

Analysis of chemical composition of precipitation in a typical background site

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Abstract—A background precipitation in Lijiang, China was investigated. Results showed that the chemical composition of atmospheric background precipitation mainly comes from fly ash and continental atmospheric transfer, and does not have any obvious correlation with oceanic aerosol, taking Amsterdam in the Pacific Ocean and St. Georges in the Atlantic Ocean and Katherine, Australia as examples for analysing.

Keywords: fly ash; background; precipitation; chemical composition.

1 Introduction

For studying the effect of the global atmospheric circulation on acid rain, its distribution, movement and transformation in regulation of chemical composition of precipitation in remote and clean regions, the United States of America has established simple ocean type precipitation background sites at the edge of Indian Ocean, Pacific Ocean, Atlantic Ocean and Arctic Ocean, such as Amsterdam, St. Georges, Hawaii in USA, as well as oceanic alternating with continent type sites such as Katherine in Australia, Sancarlos in Venezuela and a global continental precipitation background site of continental type in Lijiang, China, totally more than 10 districts. These background sites cover the globe in a network ring of encirclement.

As viewed from a microcosm level, the site at the slope of the Jade Dragon Snow Mountain in Lijiang, China, researched the background value of continental precipitation; as viewed from the macro level, it researched the source, movement and transformation regulation and chemical composition content represented in global continental precipitation. By contrast, it is extended to the relations between ocean precipitation and effect factors. Research achievement combine site with section, obtained the background value of the global continent and ocean precipitation systematic through part to the whole.

2 Analysis of the oceanic type precipitation background value

In order to thoroughly research the correlation between the oceanic precipitation background value and sea water, the contribution of sea water composition to the background value of ocean atmospheric precipitation must be determined as well as the relation between ocean atmospheric background and precipitation background value, taking Amsterdam and St. Georges as examples for analysing.

2.1 The correlation between ocean precipitation background value and sea water background value

The background values of Amsterdam, St. Georges and sea water are shown in Table 1.

Taking Amsterdam as the example, a regression calculation was carried out between the concentration of Ca^{2+} , Mg^{2+} , K^+ , Na^+ , NO_3^- , Cl^- and SO_4^{2-} in atmospheric precipitation and the concentration of their corresponding chemical composition in sea water, to obtain the Equation

(1):
$$\hat{y} = 2.06 + 3.83 \times 10^{-4}x; r = 0.999,$$
where x represents the concentration of a specific chemical composition in sea water, and \hat{y} represents the atmospheric precipitation background value corresponding to x .

Table 1 Comparison of oceanic type atmospheric precipitation background value with that for sea water, $\mu\text{eq/L}$

Concentration value	H ⁺	Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺	NH ₄ ⁺	NO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	HCOO ⁻	CH ₃ COO ⁻
Ams. precipitation	12.0	7.4	38.7	3.7	177	2.1	1.7	208	30.6	6.8	2.4
St. precipitation	16.2	9.7	34.5	4.3	147	3.8	5.5	175	36.3	5.7	2.0
Sea water background value	—	20	104	9.7	459	0.0	0.0	535	53		0.0

According to Equation (1), the background value of NO₃⁻ and SO₄²⁻ in sea water was substituted into Equation (1), respectively, one can obtain that the concentrations of NO₃⁻ and SO₄²⁻ coming from ocean aerosol are 0.0 $\mu\text{eq/L}$ and 22.4 $\mu\text{eq/L}$ respectively in oceanic type background atmospheric precipitation. Using the above two values of NO₃⁻ and SO₄²⁻ instead of the concentration of NO₃⁻ and SO₄²⁻ in the atmospheric precipitation in Amsterdam, a regression was then carried on 7 background values to obtain Equation (2):

$$\hat{y} = -0.019 + 3.87 \times 10^{-4}x; r = 0.99992. \tag{2}$$

As above, the correlation equation of the atmospheric precipitation background value with sea water background value in St. Georges can be obtained.

