Development of an Improved *in situ* Device for Monitoring Trace Metals in the Aquatic Environment

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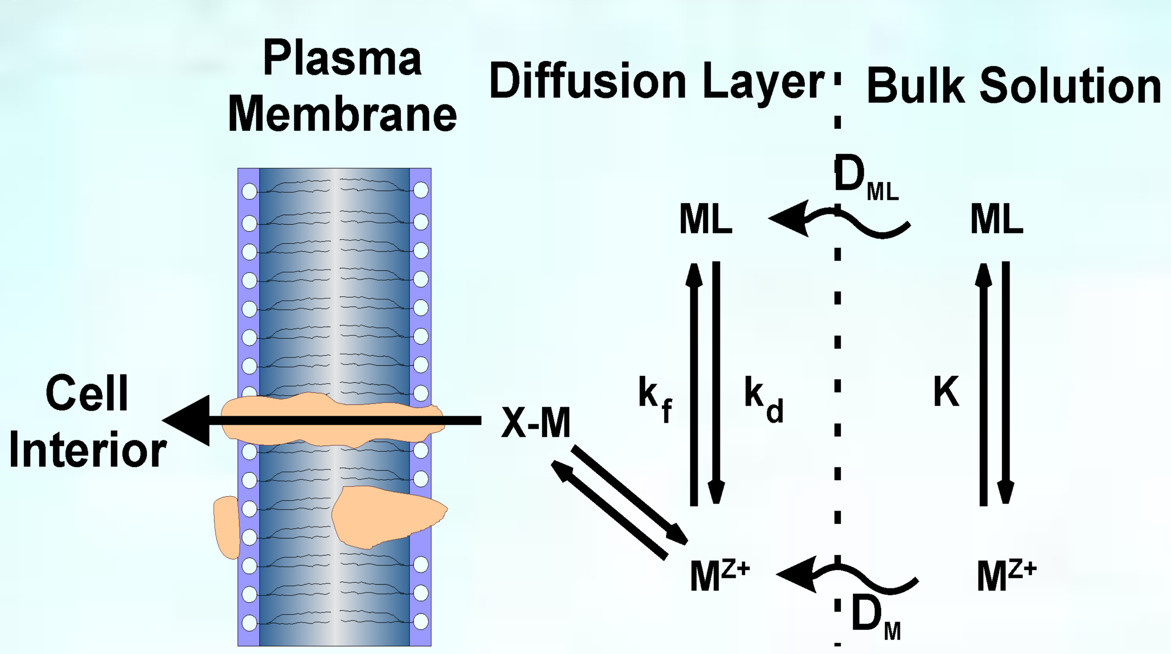
Abstract

Diffusive Gradients in Thin Films (DGT) has been widely applied as a technique for the *in situ* measurement of labile metal concentrations. Current DGT devices are limited by the ionic strength of the solution & the identity of the metal. An improved DGT device incorporating two different modifications was designed and tested. The first modification (mod-A) employed water as the diffusive layer, while the second modification (mod-B) employed membrane filters as the diffusive layer. Both modifications used an Empore extraction disk as the metal binding layer. These modifications were tested against classical DGT devices in solutions of copper.

Scientific Background

- Metals are important in biological systems because they can act as micronutrients, macronutrients or toxicants.
- The chemical form of the metal is known as its speciation and plays a crucial role in determining its reactivity, bioavailability, mobility and toxicity. Metals that are not directly bioavailable may become bioavailable via the reaction:



Free Ion Activity Model

- Diffusive Gradients in Thin Films (DGT) is an *in situ* technique for measuring trace metal concentrations.
- It consists of a three layer system: i) an outer filter, ii) a well defined hydrogel diffusive layer, and iii) a metal binding resin layer.
- DGT effectively measures metal flux: the accumulation of a mass of ions over a period of time through a well defined area.

