

## Understanding biogeochemical mechanisms for heavy metal removal in SuDS

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With urbanization on the rise, there has become a growing need for sustainable approaches to cope with increased pollutant load and reduced land available for stormwater infiltration. A type of Sustainable urban Drainage System (SuDS) of particular interest is a filter drain, which utilizes gravel media to filter and treat road runoff laden with pollutants. While the simple concept is known to remove suspended solids and heavy metals typical in road runoff, the design of such systems is based on limited scientific input. This study aims to characterize the biogeochemical mechanisms responsible for pollutant removal, specifically heavy metals, to help improve design and efficiency in SuDS systems.

While metal immobilization in filter drains may be biologically mediated and a subject of future research, initial experimentation explored removal processes by the gravel itself and with the addition of a mineral amendment. Enhancing heavy metal removal with an iron oxide coating has been explored due to the vast literature evidence of iron oxide minerals sequestering metals [1]. Kinetic batch and flow-through column experiments demonstrated that an iron oxide coated gravel removed similar concentrations of zinc to a locally sourced uncoated microgabbro gravel. Since coated gravel also buffered solution pH away from neutral, it was concluded that the difficult, costly coating process would not be suitable for use in an environmental setting.

Specifically, kinetic batch experiments showed typical adsorption curves and removal rates of zinc by uncoated microgabbro at 80% removal up to 8 hours and nearly 100% after 48 hours. Whereas other types of gravel such as dolomite, sandstone and granite removed between 10-50% less zinc overall than microgabbro. Scanning electron microscope (SEM) images of microgabbro show a rough, high surface area and mineral components of microgabbro have the ability to weather to clay minerals, which also have a high affinity for heavy metals. Further experimentation has proven the weathered surface in fact accelerates zinc immobilization by about 20% compared to an unweathered surface.

The SuDS Manual, which is used in construction and design of new SuDS systems, indicates that filter drain material should be a locally sourced graded stone/rock [2]. While this implies that the geology of the type of rock utilized in such systems does not affect pollutant removal mechanisms, kinetic batch experiments of different rock types indicates otherwise.

[1] Benjamin *et al.* (1996) *Wat. Res* **30**, 2609-2620. [2] Woods-Ballard *et al.* (2007) *The SuDS Manual* 241-249.

## Conservative behavior of Uranium vs. salinity in sea ice and brine

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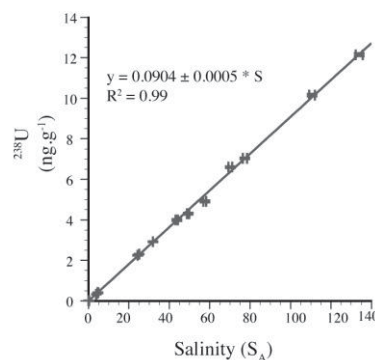
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Since studies by Ku *et al* [1] and Chen *et al* [2], it is widely accepted that uranium (U) behaves conservatively with respect to salinity (S) in seawater over the salinity range of 30 to 36. However, in low salinity environments, such as estuaries, its behavior seems more variable. Freezing in the Arctic Ocean provides a natural mechanism to concentrate dissolved seawater constituents into high salinity brine through the formation of sea ice, and reintroduce low salinity water to the surface through melt.

Here we compare U concentration and isotopic composition from samples of low-salinity sea ice, underlying surface seawater, and high salinity brine, covering a salinity range of 0 to 135. Based on these samples, we found that U behaves conservatively across a wide salinity range, producing a U-S relationship slightly different than the one described in previous studies [1] (Figure 1). The isotopic ratio  $^{234}\text{U}/^{238}\text{U}$  from melted sea ice, under-ice seawater, and sea ice brine samples were not statistically different from mean ocean values, within our statistical uncertainties.



**Figure 1:** U-Salinity relationship in sea ice, surface sea water, and brine samples [3].

[1] Ku *et al* (1977) *Deep-sea Res.* **24**, 1005-1017. [2] Chen *et al* (1986) *Earth Planet. Sci. Lett.* **80**, 241-251. [3] Not *et al* (2012) *Marine Chem.* **130-131**, 33-39.