$$\hat{y} = 6.27 + 3.12 \times 10^{-4}x; r = 0.996. \tag{3}$$

Substituting the sea water background value into Equation (3) result in NO₃⁻ = 0.0; SO₄²⁻ = 23.0 ($\mu\text{eq/L}$). Then seven regressions are carried on NO₃⁻ and SO₄²⁻ obtained, that:

$$\hat{y} = 2.26 + 3.20 \times 10^{-4}x; r = 0.9995. \tag{4}$$

Table 1 and Equations (2) and (4) clearly reflect the very close correlation between ocean type atmospheric precipitation and sea water quality. Ca²⁺, Mg²⁺, K⁺, Na⁺ and Cl⁻ in oceanic type atmospheric precipitation are mainly from ocean aerosol. Since the concentration of NH₄⁺, NO₃⁻, HCOO⁻ and CH₃COO⁻ in sea water are very low, they tend to be zero. By further research, we considered they are mainly from atmospheric pollutants, otherwise the correlation Equations (2) and (4) would not have such high correlation coefficients.

2.2 Contribution of sea water composition to the oceanic precipitation background value

Substitute sea water background value in Equations (2) and (4) to accumulate, respectively, and get the contribution of sea water composition to the precipitation background value in Amsterdam and St. Georges, as shown in Table 2.

Table 2 The contribution value of sea water composition to precipitation background value, $\mu\text{eq/L}$

Concentration	Ca ²⁺	Mg ²⁺	K ⁺	Na ⁺	NH ₄ ⁺	NO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	HCOO ⁻	CH ₃ COO ⁻
Ams. theoretical value	7.7	40	3.8	178	0.0	0.0	207	20.5	0.0	0.0
Ams. measured value	7.4	38.7	3.7	177	2.1	1.7	208	30.6	6.8	2.4
St. theoretical value	8.7	35	5.4	149	0.0	0.0	173	19	0.0	0.0
St. measured value	9.7	34.5	4.3	147	3.8	5.5	175	36.3	5.7	2.0
Sea water background value	20	104	9.7	459	0.0	0.0	535	53	0.0	0.0

We can see from Table 2:

(1) Measured values of Ca^{2+} , Mg^{2+} , K^+ , Na^+ , Cl^- tally with their theoretical value, and although some differences exist, these are rather small and belong to the range in value permitted by test error. They all enter rainwater in form of a salt from strong-acid and strong-base and do not produce an acid contribution.

(2) Because the concentration of NH_4^+ , NO_3^- , HCOO^- and CH_3COO^- are very low in the sea water background value, their contribution to the precipitation background value tend to be zero. As measured value is affected by atmospheric circulation, certain content brought in conform to the actual situation.

(3) There is a rather large gap between the SO_4^{2-} measured value and its theoretical contribution value. The reason why the measured value is higher than the theoretical value is that besides the contribution of sea water, SO_4^{2-} is also affected by SO_x which comes from atmospheric circulation, this results in the SO_4^{2-} measured value being higher than its theoretical calculated value. The sea water background value in Table 2 minus its theoretical value giving the SO_4^{2-} value coming from the atmosphere. In Amsterdam, 67% SO_4^{2-} in precipitation comes from sea water and 33% from the atmosphere. In St. Georges, 53% SO_4^{2-} in precipitation comes from sea water and 47% from the atmosphere. SO_4^{2-} from sea water are mainly in form of Na and Mg salts entering rainwater.

2.3 The relation between oceanic atmospheric circulation and oceanic precipitation background value

In Amsterdam and St. Georges, the precipitation background value is obviously affected by oceanic atmospheric circulation, Amsterdam is very obvious, St. Georges less so. In contrast, as affected by continent, St. Georges is more obvious than Amsterdam.

The ocean atmospheric circulation figure clearly indicates that:

(1) No matter whether in January, April, July and October (i. e. four seasons of winter, spring, summer, autumn), Amsterdam in the Indian Ocean is always located in the center of the oceanic atmospheric circulation. It is about 4 km far away from the continent and is little affected by the continent.

