

EVALUATION OF DENITRIFICATION MECHANISMS IN CONSTRUCTED WETLANDS

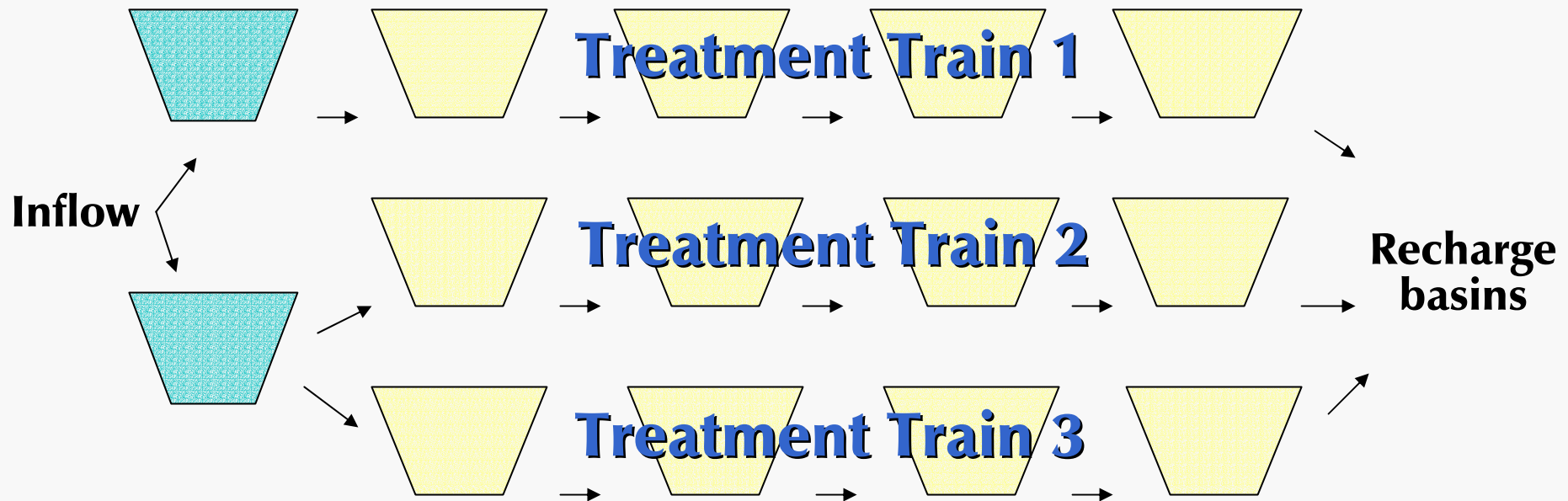
Andrew Komor - Dr. Peter Fox





PACE
PACIFIC ADVANCED
CIVIL ENGINEERING



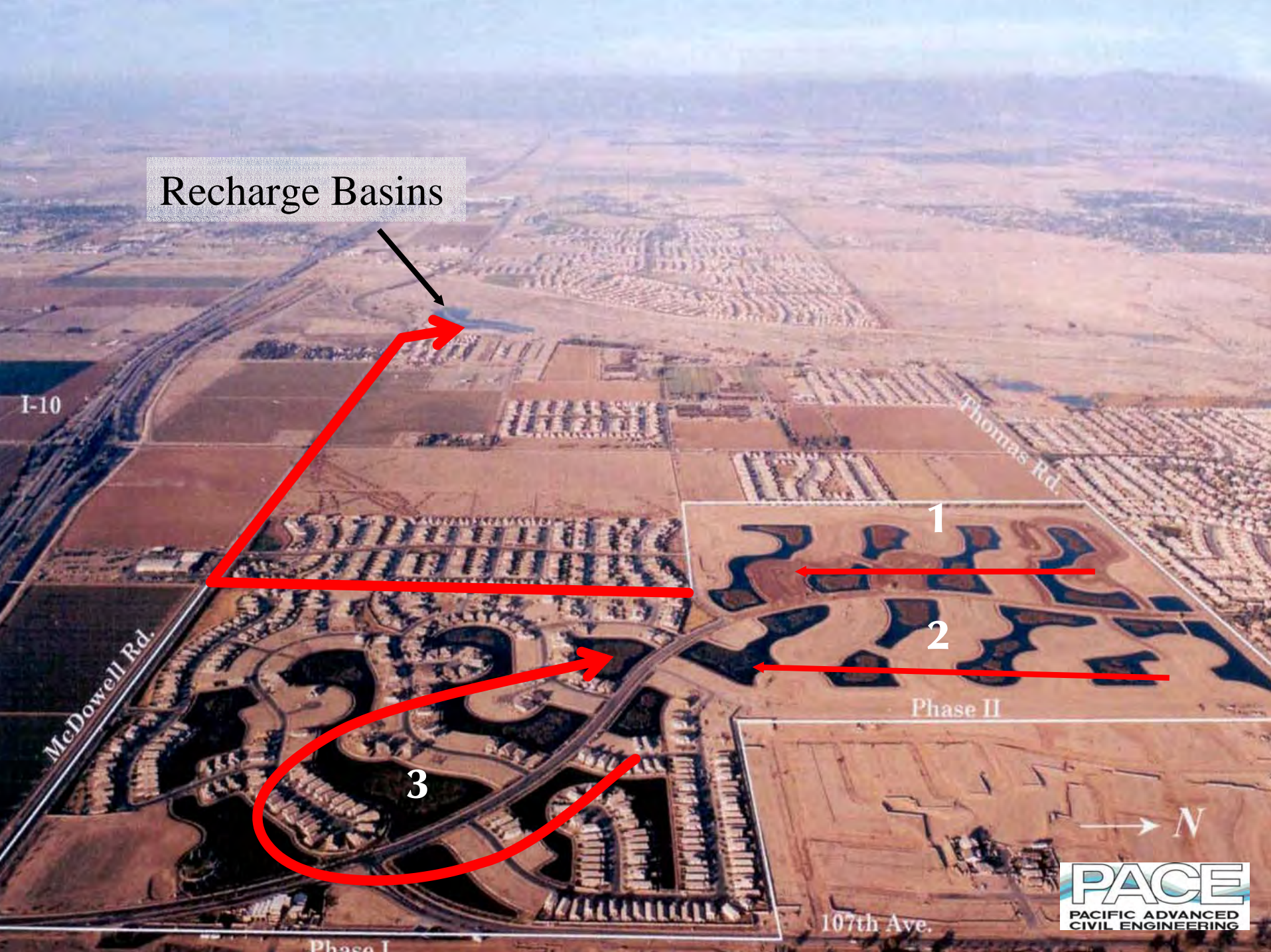
Avondale Treatment Schematic



 - 5 acre equalization basin

 - 5 acre wetland (2 acres vegetative Island)

Recharge Basins



I-10

Thomas Rd.

McDowell Rd.

1

2

3

Phase II

N

107th Ave.

Phase I

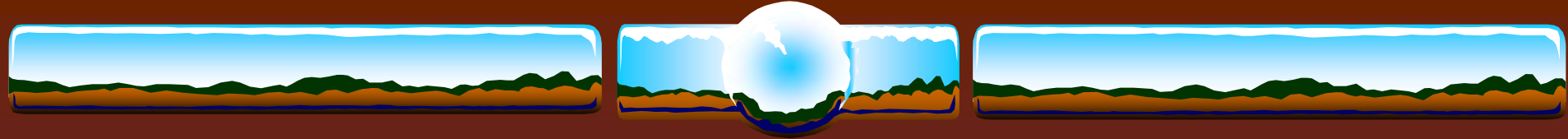


BIOLOGICAL DENITRIFICATION

Under anoxic conditions, Nitrate (NO_3^-) is used as an electron acceptor for microbial respiration.

