Characteristics of Ammonia Volatilization of the Typical *Calamagrostis angustifolia* Wetland Soils in the Sanjiang Plain, Northeast China[*]

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Abstract: From May to October in 2005, the ammonia (NH_3) volatilization from the soils of typical meadow *C. agustifolia* wetland (TMCW) and marsh meadow *C. agustifolia* wetland (MMCW) in the Sanjiang Plain of Northeast China were determined *in situ* with venting method. Results showed that the change trends of NH_3 volatilization rates and cumulative NH_3 volatilization amounts on the two typical *C. agustifolia* wetland soils were basically the same. The NH_3 volatilization rates of MMCW were relatively high, with an average value being 1.35±0.53 ($\pm$S.D., $n = 16$) folds of TMCW. In growing season, the total NH_3 volatilization amounts of TMCW and MMCW soils were 0.635 gN/m^2 and 0.687 gN/m^2, respectively. Compared with the nitrogen wet deposition amount (0.757 $gN/(m^2 \cdot a)$) of Sanjiang Plain in 2005, the NH_3 volatilization played an important role in the nitrogen balance of *C. angustifolia* wetland ecosystem. Further analysis indicated that the storage of soil nitrogenous compounds was not the limiting factor affecting NH_3 volatilization process, while atmospheric temperature and other temperature fluctuations were the important factors affecting the changes of NH_3 volatilization rates. The precipitation and the fluctuation and dissipation of soil water were the inducers of the partial fluctuation of NH_3 volatilization rates, while soil pH and texture were the main factors inducing lower NH_3 volatilization rates.

Key words: venting method; ammonia volatilization; *Calamagrostis angustifolia*; wetland; Sanjiang Plain.

1 Introduction

Ammonia (NH_3) volatilization is an important process for wetland nitrogen loss occurred in the surface of soil-water-atmosphere[1]. NH_3 is a sort of greenhouse gas which can absorb radialization at the wavelength of 10.53 μm[2], and has significant effects on global warming. NH_3 can be reacted with free radical (OH) in atmosphere to NH_2, and NH_2 also can be reacted with O_3, NO or NO_2 to N_2, N_2O or NO_X. In NH_3 transformation process, both NH_3 and its transformation product (N_2O) are the important gases, which can destroy O_3 and cause global warming[3]. NH_3 is also one and only gaseous alkali in atmosphere, it dissolves in water and can have neutral reaction with acidic aerosol or acid in precipitation, which has significant functions to prevent the acid rain from being formed[4]. Although the NH_3 in atmosphere can be re-imported into wetland ecosystems in the form of dry or wet deposition, as wetland only accounts for 6% of the terrestrial area, most of them are imported into forest, grassland, rivers or lakes which can induce the elevation of nitrogen content in soils and water bodies. Loading of excessive nitrogen to surface water or soil may cause many environmental problems, such as water eutropication and soil acidification, and have significant effects on the distribution and succession of species[5].

At present, many quantitative studies on the process of NH_3 volatilization in wetland have been widely reported. Fillery and Simpson[6] studied the influence of field environment and fertilizer management on NH_3 loss from flooded soil and established the relationship between NH_3 volatilization amount and wind speed. Fillery and De Datta[7] also studied the NH_3 volatilization mechanism from flooded rice fields. Martin and Reddy[8] found that soil pH was an important factor affecting NH_3 volatilization process in wetland, and the transformation process from NH_4^+-N to NH_3-N was mainly controlled by pH in water-soil system. Rao et al.[9] established the quantitative transformation relationship between water or soil pH and NH_4^+-N when they studied the NH_3 volatilization process in flooded soils. Hutson and Wagenet[10] simulated the nitrogen dynamics in soils using a deterministic model and found that, the NH_3 volatilization process accorded with the first-order kinetic equation. Chowdary et al.[11] also considered that the NH_3 volatilization process accorded with the first-order kinetic equation when they studied the nitrogen process in flooded rice fields in India with a coupled soil water and nitrogen balance model. In Chinese relative research fields, Zhu[12] studied the NH_3 volatilization loss and nitrogen management measures of agro-ecosystem. Cai and Zhu[13] evaluated the NH_3 volatilization losses from fertilizers applied to flooded rice fields. Tian & Song[14, 15] studied the NH_3 volatilization from paddy fields and its affecting factors in Zhenjiang hilly region and Taihu lake region, respectively. Duan et al.[16] established the quantitative relationship among NH_3 volatilization amount, soil pH and cation exchange capacity (CEC). Gao and Zhang[17] also elucidated the relationship between NH_3 volatilization and soil water dissipation in arid land soil. In general, the current researches in China mostly concentrate on agro-ecosystems and artificial wetland ecosystems (paddy field), and the information about natural wetland ecosystem is scarce.

