

# The specifics of the content of chemical elements and ash in the leaves of ornamental plants in an urban environment

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**Abstract.** The content of sulfur, nitrogen, phosphorus, ash content in the leaves of annual and perennial species and varieties of the cities of the Novosibirsk region: Iskitim, Berdsk, Koltsovo, Evsino, Sovetsky district of Novosibirsk was studied. Indications of these substances were determined in the leaves of *Hemerocallis hybrida*, *Iris hybrida*, *Hosta lancifolia*, *H. decorata*, *Salvia splendens*, *Tagetis patula*, *Senecio cineraria*, *Malva hybrida*, *Gatsania hybrida*, *Alyssum hybrida*. The individual features of the accumulation of nutrients and ash in aboveground vegetative organs have been revealed. It was noted that the level of nitrogen concentration and ash content in the leaves of floral and ornamental plants exceeded the values of phosphorus and sulfur by 6–11 times. An increase in the concentration of chemicals and ash in plant leaves in an urban environment has been established.

## 1 Introduction

The state of the environment in the cities of the Novosibirsk region is determined by natural and man-made factors, which are increasing every year. Roadside areas are especially critical to contamination with water-soluble compounds and heavy metals. The study of pollutants in the vegetative organs of floral and ornamental plants that are used in landscaping roadside and industrial areas is becoming relevant [1–4].

## 2 Material and methods

As objects of research served plants of 5 species: *Hemerocallis hybrida* hort. (*Hemerocallidaceae* family R. Br.), *Iris hybrida* hort. (*Iridaceae* Juss. family Juss.), *Hosta lancifolia* Engl, *H. decorata* Bailey (*Hostaceae* family B. Mathew), *Salvia splendens* Sello ex Nees (*Lamiaceae* family Martinov), *Tagetis patula* L., *Senecio cineraria* DC., *Malva hybrida* hort., *Gatsania hybrida* hort. (*Asteraceae* family Bercht. et Presl.), *Alyssum hybrida* hort (*Brassicaceae* family Burnett). The collection of plant materials was carried

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out from 01.VII to 28.IX in 2013 – 2022. in an urban environment. Plants were taken from flower beds near industrial zones and highways at a distance of 50–100 m in Novosibirsk (Central district: Chelyuskintsev St., Krasny Prospekt St.; Sovetsky district: Zolotodolinskaya St. (Central Siberian Botanical Garden, control), Rossiyskaya St., Shaturuskaya St.); Berdsk (Rogacheva St., Rossiyskaya St., Krasnaya Siberia St.); Iskitim (Zavodskaya St., Sovetskaya St., Komsomolskaya St., Kommunisticheskaya St., Yuzhny Microdistrict St.), Evsino village, Koltsovo Science City. The determination of ash content (total ash) was carried out by dry ashing in a muffle furnace at  $t + 400...+5000$  C according to GOST 24027.2-80 [5]. Determination of nitrogen and phosphorus content was carried out after wet ashing from one sample (0.1 g) according to the method of Kjeldahl, Murphy and Riley [6]; total sulfur – by the spectrophotometric method [7].

### 3 Results and discussion

It has been established that in an urban environment (Berdsk), the accumulating capacity of nitrogen in leaves is 10–20 times higher than that of sulfur in *H. hybrida*, *I. hybrida* and *H. decorata*. The accumulation of total nitrogen and sulfur in the leaves of *H. decorata* is 2–5 times higher compared to *H. hybrida* and *I. hybrida* in an urban environment than in the control. It was revealed that in the Science City of Koltsovo and the city of Berdsk, the nitrogen content in leaves is 3 times higher in *H. hybrida* in the area of the main highway on the street Lenin (Berdsk) and 1.5–2 times in Koltsovo compared to the control and the zone of secondary roads (Berdsk). An increase in sulfur content in leaves by 2–2.5 times and ash by 1.5 times (Krasnaya Sibir St., Lenin St., Berdsk) was detected, relative to the control. A high level of sulfur content in *M. hybrida* (2 times), in *H. decorata* (1.5 times) was observed in the areas of intra-block landscaping on the street. Microdistrict (Berdsk) and st. Shaturuskaya (Novosibirsk, Sovetsky district) in comparison with control. It has been shown that the leaves of *M. hybrida* accumulate 6 times more sulfur than *H. hybrida* and 9 times more than *I. hybrida*, nitrogen – 4 and 2 times. All studied indicators in the leaves of *T. patula* were 1.5–2.0 times higher on the street Shaturuskaya regarding control.

