Designing a "Reef-Safe" Slow Release Fertilizer for Mangrove Restoration Projects

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Problem Statement:

Restoration of Red mangroves (*Rhizophora mangle*) in high energy environments, while critical for erosional stability, has proven difficult using traditional direct planting or split PVC methods. A new method using armored concrete cultivators (Figure 1) to provide stability has been proposed, but the propagule growth is limited by the amount of nutrients within the cultivator until the young plant has established its first prop roots (about one year). While it is possible to directly fertilize these young mangroves using traditional methods, this can be labor intensive in high energy environments, and often results in wash-out and advection of a high percentage of this fertilizer into potentially sensitive systems such as coral reefs.

Purpose of this Study:

We propose fertilizer delivery by means of commercially available slow release fertilizer encased in a plaster of paris (PoP) and concrete disc, which stabilizes the fertilizer and provides for a consistent controlled release rate.

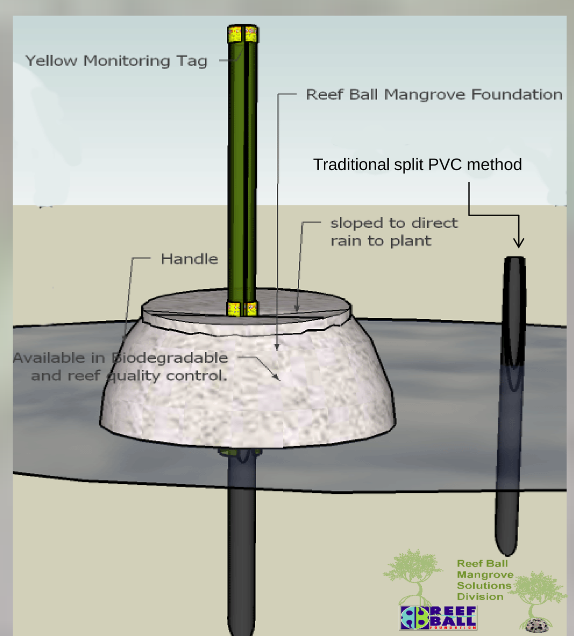


Figure 1: Conceptual drawing of armored cultivator mangrove rehabilitation unit. (image courtesy of www.mangrovesolutions.com)

Figure 2: Armored cultivator units post production awaiting deployment. (photo: J. Krumholz)

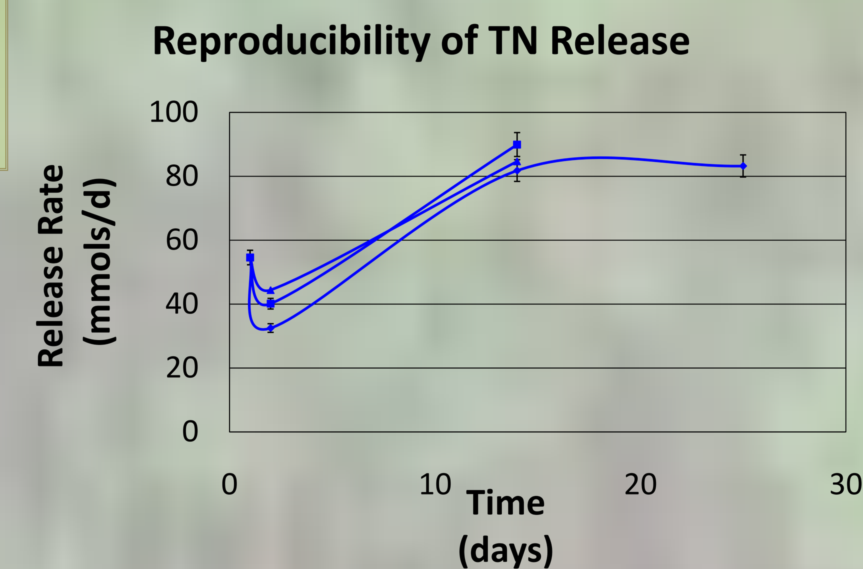
Materials & Methods:

