Key

Homework 1

ENSC/GEO 138: Pedology
Spring 2022
Show your work, units, and any assumptions you make in answering the following questions

1 a A soil is composed of 15% sand, 55% silt, and 30% clay by mass. The clay fraction is composed of 30% kaolinite [$Al_2Si_2O_5(OH)_4$], 40% illite (clay-sized mica) [$(K_{0.6}(Ca,Na)_{0.1})Al_2(Si_{3.4}Fe^{3+}_{0.4}Mg_{0.2})O_{10}(OH)_2$], 20% montmorillonite [$M^{2+}_{0.25}(Si_{3.5},Al_{0.5})Al_2O_{10}(OH)_2$], and 10% goethite [FeOOH]. Given that the soil *p*H = 7 and the CEC of the illite is 12 $cmol_c\ kg^{-1}$, calculate the CEC of this soil. (*Hint:* Assume the contribution of the sand and silt fraction to the CEC is negligible. The M^{2+} in the smectite formula stands for any divalent cation.)

→ 195 $cmol_c\ kg^{-1}$

b Assuming half of the illite transforms to vermiculite, calculate the new CEC of this soil.

c Qualitatively describe what would happen to the CEC if the pH dropped to 4.5? Why?

2 Describe how the Munsell hue, value, and/or chroma would change from a reference chip of 10YR 3/4 if the following materials were the primary soil coloring agents:

a Goethite

b Organic matter

c Hematite

1. a. 15% sand
55% silt
30% clay → 30% kaolinite
→ 40% illite → 12 $cmol_c\ kg^{-1}$
→ 20% montmorillonite
→ 10% goethite

① Sand, silt, kaolinite, & goethite do not contribute much if at all to the CEC → ignore.

②
CEC of the montmorillonite?

Elem.	Quan.	Mass	Total
Si	3.5	28	98
Al	2.5	27	67.5
O	12	16	192
H	2	1	2
			359.5 g mol^{-1}

Layer charge → $M^{2+}_{0.25}$ → 0.5 $mol_c\ mol^{-1}$

$$\frac{0.5\ mol_c}{359.5\ g}\ \Big|\ \frac{1000\ g}{kg}\ \Big|\ \frac{cmol_c}{mol_c} = \boxed{139.1\ cmol_c\ kg^{-1}}$$

③ CEC of the clay fraction?
$(0.4)(12\ cmol_c\ kg^{-1}) + (0.2)(139.1\ cmol_c\ kg^{-1})$
$= \boxed{32.62\ cmol_c\ kg^{-1}}$

④ CEC of the soil?
$(0.3)(32.62\ cmol_c\ kg^{-1}) = \boxed{9.79\ cmol_c\ kg^{-1}}$

b. Half of the illite transforms to vermiculite:

① Recalculate the clay CEC → $(0.2)(12\ cmol_c\ kg^{-1}) + (0.2)(195\ cmol_c\ kg^{-1}) + (0.2)(139.1\ cmol_c\ kg^{-1})$

$= \boxed{69.22\ cmol_c\ kg^{-1}}$

② Recalculate the CEC of the soil → $(0.3)(69.22\ cmol_c\ kg^{-1}) = \boxed{20.77\ cmol_c\ kg^{-1}}$

c. CEC would drop as edge charges would be protonated.

2. a. Goethite → Hue would likely get more yellow approaching 2.5 or 5 Y.

b. Organic matter → Value would likely drop to 2 or 1 as the material became darker.

c. Hematite → Hue would likely get more red (7.5YR, 5YR, or 2.5YR).