It was noted that the concentration of nutrients and ash in the leaves of perennial and annual ornamental plants grown near road and industrial zones of the city of Iskitim increased in the series: S < P < N < ash. A high content of ash elements (7.22–7.93%) was detected in the leaves of *H. hybrida* and their highest concentration occurs near industrial zones, which is 1.2–1.5 times higher than in the control. A comparative analysis of chemical elements and ash in the leaves of flowering and ornamental plants that are used in landscaping the inner village of Iskitim (tab. 1) showed an increase in the nitrogen content of *S. splendens*: *S. cineraria* at 32:15 compared to sulfur 8:4 times respectively. An increase in phosphorus relative to sulfur by 3–4 times was established only in the leaves of *H. hybrida* and *I. hybrida*. For comparison, in the leaves of *H. hybrid* growing 50 m from the road, the S:P:N:ash ratio -  $0.10 \pm 0.003 : 0.44 \pm 0.003 : 2.07 \pm 0.022 : 7.07 \pm 0.185$  was slightly higher. It was determined that the ash content in the leaves of *H. hybrida* is 1.5 times higher than in the leaves of *I. hybrida* and *S. splendens*. The ash concentration in the leaves of *H. lancifolia* and *S. cineraria* was the same, within the error (8.56–8.85%).

**Table 1.** The content of chemical elements and ash content (% dry matter weight) in the leaves of ornamental plants 100 m from the road in Iskitim

| № | Species                     | Elements   |            |            |             |
|---|-----------------------------|------------|------------|------------|-------------|
|   |                             | S          | P          | N          | Ash content |
| 1 | <i>Iris hybrida</i>         | 0.11±0.007 | 0.50±0.004 | 1.63±0.012 | 7.07±0.162  |
| 2 | <i>Hemerocallis hybrida</i> | 0.09±0.003 | 0.31±0.004 | 2.88±0.025 | 9.85±0.206  |
| 3 | <i>Hosta lancifolia</i>     | 0.34±0.002 | 0.30±0.006 | 2.69±0.046 | 8.56±0.232  |
| 4 | <i>Salvia splendens</i>     | 0.49±0.004 | 0.42±0.007 | 2.09±0.232 | 7.33±0.257  |
| 5 | <i>Senecio cineraria</i>    | 0.49±0.004 | 0.41±0.006 | 2.08±0.017 | 8.85±0.365  |

It was found that the nitrogen content in the leaves of annual plants *A. hybrida*, *S. splendens*, *S. cineraria* is 6–11 times higher compared to sulfur and phosphorus in flower beds of industrial zones (Iskitim). However, it has been determined that the nitrogen concentration is 2.5–3 times lower in perennial plants compared to annual plants. While the ash elements in the leaves of *H. hybrida* growing in the industrial zone are 1.2–1.5 times higher. It was revealed that in the leaves of *H. hybrida* plants growing 50 m from the road, the S:P:N ratio of sulfur is 1.5 times higher than in plants growing 100 m from the road. General and species-specific differences in the content of total nitrogen, sulfur and ash were established under the conditions of traffic load in the city of Berdsk, Science City Koltsovo and the scientific center (Akademgorodok) for the most common flower crops in landscaping plantings (tab. 2).

**Table 2.** Average values (M±m) of ash, sulfur and nitrogen content (% dry matter mass) in above-ground organs of ornamental plants

