*Proc Indian natn Sci Acad* **79** No. 1 March 2013 pp. 21-30


***Research Paper***

# Effects of Composts on Sorption and Dissipation of Tetracyclines in Different Soils of Aligarh District

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(Received 07 February 2012; Revised 13 June 2012; Accepted 25 June 2012)

This study pertains to the investigation of the effects of various composts, farm yield manure (FYM); sewage sludge and poultry manure on the sorption and dissipation of three tetracycline antibiotics *viz*., chlortetracycline (CTC), oxytetracyline (OTC) and tetracycline (TC) on six agricultural fields' soil samples of Aligarh district. The results of the study revealed that the sorption of TCs increased with the increase in their concentration both in compost amended and unamended soils, denoting that TCs sorption is influenced by the soil properties mainly organic carbon and cation exchange capacity (CEC). The TCs were adsorbed most strongly on composts and their sorption was enhanced significantly when composts were present in soils. This enhancement of sorption might be attributed to the increased organic carbon content and CEC. Sorption followed the compost order sewage sludge > FYM > poultry manure. The adsorptive capacity of soils was in the order: Soil No. 1 > 2 > 3 > 4 > 5 > 6, and was significantly positively correlated with soil organic carbon and CEC. The interaction between TCs and compost might occur via multiple bonding mechanisms including ionic bond between negatively charged organic matter and positively charged TCs and/or hydrogen bonds in between TCs and organic matter. The sorption isotherms of compost amended and unamended soils were best fitted in Freundlich adsorption equation and was 'L' type showing that there is minimum competition of solvent for sites on the soil surfaces. The TCs dissipation followed the first order, and time required for 50% dissociation ($DT_{50}$) ranged in between 29.1 to 43.4 d and that time required for 90% dissociation ($DT_{90}$) in between 96.7 to 144.2 d. Soils amended with compost enhanced the stability of TCs and reduced their mobility. The dissipation of TCs in soil environment was slow, indicating that these compounds may persist in soils.

**Key Words: Antibiotics; Compost; $DT_{50}$; Organic Carbon; Soils**

## Introduction

The use of antibiotics as veterinary pharmaceuticals has become the integral part of the animal food industry because of their valuable contributions in treating diseases [1], as growth promoters [2], and in improving feed efficiency [3]. The tetracycline's [Tetracycline (TC), Oxytetracyline (OTC) and chlortetracycline (CTC)] are broad spectrum antibiotics widely used in animal production. Tetracyclines contribute approximately 50% of total antibiotics production. After the application to animals, antibiotics will eventually enter the environment, the major route being the excretion of faeces and urine from medicated animals in live stocks and poultry farms and the subsequent application of contaminated manure as fertilizer in the agricultural land. Thus there is a geniune concern that residual concentration of antibiotics in agricultural soils can easily reach levels equal to that in pesticides if the manure loading for fertilizer increased to kg level per hectare [4].

This widespread contamination of antibiotics in the environment also put human health and sensitive ecosystem at risk, as antibiotics may alter

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the composition and diversity of indigenous soil microbial communities and may also cause the formation of antibiotic-resistant organisms in the environment and possibly threatens human health by diminishing the success of antibiotic treatments.

The use of composts derived from source-separated municipal solid waste/animal manure/FYM is now a common agronomic practice throughout the world. Such amendments improve the physico-chemical properties of the soil. Applications of such composts affect the fate and mobility of antibiotics in soil as the addition of compost increases nutrients besides the soil organic matter content [5].

The purpose of the present studies is to examine the sorption of tetracycline on soils, composts and soil/composts mixture using batch experiments as well as the dissipation of TC, OTC and CTC in soils and soil-compost mixture.

**Material and Methods**

The six soils (1-6) selected for this study were taken from different parts of Aligarh district at plough layer (0-30 cm). All the soils were air dried at room temperature and sieved by passing through a 100 mesh sieve. Their physico-chemical properties were determined by the usual soil laboratory methodology and clay mineralogy by an X-ray diffraction procedure on orientated specimen. Physico-chemical properties, clay mineralogy and classification of soils and different composts are given in Table1.

***Soil Amendment***

Soils (1-6) were amended separately with 0, 2.5 and 5 g of organic manure (FYM, sewage sludge and poultry manure) $kg^{-1}$ soil at 60% moisture level of water holding capacity and incubated for 45d at the temperature 25±2 ºC.

***Adsorption Studies***

Adsorption experiments were conducted by taking soil samples (1 g) (unamended and amended with organic material at 60% moisture level) in a large number of stoppered conical flasks adding various amounts of antibiotic solutions (0-15 mL of 50 μg $mL^{-1}$ in 0.01mol $L^{-1}$ $CaCl_2$) and making up the volume to 100 mL with distilled water. The suspensions were shaken for 30 h at 25±2 ºC (preliminary studies indicated that equilibrium was attained within <27 h) followed by centrifugation.

