GEOLOGIJA. 2006. T. 54. P. 1–7


*Geochemija • Geochemistry • Геохимия*

# Influence of atmospheric transportation of heavy metals on their values in depositional environments of West Lithuania

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Radzevičius A., Kadūnas V. Influence of atmospheric transportation of heavy metals on their values in depositional environments of West Lithuania. *Geologija*. Vilnius. 2006. No 54. P. 1–7. ISSN 1392-110X.

High background values and abundant anomalies of Ag, Pb, Zn and Sn are established in the topsoil of West Lithuania. The highered values of heavy metals in topsoil may be explained by the influence of regional and transregional atmospheric transportation of heavy metals. The study results of snow mineral dust in winters of 1995–1996 and 2002–2003 have emphasized a distinct enrichment by heavy metals of atmospherically transportable dust in this region as compared to others.

**Key words**: topsoil, snow dust, heavy metals, background values, Lithuania

Received 20 February 2006, accepted 15 March 2006

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## INTRODUCTION

Two specific geochemical areas, Pajūris and Žemaitija, are discerned in West Lithuania according to the geochemical zonation of the Lithuanian territory (Kadūnas et al., 2002). Their topsoils are characterized by both a high geochemical contrast index in the composition of trace elements and a high coefficient of anomaly. A characteristic feature is also the dominance of heavy metals among the accumulative trace elements. Their elevated values and abundance of anomalies were left unexplained in detail, although a possible technogenic origin was mentioned (Gregorauskienė, Kadūnas, 1999). In the recent years, after repeated studies of snow dust in the entire territory of Lithuania, the regional and transregional peculiarities of atmospheric transportation of heavy metals were elucidated, which allow, at least partly, to explain their influence on the regional background values in the topsoils including West Lithuania. The significance of regional and transregional atmospheric transportation of heavy metals in the composition of trace elements in the topsoils of large territories has been determined in Sweden (Monitor, 1987), West Poland (Grodzinska et al., 2003) and other European countries (Reimann et al., 1998, 2003; Ruhling, Steinnes, 2001).

Elucidation of the reasons for regional differences in trace element values is important for a quality evaluation of the natural living environment in the country, particularly for recreational territories, also for the planning of a landuse strategy in wide areas and substantiation of the long-term measures to decrease air pollution.

## MATERIALS AND METHODS

The study area geomorphologically occupies the Baltija Lowland and the western part of the Žemaičiai-Kuršas district (territory of the West Žemaičiai plain and plateau, including also the West Kuršas Highland and the western part of the Venta River midstream plain). According to the zonation of Lithuanian soils, this region embraces the Pajūris Plain, the northern part of the Žemaičiai Highland and the western part of the Middle Venta Plain (Fig.1).

