Lake remediation using sediment capping
Testing the capping materials

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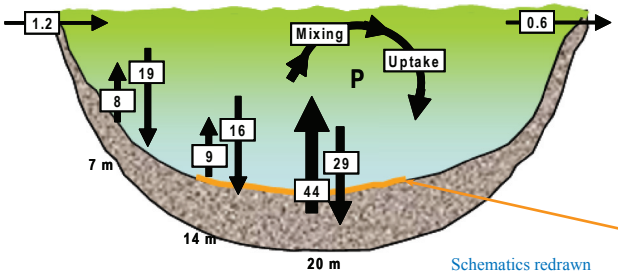
Environment Bay of Plenty commissioned NIWA to test 4 capping agents with different P-binding capacities for use on the Rotorua lakes

Background

In degraded lakes, the nutrients nitrogen (N) and phosphorus (P) released from the sediments by decomposition processes (the internal load) may be much larger than the input of N and P via surface inflows and groundwater (the external load). Lake Rotorua has this problem (Burger et al 2007).

Microbial denitrification processes that remove the N do not remove the P. An excess of P tends to favour the production of potentially toxic cyanobacteria (blue-green algae) blooms. International research has focussed on ways to reduce the internal P load by using sediment capping agents to block the P release. Capping agent materials are either passive, burying the sediments under a thick layer, or active, having a strong binding capacity for P so that a much thinner layer can be used.

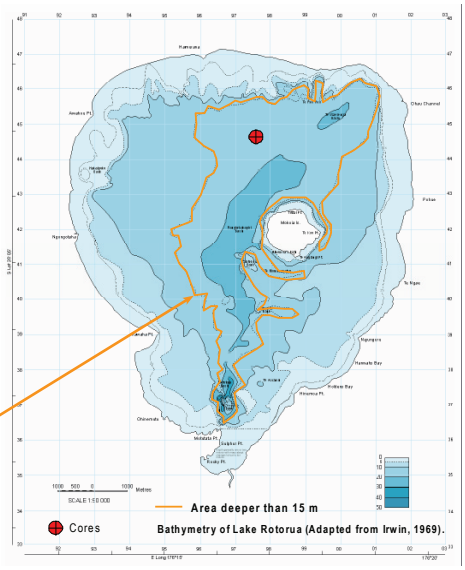
But how much should be used?



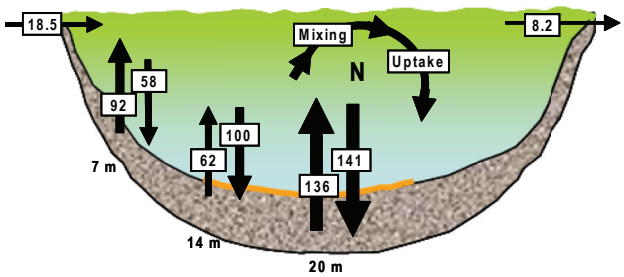
Most P released from sediments under anoxic conditions. Therefore sediment capping most effective below depth of thermal stratification.

Schematics redrawn from Burger et al. 2007

Sediment capping below 15 m



What happens to the N?



Most N released from sediments under anoxic conditions but substantial nitrification and denitrification across whole lake bed.

P-efficacy Results

Sediment Capping Agent (as supplied)	P-binding capacity (theoretical) (g P / kg)	P-binding capacity * (measured at pH 7) (g P / kg)	Required amount (to treat top 4 cm)** (g/m^2)
Alum	100	(not measured)	60*
Modified Zeolite	50	23	190
Phoslock™	20	12	280
Allophane	5	16	220

* Literature estimate
** Total Available P = 3.16 g/m^2

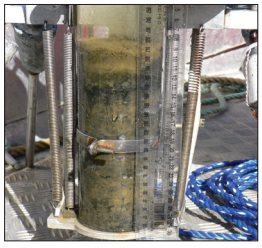
N-effect Results

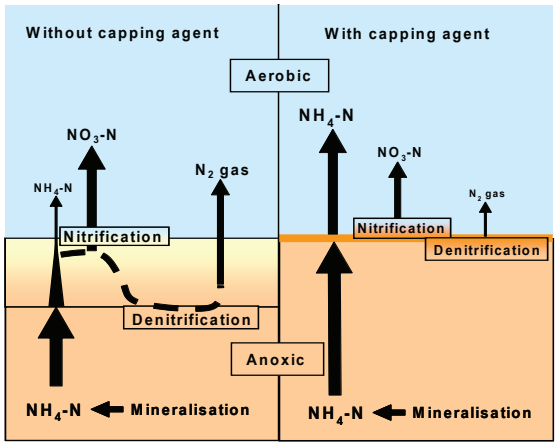
Sediment Capping Agent (as supplied)	Denitrification reduction (aerobic) (mean % vs control)	Denitrification reduction (anoxic) (mean % vs control)	Other effects observed
Alum	43	6	Floc easily re-suspended
Modified Zeolite	37	15	Blocks NH_4-N release
Phoslock™	49	13	Leaches† La ~2 mg m^{-2} d^{-1}
Allophane	28	6	

† ERMA chronic toxicity limit 1g La m^{-3}

Capping Results

Capping agents affect oxygen diffusion into the sediment, reducing nitrification and denitrification.





Conclusions

Alum: Not recommended as capping agent for Lake Rotorua – too easily re-suspended

Allophane or Modified Zeolite or PhoslockTM could be used as sediment capping agents for Lake Rotorua, below the depth of periodic stratification BUT they may cause enhanced internal N loads during non-stratified periods. This P-N benefit balance needs further investigation.

None of these capping agents should be used in the permanently aerobic littoral zone due to their potential to disrupt nitrification and denitrification and thus increase internal N loads.

Reference:

Burger, D.F.; Hamilton, D.P.; Pilditch, C.A.; Gibbs, M.M. (2007). Benthic nutrient fluxes in a eutrophic, polymictic lake. *Hydrobiologia 584:*13–25.

Acknowledgements:

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