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INCUBATION STUDY ON KINETIC AND MINERALIZATION RATE OF NITROGEN OF ORGANIC SOURCES IN ULTISOL

Lumbini Kalita, N. J. Singh*, Lala IP Ray and AK Singh

School of Natural Resource Management, CPGS-AS, CAU-Imphal, Umiam - 793103,
Meghalaya, India

lumbini_k27@yahoo.com, liprbabu4u@gmail.com, aditykumar1972@gmail.com

*Corresponding author: naorem2005@gmail.com

Abstract

The age-old traditional farming practice was followed by tribal inhabitants using locally available organic sources as plant nutrient sources. The aim of the study was to quantify the kinetics and rate of mineralization of different local organic sources. An incubation study of 100 days was carried out using locally available organic sources i.e. Farm Yard Manure (FYM) (T1), Poultry manure (T2), Pig manure (T3), and Vermicompost (T4) at the rate of 120 kg N/ha (considering RDF of rice as 120 kg N/ha). The bulk soil sample of *Typic kandihumultis* at 0 – 15 cm was collected from the CPGS-AS research farm and treated with organic sources and kept in an incubator at field capacity soil moisture and 25⁰C temperature. Observations were taken at 10 days intervals up to 100 days of Incubation (DOI). A control treatment (T0) of no organic was set for comparison. The result was showed that the average nitrogen mineralization rate (Nmin) of T3 was found highest (64.88%) followed by T2 (57.77%), T4 (42.98%), and T1 (35.24%). The highest Nmin rate of T3 and T2 was noted at 60 DOI as 79.37% and 76.10% respectively. At 50 – 60 DOI, total nitrogen, available nitrogen, and nitrogen fractions (ammonical nitrogen and nitrate nitrogen) were the highest released irrespective of organic sources. The R² (coefficient of determinate) of first-order kinetics of all organic sources was found as 0.91

(T3)>0.90(T2)>0.89(T4) >0.88(T1) and R^2 of second-order kinetic found as 0.66 (T3)>0.65 (T2)>0.64 (T1 and T4). It was concluded that T3 (Pig manure) was the best organic nutrient source among the treatments considered for the study.

Keywords: Local organic source, Nitrogen mineralization, kinetics.

Introduction

The prudent management of locally accessible organic resources was the best option for tribal occupants who used a traditional farming system (>150 years). However, the appropriateness of organic resources as nutrient sources depended on the rate of mineralization and kinetic¹. The kinetic was the study of rates of chemical processes and the rate of a reaction is the change in concentration over time. Due to the scarcity of scientific interventions and equipment, it was difficult to quantify the kinetics and rate of N mineralization of local organic sources. By measuring the kinetics and rate of mineralization of various locally accessible organic sources, farmers could increase agricultural output and better feed the people. The kinetics and rate of mineralization depended upon the soil moisture, temperature, type of soil and properties, organic matter addition, microbial activity, and management practices^{2,3}. Rapid Nitrogen (N) mineralization occurred in pH 5.5 - 10 with optimum at 8.5⁴. The dissociation of functional groups of soil organic matter and reduction of bonds between the organic constituents and clays was increased with increased soil pH i.e. solubility and mineralizable Nitrogen increase⁵. Organic sources such as farmyard manure (FYM)⁶, cattle manure, pig manure, poultry manure, composts, and vermicomposts, etc.⁷ was the best alternative nutrient source. About 3.30 million tonnes of poultry waste per year were generated in India annually. Notably, poultry droppings were rich in nutrients, cellulose, hemicelluloses, and lignin⁸. The pig manure contained all essential plant nutrients. Given that North East India was one of the world's major hotspots for biodiversity, forest waste was an alternate source of plant nutrients as farm yard manure

(FYM) and vermicompost. Due to the abundance of locally available organic sources, an effort had been made to study the local organic sources as plant nutrition with the goals of determining the kinetics of various organic sources as well as the rate at which they were mineralized.

Materials and methods

Study site

The study site was located at 91° 18' to 92° 18' E longitudes and 25° 40' to 26° 20' N latitude with an altitude of 950 m above sea level. It was fallen under a subtropical humid climate characterized by high rainfall and cold winter. Monsoon normally was set in the first fortnight of June and remained active till October and received 2617.10 mm mean annual rainfall with a good amount of pre-monsoon showers during March to May and high humidity (above 80%) and low sunshine hours. The maximum temperature was rise up to 35°C in July- August and the minimum falls down to 5-6°C during the first week of January. The soil belongs to the taxonomy *Typic kandihumultis*⁹.

Soil sample collection and processing

A bulk soil sample was prepared from 20 randomly collected soil samples at 0 – 15 cm depth from the CPGS-AS research farm (2 ha) (figure 1).

The samples were air-dried, ground, and passed through a 2.0 mm sieve, and analysis of soil texture¹⁰, pH, and EC (1:2.5 ratio of soil: water suspension^{11,12}, soil organic carbon (SOC) (Dichromate Wet Oxidation¹³, Water-soluble carbon (WSC)¹⁴, cation exchange capacity (CEC) (1N Ammonium acetate extraction)¹⁵, Available Nitrogen (Alkaline Permanganate Method)¹⁶, Total Nitrogen¹⁷, Nitrate Nitrogen¹⁸, Ammonical Nitrogen¹⁹ were carried out. The WSC is extracted by shaking 5 g soil with 10 mL deionized water for 60 min, followed by centrifugation at 10000 x g at 4°C for 30 min. The supernatant was filtered with suction through a 47 mm diameter, 0.2 µm metrical membrane filter

previously washed with 150 mL deionized water. The initial soil properties are presented in Table (1).

