

**MOBILITY AND LEACHING OF NITROGEN FORMS  
THROUGH SANDY AND CALCAREOUS SOILS  
AS AFFECTED BY THE APPLICATION  
OF SOME SOIL AMENDMENTS**

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**ABSTRACT:** A laboratory experiment was conducted to study the effect of some soil amendments i.e. biogas manure (BM), chicken manure (CM), taffla material (T), sulfur (S) and two water capture fertilizers (acidic and neutral WCF) on nitrogen behaviour through intermittent leaching using sandy and calcareous soils. The soil amendments were used individually and in different combinations.

The obtained results can be summarized as follows:

1. Application of CM, BM, T and WCF increased the available nitrogen forms ( $\text{NH}_4^+$  and  $\text{NO}_3^-$ ) due to their effect on CEC and pH of the media.
2. The highest values of leached ( $\text{NH}_4^+ + \text{NO}_3^-$ )-N were found under the application of CM+T+acidic WCF in the first leachate of calcareous soil, but in the sandy soil the highest values were observed under the application of CM+T+S and acidic WCF in the 5<sup>th</sup> soil leachate
3. Application of chicken manure individual or combined with other soil amendments increased the values of residual ( $\text{NH}_4^+ + \text{NO}_3^-$ )-N in the soil compared to the biogas manure treatments.
4. The greatest value residual available ( $\text{NH}_4^+ + \text{NO}_3^-$ )-N was recorded at the third layer (20-30 cm) of soil columns of both sandy and calcareous soils, while the lowest value was recorded at the first layer (0-10 cm).

5. Nitrification rate was clearly affected by the different soil amendments and their combinations, The greatest value of nitrification rate was observed under the addition of BM+T+S+acidic WCF in the second layer (10-20cm) of sandy soil, while in the calcareous soil, the highest value was observed under the addition of CM+T+S in the same layer.
6. The highest mean value of nitrate : ammonium ratio for different treatments were 0.67 using biogas manure and 0.24 with chicken manure in the sandy soil, but in the calcareous soil, the greatest one were 0.48 using BM and 0.36 with CM.
7. The highest accumulated leached  $(\text{NH}_4^+ + \text{NO}_3^-)$ -N were observed under treatment of CM+T+S+neutral WCF in both sandy and calcareous soils.

**Key words:** Soil amendments, leaching of nitrogen forms, sandy and calcareous soils, Nitrification rate.

## INTRODUCTION

Recently reclaimed sandy and calcareous soils are generally poor in organic materials, colloids and nutrients content. Therefore, cultivation of these soils became necessary to overcome the fast growing population. In these soils, added nutrients are subjected to loss via leaching or volatilization. One of the possibilities to increase the efficiency of added fertilizers is using soil amendments.

Reduction of nutrient loss via leaching and run off; reduction of chemical and biological immobilization reactions in soils which cause plant unavailable form of nitrogen, reduction of

rapid nitrification and nitrogen loss through ammonia volatilization and denitrification, Fox *et al.* (1996). Belkacem and Nys (1997) investigated the effects of liming and gypsum addition on the chemical characteristics of soil and leachates through soil column and  $\text{NH}_4\text{-N}$  at monthly intervals through out the 20-months period. Nitrogen was leached mostly as  $\text{NO}_3^- \text{N}$  in the lime treatments and in the control, whereas nitrification was inhibited in gypsum treatment and nitrogen was predominately  $\text{NH}_4\text{-N}$  form. Awad (1990) reported that urea fertilizer combined with soil conditioner (veterra hydrogel) gave the greatest value of nitrogen

efficiency ratio. Dahdouh *et al.* (2004) found that the addition of nitrification inhibitor slightly affected the transformation of ammonium to nitrate due to the adsorption of the inhibitor on adsorptive sites of organic manure. Farid *et al.* (2006) concluded that organic waste materials can be used as sources of nutritive nutrients. On the other hand, they stated heavy application of organic wastes lead to accumulation of heavy metals in dangerous level. High pH value and  $\text{CaCO}_3$  content of the calcareous soils may be considered as an advantage prevents toxic hazard of such heavy elements.

The present study aimed to investigate the effect of soil amendments on mobility and leaching of N through intermittent leaching in sandy and calcareous soils.

## MATERIALS AND METHODS

Soil columns experiment was conducted using loamy sand and clay loam calcareous soils to study the effect of some soil amendments on the distribution of  $\text{NH}_4\text{-N}$  and  $\text{NO}_3\text{-N}$  ions in soil and leachates. Nine hundred grams of air dried soil samples were placed

in plastic columns of 50 cm in height and 12 cm in diameter. The soil in each column was packed to 30 cm by tapping. At the end of the experiment, the soil columns were divided into three sections i.e. (0-10), (10-20) and (20-30 cm).

