted as a scientifically valid approach in nutrition and health management

Bioaugmentation

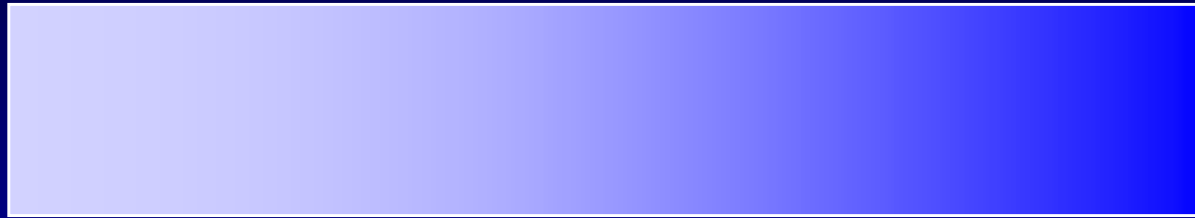
Limited here to environmental remediation

Activated Sludge Waste Treatment

waste inflow



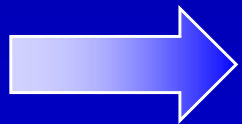
without inoculation



treated waste outflow



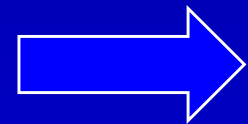
waste inflow



with inoculation



treated waste outflow



"return activated sludge"



Bioaugmentation in environmental management

Waste treatment facilities

Oil-spill remediation

Toxic waste remediation

Lake and pond management

- reduces algal abundance
- removes "sludge"
- improves dissolved oxygen
- removes ammonia

Why does interest persist in scientific and commercial settings?

- Appealing approach and seems logical
- Some successes in small-scale studies
especially with genetically modified bacteria used to break down unusual compounds
- Some “brute-force” applications succeed
very high inoculum levels
- Very, very few large-scale, controlled studies to either prove or disprove

