Nitrification Rates of Some Soils from Northern Iraq

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Introduction

An important amount of ammonium is oxidized to nitrate by the process of nitrification (Killham, 1996; Alexander, 1977; Tisdale & Nelson, 1975). Nitrification is a two-step bacterial process by which ammonium is oxidized to nitrite then to nitrate, mainly by chemoautotrophic bacteria represented by the genus *Nitrosomonas* (1st step) and *Nitrobacter* (2nd step). Chemoheterotrophic microorganisms including bacteria and fungi may also nitrified ammonium, but in different pathways (Killham, 1986; Alexander, 1977). Nitrate is a negatively charged ion and may be leached from the soil to contaminate the ground water, lakes and rivers.

Drinking water containing high concentration of nitrate may be hazard to human health especially infant babies, since it cause the disease so called methemoglobinaemia. World Health Organization (WHO) recommended that water containing more than 45 PPm NO3 is perfectly unsafe to be used for drinking. Nitrate may also be reduced to nitrous oxide (N2O) by anaerobic bacteria through the process of denitrification (Focht & Verstraete, 1977; Kuenen & Robertson, 1967). A continuos emission of N2O to the atmosphere may result in the destruction of the ozone layer. The quantity of ammonium nitrified (nitrification) is affected by the physical and chemical properties of the soil

Among them are, soil temperature, PH , moisture and aeration, repeated wetting and drying, soil texture and its organic matter contents, in addition to the concentration of the available substrate (ammonium) (Bhaskar & Charyulu, 2005; Nui Milton, 2001; Deboer, 1989; Broadbent, 1978). The present work endeavor to focus on the effect of the form and concentration of the added ammonical nitrogen fertilizer on the process of nitrification, using liquid culture medium and in soils of different chemical and physical properties.

Three experiments on the process of nitrification were conducted in the microbiology lab. of the department of soil and water sciences, college of Agriculture and Forestry-Mosul- Iraq. Two of them using liquid culture media and one was directly in the soil.

Table 1: some of the physical and chemical characteristics of the soil tested.

Characteristic	Rashidia	Zakho	Swaratoka	Sumeil
Taxonomy (order)	Inceptisol	Mollisol	Mollisol	Inceptisol
Texture	Loam	Loam	Loam	Silty C.L.
Moisture % (F.C.)	22.00	28.00	29.00	34.00
Ece ($ds.m^{-1}$)	2.53	0.45	0.49	0.72
P^H	7.73	8.11	7.98	7.91
O.M. ($g.kg^{-1}$)	25.50	35.30	31.40	20.60
$CaCO_3(g.kg^{-1})$	122.00	308.00	296.00	201.00
CEC centimole kg^{-1}	38.40	24.80	27.80	30.40
Total N (%)	0.175	0.160	0.115	0.127
Av.NH_4–N (PPm)	39.00	46.00	29.00	43.00
Av.NO_3–N (PPm)	23.00	17.00	20.00	27.00
Av.P (PPm)	7.60	7.20	4.70	4.90

Results and discussion:

Experiment 1

Effect of concentration of ammonium–N added as ammonium sulfate on the rate of nitrification in liquid medium:

$$\text{Nitrification rate \%} = \frac{\text{NO3–N produced}}{\text{NH4–N added}} \times 100$$

Table 2: Effect of concentration of NH_4 –N added as $(NH_4)_2SO_4$ on the rate of nitrification in liquid medium inoculated with soil from different region

Soil region	Conc. Of NH_4–N PPm	1st incubation (10days)		2nd incubation (20days)		3rd incubation (30days)	
		NO_3–N PPm	Nitrific.rate(%)	NO_3–N PPm	Nitrific.rate(%)	NO_3–N PPm	Nitrific.rate(%)
Rashidia	50	26.4	52.8	21.8	43.6	31.5	63.0
	100	52.5	52.5	54.0	54.0	51.1	51.1
	200	103.5	51.7	86.3	43.2	98.7	49.3
	300	131.2	43.7	119.9	40.0	150.8	50.3
Average			50.2		45.2		53.4
Zakho	50	17.0	34.0	21.6	43.3	26.6	53.2
	100	40.6	40.6	42.4	42.4	54.6	54.6
	200	82.1	41.0	106.4	53.2	99.1	49.5
	300	118.7	39.6	124.7	41.6	138.9	46.3
Average			38.6		45.1		50.9
Swaratoka	50	29.4	58.9	15.9	51.9	28.4	56.9
	100	43.9	43.9	52.8	52.8	55.0	55.0
	200	104.1	52.1	99.8	49.9	100.9	50.5
	300	142.04	47.5	155.9	52.0	153.7	51.2
Average			50.6		51.7		53.4
Sumeil	50	28.0	56.1	26.6	53.3	27.0	54.6
	100	56.1	56.1	49.3	49.3	45.5	45.5
	200	117.8	58.9	100.4	50.2	110.6	55.0
	300	136.1	45.4	135.6	45.2	142.6	47.5
Average			54.1		49.5		50.5

