



Phosphorus Wastewater Treatment

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Background

Excessive phosphorus in wastewater causes damage to aquatic environments due to eutrophication^[1]:

- ▶ Increased nutrients leads to high growth of plant life; algae in particular may dominate the environment
- ▶ Algae blooms block sunlight, and bacteria use oxygen to decompose it
- ▶ Most of the oxygen in the immediate area is removed, creating a hypoxic zone
- ▶ Plant and animal life trapped in the hypoxic zone are at risk of harm or death, and the ecosystem is destabilized

Eutrophication is a major environmental issue around the world, and in Southern California:

- ▶ The Baltic Sea has 8 times more phosphorus than it did 100 years ago^[2]
- ▶ Most of the contiguous US coast is “moderately to severely” affected^[3]
- ▶ 12 out of 15 analyzed sites in Southern California had “moderate” or “worse” eutrophic condition^[4]

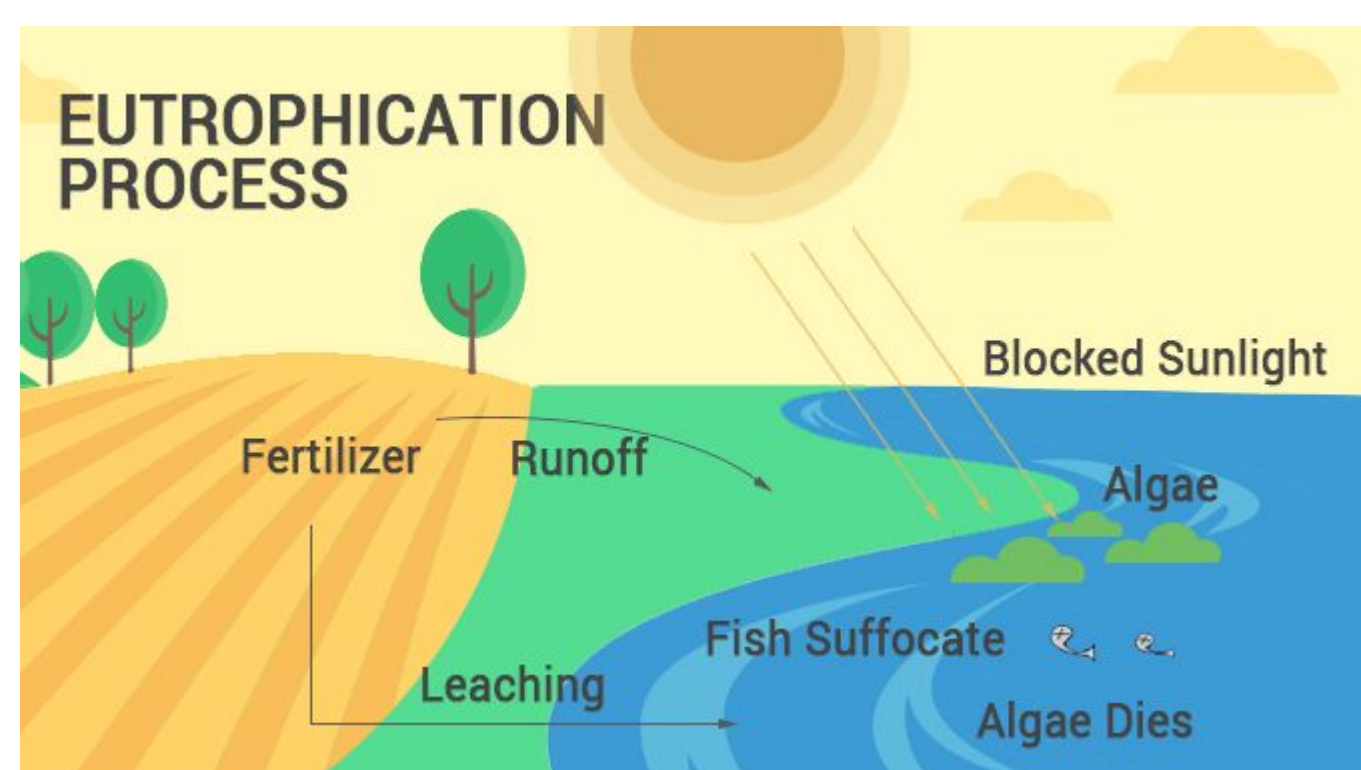


Figure 1 : The process of **Eutrophication**. Runoff **phosphorus** depletes aquatic oxygen and results in hypoxic zones.