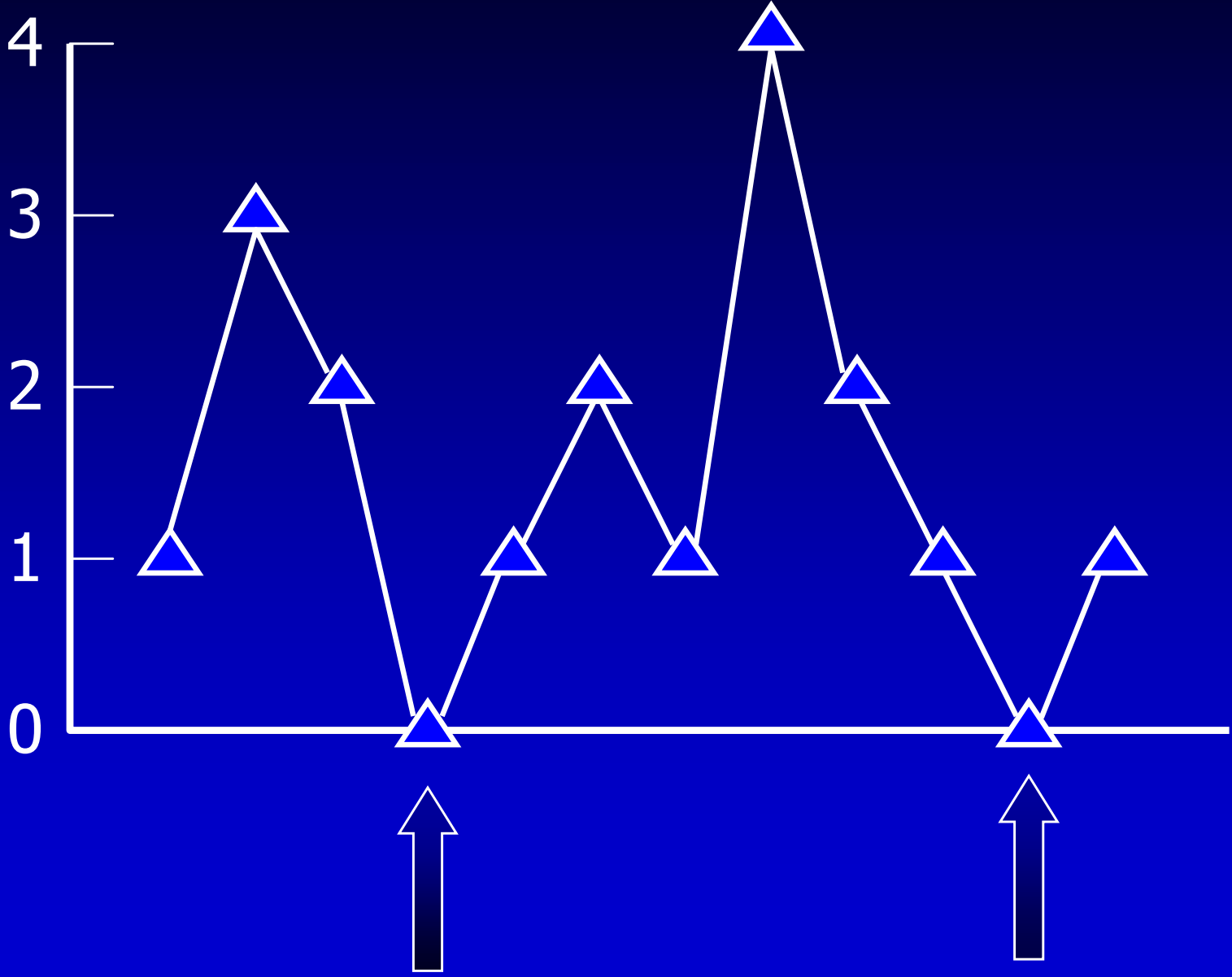
Observer-Expectancy Effect

A cognitive bias where a person expects a given result and therefore interprets results in light of that expectation

Extremely pervasive problem in science

Requires replicated, blinded studies

morning dissolved oxygen



Nine studies in catfish ponds

Four products

Used according to label directions or
advice of manufacturer

Response variables selected by manufacturer

Most studies either single or double blinded

1983

Liquid, consortium of nitrifiers, denitrifiers, heterotrophic bacteria

Twenty, 12-ft diameter, 3-ft deep pools treated weekly

No effects on sediment organic matter

1985

Liquid, consortium of nitrifiers, denitrifiers, heterotrophic bacteria

Eight, 0.1-acre ponds treated weekly

No effects on

algal abundance, ammonia, nitrite,
dissolved oxygen (dawn or dusk), aeration

Harvest weights

treated = 3407 pounds/acre

control = 3660 pounds/acre

1988

Liquid, consortium of nitrifiers, denitrifiers, heterotrophic bacteria

24, 7- to 15-acre ponds treated weekly

Single-blinded protocol

No effects on

algal abundance, ammonia, nitrite, dissolved oxygen (dawn or dusk), aeration, incidence and severity of off-flavor

1995

Powder, *Bacillus* (three species), incubated with a nutrient solution before application

Eight, 10- to 15-acre ponds treated monthly

Single-blinded protocol

No effects on

- Algal abundance

- BOD

- Incidence and severity of off-flavor

1996

Liquid, consortium of seven heterotrophic bacteria

Sixteen, 12-acre ponds treated monthly

Single-blinded protocol

No effects on

pH, ammonia, COD, algae abundance

1996

Powder, *Bacillus* (probably one species),
incubated in pond water to sporulate

Twelve, 0.25-acre ponds treated weekly

Double-blinded protocol

No effects on

Algal abundance, ammonia, or nitrite

Harvest weights

treated = 4788 pounds/acre, 1.81 FCR

control = 4760 pounds/acre, 1.84 FCR

1997

Powder, *Bacillus* (probably one species),
incubated in pond water to sporulate

Twelve, 15-acre ponds treated weekly

Single-blinded test protocol

| | control | treated |
|---------|---------------|---------------|
| Algae | 290 (120-700) | 240 (190-560) |
| Ammonia | 2.8 (0.2-6.4) | 2.4 (0.1-6.6) |
| Nitrite | 0.2 | 0.2 |

1997

Powder, *Bacillus* (probably one species),
incubated in pond water to sporulate

Twelve, 7 to 12-acre ponds treated weekly

Single-blinded test protocol

| | control | treated |
|---------|----------------|---------------|
| Algae | 700 (160-1220) | 630 (230-950) |
| Ammonia | 5.8 (0.1-14.5) | 4.0 (0.2-7.6) |
| Nitrite | 0.2 | 0.1 |

1998

Powder, *Bacillus* (probably one species),
incubated in pond water to sporulate

Twelve, 0.25-acre ponds treated weekly
(higher rate than 1996 test)

Double-blinded test protocol

No effects on

Algal abundance, ammonia, or nitrite

Harvest weights

treated = 5968 pounds/acre, 1.73 FCR

control = 5920 pounds/acre, 1.73 FCR

Pond microbial communities are at quasi-equilibrium

- “The environment selects the community”
- chemical and physical factors control microbial abundance and types of bacteria present

Pond water and sediments have abundant bacteria (millions to billions per mL)

- no shortage of a source of bacteria

Inoculum levels are low (tens to thousands per mL)