The Sanjiang Plain is one of the biggest regions in northeast China, where wetland is widely distributed and the wetland types are variety. *Calamagrostis angustifolia* wetland is the main wetland type in the Sanjiang Plain (accounts for 34.45% of total area of wetland), which includes typical meadow *C. angustifolia* wetland (TMCW, no standing water) and marsh meadow *C. angustifolia* wetland (MMCW, with seasonal standing water)[18]. The two types of wetlands are located in different water gradient, which are sensitive to the changes of water conditions. In this paper, the venting method was applied to determine the NH_3 volatilization from the soils of TMCW and MMCW in the Sanjiang Plain in order to study the difference of NH_3 volatilization characteristics between them, and identify the main affecting factors.

2　Study Site and Methods

2.1　Study Site

From May to October in 2005, the study was carried out in experimental field at Ecological Experiment Station of Mire Wetland in the Sanjiang Plain, Chinese Academy of Sciences (latitude 47°35′ N; longitude 133°31′ E). The experimental field is located in river terrain between Bielahong River and Nongjiang River. It is at 55.4-57.0 m elevation and the total area is about 100 hm^2. The site is of typical continental monsoon climate, summer is warm and rainy while winter is long-term cold. Annual average temperature is 1.9 ℃ and the valid cumulative temperature is about 2300 ℃. The distribution of precipitation is odds in a year. The annual average precipitation is about 600 mm, and approximately sixty percent of it focuses on between June and September. The physiognomy type of experimental field is depressional wetland, which is the most typical distribution in the Sanjiang Plain. From centre to outside, the vegetations of depressional wetland are circularly distributed with *Carex pseudocuraica*, *Carex lasiocarpa* and *C. angustifolia*, etc. The soils are predominantly meadow marsh soil and humus marsh soil[19].

2.2　Materials and Methods

2.2.1　Capture equipment

The polyvinyl chloride pipe (inside diameter: 15 cm; height: 10 cm) and sponge (diameter: 16 cm; thickness: 2 cm) were used to make NH$_3$ capture equipment[20] (Fig. 1). In the process of determination, two sponges immersed with 15 mL phosphoglycerol solution (50 mL phosphoric acid, 40 mL propyl alcohol, diluted to 1000 mL) were installed in pipe as showed in Figure 1. The upper sponge was even with pipe top, and the nether sponge had 4 cm interval with pipe bottom.

2.2.2　Experimental design

The two typical determination microcosms were firstly selected, before experiment, in TMCW and MMCW plots, respectively. Three NH$_3$ capture equipments were placed in different sites of each microcosm, and the experiment was carried out after the sponges

Fig.1　Equipment of venting method for determination of NH$_3$ volatilization from wetland soil

were installed in capture equipments. The sampling frequency was 4-7 d which was based on the NH$_3$ volatilization amount determined by venting method. The upper sponges were replaced per 3-7 d which was based on humid status. On sampling date, the nether sponge was taken out and sealed in the plastic rapidly according to the serial number, and another sponge immersed with phosphoglycerol solution was replaced. After the sites of capture equipments were altered and the sponges were installed, the next absorption process was carried out. These processes were then repeated in turn in the following experiment. The sponges sealed in the plastics were transported to the laboratory and put into 500 mL plastic bottles respectively. 300 mL 1.0 mol/L KCL solution was added to the each plastic bottle (the sponges were immersed completely), and the ammonium nitrogen (NH$_4^+$-N) in lixivium was measured by SKALAR-SAN^{++} after shaking 1 h.

