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INVENTORY AND MITIGATION OPTIONS OF NITROUS OXIDES GASES FROM AGRICULTURE SOILS UNDER EGYPTIAN CONDITIONS

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ABSTRACT

Nitrous oxides (NO and N_2O) are some of the greenhouse gases that play a key role in atmospheric chemistry. The conversion values according to the global warming potential (GWP) for N_2O is 310 times CO_2. This means that N_2O is 310 times more effective in its GWP (global warming potential). One of the main sources of N_2O emissions are synthetic nitrogen fertilizers. Emissions of N_2O from soils show variability based on a number of factors including, differences in soil type, moisture, temperature, season, crop type, fertilization, and other agricultural practices. Soils emit N_2O through biological pathways. Emission rates can be categorized either by fertilizer application or land use. The quantity of N_2O emitted from agricultural land depends on fertilizer application and the subsequent microbial denitrification of the soil. Microbial denitrification is a natural process in soil, but denitrification is higher when soil has been fertilized with chemical fertilizers. The main objective of this work is to determine greenhouse gas emissions (Nitrous oxides) from agriculture soils and to study its mitigation options under Egyptian conditions from year 2000 to 2004. Nitrous oxides, emissions from soils were calculated according to the IPCC methodology. The results indicated that:1] Total N_2O from agriculture fields and cultivation of histosols was 68.54 Gg N_2O-N/yr; 2] indirect N_2O emissions from atmospheric deposition of NH_3 and NO_x was 4.96 Gg N_2O-N/yr;3] indirect N_2O emissions from leaching and runoff was 30.04 Gg N_2O-N/yr and 4] total N_2O emission from agriculture

soils (direct and indirect emissions) was 103.54 Gg N_2O-N/yr, or 32096.6 Gg CO_2 equivalent/yr.

Mitigation option for emissions N_2O was tested by several treatments: Reduction of chemical N fertilizers dose and splitting N fertilizer applications. Results indicated that, not only the nitrogen rate, but also the time of N application are considered among the important agricultural practices used to minimize nitrogen loses (leaching and runoff) and increase maize productivity.

INTRODUCTION

Over the last decades, the term of "Global Climate Change" became one of the evident facts that have to be faced every time one should think about the future. These changes in climate are highly linked to greenhouse gases "GHG" emissions produced due to human activities. Egypt is one of the developing countries and highly vulnerable to climate change impacts, due to its arid climate and its intensive agricultural system. This requires intensive use of fertilizers to optimize production from small areas.

According to the United Nations Framework Convention on Climate Change (UNFCCC) which was signed in Rio de Janeiro in June 1992 and entered into force on the 21st of March 1994, the parties to the Convention should take precautionary actions to prevent or minimize the emissions of greenhouse gases and consequently the causes of climate change. The agriculture sector generates five different types of sources for GHG: 1] animal production (CH4 emissions from enteric fermentation; and CH4 and N2O emissions from manure management); 2] rice cultivation: flooded rice fields; 3] prescribed burning of savannas; 4] field burning of agricultural residues; and 5] agricultural soils since there is no savanna burning, only the rest should be considered in Egypt. Soils are linked to the atmosphere through fluxes of energy, matter and water. Soils are sinks and sources of carbon dioxide, nitrous oxide and methane. Soils are the source of nutrients for plants. Soils store water and sites of turnover of nitrogen and carbon (IPCC, TAR 2001). Nitrous oxide is a greenhouse gas and also participate in the destruction of the stratospheric ozone. Nitric oxide (NO) is a precursor of tropospheric ozone, which is a greenhouse gas formed by photochemical reaction. Nitrogen dioxide is derived from NO by photochemical reaction, and is a precursor of nitric acid, which is a major component of acid rain. Nitric oxide and N_2O play a key role in atmospheric chemistry (Williams *et al.,* 1992). Agricultural soil is a major source of N_2O, accounting for approximately 6.2 Tg N_2O-N yr^{-1}, which is 35% of the global annual emission (Kroeze *et al*., 1999). (There are two ways for emissions of N_2O: 1] direct soil emission of N_2O from N applied fertilizers (inorganic, organic), N input via N_2 fixation, N from residues, or N released by mineralization of soil organic matter and 2] indirect emissions of N_2O by volatization and subsequent atmospheric deposition of ammonia and NO_x, nitrogen leaching and runoff, human consumption of crops followed by municipal sewage treatment. Nitrous oxides and NO are produced in soils by the microbial processes of nitrification and denitrification after the application of nitrogen fertilizer or organic matter to the field. Nitrification is an aerobic process, and denitrification is an anaerobic process (Davidson, 1991; Granli and Bockman, 1994). Input of organic matter to the agricultural field is one important N_2O source. After organic matter is added to soil, the C source for denitrification is increased, microbial activity is enhanced, O_2 is consumed, and anaerobic microsites can develop (Granli and Bockman, 1994). Bouwman, and Sombrok (1990) indicated that legumes may contribute to N_2O emission in a number of ways, atmospheric N2 fixed by legumes can be nitrified and denitrified in the same way as fertilizer N, thus providing a source of N_2O. Additionally, symbiotically living Rhizobia in root nodules are able to denitrify and produce N_2O (Ohara and Daniel, 1985). Considerable N_2O emissions from animal waste have been estimated. Bouwman *et al.* (1995) estimated the global N_2O emission from animal waste to be 1.0 Tg N_2O-N yr^{-1}, based on an estimated production of 100 Tg animal waste N yr^{-1} and a 1% N_2O emission rate from animal waste.

