Study on the Precipitation Chemical Elements Property of the Water Resources Protection Forest in the Miyun Reservoir Watershed, Beijing

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Abstract: The paper study on the precipitation chemical elements of *Robinia pseudoacacia*, *Pinus tabuleaeformis* and *Castanea mollissima* water resource protection forest in the Miyun reservoir watershed. It results show that total precipitation chemical elements amount was 12.0011 mg • L^{-1} and its quantity greatly varied in the mainly rainfall period. To list the sequence of the water elements concentration of the precipitation is follows: Ca > N > K > Mg > Na > P > Fe > Zn > Cu > Mn. The chemical elements of through-fall and stem-flow varied in different direction of the three type forests, but the total chemical elements content of the through-fall and stem-flow of the three type forests increased in comparison with the precipitation chemical elements content. Through-fall total chemical elements concentration of the *Robinia pseudoacacia*, *Pinus tabuleaeformis* and *Castanea mollissima* forests are 46.1924 mg • L^{-1}, 20.6135 mg • L^{-1} and 17.1105 mg • L^{-1}, respectively. Stem-flow total chemical element concentration are 61.5862 mg • L^{-1}, 73.3235 mg • L^{-1} and 35.5074 mg • L^{-1}, respectively.

Keywords: water resources protection forest, precipitation, through-fall, stem-flow, chemical elements

1 Introduction

Beijing city is a serious lack of the water resources; the average amount is per capita 300 cubic meters. It is about 15% of the national average amount, and only 4% of the world average amount. There will be shorted about 1.185 billion cubic meters of the normal hydrological year and about 1.999 billion cubic meters of low hydrologic year in the first decades of the 21st, and 2.376 billion cubic meters of normal hydrological year and 3.090 billion cubic meters of low hydrological year of the second decades of the 21st. It has been show that the shorted of the water resources manacle the development of the Beijing city.

Miyun reservoir provides about 70% living water resources with the Beijing city. It is very important that water resources and water quality protect of the reservoir to supplying the fresh water for the city. The government had made the deliberated protection plan for the reservoir watershed management. The water resources protection forest planting is most important matter of the reservoir watershed managed. The paper studies on the water chemical elements property in the distribution of the precipitation in the water resources protection forest. And show it principle of the water resources protection forest to improve water quantity and quality in the Miyun reservoir watershed, to help the planting and managing of the water resources protection forest in the Miyun reservoir watershed.

2 Site and methods

2.1 Site

The experiment area locates in the upper watershed of the Miyun reservoir watershed, at coordinates 116º31'—117º31'E and the 40º13'—40º48'N bisect area. The climate is continental, temperate, monsoon climate with a mean annual temperature of 10.5℃, extremely lowest temperature is –18℃, the extremely highest temperature is 38℃, frost-free period is 176 d. Annual average

precipitation is 669mm, hot and more rainfall in summer. The presently plantation is *Pinus tabuleaeformis* and *Robinia pseudoacacia* forest. Soil group includes drab soil, cultivated meadow soil.

2.2 Methods

Runoff plots planning Three type forests runoff plots, *Robinia pseudoacacia* forest *Pinus tabuleaeformis* forest and *Castanea mollissima* forest plot were built in the Beizhuang county water resources protection forest working station. The age of *Robinia pseudoacacia* forest is about 10a—15a, *Pinus tabuleaeformis* forest is about 25a—30a and *Castanea mollissima* forest is about 20a—25a, respectively. The chemical elements total N and P, Na, Ca, Mg, Cu, Zn, Fe, Mn was monitored in the precipitation samples, through-fall samples and stern-flow. Samples chemical analyses according with the national standard methods (Xie X-Q, *et al*., 1998).

Samples Collection The precipitation samples are collected in the Beizhunag water resources protection forest working station accompanied with the precipitation monitor. The through-fall samples get from the applicant which diameter same with the precipitation monitor apparatus diameter, the collector distributed in the mechanism way，and repeat 20 times. The stern-flow collect from the polythene plastic tube that cut opening from the portrait direction and it spiral stick in the trunk, apparatus in the foot of the tube to collect the water samples (Xie X-Q, *et al*., 1998).