Wetland sediments generally contain:

- 1. Low concentrations of oxygen**
- 2. Large quantities of electron donor**



STUDY EXAMINED EFFECTS OF:

1. TYPE OF ELECTRON DONOR
2. SEDIMENT DEPTH
3. OXYGEN & ABIOTIC REACTIONS
4. PLANTS & ATTACHED MICROBES
5. INHIBITORS TO REDUCTION OF NITROUS OXIDE



How were Batch Experiments Performed?

1. Collect 1" diameter sediment cores
2. Fill 165mL serum bottles with sediment, 80mL wetland water
3. Purge headspace with nitrogen gas



4. Ammend bottles with nitrate and electron donor
5. Mix bottles on shaker table in the dark
6. Monitor ionic concentrations with time

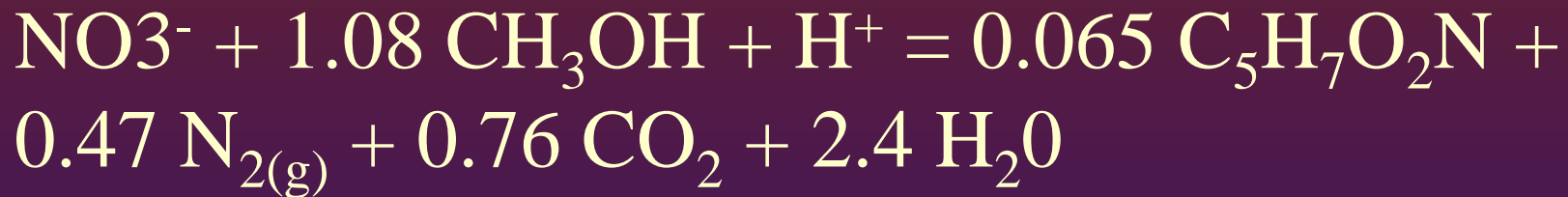
Wetland Microcosms





1. Organic/Inorganic Electron Donor

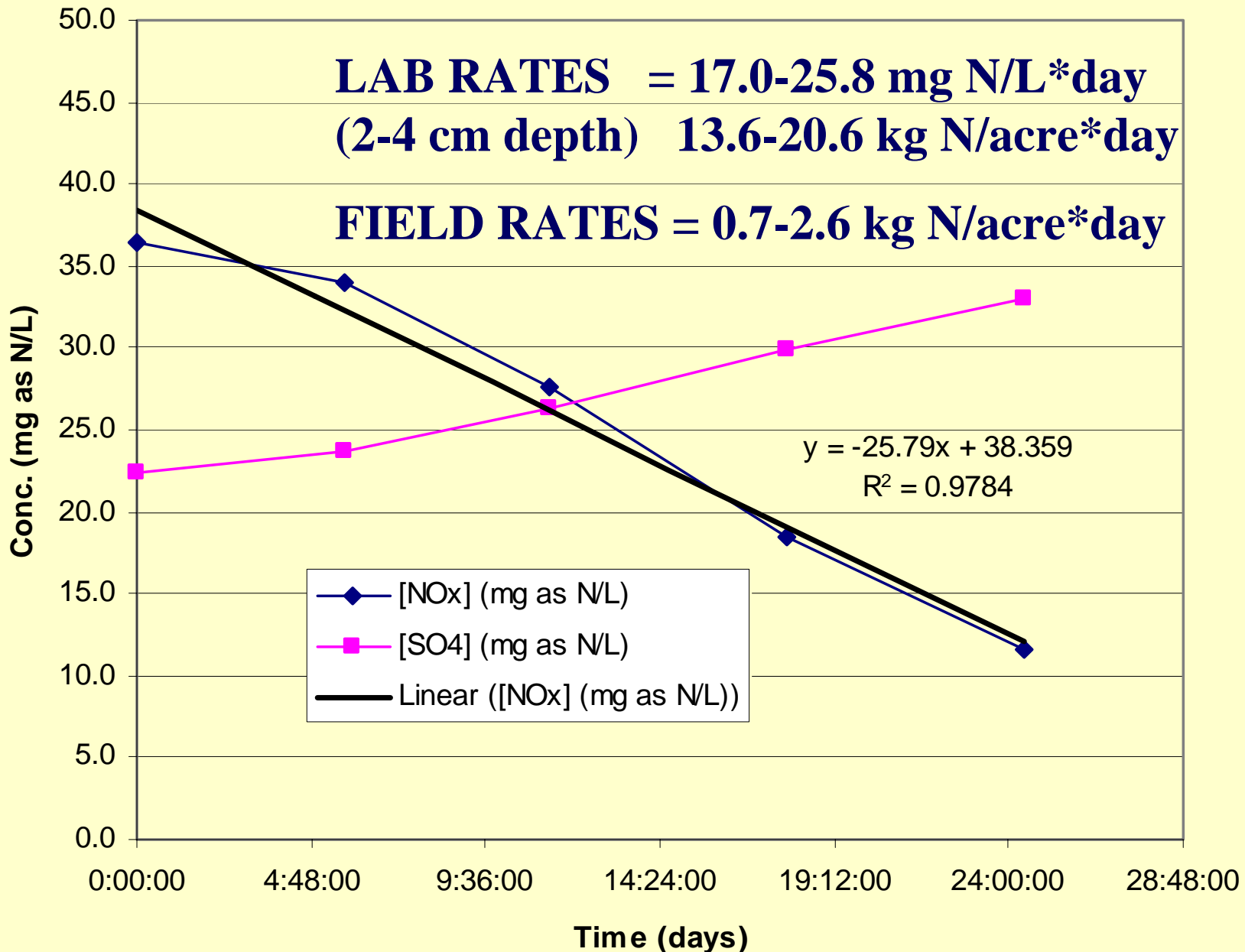
ORGANIC: heterotrophic denitrification



INORGANIC: autotrophic denitrification

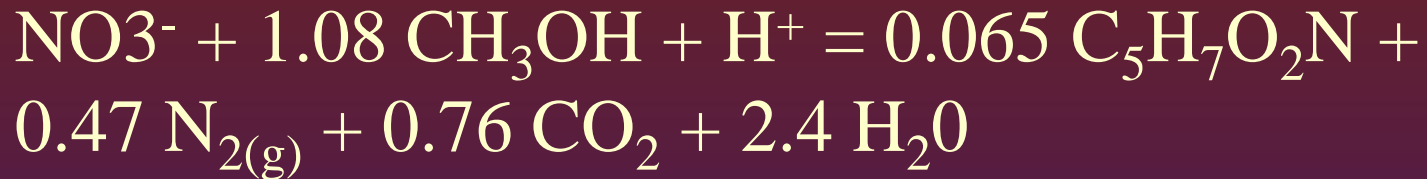


Avondale010207: soil (2-4 cm depth); 2m M NO3-

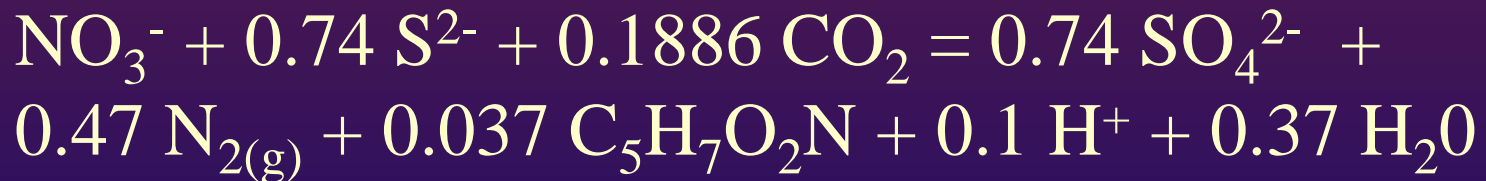




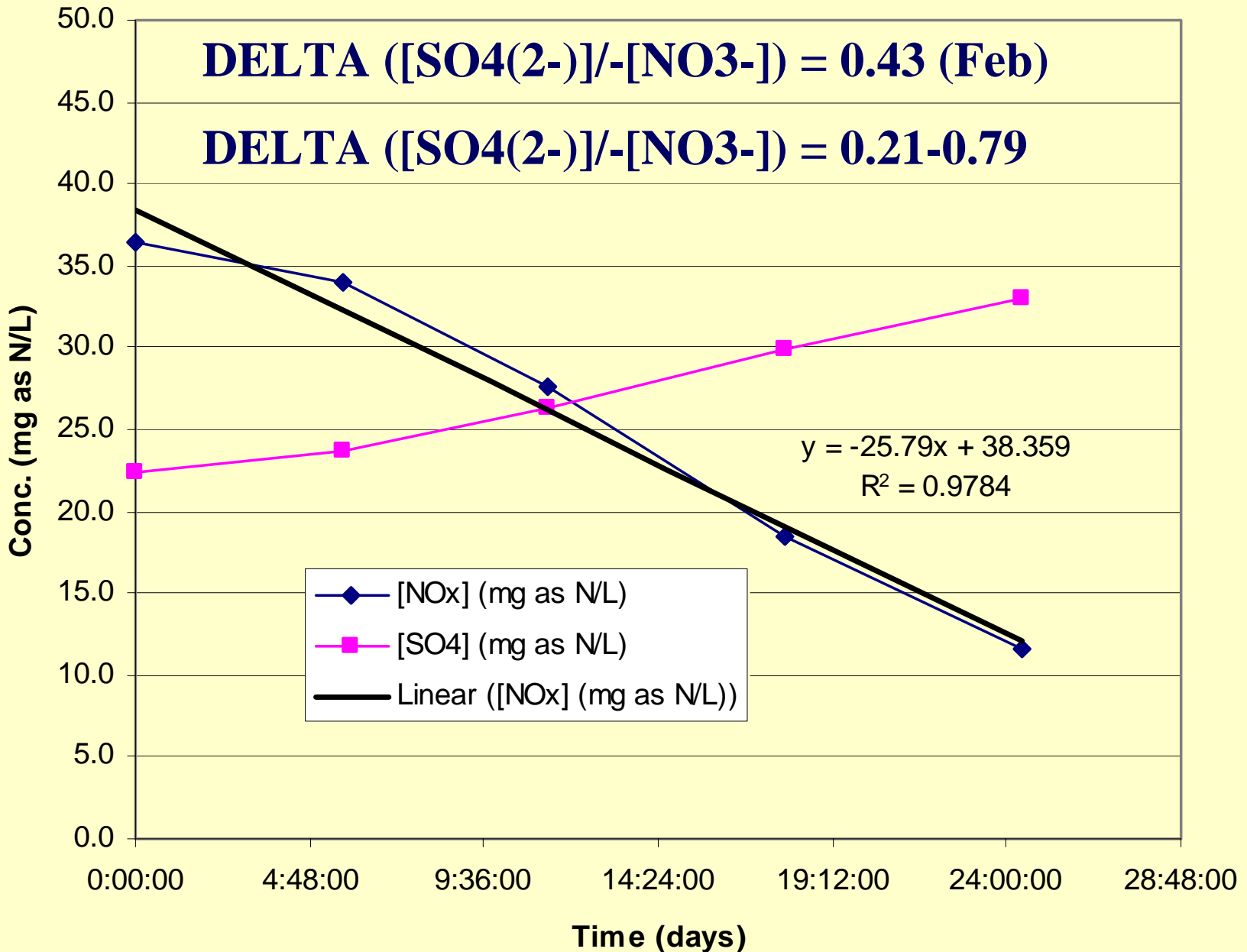
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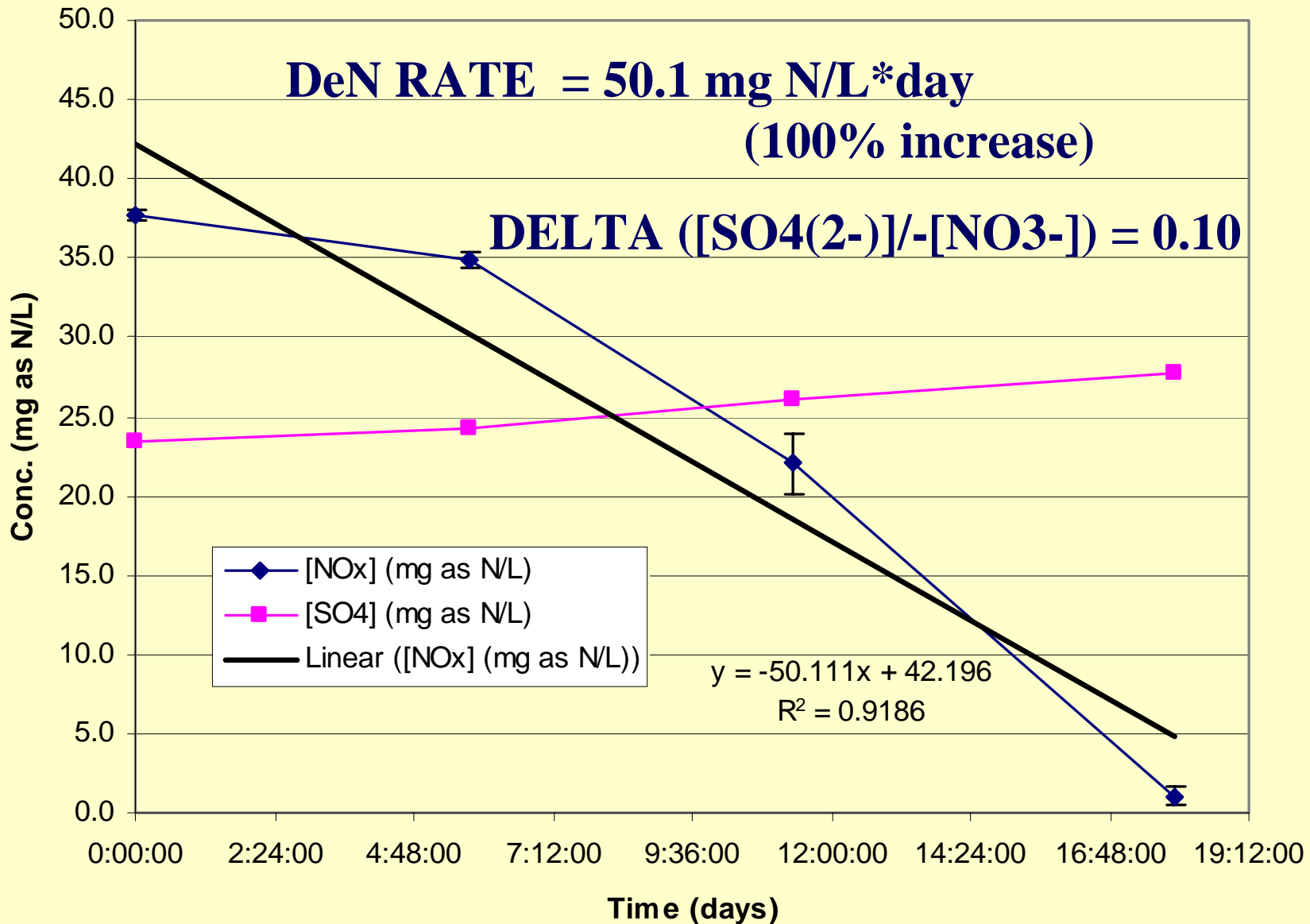
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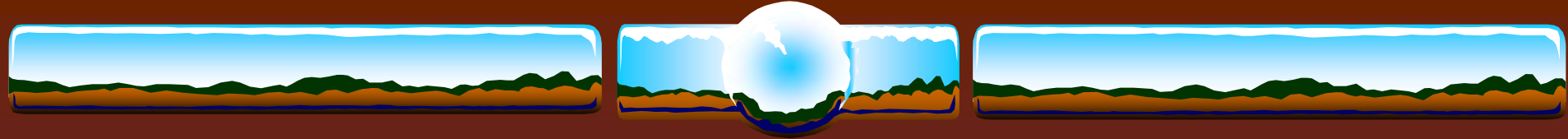


