Algal Bioremediation of Landfill Leachate

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Abstract

The majority of anthropogenic waste is disposed of in landfills, which must be managed after closure. Decomposing waste in landfills produces a liquid called leachate. Current leachate treatment methods use extensive energy, capital and natural resources, however treatment is required in order to prevent groundwater and environmental pollution. The Alachua County Southwest Landfill currently uses an experimental reverse osmosis (RO) system for leachate remediation. This system does not reduce total ammonia nitrogen (TAN) levels to meet groundwater cleanup target levels (GCTL). Algal bioremediation was used to test biological TAN reduction ability. The two treatment methods were compared for remediation ability and cost.

Introduction

Increasingly affluent lifestyles and continuing industrial and commercial growth around the world has been paired with an increased production of municipal and industrial solid waste. The sanitary landfill is the most common method for the final disposal of anthropogenic waste. Landfills must be lined to prevent leachate, the liquid which accumulates with the waste in the landfill, from percolating into the environment. Upon closure of a landfill, this leachate must be managed for 30 years. Leachate is expensive to treat, and not all treatment methods allow for discharge into the environment. Current treatment methods include transport to a publically-owned water treatment facility to satisfy Groundwater Cleanup Target Levels (GCTLs) (FDEP 2005). Due to its toxicity, leachate is usually pretreated before it is transported. Processes involving biodegradation, physical and chemical pretreatment methods are being implemented, but these methods use large energy, chemical, capital and natural resource inputs. Membrane filtration, specifically reverse osmosis (RO), is a promising process with the ability to remediate landfill leachate.

This research combined RO and algal bioremediation to remediate landfill leachate at the Alachua County Southwest Landfill (ACSWL). The combination of RO and algal bioremediation may provide for a more ecological and economical remediation approach. Cost and remediation ability were compared for two treatment methods. Remediation ability was evaluated with TAN.

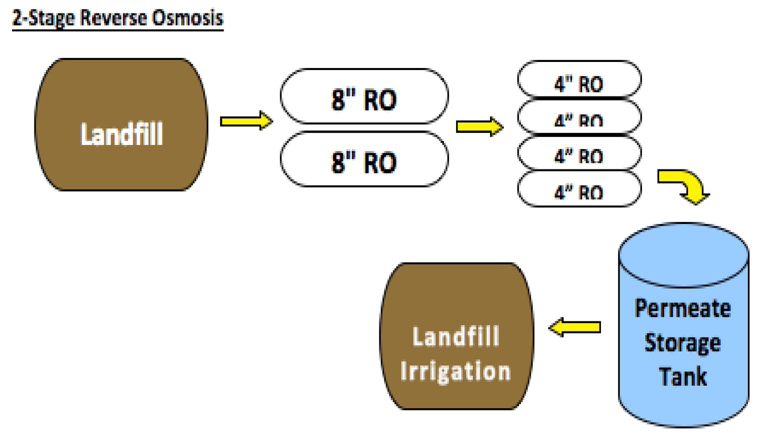


Figure 1: Current landfill leachate treatment system at ACSWL: primary treatment with 8" RO followed by secondary treatment with 4" RO

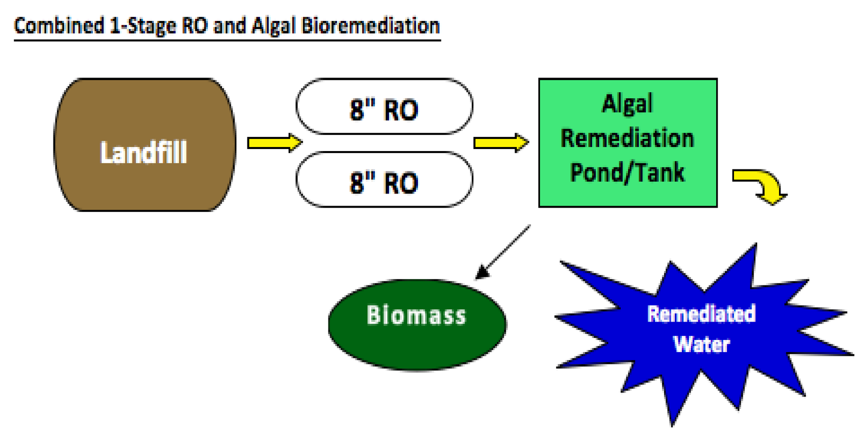


Figure 2: Combined RO and algal bioremediation system: primary treatment with 8" RO. Potential algal biomass co-product.

Objectives

- Compare remediation ability between 2-stage RO and combined RO algal bioremediation systems using TAN.
- Compare remediation costs between 2-stage RO and combined RO algal bioremediation systems.