3 Results and interpretation

3.1 Precipitation chemical elements property

Twenty-five precipitation samples analyzed from 1999 to 2000. The chemical elements content varied greatly in the precipitation sample of the experimental period. According the results that the highest relatively varied chemical element is sodium and the smallest relatively varied chemical element is phosphorus of the normal chemical elements, which include chemical elements N, P, K, Na, Ca and Mg. The maximum concentration is about seventy times to minimum concentration of the Na. Zinc is the highest relatively varied chemical element and manganese is the smallest relatively varied chemical element of the microelement, which include Fe, Zn, Cu and Mn.

The sequence of the weighted average concentration of the chemical elements in the precipitation is Ca > N > K >Mg > Na > P >Fe > Zn > Cu > Mn (Table 1), Why varied chemical elements greatly in the precipitation, two factors must be considered. (1) The precipitation property, such as precipitation density and period, precipitation amounts, precipitating time, interval of the precipitation, it results show that the chemical elements concentration are different in the different months (Liu S-H, *et al*., 2000); and (2) The environment factors and climate factors, air pollution, the taking material of the atmosphere circumfluence and it heavily changed by the influence of the weather conditions. The factors not only affect the precipitation chemical elements concentration in the same climate zone, but also impact on the different climate zone precipitation chemical elements concentration.

There are different climate zones precipitation chemical elements concentrations studied in China (Chen L-Z, *et al*., 1988, Jiang, Y-X, *et al*., 1991, Chen B-F, *et al*., 1993, Liu S-R, *et al*., 1996, Zhou X-F, *et al*., 1994, Tian D-L, *et al*., 1997, Liu S-H, *et al*., 2000, 2001a, 2001b), it has been show that the nitrogen content sequence in the different climate zones is follow: temperate zone > frigid zone > sub tropic > torrid zone, phosphorus and potassium in the different climate zones is follow: frigid zone > sub tropic > torrid zone > temperate zone, calcium in the different climate zones is follow: temperate zone > sub tropic > torrid zone > frigid zone, magnesium in the different climate zones is follows: torrid zone > temperate zone > frigid zone > sub tropic. The total amount of five elements concentration in the different climate is follow: frigid zone > sub topic > torrid zone.

Parker (1983) analysis the results which come from the different area, according the studying results, though the elements input amount greatly varied in the different zone and same plot chemical elements input amount change in the different year, but it show the same trend in the whole globe, the sulphur, chlorin and sodiumas are more input amount of the precipitation chemical elements in the

world wide, according the results of the world wide weighted average value, chemical elements content sequence is follows: S > Na > Cl > N > Ca > K > P. Our data are differ with the Parker's results but conform with the contents of chemical elements in *Robinia pseudoacacia* plantation in Beijing (Chen L-Z, 1988) and water chemistry in *Vingin* forest of *Larix Gmeline* (Zhou M, 1999).

Table 1 The chemical elements concentration in the precipitation (mg • L^{-1})

Item	N	P	K	Na	Ca	Mg	Fe	Zn	Cu	Mn
minimum concentration	0.2209	0.0315	0.1945	0.0310	0.5575	0.0498	0.0147	0.0114	0.0029	0.0208
maximum concentration	10.1081	0.5156	11.1200	2.2126	15.5651	1.8560	0.3258	0.8497	0.1603	0.1200
weighted average concentration	2.8012	0.1797	1.5692	0.6548	5.5962	0.7794	0.1615	0.1578	0.0562	0.0451

3.2 *Robinia pseudoacacia* forest precipitation chemical elements property

In the forest watershed, the precipitation distributes in the three sections, the canopy intercept, and through-fall and stern-flow, at last, it reaches on the ground. It is most important that the interceptions and eluviations of the forest which affect the precipitation chemical elements in the process of the precipitation distribution. Such as the precipitation dissolved the material that come from the inner and surface of the leaf, and twigs, and flowers of the plant, plant assimilation and absorption of the precipitation's, which strictly influenced the chemical elements property of the distribution of precipitation.