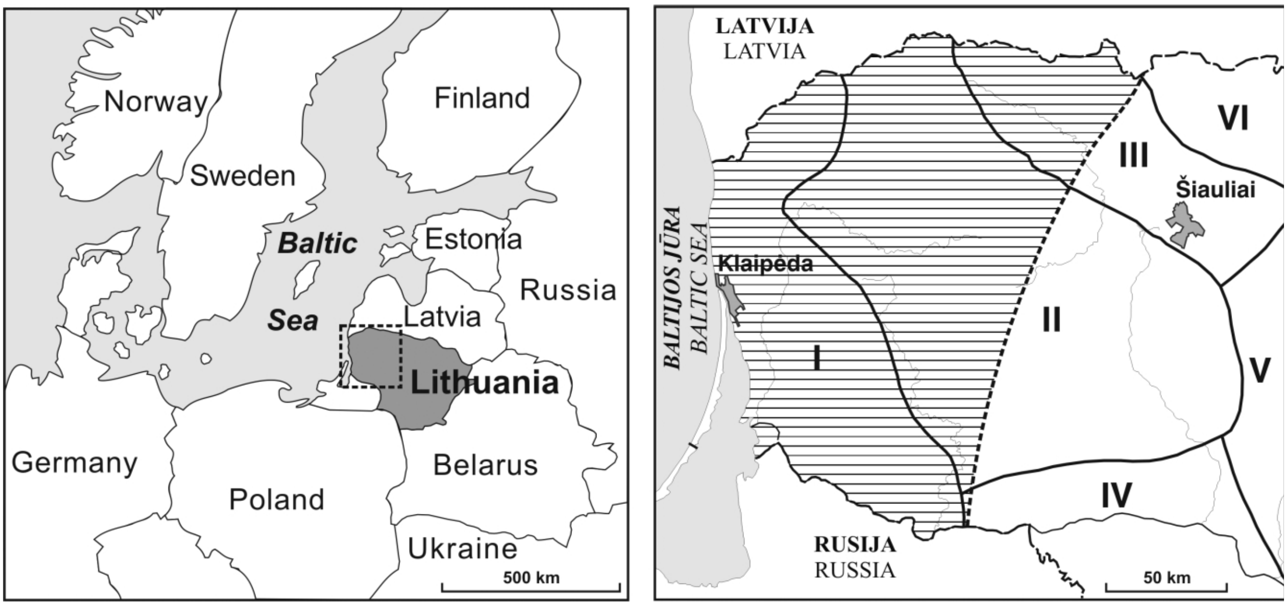


**Fig. 1.** The study area Western Lithuania. Districts of soil: I – Pajūris Plain, II – Žemaičiai Highland, III – Middle Venta Plain

**1 pav.** Sunkiųjų metalų dirvožemyje ir sniego dulkėse tyrimų plotas Vakarų Lietuvoje. Dirvožemio rajonai: I – Pajūrio lygumos, II – Žemaičių aukštumų, III – Ventos vidurupio lygumos

Materials obtained during the mentioned geochemical mapping (Kadūnas et al., 1999) were used to characterize the background values of heavy metals in the topsoils of West Lithuania. They are based on the test results of 380 samples.

*Methods of sampling, laboratory testing* and the qualitative examination of topsoils and snow are described in a previous publication (Kadūnas et al., 1999). The values of heavy metals in topsoils and snow dust were established using the method of emissional spectral analysis at the Institute of Geology and Geography.

*Interpretation of data.* All results of laboratory tests are stored on computer discs using Excel software which was used to calculate all statistical indices. Associations of trace elements are distinguished using the Ward method of cluster analysis, when the distance among the classifiable elements is *1-r*, and *r* is the Pearson correlational coefficient. The classification of associations of trace elements is the same as in the previous publications (Kadūnas et al., 2004). The background values of heavy metals and other trace elements are calculated as the median values. The coefficient of anomaly of trace elements is a ratio of samples with anomalous values of elements (three times exceeding the background values) to those of all samples. The geochemical contrast index is a ratio of the summarized concentration coefficients of accumulative (concentration coefficient >1) and deficient (<1) elements.

## RESULTS

After the geochemical mapping of Lithuanian territory at a scale 1:500 000 and calculation of the background values of trace elements for soils of different regions, as well as on establishing the distributional peculiarities of anomalous values, specific compositional characteristics of trace elements in West Lithuania were defined (Kadūnas, 1998; Kadūnas et al., 2002). First, topsoils of this region showed increased background values of many heavy metals as compared to the rest of Lithuania (Table 1).

In the mineral topsoils of West Lithuania (sandy, loamy sand and loamy clay-clayey), the background values of Pb and Sn are increased by 10%, whereas those

Table 1. **Background values of heavy metals in topsoil and highbog peat, mg/kg**

1 lentelė. **Sunkiųjų metalų foninis kiekis dirvožemyje ir aukštapelkių durpėje mg/kg**

| Type of soil | Regions | Ag | Cr | Cu | Mo | Ni | Pb | Sn | V | Zn |
|---|---|---|---|---|---|---|---|---|---|---|
| All types of mineral soil | Lithuania (L) | 0.066 | 33.2 | 9.2 | 0.63 | 13.1 | 15 | 2.1 | 36 | 28.5 |
| | West Lithuania (VL) | 0.072 | 33.7 | 9.2 | 0.66 | 13.8 | 16.9 | 2.3 | 37.5 | 30.6 |
| | VL/L | **1.09** | **1.02** | 1.00 | **1.04** | **1.05** | **1.13** | **1.10** | **1.04** | **1.07** |
| The highbog peat | Lithuania (L) | 0.046 | 8.9 | 5.8 | 0.72 | 6.5 | 16.6 | 0.9 | 13 | 20.4 |
| | West Lithuania (VL) | 0.059 | 11.0 | 5.6 | 0.76 | 6.8 | 24.9 | 1.3 | 16.2 | 29.6 |
| | VL/L | **1.28** | **1.23** | 0.96 | **1.05** | **1.05** | **1.50** | **1.42** | **1.25** | **1.45** |

of V, Ag and Zn more than by 5%. The elements make the following accumulational sequence: Pb>Sn>Ag>Zn>Ni. In the highbog peat, where the background values of heavy metals are often distinctly lower than in mineral topsoils (except for Mo), these differences are more distinct and exceed 25% for most metals and 40% for Pb, Zn and Sn. Their accumulational sequence (Pb> Zn> Sn> Ag>V) approximates that

