

Article

# Pilot-Scale Evaluation of a Permeable Reactive Barrier with Compost and Brown Coal to Treat Groundwater Contaminated with Trichloroethylene

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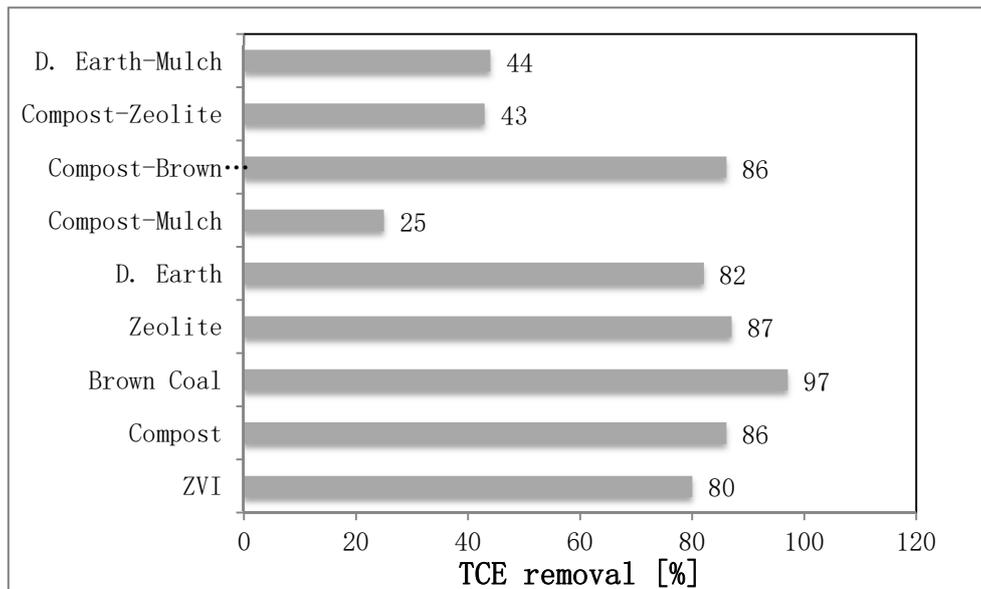
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## 1.1. Reactive materials evaluated



Figure 1. Reactive materials tested.

## 1.2. Removal efficiencies of the evaluated reactive materials [39]



**Figure 2.** TCE removal efficiency for each reactive material used in batch tests [39].

### 1.3. Hydraulic conductivities of the reactive materials

Hydraulic conductivity ( $K_h$ ) was determined using the falling head permeability method. A tube containing water was connected to the saturated column. The water in the tube at  $H_1$  was then allowed to flow through the columns to  $H_2$ . The time taken for the water to fall from  $H_1$  to  $H_2$  was recorded. The  $K_h$  was then calculated using equation 1 below.

$$K_h = \left[ \frac{aL}{A(t_2 - t_1)} \right] \ln \left( \frac{H_1}{H_2} \right), \quad (1)$$

where:  $K_h$  is the hydraulic conductivity (m/s);  $a$  and  $A$  are the cross-sectional area of the tube and the column ( $m^2$ ), respectively;  $t_1$  (sec) is the initial time at  $H_1$ ,  $t_2$  (sec) is the time taken for the head drop from  $H_1$  to  $H_2$ .  $H_1$  and  $H_2$  are the initial and final head of the water in the tube (m).  $L$  is the length of the column (m).

**Table 1.** Hydraulic conductivities for the individual materials and the mixtures.

Reactive materials	Hydraulic conductivity (m/s)
Brown coal	$3.04 \times 10^{-5}$
Compost	$1.12 \times 10^{-3}$
Brown coal-Compost (3:1)	$5.15 \times 10^{-4}$

### 1.4. Procedures for measuring physico-chemical properties of the materials

#### pH in water and 1M KCl (1:2.5)

The pH of the materials was determined in water and 1M KCl at a solid to liquid ratio of 1:2.5 using a multifunctional computer meter (Elmetron Cx-742). Ten grams (10 g) of air-dried materials was weighed into a 100 ml beaker and 25 ml of deionized water or KCl was added. The material-liquid suspensions were then stirred several times for 30 minutes and allowed to equilibrate to the temperature of the pH meter. Prior to use, the pH meter was standardized with buffer solutions of pH 4.0 and 7.0. The standardized electrode was then inserted into the supernatant of each suspension to measure the pH.