Table 2 Comparison of chemical composition of through-fall, stem-flow and rainfall of the *Robinia pseudoacacia* forest[a] (mg • L^{-1})

Item	N	P	K	Na	Ca	Mg	Fe	Zn	Cu	Mn
Stern-flow	14.504	2.5134	36.6202	0.8813	5.0875	1.4758	0.1210	0.2466	0.1121	0.0243
Through-fall	12.5363	2.5508	23.7024	0.7066	4.4799	1.9565	0.0742	0.151	0.0107	0.0240
Precipitation	2.8012	0.1797	1.5692	0.6548	5.5962	0.7794	0.1615	0.1578	0.0562	0.0451

a weighted average value

Among of the chemical elements of the through-fall, Ca, Fe, Cu, Mn and Zn content decreased in comparison with precipitation contend, and it amount is 1.1163 mg • L^{-1}, 0.0873 mg • L^{-1}, 0.0455 mg • L^{-1}, 0.0211 mg • L^{-1} and 0.0068 mg • L^{-1}, respectively. K, N, P, Mg and Na concentration enhanced in contrast with the precipitation concentration, and it amount is 22.1332 mg • L^{-1}, 9.7351 mg • L^{-1}, 2.3711 mg • L^{-1}, 1.1771 mg • L^{-1} and 0.0518 mg • L^{-1}, respectively (Table 2). There are seven elements concentration increased in the stern-flow, it increases sequence as follow: K > N > P > Mg > Na > Zn > Cu, others decreased. In comparison with the precipitation, the chemical elements concentration in the through-fall and stern-flow show the same change trend, some increased, and some decreased.

Our sum up data of weighted average content show that the precipitation, through-fall and stern fall is 12.0011 mg •L^{-1}, 46.1924 mg •L^{-1} and 61.5862 mg •L^{-1}, respectively. Stern-flow total chemical elements content increased greatly than others, it due to the stern-flow chemical elements comes from the chemical elements interchange with precipitation and canopy, and also the interchange with the trunks.

3.3 *Pinus tabuleaeformis* forest precipitation chemical elements property

The chemical elements of through-fall show that five category elements contend enhanced and the rest decreased in comparison with the precipitation chemical elements content. Normal elements N, P, K and Mg content increased, Ca and Na concentration become low. Microelement copper content increased, Fe, Mn and Zn content decreased. The sequence of the chemical elements increased amount of the through-fall is follows: N > K > Mg > P > Cu, and it increased amount is 4.9274 mg • L^{-1}, 2.6454 mg • L^{-1}, 0.7876 mg • L^{-1}, 0.2984 mg • L^{-1} and 0.1528 mg • L^{-1},respectively (Table 3). The chemical elements decreased amount sequence is follows: Na > Ca > Fe > Zn > Mn, and it amount is 0.1042 mg • L^{-1}, 0.0298 mg • L^{-1}, 0.0249 mg • L^{-1}, 0.0217 mg • L^{-1} and 0.0186 mg • L^{-1}, respectively (Table 3).

There is about eight-type element concentration increased in the stern-flow, and two category elements decreased. K content increased more than twenty nine times in comparison with the precipitation content and N is nine times of the precipitation content. The sequence of the chemical element increased amount is follows: K > N > P > Ca > Mg > Na > Zn > Cu, Fe and Mn concentration is lower than precipitation concentration.

Table 3 Comparison of chemical composition of through-fall, stem-flow and rainfall of the *Pinus tabuleaeformis* forest [a] (mg • L^{-1})

Item	N	P	K	Na	Ca	Mg	Fe	Zn	Cu	Mn
Stern-flow	19.2942	2.8758	39.1171	1.0624	8.2616	2.2338	0.1279	0.2216	0.0968	0.0323
Through-fall	7.7286	0.4781	4.2146	0.5506	5.5664	1.5670	0.1366	0.1361	0.2090	0.0265
Precipitation	2.8012	0.1797	1.5692	0.6548	5.5962	0.7794	0.1615	0.1578	0.0562	0.0451

a weighted average value

According the statistics of total chemical elements content of the through-fall and stern-flow elements, through-fall is higher than stern-flow. Through-fall total content of ten chemical elements concentration is 20.6135 mg •L^{-1}, and stern-flow is 73.3235 mg •L^{-1}, stern-flow greatly higher than the through-fall and precipitation chemical elements content (Table 3).

