

Opinion Article

Soil Analytics: Inter-conversion of units among different parameters in soil science

Abstract

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 factor 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 practice of fertilizer calculation for fertility studies.

Comment [mm1]: Add background, problems, aims, data analysis, results, conclusions

Keywords: unit-conversion, analytical-results, fertilizer-application, soil parameters, conversion factor

1. Introduction

Soil analytic is not a new phenomenon in soil science. It is the aspect of soil science which occurs in soil science laboratories. It usually involves the calculation and conversion of units of measurements of different soil parameters. During manufacture of fertilizers and other chemical processes, we are bound to arrive at an entirely different product, whose unit of measurement differ from those of the reactants. Majority of cases used here as examples are obtained from calculations of rates of fertilizer application.

Fertilizer 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 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 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 by 15 centimeters. Hectare furrow slice represents the cross-section of 15cm depth of top soil in a 100m x 100m area dimension [1]. It is the volume of soil in the above-mention 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 agricultural purposes, because it houses the organic matter present in soil [2, 3].

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

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

Area of an hectare = $100\text{m} \times 100\text{m}$

Depth of topsoil = height = $15\text{cm} = 0.15\text{m}$

Volume = Area x height = $(100\text{m} \times 100\text{m}) \times 0.15\text{m}$

Density = Mass / Volume,

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

Mass = $1.995 \times 10^6 = 2 \times 10^6 \text{ kg}$

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 $1.33\text{g/cm}^3 = 1.33 \times 10^{-3}/10^{-6} \text{ kg/m}^3 = 1.33 \times 10^3 \text{ kg/m}^3$

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

Since Mass = Density x Volume,

Mass = $1.33 \times 10^3 \text{ kg/m}^3 \times 1.5 \times 10^3 \text{ m}^3$
 $= 1.995 \times 10^6$

Approximately = $2 \times 10^6 \text{ kg}$

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 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.

2.1. 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 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 rate or simple proportion.

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

Therefore, 200kg of N-P-K 15 -15-15 fertilizer will supply 30kg 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 50kg-bag, therefore, 4 bags will make 200kg.

2.2. What is the quantity of Urea (46%N) that would serve as top dresser for a 4000 m² plot size if the recommendation is 30Kg N/ha?

Recommendation = 30kgN/ha

Land size = 4000 m²

1 ha of land requires 30kg N

10,000 m² requires 30kg N

Therefore, 4000 m² will require $30/10000 \times 4000$ kg N =12kg N.

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

46kg N is provided by 100kg Urea

Hence 12kg N will be provided by $100/46 \times 12 = 26.087$ kg Urea.

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 provide a bridge or linkage between various units of relevance in fertilizer 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 page with various methods, it is necessary to provide some inter-unit conversion or provide 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 the need to get 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.

Table 1 below gives 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	<i>g/kg</i>	<i>%; ppm</i>
Organic Carbon	"	<i>%; ppm</i>
Avail. P	<i>mg/kg</i>	<i>%; ppm</i>
Exchangeable cations		
Ca	<i>mg/kg</i>	<i>meq wt/100g soil</i>

Mg	“	“
K	<i>cmol/kg</i>	“
Na	<i>mg/kg</i>	“
Exchangeable micronutrients		
Fe	<i>mg/kg</i>	<i>ppm</i>
Mn	“	“
Cu	“	“
Zn	“	“
Particle size distribution		
Clay	<i>g/kg</i>	%
Silt	<i>g/kg</i>	%
Sand	<i>g/kg</i>	%

These units are inter-convertible, the knowledge of which will enhance students' and learners' skill 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*.

$$\boxed{mg/kg \times 1000 = g/kg}$$

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

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

kg/ha = $1/2 \times 10^6$

$$kg/ha \times 2 = 1 / (2 \times 10^6) \times 2 = 1/10^6 = 10^{-6}$$

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

$$kg/ha \times 2 = mg/kg$$

3.4 Conversion of % to ppm

$$\text{Percentage (\%)} = 1/100$$

$$\text{Part per million (ppm)} = 1/1000000$$

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

$$ppm \times 10000 = 1/1000000 \times 10000 = 1/100 (\%)$$

Conversely by dividing % by 10000, we get ppm

$$ppm \times 10^{-4} = \% \text{ or } \% \text{ divided by } 10^4 = ppm$$

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.

$$\text{Total Nitrogen} = 0.15/100 = 0.015 / 10000 = 1.5 \times 10^6 \text{ ppm}$$

$$P = 0.025/100 = 0.0025 / 10000 = 2.5 \times 10^6 \text{ ppm}$$

$$K = 0.10/100 = 0.001 \times 10000 = 1.0 \times 10^7 \text{ ppm}$$

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

$$g/kg \times 10 = \% \text{ or } \% / 10 = g/kg$$

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

$$1g = 10^{-3} kg$$

$$1m^2 = 10^{-4} ha$$

$$1 g/m^2 = 10^{-3}/10^{-4} kg/ha$$

$$1g/m^2 = 10 kg/ha$$

4. References

1. Foth, H. D. 1990. Fundamentals of Soil Science, 8th Edition, John Wiley and Sons. N. Y. 380pp
2. Organismal Biology (2016). Content of Introduction to Organismal Biology at <https://sites.gatech.edu/organismalbio/>
3. Wikipedia, 2022. <https://en.wikipedia.org/wiki/Topsoil>

Further Reading

1. B.T. Kang. (1995). Fertilizer: Definitions and Calculations. IITA Research Guide 24. Training program, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. 28 p.
2. Cornell University Cooperative Extension (CUCE) (2007). Cation Exchange Capacity (CEC). Agronomy Fact Sheet Series # 22. Department of Crop and Soil Sciences, College of Agriculture and Life Sciences, Cornell University.
3. Soil Analysis: An Interpretation Manual. Edited by K.I. Peverill, L.A Sparrow and D.J Reuter. CSIRO: Melbourne, 1999.

Comment [mm2]: Add discussion

Comment [mm3]: Add 15-20 references using limited 5 years ago

Comment [mm4]: Delete. Using references from journal or books