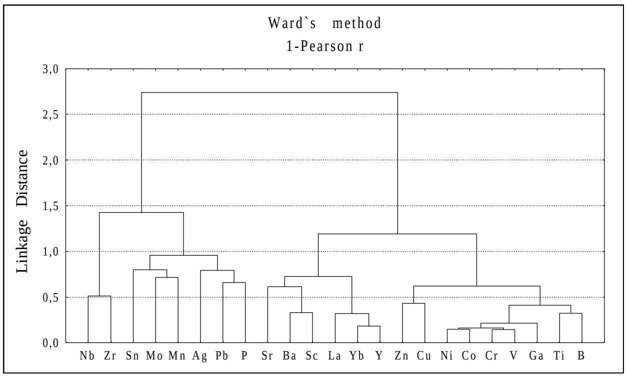


**Fig. 2**. Associations of trace elements in mineral soils of Lithuania

**2 pav.** Mikroelementų asociacijos Lietuvos mineraliniuose dirvožemiuose

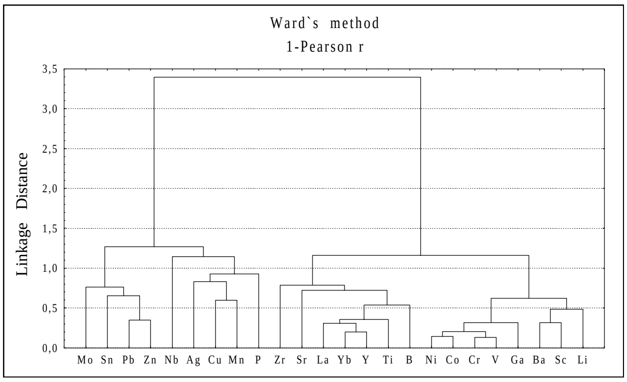


**Fig. 3.** Associations of trace elements in mineral soils of West Lithuania

**3 pav.** Mikroelementų asociacijos Vakarų Lietuvos mineraliniuose dirvožemiuose

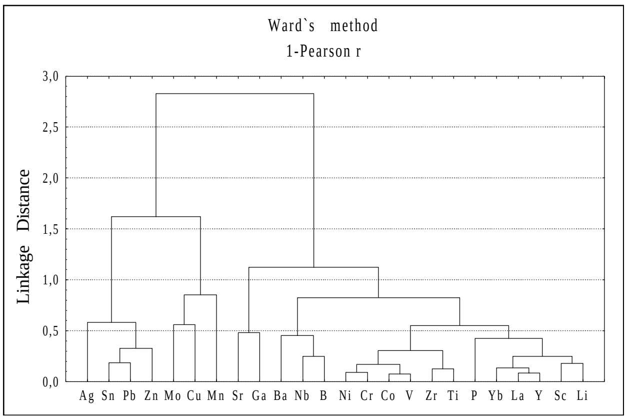


**Fig. 4.** Associations of trace elements in highbog peat of West Lithuania

**4 pav.** Mikroelementų asociacijos Vakarų Lietuvos aukštapelkių durpėse

of mineral topsoils, with only Ni in the peat replaced by a more biophilic V.

The calculated coefficients of anomaly of heavy metals in the mineral topsoil of this region (0.09) exceed those of the rest territory of Lithuania (0.06). Pb and Sn (0.1 each), Zn (0.08) and Ag (0.07) step out by the largest coefficients of anomaly in the Pajūris Plain. These are metals with the most elevated background values. The areal anomalies of these metals are also most numerous here. The anomalous values are obtained in an elementary mapping square (25 km$^2$) of different topsoil types or they are discovered in some adjacent squares (Kadūnas, 1998).