Incubation study

An incubation study of 100 days was carried out under control conditions (moisture at field capacity and temperature at 25⁰C) in a BOD incubator²⁰. A 50 gm of soil was treated with organic sources viz., FYM (T1), Poultry manure (T2), Pig manure (T3), and Vermicompost (T4) at the equivalent dose of 120 kg N/ha and placed in 50 ml capacity centrifuge tube for 100 days. A control treatment (T0) with no organic source was set for comparison. The treatments were replicated four times in a completely randomized design (CRD) and observations were recorded at every 10 days interval i.e., 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 Days of Incubation (DOI). As soon as the samples were taken out, it was immediately extracted for analysis. The initial nutrient content and ratio of organic sources were given in Table 2.

Determination of nutrient mineralization rate

The N mineralization rate was calculated at every 10 intervals of DOI till 100 DOI using Preusch *et al.*,²¹ equation as:

$$\text{N mineralization rate (\%)} = [\{ (N_f - S_f) - (N_i - S_i) \} \times 100] / N_o$$

Where, N_f = Total nitrogen at final sampling time.

S_f = Total nitrogen in control soil at final sampling time.

N_i = Soil total N at initial sampling time in amended soil.

S_i = Total soil nitrogen in control soil in initial sampling time.

N_o = initial organic N content.

N kinetics in soil

Kinetics studied the rates of nutrient transformation and associated chemical reactions. It also aided in gathering and analyzing information regarding the reaction's

mechanism and defining the features of a chemical reaction. The change in the rate of mineralizable nitrogen was estimated as (dN/dt) and fitted to the kinetic equations:

$$\text{First order equation}^{22}, q_t = q_0 \cdot e^{-k_1 t},$$

$$\text{Second order equation}^6, 1/q_t = 1/q_0 + k_2 t$$

Where, q_0 is the initial amount of nutrient present in different organic sources (mg/kg), and q_t is the amount of nutrient present in different organic sources (mg/kg) at the time (t , in days). The k_1 and k_2 are the constants of first and second-order kinetics, respectively.

Statistical analysis

The one-way ANOVA analysis and Duncan Multiple Range Test (DMRT) tests are performed to compare the means and determine the significant effect of organic sources in MS-Excel 2010 and Web Agri Stat Package (WASP) version 2.0.

Results and discussion

Nitrogen releasing pattern

Figure 2 was described the nitrogen-releasing pattern of different organic sources during the incubation period (days). The soil total nitrogen (TN) is varying between 1490 (T0 (control) at 60 DOI) - 1980 ppm (T3 (Pig manure) at 80 DOI). All the organic treated soil gradually increased the TN to 60 DOI. The TN curved attained the maximum at 70 DOI and maintained the curve level till 100 DOI. Among the organic treatments, T3 was recorded as the highest TN (1833.03 ppm) (increase of 14.69% over T0) followed by T2 (1779.09 ppm) (increase of 2.94% over T2), T4 (1766.66 ppm) (increase 3.62% over T4) and T1 (1697.57 ppm) (increase 7.38% over T1) during the entire period of incubation. The TN variable in the soil was because of the mineralization of organic matter present in the organic sources, not from the inorganic soil. It seemed the high mineralization rate of T3 resulting the highest TN (1980 ppm) at 80 DOI among organic treatments and also T3 content higher TN (1.72% or 1720 ppm), followed by T2 (1.54% or 1540 ppm), T4 (0.76%

or 760 ppm) and T1 (0.153% or 153 ppm) depending upon the type of feed feeding to the pig and poultry as well as classified as the concentrate nutrient sources²³. The FYM (T1) prepared from the forest waste has a wide C/N ratio and low nitrogen content.

The available N (AN) was also increased with the organic application over T0 (control) (95.08 ppm). The highest AN was noted with T3 (133.81 ppm) and T2 (129.73 ppm) which were increased by about 26.47% and 24.17% over T0 (control) respectively, and the lowest AN with T1 (FYM) (117.46 ppm) (16.25% higher over the control). Abbasi and Khaliq²³ classified the poultry and pig feed as concentrated feed and also Nair²⁴ suggested the bioavailability of AN controlled by the interaction N, P, and K present in it. AN attained a maximum of 60 DOI for T2, T3, and T4, whereas 70 DOI for T1. The availability of nitrogen from the organic sources through mineralization was maximized at 60 – 70 DOI.

The ammonical Nitrogen (NH_4^+) (AmN) varied between 28.0 - 72.3 ppm. The AmN released pattern during the incubation time (days) was found that 10 – 40 DOI attained the maximum peak and AmN released gradually decreased with increasing days. Initially, the AmN released might not fix to the soil and the rate of fixation might be increased with increasing DOI. The maximum AmN was noted with T3 (61.26 ppm) (50.88% increase over T0) at 20 - 40 DOI, followed by T4 (54.16 ppm), (44.44% increase over T0), T2 (38.88 ppm), (22.60% increase over T0) and T1 (36.13 ppm) (16.71% increase over T0).