Our main objectives were to: 1] determine the emissions of nitrous oxide from agriculture soils and 2] study N_2O mitigation options under Egyptian conditions.

MATERIALS AND METHODS

The materials and methods of this investigation were explained under two main topics, i.e. estimating Greenhouse Gas Emissions (Nitrous oxide) from Agriculture Soils and Mitigation Options methods as follows:

1. Emissions of nitrous oxide from agriculture soils :

The agriculture soil generates nitrous oxide by three ways: 1- Direct emission of N_2O from agriculture soils (including glasshouse farming systems and excluding effects of grazing animals); 2- Direct soil emission of N_2O from animal production and; 3-Indirect emissions of N_2O from nitrogen used in agriculture. Methodology of estimating N_2O Emissions from agriculture soils is followed according to the revised 1996 methodology for assessing direct and indirect soil emission of N_2O. Total N_2O-N emissions from Egypt (kg N_2O-N/yr) are: $N_2O = N_2O_{DIRECT} + N_2O_{ANIMALS} + N_2O_{INDIRECT}$.

1.1. Direct N_2O emissions from agriculture fields :

1.1.1. Amount of N input :

Calculation of fertilizer use (F_{SN}): Total use of synthetic fertilizer in Egypt is obtained from 2000 to 2004 years (Bulletin of Agriculture Economics, Ministry of Agriculture, Egypt, 2000, 2001, 2002, 2003 and 2004). Pure synthetic fertilizer N was calculated (Pure N = Total use of synthetic fertilizer from each source ×Fertilizer purity). The total synthetic fertilizer (F_{SN}) used in Egypt excluding emissions of NH_3 and NO_X (FSN) was calculated from the following equation: $F_{SN} = N_{FERT} \times (1\text{-}Frac_{GASF})$. Where N_{FERT} = Total use of synthetic fertilizer in Egypt (kg N/yr), $Frac_{GASF}$ = fraction of total of synthetic fertilizer nitrogen that is emitted as $NO_X + NH_3$ (kg N/kg N). The default values for $Frac_{GASF}$= 0.1 kg NH_3-N + NO_X N/kg of synthetic fertilizer nitrogen applied.

The Quantity of nitrogenous synthetic fertilizer consumption (kg/year) for five consecutive years are presented in Table 1.The fast growing population increase Egypt food needs, and fertilizers are among the most important elements to secure sufficient food production from small area. Egyptian nitrogen fertilizer industry is comprised of manufacturers of some categorized as nitrogen fertilizers Urea (46% N), Ammonium Nitrate (33.5% N), Calcium

Nitrate (15.5 % N) and Ammonium Sulphate (20.6 %N). The average Quantities of nitrogen fertilizers consumption (Ton/year) for five consecutive years from 2000 to 2004 was 7.4 million ton/year.

