

The international research progress of Ammonia(NH₃) emissions and emissions reduction technology in farmland ecosystem

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Abstract. NH₃ is the important factor leading to the grey haze, and one of the main causes of environmental problems of serious ecological imbalance, such as acid rain and air quality deterioration. The fertilizer excessive application of the current farmland results NH₃ emissions intensity greatly. In order to clear the farmland NH₃ emissions research status and achievements, the literature of farmland NH₃ emission related were retrieved by the SCI journals and Chinese science citation database. Some factors of NH₃ emission were analyzed such as soil factors, climate factors and farmland management measures. The research progress was inducted on farmland NH₃ emission reduction technology. The results will help to clarify farmland NH₃ emissions research progress. The theoretical guidance was provided on the future of farmland NH₃ emissions research.

1. Introduction

NH₃ emissions is the largest in the gas of containing N^[1]. NH₃ is the only source of particulate NH₄⁺ and alkaline gaseous substance in the gas. The NH₃ 90 percent was converted to NH₄⁺, which was reacted with the acid in the atmosphere. There are NH₄⁺ 84 percent photochemical reactions. NH₃ exists in aerosol particles with NH₄NO₃, (NH₄)₂SO₄ and NH₄Cl binding mode(such as PM_{2.5})^[2,3]. especially the haze formation process, they accounted for 30 percent to 70 percent of PM_{2.5} mass concentration^[4]. Simultaneously, the NH₃ accumulating in the atmosphere will be oxidized into N₂O and NO, etc. The N₂O is not only an important greenhouse gas, but also participate in the stratospheric optical process, destroy the ozone layer, enhance ultraviolet radiation to the earth's surface, causing environmental pollution and huge economic losses^[5]. The increase of NH₃ concentration in atmosphere is closely related to the change of agricultural production mode. Agricultural production is an important source of NH₃ emissions^[6].

2. NH₃ emissions research progress at home and abroad

In recent years, a lot of field data have been accumulated at home and abroad on the NH₃ emissions. Some researchers have done a lot of quantitative research on the NH₃ emission rate and influencing factors under field conditions. There are 3 main factors affecting the NH₃-N loss of nitrogenous fertilizer, such as soil properties, meteorological conditions and agricultural technical measures^[7,8].

2.1. Soil factors

Soil pH is one of the important factors affecting NH₃ emissions. The NH₃ emissions increase with the



increase of soil pH value^[9]. Urea applied into the soil, the soil pH increase after a short period of time, and reach maximum on the second day after fertigation, then fell rapidly, and maintain between 7.6-8.0. Some is absorbed by crops in the hydrolysis product NH_4^+ , part are transformed into NO_3^- -N, part are adsorbed by soil, the rest are released into atmosphere in the form of NH_3 emission loss. The soil cation exchange capacity (CEC) changes H^+ concentration in soil solution, adsorb NH_4^+ and NH_3 strongly, decrease the concentration of NH_3 , inhibit NH_3 emission, reduce NH_3 emission^[10]. Xiao(2016) studied soil's clay content was much and organic matter content was high in winter wheat field, and cumulative NH_3 emissions is 3.40-5.06 kg N/hm² in different fertilization treatment. The reason is that the texture of clay soil has a strong adsorption capacity of NH_4^+ generally, reduce the NH_4^+ content in the soil liquid phase effectively, thus reduce the loss of NH_3 emission^[11,12]. CaCO_3 content and total salt content in soil were closely related to the NH_3 emission of nitrogen fertilizer. Zhu(1989) researched that urea is in calcareous soil contained more calcium carbonate, NH_3 emission was more than that in acid paddy soil. Dry land, especially, on calcareous soil, NH_3 emissions is a great loss on application of urea and ammonium bicarbonate^[13].

2.2. Meteorological factors

Soil temperature directly affects the $\text{NH}_4^+ \rightleftharpoons \text{NH}_3 + \text{H}^+$ reaction equilibrium constant and NH_3 diffusion rate from the soil to the atmosphere. Temperatures elevated accelerate the emission rate of NH_3 . On the one hand, Temperature increased the proportion of the liquid NH_4^+ -N in the total ammonia significantly and promotes NH_4^+ conversion to NH_3 . On the other hand, the soil urease activity increased with the increase of temperature^[15].