Avondale010207: soil (2-4 cm), 2mM NO₃⁻, 2g finely chopped fresh plants

**DeN RATE = 50.1 mg N/L*day
(100% increase)**

DELTA ([SO₄(2-)]/-[NO₃-]) = 0.10





Addition of Sulfur:

Increased rates 64% in August

Decreased rates 51% in November

Effect dependent on sediment characteristics

Enriched batch tests (w/negligible remaining electron donor):

Autotrophic substrate utilization 68% of heterotrophic rate

2. Sediment Depth





DENITRIFICATION RATE (mg N/L*day)

	<u>NO₃- ONLY</u>	<u>NO₃- + S(2-)</u>
0-2 cm depth (sandy/leafy)	13.7	21.4
2-4 cm depth (black sediment)	19.4	14.9



3. Oxygen & Abiotic Reactions

Microcosm Experiments Performed With:

1. Headspace purged w/air instead of nitrogen
2. Sterilized soil and water

**1B: Hagfield Sterile Soil, dl water, 1.5mM NO₃⁻, 1.2mM S(2-)
Conc. (mg as N/L) versus Time (hours)**

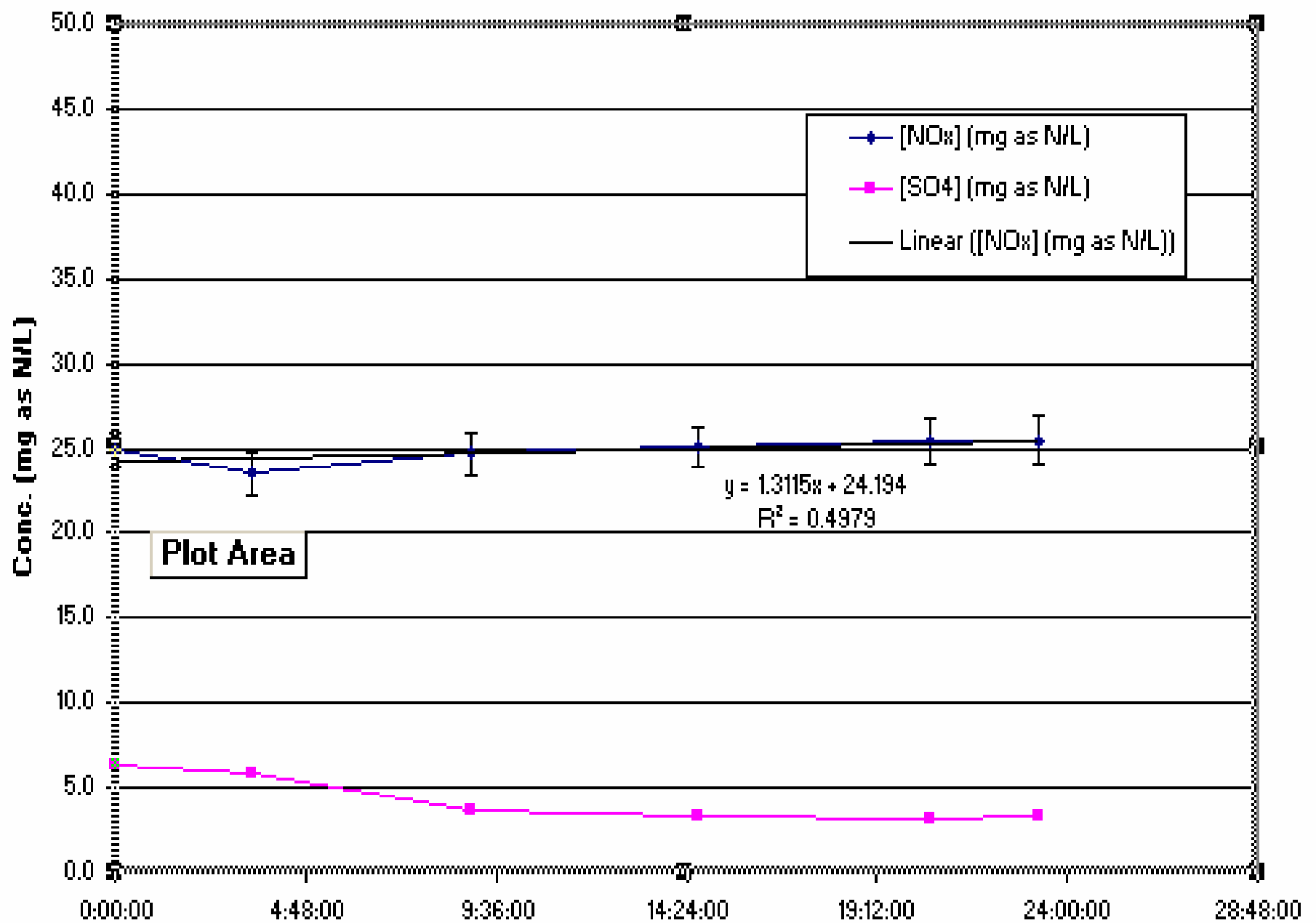
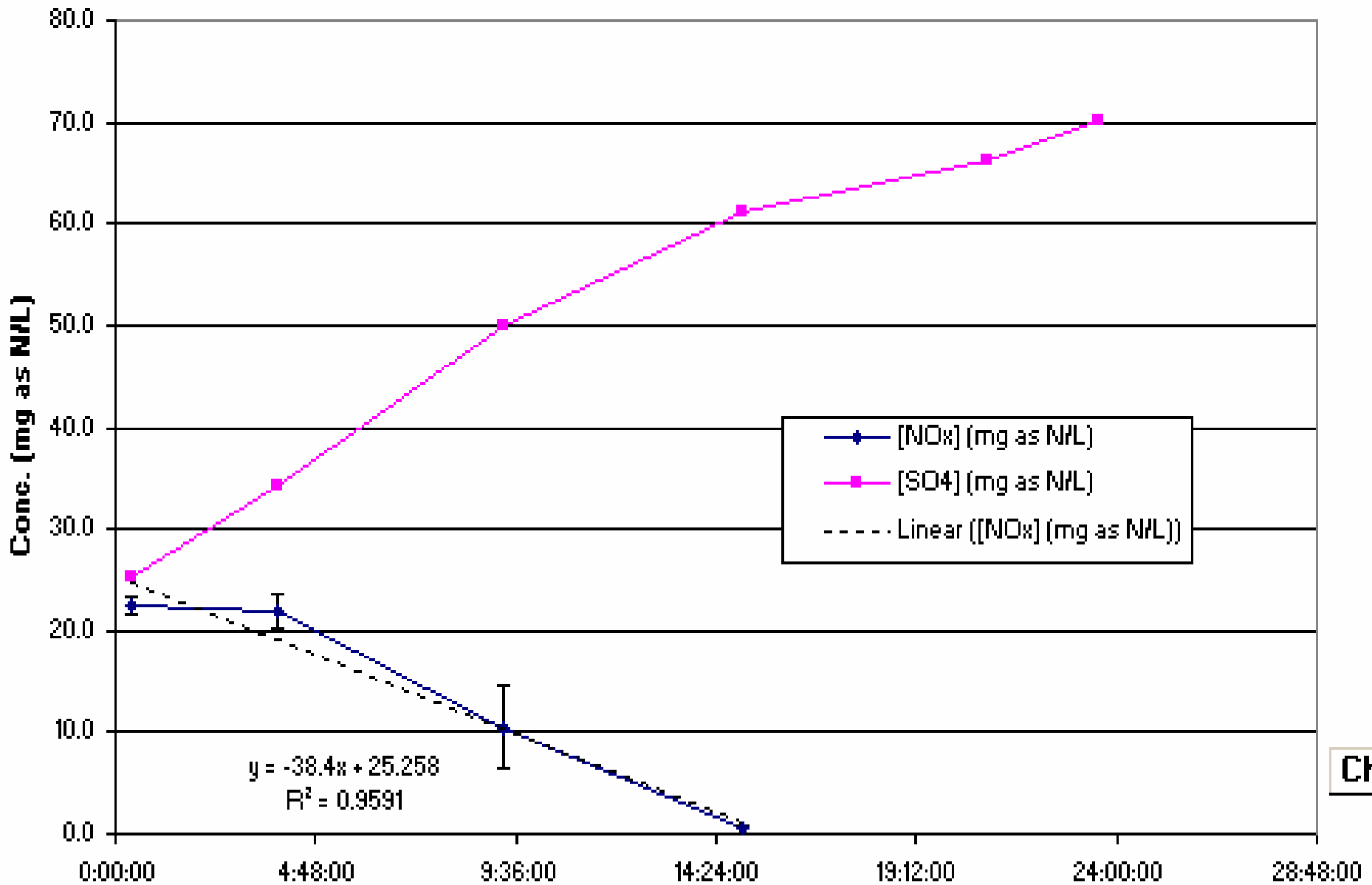