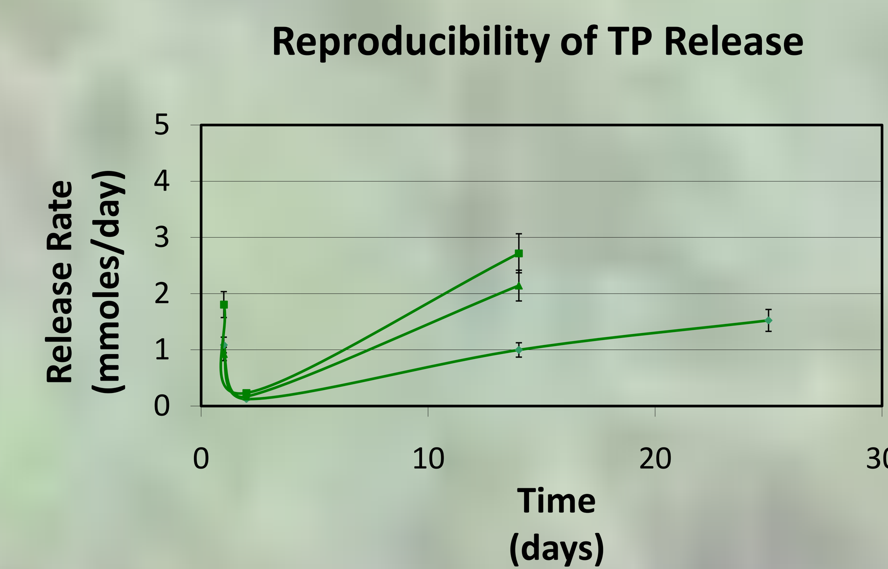
We designed a PoP disc which is custom fit to the base of the armored cultivator unit. Discs were made using a PVC mold, and a measured amount of 19/6/12 NPK slow release Osmocote™ fertilizer (donated by the Scotts corporation) was mixed into each disc. Discs were made from either 100% PoP or an 60/20/20 mix of PoP/Sand/Portland cement (type II). Cement was added in an attempt to increase longevity. Discs were buried in sieved beach sand to a depth of 1" and placed in a flow-through seawater tray filled with ambient seawater (residence time ≈ 6 hours). Discs were periodically removed and sampled for nutrient concentration by incubating discs in 1L of artificial seawater for one hour. After the incubation samples were extracted using a persulfate oxidation (Oviatt and Hindle, 1994), and analyzed for TN and TP on a Technicon Autoanalyzer II.

Figure 3: Photographic review of the experimental process. Discs are made using a PVC mold (**Far Left**). Holes to allow circulation and rooting (**Left**) are made by mounting PVC into a solid base in the bottom of the mold. Fertilizer is mixed into the plaster at the time of casting. Experimental discs (**Right**) were identified with colored cable ties, and buried to a depth of 1" (shown unburied) in a flow-through seawater tray with a residence time of approximately 6 hours, to simulate a tidal cycle. Periodically discs were removed (**Far Right**) and 60 minute nutrient extractions were performed using artificial seawater. (photos: J. Krumholz, T. Barber)

Data Analysis:

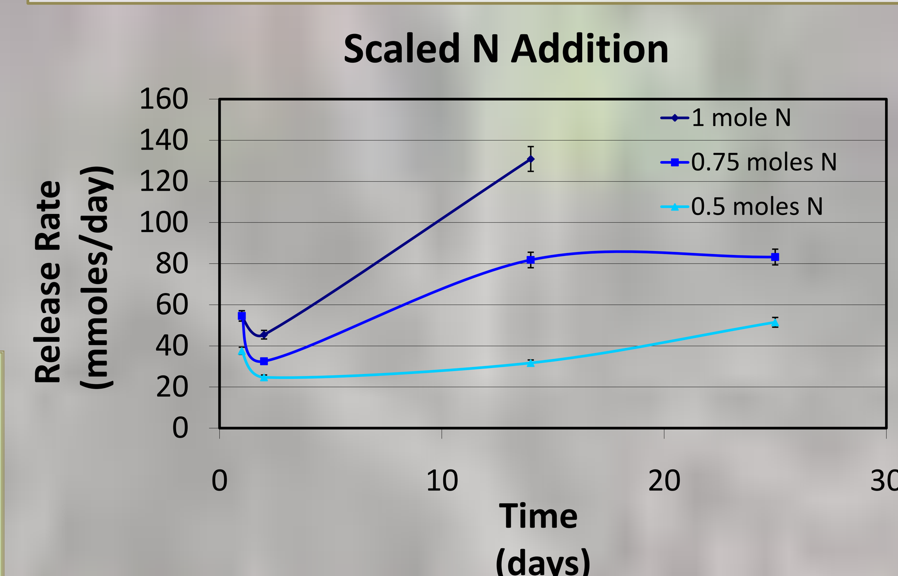
- Nutrient concentrations from extractions were standardized against a blank disc to determine micromoles released per disc per day.
- Release rates were compared across a range of nutrient concentrations and disc types (pure plaster vs. cement fortified) and compared to literature values for mangrove nutrient requirements.
- Error bars are calculated as mean RSD % for all replicated samples (25%).

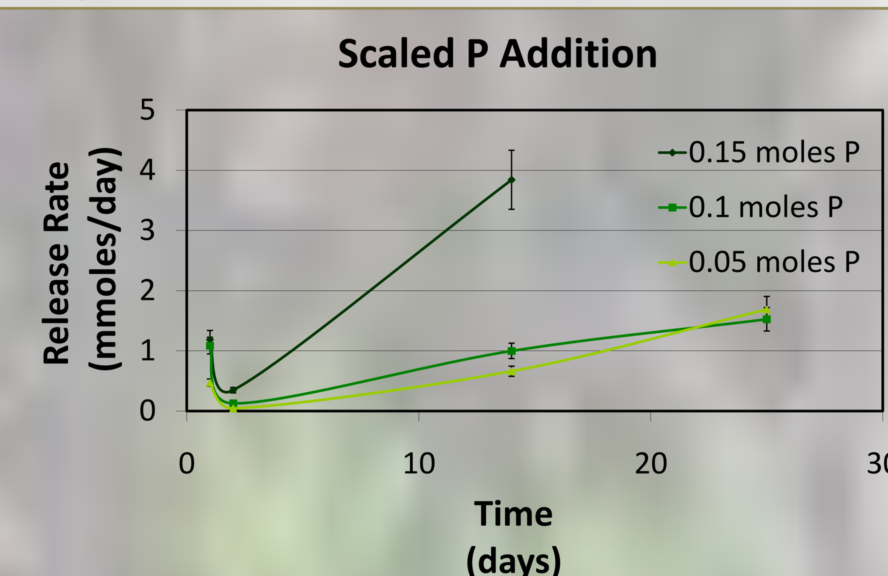




Figures 3 & 4: Release rate in millimoles of N (**left**) and P (**right**) per day for three identical replicated PoP discs with 50 grams of fertilizer each. Two of the discs were destroyed after 15 days, the third lasted 25 days

