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Soil Analytics: Inter-conversion of Units among Different Parameters in Soil Science

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Soil analytics involves a variety of chemical processes that determine that amount of available plant nutrients in the soil, including their physico-chemical and biological properties important for plant nutrition. The chemical analysis determines plant nutrients content and other physical characteristics. Based on quality soil analysis, it is easier to determine the required fertilizer needed by plants for quality growth and yield. Analytical procedures in soil science vary from one method to another, each with its peculiar unit of measurement. This article seeks to provide some inter-unit conversion or provide conversion factors to satisfy the yearnings of all interest groups. The calculation and conversion of units of measurement of different soil parameters will unify conclusions of different analytical results, such as in fertilizer application and experimental reactionary systems. The outcome of this article has provided meaningful inter- unit conversion through simple derivation principles, by the derivation of conversion factors, and in the practice of fertilizer calculation for fertility studies.

Keywords: Unit-conversion; analytical results; fertilizer application; soil parameters; conversion factor.

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1. INTRODUCTION

Soil analytics is not a new phenomenon in soil science. It is an aspect of Soil Sciences which is applied in the Soil Science laboratories. It usually involves the calculation and conversion of units of measurement of different soil parameters. During the manufacture of fertilizers and other chemical processes, we are bound to arrive at an entirely different product, whose unit of measurement differs from those of the initial reactants [1-3]. Majority of cases used here as examples are obtained from calculations of rates of fertilizer application.

Fertilizer application calculation involves the use of simple proportions to estimate the amount of fertilizer needed to be applied on a given land area or experimental land size. However, land area or size can be expressed both in terms of weight and volume dimensions.

The weight dimension of soil presumes a hectare of soil to be 2×10^6 kg. The weight of a hectare of soil is derived from the weight of the furrow slice. A hectare furrow slice is the volume of one hectare to a depth of 15 centimeters, or 100 meters x 100 meters x 15 centimeters. The hectare furrow slice represents the cross-section of 15cm depth of top soil in a 100m x 100m area dimension [4]. It is the volume of soil in the above mentioned dimension, where the roots of plants majorly obtain their nutrients (commonly referred to as the topsoil). It is the topmost layer of soil needed for germination purposes, because it houses the organic matter present in soil [5,6].

This is shown by its derivation from the first principle expressed below:

The bulk density (BD) of soil $=1.33 g/cm^3$

Area of an hectare = 100m x 100m

Depth of topsoil = height = 15cm = 0.15m

Volume = Area x height = (100m x 100m) x 0.15m

Density = Mass / Volume,

Mass = Density x Volume = $[1.33 \times 10^3/10^6\ kg/m^3] \times [0.15m \times 100m \times 100m]$

Mass = $1.995 \times 10^6 = 2 \times 10^6$ kg

Habitually, there are series of units' conversion in the above derivation. For example bulk density which was expressed as g/cm^3 needed conversion to kg/m^3 which is the SI unit.

For g to be converted to *kg* you must multiply by 1000 or 10^3

For *cm* to be converted to *m*, you divide by 100 or multiply by 10^{-2}

Therefore, cubic centimeter (cm^3) to cubic meter (m^3) will give $(10^{-2})^3 = 10^{-6}$

Hence, the bulk density of soil which is $1.33 g/cm^3 = 1.33 \times 10^{-3}/10^{-6}\ kg/m^3 = 1.33 \times 10^3\ kg/m^3$

Volume of an hectare soil = 100m x 100m x 0.15m = $1.5 \times 10^3\ m^3$

Since Mass = Density x Volume,

Mass = $1.33 \times 10^3\ kg/m^3 \times 1.5 \times 10^3\ m^3$
= 1.995×10^6

Approximately = 2×10^6 kg

In similar circumstances, the amount of fertilizer needed to be applied to a given land size can be calculated by simple proportions, having in mind that a hectare of land can be expressed in both volume and weight dimensions.

2. FERTILIZER CALCULATION

Let us consider some examples of fertilizer calculations using simple rate proportions.

Fertilizers are usually packaged in a 50-kg bag and the amount of the nutrient element contained is always written or inscribed on the fertilizer bag e.g. N-P-K 15 -15-15 expresses that 15% each of N, P and K are present in a 100kg of N-P-K 15 -15-15 fertilizer.

If we are to apply 30kg N/ha, 30kg P/ha and 30kg K/ha on a hectare of land, it means that we need to apply 4 bags (50 kg/bag) of this fertilizer on the field.

See the calculation thus:

Recommendation is: to apply 30kg N/ha, 30kg P/ha and 30kg K/ha

Land size = 1 hectare

To calculate the quantity of fertilizer needed, we must be knowledgeable on the rate of application or simple proportions of measurement.

If N-P-K 15 -15-15 expresses that 15 kg each of N., P. and K. are present in a 100 kg.

Therefore, 200 kg of N-P-K, 15 -15-15 fertilizer will supply 30 kg each of N, P and K per hectare of land.

Since a bag of N-P-K 15 -15-15 fertilizer is packaged in a 50 kg-bag, therefore, 4 bags will make 200 kg.

What is the quantity of Urea (46%N) that would serve as a top dresser for a 4000 m^2 plot size if the recommendation is 30 kg N/ha?

Recommendation = 30 kg N/ha

Land size = 4000 m^2

1 ha of land requires 30 kg N

10,000 m^2 requires 30 kg N

Therefore, 4000 m^2 will require 30/10000 x 4000 kg N =12 kg N.

Since 100 kg Urea contains 46 kg N or vice versa,

46 kg N is provided by 100 kg Urea

Hence 12 kg N will be provided by 100/46 x 12 = 26.087 kg Urea.