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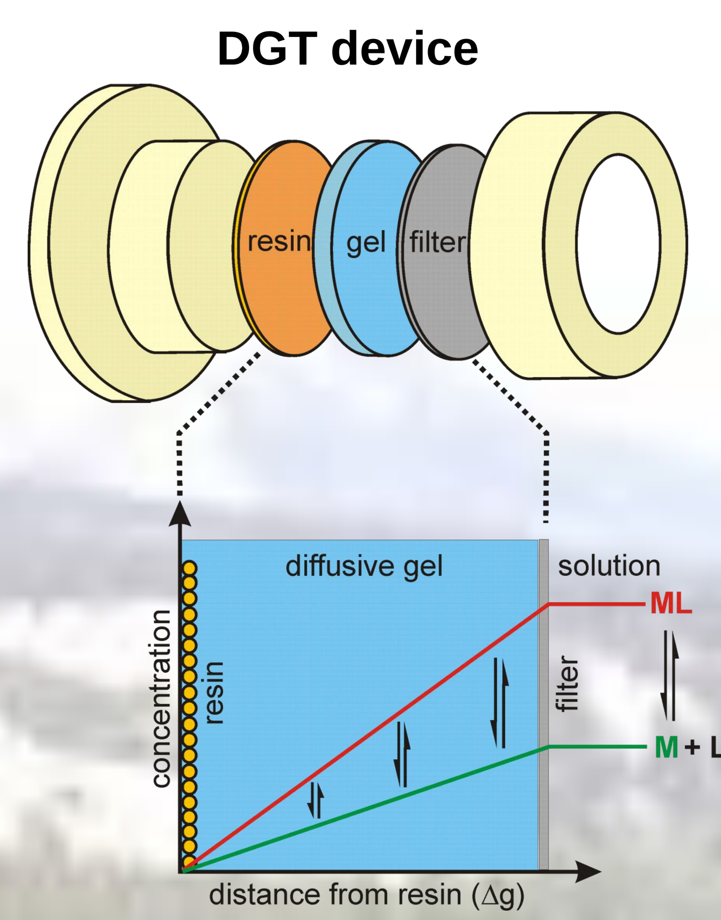


Advantages

- Ease of use, capability for multi-element analysis, provides time-averaged concentrations when used for extended deployment times.

Disadvantages

1) Ionic strength, pH, and solution composition can affect the diffusion rate.
3) Measurements in environments of low ionic strength, such as pristine natural waters, are erroneous.
4) DGT is not useful for measuring certain metals, e.g. zinc.

The **objective** of this research was to design and test an improved DGT device for monitoring trace metals.

Experimental Design

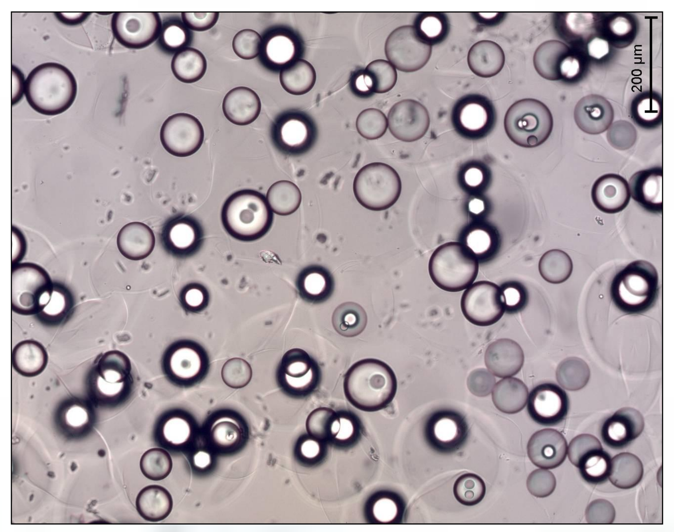
Two modifications were designed and tested.

First modification (mod-A) - a three layer system composed of:

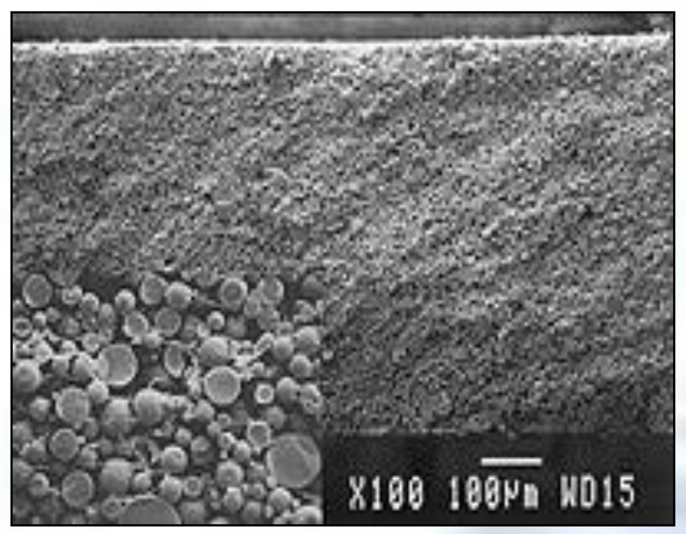
1. An outer filter for size fractionation;
2. A diffusive layer composed of deionized water which controls transport to the metal binding layer;
3. A metal binding layer composed of a 3M Empore high performance extraction disk.