(2) Although St. Georges is an oceanic site, it is about 1 km away from the America continent, a rather short distance. It is controlled by the air current of east America in January and April, as the continental atmospheric pollutants move to St. Georges, and in July and October it is affected by atmospheric circulation of the Atlantic Ocean, so the continental atmospheric pollutants of America have some difficulty moving to St. Georges Island. At this time it is obviously affected by the atmospheric circulation of west Europe.

(3) According to Table 2, in Amsterdam and St. Georges, the difference between the theoretical value and the measured value of SO_4^{2-} is 1.71 (i. e. SO_4^{2-} in St. Georges is equal to 1.71 times of it in Amsterdam provided by SO_x which is transferred by atmospheric circulation). This fully indicates that St. Georges is affected by the moving of SO_x in the American continent, but Amsterdam is not. This enables the measured precipitation background value of SO_4^{2-} in St. Georges to be 5.7 ($\mu\text{eq/L}$) higher than that in Amsterdam and equal to 1.19 times, NO_3^- 3.2 times and NH_4^+ 1.81 times.

(4) The organic background value in the Amsterdam precipitation background site approach that in St. Georges.

(5) The order of contribution to precipitation acidity is $\text{H}_2\text{SO}_4 > \text{CH}_3\text{COOH} + \text{HCOOH} > \text{HNO}_3$.

(6) Assuming no effect by ocean aerosols, according to Table 2, the acidity of background precipitation in Amsterdam should be:

$[H^+] = [HCOO^-] + [CH_3COO^-] + [SO_4^{2-}] + [NO_3^-] + [Cl^-] - [NH_4^+] - [H^+ \text{ neutralized by } HCO_3^-] = 6.8 + 2.4 - (30.6 - 20.5) + (208 - 207) + 1.7 - 2.1 - 2.2 = 17.7 \mu\text{eq/L}$, i.e. $\text{pH} = 4.75 \approx 4.8$. In fact, precipitation in Amsterdam is affected by ocean aerosol, and the pH background value is 4.92. This shows that although the iron provided by atmospheric circulation is only a small part in the precipitation background value in Amsterdam, it determined the acidity of background precipitation. The same conclusion also can be obtained from the background value in St. Georges.

3 Analysis on atmospheric precipitation background value of ocean alternating with continent type

Katherine site is located in Carpentaria Plain in North Australia, affected by the air current of Indian Ocean, Pacific Ocean and Australia Continent. It has a savanna climate with abundant precipitation. This background site is affected by ocean or continent. Katherine site is more than 200 km away from the Pacific Ocean and the Indian Ocean, about 800 km away from the large desert, and more than 2000 km away from the Southeast sea coast, population and industry concentrated region in Australia. It is a typical ocean alternating with continent type atmospheric precipitation background site.

3.1 The effect of ocean aerosol on the atmospheric precipitation background value of ocean alternating with continent type

Katherine is a typical site representing an oceanic alternating with continent type. It is affected by ocean aerosol and pollutants transferred by continental atmospheric circulation. The relevant basic data for calculations are shown in Table 3.

Table 3 Comparison of atmospheric precipitation background value in Katherine and Lijiang, and sea water background value, $\mu\text{g/L}$

Background value	Ca^{2+}	Mg^{2+}	K^+	Na^+	NH_4^+	NO_3^-	Cl^-	SO_4^{2-}	HCOO^-	CH_3COO^-
Precipitation in Katherine	2.5	2.0	0.9	7.0	2.0	4.3	11.8	6.3	24.6	7.4
Precipitation background value in Lijiang	4.6	1.8	1.6	0.9	6.8	2.4	3.6	9.3	6.1	3.2
Sea water background value	20	104	9.7	459	0.0	0.0	535	53	0.0	0.0

By analyzing and comparing the data in Table 3 we can see that: Katherine, ocean alternating with continent type atmospheric precipitation background site, is obviously affected by ocean aerosol.