A series of fertilizer calculations had been treated in various textbooks and laboratory manuals. However, there are contending issues of conversion from one unit to the other, especially where new SI units are involved. For this reason, this article provides a bridge or linkage between various units of relevance in fertilizer application and laboratory studies in soil science.

Analytical procedures in soil science vary from one method to another, each with its peculiar unit of measurement. To be on the same size with various methods, it is necessary to provide some inter-unit conversion or provide a conversion factor to satisfy the yearnings of all interest groups.

Hence, we shall consider some of the available units with their conversion to the SI units.

3. INTER-UNIT CONVERSION

Some units of consideration include *mg/kg*, *g/kg, ppm*, *%*, *kg/ha*, *cmol/kg soil* and *meq/100g* soil. Some of these units occur in the analytical or laboratory evaluation or assay of some mineral elements and there could be the need to get an accurate measurement for the field situations. Such measurements used in the laboratory or field experimentations are usually expressed in concentration, weight or volume dimensions, particularly those relating to the soil.

In Table 1 is presented the nutrient elements, particle-size analysis and their SI units, as well as other alternative units of measurement.

Table 1. Physic-chemical properties of soil

Parameters	SI unit of measurement	Other units of measurements
Total Nitrogen	g/kg	%; ppm
Organic Carbon	“	%; ppm
Avail. P	mg/kg	%; ppm
Exchangeable cations		
Ca	mg/kg	meq wt/100g soil
Mg	“	“
K	cmol/kg	“
Na	mg/kg	“
Exchangeable micronutrients		
Fe	mg/kg	ppm
Mn	“	“
Cu	“	“
Zn	“	“
Particle size distribution		
Clay	g/kg	%
Silt	g/kg	%
Sand	g/kg	%

These units are inter-convertible, the knowledge of which will enhance students' and learners' skills of accuracy and precision in analytical and laboratory practices.

Let us consider some of the units' conversion as described by the understated calculations.

3.1 Conversion of mg/kg to ppm

ppm represents part per million = 1/1000000 = 10^{-6}

mg/kg = 1/1000000 = 10^{-6}

Hence, *ppm* = *mg/kg*. The conversion factor is 1 for either unit.

3.2 Conversion of mg/kg to g/kg

mg/kg → *g/kg*

1/1000000 → 1000/1000000

mg/kg → 1/1000

To convert *mg/kg* to *g/kg*, we will need to multiply *mg/kg* by 1000 and the resulting unit is *g/kg*.

mg/kg x 1000 = g/kg

3.3 Conversion of *mg/kg* to *kg/ha*

mg/kg = 1/1000000 =10^{-6}

kg/ha = 1/2 x $10^{6\backslash}$

kg/ha x 2 = 1 / (2x10^{6}) x 2 = 1/10^{6} = 10^{-6}

To convert *mg/kg* to *kg/ha*, we need to multiply *kg/ha* by 2 and the resulting unit is *mg/kg*.

kg/ha x 2 = mg/kg

3.4 Conversion of *% to ppm*

Percentage (%) = 1/100

Part per million (*ppm*) = 1/ 1000000

To convert *%* to *ppm*, we need to multiply *ppm* by 10000 (10^{4})

ppm x 10000 = 1/1000000 x 10000 = 1/100 (%)

Conversely, by dividing *%* by 10000, we get *ppm*

ppm x 10^{-4} = % or % divided by 10^{4} = ppm

Let us consider this example, the result of soil analysis showed that total nitrogen was 0.15%, P was 0.025% and K was 0.10%. Express these results in ppm.

Total Nitrogen = 0.15/100 = 0.0015 / 10000 = 1.5 x 10($^{-3+-4}$) = 1.5 x 10^{-7} = 1.5 x 10^{-7}*ppm*

P = 0.025/100 =0.00025 / 10000 = 2.5 x 10^{-4} / 10^{4} *ppm* = 2.5 x $10^{(-4-4)}$ = 2.5 x 10^{-8} *ppm*

K = 0.10/100 = 0.001 x 10000 = 1.0 x 10 $^{(-3+-4)}$ = 1.0 x 10^{-7} *ppm*

You may revert ppm to *%* if you divide *ppm* by 10000.

Since *ppm* = *mg/kg*, the above calculation also applies when converting *% to mg/kg*.

3.5 Conversion of % to g/kg

% = 1/100

g/kg = 1/1000

Divide *%* by 10 to get *g/kg* unit or vice versa

g/kg x 10 = *%;* or % / 10 = *g/kg*

3.6 Conversion of cmol/kg to meq/100g

cmol/kg = *meq/100g*

cmol/kg is numerically equal to *meq/100g*. The conversion factor is 1.

3.7 Conversion of g/m^{2} to kg/ha

1*g* = 1 x 10^{-3} *kg* = 10^{-3} *kg*
I *m*^{2} = 1 x 10^{-4} *ha* = 10^{-4} *ha*
1 *g/m*^{2} = 10^{-3}/10^{-4} = 10 $^{(-3+4)}$ = 10^{1} = 10 *kg/ha*

1g/m^{2} = 10 kg/ha

4. DISCUSSION

Different soil analytical methods are employed during soil analysis to determine different plant nutrients [7–11] and their physical characteristics [12,13]. Each of these methods has its peculiar unit of measurement. The inter-conversion of these units or the provision of conversion factors provides a unity of purpose among various methods and satisfy the yearnings of all interest groups on soil analytics. This knowledge will further enhance the students' and learners' skills of accuracy and precision in analytical and laboratory practices.

5. CONCLUSION

The outcome of this article has provided meaningful inter-unit conversion through simple derivation principles, by the derivation of conversion factors, and in the practice of fertilizer calculation for fertility studies.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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