For the dissipation studies 5 g soil samples (unamended and amended with organic material at 60% moisture level) were taken in a large number of stoppered conical flasks. These flasks were spiked with 100 mg $kg^{-1}$ tetracycline in methanol separately and were aerated by opening the lid of tube and shaking the tubes daily during the incubation period. The flasks were capped and left in an incubator at 25±1 ºC after 0, 1, 7, 14, 21, 28, 35, 42, 49 and 56 days of treatment the samples were taken out and TCs were extracted and analyzed immediately to determine the concentration.

***Extraction and Analysis of Tetracyclines***

The TCs were extracted from the soils and soil-compost mixtures samples by solid phase extraction method [6]. 1 g of soil sample was taken in a centrifuge tube, 15 ml of extraction buffer [0.1 M Mellvaine buffer ($Na_2$ $HPO_4$ and citric acid); 0.1 M EDTA and methanol 25:25:50 v/v] was added to it. The tubes were mixed with a vortex for 30 sec and then placed in an ultrasonic bath for 10 minutes, followed by centrifugation at 1200 g for 15 min. The supernatant was decanted into a glass bottle. The soil residues were extracted two more times and supernatants were combined and diluted to 400 mL with water, the pH of solution was adjusted to 2.8 using phosphoric acid. The three antibiotics were extracted from the solution by solid phase extraction, using an Isolute strong anion exchange catridge to remove interfering humic materials in tandem with a hydrophilic-lithophilic-balanced catridge to extract the compounds. The catridges were preconditioned with methanol and buffer, after washing the extracts were eluted with 2x1 mL of methanol. A flow rate of 10 mL $min^{-1}$ was used for the extractions· The extracts were stored at –20 ºC till the completion of analysis.

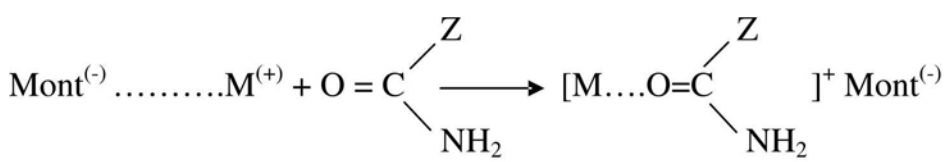
The concentration of TC, OTC and CTC in soil and water extracts were analyzed by HPLC using an Agillent 1100 system with an octadecilsilan column

(50mmx4mmx3um, AQ-YMC), TC, OTC and CTC were analyzed simultaneously. A gradient elution was carried out over 20 min with 0.1% formic acid in acetonitrile (Solvent A) and 0.1% formic acid in water (Solvent B). The initial percent of Solvent A was 5%, which was then increased to 30% from 0 to 7 min and remained at 30% from 7 to 8.5 min. The percentage of Solvent A was returned to 5% from 8.5 to 10 min and remained at 5% from 10 to 12 min. The flow rate was maintained at 0.70 mL $min^{-1}$ throughout the analysis and simultaneous detection of TC, OTC and CTC was performed at 360 nm. Retention times of OTC, CTC and TC were 6.4, 17.3 and 9.6 min. respectively. The minimum limit of detection was 0.5µg $kg^{-1}$ soil.

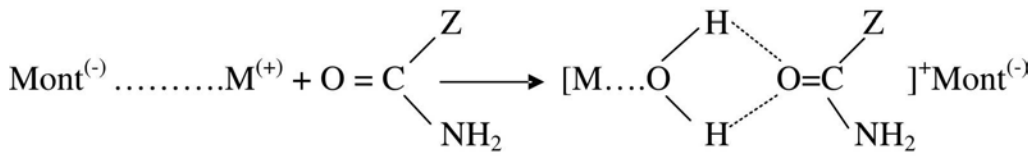
All the chemicals used were of analytical grade and all the experiments were done in three replicates.

**Results and Discussion**

The sorption isotherms (Fig. 1) showed that the quantity of TCs adsorbed on all matrices increased with increasing TC concentration in equilibrium solution. The slope of the isotherm steadily decreases with the rise in solute concentration as vacant sites become less accessible with the progressive covering of the surface. The curvilinear isotherm suggests that the number of available sites for the adsorption become a limiting factor. The sorption isotherms were convex or 'L' type (Fig. 1) [7]. These kinds of isotherm arise because of minimum competition of solvent for sites on the adsorbing surface. The adsorption was in the order CTC > OTC >TC. The adsorption of all the three antibiotics followed the order soil 1 > 2 > 3 > 4 > 5 > 6 supporting the hypothesis that clay content, CEC and organic matter plays an important role in sorption of antibiotics. The sorption isotherms for organic manure amended soils (Fig. 1) were non-linear and similar to those unamended soils. Sorption of TCs increased significantly with the addition of composts in soils as composts increase the organic carbon content and CEC of soils. The amount of sorption was directly correlated with the amount of compost added. The sorption of TCs followed the order composts > amended ++ soil > amended + soil > unamended soil. This increase could be related to the sorption of organic matter to the soil by increasing the sorption sites available for adsorption as organic matter enhanced carboxyl and phenolic groups that may interact with polar groups of TCs. The interaction between TCs and organic manure occur via multiple bonding mechanisms including ionic bond between negatively charged organic matter and positively charged TCs and/or hydrogen bonds in between TCs and organic matter [8]. Earlier sorption studies by the author [9] on pure clay indicated that sorption of TCs on clay surfaces occur via cation bridging, ionic bonding and hydrogen bonding as:




(1)




(2)

$$(M\ (H_2O)_x)^{n+} \rightleftharpoons [M\ (^-OH)\ [H_2O]\ x\text{-}1]^{(n-1)} + H^+ \quad (3)$$

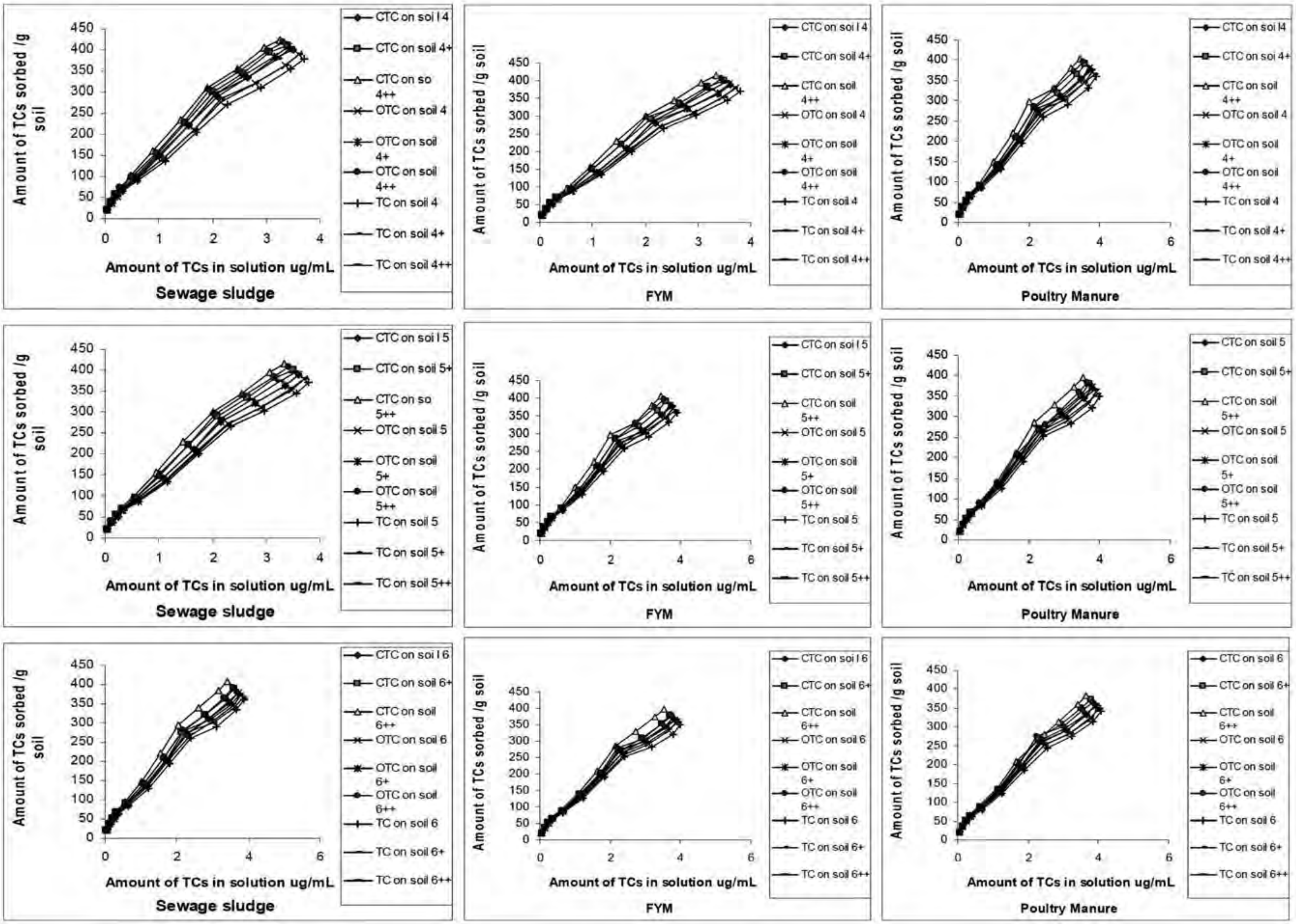
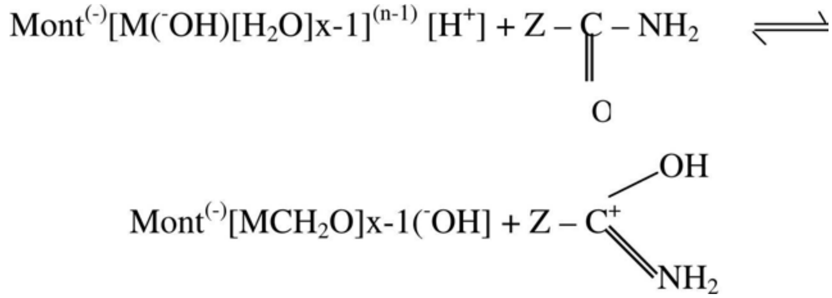
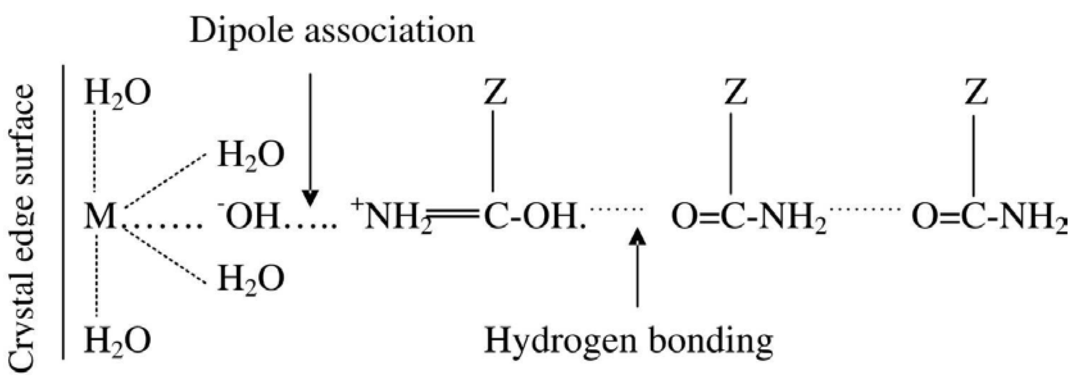