The following soil amendments treatments were applied to different soil columns. (1) Control (2) Biogas manure (BM). (3) Biogas manure + Taffla (BM+T). (4) Biogas manure + Taffla + acidic water capture fertilizer (BM+T+ acidic WCF). (5) Biogas manure + Taffla + neutral water capture fertilizer (BM+T+ neutral WCF). (6) Biogas manure + Taffla + sulphur (BM+M+S). (7) Biogas manure + Taffla + sulphur + acidic water capture fertilizer (BM+T+S+ acidic WCF). (8) Biogas manure + Taffla material + sulphur + neutral water capture fertilizer (BM+T+S+ neutral WCF). (9) Chicken manure (CM). (10) Chicken manure + Taffla (CM+T). (11) Chicken manure + Taffla + acidic water capture fertilizer (CM+T+ acidic WCF). (12) Chicken manure + Taffla + neutral water capture fertilizer (CM+T+ neutral WCF). (13) Chicken manure + Taffla + sulphur (CM+T+S). (14) Chicken manure + Taffla + sulphur + acidic water capture fertilizer (CM+T+S+

acidicWCF). (15) Chicken manure + Taffla + sulphur+ neutral water capture fertilizer (CM+T+S+ neutral WCF).

Physical and chemical analyses of investigated soils, Taffla material, water capture fertilizer and organic materials are presented in Tables (1, 2, 3and 4).

**Table 1. Some physical and chemical properties of the investigated soils**

Characteristic	Sandy soil	calcareous soil
<b>Soil particles distribution</b>		
Sand ,%	81.91	36.17
Silt,%	12.06	29.79
Clay,%	6.03	34.04
Textural class	loamy sand	clay loam
Field capacity (FC),%	11.85	26.25
CaCO <sub>3</sub> ,%	0.48	35.5
Organic matter,%	0.48	0.64
pH*	8.01	7.74
EC dS/m**	0.34	0.88
<b>Soluble cations and anions,** (mmole/L)</b>		
Ca <sup>++</sup>	1.3	3.2
Mg <sup>++</sup>	0.6	1.9
Na <sup>+</sup>	1.25	3.0
K <sup>+</sup>	0.30	1.35
CO <sub>3</sub> <sup>-</sup>	-	-
HCO <sub>3</sub> <sup>-</sup>	1.12	1.28
Cl <sup>-</sup>	0.99	3.78
SO <sub>4</sub> <sup>-</sup>	1.34	4.39
Total N,%	0.36	0.34
Total P,%	0.16	0.24
Total K,%	0.08	0.10

\* Soil-water suspension 1: 2.5

\*\* Soil water extract 1:5

Table 2. Some Physical and chemical properties of the taffla material

Characteristic	Value
<b>Taffla particles distribution</b>	
Sand, %	44.60
Silt, %	4.26
Clay, %	51.14
Textural class	clay
Field capacity (FC), %	33.04
CaCO <sub>3</sub> , %	4.88
Organic matter, %	0.48
pH*	7.25
EC, dS/m**	1.88
<b>Soluble cations and anions**, (mmole/L)</b>	
Ca <sup>++</sup>	3.5
Mg <sup>++</sup>	3.2
Na <sup>+</sup>	9.43
K <sup>+</sup>	0.39
CO <sub>3</sub> <sup>-</sup>	-
HCO <sub>3</sub> <sup>-</sup>	1.6
Cl <sup>-</sup>	8.19
SO <sub>4</sub> <sup>--</sup>	6.73
Total N, %	0.37
Total P, %	0.21
Total K, %	0.15

\* Soil-water suspension 1: 2.5

\*\* Soil water extract 1: 5

**Table 3. Some chemical composition of the water capture fertilizer (WCF) used**

Nutrient	Value%
N	13.0
P	5.0
K	11.0
Zn	0.13
Fe	0.085
Mn	0.07
Mg	0.06
Cu	0.15
Mo	0.015

**Table 4. Some chemical composition of biogas and chicken manure used**

Characteristic	Chicken manure	Biogas manure
EC**, dS/m	4.8	3.1
pH*	7.58	7.84
organic matter,(%)	23.49	40.30
Total N,(%)	3.15	2.48
Total P,(%)	5.53	1.82
Total K,(%)	0.39	0.2
C/N ratio	4.32	9.42

\*Soil-water suspension 1: 2.5

\*\*Soil water extract 1: 5

Biogas, chicken manures as well as taffla material were added to the soils at the rate of 20 tons /fed. The treatments of acidic and neutral water capture fertilizers were added to the same soils at the rate of 40 kg /fed. The elemental sulphur was applied at a rate of 500 kgs/fed. Different soil amendements were firstly mixed with the soil of each column, Then moisture content of all columns was maintained to reach water holding capacity. Ammonium nitrate fertilizer was added at the rate of 200 ppmN.

