Agronomy 354
Milligram Equivalent Weight
(Milliequivalent Weight)

Milliequivalent weight (or mass) and milliequivalents are important concepts in soil science because they are useful in understanding charge in soil and quantities of ions (often nutrients) that various soils can hold. The units of cation exchange capacity (CEC) are milliequivalents per 100 g (meq/100 g) or centimoles per kg ($cmol_c/kg$). Iowa soils have high CECs. Unfortunately, the concept of milliequivalents is not stressed in most basic chemistry courses. The use of equivalent weights in general chemistry has largely been superseded by the use of molar masses. Thus, this page will give a short review of milliequivalents and milliequivalent weights.

The correct notation for scientific audiences is $cmol_c/kg$ (centimoles of charge per kg soil). Many soil testing laboratories, however, continue to use meq/100 g. The "c" subscript before the slash in $cmol_c/kg$ denotes "charge." The magnitude of the numbers is the same; thus, 10 meq/100 g = 10 $cmol_c/kg$.

An equivalent (eq or Eq) is an amount of substance. It can be defined as the amount that will either react with or replace one mole of hydrogen ions (H^+) (which weighs 1 g). The mass of one equivalent is called its equivalent weight (although the term equivalent weight is widely used, equivalent mass is more correct).

In soil science, the amount of a substance in equivalents often is too small to be convenient, so it is frequently described as milliequivalents (mEq or meq), the prefix milli denoting that the measure is divided by 1000.

A millimole of an element is its atomic weight written in terms of milligrams (i.e., milligram-molecular weight); thus, a millimole of sodium (Na) weighs 22.99 mg, and a millimole of calcium (Ca) weights 40.08 mg. Soils often have a net negative charge (thus they can attract and hold cations). Because the number of cations that can be held in soil depends on the charge of the species being exchanged, i.e., 2 Na^+ cations can be exchanged for one Ca^{2+} cation or one Ca^{2+} can be exchanged for 2 K^+ cations, expressing the cation exchange capacity in terms of millimoles requires that the nature of the exchanging cations be stated for each exchange reaction. Expressing CEC in terms of milliequivalents eliminates the need for such cumbersome expressions because the number of milliequivalents being exchanged is the same regardless of the charge on the cation. But to equal similar charge, the weight of a divalent-charged cation must be divided by 2 to equal the weight of a monovalent-charged cation.

To calculate milliequivalent weight (or milligram-equivalent weight) of a given cation, the milligram-molecular weight (millimole) must be divided by the charge on the cation. Thus, the milligram equivalent weight of calcium (Ca^{2+}) is 40.08/2 = 20.04 mg, which is equal to one-half the milligram-molecular weight. Hence, one millimole of Ca^{2+} (40.08 mg) would equal two milliequivalents of Ca^{2+} (20.04 mg X 2), but one millimole of Na^+ (22.99 mg) would still be equal to one milliequivalent of Na^+ (22.99 mg). In a reaction, one milliequivalent (meq) weight of one compound will always react with or replace one milliequivalent weight of another.

For milliequivalent weights (expressed in mg/meq), use this formula:

milliequivalent weight (mg/meq) = atomic weight (mg) ÷ (valence)

Common cations held in soil on the CEC sites:

Element	Atomic weight	Valence	Meq weight (mg/meq)
Calcium	40.08	2	20.04
Hydrogen	1.01	1	1.01
Magnesium	24.31	2	12.16
Potassium	39.10	1	39.10
Sodium	22.99	1	22.99

Another important concept of CEC is that it can be related directly to the number of charges in the soil. Avogadro's number is the number of atoms needed so that the number of grams of a substance equals the atomic mass of the substance (6.022×10^{23}). For example, 39.10 g of K contains 6.022×10^{23} atoms of K. In the case of a monovalent cation such as K where each atom carries one charge, this also equals the number of charges contained in 39.10 g of K^+. In a millimole of K^+ (a mole divided by 1000), the quantity of charge equals 6.022×10^{20}. Thus, a soil with 1 meq/100 g of CEC has 6.022×10^{20} negative charges that can hold 39.10 mg of K^+.

1 meq/100 g = 6.022×10^{20} charges