Table 1: Quantities of nitrogenous fertilizers consumption (Ton/year) for five consecutive years from 2000 to 2004

Fertilizer type	2000	2001	2002	2003	2004	Average
Urea 46% N	5082180	5417091	3837042	4250019	5821710	4881608
Ammonium Nitrate 33.5% N	2992360	2811704	2541206	2518392	284412	2229615
Calcium Nitrate 15.5 % N	1300	6784	6021	1300	3701	3821
Ammonium Sulphate 20.6%N	286232	328172	349462	235644	212175	282337
Total	8362072	8563751	6733731	7005355	6321998	7397381

Calculation of animal waste: The data needed are amount of N input from manure (kg N/yr). Using total manure produced by animals and average of nitrogen amount/kg manure default=0.042 (CLAC 2006) the amount of N input (kg N/yr) was calculated (Amount of N input= total manure× average of nitrogen per kg manure).

Calculation of nitrogen input in N-fixing crops (F_{BN}): Nitrogen input from N-fixing crops was calculated by equation $F_{BN} = 2\times Crop_{BF} \times Frac_{NCRBF}$. Where, $Crop_{BF}$ = Total dry legume crop biomass (kg/yr) production in Egypt (CLAC 2006), $Frac_{NCRBF}$ = fraction of nitrogen in N-fixing crops (default value =0.03kgN/kg of dry biomass) and this factor converts crop production to total crop biomass

Calculation of nitrogen input from crop residues (F_{CR}): The data needed are amount of N input from crop residues (kg N/yr). Using total biomass produced by all crops and average of nitrogen amount/kg biomass (default= 0.0093) (CLAC 2006) the amount of N input (kg N/yr) was calculated (Amount of N input= total biomass kg per year × average of nitrogen amount per kg biomass).

1.1.2. Direct N_2O emissions excluding cultivation of Histosols :

The default value for direct emission factor (EF1) = 0.0125 kg N_2O-N/kg N. Direct soil emissions = Amount of N input (kg/yr) × EF1. The final results are multiplied by 10^{-6} to convert it to gigagrams. Sum direct soil emission *from* all recourses (Synthetic fertilizer; Animal waste; Biological N_2 fixation and Crop residue). Multiply the final results by 44/28 = ratio of molecular weight of N_2O to molecular weight of N_2.

1.1.3. Direct N_2O emissions from cultivation Histosols :

Area of cultivated organic soils, is obtained from the world of organic agriculture statistics and emerging trends 2004. Emission factor for direct soil emission EF_2 for histosols (default=5 kg N/ha/yr). Multiply the area of cultivated organic soils by emission factor for direct soil emission to give direct emission from Histosols. Multiply the final results by 10^{-6} express it as gigagrams. Multiply the final results by 44/28 = ratio of molecular weight of N2O to molecular weight of N_2.

1.1.4. Total direct N_2O emissions :

Direct N_2O emissions (N_2O direct) are estimated as the equation: N_2O_{direct}=direct N_2O emissions excluding cultivation of Histosols +direct N_2O emissions from cultivation Histosols.

1.1.5. Indirect N2O emissions from atmospheric deposition of NH3 and NOX :

Total amount of nitrogen synthetic fertilizers applied to soil (amount of nitrogen =Synthetic N applied to soil ×purity for each type). Fraction of synthetic fertilizer N applied that volatilizers $Frac_{GASF}$ (default = 0.1Kg NH_3-N + NO_X- N/kg of synthetic fertilizer N applied). Amount of synthetic fertilizer applied to soil that volatizes was calculated by multiply the total amount of synthetic fertilizer applied in Egypt by fraction of the synthetic fertilizer N applied that volatizes. Total N excretion by livestock that volatilizes (kg N/kg N) was calculated from equation. Total N excretion by livestock that volatilizes (kg N/kg N) = N_{EX} (kg N/yr)× $Frac_{GASM}$. N_{EX} (kg N/yr) =Total N excretion by livestock. N_{EX} was calculated from equation: N_{EX} (kg N/yr) = default value for nitrogen excretion per head of animal in Africa× livestock number in Egypt, the default value for nitrogen excretion per head of animal in Africa: dairy & Non dairy cattle (Bulls, Dairy Cows, Beef Cows, Dairy Heifers, Beef Heifers, Steers) =50; poultry (Chickens, Hens, Turkeys) =0.6; sheep=12 and other animals (=40 kg/animal/yr). Livestock number in Egypt for the following categories: non dairy cattle, dairy cattle, poultry, and other animals (Bulletin of Agriculture Economics, Ministry of Agriculture, Egypt). $Frac_{GASM}$ =Fraction of total manure N excreted that volatilizes (default value =0.2Kg NH3-N + NOX- N/kg of nitrogen excreted by livestock).