Treated soils were subjected to eight times intermittent leaching by tap water every seven days. Leaching was observed by adding sufficient amounts of water (108 ml and 234 ml for sandy and calcareous soil, respectively) to displace the soil solution at field capacity.

The leachates were collected at the beginning of the experiment (zero time) then each seven days until the end of the experiment and directly analysed for  $\text{NH}_4\text{-N}$  and  $\text{NO}_3\text{-N}$  after carrying out each of the different leaching treatment. The soil columns were divided into three sections according to depth (0 – 10, 10 – 20 and 20 – 30 cm). The soil samples of the three

sections were directly analyzed for  $\text{NH}_4^+\text{-N}$  and  $\text{NO}_3^-\text{-N}$ , once at the end of experiment.

### Methods of Analysis

The particles size distribution of the soil samples was measured using the international pipette methods as described by Piper (1950).

- The electrical conductivity (EC) of soil water extract was determined by using the bridge, Jackson (1958).
- Calcium carbonate content of the soil was determined volumetrically using collions calcimeter described by Piper (1950).
- Soil pH was measured using glass electrode pH meter in a 1:2.5 soil water suspension (Cottenie, 1982).
- Soluble cations and anions were determined in (1: 5) soil water extract (Black, 1965).
- Sodium and potassium were determined by using flame photometer as described by Cottenie (1982).
- Organic matter was determined following walkelly and Black method, as described by Jackson (1958).

- Calcium and magnesium were determined following the versenate method (Jackson, 1958).
- Total nitrogen in soil was determined using the microkjeldahl method according to Jackson (1958).
- Total potassium in soil was determined by flame photometer according to Jackson, (1958).
- Total phosphorus in soil was determined colourmetrically using ascorbic acid method (Watanabe and Olsen, 1965).

## RESULTS AND DISCUSSION

The effect of tested soil amendments and their interactions on nitrogen mobility and leaching through sandy and calcareous soils under intermittent leaching through soil columns are discussed in the following sub headings:

### Soluble Nitrogen Fractions

#### Sandy soil

Regarding the effect of biogas manure (BM) combined with different soil amendments, values of soluble nitrogen fractions ( $\text{NH}_4$  - N and  $\text{NO}_3$  - N) leached under

the investigated treatments are recorded in Table 5 and Fig. 1. Results show that the addition of biogas manure combined with taffla material (T), Sulphur (S) and water capture fertilizer (WCF) clearly affected the transformation of ammonium to nitrate. The highest value of leached  $\text{NH}_4$ -N at the first week was observed under the addition of biogas manure individual. On the other hand, the greatest value of leached  $\text{NO}_3$ -N was found under the treatment of biogas manure combined with taffla material, sulfur and neutral WCF. This result may be attributed to the effect of WCF as indicated by Osman Fatma and El-Mogy (2005) who mentioned that the combination between organic biogas manure and WCF led to increase the fertilizer N efficiency.

In the second leachate, the highest value of  $\text{NH}_4$  - N was observed under the addition of BM + T + S or BM + T + S + WCF; that may be due to the effect of taffla material as well as organic manure for increasing CEC as confirmed by Mahmoud (1996). While the highest value of  $\text{NO}_3$ -N was observed under no addition of soil amendments.

In the third leachate, similar trend to that recorded at the second



leachate was observed for leached  $\text{NH}_4\text{-N}$ ; while the greatest value of  $\text{NO}_3\text{-N}$  was found under the treatment of biogas manure individual.

From the fourth leachate to the end of experiment, data showed that the highest values of leached  $\text{NH}_4\text{-N}$  were recorded under no addition of soil amendments; except of the fifth leachate hence the highest value was observed under no addition of soil amendments or under the treatment of (BM+T), while the highest values of leached  $\text{NO}_3\text{-N}$  were observed under the application of (BM+T) or (BM +T +S + neutralWCF); (BM+ T+ neutral WCF); and (BM+T+S), respectively. Gouda (1979), Abdel-Aziz *et al.* (1990) and El-Shanawany *et al.* (1994) mentioned that using taffla material in coarse textured soils caused an increase in CEC.

Regarding the effect of chicken manure (CM) combined with different soil amendments, data in Table 5 and illustrated in Fig. 1 show that generally the highest value of leached  $\text{NH}_4\text{-N}$  was observed under the treatments of (CM+T+S+WCF) except for the first and final leachates; hence the highest values were observed

under the treatment of (CM +T + acidic WCF). These results may be attributed to the effect of CM which increased available N as reported by Dahdouh *et al.* (2004).

