APBI 200 - Problem Set No. 3

Due: April 8, 2020 (by 5 pm)

Upload your completed assignment in canvas (as pdf or Microsoft word format)

Honesty Pledge

I hereby pledge that I have read and will abide by the rules, regulations, and expectations set out in the UBC Academic Calendar, with particular attention paid to:

1. **The Student Declaration** (http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3,285,0,0)
2. **The Academic Honesty and Standards** http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3,286,0,0
3. **The Student Conduct During Examinations** http://www.calendar.ubc.ca/vancouver/index.cfm?tree=3,41,90,0

☐ I affirm that I will not give or receive any unauthorized help on this assignment, that all work will be my own, and that all answers are written in my own words (unless given as a direct quote).

Please answer the following questions:

1. Define the paired terms shown below. Identify important distinctions between the paired terms. Consider how they differently affect what goes on in the soil and/or how plants grow on that soil.

    a) Ammonification & nitrification

    b) Fulvic acid & humin

[14 points]

2. Consider the soil phosphorus cycle diagram from your class notes (see l*ecture 25, slide 4*), and answer the following True/False questions:

   a) Phosphorus can be lost from the soil by volatilization.

      True _____ False _____

   b) Through chemical weathering, primary minerals such as apatite (rock phosphate) release P to soil solution.

      True _____ False _____

   c) The principle form of P taken up by plant roots is Phosphate.

      True _____ False _____

   d) Chemical process called phosphate fixation results in reduction of plant-available P.

      True _____ False _____

   e) Organic residues are one of the sources of plant-available P in soil.

      True _____ False _____

[5 points]

3. Consider the following data for 4 mineral soils that all have a <u>clay loam</u> texture:

Soil Property	**Soil #1**	**Soil #2**	**Soil #3**	**Soil #4**
pH	8.8	8.1	7.5	7.6
electrical conductivity (dS/m)	2.7	12.2	1.0	4.3
base saturation (%)	90	90	60	86
cation exchange capacity ($cmol_c$/kg)	12	11	19	9
exchangeable sodium (%) or ESP	17.3	16.8	2.1	2.5
Salinity classification				

a) Determine the salinity classification (i.e., saline, sodic, saline-sodic, or non saline) for each of these 4 soils; and fill in the last row of the table.

   [*Hint: see lecture 17 from Feb 14th*]

b) Which of the above soil(s) would most likely be in a dispersed state? Briefly explain your answer based on the information provided.

c) Briefly explain the role of sodium ion in dispersion.

d) What are the implications of a dispersed soil for plant growth?

[9 marks]

4. Identify the soil organism based on the descriptions provided. [*Hint: consult lecture notes and your textbook*]

    a) I can fix atmospheric N
    I form nodules
    I like to associate with legumes

    b) I have chlorophyll and perform photosynthesis
    I form colonies
    I live at or close to the soil surface

[4 points]

5. Examine the soil profile found at this web address: https://monoliths.soilweb.ca/4-03/

   Describe any **2 soil formation factors** and any **2 soil formation process** that have likely occurred to produce this soil profile.

a) Soil formation factors:

b) Soil formation processes:

[4 points]

6. Identify the diagnostic horizon for the following soil orders

   a) Vertisol

   b) Solonetz

   c) Brunisol

[3 points]

7. Taking into account horizon thickness (values given in brackets) and information about environmental conditions of a region where the soil is located, identify:

•**<u>diagnostic horizon(s)</u>** and

•**<u>soil order</u>** according to the Canadian System of Soil Classification

(a)

Of	(0-67 cm)
Oh	(67-110 cm)
C	(110-150 cm)

(*Bog in a humid climate, on a site with poor drainage*)

(b)

LFH	(4-0 cm)
Ae	(0-20 cm)
Bm	(20-38 cm)
BC	(38-60 cm)
Ck	(60-120 cm)

(*Ponderosa pine forest on a gentle slope in a region with mean annual precipitation of about 400 mm; good drainage*)

(c)

LFH	(2-0 cm)
Ae	(0-5 cm)
Btj	(5-30 cm)
Bm	(30-43 cm)
Ck	(43-114 cm)

(*Coniferous forest under humid to sub-humid climate; moderately well drained*)

[9 points]

Total for problem set no.3 [48 points]

Worked Examples

Two 'worked examples' provide example answers to questions similar to those in the problem set. These questions are designed not only to help you learn the content, but to help you get an idea for what kind of answers we expect on the problem sets and ultimately the final exam. This may help you write similar types of answers when doing the practice problems, and when writing your exams. Note that what is highlighted in yellow is for your benefit and is not necessary for full marks.