N_2O emissions from atmospheric deposition of NH_3 and NO_X = (Amount of synthetic N applied to soil that volatizes + Total N excretion by livestock that volatilizes)× Emission factor $EF_4 \times 10^{-6}$. Emission factor EF_4= default value= 0.01 (kgN_2O-N/kgN).

1.2. Indirect Nitrous oxide emissions from leaching:

Nitrous oxide emissions from leaching was calculated by equation = $(N_{FERT} + N_{EX}) \times Frac_{LEACH} \times EF5 \times 10^{-6}$. $Frac_{LEACH}$ = Nitrogen of fertilizer or manure (default value= 0.3kg N/kg). EF_5= Default emission factors for nitrogen leaching/runoff (EF_5= 0.025 kg N_2O-N per nitrogen leaching/runoff

1.3. Total Nitrous oxide emissions from agriculture soils :

Total N2O emissions from agriculture soil was calculated as the sum of direct emissions from agriculture fields and cultivation of Histosols, Indirect Nitrous oxide emissions from atmospheric deposition of NH3 and NO× and Indirect Nitrous oxide emissions from leaching

1.4. Carbon dioxide (CO2) equivalent emissions :

Total CO2 equivalent emissions were calculated by multiplying CO2, and N2O, by factors of 1, and 310, respectively and then summing them. These are the conversion values according to the global warming potential (GWP) for each molecule. This means that N_2O is 310 times more effective in its GWP **(IPCC, 1996).**

1.5. Mitigation Options under Egyptian Conditions :

A mitigation option for emissions N_2O was tested by several treatments: 1- Reduce of chemical n fertilizers dose, data were taken from paper El kholi (1998), essentiality of biofertilizers with special reference to biological nitrogen fixation; 2-response of maize to N fertilizer splitting, data were taken from Mowafy (2003), response of some maize hybrids to fertilizer splitting under drip irrigation system in sandy soils.

RESULTS AND DISCUSSION

Nitrogen input to Agriculture Soils (kg N/yr) :

The amount of N input from nitrogenous synthetic fertilizer consumption, animal waste, biological N_2 fixation, biological N_2 fixation and crop residue are presented in Table 2. Total use of synthetic fertilizer in Egypt from 2000 to 2004 years, pure synthetic fertilizer N was 2.7 million ton N/yr. nitrogen input from animal waste (manure) was 504000 ton N/yr, nitrogen input from N-fixing crops (dry legume crop biomass kg/yr) was 34 ton N/yr. the nitrogen input from crop residues (using total biomass produce by all crops and average of nitrogen amount/kg biomass) was 232500 ton N/yr. Amount of N input from all resources to soils was 3482627 ton/yr.

Table 2 : Amount of N input from nitrogenous Synthetic fertilizer consumption, Animal waste, Biological N2 fixation, Biological N2 fixation and Crop residue

<table>
<tr><th colspan="2">Type of N input to soil</th><th>Average (Ton/yr)</th><th colspan="2">Amount of N input (Ton N/yr)</th></tr>
<tr><td rowspan="4">Synthetic fertilizers</td><td>Urea 46% N</td><td>4881608</td><td>2020986</td><td rowspan="4">27460 93</td></tr>
<tr><td>Ammonium Nitrate 33.5%N</td><td>2229615</td><td>672229</td></tr>
<tr><td>Calcium Nitrate 15.5 %N</td><td>3821</td><td>533</td></tr>
<tr><td>Ammonium Sulphate 20.6%N</td><td>282337</td><td>52345</td></tr>
<tr><td colspan="2">Animal waste</td><td>12000000</td><td colspan="2">504000</td></tr>
<tr><td colspan="2">Biological N_2 fixation</td><td>573</td><td colspan="2">34</td></tr>
<tr><td colspan="2">Crop residue</td><td>25000000</td><td colspan="2">232500</td></tr>
<tr><td colspan="2">Total</td><td></td><td colspan="2">3482627</td></tr>
</table>

Bouwman (1994) estimated that 0.0125 of the applied nitrogen was directly emitted as N_2O. The amount of nitrogen from animal excreta for convention to N2O is therefore equal to 90 percent of the synthetic fertilizer nitrogen applied and 80 percent of the animal waste nitrogen applied (Schepers and Mosier, 1991). Bouwman and Sombrok (1990) indicate that legumes may contribute to N_2O emission in a number of ways, atmospheric N2 fixed by legumes can be nitrified and denitrified in the same way as fertilizer N.