In respect to leached  $\text{NO}_3\text{-N}$ ; data reveal that generally the highest value was observed under the treatments of (CM+T) and (CM+T+S), respectively. These results may be due to the addition of CM and taffla material which increase the available nitrogen as reported by Mahmoud (2001) and Khater *et al.* (2002).

From the abovementioned results, data showed that application of soil amendments i.e. CM, S, taffla material and WCF increased the availability of nitrogen forms due to their effect on CEC and pH of the media as mentioned by Basyony (2002), Negm *et al.* (2003) and Wahdan *et al.* (2005).

#### Calcareous soil

Regarding the effect of biogas manure combined with different soil amendments, values of soluble nitrogen fractions ( $\text{NH}_4\text{-N}$  and  $\text{NO}_3\text{-N}$ ) leached from the investigated treatments are recorded in Table 6 and illustrated in Fig. 2. Results show that the addition of biogas manure

combined with taffla material, sulfur and water capture fertilizer affected the transformation of ammonium to nitrate. Data reveal that the highest value of  $\text{NH}_4\text{-N}$  in second and third weeks were observed under the application treatment of (BM + T + WCF). While, the highest values from the fourth to the seventh weeks were recorded under the application treatment of (BM individually). However, in the final leachate the highest value was observed due to the application of (BM+T+S).

Concerning the highest values of leached  $\text{NO}_3\text{-N}$ , data showed that the highest values were observed due to the addition of (BM+T+S+WCF) at the first and sixth leachates. In the second and fifth leachates, the highest values were obtained under the addition of (BM+T+S); while in the third and fourth leachates the highest values were found under the addition of (BM individually). However, the highest values at the seventh and eighth leachates were recorded under the treatment of (BM+T+WCF). From the results, mentioned before, it could be reported that addition of organic manure, S, taffla material and WCF acidic affected the availability of nitrogen forms due

to their effect on reducing the soil pH and increasing the availability of nitrogen forms as stated by Wahdan *et al.* (2005) and Abdel-All *et al.* (2007).

Investigating the effect of chicken manure combined with different soil amendments, data in Table 6 and Fig. 2 Show that the highest values of leached  $\text{NH}_4\text{-N}$  in the first, seventh and final leachates were observed under the treatment of (CM + T+ WCF). In the second and sixth leachates the addition of (CM+T) gave the highest values of leached  $\text{NH}_4\text{-N}$ , while in the third and fifth leachates the highest values were obtained due to the addition of (CM + T + S + neutralWCF). However, in the fourth leachate, the addition of (CM+T+S) gave the highest values of leached  $\text{NH}_4\text{-N}$ .

Concerning the leached  $\text{NO}_3\text{-N}$ , data reveal that the application of (CM+T) gave the highest value in the fifth leachate, while in the third and sixth leachates the highest values were recorded under the treatment of (CM+T+S). In the first and second leachates, the addition of (CM + T + S + neutral WCF) gave the highest values. However, the addition of (CM + T + acidicWCF) gave the highest value in the fourth leachate. Moreover, the highest values of

Table 5. Effect of some soil amendments and their combination on leaching nitrogen forms through sandy soil columns