Figure 2 depicted that among the organic sources T2, T3, and T4 enhanced nitrate released and attained the maximum peak of nitrate released during 50 – 60 DOI. The soil without organic treatment (control) was shown a little fluctuation of nitrate released during the incubation, the incubation days (time) were independent of nitrate released from such soil. This might be the chemical properties of nitrate and its ability to high leach from the soil. The nitrate nitrogen (NO_3^-) ranges from 17.50 ppm (T0) to 39.6 ppm (T3) during the

incubation period and maximum during 30 - 70 DOI. The average NO_3^- contribution during the incubation period is 33.90% (T3 record maximum) > 31.33% (T4) > 26.16% (T2) and 21.49% (T1) which are increased 44.27%, 39.70%, 27.79% and 12.09% over T0 respectively.

Rate of nitrogen mineralization (Nmin)

The Nmin rate (%) was estimated at every 10 days intervals up to 100 DOI (figure 3). Among the organic treatments, T3 (pig manure) was found the highest nitrogen mineralization rate (64.88%) followed by T2 (poultry manure) (57.77%), T4 (vermicompost) (42.98%), and T1 (farm yard manure) (35.24%). The Nmin rate of T3 and T2 were rapidly raised from 0 DOI onwards to 60 DOI after which it gradually decreased, however, T4 and T1 followed a similar trend of N mineralization rate, and after 60 DOI till the end of incubation time, the N mineralization rate remained same. The Nmin rate of T3 increased by about 10.95% over T2, 33.75% over T4, and 45.68% over T1. The nitrogen concentration and C: N ratio of the manure strongly affected the N mineralization rate of manure. The mineralization rate was expressed as a decrease in manure (as a reactant) concentration i.e. the rate is $(-d [\text{manure}])/(dt)^{25}$. Joffre and Agren²⁶ and Singh *et al.*²⁷ reported a similar finding.

Kinetics of nitrogen mineralization

The kinetics of nitrogen mineralization is presented in Table 3 and Figure 4. The analysis of the kinetic of N release from organic sources was to know whether the release of N from organic treatments was independent of their initial concentration (zero order) or a concentration-dependent where a constant proportion of N was mineralized (first order) or the release of a nutrient was dependent on the square of its concentration or the concentration of some other nutrient (second order). The first-order kinetic constants of N from different organic treatments were T1 (0.1066 $\mu\text{g/g/day}$), T2 (0.1058 $\mu\text{g/g/day}$), T3

(0.1059 $\mu\text{g/g/day}$), and T4 (0.1054 $\mu\text{g/g/day}$), and second-order kinetic constants were T1 (-0.0007 $\mu\text{g/g/day}$), T2 (-0.0006 $\mu\text{g/g/day}$), T3 (-0.0006 $\mu\text{g/g/day}$) and T4 (-0.0007 $\mu\text{g/g/day}$). The coefficient of determination (R^2) estimated using a first-order kinetic equation at $p \leq 0.05$ was found the $R^2 > 0.88$ for all the organic treatments which were satisfactorily released N (Nmin rate), R^2 varied between 0.88 (T1) to 0.91 (T3) significant at $p \leq 0.01$, however, the R^2 of second-order kinetic were varied from 0.64 (T1 and T4) to 0.66 (T3) (table 3). The high R^2 of first-order kinetic was shown the changes in the particle structure which directly affected the organic matter degradation process. The N releases (mineralization, Nmin) from different organic sources conformed to first-order kinetics, while second-order kinetic was shown as the immobilization of N. The result was in agreement with the findings of Preusch *et al.*²¹ and Dey *et al.*⁶. The potentially mineralizable nitrogen (N_0) was the amount of nitrogen present that could be mineralized. The initial nitrogen (N_0) for first-order kinetics was found as 2.20 ppm (T3) > 2.17 ppm (T2) > 2.14 ppm (T4) > 2.11 ppm (T1). The T3 (pig manure) exhibits the highest kinetic rate (0.41 mg/kg/day) followed by T2 (poultry manure) (0.34 mg/kg/day), T4 (vermicompost) (0.25 mg/kg/day) and T1 (Farm Yard Manure) (0.2 mg/kg/day). Ge *et al.*²⁸ found initially (0 days) particles large with a relatively smooth external surface and a nearly intact internal structure of pig manure, after 7 days (i.e. mesophilic–thermophilic phase) Baharuddin *et al.*²⁹ noticed the particles decreased in size, cracked on the particle surface (cracks deepened with days increase, more fragments attached to a surface), and increased the internal pores (elongated shape between 28 - 35 days) and microbial activities. The kinetics rapidly decreased from 10 DOI to 100 DOI and this might be the reason for the highest kinetic of nitrogen mineralization of T3 among the organic treatments. A similar, result was reported²⁴. Baharuddin *et al.*²⁹, Ravindran and Sekaran³⁰, and Gómez *et al.*³¹ found that the particles of pig manure decreased in size, and increased in surface roughness, fragments, and pores

