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Terminology for Reporting Nitrate Concentration

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Published reports showing wide differences in the levels of nitrate and nitrite in feedstuffs and in water required to produce toxicity have resulted in confusion and controversy. The controversy has been due to lack of agreement in experiments conducted at various Agricultural Experiment Stations.

The confusion is related to the many different ways in which the concentrations of the nitrate and nitrite ions in forages and water are reported after chemical analysis. Examples of the most commonly used terms are: potassium nitrate (KNO_3), sodium nitrate ($NaNO_3$), nitrate ion (NO_3^-), nitrate nitrogen (NO_3-N), potassium nitrite (KNO_2), sodium nitrite ($NaNO_2$), nitrite ion (NO_2^-) and nitrite nitrogen (NO_2-N).

The purpose of this publication is to show how the concentration can be converted from one designation to another.

Differences in reporting and use

Unfortunately, each team of investigators or laboratory has adopted its own way of reporting nitrate ion and continues to use its established designation. Each group can justify its method of reporting results.

For example, the soil scientist is accustomed to speaking in terms of nitrogen (N) in plant foods, so it is only natural that the expression of nitrate nitrogen (NO_3-N) be used. Other scientists reason that since potassium is the major cation found in forage products, the accumulated nitrate is present as the potassium salt (KNO_3).

Biochemically it is the nitrate ion (NO_3^-) or nitrite (NO_2^-) in which we are most interested. It is the nitrate ion (NO_3^-) and/or nitrite ion (NO_2^-) that is consumed by man and his animals that causes the toxicity. The toxic dose of nitrate or nitrite is more a function of the amount a given animal receives in relation to his body weight and the time over which it was received than it is to a specific concentration in feed and water.

For example, the dose that is fatal if given as a drench may cause no difficulties if mixed in a total day's feed supply. Thus, it becomes important to be able to convert the concentration values reported by a laboratory into a meaningful form depending on how you plan to use the information. For example, as plant food, nitrate-nitrogen (NO_3-N); as part of a forage plant, potassium nitrate (KNO_3), or for animal toxicity, nitrate ion (NO_3^-).

Nitrate and nitrite value are not interchangeable

Due to chemical actions and bacterial and other enzymatic processes, nitrate can be converted to nitrite. Nitrite is considered 10 times as toxic as nitrate for animals. Fortunately, nitrate is rarely quantitatively converted to nitrite, but it

always has this potential. In calculations, the factors described in Table 1 are specific for nitrate and in Table 2 specific for nitrite (NO_2^-).

Table 1
Method of converting various *nitrate* designations.

B*		A*			
		NO_3-N	NO_3^-	KNO_3	$NaNO_3$
Nitrate-nitrogen	NO_3-N		0.226	0.139	0.165
Nitrate ion	NO_3^-	4.43		0.614	0.729
Potassium nitrate	KNO_3	7.21	1.63		1.19
Sodium nitrate	$NaNO_3$	6.07	1.37	0.842	

***To convert the A designations on the right into the B values on the left, multiply the A values by the appropriate factor shown in the space opposite the desired designations.**
Amount of A x Factor = Amount of B
Example: To convert 2 percent KNO_3 to nitrate-nitrogen, multiply 2 percent times the factor 0.139. Thus 2 percent KNO_3 x 0.139 = 0.278 percent NO_3-N.

Table 2
Method of converting various *nitrite* designations.

B*		A*			
		NO_2-N	NO_2^-	KNO_2	$NaNO_2$
Nitrite-nitrogen	NO_2-N		0.304	0.165	0.203
Nitrite ion	NO_2^-	3.29		0.541	0.667
Potassium nitrite	KNO_2	6.07	1.85		1.23
Sodium nitrite	$NaNO_2$	4.93	1.50	0.812	

***To convert the A designations on the right into the B values on the left, multiply the A values by the appropriate factor shown in the space opposite the desired designations.**
Amount of A x Factor = Amount of B
Example: To convert 2 percent KNO_3 to nitrate-nitrogen, multiply 2 percent times the factor 0.139. Thus 2 percent KNO_3 x 0.139 = 0.278 percent NO_3-N.

Use of conversion factor

Examples of how to convert one nitrate designation to another is given as a footnote in Table 1.

To convert one nitrite designation to another, follow the same procedure using the appropriate factor from Table 2.

The concentration of trace substances are often expressed as parts per million (ppm). Thus, one milligram of KNO_3 in a kilogram of feed (0.0001 percent) is one ppm. Similarly, one milligram per liter of water was called one ppm. This later designation is not exact and the preferred terminology is milligrams per liter. The factors in Tables 1 and 2 can be used for either percentages or parts per million. Table 3 represents the relationship of the different designations expressed as

specific percentages or parts per million.

