

## **Kinetics of Ammonium, Nitrates and Manganese Release from Different Organic Composts as Affected by Sulphur**

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**A**N INCUBATION experiment in which four different manures; mixed composted manure (MCM), composted chicken manure (CCM), composted crop residues (CCR) and composted town refuses (CTR), common in the Egyptian market were mixed with sulphur to study the effect of sulphur on nitrogen transformation. A control experiment was conducted in which the same manures were used without sulphur. The ammonium and nitrates released as functions of time were followed. A kinetic analysis of the results of the experiment was done. To justify the calculated ammonification and nitrification first order rate constants, Mn was used as a tracer, since it is not susceptible to any losses. The results reveal that sulphur has a significant effect in increasing the value of the ammonification first order rate reaction constant ( $k_1$ ) for the MCM, CTR, and CCM. The ammonification first order reaction rate constant were  $0.289 \text{ month}^{-1}$ ,  $0.096 \text{ month}^{-1}$  for MCM+S versus MCM respectively,  $0.152 \text{ month}^{-1}$ ,  $0.075 \text{ month}^{-1}$  for CTR+S and CTR respectively,  $0.096 \text{ month}^{-1}$  and  $0.046 \text{ month}^{-1}$  for CCR+S and CCR respectively and  $0.204 \text{ month}^{-1}$  and  $0.145 \text{ month}^{-1}$  for CCM+S and CCM respectively.

The nitrification reaction first order reaction rate constant ( $k_2$ ) were  $9.5 \text{ month}^{-1}$ ,  $10.05 \text{ month}^{-1}$  for MCM+S versus MCM respectively,  $8.51 \text{ month}^{-1}$ ,  $8.22 \text{ month}^{-1}$  for CTR+S and CTR respectively,  $6.02 \text{ month}^{-1}$ ,  $5.4 \text{ month}^{-1}$  for CCR+S and CCR respectively, and  $11.2 \text{ month}^{-1}$  and  $10.40 \text{ month}^{-1}$  for CCM+S and CCM respectively. The sulphur addition enhanced the initial slow ammonification probably through the decrease of the soil pH, due to the production of sulphuric acid. This will neutralize the resulting ammonium and lead to an increase in the reaction rate. The ratio of the nitrification to ammonification ( $k_2/k_1$ ) were 33, 105, 56, 126, 51.5, 95.5, 55 and 71.5 for the MCM+S, MCM, CTR+S, CTR, CCR+S, CCR, CCM+S and CCM respectively. It seems that sulphur reduced this ratio, since nitrification reaction produces two  $\text{H}^+$  ions for every molecule of  $\text{NH}_4^+$  which is also produced from sulphur oxidation to sulphuric acid. So, the nitrification reaction may be more reduced relative to the ammonification reaction. The variation in the values of the nitrification rate constants  $k_2$  was wider between the different kinds of manures than between the same kind of manure either with sulphur or no sulphur.

There are several factors which contribute to the increasing demand on the use of organic fertilization. One factor is the large increase in the prices of products of the energy demanding industries. The nitrogen fertilizers industry, among few others, requires large amounts of energy in the initial process of ammonia manufacturing in the process of Haber-Bosch reaction. Egypt currently consumes annually about 1.25 million tons of mineral fertilizers. The awareness of the load of heavy metals in some fertilizers, *i.e.*, cadmium in phosphatic fertilizers, puts a demand on decreasing its rate of application and looking for organic fertilization (Shahin 1993 & 1996).

Another factor which may increase the demand on the use of organic fertilization is the environmental concerns. There are large amounts of agricultural and household organic wastes which are produced annually and which need to be recycled. The amounts of agricultural organic wastes produced annually in Egypt mounts to 31 million tons. The organic household wastes produced annually mount to 9-12 million tons, that from irrigation canals and ditches cleaning mount to 22 million tons. The total amounts of organic wastes produced in Egypt mount to 70-100 million tons yearly (El-Hagggar, 2008). These huge amounts of wastes need to be recycled; otherwise there is a large stress on the environment due to unfriendly methods of getting rid of these wastes such as burning and the resulting pollution load (El-Kilani, 2002a). A last factor is the green movement and the demand for going back to environmental friendly soil management methods.

All these factors put an increasing demand on how to increase the efficiency of organic fertilization. This can be done by the use of some additives such as sulphur which tend to decrease the loss of ammonia due to volatilization (Shahin & Soliman 1998 and Shahin *et al.*, 1999). Determining the kinetic reaction rates constants of organic manures nutrients release and coupling these kinetic rates to canopy and soil climate models (El-Kilani, 1997 & 2002b), can have a favorable effect on the management of organic manure fertilization through the optimization of organic manuring and methods of application which can be valuable for increasing organic fertilization efficiency. This paper aims toward determining these kinetic rates and how it is affected by sulphur addition to the manure.

### Theory

Organic matter transformation and the release of its nutrient constituents follow, for the case of nitrogen, a two stage process: ammonification (decomposition of organic matter and release of ammonia) and then nitrification (the transformation of the formed ammonia into nitrate). The latter process goes through a two stage process of ammonia transformation to nitrite and then from nitrite to nitrate. For such a consecutive reaction



where A, B and C represent the consecutive steps in the reaction.  $k_1$  and  $k_2$  represent the kinetic rates of the irreversible reactions from A to B and from B to C respectively. The amount of ammonia released, if not kept inside the soil system till its nitrification, could be reduced by volatilization and lost to the surrounding air which could lead to an air pollution problem.

