MDAG.com Internet Case Study 49

Time-Dependent Toxicity Related to Short-Term Peaks of Contaminant Release

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Abstract

MDAG case studies and books have discussed short-term peaks of contaminant concentrations and flows that go undetected at many minesites. Such peaks can be dismissed as unimportant, because of their short durations. However, recent biological studies have shown that short peaks can contribute significantly to toxicity due to aspects like damage per unit of time, accumulating damage through time, damage at any concentration, temporally aligned or offset synergistic and antagonistic interactions, and slowly reversible or non-reversible uptake and binding of some metals and other elements. Thus, monitoring, characterizing, predicting, and limiting of short-term peaks of contaminant release can be critical for minesites in certain environments and ecosystems.

1. Introduction

In the last few years, several MDAG.com Case Studies and a book have discussed short-term peaks of contaminant concentrations and flows at minesites (Morin 2015, 2016, and 2017a and b) initially detected in the 1990's (e.g., Morin and Hutt, 1997). These short-term peaks have rarely been documented because of the time and the cost of high-frequency monitoring, which has led to the common assumption they do not occur. Where searched for, they have been found, both in mining-affected and non-mining catchments (Morin, 2016).

Besides the issues of environmental compliance and water quality, the issue of biological toxicity becomes relevant here. However, short-term peaks of contaminants are rarely of concern, because of the short exposure of organisms to elevated toxicity. This goes hand-in-hand with the lack of high-frequency monitoring to quantify short-term peaks.

This MDAG.com Case Study 49 provides a concise review of literature on time-dependent toxicity related to short-term contaminant peaks. This review shows that short-term peaks cannot be simply dismissed, and in some cases have major effects on biological activity.

2. Literature Review of Time-Dependent Toxicity

Environmentally, short-term peaks of contaminant concentrations or loadings are a concern only if they cause, or significantly contribute to, environmental damage. Assessments of toxicity and environmental risk can be simplified to evaluations based on occasionally measured, or long-term-average, aqueous concentrations. In this simplified case, short-term peak concentrations would not be important.

In reality, toxicity and risk include dynamic aspects, such as damage per unit of time, accumulating damage through time, and damage at any concentration (e.g., Baas et al., 2010; Shimako et al., 2017; Tennekes and Sáncho-Bayo, 2011 and 2012; Tennekes, 2016). In these cases, short-term peak aqueous concentrations can cause significant environmental and toxicity effects.

Moreover, due to synergistic and antagonistic interactions (Baas et al., 2010), temporally coinciding peak concentrations of two contaminants can have different environmental effects than if the peaks were temporally offset (Ashauer et al., 2017).

The importance of short-term peak levels of aqueous contaminants, relative to long-term average levels, can depend on the biological processes of contaminant uptake and binding. For organisms with a rapidly reversible uptake and binding of a particular contaminant, short-term peaks may have little long-term effect.

In contrast, for organisms with slowly reversible or non-reversible uptake and binding of a particular contaminant, short-term peaks and time dependency become more important (Tennekes and Sáncho-Bayo, 2013). Examples of such uptake and binding for some species include metals (Shimako et al., 2017), such as arsenic, copper, cadmium, chromium, lead, manganese, mercury, nickel, selenium, zinc (Utgikar et al., 2004; Ahmad et al., 2005; Sáncho-Bayo, 2009; Tennekes and Sáncho-Bayo, 2011; Pletz et al., 2016; Tennekes, 2016).

Therefore, characterizing and monitoring short-term peak aqueous concentration and their periodicities can be important for characterizing, understanding, predicting, and limiting toxicity at minesites in certain environments and ecosystems.

3. References

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