Figure B1E. (8-7-00) Conc. (mg as N/L) versus Time (hours)
Air Headspace, 20 g Hayfield Soil, 1.5 mM NO₃⁻, 1.2mM S(2-)



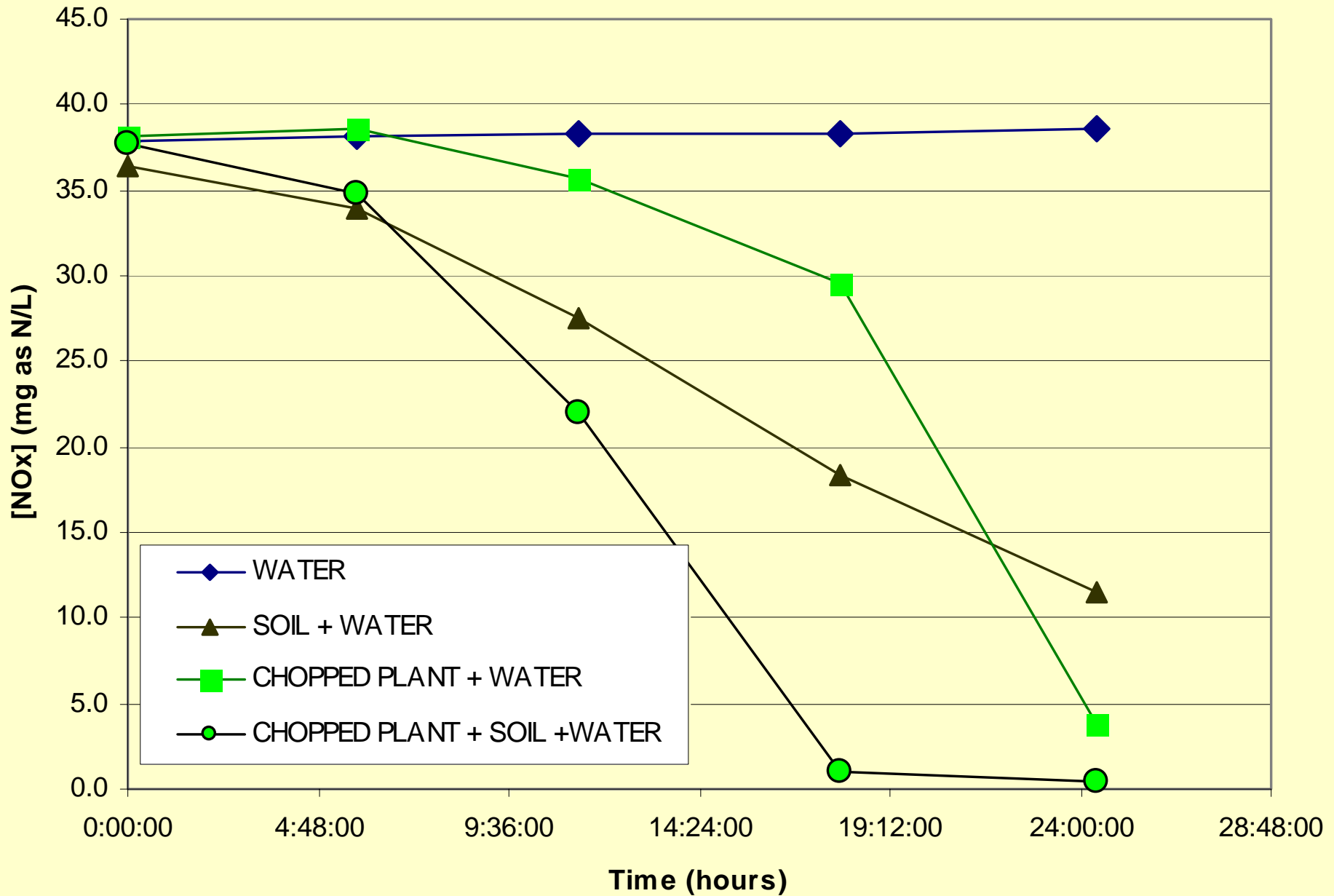
Char

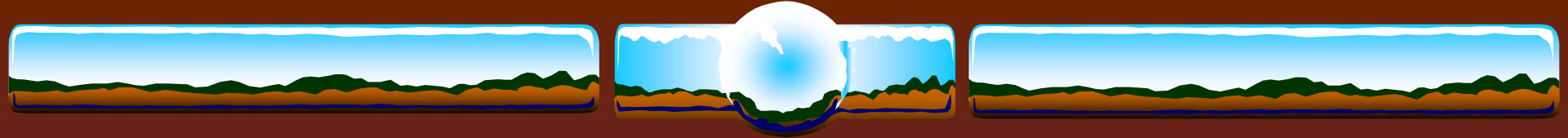


4. Plants and Attached Microbes

<u>SAMPLE</u>	<u>[DOC]avg (mg/L)</u>
Water	2
Soil + water	4
Chopped plants + water	55
Cut plants + water	30
Oven-dried plants + water	325

[NOx] versus Time (hours)





5. Inhibitors to Reduction of Nitrous Oxide to Nitrogen Gas

ACETYLENE

SULFIDE

Figure B5C. (3-15-01) Conc. (mg as N/L) versus Time (hours)
NdeN Sludge, 2mM NO3-, 1.6mM Glucose, 10% Acetylene Headspace