during decomposition. The rate of ion exchange was increased with decreasing particle size of the exchanger³² i.e. ion exchange controlled by diffusion, mass-transfer phenomena limited reaction rate. Diffusion occurred with the influence of the electric field caused by ionic charge³³⁻³⁵. The pig manure was cellular structure³⁶ and stabilized the crystal structure of pig manure particles^{37&38}. Hemicellulose was more highly biodegradable than lignin^{39&40} due to its amorphous structure and polysaccharide nature, which resulted from the microbial degradation⁴⁰ increased with specific surface area^{41&42}. The growth of microorganisms (i.e. *Nitrosomonas* and *Nitrobacter*) was described by Michaelis-Menten kinetics⁴³ which explained the rate at which the organisms growth and the mechanism of enzyme-catalyzed reactions. It assumed the rapid reversible formation of a complex between an enzyme and its substrate and also assumed the rate of product formation proportional to the concentration of the complex. Hence, the initial rate of reaction was greater and decline later. Beek and Frissel⁴⁴ also described that NH_4^+ oxidation, mineralization of proteins, sugars, cellulose, lignin, and living biomass followed the first-order kinetics. The sharp decline in the rate of nitrogen after 70 DOI might be attributed to the immobilization, NH_3 volatilization by diffusion, and NH_4^+ clay fixation. This was explained by Frissel and van Veen⁴³, Mehran and Tanji⁴⁵. Soil organic matter aggregates the soils⁴⁶.

Conclusion

It was revealed that different organic treatments (sources) varied the rate of nitrogen release, which could be accounted for well by the first-order kinetics (R^2 0.91) as compared to second-order kinetics. FYM from forest waste was the lowest nutrient supplying capacity (117.46 ppm AN), gradually increased the nutrient supply curve from 0 DOI, and attained the maximum at 70 DOI. The pig (T3) and poultry (T2) manure were the best options for nutrient sources with maximum nutrient released at 50 - 60 DOI. The combination of pig/poultry manure with FYM might be the best solution for enhancing crop production,

however further research on the mineralization rate and kinetics was necessary for nutrient and land management programs.

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References

1. Murugan, A. V. and Swarnam, T. P., Nitrogen release pattern from organic manures applied to an acid soil. *Journal of Agricultural Science*, 2013, 5(6), 174-184, ISSN 1916-9752, E-ISSN 1916-9760
2. Grzyb, A., Wolna-Maruwka, A., and Niewiadomska, A., Environmental factors affecting the mineralization of crop residues. *Agronomy*, 2020, **10**(12), 1951.
3. Risch, A. C., Zimmermann, S., Moser, B., Schütz, M., Hagedorn, F., Firn, J., ... and Ochoa-Hueso, R., Global impacts of fertilization and herbivore removal on soil net nitrogen mineralization are modulated by local climate and soil properties. *Global change biology*, 2020, **26**(12), 7173-7185.
4. Braos, L. B., Ruiz, J. G. C. L., Lopes, I. G., Ferreira, M. E., and da Cruz, M. C. P., Mineralization of nitrogen in soils with application of acid whey at different pH. *Journal of Soil Science and Plant Nutrition*, 2020, **20**(3), 1102-1109.
5. Neina, D., The role of soil pH in plant nutrition and soil remediation. *Appl. Environ. Soil Sci.*, 2019, 1-9. Article ID 5794869.
6. Dey, A., Srivastava, P. C., Pachauri, S. P. and Shukla, A. K., Time-dependent release of some plant nutrients from different organic amendments in a laboratory study. *Int. J. Recycl. Org. Waste Agric*, 2019, **8**(1), 173-188.

7. Nishigaki, T., Tsujimoto, Y., Rinasoa, S., Rakotoson, T., Andriamananjara, A. and Razafimbelo, T., Phosphorus uptake of rice plants is affected by phosphorus forms and physicochemical properties of tropical weathered soils. *Plant and Soil*, 2019, **435**(1), 27-38.
8. TNAU Agritech portal, Organic Farming. Access from http://www.agritech.tnau.ac.in/org_farm/orgfarm_poultry.html
9. Chanu, P. H., Bora, P. K., Thakuria, D. and Ram, V., Influence of land use type on different aggregating elements of acidic soil of Meghalaya India. *Int. J. Chem. Stud*, 2019, **7**(1), 1819-1823.
10. International Society of Soil Science, Minutes of the first commission meetings, International Congress of Soil Science, *International Society of Soil Science*, 1929, 215–220, Washington, D. C.
11. McLean, E. O., Soil pH and lime requirement. In *Methods of soil analysis. Part 2 - Chemical and microbiological properties* (2nd ed. Page, A. L., Miller, R. H. And Keeney, D. R.). *Agron. Monogr.*, 9, ASA, SSSA, CSSA, Madison, WI. 1982, 199-223.
12. Corwin, D. L., and Rhoades, J. D., An improved technique for determining soil electrical conductivity-depth relations from above ground electromagnetic measurements. *Soil Science Society of America Journal*, 1982, **46**(3), 517-520.
13. Walkley, A. and Black, I. A., An examination of the degtjareff method for determining soil organic matter and proposed modification of the chromic and titration method. *Soil Sci.*, 1934, **34**, 29-38.
14. McGill, W. B., Cannon, K. R., Robertson, J. A., and Cook, F. D., Dynamics of soil microbial biomass and water-soluble organic C in Breton L after 50 years of cropping to two rotations. *Canadian journal of soil science*, 1986, **66**(1), 1-19.