The rate of organic matter decomposition and the rate of release of ammonia, could be justified by taking a conservative substance which is also released by organic matter decomposition but which is not volatilized or lost from the system, since the first step of decomposition will also bring into the system all other mineral constituents which were part of the organic matter. For our case, we used manganese as a stable tracer element to justify the first step of manure decomposition (ammonification).

For the kinetics of the reaction; at the initial moment,  $t=0$  if we have a moles of substance A. At a moment  $t \neq 0$  later, there remains  $a-x$  moles of substance A and correspondingly, there appear  $x-y$  moles of substance B and  $y$  moles of substance C. The equations expressing the behavior of the quantities  $a-x$ ,  $x-y$  and  $y$  as a function of time are given by (Panchenkov & Lebedev, 1976)

$$a - x = a e^{-k_1 t} \quad (\text{eq.2})$$

$$x - y = a \frac{k_1}{k_2 - k_1} (e^{-k_1 t} - e^{-k_2 t}) \quad (\text{eq.3})$$

$$y = a \left( 1 - \frac{k_2}{k_2 - k_1} e^{-k_1 t} + \frac{k_1}{k_2 - k_1} e^{-k_2 t} \right) \quad (\text{eq.4})$$

The graph of the second quantity  $x-y$  has a maximum at which the derivative of the second function equals zero. At this instant of time, we have:

$$t_{\max} = \frac{\ln \left( \frac{k_2}{k_1} \right)}{\left( \frac{k_2}{k_1} - 1 \right) k_1} \quad (\text{eq.5})$$

For the case in which  $k_1 \ll k_2$ , equation 4 reduces to

$$y = a(1 - e^{-k_1 t}) \quad (\text{eq.6})$$

These are the set of equations which will be used to determine the kinetic reaction rates constants of organic matter transformation from different manures.

Stanford & Smith (1972) defined soil mineralization potential as the quantity of soil organic N susceptible to mineralization at a rate of mineralization (k) according to first order kinetics:

$$\frac{dN}{dt} = -kN \quad (\text{eq.7})$$

Where N is the concentration of mineralizable substrate (N) and t is time. Integration of this equation between time  $t_0$  and t yields

$$N_t = N_0 e^{-kt} \quad (\text{eq.8})$$

Where  $N_0$  is the initial substrate concentration or the potentially mineralizable nitrogen and  $N_t$  is the substrate concentration at time t. Using the previous equation, Stanford & Smith (1972) found that the values of k ranged from 0.035 to 0.095 week<sup>-1</sup>, with a weighed average of 0.054 week<sup>-1</sup>. However, widely varying k values have been reported for different soils indicating that soils differ not only in the amounts of active organic N but also in their turnover rates by microorganisms.

The first order single compartment kinetic model has been used to describe N mineralization under different land use, crop and climatic conditions. A number of studies have shown the inadequacy of the single pool first order model to describe N mineralization in soils (Molina *et al.*, 1980; Nuske & Richter, 1981; Deans *et al.*, 1986 and Singh & Benbi, 2000). Models have been developed to describe net N mineralization by dividing the mineralizable soil organic N into different fractions. Each fraction is assumed to mineralize according to first order kinetics. Since we are working with organic manures which has gone through composting so, their C/N ratios are close except for one, *i.e.*, composted chicken manures (CCM) which has a value of C/N ratio of 10.70. The others range from 16 to 20. The deviation of CCM from the other three manures is in the side which make decomposition easier (*i.e.*, narrower C/N ratio), as shown in Table 1. This makes the use of a single pool compartment model for mineralization justifiable.

## Material and Methods

### Experiments

Samples of mixed composted manures (MCM), composted chicken manures (CCM), composted crop residues (CCR) and composted town refuses (CTR) were taken to represent some commercial organic composts somewhat familiar in the Egyptian market. The collected composts were analysed for some physical and chemical properties (Table 1) according to standard methods (Page, 1982).

TABLE 1. Some physical and chemical characteristics of the studied.

Commercial composts.				
Compost properties	CTR	CCM	CCR	MCM
Bulk density (kg/m <sup>3</sup> )	614.00	625.00	769.00	669.00
Moisture % (Wt)	18.90	9.70	29.30	15.90
Saturation % (Wt)	167.00	196.00	225.00	141.00
Organic matter %	35.70	66.18	59.50	41.10
Ash %	64.12	32.16	39.60	60.60
pH (1:10)	8.22	6.30	8.34	8.58
EC (1:10) dS/m	1.52	3.96	2.62	2.12
Total-N %	1.28	3.58	2.12	1.18
Ammonium-N (mg/kg)	374.00	233.00	140.00	735.00
Nitrate-N (mg/kg)	96.00	108.00	124.00	28.00
Organic carbon (OC)%	20.70	38.38	34.50	23.80
C/N ratio	16.20	10.70	16.30	20.20
Total-P %	0.38	0.76	0.45	1.31
Total-K %	0.62	2.33	2.17	1.12
Total-Mn	251.00	253.00	175.00	154.00
Available-Mn	0.04	0.56	0.64	1.19

An incubation experiment was done to study the transformation pattern of different N and Mn nutrients. Triplicates 2 gram samples of each of four organic fertilizers were mixed with 98 gram quartz sand and placed in polyethylene containers. Another set of samples was treated with 0.2% elemental sulphur. The mixtures were moistened using a fine spray of distilled water to reach the level of 75% of field capacity. The samples were incubated at 30°C ± 2 for 0.5, 1, 2, 4, 6, and 12 months. At each period, the collected samples were extracted to determine available forms of NH<sub>4</sub>, NO<sub>3</sub> and Mn. Available NH<sub>4</sub> and NO<sub>3</sub> were extracted by 0.1 N CaCl<sub>2</sub>. Ammonium and NO<sub>3</sub> were determined by VIS-UV Spectrophotometer. Available Mn was extracted by DTPA method and determined using Atomic absorption spectrophotometer (Page, 1982).