**Fig. 1: Adsorption isotherms for sorption of CTC, OTC and TC on soils (1 and 6) in compost amended and un-amended soils**

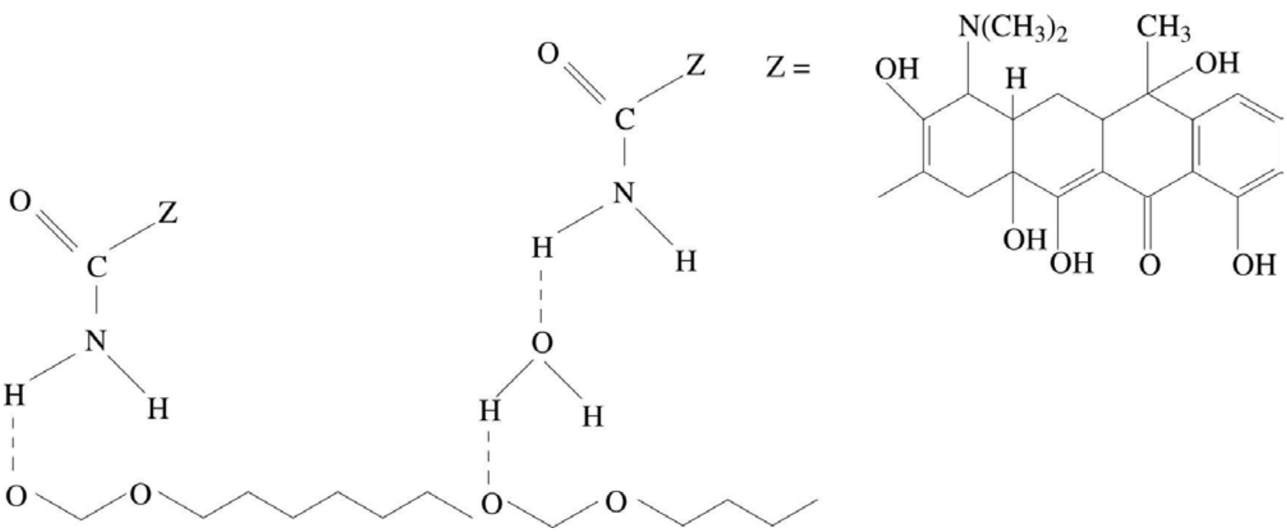
The protons released bind the antibiotic molecule to the clay surface by ionic bonding as:




(4)




(5)