15. Page, A. L., Miller, R. H. and Keeney, D. R., Chemical and microbiological properties. In *Methods of soil analysis, Part 2*, (2nd ed.), *Agron. Monogr.*, 9, ASA, SSSA, CSSA, Madison, WI. 1982, 961-1010.
16. Subbiah, B. V. and Asija, G. L., A rapid method for the estimation of nitrogen in soil. *Curr. Sci.*, 1956, **26**, 259-260.
17. Bremner, J. M. and Mulvaney, C. S., Nitrogen-Total. In *Methods of soil analysis, Part 2: Chemical and microbiological properties*, (2nd ed. Page, A. L., Miller, R. H. And Keeney). *Agron. Monogr.* 9. ASA and SSSA, Madison, WI., 1982, 595–624.
18. Keeney, D. R. and Nelson, D. W., Nitrogen-Inorganic forms. In *Methods of soil analysis, Part 2: Chemical and microbiological properties*, (2nd ed. Page, A. L., Miller, R. H. And Keeney). *Agron. Monogr.* 9. ASA and SSSA, Madison, WI., 1982, 643-698
19. Richardson, H. L., The nitrogen cycle in grassland soils: with especial reference to the Rothamsted Park Grass Experiment. *The Journal of Agricultural Science*, 1938, **28**(1), 73-121.
20. Pelican Equipment, Model ROTEK LIS: Laboratory Incubator Shaker Variable RPM. <https://www.pelicanequipments.com/>
21. Preusch, P. L., Adler, P. R., Sikora, L. J. and Tworkoski, T. J., Nitrogen and phosphorus availability in composted and uncomposted poultry litter. *J. Environ.Qual.*, 2002, **31**(6), 2051-2057.
22. Stanford, G., and Smith, S. J., Nitrogen mineralization potentials of soils. *Soil Science Society of America Journal*, 1972, **36**(3), 465-472.
23. Abbasi, M. K., and Khaliq, A., Nitrogen mineralization of a loam soil supplemented with organic–inorganic amendments under laboratory incubation. *Frontiers in Plant Science*, 2016, **7**, 1038.

24. Nair, K. P. P., *Intelligent Soil Management for Sustainable Agriculture: The Nutrient Buffer Power Concept*. Springer Nature Switzerland AG, Gewerbestrasse 11, 6330 Cham, Switzerland, 2019. ISBN 978-3-030-15529-2 ISBN 978-3-030-15530-8 (eBook), <https://doi.org/10.1007/978-3-030-15530-8>
25. Bunnett, J. F., Kinetics in solution. In *Investigations of Rates and Mechanisms of Reactions* (ed. Bernasconi, C. F.), 4th ed., Wiley, New York, 1986, 171-250.
26. Joffre, R. and Agren, G. I., From plant to soil: litter production and decomposition. In: *Terr. Glob. Product.* (eds Roy J., Saugier B, Mooney HA). *Academic Press*, New York, 2001, 83-99.
27. Singh, B. P., Rengel, Z. and Bowden, J. W., Carbon, nitrogen and sulphur cycling following incorporation of canola residue of different sizes into a nutrient poor sandy soil. *Soil. Biol. Biochem.* 2006, **38**, 32–42.
28. Ge, J., Huang, G., Huang, J., Zeng, J. and Han, L., Mechanism and kinetics of organic matter degradation based on particle structure variation during pig manure aerobic composting. *Journal of Hazardous Materials*, 2015, **292**, 19–26.
29. Baharuddin, A. S., Kazunori, N., Abd-Aziz, S., Tabatabaei, M., Rahman, N. A., Hassan, M. A., Wakisaka, M., Sakai, K. and Shirai, Y., Characteristics and microbial succession in co-composting of oil palm empty fruit bunch and partially treated palm oil mill effluent. *Open Biotechnol. J.* 2009, **3**, 92–100.
30. Ravindran, B. and Sekaran, G., Bacterial composting of animal fleshing generated from tannery industries. *Waste Manage*, 2010, **30**, 2622–2630.
31. Gómez, E. F., Luo, X., Li, C., Michel, F. C. and Li, Y., Biodegradability of crude glycerol-based polyurethane foams during composting, anaerobic digestion and soil incubation. *Polym. Degrad. Stab.*, 2014, **102**, 195–203.

32. Boyd, G. E., Myers Jr., L. S. and Adamson, A. W., The Exchange Adsorption of Ions from Aqueous Solutions by Organic Zeolites. III. Performance of Deep Adsorbent Beds under Non-equilibrium Conditions. *J. Am. Chem. Soc.*, 1947, **69** (11), 2849–2859. <https://doi.org/10.1021/ja01203a067>
33. Glaski, F. A. and Dranoff, J. S., Ion Exchange Kinetics: A Comparison of Models. *American Institute of Chemical Engineers Journal*, 1963, **9**(3), 426-431.
34. Smith, T. G. and Dranoff, J. S., Film Diffusion-Controlled Kinetics in Binary Ion Exchange. *Ind. Eng. Chem. Fundamen.* 1964, **3**(3), 195–200. <https://doi.org/10.1021/i160011a003>
35. Sharma, H. D., Jervis, R. E. and McMillen, L. W., Kinetics of ion exchange. Diffusion of trace components. *J. Phys. Chem.*, 1970, **74**, 969-978.
36. Bitou, M. and Okamoto, M., Fabrication of porous 3-D structure from poly (l-lactide)-based nano-composite foams. Effect of foam structure on enzymatic degradation. *Polym. Degrad. Stab.*, 2008, **93**, 1081–1087.
37. Sam, S., Ismail, H. and Ahmad, Z., Soil burial of polyethylene-g-(maleic anhydride) compatibilised LLDPE/soya powder blends. *Polym.-Plast. Technol.*, 2011, **50**, 851–861.
38. Cheng, J., Lin, R., Xia, A., Liu, Y., Zhou, J. and Cen, K., Sequential generation of fermentative hydrogen and methane from swine manure with physicochemical characterization. *Energy Fuel*, 2013, **28**, 563–570.
39. Lashermes, G., Barriuso, E., Le Villio-Poitrenaud, M. and Houot, S., Composting in small laboratory pilots: performance and reproducibility. *Waste Manage.*, 2012, **32**, 271–277.
40. Razali, W. A. W., Baharuddin, A. S., Talib, A. T., Sulaiman, A., Naim, M. N., Hassan, M. A. and Shirai, Y., Degradation of oil palm empty fruit bunches (OPEFB) fibre during composting process using in-vessel composter. *BioResources*, 2012, **7**, 4786–4805.