#### *Analysis of the experimental results*

There are two options for determining the first order reaction rate constants of the first step (*i.e.*, from A to B).

The first is plotting the value of the natural logarithm of the concentration of remaining un-mineralized quantity of a mineral constituent, *i.e.*, ammonium or Mn, divided by its original concentration versus time, which should yield a straight line with a slope of  $k_1$  ( the reaction rate constant) ( Table 2).

$$-\ln \frac{a-x}{a} = k_1 t \quad (\text{eq.9})$$

**TABLE 2.** The values  $k_1$  determined by eq.9 and eq.10 and  $k_1$  determined from Mn release.

	MCM+S	MCM	CTR+S	CTR	CCR+S	CCR	CCM+S	CCM
$k_1$ ammonium (month <sup>-1</sup> )	0.2881	0.0958	0.1521	0.0653	0.117	0.057	0.203	0.146
$k_1$ nitrates (month <sup>-1</sup> )	0.0199	0.0064	0.0106	0.0057	0.0105	0.0077	0.0119	0.0093
$k_1$ Mn release (month <sup>-1</sup> )	0.2464	0.0828	0.1865	0.0291	0.1877	0.0602	0.1079	0.0374

The second approach is assuming that  $k_1 \ll k_2$ , *i.e.*, ammonification is much lower than nitrification, which will be proven from the analysis of the release data, as shown in Table 3 and solving for the value of  $k_1$  by the use of the following equation (derived from eq.6),

$$-\ln\left(1 - \frac{y}{a}\right) = k_1 t \quad (\text{eq.10})$$

Where  $y$  here is the nitrate concentration, *i.e.*, the plotting the  $-(\ln(1-y/a))$  versus time should yield a straight line with a slope of  $k_1$ . Since this should be the same as the value of  $k_1$  obtained from equation eq.9, any deviation is an indication of an ammonia quantity which has been released to the soil system but which has not gone through the second step of nitrification. The ratio of the rates of the two consecutive reactions  $k_2/k_1$  goes into eq.5. The value of  $k_1$ , obtained by the second approach is the value used to determine the value of the ratio  $k_2/k_1$ , denoted by  $r$ , since this is the value expressing the amount on ammonia which has gone through the second reaction. This ratio ( $r$ ) is independent of the amount of the ammonia going through the second reaction. Solving for ( $r$ ) by using equation 5 for the observed value of  $t_{\max}$  which is 6 month is done. The obtained ( $r$ ) value in combination with the value of the  $k_1$  determined by the first method should give the value of  $k_2$ .

**TABLE 3.** The values  $k_1$  determined by eq.9 and eq.10 and the ratio ( $r$ ) for the different manures.

	MCM+S	MCM	CTR+S	CTR	CCR+S	CCR	CCM+S	CCM
$k_1$ nitrates (month <sup>-1</sup> )	0.0179	0.0074	0.0121	0.0064	0.0130	0.0080	0.0123	0.0100
$r = k_2/k_1$	33	105	56	126	51.5	95.5	55	71.5
$k_1$ ammonium	0.2881	0.0958	0.1521	0.0653	0.117	0.057	0.20	0.14
$k_2 =$	9.50	10.05	8.51	8.22	6.02	5.4	11.20	10.40

### Results and Discussion

Figure 1.a shows the behavior of ammonium release into the system. Fig. 1.b shows the nitrate accumulation in the system. It is clear that there is a  $t_{max}$  period which is six months for all the used manures. This is the value for which the ratio of  $k_2/k_1$  was calculated by the use of eq.5. The original amount of ammonia in the organic matter was used as the value of (a) in eq. 9. The amount of ammonia remaining after decomposition was used as the value of (a-x) in eq.6. The values of the  $k_1$  was obtained from the curve fitting of  $-\ln((a-x)/a)$  versus time in eq. 9. This was done for all the four organic manures with the addition of sulphur and no sulphur. The results are shown in Fig. 2. a, b, c and d. This figures shows on each curve the values of the  $k_1$  expressed as the slope of the line of best fit between  $-\ln((a-x)/a)$  versus time for the case of sulphur as opposed to no sulphur (CCM +S and CCM legend on the graph respectively). The values of  $R^2$  for each case is shown on the graph.