The adsorption equations, Freundlich and Langmuir were used to fit the sorption of TCs in the sorbents. The results showed that Freundlich relationship ($R^2 > 0.88$) can best be used to describe TCs adsorption results on soils and soil/compost of Aligarh district. The linear form of this equation is log C = log K + 1/n log Ce, where, C is the amount (mg $kg^{-1}$) of TCs adsorbed, Ce is the equilibrium concentration in solution (mg $L^{-1}$), K ($mg1^{-1}/nL^{1}/nkg^{-1}$) is the Freundlich adsorption coefficient and 1/n is a describer of isotherm curvature. The values of 1/n (Table 2) were less than unity indicating ‘L’ type of isotherm. The values of K and 1/n (Table 2) followed the order CTC > OTC >TC and were

**Table 1: Characteristics of soils**

| S.No. | Place | Taxonomical name | Soil units | Silt % | Clay % | pH (1:2:5) | Organic C % | $CaCO_3$ % | CEC (Cmol $(P^+)$ $kg^{-1}$) | Surface area $m^2g^{-1}$ | Major clay minerals |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Hathras | Entisol | Typic Ustochrept | 38.8 | 16.2 | 7.8 | 0.88 | 6.3 | 12.8 | 38.6 | Q,I,C |
| 2. | Sikandra Rao | Acidisol | Typic Arigids | 52.0 | 14.0 | 8.8 | 0.72 | 7.6 | 11.6 | 36.2 | Q,I,C |
| 3. | Datawali | Aridisol | Typic Orthids | 37.5 | 12.0 | 7.4 | 0.63 | 5.8 | 10. 8 | 30.1 | Q,M,I,C |
| 4. | Khair | Aridisol | Typic Orthids | 44.9 | 13.6 | 7.6 | 0.56 | 6.6 | 10.3 | 27.2 | Q,I,C |
| 5. | Atrauli | Alfisol | Calciorthents | 24.9 | 9.8 | 8.3 | 0.44 | 8.8 | 9.9 | 32.1 | Q,I,K,C |
| 6. | Bank of Yamuna Tappal | Inceptisol | Calciorthents | 27.1 | 8.5 | 8.1 | 0.48 | 9.0 | 8.6 | 25.6 | Q,I,K,C |
| | Sewage Sludge | | | | | 7.6 | 26.6 | | 46 | | |
| | FYM | | | | | 7.9 | 23.3 | | 42 | | |
| | Poultry Manure | | | | | 6.9 | 20.2 | | 38 | | |

Q = Quartz, I – Illite, M = Montmorillonite, C = Calcite, K = Kaolinite

maximum for composts followed by amended ++ soil > amended + soil > unamended soil. The data of Table 2 also denote that sorption of TCs on different soils were in the order: Soil 1 > 2 > 3 > 4 > 5 > 6, supporting the inferences regarding sorption of TCs on soils. The adsorption of TCs in presence of different composts followed the order sewage sludge > FYM > poultry manure which may be significantly correlated with organic carbon content and CEC of compost.

The values of Kd (distribution coefficient) [Kd = (X/m) /Ce] were 242.5-48.4; 210-35.3 and 181.7-26.7 for sewage sluge, FYM and poultry manure amended soils respectively, supporting the above inferences. The values of Kd increases with the amendment of organic manure (28-8.2 to 42.5-13 on amending 0-5 g sewage sludge $kg^{-1}$ soil). The values were minimum in unamended soil No. 6 and maximum in sewage sludge amended soil 1. These results confirm the role of organic matter as the primary adsorbing component for the studied TCs. Similar results are also reported by other workers [10-11].

Preliminary studies denoted that the dissipation of TCs on studied samples followed the first order kinetics, as all the generated regression lines have a coefficient of determination ($R^2$) more than 0.92.

The Equation (1) describes the dissipation kinetics and Equation (2) is used to calculate dissipation half lives.

$$C_t = Co \times e^{-(kt)} \quad (1)$$

$$DT_{50} = 0.693/k \quad (2)$$

$$DT_{90} = 2.303/k \quad (3)$$

where, Co and $C_t$ are the concentration of analytes at time 0 and time t (days) and k is the first order rate constant determined as the slope value from test substance dissipation curves.

The time taken for dissipation of 50% ($DT_{50}$) of the CTC in all the treatments were 31.2 to 43.4 d and the time taken for 90% dissipation ($DT_{90}$) were 103.7 to 144.2 d (Table 3) which were longer than OTC (30.5-42.1 and 101.3-139.9 d respectively), which were longer than TC (30-41.2 and 99.7-136.9 d respectively), denoting that CTC was more stable in the soils and soil compost mixture followed by OTC and TC. An examination of data of Table 3 showed that the rate of degradation followed the soil order $S_6 > S_5 > S_4 > S_3 > S_2 > S_1$ indicating thereby a role of soil organic matter, CEC and clay content [11-12]. The rate of degradation was inverse of the order of sorption. The $DT_{50}$ or $DT_{90}$ increased with