41. Sanders, W. T. M., Geerink, M., Zeeman, G. and Lettinga, G., Anaerobic hydrolysis kinetics of particulate substrates. *Water Sci. Technol.*, 2000, **41**, 17–24.
42. Liotta, F., d'Antonio, G., Esposito, G., Fabbricino, M., Frunzo, L., van Hullebusch, E. D., Lens, P. N. L. and Pirozzi, F., Effect of moisture on disintegration kinetics during anaerobic digestion of complex organic substrates. *Waste Manage. Res.*, 2014, **32**, 40–48.
43. Frissel, M. J., and van Veen, J. A. (1981). Simulation model for nitrogen immobilization and mineralization. In "Modeling Wastewater Renovation by Land Disposal" (I. K. Iskandar, ed.), pp. 359-381. Wiley, New York.
44. Beek, J., and Frissel, M. J. (1973). Simulation of Nitrogen Behavior in Soil. Centre for Agricultural Publishing and Documentation, Wageningen, The Netherlands.
45. Mehran, M., and Tanji, K. K. (1974). Computer modeling of nitrogen transformations in soils. *J. Environ. Qual.* 3, 391-395.
46. Jastrow, J. D., Boutton, T. W. and Miller, R. M., Carbon dynamics of aggregate-associated organic matter, estimated by C-13 natural abundance. *Soil Science Society of America Journal*, 1996, **60**, 81–807.

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The caption of tables and figures:

Tables

Table 1: Initial physico-chemical properties of soil.

Table 2: Initial Total nitrogen and Organic Carbon content and C: N ratio of different organic sources.

Table 3: The kinetics of nitrogen mineralization of different organic sources.

Figures

Figure 1: Sampling site with the boundary area (2 ha).

Figure 2: Effect of local organic sources on total, available, ammonical, and nitrate nitrogen release (ppm) during the incubation period (days).

Figure 3: Nitrogen mineralization (Nmin) rate of different organic sources during the incubation time.

Figure 4: Change in the rate of nitrogen for different organic sources during the incubation time.

Table 1: Initial physico-chemical properties of soil.

Sl. No.	Soil properties	Values
1	Texture	
	Sand (%)	42.6
	Silt (%)	9.56
	Clay (%)	39.67
2	Soil pH _{1:2.5}	4.73
3	Soil EC _{1:2.5} (d Sm/m)	0.11
4	CEC (milliequivalence/100g)	11.01
5	Soil Organic Carbon (%)	1.31
6	Total Nitrogen (%)	0.15
7	Available Nitrogen (ppm)	213
8	Nitrate Nitrogen (ppm)	17.5
9	Ammonical nitrogen (ppm)	28.0

Note: EC – Electrical conductivity, CEC – Cation Exchange Capacity

Table 2: Initial Total nitrogen and Organic Carbon content and C: N ratio of different organic sources.

Sl. No.	Treatment	Total N (%)	Organic Carbon (%)	C:N
1	T1 (FYM)	0.153	31.2	37.59
2	T2 (Poultry)	1.54	26.1	16.94
3	T3 (Pig Manure)	1.72	26.8	15.58
4	T4 (Vermicompost)	0.76	23.00	30.26

Table 3: The kinetics of nitrogen mineralization of different organic sources.

Parameters	Kinetic equation	Treatments			
		T ₁	T ₂	T ₃	T ₄
N cumulative (ppm)	1st order kinetic	1172.46	1312.5	1354.09	1225.08
	2nd order kinetic	1172.46	1312.5	1354.09	1225.08
N ₀ (ppm)	1st order kinetic	2.11	2.17	2.2	2.14
	2nd order kinetic	0.0068	0.0063	0.0067	0.0059
K (µg/g/day) (Kinetic constant)	1st order kinetic	0.1066	0.1058	0.1059	0.1054
	2nd order kinetic	-0.0007	-0.0006	-0.0006	-0.0007
R ² (Coefficient of determination)	1st order kinetic	0.88	0.9	0.91	0.89
	2nd order kinetic	0.64	0.65	0.66	0.64

Note: N – Nitrogen.