Treatments	N-form (ppm)	Number of leachates							
		1	2	3	4	5	6	7	8
Control	NH <sub>4</sub> -N	1.33	1.26	1.12	1.82	1.54	1.54	1.12	0.56
	NO <sub>3</sub> -N	0.38	2.80	1.26	0.28	0.00	0.00	0.14	0.00
BM	NH <sub>4</sub> -N	1.86	1.12	1.12	0.98	1.40	1.54	0.70	0.56
	NO <sub>3</sub> -N	0.35	1.54	1.68	1.40	0.70	0.14	0.14	0.00
BM + T	NH <sub>4</sub> -N	1.35	1.26	0.98	0.70	1.54	1.26	0.56	0.56
	NO <sub>3</sub> -N	0.23	0.84	0.56	2.80	0.84	0.28	0.14	0.00
BM + T + acidic WCF	NH <sub>4</sub> -N	1.47	1.26	0.98	0.70	1.26	1.26	0.98	0.56
	NO <sub>3</sub> -N	0.28	0.84	0.42	1.96	0.84	0.00	0.14	0.14
BM + T + neutral WCF	NH <sub>4</sub> -N	1.31	1.26	0.84	0.84	1.26	1.26	0.70	0.42
	NO <sub>3</sub> -N	0.39	0.70	0.84	1.82	0.98	0.14	0.14	0.14
BM + T + S	NH <sub>4</sub> -N	1.44	1.40	0.98	0.84	1.26	1.12	0.84	0.28
	NO <sub>3</sub> -N	0.25	0.84	1.40	1.26	1.12	0.14	0.00	0.42
BM + T + S + acidic WCF	NH <sub>4</sub> -N	1.75	1.40	1.26	0.84	1.40	0.98	0.70	0.84
	NO <sub>3</sub> -N	0.35	0.70	0.56	1.40	0.70	0.28	0.00	0.00
BM + T + S + neutral WCF	NH <sub>4</sub> -N	1.24	1.40	0.98	0.84	0.98	1.12	0.70	0.56
	NO <sub>3</sub> -N	0.72	0.98	0.42	1.40	1.12	0.28	0.00	0.14
CM	NH <sub>4</sub> -N	2.61	5.46	5.04	3.78	3.22	3.50	3.36	2.66
	NO <sub>3</sub> -N	0.24	0.70	0.14	1.26	0.98	0.28	0.00	0.56
CM + T	NH <sub>4</sub> -N	2.22	4.90	3.92	2.94	2.66	2.10	0.56	0.70
	NO <sub>3</sub> -N	0.36	0.42	0.70	1.26	0.98	0.14	0.70	0.98
CM + T + acidic WCF	NH <sub>4</sub> -N	2.75	4.48	1.96	2.94	3.92	4.62	3.36	3.36
	NO <sub>3</sub> -N	0.22	1.26	0.70	0.42	0.28	0.14	0.56	1.26
CM + T + neutral WCF	NH <sub>4</sub> -N	1.57	5.32	4.76	4.62	3.78	3.92	2.66	1.54
	NO <sub>3</sub> -N	0.24	0.14	0.42	0.14	0.42	0.42	0.28	1.40
CM + T + S	NH <sub>4</sub> -N	1.94	4.34	4.76	4.62	4.90	3.22	0.84	0.28
	NO <sub>3</sub> -N	0.41	0.28	0.42	0.28	0.70	1.12	0.84	0.28
CM + T + S + acidic WCF	NH <sub>4</sub> -N	2.48	4.20	5.04	5.88	6.72	5.32	2.80	1.26
	NO <sub>3</sub> -N	0.45	0.42	0.98	0.56	0.70	0.14	1.26	1.54
CM + T + S + neutral WCF	NH <sub>4</sub> -N	1.71	4.34	5.32	5.18	4.20	5.74	6.58	1.40
	NO <sub>3</sub> -N	0.39	1.26	0.28	0.14	0.56	0.56	0.28	0.42

BM: Biogas manure, T: Taffla, acidic WCF: Acidic water capture fertilizer, neutral WCF: Neutral capture fertilizer, S: Sulfur, CM: Chicken manure.

**Table 6. Effect of some soil amendments and their combination on leaching nitrogen forms through calcareous soil columns**

Treatments	N-form (ppm)	Number of leachates							
		1	2	3	4	5	6	7	8
<b>Control</b>	NH <sub>4</sub> -N	3.47	1.68	2.24	2.24	1.68	1.82	0.98	0.84
	NO <sub>3</sub> -N	0.24	1.26	1.82	1.26	0.70	0.14	0.70	0.56
<b>BM</b>	NH <sub>4</sub> -N	3.23	1.68	2.24	1.96	2.52	1.96	1.68	0.84
	NO <sub>3</sub> -N	0.69	1.54	2.24	2.38	0.28	0.14	0.42	0.42
<b>BM + T</b>	NH <sub>4</sub> -N	2.99	1.40	1.68	1.82	1.96	1.82	1.12	0.70
	NO <sub>3</sub> -N	0.75	1.26	1.68	0.42	0.28	0.56	0.28	0.00
<b>BM + T + acidic WCF</b>	NH <sub>4</sub> -N	3.44	2.10	1.96	2.10	2.24	0.98	1.40	0.84
	NO <sub>3</sub> -N	0.16	0.70	0.28	1.54	0.28	0.14	0.84	0.14
<b>BM + T + neutral WCF</b>	NH <sub>4</sub> -N	3.61	1.82	3.08	1.68	1.82	0.84	0.98	0.98
	NO <sub>3</sub> -N	2.19	0.70	1.12	0.98	0.28	0.42	0.56	0.56
<b>BM + T + S</b>	NH <sub>4</sub> -N	2.79	1.26	1.82	1.68	2.10	1.12	1.40	1.12
	NO <sub>3</sub> -N	0.40	2.10	0.42	0.14	0.70	0.14	0.00	0.14
<b>BM + T + S + acidic WCF</b>	NH <sub>4</sub> -N	3.12	1.26	2.10	1.40	1.82	0.84	1.40	0.98
	NO <sub>3</sub> -N	3.90	1.54	0.28	0.84	0.28	0.42	0.00	0.28
<b>BM + T + S + neutral WCF</b>	NH <sub>4</sub> -N	3.52	1.68	1.68	1.68	1.96	0.70	1.26	0.98
	NO <sub>3</sub> -N	3.13	2.38	1.40	2.38	0.28	0.84	0.28	0.42
<b>CM</b>	NH <sub>4</sub> -N	4.04	1.82	1.96	3.50	1.54	1.26	1.26	1.26
	NO <sub>3</sub> -N	0.38	0.70	1.82	0.42	0.14	0.14	0.28	0.00
<b>CM + T</b>	NH <sub>4</sub> -N	3.65	2.66	2.52	3.08	2.24	1.26	1.68	1.26
	NO <sub>3</sub> -N	2.71	0.56	0.42	1.82	0.84	0.14	0.14	0.28
<b>CM + T + acidic WCF</b>	NH <sub>4</sub> -N	7.01	1.96	2.10	2.24	2.38	0.98	1.26	1.33
	NO <sub>3</sub> -N	2.17	0.42	0.28	1.68	0.14	0.14	0.00	0.24
<b>CM + T + neutral WCF</b>	NH <sub>4</sub> -N	2.89	1.82	2.52	3.92	1.82	1.54	1.54	0.84
	NO <sub>3</sub> -N	0.70	0.56	1.54	0.28	0.42	0.42	0.00	0.00
<b>CM + T + S</b>	NH <sub>4</sub> -N	4.01	1.82	1.12	5.04	3.50	1.12	2.24	0.84
	NO <sub>3</sub> -N	0.58	0.42	1.82	0.56	0.14	0.70	0.14	0.00
<b>CM + T + S + acidic WCF</b>	NH <sub>4</sub> -N	3.37	1.68	1.82	4.90	2.1	0.84	1.54	0.00
	NO <sub>3</sub> -N	0.77	0.70	1.26	0.56	0.28	0.56	0.42	0.00
<b>CM + T + S + neutral WCF</b>	NH <sub>4</sub> -N	4.56	1.68	3.08	4.34	2.80	0.84	1.26	1.12
	NO <sub>3</sub> -N	3.24	0.84	0.56	0.56	0.14	0.42	0.28	0.00