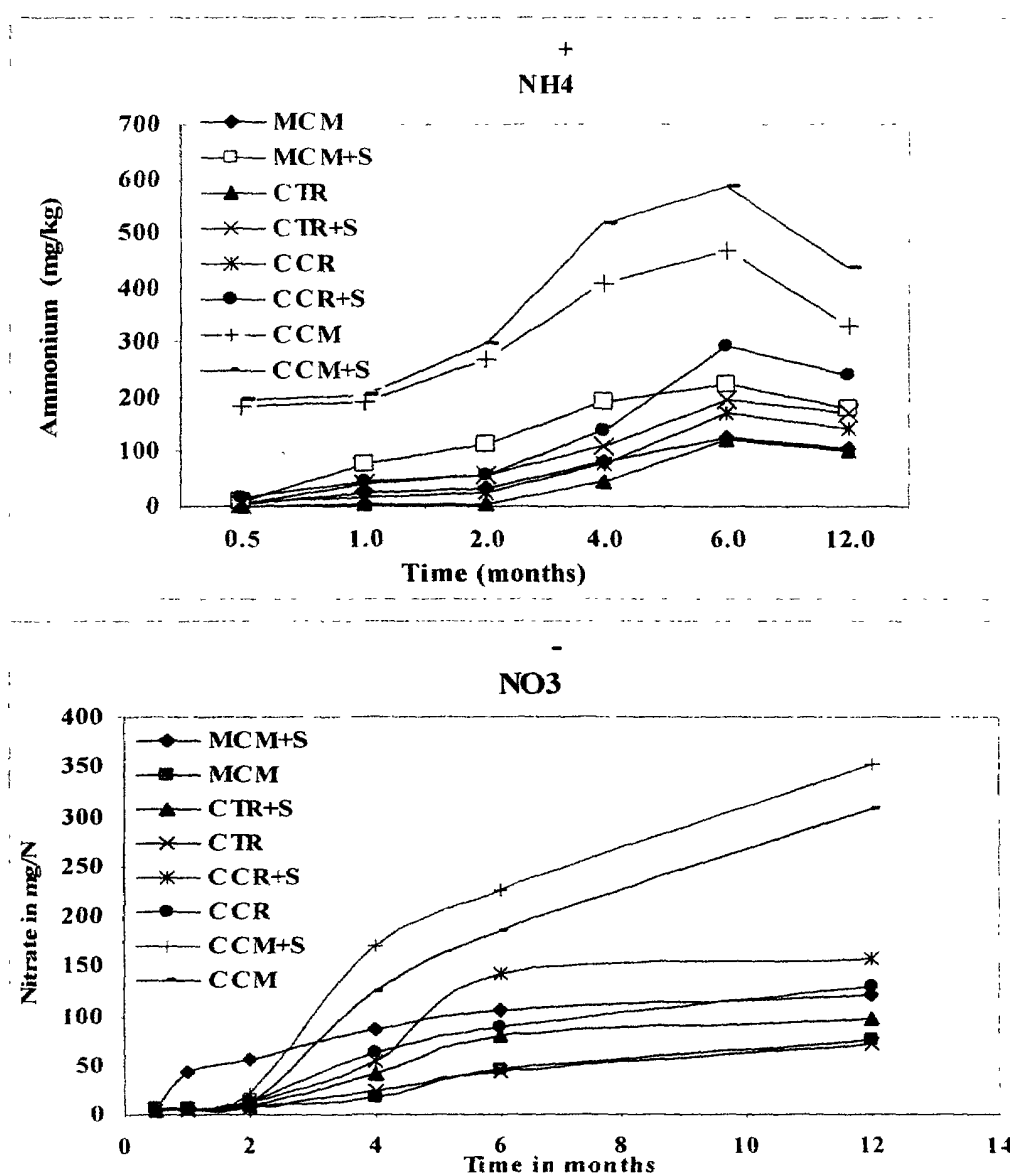


Fig. 1 a, b. Release curves of ammonium and nitrates from different composts.

