

# 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.

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

### 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 measurements 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 differ from those of the initial reactants. 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 or volume dimensions.

The weight dimension of soil presumes a hectare of soil to be  $2 \times 10^6$  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 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 [2, 3].

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

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

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 =  $(100\text{m} \times 100\text{m}) \times 0.15\text{m}$

38 Density = Mass / Volume,

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

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

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

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

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

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

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

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

48 Since Mass = Density x Volume,

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

50  $= 1.995 \times 10^6$

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

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

## 55 2. Fertilizer Calculation

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

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

60 **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  
61 need to apply 4 bags(50 kg/bag) of this fertilizer on the field.

62 See the calculation thus:

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

64 Land size = 1 hectare

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

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

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

70 Since a bag of N-P-K 15 -15-15 fertilizer is packaged in a 50kg-bag, therefore, 4 bags will make  
71 200kg.

72 **2.2.**What is the quantity of Urea (46%N) that would serve as top dresser for a 4000m<sup>2</sup> plot size if  
73 the recommendation is 30Kg N/ha?

74 Recommendation = 30kgN/ha

75 Land size = 4000 m<sup>2</sup>

76 1 ha of land requires 30kg N

77 10,000 m<sup>2</sup> requires 30kg N

78 Therefore, 4000 m<sup>2</sup> will require  $30/10000 \times 4000$  kg N =12kg N.

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

80 46kg N is provided by 100kg Urea

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

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

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

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

### 90 3. Inter-unit conversion

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

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

98 Table 1: Physic-chemical properties of soil

Parameters	SI unit measurement	of	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>meqwt/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>	%

99

100 These units are inter-convertible, the knowledge of which will enhance students’ and learners’  
 101 skill of accuracy and precision in analytical and laboratory practices.

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

103 **3.1 Conversion of *mg/kg* to *ppm***

104 *ppm* represents part per million = 1/1000000 = 10<sup>-6</sup>

105 *mg/kg* = 1/1000000 = 10<sup>-6</sup>

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

107 **3.2 Conversion of *mg/kg* to *g/kg***

108 *mg/kg*  $\xrightarrow{\hspace{2cm}}$  *g/kg*

109 1/1000000  $\xrightarrow{\hspace{2cm}}$  1000/1000000

110 *mg/kg*  $\xrightarrow{\hspace{1cm}}$  1/1000

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

$$mg/kg \times 1000 = g/kg$$

113

114 **3.3 Conversion of *mg/kg* to *kg/ha***

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

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

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

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

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

### 121 3.4 Conversion of % to ppm

122 Percentage (%) = 1/100

123 Part per million (ppm) = 1/ 1000000

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

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

126 Conversely by dividing % by 10000, we get ppm

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

129 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.

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

132 P =  $0.025/100 = 0.0025 / 10000 = 2.5 \times 10^{-4} / 10^4 ppm = 2.5 \times 10^{(-4+-4)} = 2.5 \times 10^{-8} ppm$

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

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

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

### 137 3.5 Conversion of % to g/kg

138  $\% = 1/100$

139  $g/kg = 1/1000$

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

141  $g/kg \times 10 = \%$ ; or  $\% / 10 = g/kg$

### 143 3.6 Conversion of cmol/kg to meq/100g

144  $cmol/kg = meq/100g$

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

### 146 **3.7 Conversion of $g/m^2$ to $kg/ha$**

147  $1g = 1 \times 10^{-3}kg = 10^{-3}kg$

148  $1m^2 = 1 \times 10^{-4}ha = 10^{-4}ha$

149  $1g/m^2 = 10^{-3}/10^{-4}kg/ha = 10^{(-3+4)} = 10^1 = 10kg/ha$

150  $1g/m^2 = 10kg/ha$

151

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