Zero-Valent Iron for Heavy Metal Recovery from Waste Waters

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Abstract
The potential toxicity and mobility of several heavy metals led authorities to strictly regulate its environmental concentration. For this reason a new process with fluidized zero-valent iron for a mobile and flexible remediation in the area of abandoned sites and industrial wastewater had been developed (patented ferrodecont-process). On the one hand, ground water contamination can be safeguarded, simply and with little effort, which prohibits a propagation of the soluble hazardous substances. On the other hand heavy metal containing industry and process water can be de-freighted via the process principle and returned to the sewage line. Suitable operational water can be re-circulated as the treatment method does not increase the salination. This article gives an example of a chromium and copper treatment with this technique.

Keywords
zero-valent iron; fluidized-bed; heavy metal; remediation; metal recovery

INTRODUCTION

Based on R&D-projects in the field of heavy metal reduction a new technique on heavy metal recovery from waste water has been evolved from laboratory to field scale. It was found that several soluble heavy metals can be fixed from waste waters by reduction-induced precipitation and/or adsorption using fluidized-bed reactors filled with zero-valent iron granulates. The range of soluble heavy metal treatment extends from potentially critical metals, like antimony, indium, molybdenum and vanadium to more common metals, like chromium, copper, mercury and zinc. After leaving the reactors the present insoluble metals are separated from the treated water by filtration. The flexibility of the process can be utilised from protection and reclamation of waste disposal sites, industry and process water treatment, through to recovery and recycling of raw materials.

MATERIAL AND METHODS

Iron is a powerful reactant for many contaminants considering remediation by electrochemical and sorption mechanism (Ebert, 2004). To exploit this potential for the recovery of heavy metals, zero-valent iron is filled in vertically mounted cylindrical reactors, in which the contaminated water flows from the bottom to the top, generating a fluidized bed. The redox reactions are not limited by the initial iron´s surface, due to the abrasion-effects between the granules. Batch experiments measuring soluble Cr(VI) removal by elemental iron granulates were measured photometrically and are performed first in a laboratory size fluidized-bed reactor. Copper concentrations were analysed by ICP-MS. All samples were filtered before analyses, passing a 0.45 µm filter.

In order to achieve more flexibility, the field scale treatment plant consists of a mobile container, which shelters 2 series of 10 fluidized-bed reactor elements connected to each other, several pumps, measurement and control systems. The contaminated water is pumped with a flow rate up to 3.5 L/s into the reactors, where the reduction-induced precipitation without any further addition of chemicals takes place.

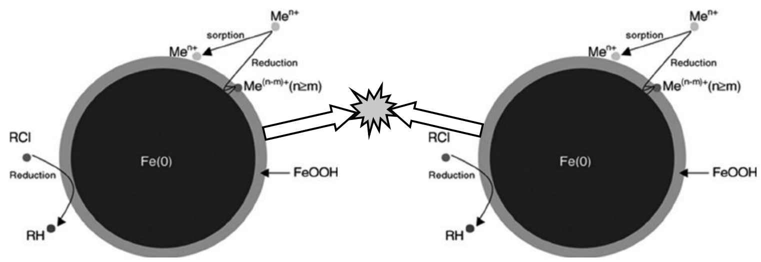

Figure 1. Principle of ferrodecont-process (drawing modified according to Kharisov, 2012).

RESULTS

Due to the exactly defined flow regime in the reactor cascades, contact with the reactants and the pollutants can be guaranteed, which results in a remarkable increase in efficiency compared to solid bed processes. Figure 2a shows a comparison of laboratory experiments from literature (Chen et al., 2008), referring to its best chromate reduction rates with a laboratory fluidized-bed reactor. The performance of fixed bed mode equals 100 %. Figure 2b demonstrates a groundwater treatment in the field-scale plant.

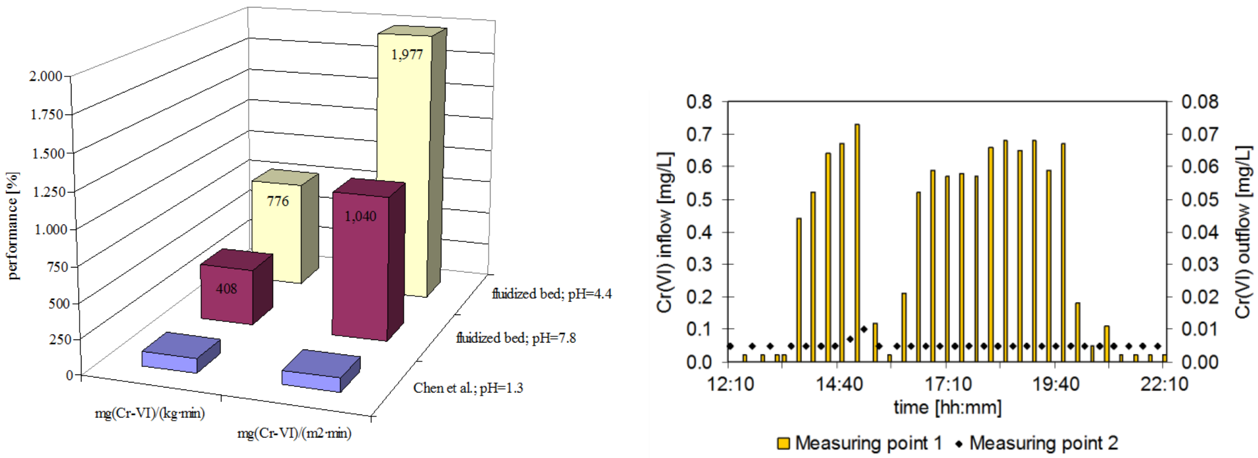

Figure 2. a) Performance of fixed-bed to fluidized bed; b) Comparison of inflow- (measuring point 1, left scale) and outflow-concentrations (measuring point 2, right scale), flow rate is 3.5 L/s (Mueller et al., 2014).

After a treatment time in a laboratory scale reactor of 1 h soluble copper concentrations from an acidified rinse water has been reduced from 570 mg/L to 11 mg/L (reduction rate of 98 %) as elemental copper. The recovered copper can be reused e.g. in the secondary metallurgy.

REFERENCES

Ebert, M. (2004) Elementares Eisen in permeablen reaktiven Barrieren zur in-situ Grundwassersanierung – Kenntnisstand nach zehn Jahren Technologieentwicklung, Habilitation, Institut für Geowissenschaften, Christian-Albrechts-Universität, Kiel (in German).

Kharisov, B.I. et al. (2012) Iron-containing nanomaterials: synthesis, properties, and environmental applications. In: RSC Adv 2 (25), p. 9325–9358. Online available under http://dx.doi.org/10.1039/C2RA20812A.

Mueller, P., Lorber, K.E., Mischitz, R. and Weiß, C. (2014) Implementation of fluidized granulated iron reactors in a chromate remediation process. *Science of the Total Environment*, **485-486**, 748-54.