The outstanding characteristic of ocean type precipitation is that $[\text{Na}^+]$ is very high, such as $[\text{Na}^+]$ in Amsterdam precipitation is equal to $177 \mu\text{eq/L}$, but $[\text{Na}^+]$ in continent type precipitation is very low, such as $[\text{Na}^+]$ in Lijiang precipitation is equal to $0.9 \mu\text{eq/L}$. Therefore, we can similarly consider that Na^+ offered by ocean aerosol in Katherine ocean alternating with continent type precipitation background site, is equal to the total quantity of Na^+ in Katherine precipitation ($7.0 \mu\text{eq/L}$) minus Na^+ background value in continent precipitation ($0.9 \mu\text{eq/L}$). The result is $6.1 \mu\text{eq/L}$. Therefore, according to the formula of $M_2 = M_1 \times N_2/N_1$ (M_2 represents sea water contribution to M Composition in atmospheric precipitation, M_1 represents M

composition background value in sea water, N_2 represents sea water contribution to Na^+ in precipitation, and N_1 represents Na^+ background value in sea water), we can calculate the contribution of sea water to each chemical composition in atmospheric precipitation in Katherine.

3.2 Effect of continental atmospheric pollutants on the background value of ocean alternating with continent type precipitation

Continental atmospheric pollutants include air pollutant and fly ash pollutant. These pollutants move with atmospheric circulation and influence the background value of ocean alternating with continent type precipitation. According to the formula of $M_2 = M_1 \times N_2/N_1$, the contribution value of sea water to the chemical composition of atmospheric precipitation in Katherine can be calculated, as shown in Table 4.

Table 4 The contribution of sea water and atmospheric pollutants to atmospheric precipitation background value in Katherine of ocean alternating with continent type, $\mu\text{eq/L}$

Contribution quantity	Ca^{2+}	Mg^{2+}	K^+	Na^+	NH_4^+	NO_3^-	Cl^-	SO_4^{2-}	HCOO^-	CH_3COO^-
Contribution of sea water to										
atmospheric precipitation	0.3	1.4	0.1	6.1	0.0	0.0	7.1	0.7	0.0	0.0
Continental atmospheric pollutants*	2.2	0.6	0.8	0.9	2.0	4.3	4.7	5.6	24.6	7.4

* : Continental atmospheric pollutant = Precipitation background value - Contribution value of sea water to atmospheric precipitation

Table 4 indicates that:

(1) Cations of Na^+ and Mg^{2+} in atmospheric precipitation in Katherine mainly come from ocean aerosol, and Ca^{2+} and K^+ mainly from continental fly ash and artificial discharged particle matter. Metal ion (K, Na, Ca, Mg) provided by sea water account for 64% of total metal ion quantity of precipitation background value in Katherine. This part of metal ion enters precipitation in form of chloride and sulfate, and does not affect the precipitation acidity. About 36% metal ion is provided by fly ash in the atmosphere and artificial discharged particle matter, enter precipitation mainly in form of carbonate, silicate and other salt from weak-acid and strong-base. They play a restraining role in raising acidic precipitation.

(2) In the anion of precipitation in Katherine, Cl^- mostly comes from ocean aerosol, a little SO_4^{2-} also comes from ocean aerosol, and other anions are from atmospheric pollutants. Cl^- and SO_4^{2-} provided by sea water account for 17% of the total anion quantity in precipitation in Katherine. They enter precipitation in form of sodium salt and magnesium salt, and do not affect precipitation acidity. Anion provided by atmospheric pollutant account for 83% of anion total quantity in precipitation in Katherine, they enter rainwater mainly in form of acid, to provide H^+ to precipitation in Katherine.

(3) The order of contribution to atmospheric precipitation acidity: organic acid $>$ H_2SO_4 $>$ HNO_3 and HCl , it is different with ocean type atmospheric precipitation.

