Influence of depth on enhancing biofilm extraction from aquifers through in-situ sonication

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Abstract

Microorganisms in aquifers are often assessed by extracting groundwater samples. Pre-treatment of groundwater extraction with in-situ low frequency sonication can improve microbial representation. This treatment induces biofilm detachment from sediment through exerting a pressure variation on the local environment. Previously, it was unknown when sonication intensity, as a function of depth, would drop below the threshold required for mobilizing biofilm.

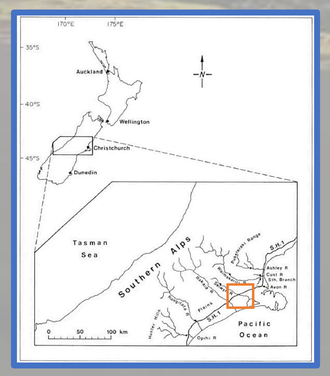


Fig. 1: Map of New Zealand and field site[2]

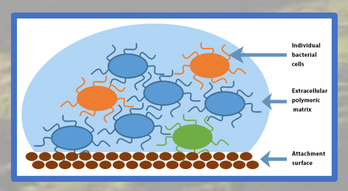


Fig. 2: Biofilm composition[4]

Background

- Anthropogenic stressors have altered groundwater ecosystems in New Zealand[1] (Fig. 1)
- Most microorganisms in groundwater exist as biofilm (attached microorganisms) (Fig. 2), but this has been underrepresented in groundwater assessment[3]
- Accurately assessing microbial life in aquifers is important because microorganisms are responsible for the majority of primary production in groundwater[3]

Procedure

- Loose gravel bags were placed in a shallow groundwater monitoring well to establish biofilm colonies in-situ over eight weeks before collection
- A series of sonication pulses (2.43 kW) of increasing duration were applied to the well (8.1 m deep, 1.7 m below ground level) at varying depths below the water table (0.7, 3.0, 5.4 m) (Fig. 3)
- Groundwater samples were collected during sonication pulses and at increasing intervals following sonication

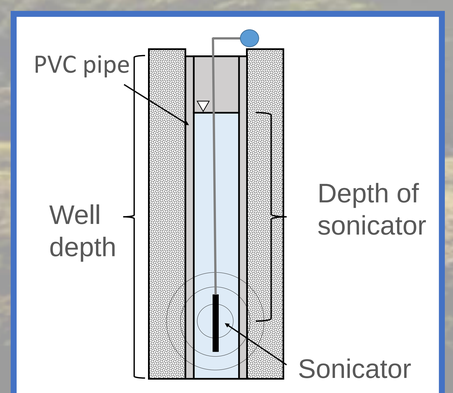


Fig. 3: Fieldwork schematic

Results

- Maximum heterotrophic plate count (HPC) values were observed during the first pulse (Fig. 4)
- Values dropped rapidly after sonication ceased and subsequent pulses provided slightly lower colony counts.
- Sonication improved the extraction efficiency up to 84-fold compared to background values and were similar to the levels extracted from the in-situ biofilm samples
- Colony counts were all on the same order of magnitude

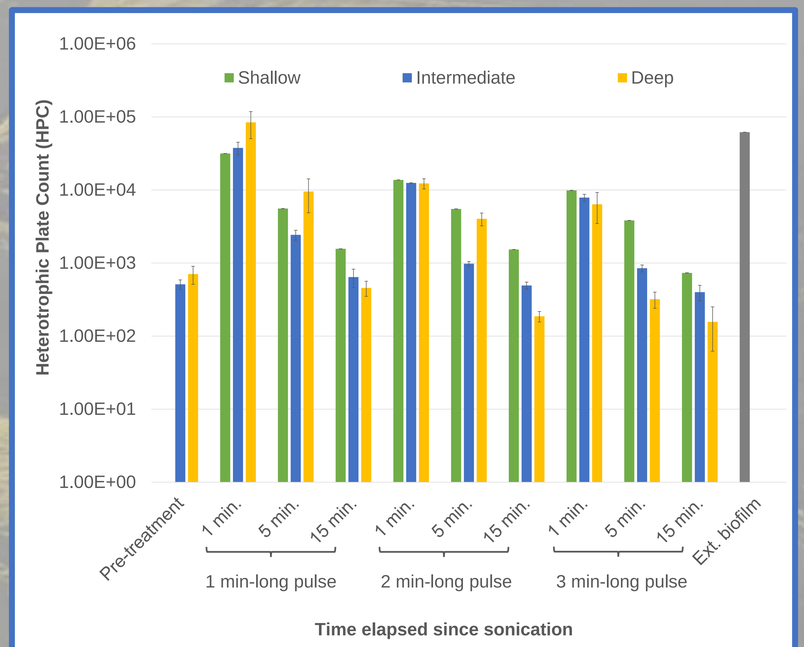
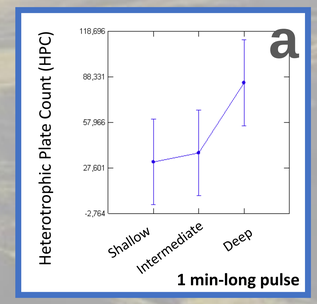
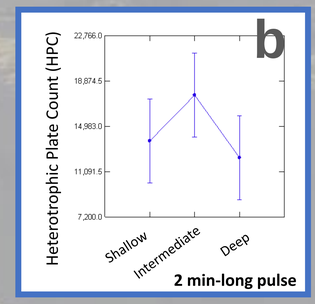


Fig. 4: HPC across the three depths, with three sonication durations

- Statistically significant but marginal difference in HPC for the first pulse (F-ratio = 6.109, *p*-value = 0.036) (Fig. 5)
- No statistically significant difference in HPC for the second pulse (F-ratio = 3.566, *p*-value = 0.095) or the third pulse (F-ratio = 2.713, *p*-value = 0.145)
- Groundwater turbidity followed the same pattern as the HPC values; sonication released sediment fines that settled over time





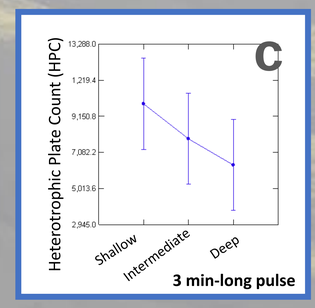


Fig. 5 (a, b, c): HPC at increasing depths for a. 1 min-long pulse, b. 2 min-long pulse, and c. 3 min-long pulse

Conclusion

In-situ sonication across all depths greatly increased extraction efficiency, making this technique a cost-effective tool for improved groundwater microbial assessment.

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3. Ugolini, F., Henneberger, R., Bürgmann, H., Zeyer, J. and Schroth, M. H. (2014), In-Situ Sonication for Enhanced Recovery of Aquifer Microbial Communities. Groundwater, 52: 737–747. doi: 10.1111/gwat.12105

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Acknowledgements

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