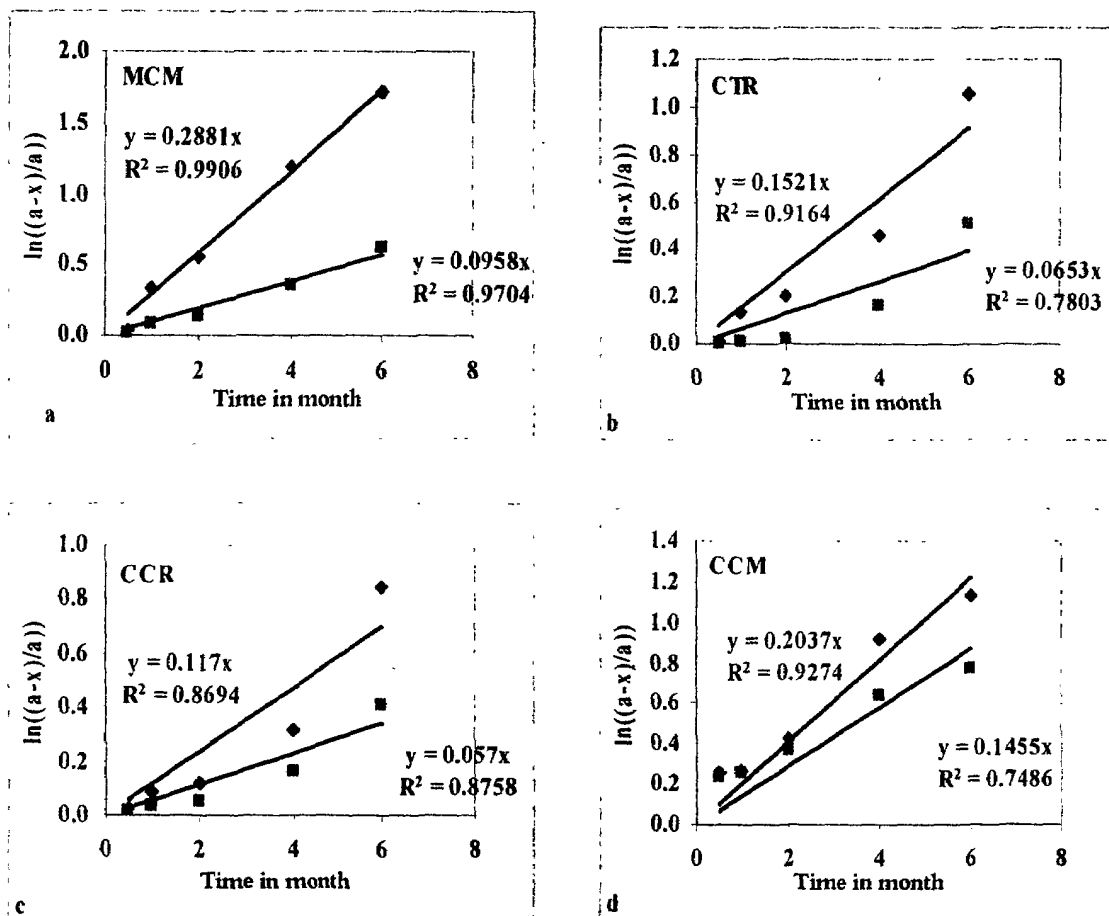


Fig. 2a,b,c & d. The effect of the sulphur on the ammonification rate as determined by the slope of the linear relation for composts with (♦) and without sulphur (■) from eq. 9.

The second method of calculating the values of the  $k_1$  values for the different manures with sulphur and no sulphur, obtained from the nitrate concentration (Fig. 3 a, b, c and d), was applied by the use of eq.10. There was a difference between the values of  $k_1$ , obtained by both methods. The second method gives lower  $k_1$  value of the ammonification first order reaction rate constant due to the loss of some ammonia. If some ammonia has been lost from the system, *i.e.*, due to volatilization, it will not go through the second step and will give rise to differences in the value of  $k_1$  obtained from eq.9 and eq. 10. The differences in the values of  $k_1$ , obtained from both equations are shown on Fig. 2 & 3 and are summarized in Table 2.

Concerning the low value of ammonia going through the second process of nitrification, Shi *et al.* (1999) estimated that only 10% of the total compost N was available for crop growth. Also, Shi *et al.* (2004) using  $N_{15}$  found that composted cattle manure released 15 and 8 % of its total-N in the first and second year of application respectively.



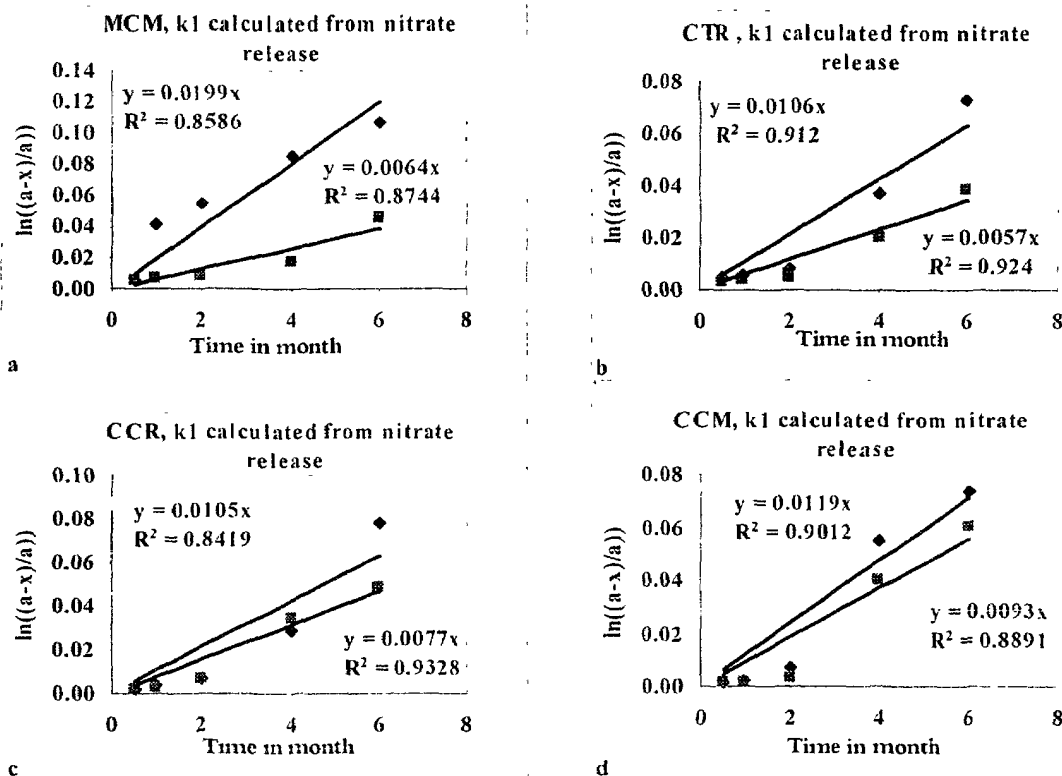


Fig. 3. The effect of sulphur on the  $k_1$  calculated from nitrate release with ( $\blacklozenge$ ) and without sulphur ( $\blacksquare$ ) from eq.10.

To check for the values of the  $k_1$  obtained from the amount of ammonia released, *i.e.*, eq. 9, the values of  $k_1$  was determined by the use of Mn as a tracer (Fig.4 & 5), since mineralized Mn does not volatilize and all the amount of released Mn will remain in the system. Fig. 4.a shows the release curve for Mn. Fig. 4.b shows the behavior of the remaining Mn as an exponential decay function. The use of Mn as a tracer yielded close values for the first stage of decomposition, *i.e.*, mineralization for organic-N and Mn, which is shown by the  $k_1$  values presented in Fig. 2 versus Fig. 5 and summarized in Table 2.