Methodology

- Algal Growth: Growth was measured by optical density at 545nm using a Thermo Scientific, Genesys 10 spectrophotometer.
- Total Ammoniacal Nitrogen (TAN): TAN was measured using an ammonia probe according to APHA standard methods.
- Remediation Cost Analysis: An economic comparison was performed between the 2-stage RO and combined 1-stage RO with algal bioremediation systems using electrical costs for algal cultivation chambers and estimates of operational costs for the 2-stage RO system.

Results

- Total Ammoniacal Nitrogen (TAN): TAN was reduced below GCTLs of 2.8mg/L (FL DEP) within 8 days (Figure 3)
- Remediation Cost Analysis: The economic comparison of 2-stage RO and combined 1-stage RO and algal bioremediation demonstrates that the combined system could be a more cost-effective treatment approach. It could also provide significant cost and environmental impact savings.

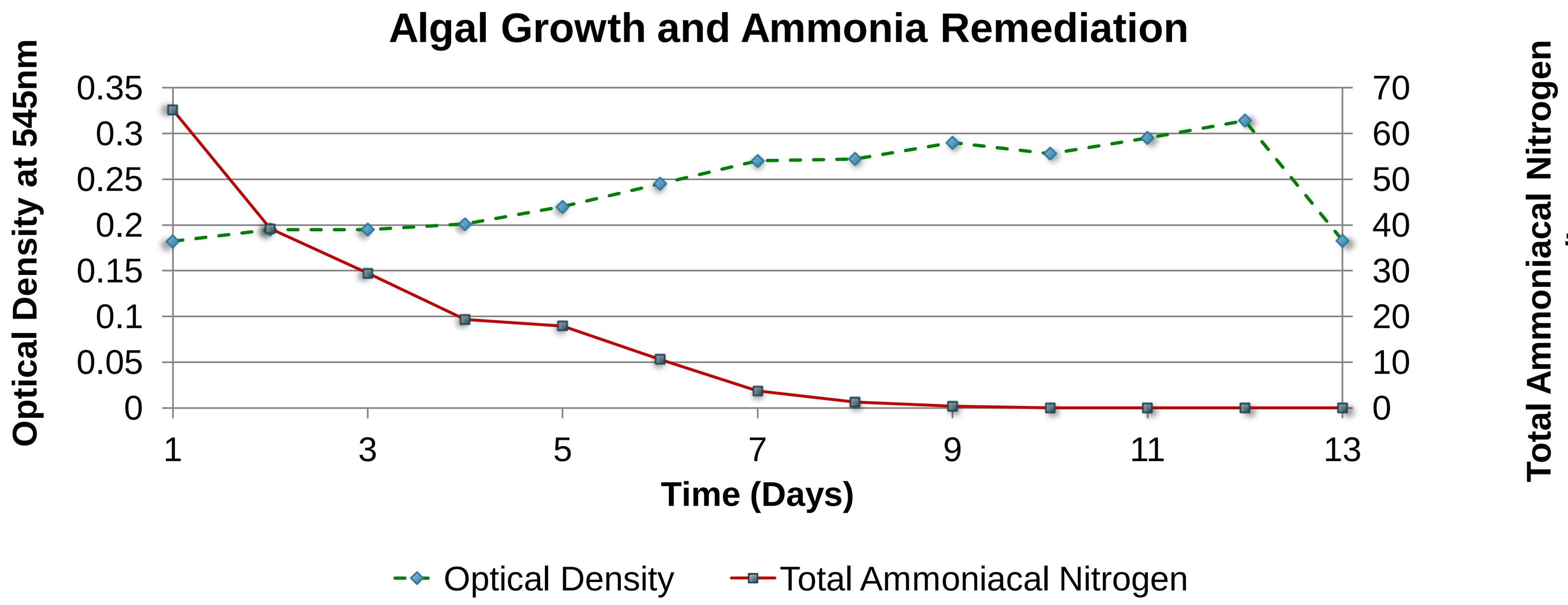


Figure 3: Algal growth and total ammoniacal nitrogen removal over time in the algal bioremediation system.