The NH$_3$ volatilization rate was calculated by the following equation:

$$\text{NH}_3 \text{ volatilization rate (kgN/(hm}^2 \cdot \text{d))} = [M/(A \times D)] \times 10^{-2} \qquad (1)$$

where M is NH$_3$ volatilization amount captured by single equipment (mg); A is the cross sectional area of capture equipment (m^2); D is capture time (d). The estimation of NH$_3$ volatilization amount in growing season was based on numerical integration method.

Moreover, the precipitation, atmospheric temperature, surface temperature, ground temperatures (5 cm, 10 cm), soil ammonium nitrogen (NH$_4^+$-N) and nitrate nitrogen (NO$_3^-$-N) contents, soil pH, soil texture and soil water contents were also determined in experimental process. The precipitation volume was determined by precipitation cylinder, and the atmospheric temperature and surface temperature, ground temperature were determined by weatherglass and geothermometer, respectively. The NH$_4^+$-N and NO$_3^-$-N contents were determined by SKALAR-SAN^{++} sequence flow analyzed instrument. The soil pH was measured by pH analyzed instrument. The soil texture was determined by granularity analyzed instrument, and the soil water content was determined by weight dried method.

2.2.3　Statistical analysis

The samples were presented as means over the replications, with standard deviation (S.D). The analysis of variance test (SPSS for windows 11.0) was employed to determine if samples differed significantly ($p < 0.05$).

3　Results and Discussion

3.1　Characteristics of NH$_3$ Volatilization

The determination results of NH$_3$ volatilization experiment showed that the change characteristics of NH$_3$ volatilization rates of TMCW and MMCW soils in growing season were basically the same, with two peaks and a valley before the middle ten days of July (Fig. 2). The first peak was appeared on May 31st, and the values were 0.151±0.003 kgN/(hm^2·d) for TMCW soil and 0.155±0.009 kgN/(hm^2·d) for MMCW soil. The second peak was appeared on July 10th, and the values were 0.173±0.008 kgN/(hm^2·d) and 0.182±0.003 kgN/(hm^2·d), respectively. The valley was appeared on June 14th, and the lower values were 0.077±0.011 kgN/(hm^2·d) and 0.069±0.001 kgN/(hm^2·d), respectively. After the middle ten days of July, the changes of NH$_3$ volatilization rates of TMCW and MMCW soils, as a whole, declined, and became smooth after August 18th, which indicated that the soils still could keep lower NH$_3$ volatilization rates (the means were 0.007±0.002 kgN/(hm^2·d) and 0.010±0.003 kgN/(hm^2·d), respectively) even at the end of growing season as the temperatures were much lower. Comparatively, the NH$_3$ volatilization rates of MMCW were relatively high, with an average value being 1.35±0.53 (±S.D., n=16) folds of TMCW, but there was no significant difference between them ($p >$
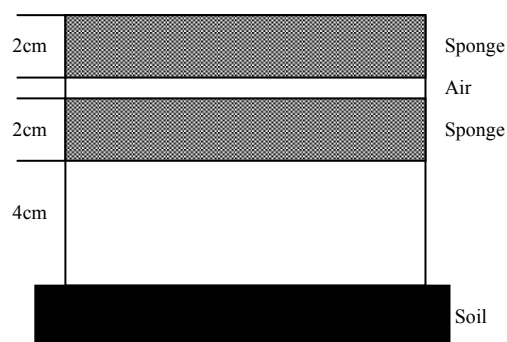
0.05). The change characteristics of cumulative NH$_3$ volatilization amounts were also basically the same, *i.e.*, they increased rapidly, before the middle ten days of July, and the values were relative proximity, but afterwards, the values increased slowly and had significant differentiations (Fig. 2). Further analysis indicated that the changes of cumulative NH$_3$ volatilization amounts between them also had no significant difference ($p > 0.05$). The estimation results showed that the total NH$_3$ volatilization amounts of TMCW and MMCW soils in growing season were 0.635 gN/m^2 and 0.687 gN/m^2, respectively, and the latter had a slightly higher value. Compared with the nitrogen wet deposition amount (0.757 gN/(m^2·a)) of Sanjiang Plain in 2005[21], the NH$_3$ volatilization amounts of wetland soils could not be neglected, which indicated that the NH$_3$ volatilization played an important role in the nitrogen balance of *C. angustifolia* wetland ecosystem.
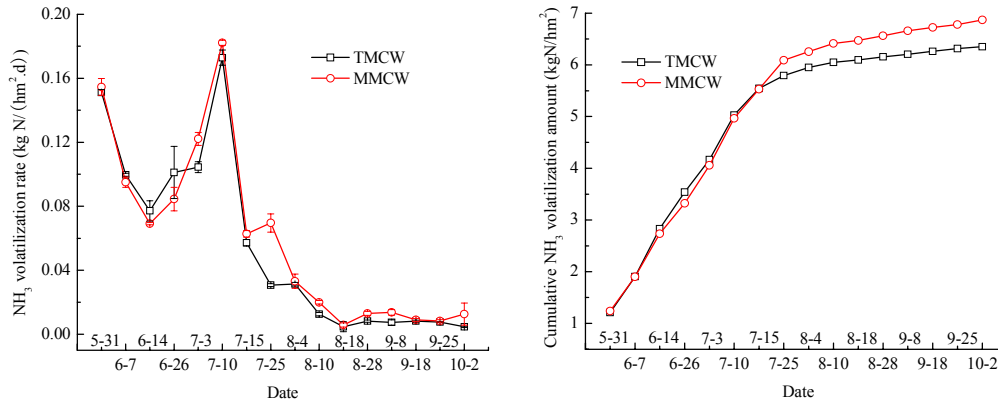