(4) HCOO^- and CH_3COO^- are high in precipitation in Katherine, ocean alternating with continent type, for two reasons: (1) Katherine is located in a hot and humid region, where organisms metabolize very actively, and therefore discharge a lot of aldehyde, ketone and acid *etc.* of organic mater. Aldehydes and ketones are easy to be oxidized in acid. Part of these organic matters are directly released in the air in gaseous form, part of them are absorbed by the soil at first, and then enter the air in the form of fly ash. (2) In the rainy season, precipitation in Katherine is mainly affected by air currents which pass over Indonesia and New Guinea Islands.

Animal and vegetation activities are still very active in these regions, and release a large amount of organic acid and organic matter. This is one of the main reasons for high organic acid in the precipitation background value.

4 Analysis on the continental atmospheric precipitation background value

The background value of continental atmospheric circulation precipitation is restricted by sea water background, continental fly ash and continental surface structure. It has a certain correlation with surface water background value, which will be analyzed one by one in the following.

4.1 The relation between continental precipitation background value and sea water background value

Here, continental precipitation background site in Lijiang region represents a simple continent type, the Amsterdam site represents a simple ocean type and Katherine site represents an ocean alternating with continental type. By comparing the background value of Na^+ with Ca^{2+} , Na^+ with K^+ in three different types of precipitation, respectively, one can prove that the sea water background value does not have any correlation, as shown in Table 5.

Table 5 Ratio of $\text{Na}^+/\text{Ca}^{2+}$ and Na^+/K^+

Ratio	Sea water	Amsterdam	Katherine	Lijiang
$\text{Na}^+/\text{Ca}^{2+}$	459/20 \approx 23	177/7.4 \approx 24	7.0/2.5 \approx 2.8	0.9/4.6 \approx 0.19
Na^+/K^+	459/9.7 \approx 48	177/3.7 \approx 48	7.0/0.9 \approx 7.8	0.9/1.9 \approx 0.56

Table 5 indicates that because Na^+ content is very high in sea water and Ca^{2+} content is high in continent, for ratio of $\text{Na}^+/\text{Ca}^{2+}$, Amsterdam of simple ocean type is basically the same as sea water (i.e. 23 and 24); Amsterdam of simple ocean type is 7.6 times higher than Katherine of ocean alternating with continent type, but Katherine is about 13.7 times higher than Lijiang of continental site, and ratio of Na^+/K^+ has the same regulation. Therefore the ratio of $\text{Na}^+/\text{Ca}^{2+}$ and Na^+/K^+ fully proves that sea water affects continental precipitation very slightly.

4.2 The relation between the continental precipitation background value and atmospheric background particle matter

Continental atmospheric background precipitation in Lijiang region is mainly a latitude direction type, with rainwater passing through the sky of the Tibetan Plateau and northwest Yunnan Province. There is a sparse population, very backward industry, slightly artificial discharged particle matter and gaseous state pollutant in this region, and very little effect on the chemical composition of precipitation in Lijiang precipitation background site. Therefore, the background value of metal ion formed in continental precipitation is mainly provided by the fly ash in Tibetan Plateau and north west Yunnan Province.

In the high altitude without dust influence, $[\text{H}^+]$ of the cloud and rain in Lijiang should be:

$$[\text{H}^+] - [\text{HCOO}^-] + [\text{CH}_3\text{COO}^-] + [\text{SO}_4^{2-}] + [\text{NO}_3^-] + [\text{Cl}^-] - [\text{NH}_4^+] - [\text{H}^+ \text{ neutralized by } \text{HCO}_3^-] = 6.1 + 3.2 + 8.7 + 2.4 + 3.1 - 6.8 - 2.2 = 14.5 \text{ (}\mu\text{eq/L)}.$$

Namely $\text{pH} = 4.8$, this value tallies with the measured value of the cloud and rain in South China, *etc.*, during the falling of cloud and rain, acid-resistance fly ash is caught and enables the pH value to go up somewhat. The measured pH value of precipitation background in Lijiang continental region is 5.0, and showing no difference with theoretical calculation and logical

reasoning.

