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AMMONIA VOLATILIZATION LOSS FROM SOIL APPLIED NITROGENOUS FERTILIZERS [1]

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ABSTRACT

Nitrogen loss through NH_3 volatilization from soil-applied N-contaning fertilizers is a potential problem affecting the efficiency of fertilizer in crop production. The magnitude of NH_3 loss by volatilization is strongly influenced by soil, environmental and management factors. Fertilizer N losses from agricultural systems have varied between 20 and 80 % of the amount applied. Thus, such a substantial loss is not only important for the efficiency of fertilizers but also has a great interest in both economic and environmental considerations. For those reasons, further research on ammonia volatilization losses and development of methodology to reduce NH_3 losses under field conditions are still needed for an improved understanding of this phenomenon.

1. Introduction

Agricultural production is dependent on N fertilizer, and a quarter and a third of input energy used in farming in particularly developed countries is attributable to fertilizer manufacture. On the of other hand, it is estimated that fertilizer N losses from agricultural systems have varied between 20 and 80 % of the amount applied. Thus, N loss from agricultural systems is an expensive waste of resources.

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From economic and environmental point of considerations much attention must be given on these losses. Discussion of this paper is focussed on nitrogen losses through NH_3 gas volatilization from nitrogen bearing fertilizers particularly urea. Because, urea is now the most popular worldwide solid nitrogen fertilizer and its use in agriculture is growing more rapidly than that of any other nitrogeneous fertilizer.

Ammonia volatilization from urea and some other nitrogen fertilizers is a considerable problem in Turkish soils because the soils proporties, such as relatively high pH and calcium carbonate contents, and climatic condition (high temperature, low humidity and relatively high wind speed) are more attractive for ammonia volatilization.

This paper is in part briefly concerned with the loss pathways of ammonia and an estimate of these losses in Turkey.

2. Ammonia volatilization

Nitrogen is transferred in gaseous forms from the earth's surfaces to the atmosphere through NH_3 volatilization from soils, waters and plant leaves. During chemodenitrification, nitrifaction and cumbustion of organic residues considerable amount of N_2 and NO_x (N-oxides) are also released. Estimates of NH_3-N volatilized annually from the global biosphere range from 18 to 244 million tons/year and N loss as N_2 and N_2O through denitrification range from 107 to 390 millions tons/year *(Hauck,1983)*. Söderlund and Svensson (1976) estimated as much as 240 million tons of NH_3-N may be returned annually from atmosphere to the earth's surfaces.

In this paper we deal with only ammonia volitilization and it's economic importance.

2.1. Losses during ammonia production and application of anhydrous NH_3

Almost all nitrogeneous fertilizers are derived from NH_3. During manufacture, storage, distribution and application to the field some NH_3

is lost as gas form. The estimates of total NH_3 emissions during production is about range from 0.55 % to 0.15 % of production according to technology used. On the otherhand, it is estimated that 10-20 % of the NH_3-N produced is lost during handling and transport *(Barber, 1978)*.

Barber (1978) has also estimated that an average 5 % loss of NH_3 occurred during the injection of anhydrous ammonia. In the field ammonia losses have been reported as negligible to 75 % of the ammonia applied for silty loam and sandy soils respectively *(Baker et al. 1959)*.

Ammonia in irrigation water also may be volatilized during irrigation or from the soil drying after irrigation. These losses may be negligible to as much 80 % of the N applied in the concentration range of 50 to 110 ppm NH_3-N in the irrigation water. The extend and rate of loss vary with NH_3 concentration, pH of the irrigation water and soil, rate of water penetration into soil, air and water turbulance and temparature during irrigation *(Miyamoto et al. 1975)*.

2.2. Loss from solid nitrogen fertilizers

The extent of N loss from various solid nitrogen fertilizers as NH_3 volatilization depending von many factors. These factors may be summarized as follows;

a) Soil physical and biochemical properties; such as soil texture, pH, temperature, water content, cationexchange capacity, $CaCO_3$ content etc.,

b) The rate, characteristics of fertilizer and manner of application and,

c) Environmental conditions; such as rain, temparature, wind speed etc.