Fig. 2 NH$_3$ volatilization characteristics and cumulative NH$_3$ volatilization amounts of wetland soils in growing season Values are means (±S.D., n=3)

3.2 Analysis of Main Affecting Factors

The current researches indicated that the factors affecting NH$_3$ volatilization process mainly included atmospheric temperature, ground temperature, soil water content, soil pH, soil texture and the storage of soil nitrogenous compounds, etc.[6-17]. The temperature indirectly influenced NH$_3$ volatilization process mainly through affecting the chemical processes related to it[7]. Soil pH was an important affecting factor, because the transformation process from NH$_4^+$-N to NH$_3$-N was mainly controlled by pH in water-soil system[8]. Soil water content directly influenced NH$_3$ volatilization process through affecting the physical movement and chemical transformation of NH$_4^+$-N in soil[22]. Soil texture influenced NH$_3$ volatilization process mainly through affecting air permeability and the adsorption character to NH$_3$-N and NH$_4^+$-N[23], and the contents of NH$_4^+$-N and NO$_3^-$-N in soil directly determined the storage of nitrogenous compounds participated in NH$_3$ volatilization process.

In order to identify the main factors affecting NH$_3$ volatilization rates of the two typical *C. agustifolia* wetland soils, this paper filtrated the possible control factors through principal components analysis (Varimax), which was based on the above-mentioned environmental factors. The principal components were selected to calculate the loads according to the eigenvalue that the range of cumulative contribution rates was 85％-95％[24] (Table 1). The results showed that the first principal component (Z_1) of TMCW had significantly positive correlations with x_2, x_3 and x_4, and negative correlation with x_8 which could be considered as the representation of soil heat condition and the storage of soil nitrogenous compounds. The second principal component (Z_2) had significantly positive correlations with x_1, x_7 and x_9, which could be considered as the representation of atmospheric heat condition, soil physical property and the storage of soil nitrogenous compounds. The third principal component (Z_3) had significantly positive correlation with x_5 and negative correlation with x_6, which could be considered as the representation of soil water condition and acid or alkali status. Therefore, wetland heat condition, the storage of soil nitrogenous compounds and soil physical properties might be the possible control factors affecting NH$_3$ volatilization rates (the variance contribution rate was 66.54%), and soil water condition, acid or alkali status also had great effects on them (the variance contribution rate was 20.09%) (Table 2). In contrast with TMCW, the first principal component (Z_1) of MMCW had significantly positive correlations with x_2, x_3, x_4 and x_7, which could be considered as the representation of soil heat condition and physical properties. The second principal component (Z_2) had significantly positive correlations with x_1 and x_9, which could be considered as the representation of atmospheric heat condition and the storage of soil nitrogenous compounds. The third principal component (Z_3) had significantly positive correlation with x_5, x_6 and x_8, which could be considered as the representation of soil water content, acid or alkali status and the storage of soil nitrogenous compounds. Therefore, wetland heat condition, the storage of soil nitrogenous compounds and soil physical properties also might be the possible control factors affecting NH$_3$ volatilization rates (the variance contribution rate was 72.33%), and soil water condition, acid or alkali status also had important influences on them (the variance contribution rate was 13.99%) (Table 2). Based on the above-mentioned filtration, this paper analyzed, in detail, these possible control factors to identify the main affecting factors in the following study.

3.2.1 Wetland heat condition

Wetland heat condition had various effects on NH$_3$ volatilization process. The elevated temperature could increase the proportions of NH$_3$-N in soil liquid phase, and the diffusion rates of NH$_3$ and NH$_4^+$ were also increased[25]. The changes of atmospheric temperatures, surface temperatures and ground temperatures (5 cm, 10 cm) in TMCW and MMCW are shown in Figure 3. Results showed that the whole change trends of NH$_3$ volatilization rates and atmospheric temperatures were, to some extent, similar, but the similarity was lacked between NH$_3$ volatilization rates and surface temperatures or ground temperatures (5 cm, 10 cm)

(Fig. 2, Fig. 3). The correlation analysis indicated that the NH_3 volatilization rates had positive correlations with atmospheric temperatures, and the correlation coefficients were 0.454 and 0.392 ($n = 16$), respectively. However, the correlations between NH_3 volatilization rates and surface temperatures or ground temperatures (5 cm, 10 cm) were much lower. The main reason was that atmospheric temperature was the original heat source of wetland ecosystem, and the changes of surface temperature and ground temperature were, to great extent, controlled by the effects of it. This also indicated that atmospheric temperature, among many heat factors, had the most significant effect on the changes of NH_3 volatilization rates of the two typical *C. angustifolia* wetlands. The fluctuated changes (with two peaks and a valley) of NH_3 volatilization rates, before the middle ten days of July, were mainly correlated with atmospheric temperature fluctuation and other temperature fluctuations caused by it (Fig. 2, Fig. 3). But afterwards, the changes (monotony downtrend and smooth changing after the middle ten days of August) of NH_3 volatilization rates were mainly correlated with, as a whole, the gradual decline of atmospheric temperatures, surface temperatures and ground temperatures.

Table 1   Load of principal components

Environmental factor	Principal component (TMCW)			Principal component (MMCW)		
	Z_1	Z_2	Z_3	Z_1	Z_2	Z_3
Atmospheric temperature x_1	0.364	0.919	0.122	9.500E-02	0.850	-0.413
Surface temperature x_2	0.781	0.541	0.266	0.903	4.421E-02	-0.387
5cm ground temperature x_3	0.951	0.242	9.677E-02	0.824	0.346	-0.323
10cm ground temperature x_4	0.948	1.237E-02	8.960E-02	0.980	2.349E-02	-7.665E-02
Soil water content x_5	8.933E-05	-6.105E-02	0.943	-1.290E-03	-0.662	0.542
Soil pH x_6	-0.134	-0.156	-0.920	-5.042E-02	-0.131	0.852
Soil clay content x_7	7.036E-02	0.793	0.300	0.967	-0.119	0.139
Soil NO_3^--N content x_8	-0.793	0.394	0.153	-0.484	5.380E-02	0.675
Soil NH_4^+-N content x_9	-5.393E-02	0.762	0.234	4.998E-03	0.897	0.294

Table 2   Eigenvalue and principal component contribution rates

| Principal component	TMCW			MMCW		
	Eigenvalue	Contribution rate /%	Cumulative contribution rate /%	Eigenvalue	Contribution rate /%	Cumulative contribution rate /%
1	3.762	41.79	41.79	4.235	47.06	47.06
2	2.227	24.74	66.54	2.275	25.28	72.33
3	1.808	20.09	86.63	1.259	13.99	86.32
4	0.758	8.42	95.05	0.638	7.09	93.40
5	0.413	4.59	99.65	0.496	5.52	98.92
6	3.182E-02	0.35	100	9.718E-02	1.08	100
7	3.037E-16	3.37E-15	100	2.835E-16	3.15E-15	100
8	1.357E-16	1.51E-15	100	-2.132E-16	-2.37E-15	100
9	-6.923E-17	-7.692E-16	100	-8.839E-16	-9.821E-15	100
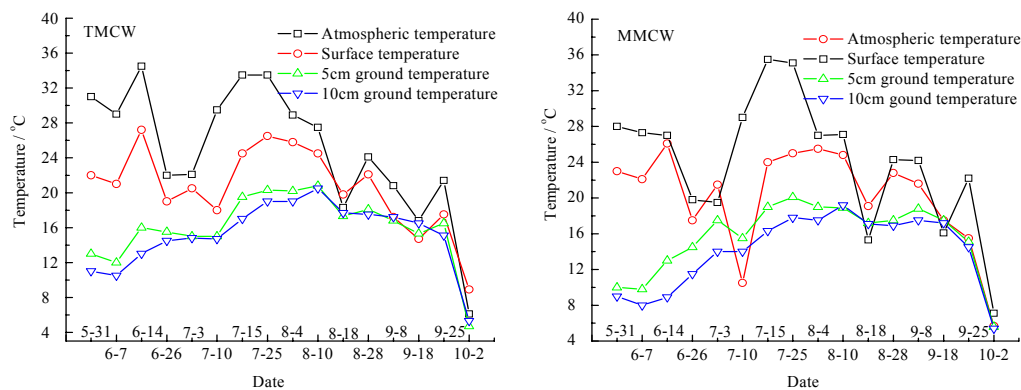
Fig. 3   Changes of temperatures in the two typical *C. angustifolia* wetlands

3.2.2   Storage of soil nitrogenous compounds

The NH_3 volatilization process in soil generally included the following chemical equilibrium, that was, NH_4^+ (interchangeability) $\Leftrightarrow NH_4^+$ (liquid phase) $\Leftrightarrow NH_3$ (liquid phase) $\Leftrightarrow NH_3$ (gas phase) $\Leftrightarrow NH_3$ (atmosphere). The factors inducing the chemical equilibrium to be processed rightward all facilitated NH_3 volatilization[15]. The contents of NH_4^+-N and NO_3^--N were the important material basement for the process of above-mentioned chemical equilibrium. The NH_4^+-N directly participated in NH_3 volatilization process, while NO_3^--N participated in the process indirectly by transforming into NH_4^+-N through DNRA (Dissimilatory Nitrate