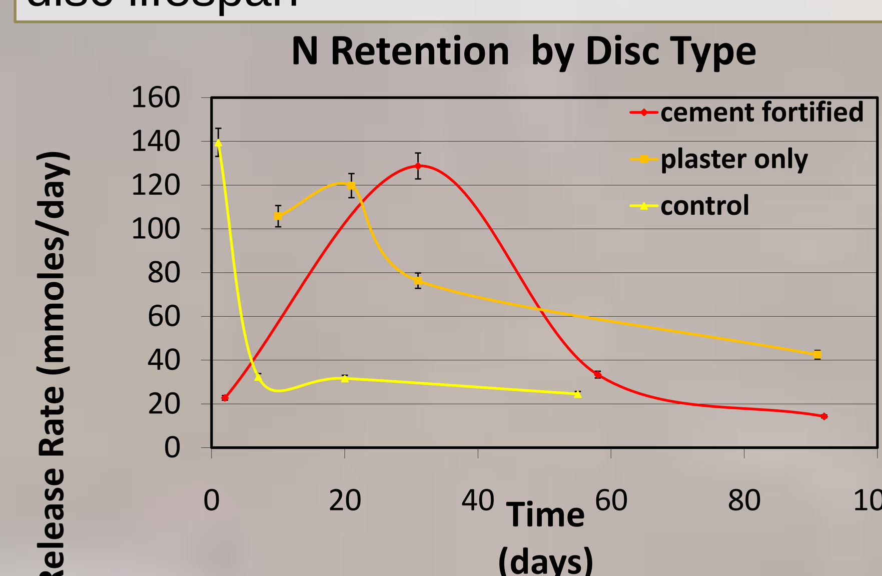
- High level of consistency between identical discs for N release rate **(left)**
- Both N and P show similar release patterns.
- Acceptable level of consistency between discs for P release rate **(right)**
- Plaster discs have unacceptably short lifespan

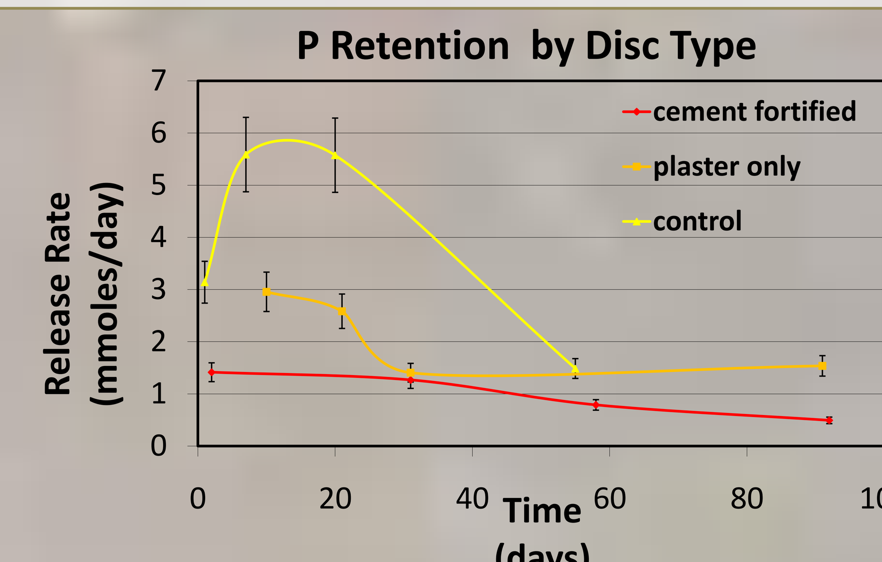




Figures 5 &6: Release rate in millimoles of N (**left**) and P (**right**) per day for three PoP discs with varying fertilizer concentrations. Molar addition calculations are based on conversion from percent by volume. One of the discs were destroyed after only 15 days, the other two lasted 25 days

- Good correlation between concentration and release rate
- Higher nutrient loading may shorten disc lifespan
- N and P show similar release patterns
- It is possible to adjust release rate to customize technique for varying field conditions





Figures 7 &8: Release rate in millimoles of N (**left**) and P (**right**) per day for plaster, cement fortified plaster, and control (no disc, just fertilizer) treatments. 50 grams of fertilizer were used per treatment.