**Table 2: Freundlich adsorption constants for sorption of tetracyclines on different soils of Aligarh district in unamended and compost amended soils**

| Soilc compost | Sewage Sludge | | | | | | FYM | | | | | | Poultry Manure | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTC | | OTC | | TC | | CTC | | OTC | | TC | | CTC | | OTC | | TC | |
| | k | 1/n | k | 1/n | k | 1/n | k | 1/n | k | 1/n | k | 1/n | k | 1/n | k | 1/n | k | 1/n |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| | 1534±16 | 0.925±0.005 | 1366±16 | 0.910±0.006 | 1267±12 | 0.895±0.006 | 1332±19 | 0.910±0.006 | 1244±12 | 0.895±0.006 | 1104±12 | 0.885±0.005 | 1267±12 | 0.885±0.005 | 1174±12 | 0.875±0.005 | 1117±15 | 0.865±0.004 |
| 1 | 1024±12 | 0.885±0.004 | 936±10 | 0.875±0.006 | 886±9 | 0.865±0.004 | 944±10 | 0.875±0.006 | 900±10 | 0.870±0.004 | 854±12 | 0.860±0.005 | 912±9 | 0.870±0.004 | 866±12 | 0.860±0.005 | 824±5 | 0.850±0.005 |
| 1+* | 1136±14 | 0.895±0.005 | 972±10 | 0.880±0.005 | 922±10 | 0.870±0.005 | 984±10 | 0.885±0.005 | 934±10 | 0.875±0.005 | 884±8 | 0.865±0.004 | 932±10 | 0.875±0.005 | 888±8 | 0.855±0.004 | 845±8 | 0.855±0.004 |
| 1++* | 1188±16 | 0.900±0.005 | 1014±12 | 0.885±0.006 | 972±12 | 0.875±0.005 | 1034±12 | 0.890±0.006 | 986±12 | 0.875±0.005 | 926±9 | 0.870±0.005 | 978±12 | 0.875±0.005 | 922±9 | 0.860±0.005 | 876±9 | 0.860±0.005 |
| 2 | 924±10 | 0.880±0.003 | 808±8 | 0.870±0.005 | 745±8 | 0.860±0.005 | 814±8 | 0.870±0.005 | 762±8 | 0.865±0.005 | 704±8 | 0.855±0.003 | 748±8 | 0.865±0.005 | 720±8 | 0.855±0.003 | 692±8 | 0.850±0.003 |
| 2+ | 965±11 | 0.885±0.004 | 842±9 | 0.875±0.005 | 808±8 | 0.865±0.004 | 856±9 | 0.875±0.005 | 824±8 | 0.870±0.004 | 756±8 | 0.855±0.003 | 822±8 | 0.870±0.004 | 776±8 | 0.860±0.003 | 738±8 | 0.855±0.003 |
| 2++ | 1014±12 | 0.890±0.003 | 872±10 | 0.875±0.005 | 842±9 | 0.865±0.005 | 888±8 | 0.880±0.005 | 854±9 | 0.865±0.005 | 801±8 | 0.860±0.002 | 851±9 | 0.865±0.005 | 808±8 | 0.860±0.002 | 777±8 | 0.860±0.002 |
| 3 | 854±9 | 0.865±0.003 | 784±7 | 0.850±0.004 | 734±7 | 0.845±0.003 | 800±8 | 0.855±0.004 | 752±7 | 0.845±0.003 | 688±9 | 0.840±0.003 | 754±7 | 0.845±0.003 | 705±9 | 0.840±0.003 | 668±9 | 0.830±0.003 |
| 3+ | 889±10 | 0.875±0.005 | 827±8 | 0.860±0.005 | 777±8 | 0.850±0.003 | 841±8 | 0.865±0.005 | 792±8 | 0.850±0.003 | 734±7 | 0.845±0.002 | 798±8 | 0.850±0.003 | 754±7 | 0.845±0.002 | 706±7 | 0.835±0.002 |

Table 2 contd.