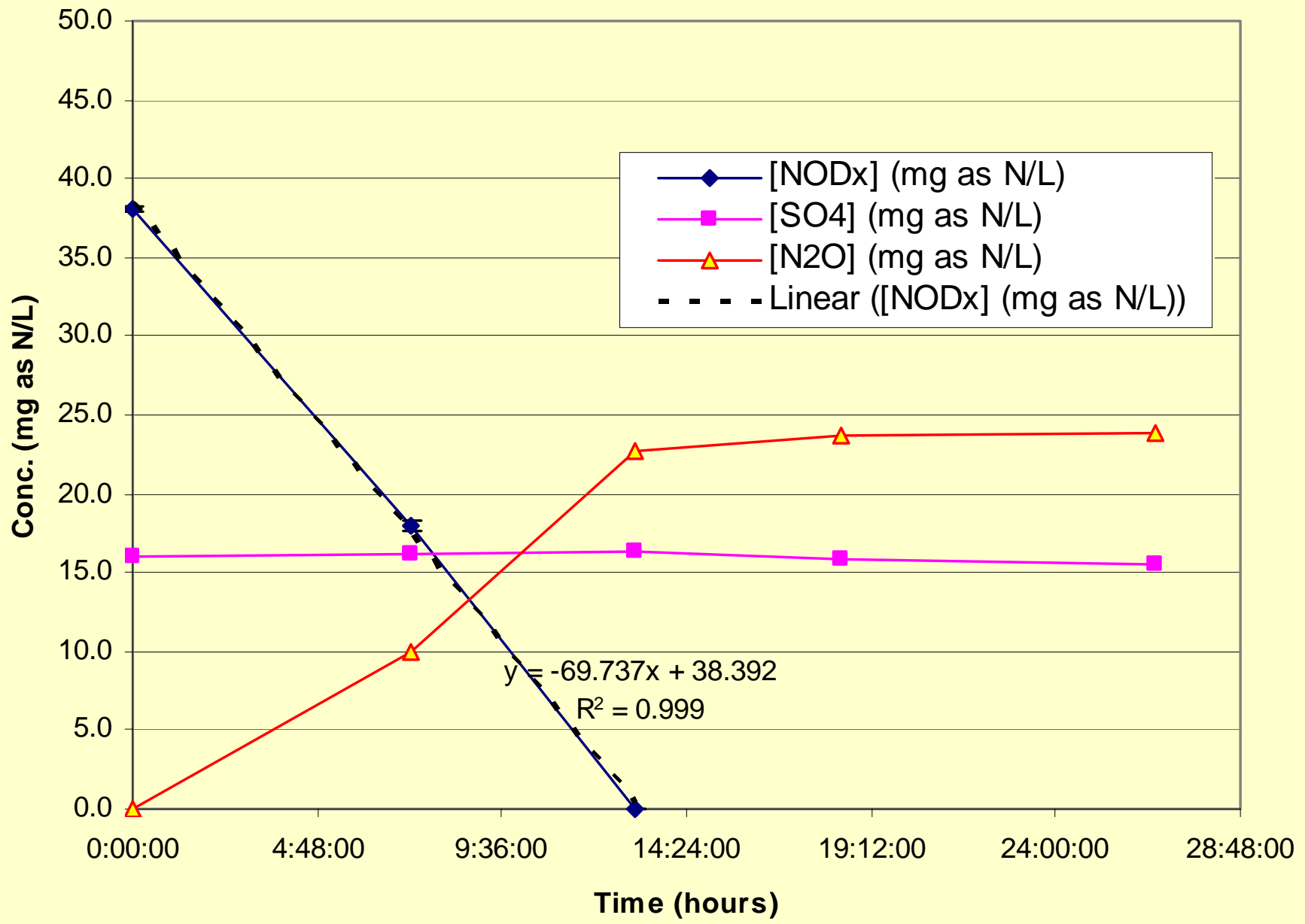


Figure B5H. (3-15-01) Conc. (mg as N/L) versus Time (hours)
Enriched Sediment, 2mM NO₃⁻, 1.6mM Glucose, 10% Acetylene Headspace

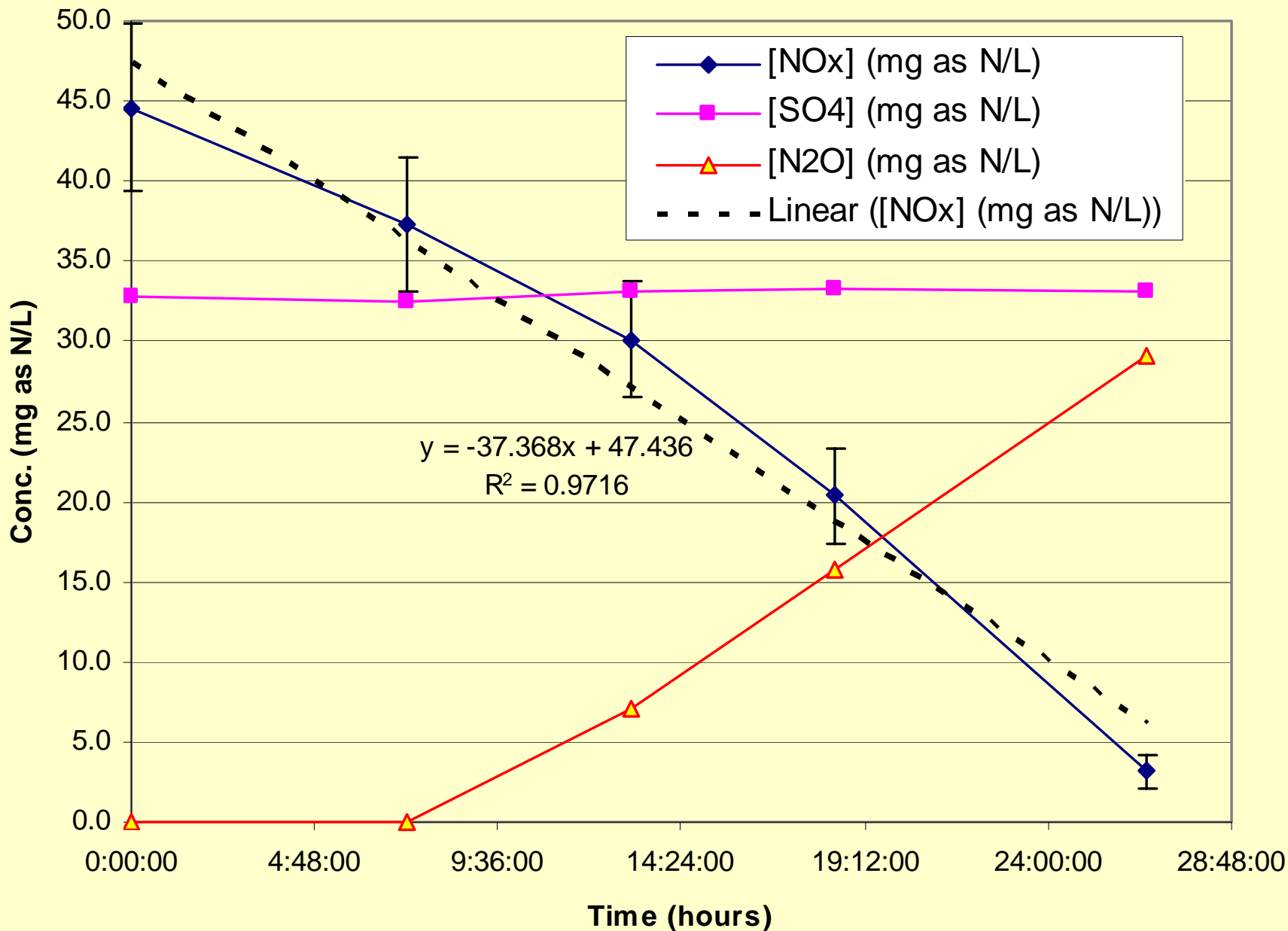


Figure B5D. (3-15-01) Conc. (mg as N/L) versus Time (hours)
NdeN Sludge, 2mM NO₃⁻, 1.6mM Glucose, 1.6mM S₂⁻