- Both fortified and unfortified discs delay nutrient release vs. controls
- Cement fortified discs delay nutrient release for longer than unfortified discs

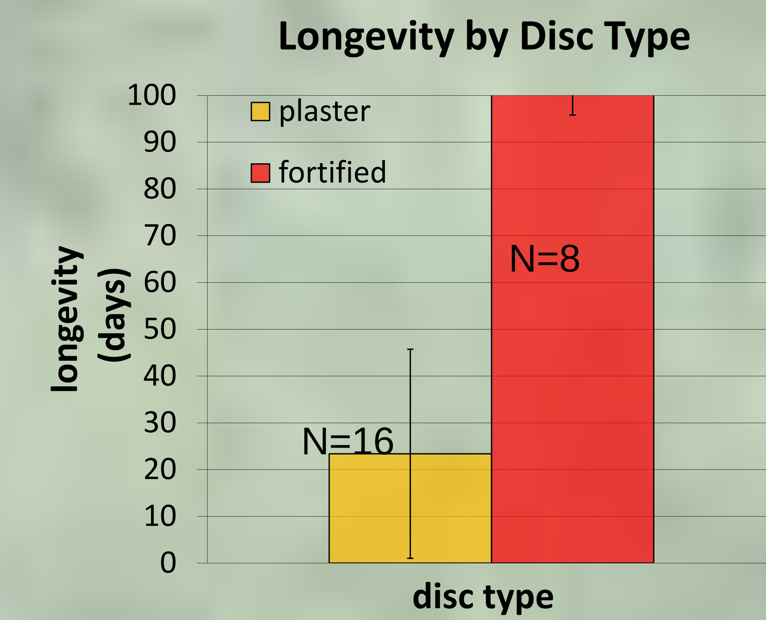


Figure 9: Mean longevity of PoP discs vs. discs fortified with 10% sand and 10% portland cement. 6 of 8 fortified discs are still intact after 120 days.

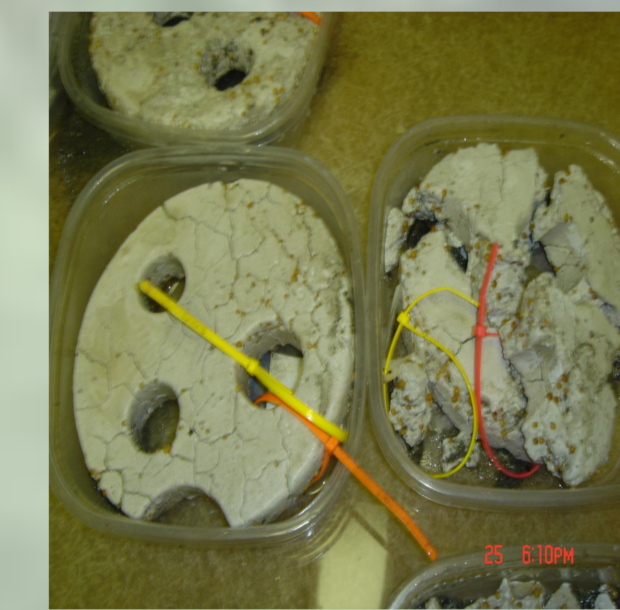


Figure 10: Discs made from 100% PoP (**right**) vs. an 80/10/10 mixture of plaster/sand/portland (**left**) Discs shown are approximately one month old.

Conclusions:

- This experiment demonstrates a feasible method for delivering measured fertilizer doses to mangroves in high energy environments.
- Release rate is adjustable, but on the low end of literature values (e.g. Feller, 1995; Koch and Snedaker, 1997), to reduce washout.
- N to P ratio could be adjusted for varying limitation scenarios (e.g. Feller et. al, 2003) by using a different blend of Osmocote™ fertilizer.
- Fortification of PoP is required to achieve adequate durability.
- Nutrient concentration may affect disc longevity.

Figure 11: Experimental nursery in Grand Cayman, BWI demonstrating the proposed high energy restoration technique. *R. mangle* propagules are approximately 9 months post planting (photo: Tim Austin, Cayman DOE)

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