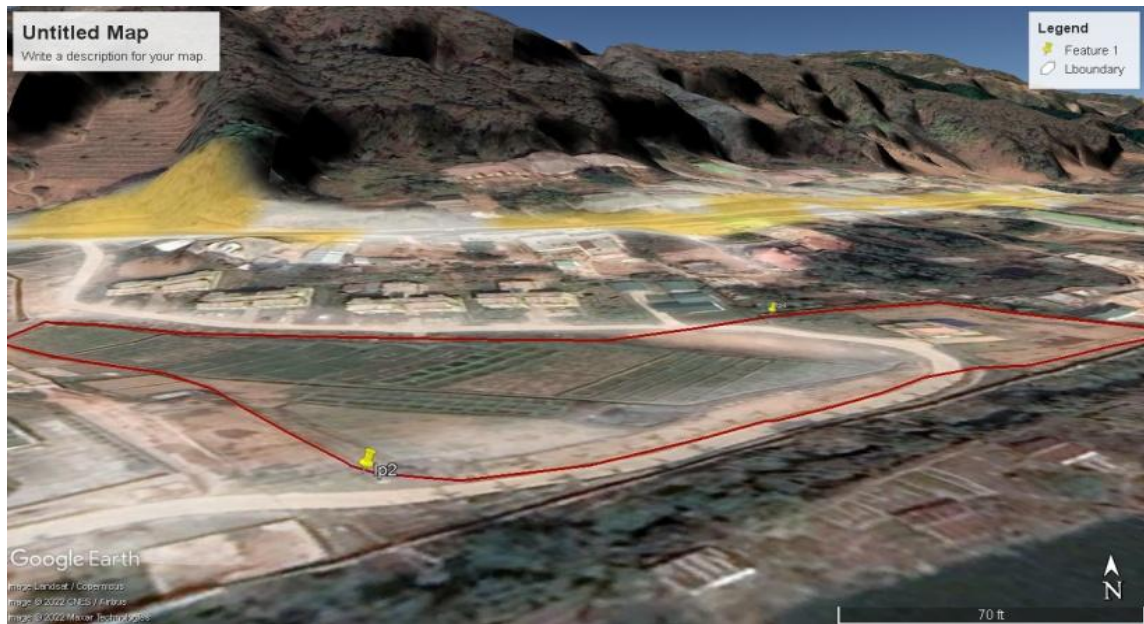


Figure 1: Sampling site with the boundary area (2 ha).

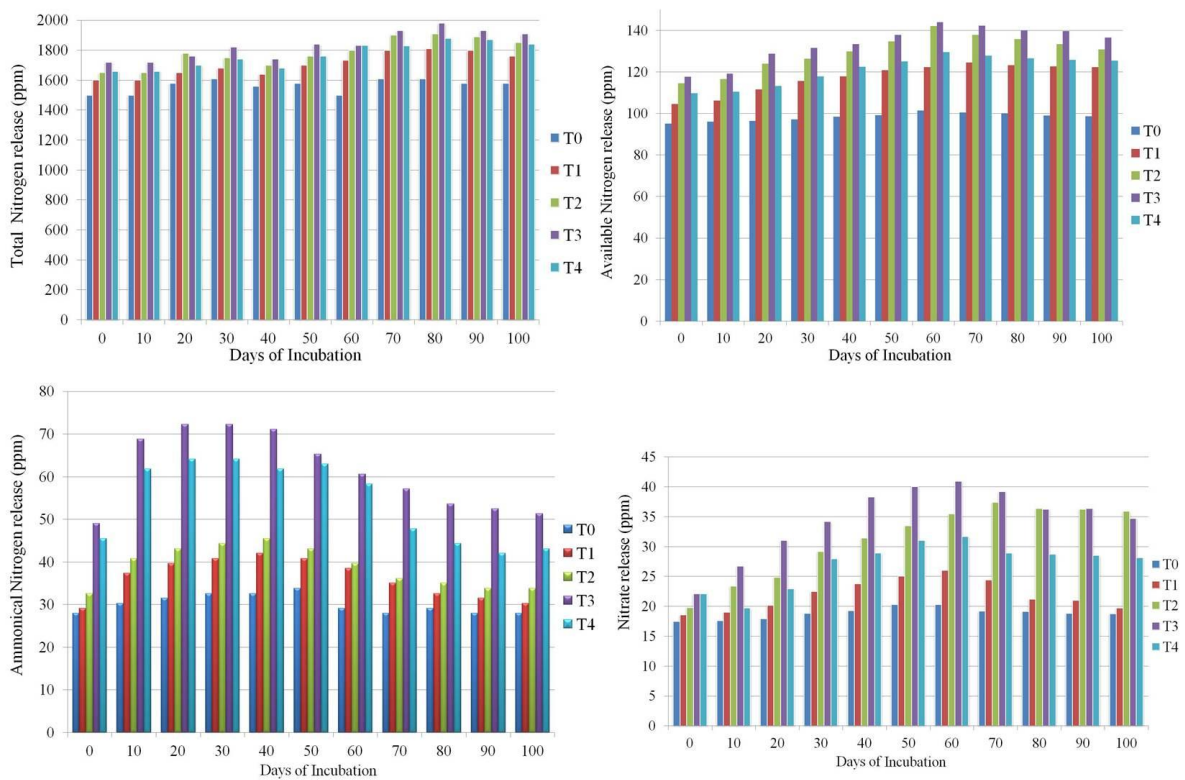


Figure 2: Effect of local organic sources on total, available, ammonical, and nitrate nitrogen release (ppm) during the incubation period (days).

