POLLEN COMPONENT OF ATMOSPHERIC AEROSOL IN NOVOSIBIRSK SUBURBS

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Pollen of twenty one plants' families is observed in the air of Novosibirsk Akademgorodok. Data on weight of pollen grains of fourteen anemophilous plants as well as data on the number and mass concentration of dominating types of pollen are presented in this paper. Seasonal and daily dynamics of the pollen content in air and its connection to the ecology of the plants' florescence and weather conditions is studied.

1. INTRODUCTION

Particles of biological origin, as viruses, bacteria, spores, pollen and others are inseparable components of the atmospheric aerosol. Their size varies from tens of nanometers to hundreds of microns, and consequently, these are represented in the whole size range of aerosol particles. In some regions of the world, a significant fraction of mass concentration of atmospheric aerosol (up to 55–90%) is made up by biological aerosol.[1–3] Pollen of plants is one of the biggest component of the coarse fraction ($D > 1$) of the bioaerosol. The size of the pollen grains (PG) varies from 2–5 to 250 μm. The pollen grains of wind-pollinated plants mostly have the size of 20 to 50 μm.[4] The wind-pollinated plants generate a tremendous amount of pollen. Thus the production of pollen by Pinus solvestris is of the order of 2 kg per tree and up to 125 kg/hectare in the plantations, and that of Abies Sibirica is of the order of 450 g per tree. Within the sparse woods near settlements the Siberian Pine produces up to 8.6 kg of pollen per tree and up to 150 kg/hc. One adult tree of Betula pendula produces, on the average, 1.7 kg of pollen. Corn field produces about 50 kg of pollen per hectare.[5,6]

Investigation of seasonal and daily dynamics of the pollen content in air, determination of number and mass concentration of different types of pollen, as well as the establishment of their connection to the time of plants' florescence and weather condition was the primary goal of the present paper.

MATERIAL AND METHODS

The samples of atmospheric aerosol have been collected in summer 1996 from the roof of the Institute of Chemical Kinetics and Combustion (the height of 15 m). All in all 20 day-and-night observational sessions have been undertaken with 3-hour intervals between samplings. The impactor of open type (d_{50} being of the order of 20 μm) was used for determination of number concentration of pollen.[7] Aerosol particles were sampled on 2.5×4 cm^2 glass plates covered with glycerin-gelatin mixture with addition of blue kumachi pigment (5 parts of the glycerin-gelatin prepared using the standard procedure, 1 part of glycerin, 2 parts of pigmenting suspension).[7] To study the seasonal dynamics of PG concentration since April 1, 1996, the pollen was caught on horizontal adhesive sampling glasses exposed during twenty-four hours. The PGs were visually analyzed and counted using an MBI–11 optical microscope (with the magnification factor of 600). The systematic properties of the pollen were determined by its morphology to within genus, and in some cases to the family (grasses, and the like). The number concentration of PGs was calculated based on the pollen quantity caught by the impactor, time of exposition of the adhesive glasses, and specifications of the impactor. The values of mass concentration of the most numerous types of the pollen were established from the number concentration and weight of their PGs.

The PGs' weight of some of anemophilous plants, whose pollen dominates in air, was determined experimentally. Pollen was picked up from the plants of natural, for Akademgorodok, population using a standard procedure.[6] Its doses (of the order of several μg) were uniformly, in thickness, deposited with the use of the device for pulsed sprayer of powder materials on the AFA–KhA filters (with a filter area of 16.62 cm^2). The spraying was performed on the "Pulsed pneumatic transportationB installation of the Pulsed gasodynamics Division of the M.A. Lavrent'ev Institute of Hydrodynamics, SB RAS.[8] The mass of the sprayed pollen was determined while weighing on an

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analytic balance. The quantity of sprayed PGs, settled on a filter, was determined when counting the PGs using an MBI–11 microscope over 30 arbitrarily chosen zones of the microscope field of view. Before the analysis the filters were covered with a transparent sticky pellicle and moistened with 50% water solution of glycerin. The weight of a PG was determined by dividing the mass of a sprayed dose by the number of PGs settled. Every experiment on determining a PG's weight was repeated six times.