Direct Nitrous Oxide Emissions :

The direct nitrous oxide emissions from agriculture fields and cultivation of Histosols are presented in Table 3. Synthetic fertilizers add large quantities of nitrogen to agricultural soils. This added nitrogen undergoes transformations, i.e. nitrification and denitrification, and releases N_2O emissions. Emission rates associated with fertilizer application will depend on many factors such as the quantity and type of nitrogen fertilizers, crop types, soil types, climate and other environmental conditions. The application of animal waste as fertilizer to soils can increase the rate of nitrification/denitrification and result in enhanced N_2O emissions from agricultural soils. Note that the manure included in this category is that treated by dry lot and liquid. Atmospheric nitrogen fixed by nitrogen-fixing plants (such as peas, beans, alfalfa) can undergo the process of nitrification and denitrification in the same manner as nitrogen applied as synthetic fertilizer. Also, Rhizobia in the plant nodules can emit N_2O as they fix nitrogen. Crop Residue Decomposition: When a crop is harvested, a portion of the crop (crop residue) is left on the field to decompose. The remaining plant matter is a nitrogen source for nitrification and denitrification processes, and thus produces N_2O. Cultivation of organic soils (Histosols) for crop production usually involves drainage for lowering below-ground water table, soil, and increased aeration, thus speeding up decomposition of organic matter. Denitrification and nitrification also take place, releasing N_2O emissions. The results indicated that, from the urea, the total N_2O emission was 39.69^ Gg N_2O-N/yr higher than the other N_2O emission recourses. The synthetic fertilizers is considered as the main source of N_2O emissions from soils due to the use of nitrogen fertilizers (mainly inorganic fertilizers), The synthetic N fertilizers gave the highest direct soil emissions (53.94Gg N_2O-N/yr) and the biological N2 fixation gave the lowest direct soil emissions (0.00067 Gg N_2O-N/yr). The Total direct emissions of N_2O from agriculture fields and cultivation of Histosols (Synthetic fertilizers, animal waste, biological N_2 fixation, crop residue and area of cultivated organic soils) was 68.5423 Gg N_2O-N/yr.

Table 3: Direct Nitrous oxide emissions from agriculture fields and cultivation of Histosols

Type of N input to soil		Direct soil emissions (Gg N_2O-N/yr)	
Synthetic fertilizers	Urea	39.6979	53.94
	Ammonium Nitrate	13.2045	
	Calcium Nitrate	0.0105	
	Ammonium Sulphate	1.0282	
Animal waste		9.90000	
Biological N2 fixation		0.0007	
Crop residue		4.57	
Area of cultivated organic soils		0.1336	
Total direct emissions of N2O (Gg)		68.54	

Most studies on N2O emissions from agricultural soils investigated the difference in N2O production between fertilized and unfertilized fields; emissions from unfertilized fields were considered background emissions. However, actual background emissions from agricultural soils may by higher than historic natural emissions as a result of enhanced mineralization of soils organic matter. This is particularly observed in organic soils in both cold and warm climates over the globe (Kroeze, 1994). Background emissions may also be lower than historic due to depletion of soil organic matter (Groffman *et al.*, 1993)

Indirect N_2O Emissions from atmospheric deposition of NO× and NH3 :

The Indirect N2O Emissions from atmospheric deposition of NO× and NH3 are presented in Table 4. Atmospheric deposition of nitrogen compounds such as nitrogen oxides (NO×) and ammonium (from NH_3) fertilize soil and surface waters and as such enhance biogenic N_2O formation.

Table 4: Indirect Nitrous oxide emissions from atmospheric deposition of NH3 and NO×

Type of deposition	Fertilizer type	Synthetic N applied to soil And N excretion by livestock (kg N/yr)	Amount of synthetic N applied to soil that volatilizes and N excretion by livestock that volatilizes (kg N /kg N)	N2O Emissions (Gg N_2O-N/yr)	
Synthetic N fertilizers	Urea	2245539864	224553986	2.246	3.05
	Ammonium Nitrate	746920958	74692096	0.7469	
	Calcium Nitrate	592286	59229	0.0006	
	Ammonium Sulphate	58161422	5816142	0.0582	
Type of animal	dairy cattle &Non dairy(animals No. 7652000)	382600000	76520000	0.7652	1.91
	Sheep (animals No. 8486000)	101832000	20366400	0.2037	
	Poultry (animals No. 692617000)	415570200	83114040	0.8311	
	Other animals (animals No. 1339400)	53576000	10715200	0.1072	
Total				4.9589	