The values of  $k_1$  obtained from ammonium release and Mn release (row 1 versus row 3) in Table 2 show close agreement in values for MCM+S, MCM, CTR+S, CCR+S, CCR. However, there is large difference between  $k_1$  values obtained for CTR, CCM+S and CCM. Anyhow, the agreement between the two values obtained from ammonia release and Mn release are much better than the values obtained from eq.9 (ammonium release) and eq.10 (nitrates release).

It is very important to mention that the ratio of  $k_2/k_1$  is independent of amount of ammonia going through the second process of nitrification. This ratio ( $r$ ) in Table 3 is calculated by the use of the  $k_1$  obtained by the use of eq. 10, which represents the actual amount of ammonia which has gone through nitrification.

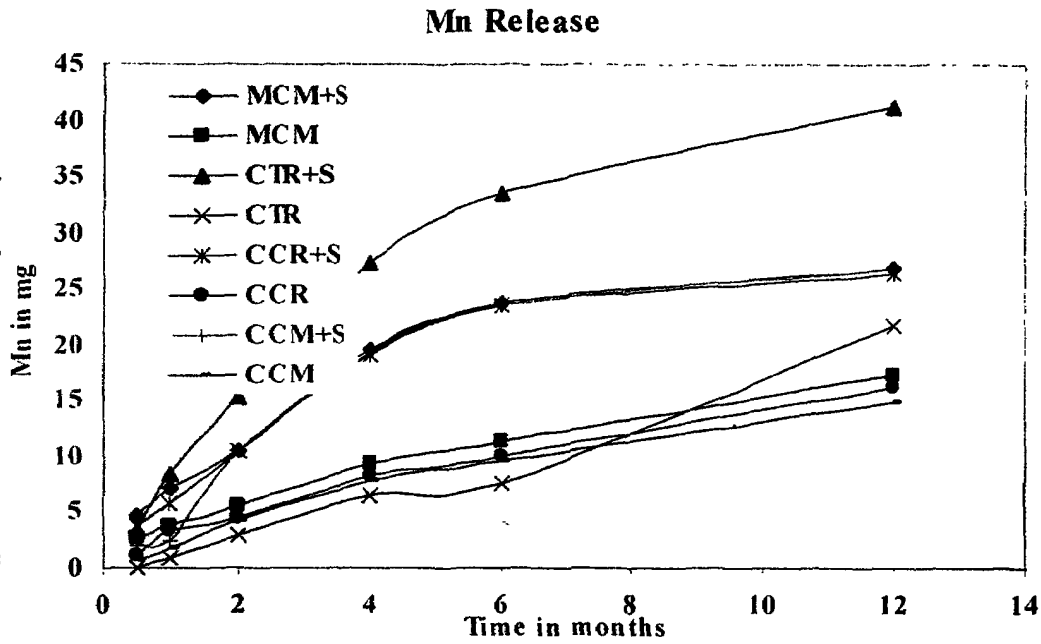


Fig.4a. Release curves of Mn from different composts.

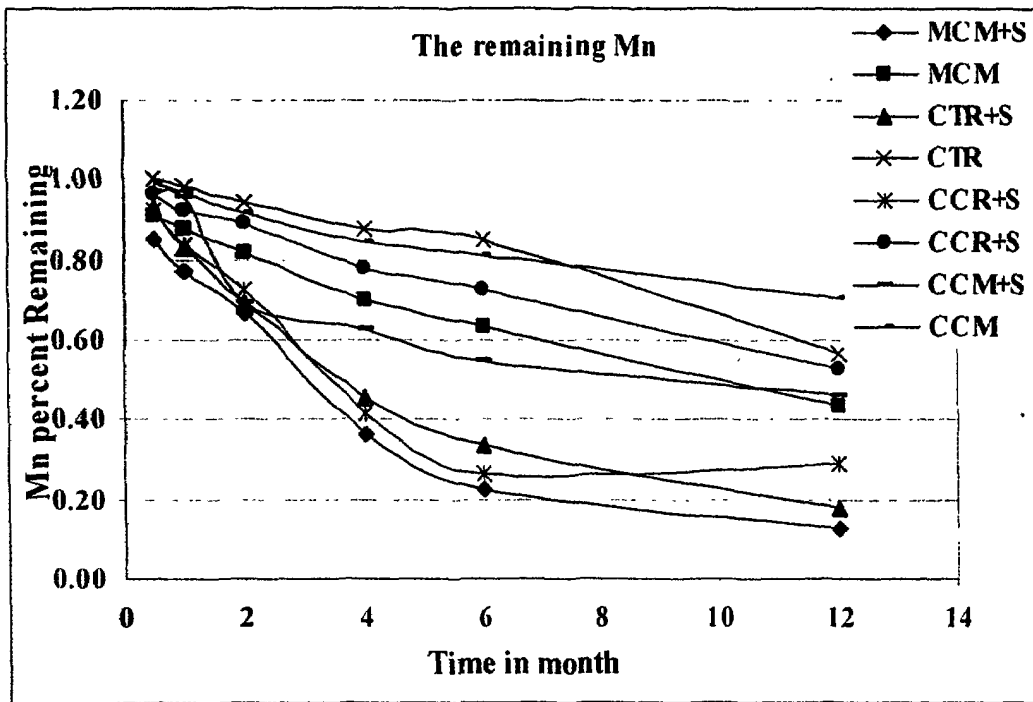


Fig. 4b. The first order behavior curves for Mn.