Current Design

Ion-Transfer Columns

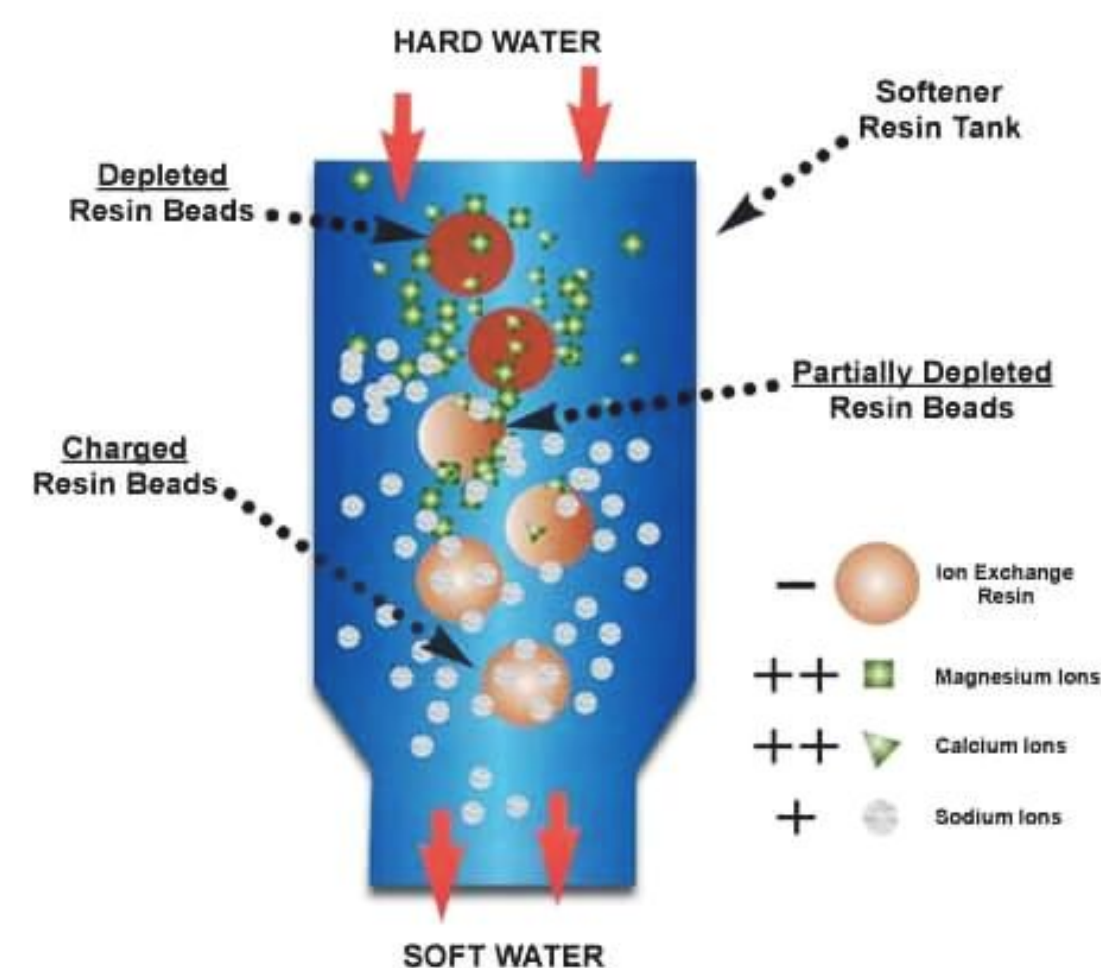


Figure 2: A diagram of the ion-transfer process, illustrated with hard water

Ion Transfer: Water with ions is fed through a column filled with charged resin beads. The target ions will be exchanged with neutral ions between the resin and the water, producing neutral water and ion saturated resin.

Regeneration: After the beads are saturated with phosphate groups, regenerating agents, i.e. NaOH, are added to the column to extract phosphate group from the beads and prepare the beads for the next experiment.



Figure 3: Wet precipitate versus dried precipitate



Figure 4: Unmodified beads versus iron oxide modified beads

Protocols

For preliminary steps, batch methods are used to determine the effectiveness of the beads, and to get rough estimates of the recovery efficiency of differently modified beads. The conditions remaining in question include the modification of beads and residence time. Further experiments can be conducted with columns to resemble the actual water treatment system. The optimal conditions to be determined include flow rate and phosphorus concentration.

Path Forward

- ▶ The next objective is to integrate our columns into a continuous flow system and optimize experimental parameters, e.g. flow rate, column length, etc.
- ▶ Our long-term goal is to implement our ion-exchange column methodology to wastewater. A possible source is the phosphate buffer solutions generated by various biology labs on the UCSD campus.
- ▶ We plan to utilize the collected phosphate as fertilizer for UCSD community gardens.

Sources:

- [1] US Department of Commerce, & National Oceanic and Atmospheric Administration. (2017, October 5). What is eutrophication? Retrieved from <https://oceanservice.noaa.gov/facts/eutrophication.html>
- [2] Threat of eutrophication to the Baltic Ecoregion. (n.d.). Retrieved from https://wwf.panda.org/knowledge_hub/where_we_work/baltic/threats/eutrophication/
- [3] US Department of Commerce, & National Oceanic and Atmospheric Administration. (2017, October 5). What is eutrophication? Retrieved from <https://oceanservice.noaa.gov/facts/eutrophication.html>
- [4] McLaughlin, K., Sutula, M., Busse, L., Anderson, S., Crooks, J., Dagit, R., ... & Stratton, L. (2014). A regional survey of the extent and magnitude of eutrophication in Mediterranean estuaries of Southern California, USA. *Estuaries and coasts*, 37(2), 259-278.
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