RESULTS AND DISCUSSION

Pollen of twenty one plant families and spores of Felicinae are observed in the air of Akademgorodok. Mostly the PGs of wind pollinating plants were observed, whose fraction varied from 90 to 99 per cent of the pollen sampled on different days. During the observations the pollen from the following plants prevailed in the air: pines, grasses, marenos, cannabis, urtica, and artemisia. The pollen of other plants was observed sporadically, and its number concentration did not exceed several PGs per 1 m^3. The mass and the size of PGs of wind pollinating plants that dominate in the flora, and also of some anemophilous plant-introducers whose pollen is frequently met in the air are given in Table I.

Maximum values of the number (m^{-3}) and mass ($\mu g/m^3$) PG concentration of those wind pollinating plants, whose pollen dominates in the air are given in Table II.

TABLE I. Weight and size of pollen grains of some anemophilous plants.

Pollen of the plant family	Average weight of a pollen grain,* ng	Diameter or length of a pollen grain,** μm
Larix sibirica	160	81 – 90
Picea obovata	63	108 – 122
Pinus solvestris	14	77 – 88
Bromus inermis	21	35 – 44
Dactilis glomerata	16	36 – 42
Phleum pratense	10	35 – 38
Quercus robur	8.6	25 – 39
Popuius tremula	4	29 – 31
Popuius nigra	3.6	29
Chenopodium album	3.9	24 – 25
Cannabis sativa	3.0	23 – 29
Betula pendula	2.8	28
Artemisia absinthium	1.7	23 – 24
Urtica dioica	0.8	18

*R.m.s. deviation ~ 6%.
**According to Refs. 9–11.

TABLE II. Maximum concentration of pollen of the types dominating in Akademgorodok.

Pollen of the plant family	Time and date of observation	Number concentration, grains/m^3	Mass concentration, $\mu g/m^3$
Pinus solvestris	9.00–9.45, June 11	1000	14
Poaceae	9.00–9.45, June 5	120	1.9*
Chenopodiaceae	12.00–12.45, July 27	29	$1.1 \cdot 10^{-1}$**
Cannabis sativa	12.00–12.45, July 27	41	$1.2 \cdot 10^{-1}$
Urtica dioica	12.00–12.45, July 27	43	$3.4 \cdot 10^{-2}$
Artemisia absinthium	12.00–13.00, August 14	61	10^{-1}

*Calculated by mass of Dactilis glomerata PGs.
**Calculated by mass of white Chenopodium album PGs.

Time of pollen appearance in air depends on time of plant florescence coming. The time of observation of the dominant types of pollen and total number of PGs, settled on 1 cm^2 of horizontal sticky glasses is shown in Fig. 1. As is seen from this figure, the maximum concentration of pinus pollen was observed early in June. The pollen of cereals appeared in air in the second decade of June and its significant quantity was observed until the end of July. The peak of florescence was observed from the third decade of June and until the second decade of July. Individual pollen grains were observed in June, 15, but the maximum florescence occurred only in the end of July and terminated in the beginning of August. The pollen urtica and mareous was first detected in the third decade of June, but the maximum in the second or third decade of July. The pollen of artemisia appeared the latest. Its PGs were detected in July, 17, and maximum florescence occurred in the first part of August. The florescence of plants terminated in the end of August and beginning of September. Insignificant quantity of felicinea spores was observed in the second half of August.

