

Supporting Information

Enhanced phytoaccumulation dynamics of chromium and nickel from spent engine oil-contaminated soil amended with biomass-derived bulking agent

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Chemical and physical analysis of uncontaminated soil

Soil reaction (pH) was measured in 1:2.5 soil water suspension with pH meter. Electrical conductivity (EC) and soluble ions in the saturated soil paste extract were determined by dipping the conductivity electrode in the paste extract soil. Calcium carbonate was determined as follows: 5 g of soil was added with 100 mL of 1.0 M HCl in 250 mL conical flask and boiled for 5 min and allowed to cool at room temperature and then filtered and pipette 10 mL of the filtrate in 100 mL flask. 2 or 3 drops of phenolphthalein were added to the content and titrated with 0.5 M NaOH.

$$CaCO_3\% = [(10 \times 1.0 \text{ M HCl}) - (mL \text{ NaOH} \times 0.5 \text{ M NaOH})] \times 10$$

Carbonate and bicarbonate were determined by adding 5 mL of the extract into a 50 mL flask and diluted with distilled water to a volume of 25 mL. The solution was titrated with 0.01 M H₂SO₄ after adding a phenolphthalein indicator until the pink color disappeared (V_{ph}). A methyl orange indicator was added to the colorless solution and titrated back with H₂SO₄ until the color changed (V_t).

$$\text{Concentration of } CO_3^{2-} = \frac{1000 \text{ mL}}{5 \text{ mL aliquot}} \times 2 (0.01 \text{ M } H_2SO_4 \times V_{ph})$$

$$\text{Concentration of } HCO_3^{1-} = \frac{1000 \text{ mL}}{5 \text{ mL aliquot}} \times 0.01 \text{ M } H_2SO_4 (V_t - 2V_{ph})$$

5 mL aliquot of the extract and some drops of K_2CrO_4 indicator were added to determine chloride in the soil and titrated with standard $AgNO_3$ (0.005 M) until a brownish-reddish endpoint appeared.

$$\text{Concentration of chloride} = \frac{1000 \text{ mL}}{5 \text{ mL aliquot}} \times \text{mL } AgNO_3 \times 0.005 \text{ M } AgNO_3$$

Determination of organic carbon: 0.1 g of soil was weighed into a conical flask in duplicate. 10 mL of 1 N $K_2Cr_2O_7$ was added into each flask and swirled gently to disperse the soil; 20 mL of conc. H_2SO_4 was added rapidly. The flask immediately swirled gently until soil and reagents were mixed. The mixture was then swirled vigorously and allowed to stand for about 30 minutes. 100 mL of distilled water was then added after 30 minutes. 4 drops of Ferroin indicator were added to the mixture and titrated with 0.5 N ferrous sulfate solution. The color changed at the end point from orange to light green and then green.

$$\text{Organic C\%} = \frac{0.003 \times N \times 10 \text{ mL} \times \left(1 - \frac{T}{S}\right) \times 100}{\text{Oven dry soil (g)}} = \frac{3 \times \left(1 - \frac{T}{S}\right)}{\text{Oven dry soil (g)}}$$

Where: N = Normality of $K_2Cr_2O_7$ solution, T = Volume of $FeSO_4$ used in sample titration (mL), S = Volume of Fe_5O_4 used in blank titration (mL).

Particle size distribution was also determined. 100 g of air-dried soil which has been passed through a 2 mm sieve was weighed and transferred to a conical flask. 100 mL of Calgon solution was added, stirred, and left overnight. The soil suspension was made up to 1000 mL mark in a 1-liter measuring cylinder. The cylinder was covered and inverted several times until all soil was suspended. The cylinder was placed on a flat surface and time was noted. At 40 seconds, the hydrometer was inserted into the soil suspension immediately and the first reading on the hydrometer was recorded. The hydrometer was removed, and the temperature of the suspension was taken using a thermometer. After the first hydrometer reading, the suspension was left to stand for 3 hours, and a second reading was taken; the temperature of the suspension was taken again:

$$\text{Sand}\% = 100 - \frac{\text{Corrected 40 seconds hydrometer reading} \times 100}{\text{Weight of sample}}$$

$$\text{Clay}\% = \frac{\text{Corrected 3 hours hydrometer reading} \times 100}{\text{Weight of sample}}$$

$$\text{Silt}\% = 100 - (\text{Sand}\% + \text{Clay}\%)$$