BM: Biogas manure, T: Tafla, acidic WCF: Acidic water capture fertilizer, neutral WCF: Neutral capture fertilizer, S: Sulfur, CM: Chicken manure.

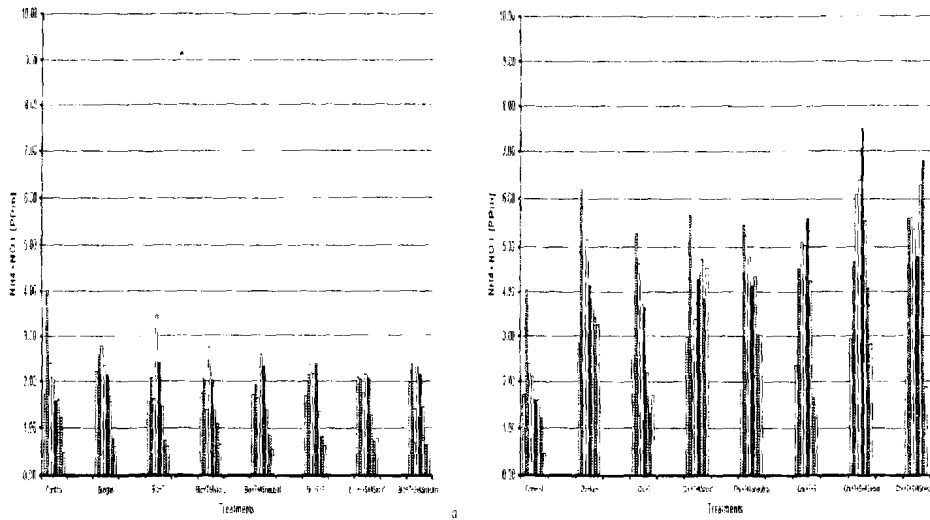


Fig. 1. Leaching of  $(\text{NH}_4^+ + \text{NO}_3^-)\text{-N}$  through sandy soil columns as affected by the application of some soil amendments