Second modification (mod-B) - a two layer system composed of:

1. Multiple filters used to simulate both the diffusive layer and the outer filter
2. A metal binding layer (3M Empore extraction disks).



Microscope image of Classical DGT Resin Binding Layer



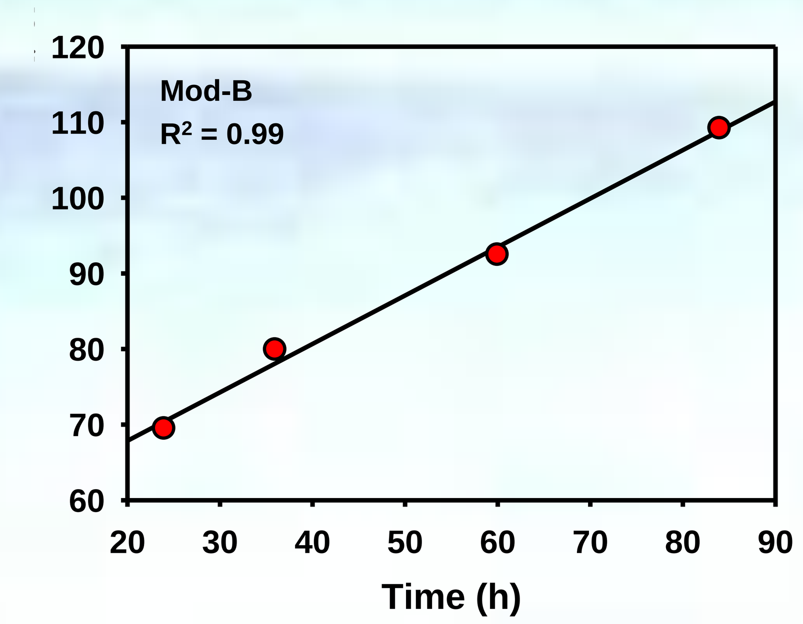
SEM image of Empore Extraction Disk

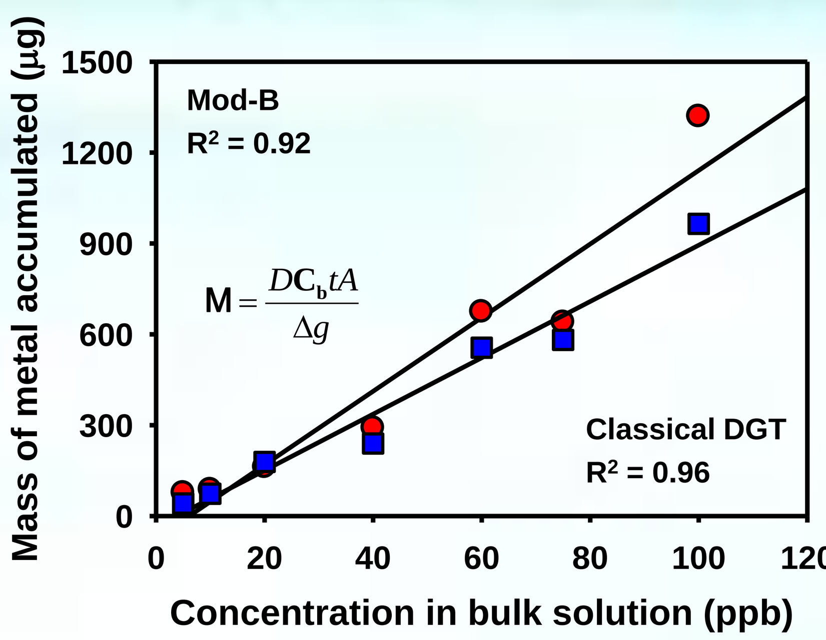
Results and Discussion

- The first modification showed the highest recovery compared to the two classical DGT units.
- However, it was nearly impossible to form a tight seal and units often leaked; a well defined diffusive layer thickness was hard to achieve.

Sample	Percent Recovery	Std Dev
Mod-A	92%	8%
Classical DGT (0.4 mm)	38%	2%
Classical DGT (0.8 mm)	90%	6%

- Based on equations derived from Fick's law, a linear relationship was observed between the mass of metal accumulated and both the deployment time and metal concentration in the bulk solution.





- The classical DGT device, along with both modifications were tested in a solution of low ionic strength. The first modification showed the highest recovery.

Sample	Percent Recovery	Std Dev
Classical DGT	65%	8%
Mod-A	67%	2%
Mod-B	49%	4%

Acknowledgements