Metal impact in the marine system

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Introduction

Metals are used during the life cycle of mobile phones. Most of the metals are recycled in EU, but emissions from these facilities may reach soil and water. In cases where effective recycling infrastructures are missing, e.g. in developing countries, this also occurs when the end of life treatment is inadequate.

The emissions to water will finally end up in the marine system, resulting in potential risks to marine organisms.

Aim of the study:

Among all metal species, only the free metal ions are toxic to marine organisms. Taking Cu and Zn as examples, this study presents how metals are transported in the marine water, and differentiate into different species. The metals' toxic risks are revealed.

Materials and methods

Toxic metal speciation:

Free metal ion (M^{2+}) = (M_T)* (M^{2+}/M_T)

M_T is the total dissolved concentration

A small continuous discharge source (discharge rate 10m^3/s) emitting metal-polluted wastewater into a middle sized bay (Donegal Bay) is simulated by MIKE21#. In addition to hydrodynamic modeling, total dissolved metal (M_T) concentrations are simulated simultaneously.

Fraction M^{2+}/M_T is estimated based on empirical data obtained from various literature sources.

#MIKE21is a model of coast and sea, developed by Danish Hydrawulic Institute

Results

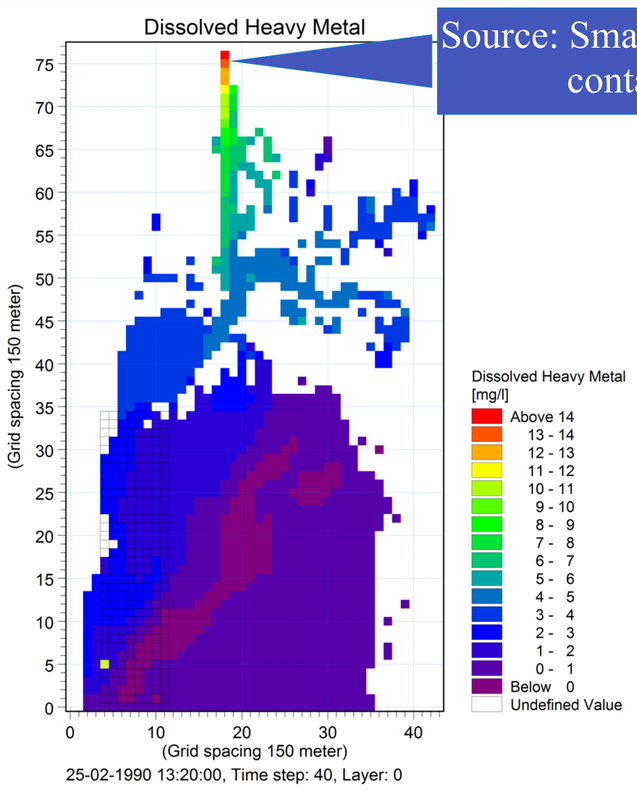

Fig. 1. Cu_T concentration (mg/l) after 2 months discharge

Due to precipitation and adsorption to the sediments and particles, both Cu and Zn concentrations decrease to less than 10% of their source concentrations after 5km. When reaching the edge of the bay, they further decrease to less than 1%.