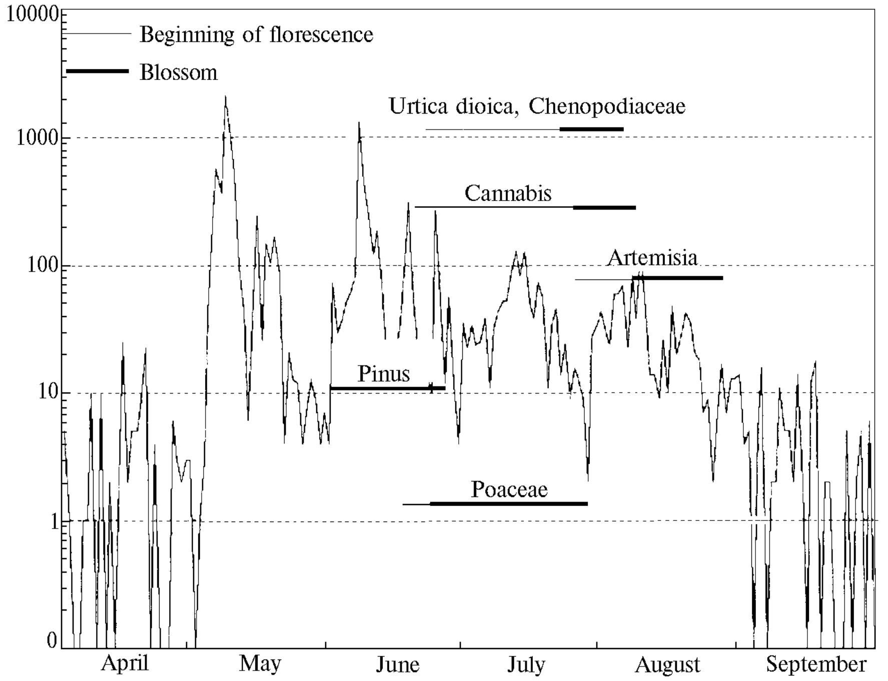

FIG. 1. Seasonal dynamics of pollen concentration according to data on sampling with sticky horizontal glasses, PGs/cm^2.

Daily dynamics of the pollen concentration in air is caused by the time of florescence, and the weather conditions. The maximum of pollen of Pinus solvestsis production is observed during the midday hours, in early morning its production is weak, and at night, because of low temperatures and high air humidity, its production almost stops.[12] That causes a sharp increase of the Pinus PGs concentration in the morning hours, high concentration during day-time and a gradual decrease in the evening and at night. Typical example of the dynamics in number concentration of Pinus silvestris is shown in Fig. 2. As is seen from this figure, the difference between the pollen concentration in air observed during day-time and at night reaches two orders of magnitude.

For grasses the situation is not so simple. The following groups are distinguished, depending on time of flower blossom out: 1) morning grasses; 2) pre-evening (post-meridium); 3) meridium; 4) grasses with double florescence (morning and evening); 5) night grasses; and 6) day-and-night florescence grasses. Explosive and partion florescence is established for number of post-meridium grasses (Argopiron repens and other).[13] Approximately forty types of grass grow in Akademgorodok, each possessing its own florescence cycle. These are different in the population and time of florescence during the vegetation period. Therefore the maximum PG concentration on different days is observed at different time: on June, 23 and 27 and on July, 5 at 9 a.m. – 100, 46, and 116 pollen grains per m^3; on June, 17 at 3 p.m. – 91 pollen grains per m^3. The number concentration of the grasses did not exceed several PGs per m^3 during night-time.

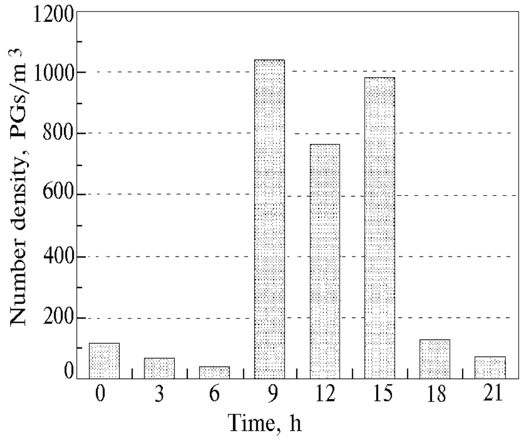

FIG. 2. Pinus pollen content in air on July 11, 1996, during the florescence time. Daily dynamics of the number concentration of pollen grains.

Maximum PG concentration of hemp, nettle, and mareous in the air has been observed at noon on every day of observations. It quickly reaches its maximum and then gradually decreases. The peak of their florescence is observed in July, 27 (Fig. 3). An increase in Artemisia pollen concentration occurs at 9 a.m., after which it remains not very high, and decreases at the evening and night hours.

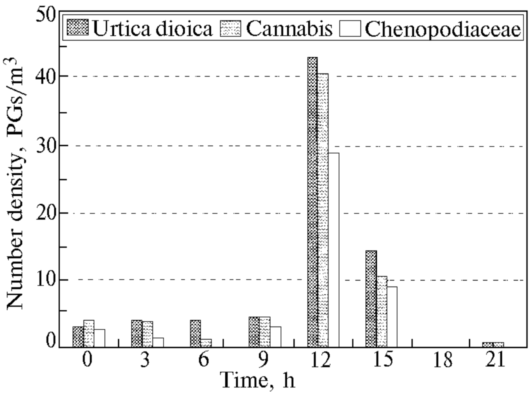

FIG. 3. Content of pollen of mareous, hemps, and urtica in air on July 27, 1996, during the florescence. Daily dynamics of the number concentration of pollen grains.