The Pajūris topsoils are characterized by a high contrast index of trace element composition, 1.46, as compared to that of the entire Lithuania, 1.32 (Kadūnas et al., 2002).

The obtained peculiarities of trace element composition in topsoils are also reflected by the correlations of heavy metals with other trace elements and by their position in geochemical associations (Figs. 2–4). According to cluster analysis, heavy metals disperse in different asociations of Lithuanian mineral topsoils. They partly (Cu–Zn**)** belong to the allotigenic association in which Co–Cr–Ni–V form a separate group, whereas others (Ag, Mo, Pb and Sn) form a mixed association with the allotigenic accessories (Nb–Zr) and allotigenic trace elements (P, Mn; Fig. 2). Most of heavy metals in the mineral soils of West Lithuania are also related to the mixed association but with a clearer distinguished group of Mo–Sn–Pb–Zn, i. e. elements with the increased values as compared with the soils of the rest of Lithuania (Fig. 3). A single but even more distinguishable biogenous technogenic association is formed by heavy metals in the highbog peat of West Lithuania (Fig. 4). Here, the Ag–Sn–Pb–Zn group connected by close correlations stands out, what may indicate a common source of origination.

The trace element composition accumulated in snow dust was studied to establish the peculiarities of heavy metals in atmospheric transport and to evaluate a possible influence of this fact on the background values of metals in topsoils. Snow dust is one of the good indicators of air pollution, because it is sampled in winter when the dust of geogenous origin has a least impact.

Since the snow samples were gathered from the entire Lithuanian territory in 1996 (winter 1995–1996) and 2003 (winter 2002–2003), it was possible to compare differences in the atmospheric pollution. High values of most heavy metals were obtained in the mineral part of snow dust of both winters; they exceeded the topsoil background values up to several dozen times (Tables 2, 3).

The mineral snow dust of 1995–1996, compared with the topsoil, is characterized by the following accumulational sequence of elements: Ag (concentration coefficient 96.8)>Zn (55.3) >Pb (30.3) >Cu (20.6) >Sn (18.5) >Ni (11.1). Accumulation of these heavy metals

Table 2**. Median values of heavy metals in mineral snow dust of winter 1995–1996, mg/kg**
2 lentelė. **Sunkiųjų metalų medianinis kiekis 1995–1996 m. žiemos sniego mineralinėse dulkėse mg/kg**

| **Region** | **Ag** | **Cr** | **Cu** | **Mo** | **Ni** | **Sn** | **Pb** | **V** | **Zn** |
|---|---|---|---|---|---|---|---|---|---|
| West Lithuania (VL) | 7.5 | 185 | 185 | 5.3 | 148 | 41.5 | 465 | 148 | 1750 |
| Middle Lithuania | 5.5 | 180 | 190 | 5.2 | 138 | 38.5 | 460 | 130 | 1600 |
| East Lithuania | 6.5 | 155 | 180 | 4.1 | 143 | 37.2 | 430 | 125 | 1225 |
| All Lithuania (L) | 6.4 | 170 | 190 | 5 | 145 | 38.5 | 455 | 130 | 1575 |
| VL/L | **1.17** | 1.03 | 0.97 | **1.06** | 1.02 | **1.08** | 1.02 | **1.12** | **1.11** |

Table 3. **Median values of heavy metals in mineral snow dust of winter 2002–2003, mg/kg**
3 lentelė. **Sunkiųjų metalų medianinis kiekis 2002–2003 m. žiemos sniego mineralinėse dulkėse mg/kg**

| **Region** | **Ag** | **Cr** | **Cu** | **Mo** | **Ni** | **Pb** | **Sn** | **V** | **Zn** |
|---|---|---|---|---|---|---|---|---|---|
| West Lithuania (VL) | 1.75 | 86 | 150 | 4.1 | 145 | 310 | 19 | 215 | 805 |
| Middle Lithuania | 1.45 | 73 | 155 | 3.2 | 88 | 300 | 10 | 120 | 790 |
| East Lithuania | 1.0 | 80 | 150 | 4 | 130 | 330 | 18 | 160 | 560 |
| All Lithuania (L) | 1.4 | 78 | 150 | 3.4 | 120 | 300 | 14 | 130 | 740 |
| VL/L | **1.25** | **1.10** | 1.00 | **1.26** | **1.20** | 1.03 | **1.36** | **1.65** | **1.09** |

was uneven in Lithuanian territory. Almost all of them, except Cu, showed the highest values in the snow dust of West Lithuania. The most accumulative were Ag, V, Zn and Sn (1.08–1.17 times exceeded the values in the rest of Lithuanian territory).