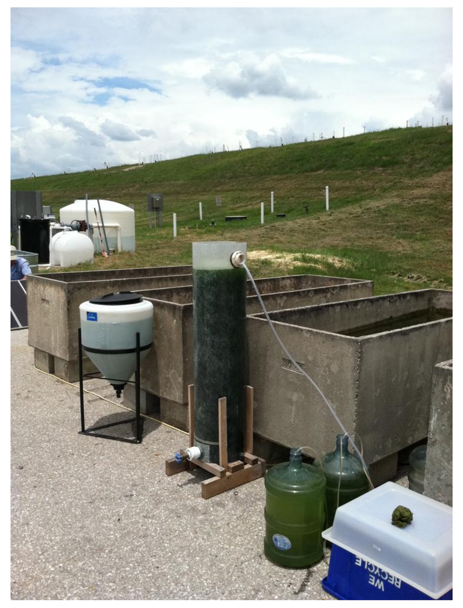
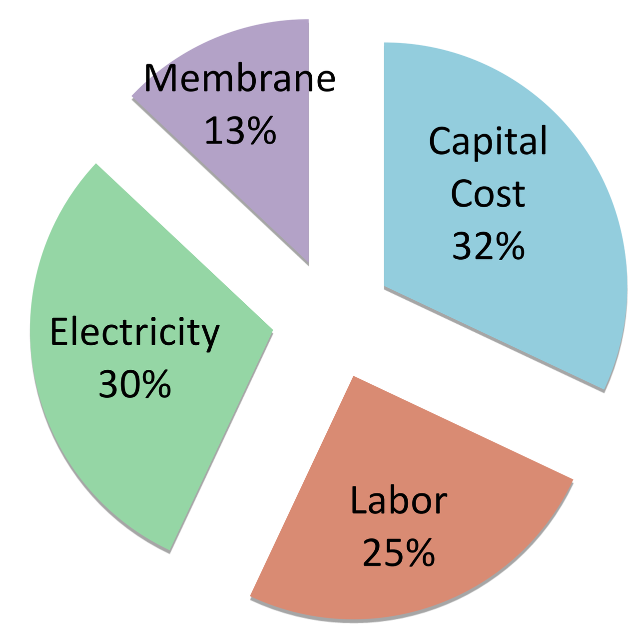


Figure 4: Experimental set up at the closed ACSWL.

Figure 5 and 6: Algal growth in impeller-mixed, 800L algal growth chamber

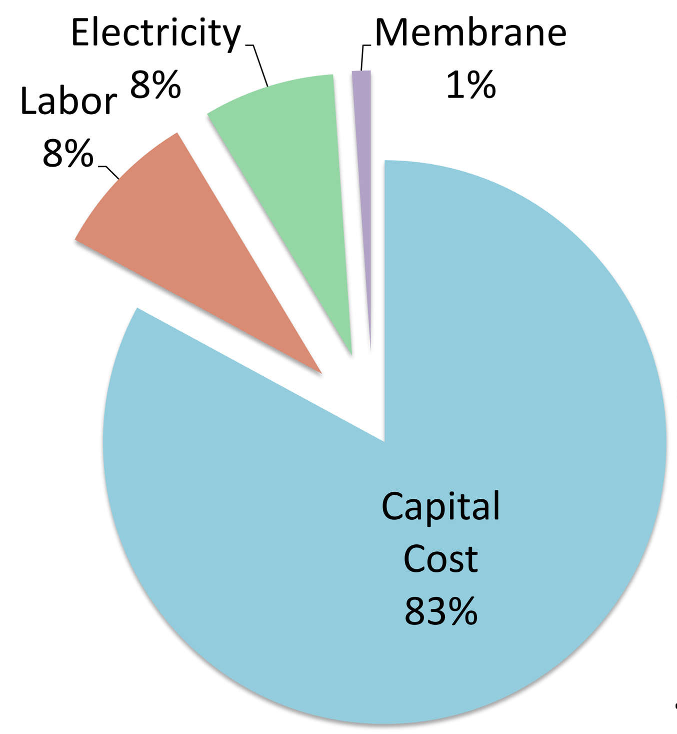
Cost Analysis

- **2-Stage Reverse Osmosis Treatment System**



Max. Daily Treatment	4,500 gal
Est. Total Volume	5,000,000 gal
Remediation Time	1,111 days
Cost Factor	*$/Total Volume*
Capital Cost	43,788.00
Electricity	40,918.00
Labor	33,330.00
Membrane	18,220.00
Total Est. Cost	**136,256.00**

- **Theoretical 1 Hectare 20cm Deep Algal Pond**



Max. Daily Treatment	28,800 gal
Est. Total Volume	5,000,000 gal
Remediation Time	173.6 days
Cost Factor	*$/Total Volume*
Capital Cost*	50,950.00
Electricity	4,631.60
Labor	5,208.00
Membrane	659.68
Total Est. Cost	**61,449.28**

* Theoretical costs adapted (Benemann 1986)

Conclusions

- Combined 1-stage RO and algal bioremediation reduced TAN levels below GCTLs of 2.8mg/L.
- Combined 1-stage RO and algal bioremediation show strong potential for reduction of landfill leachate treatment cost.

Acknowledgements

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References

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