3.4 Precipitation chemical elements property of *castanea mollissima* forest

The through-fall and stern-flow chemical elements of *Castanea mollissima* forest varied in same way. In the through-fall, there are seven category chemical elements content increased, and the others decreased. It enhanced amount sequence of different elements is follows: N > P > Mg > K > Fe > Na > Mn, and it value is 4.7294 mg •L^{-1}, 0.4896 mg •L^{-1}, 0.4000 mg •L^{-1}, 0.2789 mg •L^{-1}, 0.2643 mg •L^{-1}, 0.1829 mg • L^{-1}, respectively (Table 4).

Table 4 Comparison of chemical composition among through-fall, stem-flow and rainfall of the *Castanea mollissima* forest [a] (mg • L^{-1})

Item	N	P	K	Na	Ca	Mg	Fe	Zn	Cu	Mn
Through-fall	13.7933	1.6973	4.2800	1.0918	9.8726	4.2212	0.3241	0.1384	0.0095	0.0792
Stern-flow	7.5306	0.6693	1.8481	0.8377	4.4229	1.1794	0.4258	0.1355	0.0124	0.0488
Precipitation	2.8012	0.1797	1.5692	0.6548	5.5962	0.7794	0.1615	0.1578	0.0562	0.0451

a weighted average value

In the stern-flow, our data show that there is eight type chemical elements enhanced, and two category elements become low. It sequence of the increased amount is N > Ca > Mg > K > P > Na > Fe > Mn, and it value is 10.9921 mg • L^{-1}, 4.2764 mg • L^{-1}, 3.4418 mg • L^{-1}, 2.7108 mg • L^{-1}, 1.5176 mg •L^{-1}, 0.4370 mg •L^{-1}, 0.1626 mg •L^{-1}, 0.0341 mg •L^{-1}, respectively. Cu and Zn decreased, and it

amount is 0.0467 mg • L^{-1} and 0.0194 mg • L^{-1}, a little lower than the precipitation chemical elements content. Sum up the total content of weighted value of the precipitation, through-fall and stern-flow chemical elements, it results show that the stern-flow chemical elements content is higher than the through-fall and precipitation chemical elements content, and through-fall chemical element concentration is higher than the precipitation chemical element concentration. Three type 'precipitation' chemical elements sequence is: 'stern-fall' > 'through-fall' > 'precipitation'. We learnt from data that the concentration of the chemical elements Zn and Cu almost reach the detective lower limit, this maybe caused by the plant absorption of the Zu and Cu, the detail should be further studying.

4 Conclusion

In the Miyun reservoir watershed, the precipitation chemical elements content greatly varied in the experimental period, it total content of weighted average value is 12.0011 mg •L^{-1}, the sequence of the water elements concentration of the precipitation is follows: Ca > N > K > Mg > Na > P > Fe > Zn > Cu > Mn.

Through-fall and stern-flow of ten type chemical elements in the different category water resources protection forest vary in different direction, some chemical elements concentration increased and some decreased. In general, the total chemical elements concentration of through-fall and stern-flow of three type forest was enhanced in comparison with the precipitation chemical elements content. And the stern-flow total chemical elements content is higher than through-fall total chemical elements content of sameness forest in the Miyun reservoir watershed.

According statistics of the data, *Robinia pseudoacacia*, *Pinus tabuleaeformis* and *Castanea mollissima* water resources protection forest through-fall chemical elements concentration is 46.1924 mg • L^{-1}, 20.6135 mg • L^{-1}, 17.1105 mg • L^{-1}, respectively, and stern-flow is 61.5862 mg • L^{-1}, 73.3235 mg • L^{-1}, 35.5074 mg • L^{-1}, respectively.

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