The mineral snow dust of 2002–2003 yielded distinctly lower values of some metals, such as Ag, Cr, Sn and Zn, as compared with the winter 1995–1996. However, their accumulational sequence was similar to that of the topsoil: Zn (Kk = 26) >Ag (21.2) >Pb (20) >Cu (16.3) >Ni (9.2). The distributional enrichment of mineral dust with heavy metals were also similar, but their values were higher.

The technogenic origin of heavy metals in snow dust is proven not only by their several or several dozen times higher values, but also by the correlations among the distinguished associations (Figs. 5, 6).

Two principal associations were obtained in the snow mineral dust of 1995–1996: a particularly rich technogenic association (Ag–Mn–Cu–La–Sn–Mo–Pb–Ni–V–Ba–P–Zn–Cr–Co–B) which included all heavy metals tied by intracorrelations and the second one, mixed allotigenic and allotigenous accessoric, composed of trace elements connected with the principal minerals of the dust: Zr–Nb–Ti–Yb–Y–Sc–Ga–Li. The trace elements of the 2002–2003 winter are slightly different. Their technogenic association is more differentiated. The closest correlations tie V, Mo, Ni and La forming a separate group, whereas Zn, Co and B are correlated with trace elements of the allotigenous accessoric association.

## DISCUSSION

The regional differences in the background values of heavy metals in mineral topsoils may be explained by the features of parent matters of soils or by the impact of an additional source. As the large part of the parent matters of soils in West Lithuania compose the sandy sediments of the Nemunas glaciation with the characteristic low values of heavy metals (Kadūnas et al., 2004), their increased amounts in topsoils are most likely caused by only a regional technogenic impact. West Lithu-

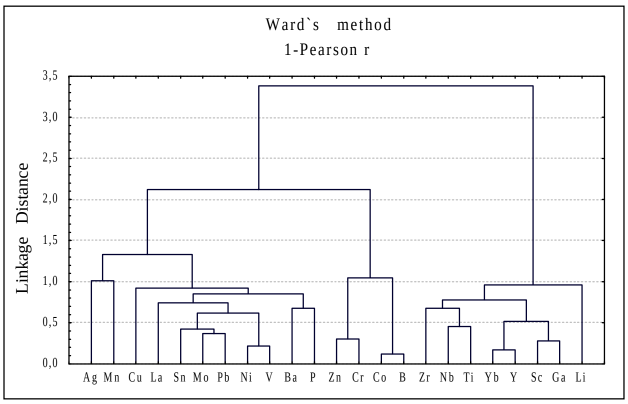


**Fig.5.** Associations of trace elements in mineral dust of snow samples taken in winter 1995–1996
**5 pav.** Mikroelementų asociacijos 1995–1996 m. žiemos sniego mineralinėse dulkėse

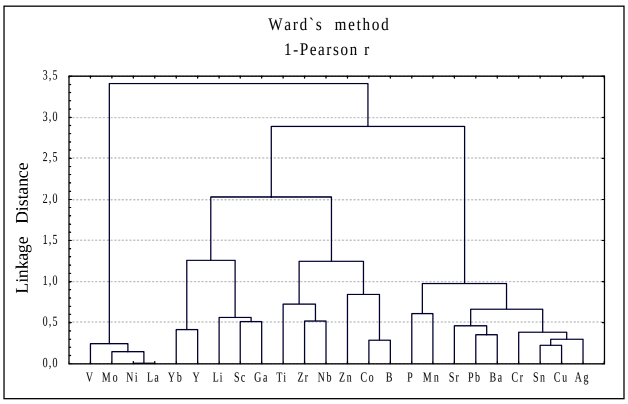


**Fig. 6.** Associations of trace elements in mineral dust of snow samples taken in winter 2002–2003
**6 pav.** Mikroelementų asociacijos 2002–2003 m. žiemos sniego mineralinėse dulkėse

ania is influenced by air transport from West and North Europe and the Kaliningrad district of Russia. The Lithuanian territory is reached by about 70–80% of the atmospherically transportable pollutants (Šopauskienė, 1994). The transregional spread of heavy metals is also proven by a study of pollution through the atmosphere of the Baltic Sea water area, which has shown that Pb contributes up to 91%, Hg 67%, and Zn 33% of this pollution (Wallgren, 1989). In this region, the integrated pollution of the Klaipėda city is manifesting itself, together with that of the "Mažeikių nafta" enterprise and the Mažeikiai electric power plant (Aplinkos.., 2003). Some influence on the background values of heavy metals in topsoils may be exerted by agricultural activity (Vareikienė, 1998).

