Testing Effectiveness of Nitrate-Reduction Through Utilization of a Biowall in a Simulated Groundwater Scenario

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ABSTRACT

Nitrates, in small amounts, pose no perceivable effects to the average person; however, when present at higher concentrations, the effects of nitrates not only prove deleterious for the human body, but for the environment and its ecosystems, as well. In such cases, pregnant women and their unborn children are at a particular risk for adverse health effects. As for the environment, excess nitrates can result in algal blooms on bodies of water, which entirely disrupts the ecosystem and is typically detrimental to the survival of aquatic life present. This investigation will entail the experimentation of multiple soil columns to be used as "biowalls" to curb the presence of nitrates in groundwater samples. Through the use of four soil columns, each with differing component compositions, the most effective blend of mulch, soil, and sand will be determined. In addition, the effect of the *Pseudomonas sp.* culture and emulsified vegetable oil (EVO) will serve the purpose of determining the most effective approach for the removal of nitrate present in groundwater. Through this research, it is expected that the composite bioactive soil mixture will remove a substantial concentration of nitrates, which suggests great potential for groundwater treatment.

INTRODUCTION

- Nitrates (NO_3^-) and nitrites (NO_2^-) in excess prove to be undesirable, as they may result in adverse effects:
  - Acquired methemoglobinemia
  - Birth defects upon exposure to pregnant individuals
  - Numerous studies pointing to the carcinogenic properties of nitrates
- Sources of excess nitrates:
  - Byproduct of the excessive use of fertilizer- both in residential utilization and commercial farming
  - Incomplete municipal wastewater treatment and runoff from livestock operations
- The significance of this research is to add information to the current literature regarding the effect of *Pseudomonas denitrificans* on the removal of nitrate from simulated groundwater, using varying carbon sources for the bacteria.

RESEARCH PURPOSE

- Determine most effective soil compositions for NO_3^- removal
  - See ***Tables 1 & 2*** for specific column components and ratios
- Investigate effects of nitrate-reducing bacteria (*Pseudomonas denitrificans*) and its interactions with/without an alternate carbon source present (EVO)

METHODS

- Contaminate deionized water with 40 ppm of nitrate using Na NO_3^-
- Feed onto columns continuously for 6-8 weeks
- Take samples daily for 1-2 weeks
- Analyze absorbance values of samples using HACH DR 900 spectrophotometer
- Repeat process of taking samples and analyzing 3-times a week for approximately 5-7 additional weeks following the first week
- Calculate concentrations from absorbance values
- Two separate runs of this experiment were conducted, and soil column compositions for each run can be seen in ***Tables 1 & 2***

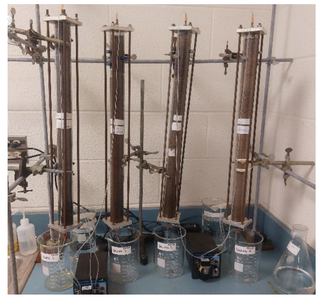


Figure 1: *Soil Column Apparatus*

Table 1: *Soil Column Content Ratios, July 2023*

Column #		Bacteria	EVO	Sand %	Mulch %	Soil %
1	B	+	-	40	30	30
2	D	+	+	40	20	40
3	C	-	+	40	10	50
4	A (control)	-	-	75	5	20

**ratios were done as % by volume*

Table 2: *Soil Column Content Ratios, September 2023*

Column #	Bacteria	EVO	Sand %	Mulch %	Soil %
1	+	-	40	30	30
2	+	+	40	30	30
3	-	+	40	30	30
4 (control)- sterilize	-	-	40	30	30

RESULTS

Table 3: *Nitrate concentrations over 2-week period, July 2023*

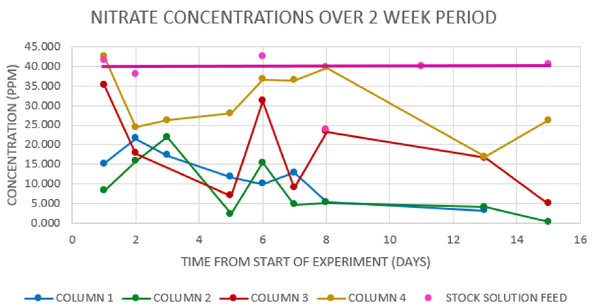
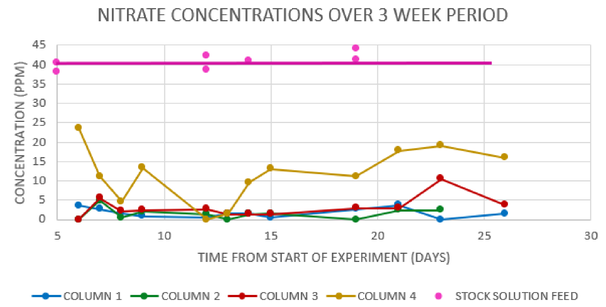


Table 4: *Nitrate concentrations over 3-week period, September 2023*



DISCUSSION

LIMITATIONS

- Time constraint
- Limited laboratory access
- Inaccuracies with measurement devices
- Limited laboratory space

FUTURE DIRECTIONS

- Bacterial growth on petri dishes
- Continue data collection
- Analyze for sulfate and phosphate

CONCLUSIONS

- Columns 1 & 2 (July & September)
  - Both contain *Pseudomonas denitrificans*
  - Most consistent decrease in concentration
  - Minimal data jumps
- September 2023 Improvements
  - Columns washed longer before start of data collection, resulting in less data jumps and inconsistencies
  - Sterilization of column 4, lower concentration
  - More consistency overall
- Denitrifying bacteria showed significant and consistent success in nitrate removal over the course of both the 2-week and the 3-week sessions

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