4.3 The relation between the continental precipitation background value and the surface water background value

The surface water background value comes from weathering rock stratum and soil, and shows no difference with the source of continental precipitation background value. Therefore, the surface water background value should be closely related to the precipitation background value. The surface water background value of Qiaojia County in the upper reaches of Yangtze River is chosen as evidence to prove the correlation with the water background value of both sides (Table 6).

Table 6 Comparison of the atmospheric precipitation background value of Lijiang region with the water background value of the upper reaches of Yangtze River, $\mu\text{eq/L}$

Concentration value	Ca^{2+}	Mg^{2+}	K^+	Na^+	NH_4^+	NO_3^-	Cl^-	SO_4^{2-}
Precipitation background value of Lijiang	4.6	1.8	1.6	0.9	6.8	2.4	3.6	9.3
Water background value of upper reaches of Yangtze River	1880	934	36.4	412	7.8	11.4	210	221

According to the chemical composition in the above table, the cations of Ca^{2+} , Mg^{2+} and Na^+ with stable chemical characteristic and single source, was chosen to be regressed (except K^+ , because of the specific geochemical characteristic, did not attend regression) and obtain equation:

$$\hat{y} = -0.3 + 0.00257x; r = 0.992.$$

In the equation, x represents the water background value of Yangtze River; \hat{y} represents continental precipitation background value. We can see from the regression coefficient r that the surface water background value has good correlation with continental precipitation background value.

According to the above equation, substitute the water background value of Yangtze River in it, and calculate out the content of NH_4^+ , NO_3^- , Cl^- and SO_4^{2-} in precipitation brought by fly ash, respectively: $\text{NH}_4^+ = 0.0$; $\text{NO}_3^- = 0.0$; $\text{Cl}^- = 0.5$; $\text{SO}_4^{2-} = 0.6$ ($\mu\text{eq/L}$).

4.4 The relation between continental precipitation background value and atmospheric circulation

The cation background value of continental precipitation is mainly from fly ash, and the anion value is mainly from the atmosphere. Because there are not much gas pollution emissions in the Lijiang local area, anions in precipitation background value are mainly provided by atmosphere by far distance transmission. We can see from the calculated value in 3.3 section; brought in the rainwater by fly ash, $\text{NH}_4^+ = 0.0$, $\text{NO}_3^- = 0.0$, $\text{Cl}^- = 0.5$, $\text{SO}_4^{2-} = 0.6$ ($\mu\text{eq/L}$), the content of each composition is very low, the background value of continental precipitation minus the content brought in precipitation by fly ash, results in: $\text{NH}_4^+ = 6.8$, $\text{NO}_3^- = 2.4$, $\text{Cl}^- = 3.1$, $\text{SO}_4^{2-} = 8.7$ ($\mu\text{eq/L}$). They are transferred by atmospheric circulation, the main transmission direction being west.

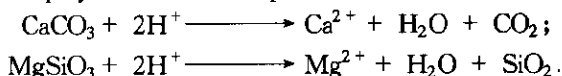
4.5 The relation between continental precipitation background acidity and chemical composition in precipitation

The form of the chemical composition in the background precipitation plays an important role in precipitation acidity. The state of composition when they enter rainwater is discussed as follows.

4.5.1 The effect of metal ion on the acidity of precipitation background

H.D Hollond's study proved that 87% of Ca^{2+} in the surface water comes from the weathering of silicate and carbonate. 13% from CaSO_4 and CaCl_2 ; 97% Mg^{2+} comes from silicate

and carbonate, 3% from MgCl_2 ; 83% K^+ from silicate, 17% from KCl ; 45% Na^+ from silicate; 55% from NaCl . Anyway, 83% metal ions come from weak-acid salt (i. e. silicate and carbonate), 17% from strong-acid salt; according to the result proved in 3.3 section: "There is a good correlation between the surface water background value and the background value of continental atmospheric precipitation, the r value is 0.992". Therefore, K^+ , Na^+ , Ca^{2+} and Mg^{2+} enter background precipitation in form of weak-acid salt accounting for almost 83%. These weak-acid strong-base salts play an acid consumption role in rainwater, for example:

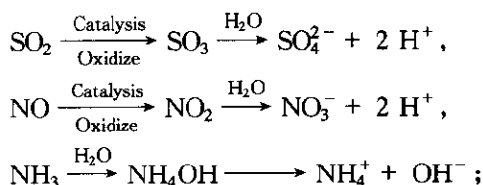


This enables the acidity of precipitation to decline, the pH value goes up, on the contrary, a few materials come into rainwater in form of salt from strong-acid and strong-base can not influence the alteration of precipitation acidity.

4.5.2 The effect of NH_4^+ , NO_3^- , Cl^- and SO_4^{2-} on the acidity of precipitation

According to the results in 4.4 section, they are mainly transferred by the atmosphere for long distance;

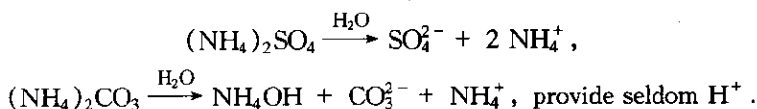
(i) Gas state—— they come into rainwater in form of SO_x , NO_x and NH_3 , and produce chemical reaction;



H^+ is produced to provide acidity to precipitation, OH^- is produced to consume H^+ , i. e. $\text{H}^+ + \text{OH}^- \longrightarrow \text{H}_2\text{O}$.

(ii) They come into rainwater in form of acid, $\text{H}_2\text{SO}_4 \longrightarrow \text{SO}_4^{2-} + 2\text{H}^+$; $\text{HNO}_3 \longrightarrow \text{NO}_3^- + \text{H}^+$, and direct provide H^+ to rainwater.

(iii) They come into rainwater in form of NH_4^+ , such as



4.5.3 The form of organic acid

The organic acids come into precipitation mainly in form of HCOOH and CH_3COOH , $\text{CH}_3\text{COOH} \longrightarrow \text{CH}_3\text{COO}^- + \text{H}^+$, and provide H^+ .

5 Conclusion

Source of precipitation background value of three different type: precipitation composition background value of simple ocean type is offered by ocean aerosol, little part of them is offered by atmospheric circulation; precipitation composition background value of ocean alternating with continent type is offered by ocean aerosol, fly ash of some areas and atmospheric circulation; precipitation composition background value of continent type is mainly offered by the continent atmospheric circulation and fly ash of some areas.

Compositions come from ocean aerosol into precipitation background value are mainly the salt from strong-acid and strong-base, do not affect the acidity of precipitation; compositions come from

atmospheric circulation into precipitation background value provide H^+ ; compositions come from fly ash into precipitation background value are mainly the salt from weak-acid and strong-base, and consume H^+ .

In Lijiang continental background site without the effect of continent aerosol, pH of cloud and rain in high altitude should be 4.8; in Amsterdam ocean type background site without the effect of ocean aerosol, pH of cloud and rain in high altitude also should be 4.8. When cloud and rain is falling down the ground and ocean, affected by aerosol, pH of continental precipitation background value is 5.0, pH of ocean type Amsterdam is 4.9; there exist low altitude aerosol in precipitation region of both Lijiang site and Amsterdam site.

References

- Galloway J N. J of Geophysical Res, 1982, 87(11): 8771—8786
- Liu J Q. Acid rain and agriculture. Beijing: Forestry Publishing House of China, 1989. 43—49
- Liu J Q, Wu G P. Shanghai Environmental Science, 1992, 1(1):36—37
- Liu J Q, Keene W C. China Environmental Science, 1993, 13(4):246—250
- Liu J Q. Research on the background value of chemical elements in water environment. Survey and Drawing Publishing House, 1993. 44—50
- Liu J Q. The tendency of acid rain developing in China and its control countermeasure. Science Publishing House of China, 1992. 7—13
- Liu J Q, Keene W C, Wu G P. China Environmental Science, 1993, 4(4):246—251

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