Contn. of Table 2

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3++ 10 | 937± 0.003 | 0.880± 9 | 868± 0.003 | 0.870± 9 | 826± 0.002 | 0.860± 9 | 880± 0.003 | 0.870± 9 | 842± 0.002 | 0.860± 7 | 780± 0.002 | 0.850± 9 | 836± 0.002 | 0.860± 7 | 784± 0.002 | 0.850± | 748±7 0.002 | 0.840± |
| 4 8 | 788± 0.004 | 0.850± 6 | 738± 0.003 | 0.840± 6 | 678± 0.003 | 0.835± 7 | 744± 0.003 | 0.845± 6 | 702± 0.003 | 0.835± 7 | 642± 0.003 | 0.825± 6 | 714± 0.003 | 0.835± 7 | 662± 0.003 | 0.830± | 642±7 0.003 | 0.825± |
| 4+ 10 | 832± 0.003 | 0.860± 7 | 772± 0.002 | 0.845± 7 | 732± 0.002 | 0.835± 7 | 780± 0.002 | 0.850± 7 | 746± 0.002 | 0.840± 6 | 697± 0.002 | 0.830± 7 | 748± 0.002 | 0.840± 7 | 703± 0.002 | 0.835± | 682±7 0.002 | 0.830± |
| 4++ 9 | 856± 0.004 | 0.865± 7 | 812± 0.003 | 0.850± 7 | 764± 0.002 | 0.840± 7 | 821± 0.003 | 0.855± 7 | 788± 0.002 | 0.845± 6 | 729± 0.004 | 0.835± 7 | 774± 0.002 | 0.845± 6 | 744± 0.004 | 0.835± | 714±6 0.004 | 0.835± |
| 5 8 | 734± 0.002 | 0.835± 6 | 672± 0.002 | 0.830± 6 | 632± 0.003 | 0.825± 6 | 677± 0.002 | 0.830± 6 | 644± 0.003 | 0.825± 6 | 596± 0.003 | 0.820± 6 | 640± 0.003 | 0.825± 6 | 602± 0.003 | 0.820± | 584±6 0.003 | 0.810± |
| 5+ 8 | 777± 0.003 | 0.845± 5 | 712± 0.002 | 0.835± 5 | 666± 0.002 | 0.825± 6 | 719± 0.002 | 0.840± 5 | 686± 0.002 | 0.830± 5 | 632± 0.005 | 0.820± 5 | 688± 0.002 | 0.830± 5 | 652± 0.005 | 0.820± | 618±5 0.005 | 0.815± |
| 5++ 6 | 822± 0.004 | 0.850± 6 | 762± 0.003 | 0.840± 6 | 724± 0.004 | 0.830± 6 | 771± 0.003 | 0.845± 6 | 736± 0.004 | 0.835± 5 | 672± 0.005 | 0.825± 6 | 738± 0.004 | 0.835± 5 | 678± 0.005 | 0.825± | 634±5 0.005 | 0.820± |
| 6 6 | 666± 0.003 | 0.830± 5 | 615± 0.002 | 0.825± 5 | 585± 0.003 | 0.820± 5 | 622± 0.002 | 0.825± 5 | 602± 0.003 | 0.820± 7 | 556± 0.004 | 0.815± 5 | 585± 0.003 | 0.820± 7 | 544± 0.004 | 0.815± | 518±7 0.004 | 0.810± |
| 6+ 8 | 698± 0.003 | 0.835± 5 | 646± 0.004 | 0.825± 5 | 624± 0.005 | 0.820± 5 | 650± 0.004 | 0.830± 5 | 632± 0.005 | 0.825± 8 | 578± 0.005 | 0.815± 5 | 624± 0.005 | 0.825± 8 | 578± 0.005 | 0.815± | 542±8 0.005 | 0.815± |
| 6++ 7 | 726± 0.003 | 0.840± 7 | 686± 0.003 | 0.830± 7 | 654± 0.005 | 0.825± 7 | 693± 0.003 | 0.835± 7 | 666± 0.005 | 0.830± 9 | 606± 0.003 | 0.820± 7 | 659± 0.005 | 0.830± 9 | 626± 0.003 | 0.820± | 602±9 0.003 | 0.820± |

* + 2.5 g compost, ++ 5 g compost $kg^{-1}$ soil.

**Table 3: Time for dissipation of 50% and 90% ( $DT_{50}$ and $DT_{90}$ respectively) of chlortetracycline (CTC), oxytetracycline (OTC) and tetracycline (TC) in different soils and soil/compost mixtures (+ 2.5 g manure, ++ 5 g manure $kg^{-1}$ soil)**