The study of snow mineral dust as an indicator of air pollution has proven the same accumulational tendency of heavy metals which was obtained in the topsoils and highbog peat: their increased values are characteristic of the snow dust in West Lithuania. This region also shows a large dust load (up to 11–12 t/km$^2$ yearly), this is why the metals reaching topsoils through the atmosphere compose from several (Pb, Ni) to several dozens of kg/km$^2$ per yer (Zn). The difference of resources of heavy metals (kg/ km$^2$) in the parent matters of soils and topsoils reaches several (Ag) up to several hundreds of kg (Pb, Zn) (Kadūnas et al., 2004). The atmospherically transportable and topsoil accumulative values of heavy metals thus may distinctly influence their background indices. The composition of snow dust and its clear metallization show that the main part of transregionally transportable finedispersal substances is connected with the pollution caused by combustible organic fuel, coal, petroleum or their products (Иванов, 1997). Such a transregionally transportable active pollution of our territory lasts for about two centuries. An additional impact on the West Lithuanian region is made also by two of the largest Lithuanian pollution sources, the "Mažeikių nafta" enterprise and the Mažeikiai electric power plant producing polyelemental pollution characterized also by several specific elements (V, Ni, Cr, La). The increased values of these elements in topsoils of Mažeikiai and the adjacent areas are undoubtfully of technogenic origin (Kadūnas et al., 2001). We may suppose that the increased values of these elements in snow mineral dust in West Lithuania are partly related to the influence of the mentioned pollution hotbeds. The latter has most likely increased recently, what is demonstrated by the increased values of V, Ni, Mo and La in the snow mineral dust of the principal association of trace elements in winter 2002–2003. The atmospheric transport of heavy metals has also caused their increased values in the highbog peat of West Lithuania (Table 1). The peat has mostly accumulated metals whose values are the highest in snow dust (Pb, Zn, Sn, Ag). The cluster analysis of trace elements in snow mineral dust has proven that the most important is the technogenic association of heavy metals composed of some groups which may indicate different pollution sources.

## CONCLUSIONS

- A study of topsoil, one of the principal depositional environments of heavy metals, has shown that their background values are unevenly distributed. The elevated values of most metals and their abundant anomalies were established in the soils of West Lithuania.
- Tests of the snow mineral dust an indicator of atmospherically transportable pollutants have proven that this transport is more intensive in West Lithuania.
- The technogenic association of trace elements composed of heavy metals is most important in snow dust.
- The study has emphasized that formation of the background values and anomalies of heavy metals in the topsoils of West Lithuania is influenced by the regional (from the local large pollution sources) and transregional (from West and Northwest Europe) atmospheric transportation.
- The increased values of heavy metals in the topsoils of West Lithuania and their relation with air pollution may be treated as one of the risk factors that lower the quality of the natural environment.

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## SUNKIŲJŲ METALŲ ATMOSFERINĖS PERNAŠOS ĮTAKA JŲ KIEKIAMS DEPONAVIMO TERPĖSE VAKARŲ LIETUVOJE

S a n t r a u k a

Vakarų Lietuvos dirvožemio viršutiniame sluoksnyje pagal 380 mėginių emisinės spektrinės analizės duomenis nustatyti padidėję Ag, Pb, Zn, Sn foniniai kiekiai ir gausios jų anomalijos. Vakarų Lietuvos mineraliniuose dirvožemiuose (smėlio, priesmėlio ir molio-priemolio) daugiau nei 10% didesni Pb ir Sn, daugiau 5% – V, Ag ir Zn foniniai kiekiai. Jų kaupimosi eilė Pb>Sn>Ag>Zn>Ni. Aukštapelkių durpėje šie skirtumai yra dar ryškesni ir daugelio metalų viršija 25%, o Pb, Zn ir Sn – 40%. Jų kaupimosi eilė (Pb>Zn>Sn>Ag>V) panaši kaip ir mineraliniuose dirvožemiuose, tik Ni vietą durpėje užima daugiau biofilinis V.