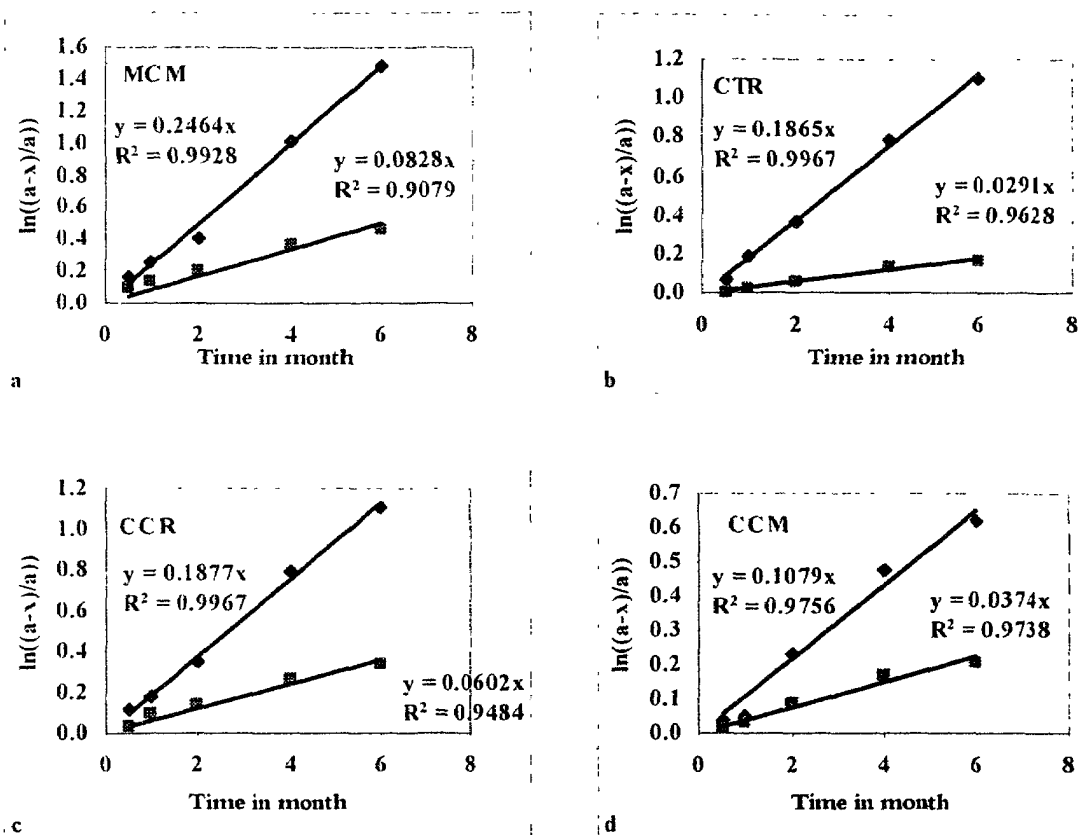


Fig. 5. The effect of the sulphur on the Mn release rate as determined by the slope of the linear relation for composts with ( $\diamond$ ) and without sulphur ( $\blacksquare$ ).

The obtained value for the first stage of mineralization by the use of eq.9 ( $k_1$ ) was multiplied by the ratio of the  $k_2/k_1$  to obtain the value of  $k_2$  as shown in Table 3.

#### The effect of sulphur

The t-test results show that there was a significant difference between the obtained values of  $k_1$  for sulphur and no sulphur for all manures except for CCR for which was no significant difference for sulphur. The values of the  $k_1$  for the four manures with sulphur and no the sulphur and the corresponding calculated t values versus the tabulated t are shown in Table 4.

TABLE 4. The values of  $k_1$  for the case of sulphur and no-sulphur and their significant differences.

	MCM	CTR	CCR	CCM
$k_1$ sulphur	0.2881	0.1521	0.117	0.2037
$k_1$ no sulphur	0.0958	0.0653	0.057	0.1455
t calculated	27.33074	15.71307	2.07465	12.37016
t tabulated (0.01,4)=	4.6			
t tabulated (0.001,4)=	8.61			

Concerning the sulphur effect, It is clear from Table 4 and Figure 2 for different manures that sulphur addition increases the rate of ammonification probably through the decrease of the pH of the soil due to sulphur oxidation to produce sulphuric acid through microbial action. This will neutralize the resulting ammonium and lead to an increase in the reaction rate. As ammonia is released in the decomposition process, other mineral constituents are also released and this is seen on the effect of Mn release.

Concerning the effect on the ratio of  $k_2/k_1$ , it seems the sulphur will reduce this ratio, as seen on the Table 3, since nitrification reaction produces two  $H^+$  ions for every molecule of  $NH_4^+$  which is also produced from sulphur oxidation to sulphuric acid. So, the nitrification reaction will be reduced relative to the ammonification reaction. So, ammonification was increased while the ratio nitrification rate/ammonification rate was decreased. So, the determined nitrification reaction rate constants were close in value to each other.

### Conclusions

The results from an incubation experiment which lasted for 12 months were presented and analyzed by the use of chemical kinetics laws. The kinetic analysis used, allows for correct determination of the values of the nitrification kinetic reaction rates constants, irrespective of volatilization losses. The analysis shows that the reaction rate constant for the ammonification  $k_1$  is enhanced by the use of sulphur. The results reveal that sulphur has a significant effect in increasing the value of the ammonification first order reaction rate constants for the MCM, CTR, and CCM but had no significant difference in the case of CCR. This is probably due to high dispersion of the CCR replicates. The determined nitrification reaction first order reaction rate constants were somewhat different between the treatments but the differences were higher between the different manures. This could be due to differences in microbial population densities of the nitrifying bacteria.