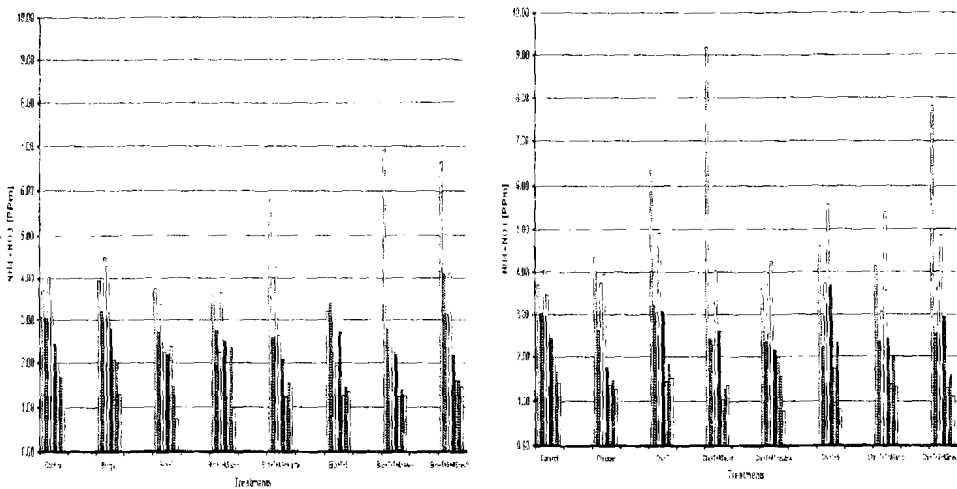


Fig. 2. Leaching of  $(\text{NH}_4^+ + \text{NO}_3^-)\text{-N}$  through calcareous soil columns as affected by the application of some soil amendments

leached  $\text{NO}_3\text{-N}$  in the seventh and eighth were observed with no addition of soil amendments. In this respect, using taffla material, elemental sulphur, and chicken manure affected the CEC, pH and consequently the availability of nitrogen forms as reported by Salem (2004), Wahdan *et al.* (2005) and Abdel-All *et al.* (2007).

### **Nitrate - Ammonium ( $\text{NO}_3^- - \text{N} / \text{NH}_4^+ - \text{N}$ ) Ratio**

#### **Sandy soil**

Nitrate-ammonium ratio for the different treatments was calculated according to the amounts of ammonium and nitrate in the leachates.

The results in Table 7 indicate that the highest mean values of the ratio were 0.67 using biogas manure and 0.24 with chicken manure. In the first leachate, the greatest ratio was found under the treatment of biogas manure combined with taffla material or combined with taffla and acidic WCF.

In the second and third leachates, the highest ratio were found under the treatments of control or BM, respectively. While the addition of chicken manure, the highest ratio was observed with CM + T + acidic WCF, and CM+ T+ acidic WCF, respectively.

In the fourth and fifth leachates, the greatest ratios were found under the addition of biogas manure combined with taffla material and under BM+ T+ S+ neutral WCF treatments, respectively.

In the sixth and seventh leachates, the greatest ratio was found with the treatment of (BM + T + S + acidic WCF) and (BM+T), respectively. On the other hand, addition of chicken manure gave the highest ratio under the addition of chicken manure combined with taffla material or with CM +T, respectively.

In the final leachate (8 weeks), the greatest ratio was found under the treatment of (BM T + S). On the other hand, addition of chicken manure, the highest ratio under the treatment of (CM + T).

El-Sherbienny *et al.* (1986) studied the activity index and leachability of some controlled - release nitrogen fertilizers and their availability in sandy soil and they stated the mean values of the nitrate ammonium ratio ranged from 0.38 to 0.88.

#### **Calcareous soil**

Data presented in Table 8 show the highest mean values of the ratio

**Table 7. Nitrification efficiency of leacheable nitrogen in the intermittent leaching through sandy soil columns as affected by tested soil amendments**

Treatments	Number of leachates							
	1	2	3	4	5	6	7	8
Control	0.17	2.22	1.13	0.15	0.00	0.00	0.13	0.00
BM	0.15	1.37	1.5	1.43	0.50	0.09	0.20	0.00
BM + T	0.66	0.66	0.57	4.0	0.54	0.22	0.25	0.00
BM + T + acidic WCF	0.66	0.66	0.43	2.80	0.66	0.00	0.14	0.25
BM + T + neutral WCF	0.33	0.56	1.0	2.16	0.78	0.11	0.20	0.33
BM + T + S	0.20	0.60	1.43	1.50	0.89	0.13	0.00	1.50
BM + T + S + acidic WCF	0.15	0.50	0.44	1.67	0.50	0.28	0.00	0.00
BM + T + S + neutral WCF	0.56	0.70	0.43	1.67	1.14	0.25	0.00	0.25
CM	0.11	0.13	0.03	0.33	0.30	0.08	0.00	0.21
CM + T	0.19	0.09	0.18	0.43	0.37	0.07	1.25	1.40
CM + T + acidic WCF	0.1	0.28	0.36	0.14	0.07	0.03	0.17	0.38
CM + T + neutral WCF	0.18	0.03	0.09	0.03	0.11	0.11	0.11	0.91
CM + T + S	0.21	0.06	0.09	0.06	0.14	0.35	1.0	0.25
CM + T + S + acidic WCF	0.17	0.1	0.19	0.10	0.10	0.03	0.45	1.22
CM + T + S + neutral WCF	0.25	0.29	0.05	0.03	0.13	0.10	0.04	0.30

BM: Biogas manure, T: Tafla, acidic WCF: Acidic water capture fertilizer, neutral WCF: Neutral water capture fertilizer, S: Sulfur, CM: Chicken manure. N.E: Nitrification efficiency ( $N.E = NO_3-N / NH_4-N$  ratio).