### Water Content

The mass of an empty, clean, and dry moisture can with its lid was determined and recorded as  $M_1$ . The materials were then placed in the moisture can and secured with the lid. The mass of the moisture can containing the material with the lid was then determined and recorded as  $M_2$ . The lid was then removed and the moisture cans containing the materials were put in a drying oven that is set at 105 °C and were left overnight to dry. The moisture was then removed, covered with the lid and placed in desiccator to allow it to cool to room temperature. The masses of the oven-dried samples together with the lid were then determined and recorded as  $M_3$ . The moisture content was then calculated using the relation below:

$$\text{Mass of (moist) material (M}_{WS}) = M_2 - M_1$$

$$\text{Mass of dry solids (M}_{DS}) = M_3 - M_1$$

$$\text{Mass of water (M}_W) = M_{WS} - M_{DS}$$

$$\% \text{Moisture content (MC)} = \frac{M_W}{M_{DS}} \times 100$$

### LOI

The total organic carbon content of the materials was determined by the loss on ignition (LOI) method, as described by Schulte & Hopkins (1996), Heiri et al. (2001) and Wright et al. (2008). The materials were first oven-dried at 105 °C in a crucible to remove moisture. After that, the dried materials were combusted at 550 °C for 4 hrs. The LOI was calculated using the equation below: where  $LOI_{550}$  represents LOI at 550 °C,  $DW_{105}$  represents the oven-dried weight of the materials before combustion and  $DW_{550}$  the dry weight of the sample after heating to 550 °C (both in g). The samples from the furnace were cooled in desiccator before measurements were done.

$$LOI_{550} = \frac{DW_{105} - DW_{550}}{DW_{105}} \times 100$$

### CEC Puustjarvi Methode described by Thorpe

Three samples were randomly chosen from each of the materials to comprise three replications. Cation exchange capacity was measured on 1 g of air-dry, material. In this procedure, sample (material) was soaked in 50 mL half-normal hydrochloric acid (0.5 N HCl) to displace the adsorbed cations and saturate the material exchange sites with  $H^+$ . The suspension was filtered through coarse, fast filter paper and the displaced cations were removed with three successive washes of deionized water (50 mL each). The HCl filtrate and wash filtrates were combined for each sample and the resulting solutions were reserved for later analysis of cation concentration. After the third wash, the material (sample) was soaked in 50 mL bariumacetate [0.25 N  $Ba(OAc)_2$ ], which displaced the  $H^+$  by saturating the exchange sites with barium ( $Ba^{2+}$ ). This suspension was filtered and the material was washed three more times with 50 mL deionized water for each wash to remove the displaced  $H^+$ . The combined  $Ba(OAc)_2$  filtrate + wash filtrates solution was collected for each sample and titrated with sodium hydroxide (0.1N NaOH) to a phenolphthalein end point (pH\_8.0).

Cation exchange capacity was calculated from the amount of titrant used and expressed as  $cmol\ kg^{-1}$  ( $cmol\ kg^{-1} = meq\ 100\ g$ ).

Solution was analyzed using atomic adsorption spectrometry

### Reagents:

0.5 N HCl

0.25N  $Ba(OAc)_2$

0.1N NaOH

phenolphthalein end point (pH  $\approx$  8.0)

### **Micro (Zn, Mn, Fe, Cu) and macroelements (K, Ca, Mg, P)**

Materials (1g) were mineralized in a mixture of concentrated acids

HNO<sub>3</sub> : HClO<sub>3</sub> : H<sub>2</sub>SO<sub>4</sub> = 21:5:1

1g  $\rightleftharpoons$  15 cm<sup>3</sup>

### **References**

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3. Heiri, O.; Lotter, A.F.; Lemcke, G. Loss on ignition as a method for estimating organic and carbonate content in sediments: reproducibility and comparability of results *Journal of Paleolimnology*, volume: 25 (2001), pp. 101–110



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