The weather conditions also influence the pollen concentration. The precipitation is one of the most important meteorological factor that determines daily behavior of the pollen concentration. The precipitation act in different ways. During the time of florescence precipitations reduce the PG concentration in air due to the capture by rain droplets. Thus, a strong rain, on July, 27 happened at 4 p.m., decreased the pollen concentration down to zero. Under the influence of precipitation the change of time of florescence of the plants is observed. Thus, on July, 1 the fog and rain caused the florescence of grasses to start late in the evening (maximum PG concentration was recorded at 9 p.m.); PG of grasses appeared only at 3:00 p.m. due to the heavy fog in the morning on July, 12. Heavy rains and low temperatures can cause temporary stop of the florescence and an absolute decrease in the pollen production. This fact was observed on July, 21, when practically no pollen was recorded in the air.

CONCLUSION

1. The mass of pollen grains of 6 wood and 8 grass plants, growing in West Siberia has been determined.

2. The number and mass concentration of dominating types of pollen in air have been determined.

3. Three periods can be isolated in summer depending on the concentration of pollen of that or other type of plants in air: period with domination of pollen from wood plants (pinus) – the beginning of June (a); period with domination of pollen from grasses – the second decade of June – the end of July (b); and period with domination of pollen from the variety of grass – the end of July – the third decade of August (c). The pollen concentration in air decreases after the end of florescence, but because of the secondary rise from the ground surface single PGs may be noticed in air even in the beginning of October.

4. Analysis of daily dynamics of concentration of all types of pollen in air shows that in the day time it is higher by one to two orders of magnitude then at night. It is same for every dominating type of the PGs (pinus, grasses, mareous, urtica, and artensia) during the florescence time of those plants.

5. Precipitation decreases the pollen concentration due to the capture by rain droplet and termination of the plant florescence or moving it to the evening hours.

REFERENCES

1. P. Artaxo, H. Storms, F. Bruynseels, R. Van Grieken, and W. Maenhaut, J. Geophys. Res. **93**, No. D2, 16005–16015 (1988).

2. P. Artaxo, W. Maenhaut, H. Storms, and R. Van Gricken, J. Geophys. Res. **95**, No. D10, 16971–16985 (1990).

3. H. Van Malderen, R. Van Grieken, T.V. Hodzher, N.S. Bufetov, and K.P. Kutsenogii, Atmos. Oceanic Opt. **7**, No. 8, 622–628 (1994).

4. A.N. Sladkov, *Introduction into Spore–Pollen Analysis* (Nauka, Moscow, 1967), 268 pp.

5. T.P. Nekrasova, *Pollen and Pollen Regime of Branches of Siberia* (Nauka, Novosibirsk, 1983), 168 pp.

6. K. Fegry and L. Van Der Pail, *Basics of Flowering Ecology* [Russian translation] (Mir, Moscow, 1982), 377 pp.

7. P. Kutsenogii, *Measurements of Remote Continental Aerosol in Siberia*. Dissertation. Mainz, (1992) 106 pp.

8. V.L. Istomin and K.P. Kutsenogii, Heat Physics and Aeromechanics (1998) (in publishing).

9. L.A. Kupriyanova and L.A. Aleshina, *Pollen and Spores of Plants of European Part of the USSR* (Nauka, Leningrad, 1972), Vol. 1, 174 pp.

10. L.A. Kupriyanova and L.A. Aleshina, *Pollen and Spores of Dicotyledonous Plants of European Part of USSR* (Nauka, Leningrad, 1978), Vol. 1, 174 pp.

11. A.E. Bobrov, L.A. Kupriyanova, M.V. Litvintseva, and V.F. Tarasevich, *Spores of Filicinae and Pollen of Gymnospermoses Plants of European Part of USSR* (Nauka, Leningrad, 1983), 208 pp.

12. T.P. Nekrasova, *Fruit bearing of Pinus in West Siberia* (Publishing House of SB AS USSR, Novosibirsk, 1960) 132 pp.

13. A.N. Ponomarev, *Florescence and Pollination of Grasses*, Uchyonye Zapiski, Ser. Biologia, Perm. Univers. **114**, 115–110 (1964).