Experiment 2:

Effect of concentration of ammonium–N added as urea on the rate of nitrification in liquid medium:

Table 3: Effect of concentration of NH_4–N added as urea on the rate of nitrification in liquid medium inoculated with soil from different region

Soil region	Conc. Of NH_4–N PPm	1st incubation (10days)		2nd incubation (20days)		3rd incubation (30days)	
		NO_3–N PPm	Nitrific.rate(%)	NO_3–N PPm	Nitrific.rate(%)	NO_3–N PPm	Nitrific.rate(%)
Rashidia	50	23.1	46.2	20.8	41.8	24.1	48.2
	100	53.5	53.5	49.7	49.7	50.7	50.7
	200	105.5	53.0	103.3	51.6	91.9	46.0
	300	142.4	47.5	166.4	55.5	148.3	49.4
Average			50.1		49.7		48.6
Zakho	50	25.2	50.4	24.0	48.0	15.1	30.2
	100	49.8	49.8	50.0	50.0	52.8	52.8
	200	94.6	47.3	97.7	48.9	96.7	48.4
	300	137.6	45.9	158.7	52.9	133.7	44.6
Average			48.4		50.0		44.0
Swaratoka	50	25.6	51.2	25.4	50.8	24.0	48.0
	100	48.2	48.2	58.0	58.0	48.5	48.5
	200	104.2	52.1	102.6	51.3	115.6	57.8
	300	154.7	51.6	154.8	51.6	150.5	50.2
Average			50.8		52.9		51.0
Sumeil	50	27.1	54.2	27.7	54.4	23.4	46.8
	100	53.7	53.7	53.4	53.4	46.6	46.6
	200	102.7	51.4	97.6	48.8	112.3	56.2
	300	143.2	47.7	151.9	50.6	157.6	52.5
Average			51.8		51.8		50.5

Experiment 3:

Effect of concentration of ammonium–N added as urea on the rate of nitrification directly in the soil:
Nitrification rate %(from urea–N only) =

$$\frac{\text{NO3–N produced(treated soil) - NO3–N produced (control)} \times 100}{\text{Concentration of the added urea–N}}$$

Table 4: Effect of the concentration of the added urea–N (PPm) on the rate of Nitrification (from urea–N only) in soils from different regions

Soil region	Conc. Of NH_4–N PPm	1st incubation (10days)		2nd incubation (20days)		3rd incubation (30days		4th incubation (40 days)	
		NO_3–N PPm	Nitrific. rate (%)	NO_3–N PPm	Nitrific. rate (%)	NO_3–N PPm	Nitrific. rate (%)	NO_3–N PPm	Nitrific. rate (%)
Rashidia	75	16.4	21.9	16.3	21.7	7.0	9.3	2.4	3.2
	150	35.0	23.3	23.3	15.5	12.7	8.5	9.6	6.3
	225	58.4	26.0	37.3	16.6	21.7	9.6	17.7	7.9
	300	70.4	23.6	54.7	18.2	11.4	3.8	21.0	7.0
Average			23.7		18		7.8		6.1
Zakho	75	30.3	40.4	14.3	19.1	10.2	13.6	9.4	12.5
	150	63.0	42.0	31.6	21.1	19.5	13.0	19.7	13.1
	225	86.3	38.4	47.0	20.9	16.2	7.2	30.4	13.5
	300	114.3	38.1	62.0	20.7	26.5	8.8	48.0	16.0
Average			39.8		20.5		10.7		13.8
Swaratoka	75	24.3	32.4	12.6	16.8	9.3	12.4	9.6	12.8
	150	42.0	28.0	26.0	17.3	3.3	2.2	11.6	7.7
	225	60.7	27.0	42.0	18.7	10.3	4.6	23.6	10.5
	300	93.3	31.1	52.6	17.5	7.3	2.4	34.0	11.3
Average			29.6		17.6		5.4		10.6
Sumeil	75	13.7	18.3	16.0	21.3	-7.3	-9.7	10.3	13.7
	150	38.4	25.6	35.0	23.3	9.0	6.0	16.3	10.9
	225	60.4	26.8	50.0	22.2	20.7	9.2	34.0	15.1
	300	77.7	25.9	80.4	26.8	18.7	6.2	44.3	14.8
Average			24.2		23.4		7.8		1`3.6

The chemical and physical properties of the soils seemed to have an important effect on the process of nitrification, since around 40% of the added ammonium–N was nitrified in the soil taken from Zakho during the first 10 days of incubation, in comparison with only 24% for Rashidia and Sumiel, while the other soil (Swaratoka) was in between (around 30%).

Conclusions

soils differ in the ability to nitrify the added ammonium' depending on their physical and chemical properties specially the calcium carbonate' and organic matter contents. The amount of nitrate formed was proportional to the quantity of ammonium fertilizer added, regardless of its type (urea or ammonium sulfate). Contamination of ground water and rivers with nitrate is expected in the near future.