The use of urea as a nitrogen fertilizer is becoming the major N source in worldagriculture. Therefore, special attention should be given to the problem associated with use of urea as a fertilizer. Of these problems, most research has been focussed on NH_3 evolution from urea that is applied to the soil. The extent of N loss from surface-applied urea ranges from % 1 - % 50 of the N applied, depending on soil characteristics and environmental factors.

Ammonia can be liberated from ammonium salts used as fertilizer. Nitrogen loss as ammonia from surface-applied ammonium fertilizers is greatest in alkaline an calcareous soils. These fertilizer form acid environment in soil in which ammonium remain as NH_4 ion thereby in acid soils ammonia volatilization risk is less than that of alkaline soils.

In alkaline soils, the liberation of NH_3 from ammonium fertilizers increases with decrease in solubility of the reaction product of the ammonium salt with calcium. Thus Terman and *Hunt (1964)* reported NH_3 loss from diammonium phosphate and ammonium sulphate which form relatively insoluble calcium salts but not the same extent from ammonium nitrate which it's reaction product with calcium is soluble calcium nitrate. Eventhough *Hargrove et. al. (1977)* observed significant losses from ammonium sulphate and ammonium nitrate applied to the calcereous soil. The extent of NH_3 losses were found 35 % and % 10 for ammonium sulphate and ammonium nitrate respectively.

3. An Estimate of NH_3 loss in Türkiye and it's economic Importance

Ammonia loss from urea and the other ammonium fertilizer must be a severe problem in Türkiye because most of Türkiye soil sare calcereous and have relatively high pH.

In Türkiye according to data of 1990 nearly 1 million tons of pure nitrogen was used in agriculture. When we follow the tables shown on next page the annual loss from urea, ammonium sulphate, DAP and ammonium nitrate was estimated as $230x10^3$ tons-N/year. This amount of lost is equal to nearly 940 billion TL. If the other N-sources (such as MAP, CAN etc) are included into above figure, N-loss through NH_3 volatilization may be reaches 250×10^3 tons-N/year. This amount of N costs nearly 1 billion TL/year or 200 million $.

4. Reducing Ammonia volatilization

The soil properties such as soil pH, buffering capacity, CEC, exchangeable cation composition and urease activity significantly influence NH_3 volatilization. On the other hand, environmental factors, such as temparature, soil water content and wind velocity play an important role in determining the magnitute of NH_3 loss under field conditions.

Therefore, reducing ammonia volatilization is only possible by controlling management factors. These measures influences the extent of loss by modifying soil properties, hydrolysis rate, chemical equilibria and microcite ecologycal conditions.

It seems possible to reduce ammonia volatilization losses by improved soil, fertilizer and crop management measures. These measures can be summarized as follows:

a) Choosing correct nitrogen source and application method, according to soil and environmental contitions,

b) If possible, fertilizer modifications must be done by using acidifying, coating and salt bearing materials,

c) Several chemicals have been shown to inhibit enzymatic hydrolysis of urea. So these chemicals can be used for reducing NH_3 loss from urea after these have consistenly proven to be successful under field conditions and,

d) Ammonia volatilization generally is increased by crop residues present on the soil surface. So, such a management practice must be avoided if possible.

Table 1. The amount of urea, ammonium sulphate, DAP and amonium nitrate used in Agriculture (x 10^3 tons)

Fertilizer	Amount (x10^3 tons)	Equivalent-N (x10^3 tons)
Urea (45 % N)	627.2	282.2
A.S. (21 % N)	450.3	94.6
A.N. (26 % N)	1659.6	431.5
DAP (18 % N)	618.5	111.3
Total	3355.6	919.6

Table 2. Estimate of ammonia-N losses (x10^3 tons/year)

Fertilizer	N-lost (x10^3 tons)	Equivalent-N (x10^3 tons)
Urea (45 % N)	127.0	282.2
A.S. (21 % N)	37.8	180.0
A.N. (26 % N)	43.2	166.2
DAP (18 % N)	22.3	123.7
Total	230.3	752.0

Table 3. Estimate of annual lost (TL)

Fertilizer	Fertilizer lost	Price (TL/kg)	Lost (x10^9 TL)
Urea	282.2	1331	375.6
A.S.	180.0	856	154.2
A.N.	166.2	1100	182.6
DAP	123.7	1838	227.4
Total	752.0	51	940.0

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