The results indicated that, the indirect N_2O emission from the urea was 2.25 Gg N_2O-N/yr higher than the other N_2O emission recourses. The synthetic fertilizers is considered as the main source of indirect N_2O emissions from soils by N volatilizes, The synthetic N fertilizers gave the highest indirect N_2O emissions (3.052 Gg N_2O-N/yr) and the total indirect N2O emissions from animals by N excretion was (1.907 Gg N_2O-N/yr). The Total Indirect emissions of N_2O from atmospheric deposition of NH_3 and NO_x (Synthetic fertilizers, animal waste) was 4.96 Gg N_2O-N/yr.

According to Van Der Hoek (1994) about 25 percent of total may be lost shortly as NH3 after application to soil. He also shows that this percentage depends considerably on the application technique used. For synthetic N fertilizer Her Hoek (1994) uses a much lower percentage of only 2 percent of the nitrogen used that is lost as NH_3. We use default value for NH_3 and NO× volatilization 0.1 kg nitrogen /kg synthetic fertilizer nitrogen applied to soils and 0.2 kg nitrogen /kg of nitrogen excreted by livestock.

Indirect N_2O emissions from leaching and runoff:

The Indirect N_2O Emissions from leaching are presented in Table 5. A considerable amount of fertilizer nitrogen is lost from agriculture soils through leaching and runoff. The leached/runoff nitrogen enters groundwater, riparian areas and wetlands, rivers and eventually the coastal ocean.

The results in Table 5 show that, the main source for indirect N2O from leaching and runoff was synthetic fertilizer (emit 22.88 Gg N2O/yr), the total indirect emissions from leaching and runoff was 30.036 Gg N_2O-N/yr. A WHO/UNEP report (1989) showed that over 10 percent of European rivers had a nitrate content ranging from 9 to 25 mg nitrate-N/L. Fertilizer nitrogen in ground water and surface waters enhances biogenic production of N2O as the nitrogen undergoes nitrification and denitrification.

Table 5: Indirect Nitrous oxide emissions from leaching

Items		Synthetic fertilizer use and N excretion by livestock (Ton//yr)	N_2O emissions (Gg N_2O-N/yr)	
Synthetic fertilizer use	Urea	2245540	16.842	22.88
	Ammonium Nitrate	746921	5.602	
	Calcium Nitrate	592.286	0.004	
	Ammonium Sulphate	58161	0.436	
Type of animal	dairy cattle &Non dairy	382600	2.869	7.15
	Sheep	101832	0.764	
	Poultry	415570	3.117	
	other animals	53576	0.402	
Total			30.036	

N_2O emissions from agriculture soils and CO_2 equivalent emissions:

The N_2O Emissions from agriculture soils and CO_2 equivalent emissions are presented in Table 6. Results indicated there're three main sources for N_2O emissions from soils by direct and indirect emissions. The direct emissions from agriculture fields and cultivation of Histosols gave the highest value N_2O soil emissions 68.54Gg N_2O-N/yr, the total indirect N_2O emission from soils was 34.98 54Gg N_2O-N/yr. The total N_2O emission from agriculture soils (direct and indirect emissions) was 103.54Gg N_2O-N/yr. The total N_2O emission from agriculture soils (direct and indirect emissions) was converted to carbon dioxide (CO_2) equivalent emissions. Total N_2O emission from agriculture soils (direct and indirect emissions) by CO2 equivalent emissions was 21248.1 Equ. Gg/yr.

Table 6: Nitrous oxide emissions from agriculture soils and CO2 equivalent emissions

Nitrous oxide emissions from agriculture soils	N2O Emission (Gg N2O-N/yr)	Emission in CO_2 Equ. Gg/yr
Direct emissions from agriculture fields and cultivation of Histosols	68.54	21248.1
Indirect Nitrous oxide emissions from atmospheric deposition of NH_3 and NO_x	4.96	1537.3
Indirect nitrous oxide emissions from leaching and runoff	30.04	9311.2
Total	103.54	32096.6

Mitigation options and constrains in agriculture:

Due to the gradual increase of population and the limitation of the cultivated area, intensive cropping has been performed. Thus, the annual requirement for fertilizers has been successively increased. It might be also surprising to note that the consumed fertilizers per hectare, in Egypt, are 10 times as much as that of the world average (Table 7).

Table 7: Comparison between the rats of the use fertilizer in several countries (Kg per hectare) 1986.

Fertilizer type	Egypt	USA	Japan	World average
N	259.3	21.8	128.2	15.4
P2O3	48.1	8.4	138.1	7.4
K2O	11.9	10.2	110.9	5.6
TOTAL	319.3	40.4	377.2	28.4

Source: FAO fertilizer year book, vol. 37, 1987, and Hamisa and El Mowelhi (1989).

The utilized nitrogen by plants from the chemical N fertilizers dose not exceed 30-40% thus, the losses, as ammonia volatilization and /or leaching nitrates, could be accounted to not less than 50%, while the remaining part (approx, 10%) may be retained by soils. In this concern, it is obvious that the supplementary addition of organic

N- fertilizers, particularly those which are biologically fixed as a result of bacterial inoculation, is of great value to soil fertility and to the plant production. In this connection, the effect of the produced inoculants (Azotobacerin) on the yield of some field crops, could be generally presented Table (8) and it could be concluded that the importance of using biofertilizers to reducing the use of chemical fertilizers and in turn high yield, it is an important factor in reducing the nitrate pollution in groundwater and greenhouse gas emission.

Table 8: average yields of some field crops, as affected by inoculation with Azotobactrin.

Crop	Applied fertilizer Kg N/Fed.				Average yield (Cereals: Ardab /Fed.) Cotton: kantar/Fed.)			
	Inoculation	Non inoculation	Saved Fert.		Inoculation	Non inoculation	Yield gain	
			Kg/Fed.	%			Amount	%
Cotton	225	300	75	25	10	8	2	25
Wheat	150	200	50	25	20	15	4	25
Maize	150	200	50	25	24	16	8	50

Source: Yz Ishac (Unpublished NARP-report).

Response of maize to N fertilizer splitting :

Not only the nitrogen rate, but also the time of N application (Better timing of applications fertilizers) are considered among the important agricultural practices used to minimize nitrogen loses (leaching and runoff) and increase maize productivity. The results (Table 9) indicated that the addition of N in four equal splits improved maize grain yield and saving the N fertilizer.

Table 9: grain yield as affected by different N splitting treatments

N splitting treatments(N) N was soil added at the level of 120 kg N/fed.	Grain yield (Ardab/Fed.)
T_1= ¼ at planting + ¼ at 20 days after planting (DAP)+ ¼ at 40 DAP+ ¼ at 60 DAP.	18.73
T_2= 1/3 at planting + 1/3 at 40 DAP+ 1/3 at 60 DAP.	16.93
T_3= 1/3 at planting + 1/3 at 20 DAP+ 1/3 at 40 DAP.	17.61
T_4= 1/3 at planting + 1/3 at 20 DAP+ 1/3 at 60 DAP.	16.8

Greenhouse gas emissions of high and low inputs used in agriculture. Performance of crops with variable rates and time of N application are considered among the important agricultural practices used to minimize nitrogen loses. The results indicated that the recommended rate of fertilizer in term of yield response, net returns. The increase application of fertilizer increased total GHG. This increase in fertilizer caused increase in total N2O emission. The Nutrient Best Management Practices is very important for the reduction of Greenhouse Gas Emissions.

Strategies management to reduce nitrogen losses in animal production :

Conservation of N in animal production must begin by improving the N use efficiency of the animals. On dairy farms today, 20 to 30% of the N consumed by the herd is in the protein of the milk and meat produced, and the remainder is excreted in manure (Dou *et al.*, 1996; Kohn *et al.*, 1997; Oenema *et al.*, 2001a). Pasture-fed dairy animals are at the lower end of this range, and pasture-produced beef have a N use efficiency of less than 10% (Hutchings *et al.*, 1996). When finishing beef in a feedlot, about 10% of the N intake is retained in body tissue (Bierman et al., 1999). In poultry production, where the protein needs of the animals can be more closely met, this efficiency may average 30 to 35% and even approach 40% (Mohan *et al.*, 1996; Jongbloed *et al.*, 1997; Lee *et al.*, 1998; Lindberg and Andersson, 1998; Lenis and Jongbloed, 1999; Han *et al.*, 2001). Through various management techniques, these utilization efficiencies can be increased. The maximum possible efficiency varies with animal species, age, stage of lactation, and so on, but this theoretical limit is about 50%. Whole-farm management is necessary to decrease nitrogen losses in animal production. If steps are taken to reduce loss in one component of the farm, the nitrogen saved will likely be lost elsewhere if all components are not equally well managed. Management must focus on improving the nitrogen use efficiency of the animals to reduce nitrogen excretion, retaining that nitrogen in the manure until it is incorporated into the soil, and applying the appropriate amount of manure in a timely manner to enhance crop uptake. Management of all the factors involved in the nitrogen cycle of the farm is complex. Whole-farm research on nitrogen management is needed (Rotz 2004)

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Inventory and mitigation of nitrous oxides from agriculture soils

انبعاث اكاسيد النيتروز المسببة لغازات للاحتباس الحراري من التربة الزراعية وخيارات الحد من اثر الانبعاث تحت الظروف المصرية

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المعمل المركزي للمناخ الزراعي- مركز البحوث الزراعية- الجيزة – مصر

تعتبر الأكاسيد الأزوتية (أول أكسيد النيتروز NO وثاني أكسيد النيتروز N_2O) من غازات الاحتباس الحراري التي تلعب دور كبير في كيمياء الغلاف الجوي ومن أقوى العوازل إذ يحتجز ثاني أكسيد النيتروجين N_2O كمية حرارة ٣١٠ مرة أكثر من ثاني أكسيد الكربونCO_2. من اهم مصادر انبعاث هذا الغاز هو الأسمدة المعدنية والعضوية المضافة للتربة الزراعية. تختلف كميات انبعاث ثاني أكسيد النيتروز من التربة تبعا لنوع التربة ، ورطوبتها ، ودرجة الحرارة ، طول الموسم الزراعي ، نوع المحصول ، ونوع التسميد. انبعاث ثاني أكسيد النيتروز من التربة يكون من خلال مسارات حيوية كما يختلف معدل الانبعاث يختلف تبعا لنوع وطريقة اضافة الاسمدة واستخدامات التربة واستمرارية ميكروبات الدنترة بالتربة. ميكروبات الدنترة موجودة طبيعيا بالتربة ولكن يزداد الانبعاث عندما يتم إضافة الأسمدة الكيميائية للتربة. الهدف الرئيسي من هذه الدراسة هو تقدير انبعاث غازات اكاسيد النيتروز من التربة الزراعية وتحديد خيارات تخفيف الانبعاث تحت الظروف المصرية. تم تقدير الانبعاث باستخدام الطرق المحددة من قبل الحكومية للتغيرات المناخية (IPCC) .

أشارت النتائج إلى الأتي:

١ – اجمالى انبعاث ثاني اكسيد النيتروز المباشر من الحقول الزراعية والزراعات العضوية كان ٦٨,٥٤ جيجاجرام N2O / سنة.

٢ – الانبعاثات غير المباشرة لاكاسيد النيتروز من الغلاف الجوي فى صورة امونيا او اكاسيد نيتروز كان ٤,٩٦ جيجاجرام N_2O / سنة.

٣- الانبعاثات غير المباشرة لاكاسيد النيتروز من التسرب لطبقات التربة او الجريان السطحي كان ٣٠,٠٤ جيجاجرام N2O / سنة .

٤- اجمالي كمية انبعاث اكاسيد النيتروز من التربة الزراعية كانت ١٠٣,٥٤ جيجاجرامN_2O/سنة) أي ما يعادل الانبعاث ٣٢٠٩٦,٦ جيجاجرام مكافئ CO_2 / سنة.

وأفادت النتائج ان اهم خيارات تخفيف الانبعاث هي:

١- تقليل استخدام الاسمدة الكيماوية بمعدل ٢٥% مع اضافة الاسمدة الحيوية التي تؤدى الى زيادة فى المحصول تزيد عن ٢٠%.

٢- تجزئة جرعات الاسمدة الازوتية لتقليل الفاقد منها عن طريق الترشيح فى طبقات التربة السفلى او الجريان السطحي. اقترحت النتائج ان تقليل اضافة الاسمدة وتحقيق الاستفادة العظمي منها يقلل من انبعاث غازات اكاسيدالنيتروز.