**Table 8. Nitrification efficiency of leacheable nitrogen in the intermittent leaching through calcareous soil columns as affected by some soil amendments**

Treatments	Number of leachates							
	1	2	3	4	5	6	7	8
<b>Control</b>	0.08	0.75	0.81	0.56	0.42	0.06	0.71	0.67
<b>BM</b>	0.22	0.92	1.0	1.21	0.05	0.07	0.25	0.50
<b>BM + T</b>	0.24	0.90	1.0	0.23	0.14	0.31	0.25	0.00
<b>BM + T + acidic WCF</b>	0.04	0.33	0.14	0.73	0.13	0.14	0.60	0.17
<b>BM + T + neutral WCF</b>	0.77	0.38	0.36	0.58	0.15	0.50	0.57	0.57
<b>BM + T + S</b>	0.15	1.70	0.33	0.08	0.33	0.13	0.00	0.13
<b>BM + T + S + acidic WCF</b>	1.27	1.22	0.13	0.60	0.15	0.50	0.00	0.29
<b>BM + T + S + neutral WCF</b>	0.88	1.42	0.83	1.42	0.14	1.20	0.22	0.43
<b>CM</b>	0.10	0.38	0.93	0.12	0.09	0.11	0.22	0.00
<b>CM + T</b>	0.73	0.21	0.17	0.59	0.38	0.11	0.08	4.50
<b>CM + T + acidic WCF</b>	0.32	0.21	0.13	0.75	0.06	0.14	0.00	0.33
<b>CM + T + neutral WCF</b>	0.24	0.31	0.61	0.07	0.23	0.27	0.00	0.00
<b>CM + T + S</b>	0.14	0.23	1.63	0.11	0.04	0.63	0.06	0.00
<b>CM + T + S + acidic WCF</b>	0.25	0.42	0.69	0.11	0.13	0.67	0.27	0.00
<b>CM + T + S + neutral WCF</b>	0.70	0.50	0.18	0.13	0.05	0.50	0.22	0.00

BM: Biogas manure, T: Taffla, acidic WCF: Acidic water capture fertilizer, neutral WCF: Neutral capture fertilizer, S: Sulfur, CM: Chicken manure, N.E: Nitrification efficiency ( $N.E = NO_3\text{-N} / NH_4\text{-N}$  ratio)



were 0.48 under the addition of biogas manure and 0.36 with chicken manure. In the first leachate, the greatest ratio was observed under the treatment of biogas manure combined with taffla material, sulfur and acidic WCF. On the other hand, addition of chicken manure gave the highest ratio under the addition of chicken manure combined with taffla material.

In the second leachate, the highest ratio was observed due to the addition of (BM + T+ S). Regarding to the addition of chicken manure, the greatest ratio was found with the treatment of chicken manure combined with taffla material and sulphur.

In the fourth leachate, the greatest ratio was found under the treatment of (BM + T+ S + neutral WCF). Concerning to the addition of chicken manure the highest ratios was observed with (CM + T + acidic WCF). In the sixth and seventh leachates, the greatest ratio were found under the treatments of (BM + TM + S + neutral WCF) and control treatments, respectively. While the addition of using chicken manure gave the greatest ratio under (CM + TM+ S + acid WCF). These results may be due to the effects of chicken

manure and taffla material in improving the soil properties and increasing the rate of nitrification process as recorded by Abdel-Samad, and Eid (1995), Negm *et al.* (2003) and Dahdouh *et al.* (2004).

### **Residual Available Nitrogen in Soil**

#### **Sandy soil**

Regarding to the residual available-N, ( $\text{NH}_4 + \text{NO}_3$ ) - N in the soil after the intermittent leaching, data in Table 9 showed that in the case of biogas manure, the highest value of residual available - N was observed under the addition of (BM + T) in the layer of (20 - 30 cm) while the lowest value was found under the addition of (BM + T+ S + neutral WCF) in first soil layer of (0 - 10 cm). Concerning the effect of chicken manure the greatest value of residual available - N was observed under the addition of (CM + T + acidic WCF) in the layer (20 - 30 cm), while the lowest value was found under the treatment of (CM + T) in the layer (10 - 20 cm) or (CM + TM + S + acidic WCF) in the first layer, (0-10cm). These results may be attributed to the effect of organic manure on the exchange capacity

