IN-SITU TREATMENT OF HEXAVALENT CHROMIUM IN GROUNDWATER

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INTRODUCTION

Hexavalent Chromium is a highly soluble and toxic element. The mobility of hexavalent Chromium in the environmental compartments (soil, subsoil and groundwater) depends on the redox potential and the pH of the system (Stumm & Morgan - 1996), as these parameters can vary its oxidation state (transition from Cr(VI) to Cr(III)). Trivalent Chromium compounds are non-toxic and less mobile (Stumm & Morgan - 1996).

It was assessed to implement a remediation by an in situ treatment of the saturated system at a site of a former Chromium plating, located in Veneto (Italy), under the environmental procedure under Legislative Decree no. 152/06, where soil and groundwater were contaminated with hexavalent Chromium (Fig. 1). Before in situ application, and to verify the effectiveness of the method, a laboratory test was prepared in accordance with a specifically designed protocol (Accoto et al. – 2014).

At the site a thin semi-confined aquifer is present, mainly consisting of fine-silty sand; the depth to the water table is about 2 m from ground level and the saturated thickness is about 2 m (Fig. 2). The hydro-chemical monitoring results showed that the highest concentrations of hexavalent Chromium in groundwater were approximately 200 mg/l.

As verified by the preliminary laboratory test, the goal of treatment was to obtain a chemical reduction of hexavalent Chromium to trivalent Chromium. The main remediation technologies applied to cases of contamination by Cr(VI) are based on the achievement of reducing conditions and / or on the availability of electron donors (such as, for example, the zero valent iron) (EPA, 2000).

The injection’s activity started from the plume area at the more distant points from the source of contamination and consisted in the injection of 70 liters of reactant mixture (including 30 kg of EHC-M) into the water-saturated sand zone downstream of the tank contaminated by hexavalent Chromium (Fig. 1).

The used product, EHC-M, is a specially formulated integrated treatment material containing controlled-release organic carbon, ZVI, a source of sulfates, and other additives and it’s designed for treatment of dissolved trace metals. The treatment helps in developing biological processes that lead to the reduction of the redox conditions. The removal of the reduced form of Chromium from the environmental components is also gained by the presence of ZVI and sulphide generated by sulphate reduction (FMC® - 2013).

The injection technology used is “direct push” GEsprobe (Fig. 4).

The injection’s activity started from the plume area at the more distant points from the source of contamination, and consisted in the injection of 70 liters of reactant mixture (including 30 kg of product EHC-M and water) into each of the 33 injection points. The injection’s depth ranged between 1.5 m and 5.0 m below ground level.

After the treatment activities, a program of groundwater hydrochemical monitoring for the determination of Chromium VI, Chromium III and other chemical of concern (Sulfates, Iron, Manganese) started.

OBSERVED TREND

Immediately after the treatment the oxidation-reduction potential of the water at piezometers Pz8 (in the middle of the treated area), Pz9 and Pz11 (downgradient of the treated area), at the groundwater surface, and at the bottom of each monitoring well was monitored.

It was observed a decrease in the redox potential at the wells in the first month of monitoring, which reached strongly negative values (~300 mV at Pz8, ~200 mV at Pz9 and Pz11) (Fig. 5). Later, there was a stabilization of redox potential at the piezometer Pz9 and a shift to less reducing conditions at the other two wells (at the piezometer Pz11 even the previous positive values were restored).

Regarding to Chromium VI, concentrations began to decrease after one week of treatment, reaching values below the detection limit after 20 days (Tab. 1, Fig. 6).

CONCLUSIONS:

Injection of EHC™ - M product into a shallow aquifer, contaminated by hexavalent Chromium, determined a high decreases of redox potential of the aquifer (up to ~300 mV). In that conditions hexavalent chromium was rapidly reduced to trivalent form (Fig. 8), and after Fe, Mn and Sulfates were noticed but limited in space (restricted to the treated area) and in time (peaks expired rapidly). After one year no evidence of hexavalent chromium in the aquifer were detected.

References:


