Bull. Environ. Contam. Toxicol. (2006) 76:728–731

DOI: 10.1007/s00128-006-0980-4

Bulletin of Environmental Contamination and Toxicology

Relationship Between Atmospheric Quality and Concentration of Nitrite in Condensed Water of Dehumidifier

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Received: 5 November 2004/Accepted: 6 February 2006

Nitrogen oxide in the atmosphere is harmful to the health of human in two aspects, that is, it can be inhaled into lungs and result in serious corrosion, thus causing pneumonedema, and it can also be brought into human body by eating the polluted food and result in anoxia in human-body tissues. Therefore, it is of significance to analyze the concentration of NO2- in atmospheric condensed water in terms of its close relationship with the atmospheric quality and the health of human beings.

Freezing is a commonly used method for collecting condensed water in air. However, only a small amount of water could be obtained by freezing and it usually takes a long time, and the volume of water obtained is hard to measure accurately (Jian and Wang 1995, Wang and Hu, 2001). Moreover, the sampling can only be performed at a temperature of over 5 ℃ and at an air humidity of over 55%; otherwise the collected amount of condensed water may fail to meet the quantitative requirements of analyses. To overcome these shortcomings, in this paper, a simple and convenient method was proposed to collect the condensed water in air, this was realized by using a domestic dehumidizer to collect the soluble substances in air.

MATERIALS AND METHODS

Sampling was carried out at the downtown, expressways, suburbs, countryside, industrial areas and natural landscapes of Zhongshan city (Guangdong province, P.R.China). Samples of condensed water and total suspended particles (TSP) were collected in duplicate. Ten common types of anions and cations were tested and the data presented here were the average values. The chemical compositions of correlation between condensed water and TSP in air were established by using the methods of mathematical statistics. To collect TSP, an intelligent sampler of the TH-1000C type was used, supplied by Tianhong Intelligent Apparatus Manufacturer (Wuhan, China). HM-120 Scale of AVD Company (Japan) was used for weighing the filter membrane of TSP. The monitored ions in this experiment contrasting aqueous vapour with TSP are F^-, Cl^-, NO^{2-}, NO^{3-}, SO_4^{2-}, Na^+, NH_4^+, K^+, Ca^{2+} and Mg^{2+}. All ions were quantitatively measured by Ionic Chromatograph of 761 Compact Type provided by Metrohm in Switzerland.

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The primary distilled water was generated by quartz-glass water distillation. The water source was the municipal tap water. The secondary de-ionized water was produced by Water Purifier of Milli-QRG (Millipore, U.S.A.).

The conversion formula for TSP is

$$i=c_i v_i/V_i \quad (1)$$

i is a certain ingredient in TSP sampler, mg/ m^3; c_i is the monitoring concentration of a certain ingredient in TSP, mg/L; v_i is the volume of water used to dissolve TSP, L ; V_i is the air sample volume of TSP under the standard condition, m^3.

The conversion formula for aqueous vapour is

$$j=c_j v_j/V_j \quad (2)$$

j is the concentration of a certain ingredient in the sample of aqueous vapour, mg/ m^3; c_j is the monitoring concentration of a certain ingredient in condensed water, mg/L; v_j is the total condensed water volume, L ; V_j is the sample volume of air under the standard conditions, m^3.

Then, the concentration of TSP can be calculated according to

$$TSP=(w_2-w_1)/ V_j \quad (3)$$

TSP is the concentration of total suspended particles in the atmosphere, mg/ m^3; w_1, w_2 are the masses of filter membranes before and after sampling respectively, g; V_i is the air sample volume of TSP under the standard conditions, m^3.

The concentration of aqueous vapour can be calculated by

$$AV=w_w/ V_j \quad (4)$$

AV is the concentration of aqueous vapour in air, mg/ m^3; w_w is the mass of sampled condensed water from aqueous vapour, kg; V_j is the air sample volume of aqueous vapour under the standard conditions, m^3.

RESULTS AND DISCUSSION

15 group data were obtained by above mentioned method, each of them consisted of two samples, i.e., aqueous vapour and TSP in the same place and the same time. Ten common types of anions and cations were measured in each group. The results are shown in Table 1.

For different typical point of atmospheric environment, the concentrations of NO_2^- and NO_3^- were measured in aqueous vapour and TSP in the same place and same time, the results are shown in Table 2.

The concentrations of the typical cations and anions listed in Table 1 in decreasing order were displayed below, that is,
For samples of aqueous vapour:
$SO_4^{2-} > NH_4^+ > NO_3^- > Ca^{2+} > NO_2^- > Cl^- > F^- > Na^+ > K^+ > Mg^{2+}$.

For samples of TSP:
$SO_4^{2-} > NO_3^- > Ca^{2+} > NH_4^+ > Cl^- > Na^+ > K^+ > F^- > Mg^{2+} > NO_2^-$.

Table 1. Average concentrations of 10 ions in the 15 groups of AV-TSP samples and correlations between them.

Monitoring items		AV(mg/ m^3)	TSP(mg/ m^3)
Anions	F^-	$2.12*10^{-4}$	$6.73*10^{-4}$
	Cl^-	$7.49*10^{-4}$	$4.39*10^{-3}$
	NO_2^-	$8.84*10^{-4}$	$4.89*10^{-6}$
	NO_3^-	$1.61*10^{-3}$	$1.29*10^{-2}$
	SO_4^{2-}	$1.38*10^{-2}$	$1.86*10^{-2}$
Cations	Na^+	$1.68*10^{-4}$	$1.98*10^{-3}$
	NH_4^+	$2.56*10^{-3}$	$4.57*10^{-3}$
	K^+	$9.81*10^{-5}$	$1.49*10^{-3}$
	Ca^{2+}	$8.95*10^{-4}$	$5.10*10^{-3}$
	Mg^{2+}	$5.29*10^{-5}$	$5.15*10^{-4}$
Correlation coefficient, γ_{10}	$\gamma_{10\text{-}2}$=0.838; [TSP]=24.6+1.22[AV]		
Significant critical value for correlation coefficient, $\gamma_{0.05,10\text{-}2}$	$\gamma_{0.05,10\text{-}2}$=0.632		

Table 2. Concentrations of NO_2^- and NO_3^- in aqueous vapour and TSP samples from different atmospheric environment.

Sampling place	AV(mg/ m^3)		TSP(mg/ m^3)	
	NO_2^-	NO_3^-	NO_2^-	NO_3^-
Expressways	1.94 10-3	$1.26*10^{-3}$	Unavailable	$7.97*10^{-3}$
Downtown	$8.24*10^{-4}$	$2.24*10^{-3}$	Unavailable	$1.87*10^{-2}$
Industrial areas	$9.32*10^{-4}$	$1.13*10^{-3}$	Unavailable	$1.03*10^{-2}$
Suburbs	$3.30*10^{-4}$	$4.61*10^{-4}$	$5*10^{-2}$	$7.09*10^{-3}$
Countryside	$2.74*10^{-4}$	$2.17*10^{-3}$	Unavailable	$1.37*10^{-2}$
Natural landscape	$4.41*10^{-4}$	$1.47*10^{-3}$	Unavailable	$7.58*10^{-3}$

Obviously, there were differences in decreasing order between aqueous vapour and TSP. In fact, there were only two groups in TSP samples where NO_2^- was proved to be present, and their concentrations were hundreds times less than that of the counterparts in AV samples. Therefore, a noticeable characteristic of the chemical constitutions of aqueous vapour was that relatively higher concentrations of NO_2^- can be found. From the correlation coefficient of AV and TSP samples, it was proved that γ_{10} (correlation coefficient) was greater than $\gamma_{0.05,10\text{-}2}$ (significant critical values for correlation coefficient). The results demonstrate that dehumidizer is a convenient and reliable sampler of the aqueous

vapour for atmosphere. By measuring the condensed water, the quality of atmosphere can be evaluated.

The concentrations of NO_2^- and NO_3^- in samples of AV and TSP from different places showed that in aqueous vapour obtained by dehumidizer, NO_2^- was found in almost all the samples, while in TSP, only in samples from industrial district NO_2^- can be detected. On the other hand, in aqueous vapour the highest concentration of NO_2^- was obtained in the samples from expressways, while the lowest concentration was found in countryside. The concentrations were nearly the same in suburb and natural landscapes. The highest concentration of NO_2^- observed in expressways could probably be attributed to the discharge from motor vehicles.

The concentration of NO_3^- was the highest in samples of aqueous vapour and TSP in downtown. Based on data from the monitoring, both the concentrations of NO_2^- and NO_3^- in samples from different areas did not have the same sequence. This could probably be explained by the short retention time of NO_2^- , since it can be easily absorbed and converted in atmosphere.

The concentration of NO_2^- should be considered as an important element for assessing the atmospheric quality because of notorious toxicity of nitrite to human being and animals. It is valuable that condensed water by dehumidizer, can be used to measure the amount of NO_2^- and confer its concentration in air ultimately. However, the concentration of NO_2^- which affects the health of human being and animals remains to be further explored.

Compared with the conventional methods of dissolving the atmospheric particulates, the proposed method of utilizing domestic dehumidizer offers the advantages of more convenience of gathering soluble substance from atmosphere, higher capacity and quicker for sampling. The development of a standard sampling method needs further investigation.

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