Reduction to Ammonium) process[26]. The changes of NH_3 volatilization rates, NH_4^+-N and NO_3^--N contents in soils (0-20 cm) of the two typical *C. angustifolia* wetlands are shown in Figure 4. The results indicated that the NH_4^+-N or NO_3^--N contents in the two types of soils were comparatively approximate. Both of them changed smoothly except an abrupt increase was observed at the end of growing season. In general, the NH_4^+-N contents in the two typical *C. angustifolia* wetland soils were comparatively high, with the average value being 23.90±14.50 and 17.61±7.87 (n = 11) folds of NO_3^--N, respectively. This indicated that NH_4^+-N might be an important material basement participated in the process of NH_3 volatilization, and the relatively approximate material basement of the two typical *C. angustifolia* wetland soils might be the important reason to induce the NH_3 volatilization rates to be much approximated. Comparatively, there was no similarity between the changes of NH_3 volatilization rates and NH_4^+-N or NO_3^--N contents (Fig. 4). The correlation analysis showed that the NH_3 volatilization rates of TMCW had weak positive

Fig. 4 Changes of NH_3 volatilization rates and NH_4^+-N, NO_3^--N contents in the two typical *C. angustifolia* wetland soils

correlations with NH_4^+-N or NO_3^--N contents (the correlation coefficients were 0.336 and 0.237 (n = 11), respectively), while the values of MMCW had weak negative correlations with them (the correlation coefficients were -0.228 and -0.142 (n = 11), respectively). These indicated that, to some extent, the relatively abundant nitrogen in the two typical *C. angustifolia* wetland soils might have no significant effects on the process of NH_3 volatilization, while other factors might be the important driving forces.

3.2.3 Moisture conditions

The moisture conditions affecting NH_3 volatilization process mainly included soil water content and precipitation. Soil water content directly influenced the physical movement and chemical transformation of NH_4^+-N in soils, while precipitation indirectly affected NH_3 volatilization process through altering soil water content and increasing water infiltration. The correlation analysis showed that the NH_3 volatilization rates of TMCW had weak positive correlation with soil water contents (r = 0.084, n = 10), while the correlation between them in MMCW was negative (r = -0.294, n = 10), which was mainly correlated with the difference of moisture conditions in TMCW and MMCW. In contrast with TMCW, the surface of MMCW had seasonal standing water and kept excessive moistening status outlined previously. Therefore, the much water in MMCW soil could take NH_4^+-N to the deep soil layers through water infiltration, and this process increased its resistance raised to the surface layer and the chances of being adsorbed by soil granularity or absorbed by plant, which indirectly decreased the NH_3 volatilization amount[22]. The changes of precipitation and soil water contents of the two typical *C. angustifolia* wetlands in growing season were shown in Figure 5. The results indicated that the precipitation was mainly focused on the last ten days of July during study period, and the NH_3 volatilization rates presented downtrend during the period (Fig. 2), which implied that, to some extent, the abundant precipitation had significant inhibition on NH_3 volatilization process through increasing soil water infiltration and NH_4^+--N vertical movement. In addition, the fluctuation of soil water content also had significant response to the precipitation interval. The lower soil water content occurred in the period of long interval and little precipitation, while the partial fluctuation of NH_3 volatilization rates, on the whole, occurred in the period of water fluctuations (Fig. 2, Fig. 5). In general, the fluctuation of soil water content caused by precipitation, to some extent, indicated that the soil water in TMCW and MMCW had dissipation in different periods. Gao and Zhang[17] found that the NH_3 volatilization amount would be elevated as the increase of soil humidity if the soil water had dissipation. Therefore, the fluctuation of soil water content had significant promotion to the NH_3 volatilization process of the two typical *C. angustifolia* wetlands, but it only had comparatively significant effects on NH_3 volatilization in special periods.

Fig. 5 Changes of precipitation and soil water content in the two typical *C. angustifolia* wetlands