| Soil | Sewage Sludge | | | | | | FYM | | | | | | Poultry Manure | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CTC | | OTC | | TC | | CTC | | OTC | | TC | | CTC | | OTC | | TC | |
| | $DT_{50}$ | $DT_{90}$ | $DT_{50}$ | $DT_{90}$ | $DT_{50}$ | $DT_{90}$ | $DT_{50}$ | $DT_{90}$ | $DT_{50}$ | $DT_{90}$ | $DT_{50}$ | $DT_{90}$ | $DT_{50}$ | $DT_{90}$ | $DT_{50}$ | $DT_{90}$ | $DT_{50}$ | $DT_{90}$ |
| 1 | 38.5 | 127.9 | 37.7 | 125.3 | 37 | 122.9 | 37.8 | 125.6 | 37 | 122.9 | 36.4 | 120.9 | 37.1 | 123.3 | 36.5 | 121.3 | 36 | 119.6 |
| 1+ | 41.5 | 137.9 | 40.2 | 133.5 | 39.4 | 130.9 | 40.3 | 133.9 | 39.4 | 130.9 | 38.7 | 128.6 | 39.4 | 130.9 | 38.7 | 128.6 | 38.1 | 126.6 |
| 1++ | 43.4 | 144.2 | 42.1 | 139.9 | 41.2 | 136.9 | 42 | 139.5 | 41.2 | 136.9 | 40.4 | 134.2 | 41.3 | 137.2 | 40.4 | 134.2 | 39.7 | 131.9 |
| 2 | 37.1 | 123.3 | 36.3 | 120.6 | 35.7 | 118.6 | 36.4 | 120.9 | 35.5 | 117.9 | 35.2 | 116.9 | 35.6 | 118.3 | 35 | 116.3 | 34.8 | 115.6 |
| 2+ | 40 | 132.9 | 39 | 129.6 | 38.2 | 126.9 | 38.7 | 128.6 | 38.1 | 126.6 | 37.6 | 124.9 | 37.9 | 125.9 | 37.4 | 124.3 | 37 | 122.9 |
| 2++ | 41.5 | 137.9 | 40.2 | 133.5 | 39.3 | 130.6 | 40 | 132.9 | 39.3 | 130.6 | 38.5 | 127.9 | 39 | 129.6 | 38.5 | 127.9 | 37.8 | 125.6 |
| 3 | 35.7 | 118.6 | 35 | 116.3 | 34.4 | 114.3 | 35 | 116.3 | 34.2 | 113.6 | 33.9 | 112.6 | 34.2 | 113.6 | 33.6 | 111.6 | 33.4 | 111 |
| 3+ | 37.6 | 124.9 | 36.8 | 122.3 | 36.1 | 119.9 | 36.3 | 120.6 | 36 | 119.6 | 35.4 | 117.6 | 34.5 | 114.6 | 35.2 | 116.9 | 34.9 | 115.9 |
| 3++ | 39.1 | 129.9 | 38 | 126.2 | 37.3 | 123.9 | 37.5 | 124.6 | 37.1 | 123.3 | 36.5 | 121.3 | 36.8 | 122.3 | 36.2 | 120.3 | 36 | 119.6 |
| 4 | 33.1 | 110 | 32.3 | 107.3 | 31.8 | 105.6 | 32 | 106.3 | 31.6 | 105 | 31.3 | 104 | 31.3 | 104 | 31 | 103 | 30.8 | 102.3 |
| 4+ | 35.4 | 117.6 | 34.5 | 114.6 | 33.7 | 112 | 34 | 113 | 33.7 | 112 | 33.1 | 110 | 33.2 | 110.3 | 33 | 109.6 | 32.5 | 108 |
| 4++ | 37.8 | 125.6 | 36.8 | 122.3 | 36 | 119.6 | 36.3 | 120.6 | 36 | 119.6 | 35.3 | 117.3 | 35.4 | 117.6 | 35 | 116.3 | 34.6 | 115 |
| 5 | 32.0 | 10633 | 31.4 | 104.3 | 31 | 103 | 31 | 103 | 30.7 | 102 | 30.4 | 101 | 30.2 | 100.3 | 30.1 | 100 | 30 | 99.7 |
| 5+ | 33.8 | 112.3 | 33 | 109.6 | 32.4 | 107.6 | 32.4 | 107.6 | 32.3 | 107.3 | 31.7 | 105.3 | 31.5 | 104.7 | 31.4 | 104.3 | 31.1 | 103.3 |
| 5++ | 35.4 | 117.6 | 34.5 | 114.6 | 33.8 | 112.3 | 34 | 113 | 33.6 | 111.6 | 33 | 109.6 | 33 | 109.6 | 33 | 109.6 | 32.4 | 107.6 |
| 6 | 31.2 | 103.7 | 30.5 | 101.3 | 30 | 99.7 | 30.3 | 100.7 | 30.1 | 100 | 29.5 | 98 | 29.6 | 98.3 | 29.4 | 97.7 | 29.1 | 96.7 |
| 6+ | 32.6 | 108.3 | 32 | 106.3 | 31.4 | 104.3 | 31.7 | 105.3 | 31.3 | 104 | 30.8 | 102.3 | 31 | 103 | 30.5 | 101.3 | 30.2 | 100.3 |
| 6++ | 33.2 | 110.3 | 32.5 | 108 | 32 | 106.3 | 32.5 | 108 | 31.8 | 105.6 | 31.3 | 104 | 31.7 | 105.3 | 31 | 103 | 30.6 | 101.7 |

increase in amount of compost. The dissipation in different compost amended soils was in the order sewage sludge < FYM < poultry manure which might be significantly correlated with soil organic carbon and CEC which in turn enhances the sorption of TCs [12]. The difference in dissipation times of different antibiotics on same substrates may be attributed to their characteristics and the nature of substrate.

## Conclusions

The batch sorption studies of this work demonstrate that the sorption behaviour of TCs in soils is caused by interactions of soils and antibiotics which is related to soil and antibiotic properties. The results of this study also showed that soil amended with compost enhances the sorption of TCs, reduce their mobility and decrease the environmental risk. The dissipation of TCs in the soil environment was slow denoting that these compounds persist in soils for a longer period.

## Acknowledgement

The author expresses his sincere thanks to the University Grants Commission, New Delhi for financial assistance.

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