There is a close relationship between the NH_3 emission and precipitation and other environmental factors in the field of nitrogen fertilizer. Nastr(2000) studied that fertilizer was brought into the deep soil with the rain infiltration, thereby reducing the loss of NH_3 emissions^[16]. The rainfall reduced NH_3 emissions a week after fertilization significantly. Rainfall duration affects NH_3 emission^[17]. However, a small amount of rain affected NH_3 emissions under irrigation conditions^[18,19].

2.3. Agricultural management measures

It is difficult that the researchers realize the NH_3 emission reduction in agricultural production practice by changing the physical and chemical properties of soil and climate environment. How to reduce the NH_3 emission losses in agricultural production, it is the key for adjustment of agricultural management measures. Agricultural management practices influence NH_3 emissions significantly.

2.3.1. Fertilizer amount. NH_3 emissions were positively correlated with the amount of nitrogen application^[20]. Zhang(2007) studied that NH_3 emissions were 8.2-28.7kg/hm² and 21.8-62.1kg/hm² on different fertilizer levels of rice season. NH_3 emissions accounted for 3.7%-8.8% and 10.0%-18.9% of urea application rate^[21]. Wang(2006) show that increasing N application rate significantly increased soil NH_3 emission rate^[22]. The peak of NH_3 emission rate in different nitrogen application treatments appeared at third days (N 140~165 g/hm²h) and fifth days (N 100~400g/hm²h). The effective way to reduce the loss of nitrogen fertilizer was to control nitrogen fertilizer application amount^[4,23].

2.3.2. Tillage and fertilization methods. A variety of N fertilizer deep application technology to reduce the effect of NH_3 emission is better by reducing the time of NH_4^+ -N fertilizer exposed to the air than surface application. NH_3 emission is the strongest in the case of surface application of N fertilizer, NH_3 emissions on a mixed mode of surface and deep application fertilization are less than that of surface application, and that is weakest on deep application.

2.3.3. Fertilization application period. Fertilizer application period significantly affected NH_3 emission losses. NH_3 emission rate was the highest in tillering fertilizer, and panicle fertilizer was the lowest. Wang Xiubin studied the total amount of NH_3 emission in different fertilization application period. The results showed that the method of reducing the amount of nitrogen application and nitrogen fertilizer application delayed backwards in time can reduce the loss of NH_3 emission and

increase the yield^[24,25,26]. NO_3^- -N and NH_4^+ -N seasonal dynamic changes are different on different nitrogen treatment of soil, and mainly depends on the different nitrogen fertilizer N release characteristics, fertilizer use time and Fertilizer use by several times, etc^[27].

3. Conclusions

In fact, to take effective control measures, this problem is not confined to China, but worldwide. To strengthen the following several aspects:

In recent years, the domestic scientific research workers studied more NH_3 emission factors, however, most of the existing research focused on paddy and corn field ecosystem. NH_3 emissions vary for the planting patterns and soil environment. To achieve accurate quantitative evaluation model of NH_3 emissions, it is necessary for NH_3 emissions affecting factors and mechanism research on different ecological conditions, different planting patterns and different types of farmland soil.

Previous studies have a lot of potted plants and greenhouse cultivation on NH_3 emissions research work. Their environmental factors control is different on field crops compared in situ observation study, such as moisture and temperature. To strengthen the wild farmland NH_3 emission research, measures of NH_3 emission reduction can help farmland the practical application.

Temperature effect on NH_3 emissions research results are inconsistent. Some think temperature and NH_3 emissions have significant positive correlation, however, some studies suggest temperature is not NH_3 emissions limits. the following work need study temperature to influence the NH_3 emission, to clear temperature influence mechanism of NH_3 emissions on different ecological environment.

To agricultural sustainable development, future research direction must adhere to the general principle of "high-yield, high-quality, high efficiency" and "low consumption, no pollution", actively research the effective and easy technology to reduce NH_3 emission loss.

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