The sulphur addition increases the rate of ammonification probably through the decrease of the pH of the soil due to sulphur oxidation to produce sulphuric acid through microbial action. This will neutralize the resulting ammonium and lead to an increase in the reaction rate. The ratio of nitrification to ammonification seems hindered by sulphur addition, since nitrification reaction produces two  $H^+$  ions for every molecule of  $NH_4^+$  nitrified, which is also produced from sulphur oxidation to sulphuric acid. So, the nitrification reaction will be reduced relative to the ammonification reaction. So, ammonification was increased while the ratio nitrification rate/ammonification rate was decreased. However, the determined nitrification reaction rate constants were close in value to each other.

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## حركات انطلاق الأمونيا والنترات والمنجنيز في أسمدة عضوية مختلفة وتأثرها بالكبريت

رضارجب شاهين و رشدي محمد محمد الكيلاني

قسم الأراضي والمياه - كلية الزراعة - جامعة القاهرة - الجيزة - مصر .

لقد تم إجراء تحضين تم فيه خلط أربع أنواع من الأسمدة العضوية الشائعة في السوق المصري بالكبريت وهي: سماد بلدي مخلوط (أ) ، مخلفات دواجن مككور (ب) ، مخلفات محاصيل مككور (ج) ، وبقايا منازل مككور (د) ، وذلك لدراسة أثر الكبريت علي تحولات النتروجين. وتم إجراء تجربة مقارنة تم فيها استخدام نفس الأسمدة بدون كبريت. ولقد تم تعقب كميات الأمونيوم والنترات المنطلقة كدالة في الزمن. و تم إجراء تحليل حركي كيميائي لنتائج التجربة. ولكي نبرر الثوابت المحسوبة لمعدلات الدرجة الأولى للنشطرة و التآزت ، تم استخدام المنجنيز كدليل نظراً لعدم تعرضه لأي فقد. ولقد أظهرت النتائج أن الكبريت له تأثير معنوي في زيادة قيم ثوابت تفاعل الدرجة الأولى للنشطرة ( $k_1$ ) لسماد أ ، د ، ب. ولقد كانت ثوابت الدرجة الأولى ٢٨٩، (شهر<sup>-1</sup>) ، ٠٩٦ ، (شهر<sup>-1</sup>) للسماد أ + كبريت علي وجه الترتيب ، ١٥٢ ، (شهر<sup>-1</sup>) و ٠٥٧ ، (شهر<sup>-1</sup>) للسماد (د + كبريت) ولسماد (د) علي وجه الترتيب ، ٠٩٦ ، (شهر<sup>-1</sup>) و ٠٠٤٦ (شهر<sup>-1</sup>) لسماد ج + كبريت ولسماد ج علي وجه الترتيب و ٢٠٤ ، (شهر<sup>-1</sup>) و ١٤٥ ، (شهر<sup>-1</sup>) لسماد ب + كبريت ولسماد ب علي وجه الترتيب.

و كان ثابت الدرجة لمعدل التآزت ٩٥ (شهر<sup>-1</sup>) ، ١٠٠٥ (شهر<sup>-1</sup>) لسماد أ + كبريت وسماد أ علي وجه الترتيب ، ٨٥١ (شهر<sup>-1</sup>) ، ٨٢٢ (شهر<sup>-1</sup>) لسماد د + كبريت ، لسماد علي وجه الترتيب و ٦٠٢ (شهر<sup>-1</sup>) و ٥٠٤ (شهر<sup>-1</sup>) لسماد ج + كبريت ولسماد ج علي وجه الترتيب و ١١٢ (شهر<sup>-1</sup>) و ١٠٤ (شهر<sup>-1</sup>) لسماد ب + كبريت وسماد ب علي وجه الترتيب.

ولقد شجع الكبريت من معدل النشطرة البيطبي مبدئياً غالباً من خلال خفض رقم الحموضة للتربة نتيجة لإنتاج حامض الكبريتيك وهذا سوف يعادل الأمونيا الناتجة ويؤدي إلي زيادة في معدل التفاعل. ولقد كانت نسبة ثابت التفاعل الثاني إلي ثابت التفاعل الأول  $K_2/K_1$  ٣٣ ، ١٠٥ ، ٥٦ ، ١٢٦ ، ٥١٥ ، ٩٥٥ ، ٥٥ و ٧١ للسماد أ + كبريت ، أ ، د + كبريت ، د ، ج + كبريت ، ج ، ب + كبريت و ب علي وجه الترتيب. ويبدو أن الكبريت خفض من هذه النسبة حيث أن تفاعل التآزت ينتج أيوني هيدروجيني لكل جزئ من الأمونيوم والذي ينتج أيضاً من أكسدة الكبريت إلي حامض كبريتيك ولذلك فإن معدل تفاعل التآزت يتم خفضه أكثر بالنسبة لمعدل النشطرة. ولقد كان الاختلاف في قيم ثوابت تفاعل التآزت ( $K_2$ ) أكثر اختلافاً بين الأنواع المختلفة للأسمدة البلدية عنه بين نفس النوع في السماد البلدي أما مخلوط بالكبريت أو بدونه.