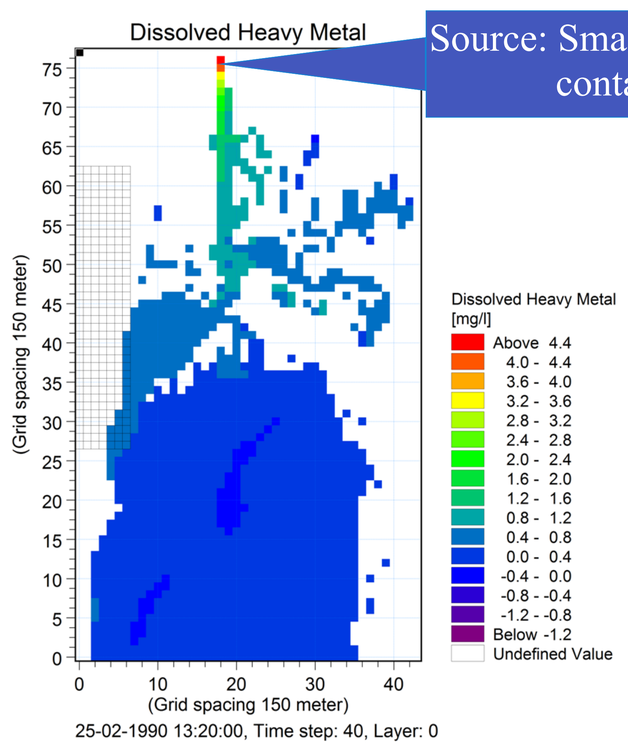

Fig. 2. Zn_T concentration (mg/l) after 2 months discharge

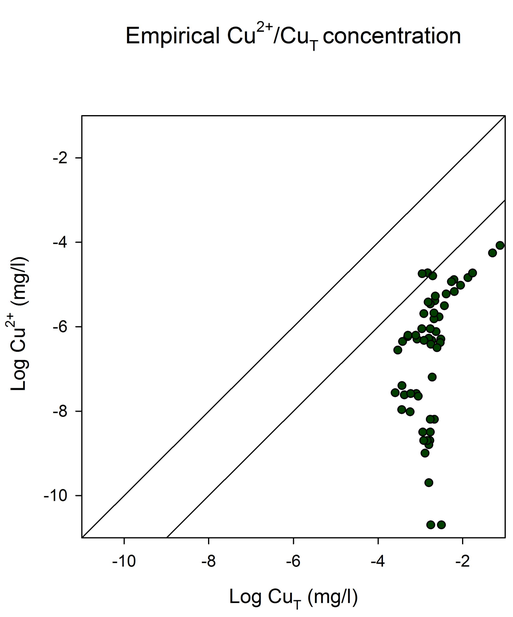

Fig. 3. Empirical Cu^{2+} /Cu_T

Fig. 3 shows that in the marine water, concentration of $Cu^{2+}$is at least 2 orders of magnitudes lower than Cu_T, which means that Cu^{2+}/Cu^{2+}< 1%. Fig. 4 shows that Zn^{2+} is 0.5—2 magnitudes lower than Zn_T, which means that 1% < Zn^{2+}/Zn_T < 32%.

Combined with Fig. 1. and Fig. 2., when reaching bay's edge, Cu^{2+} /(Cu_T at source) < 0.01%, which results in 1.5 µg/l Cu^{2+}; Zn^{2+}/(Zn_T at source) <0.32%, which results in 16 µg/l Zn^{2+}. Comparing to free ion EC50s of marine organisms, which are 120.6 µg/l for Cu^{2+} and 263.2 µg/l for Zn^{2+} (data calculated from epa.org database), the emissions probably will not cause adverse effects to the marine organisms.

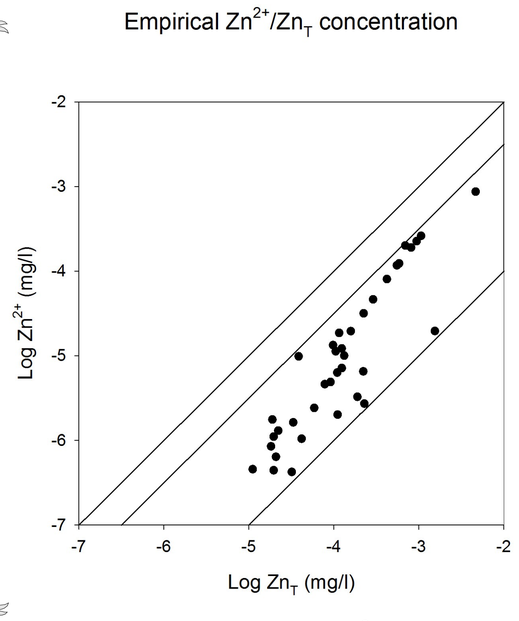

Fig. 4. Empirical Zn^{2+} /Zn_T

Conclusion

From this study, it appears that most of the metal emissions precipitate to the sediments before they enter the marine system, or they are bound to ligands in the marine water reducing their availability to marine life. Only a small portion of metals in the marine system exist as toxic free ions, which may cause very limited damages to the marine organisms. Therefore, metals impacts in the marine environment is highly overestimated by existing ecotoxicity characterization methods for use in LCA which consider the full dissolved fraction as toxic and tend to disregard the strong attenuation in estuaries.