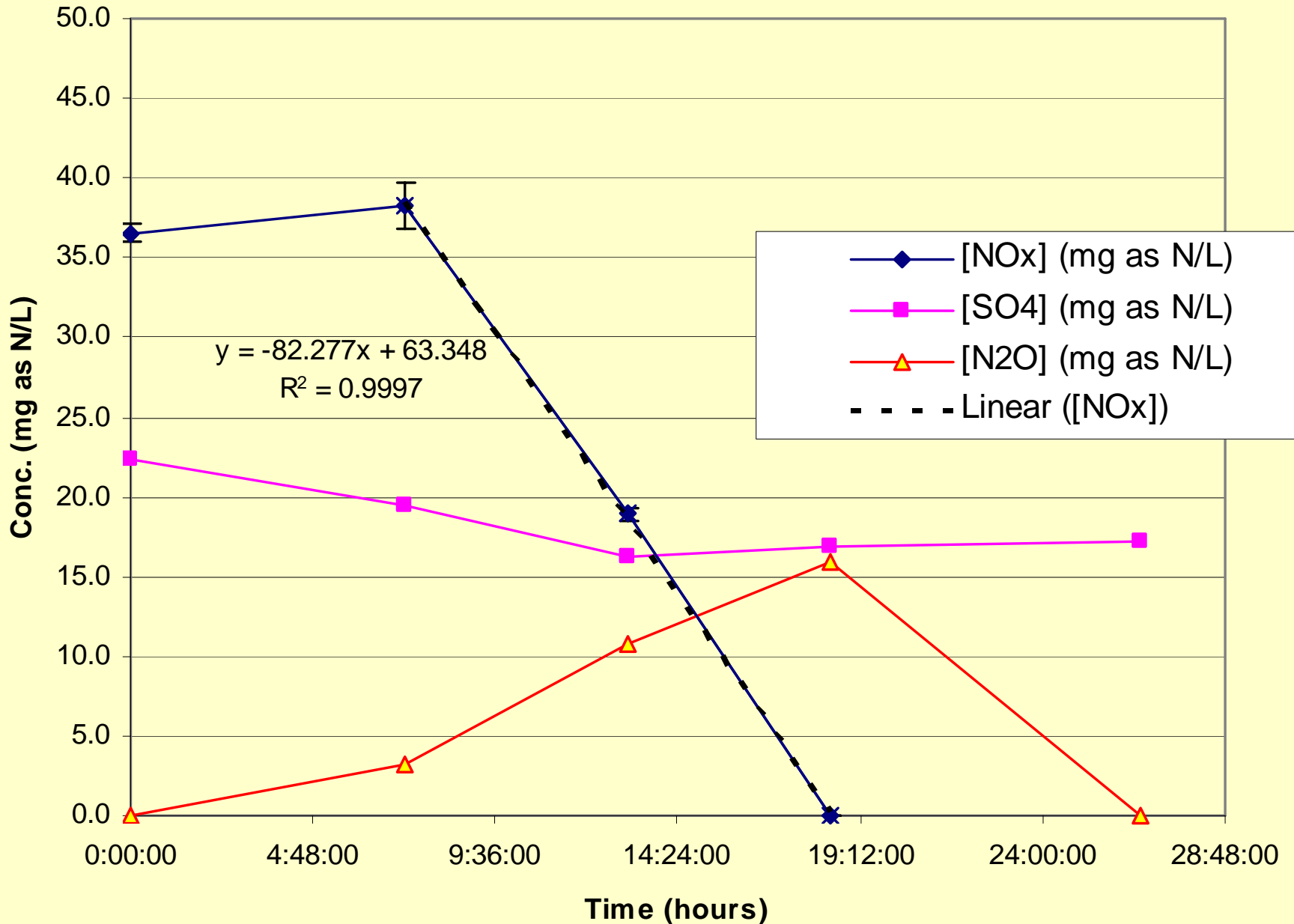


Figure B5I2. (3-15-01) Conc. (mg as N/L) versus Time (hours)
Enriched Sediment, 2mM NO₃⁻, 1.6mM Glucose, 4.8mM S₂⁻

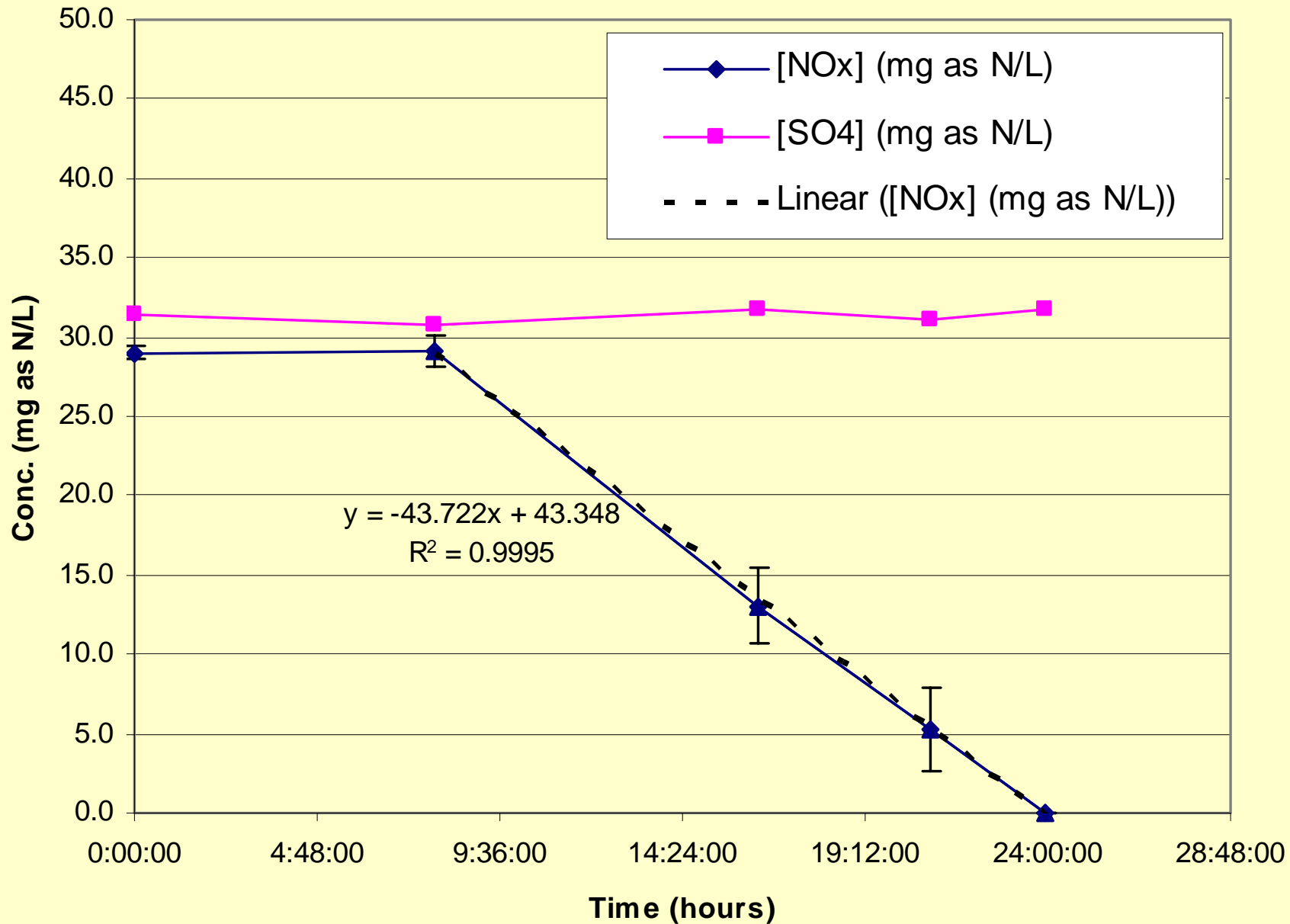


Figure B5E2. (3-15-01) Conc. (mg as N/L) versus Time (hours)
Enriched Sediment 2-4 cm, 2mM NO₃⁻, 1.6mM S(2⁻), 10% Acetylene Headspace