Table 3
Examples of the relationship of percentage (percent) and parts per million (ppm) expressed in different ways.**

Designation	Percent	ppm	percent	ppm	percent	ppm
Nitrate-nitrogen (NO_3-N)	1.00	10,000	0.226	2,260	0.139	1,390
Nitrate (NO_3^-)	4.43	44,300	1.00	10,000	0.614	6,140
Potassium nitrate (KNO_3)	7.21	72,100	1.63	16,300	1.00	10,000

****Example: A sample that contained 1.00 percent nitrate nitrogen (NO_3-N) would contain 10,000 ppm (NO_3-N), 4.43 percent nitrate (NO_3^-) and 7.21 percent potassium nitrate (KNO_3).**

For feedstuffs, many laboratories report nitrate (NO_3^-) values in ppm. Safe limits for feeding are given in percent NO_3^- of the sample or in amount of nitrate (in grams) consumed per 100 pounds of body weight of the animal per day. By using Table 3 or Table 6, the percentage can be determined and then using Table 4, consumption can be determined.

Table 4
Relationship of grams and pounds.***

gm	Pounds
1.0 (1,000 milligrams)	0.0022
453.6	1.00
1000.0 (1 kilogram (Kg))	2.205

*****Example: A 1,000 pound cow eating 20 pounds of hay per day that contains 1.0 percent nitrate (NO_3^-) will receive how many gm of nitrate per 100 pounds body weight per day?**

<u>20 pounds x 1.0 percent x 453.6 gm</u> = 9.072 gm per hundredweight
animal weight (in pounds)/100

Chemists and biochemists sometimes use another designation in reporting nitrate values — moles, millimoles or micromoles. A mole is defined as one gram molecular weight or the total of the atomic weights of the atoms in the compound, expressed as grams. An example would be potassium nitrate (KNO_3). This compound contains one atom each of potassium and nitrogen and three of oxygen. We can designate this relationship and indicate the weights as follows: potassium (K = 39), nitrogen (N = 14), and oxygen (O = 16). Therefore, one gram molecular weight would be 39 + 14 + (3 x 16) = 101. This 101 grams of potassium nitrate would represent one mole. A millimole is 1/1000 of a mole; therefore, a millimole of KNO_3 is 0.101 grams or 101 milligrams.

This also enables the chemists to multiply the number of moles times the atomic weight or molecular weight of the constituent part in which they are interested and arrive at the grams of this constituent. One mole of potassium nitrate (KNO_3) would contain [1 mole x 14 (atomic weight of nitrogen)] 14 grams of nitrate-nitrogen.

Table 5 shows the method of converting moles to the various other designations. Since the majority of reporting agencies using the mole designation will refer to solutions, a method of converting moles per liter into parts per million (ppm) is also given.

Table 5
A method of converting moles to grams and subsequently to parts per million.****

Designation desired	A	Factor (F)
Nitrate-nitrogen	NO_3-N	14
Nitrite-nitrogen	NO_2-N	14
Nitrate	NO_3^-	62
Nitrite	NO_2^-	46
Potassium nitrate	KNO_3	101
Potassium nitrite	KNO_2	85
Sodium nitrate	$NaNO_3$	85
Sodium nitrite	$NaNO_2$	69

******To convert moles into grams, millimoles into milligrams and micromoles into micrograms, multiply the mole designation on the left by the factor on the right.**
Example: To convert 2 moles of nitrate to grams of potassium nitrate, multiply 2 moles times the factor 101. Thus 2 moles x 101 = 202 grams potassium nitrate.
Since most mole designations are as moles per liter, which is a solution, the conversion to parts per million (ppm) is usually desirable.
Moles per liter x 1,000 x Factor (F) = ppm A
For Millimoles use: millimoles per liter x factor (F) = ppm A
For Micromoles use: micromoles per liter x factor (F) divided by 1,000 = ppm A

Sometimes it is desirable to convert ppm into percentage or percentage into ppm. Table 6 shows one method.

Table 6
Interconversion of percentage to parts per million.

Percentage x 10,000 = parts per million (ppm)

Parts per million (ppm) ÷ 10,000 = Percentage

Example
To convert 0.04 percent nitrate-nitrogen into parts per million, multiply 0.04 percent times 10,000. Thus 0.04 percent NO_3-N x 10,000 = 400 ppm NO_3-N.

To convert 5000 ppm nitrate (NO_3^-) to percentage, divide 5,000 ppm by 10,000 to equal 0.5 percent nitrate.

Fertilizer nitrogen values

The nitrogen content of commercial fertilizer must be guaranteed to be a certain percentage of the fertilizer expressed as total nitrogen according to the Missouri Revised Statutes. The form of the nitrogen may or may not be clearly specified, although most commercial fertilizers contain nitrate N, ammonium N, urea N or a combination of these three soluble nitrogen forms. If the chemical form of the nitrogen is known, conversion to moles is easily performed as illustrated above.

Nitrogen fertilizer recommendations are made on an area basis,. e.g. pounds per acre. To convert from the English to the metric system of kilograms per hectare, multiply pounds per acre by 1.12 (one acre = 0.405 hectares; one pound = 0.454 kilograms).

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