3.2.4 Soil physical property, acid or alkali status

Soil pH and texture were also the important factors affecting NH_3 volatilization process. Rao et al.[9] found that the NH_4^+-N would be largely transformed into NH_3-N if water or soil pH are between 8 and 9. Therefore, if soil pH was high, the proportion of NH_4^+-N in soil liquid phase would be elevated and the potential of NH_3 volatilization would be increased[25]. In this study, the soils of TMCW and MMCW were apt to acidity (pH: 5.36-6.37), which induced, in general, the NH_3 volatilization rates to be lower. The correlation analysis showed that the NH_3 volatilization rates had weak negative correlation with soil pH, and the correlation coefficients were -0.235 and -0.222 (n = 16), respectively. The analysis of soil granularity indicated that the proportions of clay in TMCW and MMCW soils were high (the values were 602.0 g/kg and 568.2 g/kg (n = 3), respectively), which directly influenced NH_3 volatilization process through affecting soil air permeability and the adsorption character to NH_3-N and NH_4^+-N (the former had much higher adsorption character). In general, the NH_3 volatilization amounts from coarse texture soil was much higher than those from fine texture soil, and the values from sand soil, sandy loam and loam soil were 5.2, 4.6 and 3.4 folds of clay soil, respectively[23].
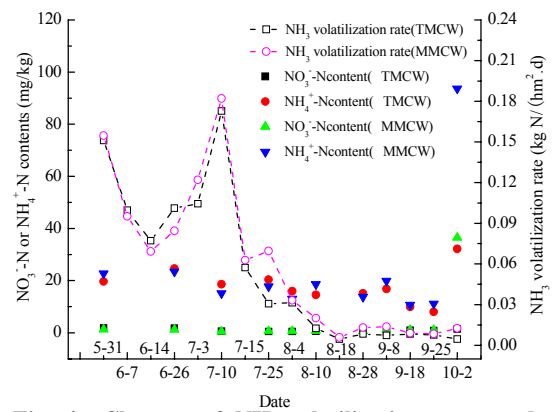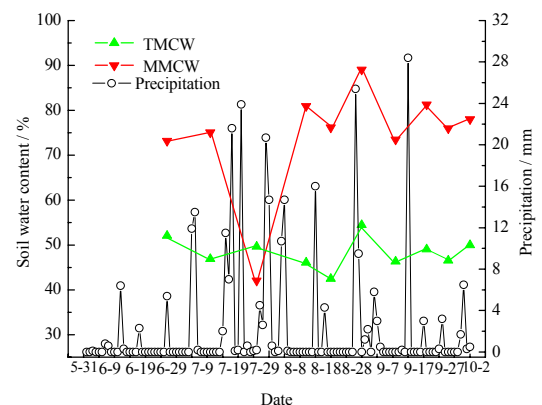
The clay content of MMCW soil was much lower than that of TMCW soil, which might be the important reason to induce the NH_3 volatilization amounts from MMCW soil to be much higher. The correlation analysis showed that the NH_3 volatilization rates had significantly negative correlations with soil clay content ($p < 0.05$), and the correlation coefficients were -0.505 and -0.613 ($n = 16$), respectively.

In general, the NH_3 volatilization was a complex kinetics process, and any single factor could not interpret all the complex details of it. Therefore, in order to understand the integrative actions of different factors, further studies still needed to be carried out.

4 Conclusions

The study of NH_3 volatilization, with venting method, from TMCW and MMCW soils had demonstrated that: (1) the change trends of NH_3 volatilization rates and cumulative NH_3 volatilization amounts on the two typical *C. agustifolia* wetland soils were basically the same. (2) The NH_3 volatilization rates of MMCW were relatively high, with an average value being 1.35±0.53 (±S.D., *n* = 16) folds of TMCW. The total NH_3 volatilization amounts of the two typical *C. agustifolia* wetland soils, in growing season, were 0.635 gN/m^2 and 0.687 gN/m^2, respectively. Compared with the nitrogen wet deposition amount (0.757 $gN/(m^2 \cdot a)$) of Sanjiang Plain in 2005, the NH_3 volatilization played an important role in the nitrogen balance of *C. angustifolia* wetland ecosystem. (3) The storage of soil nitrogenous compounds was not the limiting factor affecting NH_3 volatilization process, while atmospheric temperature and other temperature fluctuations were the important factors affecting the changes of NH_3 volatilization rates. The precipitation and the fluctuation and dissipation of soil water were the inducers of the partial fluctuation of NH_3 volatilization rates, while soil pH and texture were the main factors inducing lower NH_3 volatilization rates.

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