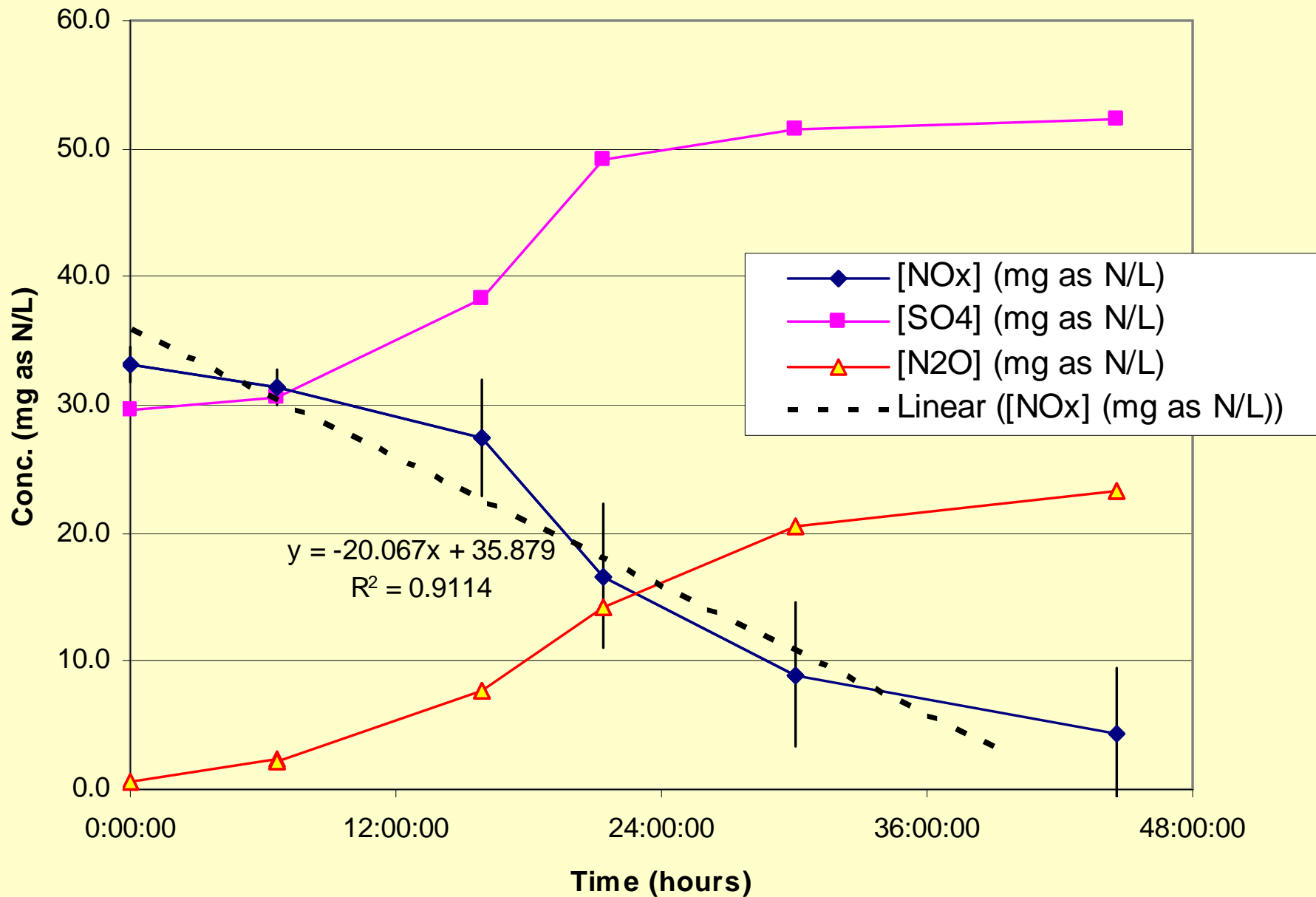
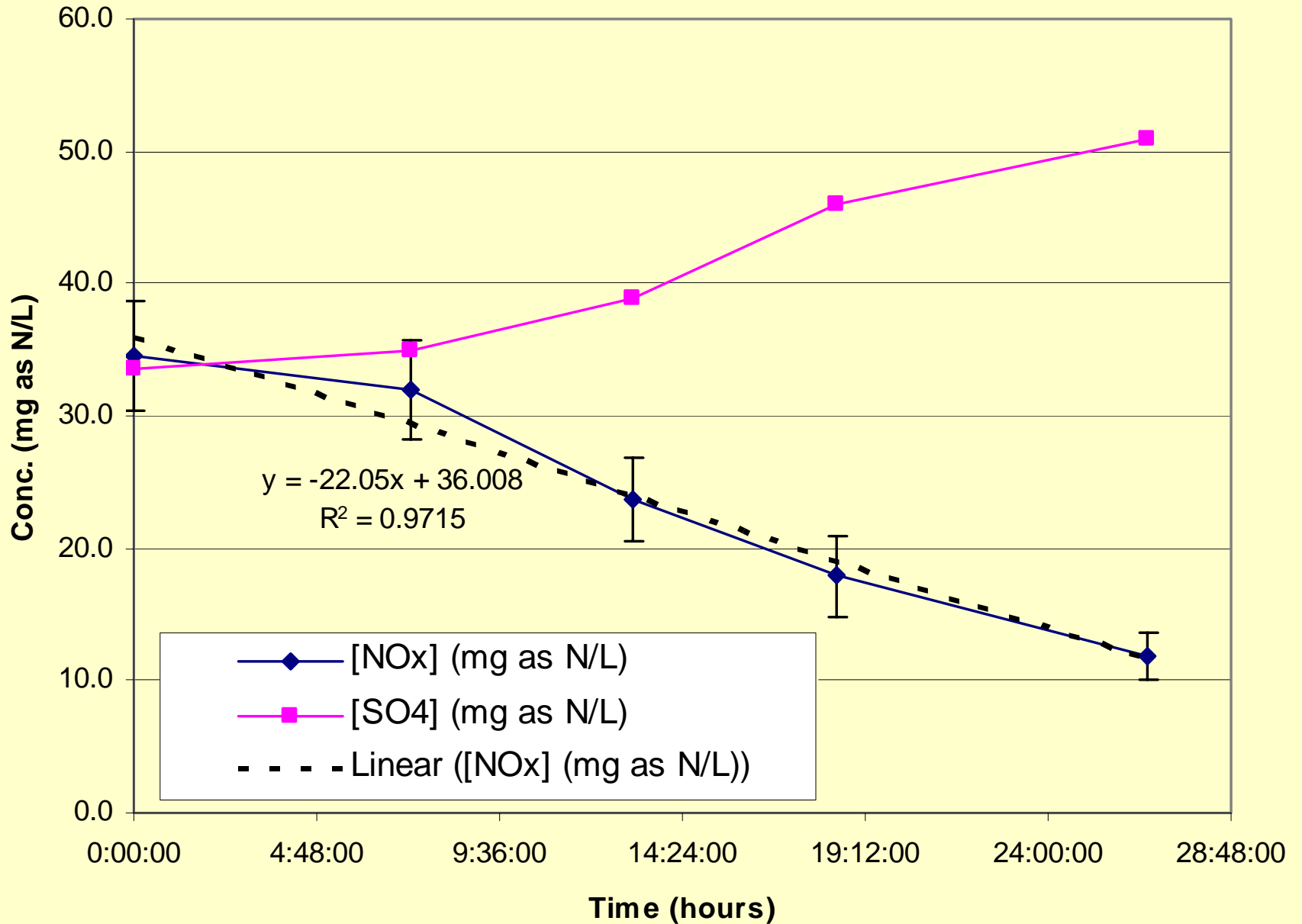


Figure B5G1. (3-15-01) Conc. (mg as N/L) versus Time (hours)
Enriched Sediment, 2mM NO₃⁻, 1.6mM S₂⁻





Conclusions

1. Denitrification via autotrophic & heterotrophic reactions occurred simultaneously, with rates dependent on donor available (seasonal)
2. Similar populations of microbes exist from 0-2 cm as 2-4 cm depth of sediment
3. Non-biological denitrification was insignificant
4. Oxygen did not effect denitrification rates; sulfide oxidation likely scavanged available O₂



Conclusions (cont...)

4. Denitrifiers only present in sediment & plants
5. Wetland plants provide attachment for microbes as well as addition of electron donor
6. Acetylene inhibited reduction of $\text{N}_2\text{O} \rightarrow \text{N}_2$, but not the rate of denitrification for both rxn's
7. Sulfide delayed reduction of nitrate & produced some N_2O for heterotrophs, autotrophs inhibited by high pH



Arizona Dept. of Water Resources

City of Avondale



Integrated Water Resources