| Plant collection place      | Elements    |             |            |
|-----------------------------|-------------|-------------|------------|
|                             | Ash content | S           | N          |
| <i>Hosta lancifolia</i>     |             |             |            |
| Control (Zolotodolinskaya)  | 7.71±0.090  | 0.325±0.003 | 1.59±0.035 |
| Rossiyskaya (Akademgorodok) | 9.59±0.206  | 0.222±0.002 | 1.35±0.039 |
| Rogacheva (Berdsk)          | 9.67±0.216  | 0.425±0.003 | 1.79±0.018 |
| <i>Hosta decorata</i>       |             |             |            |
| Control (Zolotodolinskaya)  | 9.45±0.150  | 0.168±0.002 | 1.18±0.036 |
| Red Siberia (Berdsk)        | 8.92±0.80   | 0.318±0.003 | 1.74±0.031 |
| Microdistrict (Berdsk)      | 6.48±0.150  | 0.343±0.003 | 1.53±0.036 |
| <i>Hemerocallis hybrida</i> |             |             |            |
| Control (Zolotodolinskaya)  | 6.51±0.241  | 0.072±0.004 | 0.61±0.030 |
| Koltsovo science city       | 6.21±0.045  | 0.065±0.008 | 1.07±0.40  |
| Rogacheva (Berdsk)          | 11.64±0.351 | 0.112±0.006 | 0.55±0.024 |
| Lenina (Berdsk)             | 9.75±0.251  | 0.103±0.003 | 1.77±0.027 |
| <i>Iris hybrida</i>         |             |             |            |
| Control (Zolotodolinskaya)  | 9.21±0.226  | 0.048±0.010 | 1.14±0.040 |
| Red Siberia (Berdsk)        | 6.11±0.025  | 0.149±0.001 | 0.99±0.034 |
| Lenina (Berdsk)             | 6.59±0.100  | 0.132±0.002 | 1.15±0.027 |
| <i>Malva hybrida</i>        |             |             |            |
| Control (Zolotodolinskaya)  | 6,27±0,246  | 0,22±0,014  | 1,53±0,015 |
| Microdistrict (Berdsk)      | 11,80±0,176 | 0,447±0,003 | 2,49±0,035 |
| <i>Tagetis patula</i>       |             |             |            |
| Control (Zolotodolinskaya)  | 5.85±0.140  | 0.187±0.007 | 1.09±0.046 |
| Rossiyskaya (Akademgorodok) | 10.07±0.115 | 0.367±0.004 | 1.92±0.027 |

Accumulation of leaves of these substances in *H. lancifolia* near the highway on the street. Rogacheva (Berdsk) is higher compared to the readings of samples of this species growing on the street. Russian (Akademgorodok). A comparison with the control showed that there are 1.5 times more of them in the leaves of plants growing in areas of traffic load in Berdsk, where there are more industrial zones than in the Scientific Center (Akademgorodok) and Science City (Koltsovo) (fig. 1).

It was revealed that in intra-block areas (Mikrorayon St.) the content of these substances is 1.5 times less than in areas adjacent to main roads (Rogacheva St., Lenin St., Krasnaya Sibir St.).



**Fig. 1.** *Hosta lancifolia*, *H. decorata*, *Iris hybrida*, *Salvia splendens* in the flower beds of Akademgorodok, Shaturskaya St., Novosibirsk (a–c), Berdsk (d),

In representatives of the genus *Hemerocallis* L. in the cities and towns of the Novosibirsk region – Berdsk, Evsino, Koltsovo, changes in the quantitative content of these compounds were also revealed depending on the growing conditions. In an urban environment, there was a tendency to increase (1.5–2 times) the ash content in the leaves of *H. fulva* and in varieties (Speak to Me, Luxury Lace, Green Wood Hall, President Marcus, Goie) relative to the control.

## 4 Conclusion

As a result of the study, new data were obtained on the content of chemical elements and ash in the leaves of plants cultivated in industrial cities of the forest-steppe zone of the Novosibirsk Region. Species-specificity was established in the accumulation of total nitrogen and sulfur in the leaves of hostas with a decrease in elements: *H. decorata* > *H. hybrida* > *I. hybrida* near highways in the urban environment of Berdsk along the streets: Krasnaya Sibir, Lenina, Lunnaya, Borovaya, Rogacheva. Under conditions of pollution of the central part of the urban environment by vehicle emissions, the accumulating capacity of nitrogen was 10–20 times higher than that of sulfur in *H. hybrida*, *I. hybrida*, and *H. decorata*. Varying degrees of technogenic load had a certain impact on the accumulation of ash content in the leaves of herbaceous plants from different systematic groups. Various data on the content of substances in industrial zones were obtained. It is demonstrated that the level of accumulation of ash in the leaves of *S. splendens* (7.9–8.0%) and *T. patula* (7.7–7.9%) is high near the Brick Factory (Berdsk) and the Reinforced Concrete Factory (Iskitim), than compared to control. A high concentration of ash in the leaves of *I. hybrida* (8.8–9.9%) in the vicinity of industrial zones in the city of Iskitim was noted. It was revealed that the ash readings in the leaves of *I. hybrida* and *H. lancifolia* near the roads of the Sovetsky district of Novosibirsk are 1.1–2.0% higher in relation to the conditions of Berdsk and Iskitim. The order of decreasing ash content in plant leaves is presented relative to their belonging to families in the study area of Iskitim: Hemerocallidaceae > Iridaceae > Hostaceae > Laminaceae > Asteraceae. Floral and ornamental plants are bioindicators of urban pollution.

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