Šiame regione apskaičiuotas sunkiųjų metalų anomalumo mineraliniame dirvožemyje koeficientas (0,09) yra didesnis nei visoje Lietuvos teritorijoje (0,06). Pajūrio dirvožemiams būdingas ir aukštas mikroelementinės sudėties kontrastingumo laipsnis (1,46, kai visos Lietuvos dirvožemiuose jis sudaro 1,32), rodantis, kad yra daugiau besikaupiančių nei deficitinių mikroelementų.

Tokius dirvožemių mikroelementinės sudėties ypatumus atspindi ir sunkiųjų metalų koreliacijos ryšiai su kitais dirvožemio mikroelementais bei jų padėtis geocheminėse asociacijose. Vakarų Lietuvos mineraliniuose dirvožemiuose stipriais koreliacijos ryšiais išsiskiria Mo–Sn–Pb–Zn grupė, t. y. tie elementai, kurių kiekiai, lyginant su visos Lietuvos mineraliniais dirvožemiais, yra padidėję.

1995–1996 ir 2002–2003 m. žiemų sniego mineralinių dulkių, kaip oro užterštumo indikatoriaus, tyrimai patvirtino tą pačią sunkiųjų metalų kaupimosi tendenciją, kuri buvo nustatyta dirvožemyje ir aukštapelkių durpėje, – didesni jų kiekiai (iki 1,65 karto) būdingi Vakarų Lietuvos regiono sniego dulkėms. Šiam regionui taip pat būdinga didelė dulkių apkrova (iki 11–12 t/$km^2$ per metus), todėl metalų, patenkančių per atmosferą į dirvožemį, per metus susidaro nuo kelių (Pb, Ni) iki keliasdešimt kilogramų kvadratiniame kilometre (Zn). Skirtumas tarp sunkiųjų metalų atsargų (kg/$km^2$) dirvodarinėse uolienose ir humusiniame horizonte siekia nuo kelių (Ag) iki kelių šimtų kilogramų (Pb, Zn), todėl su atmosferine pernaša į dirvožemį patenkančių sunkiųjų metalų kiekis gali turėti apčiuopiamą poveikį foniniams jų kiekiams. Sniego dulkių sudėtis ir ryški jos metalizacija rodo, kad didžioji dalis regioninių ir transregioninių smulkiadispersinių pernašų yra susijusi su deginamo organinio kuro (akmens anglies ir naftos bei jos produktų) sukeliama tarša, kuri vyksta jau apie du šimtmečius. Vakarų Lietuvos regionui papildomą poveikį daro didžiausių taršos šaltinių Lietuvoje – AB „Mažeikių nafta“ ir Mažeikių elektrinės – skleidžiama sudėtinė tarša, kuriai taip pat būdingi ir specifiniai elementai – V, Ni, Cr, La. Padidėjęs šių elementų kiekis dirvožemio humusiniame horizonte ir sniego mineralinėse dulkėse Mažeikių bei gretimuose rajonuose yra neabejotinai technogeninės kilmės ir gali būti siejamas su šiais stambiais taršos židiniais. Šis poveikis greičiausiai pastaruoju metu yra santykinai išaugęs, tą rodo padidėjusi V, Ni, Mo ir La reikšmė 2002–2003 m. žiemos sniego mineralinių dulkių svarbiausioje (technogeninėje) mikroelementų asociacijoje. Sunkiųjų metalų pernaša atmosfera galima paaiškinti jų gerokai padidėjusius kiekius aukštapelkių durpėje Vakarų Lietuvoje. Joje labiausiai kaupėsi tie sunkieji metalai, kurių kiekiai ir sniego dulkėse dažniausiai yra didžiausi (Pb, Zn, Sn, Ag).

Sniego mineralinių dulkių mikroelementinės sudėties klasterinės analizės duomenys patvirtina, kad svarbiausia asociacija yra technogeninė, sudaryta iš sunkiųjų metalų, o tai, kad ji susideda iš kelių grupių, gali rodyti skirtingus taršos šaltinius.