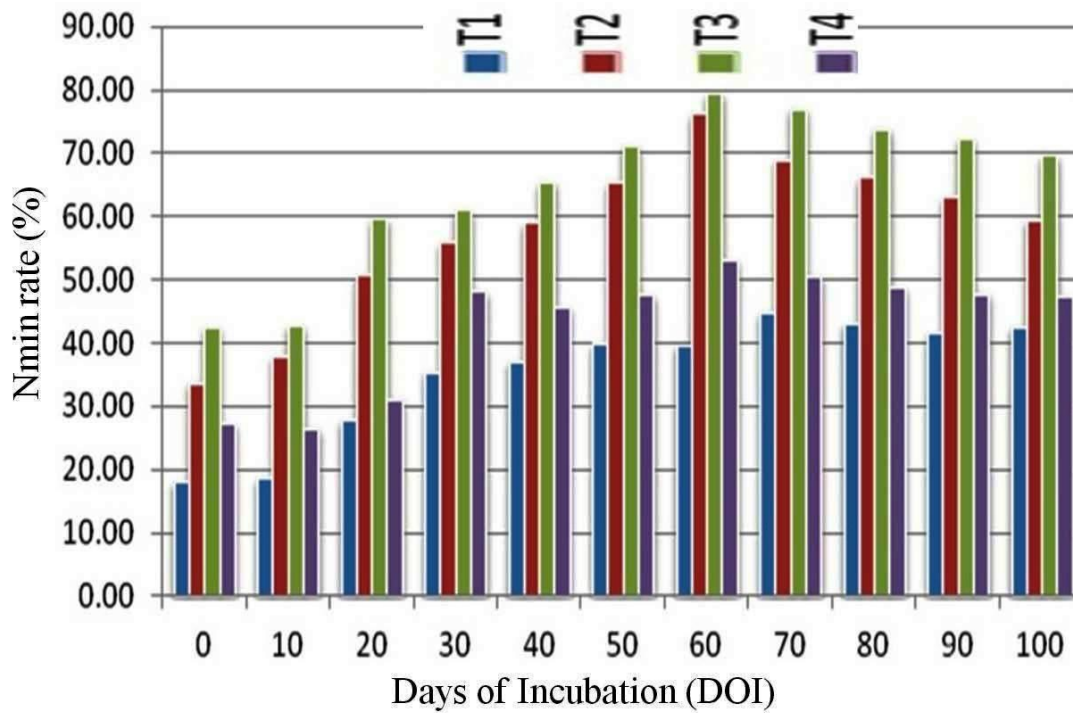


Figure 3: Nitrogen mineralization (Nmin) rate of different organic sources during the incubation time.

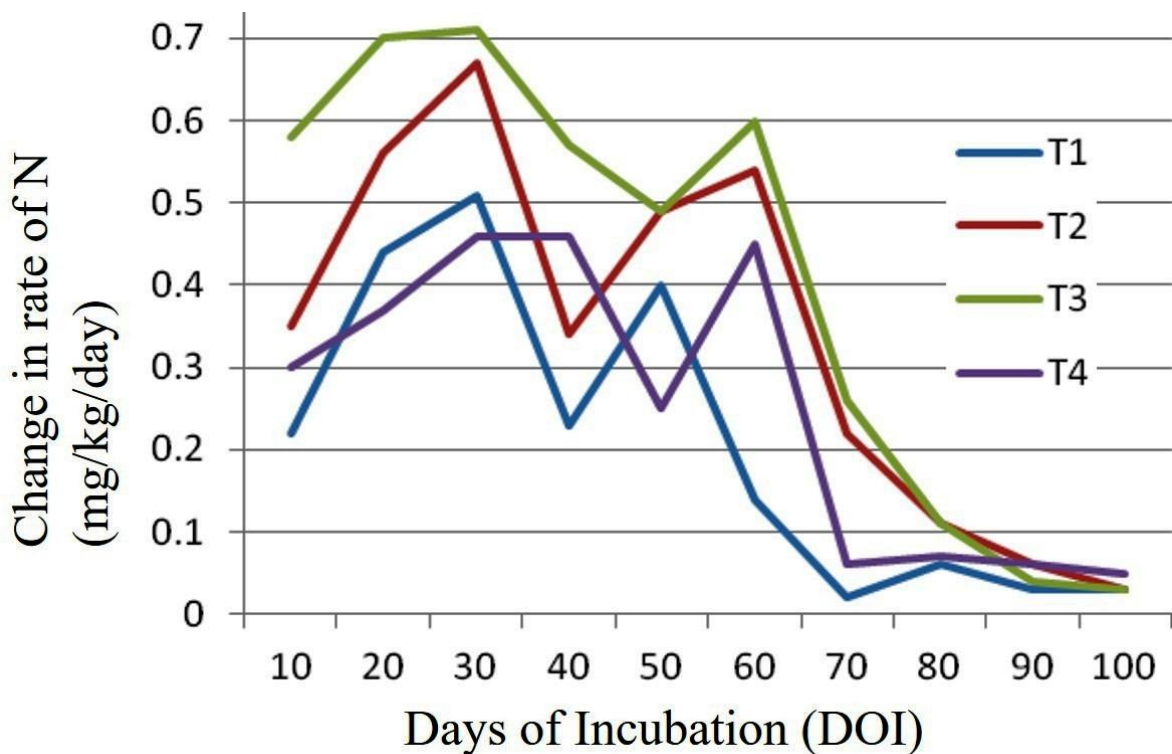


Figure 4: Change in the rate of nitrogen for different organic sources during the incubation time.