Worked Example #1:

Define the paired terms shown below. Identify important distinctions between the paired terms. Consider how they differently affect what goes on in the soil and/or how plants grow on that soil:

Biological nitrogen fixation & phosphate fixation

Biological N fixation is the conversion of N_2 gas from the atmosphere to NH_3 (ammonia) by bacteria, thereby making N available to plants (and soil organisms). Two common N fixating bacteria are Frankia, associated with alder, and Rhizobium, associated with legumes (alfalfa, clover, vetch), both of which form nodules. Note: other examples such as Azotobacter and/or endophytic bacteria (which do not form nodules) could be listed.

Phosphate fixation: Ionic forms of P ($H_2PO_4^-$ and HPO_4^{2-}) are susceptible to fixation; specifically by Fe and Al (as well as Mn) at low pH (acidic soils), by Ca^{2+} ions at high pH (alkaline soils); and by clay minerals at neutral pH. Fixed forms of phosphorus have a very low solubility; thus, they tie up phosphate ions, making them unavailable to plants.

Distinction: biological N fixation makes N available to plants (and soil microbes), while phosphate fixation makes P unavailable (or very slowly available) to plants and soil microbes).

Worked Example #2:

The cation exchange capacity (CEC) of two soils are compared in the table below.

a. Use the following assumptions to fill in the blanks in the table:

- the CEC of montmorillonite is 100 $cmol_c/kg$
- the CEC of kaolinite is 10 $cmol_c/kg$
- the CEC of organic matter is 250 $cmol_c/kg$

Please show complete calculation and units!

	SOIL #1	**SOIL #2**
Clay %	36	12
Organic matter %	51	15
Clay mineral type	Montmorillonite	Kaolinite
Negative charge from clay	0.36 x 100 $cmol_c/kg$ = 36 $cmol_c/kg$	0.12 x 10 $cmol_c/kg$ = 1.2 $cmol_c/kg$
Negative charge from organic matter	0.51 x 250 $cmol_c/kg$ = 127.5 $cmol_c/kg$	0.15 x 250 $cmol_c/kg$ = 37.5 $cmol_c/kg$
Total net negative charge ($cmol_c/kg$)	36 $cmol_c/kg$ + 127.5 $cmol_c/kg$ = 163.5 $cmol_c/kg$	1.2 $cmol_c/kg$ + 37.5 $cmol_c/kg$ = 38.7 $cmol_c/kg$

b. Explain why the clay mineral montmorillonite has a higher CEC than kaolinite (*hint: see lectures 5-6 from January 17th & 22nd*)

Montmorillonite is a 2:1 phyllosilicate clay mineral with 2 silicon tetrahedral sheets enclosing an aluminum octahedral sheet. Isomorphic substitution, e.g. of magnesium (Mg^{2+}) for some of the aluminum (Al^{3+}) in the octahedral sheet results in a permanent negative charge. In addition, montmorillonite clays expand when wetted, as water enters the interlayer space between adjacent tetrahedral sheets. This increases the available surface area for cation adsorption, since in montmorillonite has both external & internal surfaces available for cation adsorption. The combination of net negative charge due to isomorphic substitution and high specific surface area gives Montmorillonite a high CEC.

Kaolinite, on the other hand, is a 1:1 phyllosilicate clay mineral, which consists of single silicon tetrahedral sheets alternating with single aluminum octahedral sheets. There is very limited isomorphic substitution, and therefore the kaolinite has a limited number of negative charges. Additionally, being a 1:1 phyllosilicate clay mineral, which does not expand, kaolinite has lower effective surface area on which cations can be adsorbed. Thus kaolinite has a lower CEC.