Padidėjęs sunkiųjų metalų kiekis Vakarų Lietuvos dirvožemiuose ir aukštapelkių durpėje bei jo ryšys su oro tarša gali būti laikomas vienu iš rizikos veiksnių, darančių neigiamą įtaką šio regiono gamtinės aplinkos kokybei.

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## ВЛИЯНИЕ АТМОСФЕРНОГО ПЕРЕНОСА ТЯЖЕЛЫХ МЕТАЛЛОВ НА ИХ СОДЕРЖАНИЕ В ДЕПОНИРУЮЩИХ СРЕДАХ ЗАПАДНОЙ ЛИТВЫ

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В гумусовом горизонте почв Западной Литвы по данным эмиссионного спектрального анализа 380 проб установлены повышенные фоновые содержания Ag, Pb, Zn, Sn, а также многочисленные их аномалии. В минеральных почвах фоновые содержания Pb и Sn на 10%, а Ag, Zn и V – на 5% выше, чем на территории Литвы в среднем. Они образуют такой ряд накопления: Pb>Sn>Ag>Zn>Ni. В верховом торфе эти различия еще больше и для большинства металлов превышают 25%, а для Pb, Zn и Sn – 40%. Их ряд накопления (Pb >Sn>Ag>Zn> V) такой же, как и в минеральных почвах, только Ni заменяет более биофильный V.

Коэффициент аномальности тяжелых металлов в почвах этого региона (0,09) выше, чем на всей тер-

ритории Литвы (0,06). Показывающий разницу между накапливающимися и дефицитными микро-элементами коэффициент контрастности микроэле-ментного состава (1,46) также выше, чем на всей территории Литвы (1,32).

Такие особенности микроэлементного состава почв влияют на корреляционные связи тяжелых металлов с остальными микроэлементами, а также на их положение в геохимических ассоциациях. В гумусовом горизонте почв Западной Литвы сильными корреляционными связями выделяется группа Mo-Sn-Pb-Zn, т. е. металлов с повышенным фоновым содержанием.

Исследование минеральной части снежной пыли 1995–1996 и 2002–2003 г. г. выявило ту же тенденцию накоп-ления тяжелых металлов: повышенное их содержание (до 1,65 раза) установлено в пыли снега Западной Литвы. Этот регион отличается также повышенной пылевой нагрузкой (11–12 т/км$^2$/год), поэтому нагрузка тяжелых металлов, выпадающих на поверхность почв за год, составляет от нескольких (Pb, Ni) до десятков килограммов (Zn) на квадратный километр. Разница между запасами (в кг/км$^2$) в материнских породах и в гумусовом горизонте почв составляет от нескольких (Ag) до нескольких сот килограммов (Pb, Zn), поэтому ежегодная атмосферная нагрузка тяжелых металлов может влиять на их фоновое содержание в почвах. Состав минеральной части снежной пыли и явная её металлизация показывают, что тонкодисперсные частицы, участвующне в региональном и трансрегиональном атмосферном переносе, являются в основном продуктами сжигания органического топлива. Этот процесс продолжается уже более двухсот лет. На фоновое содержание тяжелых металлов в почвах этого региона также оказывает влияние деятельность нефтеперерабатывающего эавода „Мажейкю нафта“ и Мажейкской электростанции. Из-за их деятельности атмосфера эагрязняется многими тяжелыми металлами, особенно V, Ni, Cr, La. Повышенное их содержание установлено и в гумусовом горизонте почв Мажейкского и соседних с ним районов. Влияние деятельности вышеуказанных объектов на загрязнение почв в настоящее время возросло, на что указывает усиление корреляционных связей между V, Ni, Mo и La в основной техногенной ассоциации микроэлементов снежной пыли 2002–2003 г. г.

Влиянием атмосферного переноса тяжелых металлов можно объяснить повышенное их содержание в верховом торфе Западной Литвы. Здесь накапливаются те же тяжелые металлы, что и в снежной пыли.

Кластерный анализ микроэлементного состава пыли показал, что основная ассоциация является техногенной, состоящей из нескольких групп тяжелых металлов. Это может свидетельствовать о наличии нескольких источников тяжелых металлов.

Повышенное содержание тяжелых металлов в гумусовом горизонте почв, а также в верховом торфе Западной Литвы является одним из факторов риска, оказывающих негативное влияние на качество природной среды в этом регионе.