ICP VEGETATION

30th Task Force Meeting

14th – 17th February 2017

Poznan, Poland

Programme & Abstracts

Working Group on Effects of the Convention on Long-range Transboundary Air Pollution

ICP VEGETATION
30th Task Force Meeting

14th – 17th February 2017
Poznan, Poland

Organizers:

ICP Vegetation Programme Coordination Centre
Centre for Ecology & Hydrology
Bangor, UK

Harry Harmens
Gina Mills

Local organizers:

Dr. Klaudia Borowiak – chairperson
Prof. Dr. Barbara Godzik
Dr. Anna Budka
Dr. Maria Drapikowska
Dr. Jolanta Kanclerz
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Dr. Alicja Niewiadomska
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PROGRAMME

Tuesday 14th February, 2017

Main hall of the building:

17:30 – Registration in the building of Faculty of Environmental Engineering and Spatial Management, Poznan University of Life Sciences, Piatkowska 94E, Poznan

18:30 – Welcome buffet

Wednesday 15th February, 2017

Main building of the Faculty of Environmental Engineering and Spatial Management:

- ***Plenary and moss survey sessions will be in the room 111***
- ***Ozone sessions will be in room 109***
- ***Poster session in the main hall***

08:30 Late registration and putting up posters

Session 1: 9:00 – 10:45 Plenary session Chair: Klaudia Borowiak

09:00 Welcome address – Welcome by Prof. Jan Pikul, rector/vice-rector of Poznan University of Life Sciences

09:15 *Harry Harmens et al.* – Overview of the achievements of the ICP Vegetation in 2016 and future workplan (2017-2019).

09:40 *Marina Frontasyeva, Harry Harmens et al.* – Present status of the moss survey in 2015-2016.

10:00 *Walter Seidling* – Activities under ICP Forests with reference to ICP Vegetation.

10:20 *Janusz Olejnik* – Greenhouse gases and energy fluxes in different ecosystems – overview of long-term observations and different measurement techniques applied at PULS sites.

10:40 Discussion

10:45 – 11:30 Coffee/tea and poster viewing (with authors at poster)

Session 2: 11:30 – 13:00 (Two parallel sessions: Ozone and Moss survey)

Session 2a: Ozone – Revision of Chapter 3 of the Modelling and Mapping Manual (part 1) Chair: Gina Mills

11:30 *Harry Harmens et al.* – Restructuring Chapter 3 of Modelling and Mapping Manual and new scientific background document.

11:45 *Håkan Pleijel et al.* – Ozone critical levels for crops for inclusion in the Modelling and Mapping Manual.

12:00 *Felicity Hayes et al.* – Ozone critical levels for (semi-)natural vegetation in temperate perennial grasslands for inclusion in the Modelling and Mapping Manual.

12:15 *Ignacio González Fernández et al.* - New ozone critical levels for (semi-) natural vegetation for Mediterranean annual pastures, for inclusion in the Modelling and Mapping Manual.

12:30 General discussion – critical levels for crops and (semi-)natural vegetation.

Session 2b: Moss survey **Chair: Marina Frontasyeva**

11:30 *Eiliv Steinnes* – Monitoring of atmospheric deposition of metals: where do we stand after forty years of experience?

11:50 *Pranvera Lazo et al.* – Mineral particles dust important sources of trace metal in atmospheric deposition in Albania.

12:10 Discussion:
- – Issues raised in previous two presentations, including some SEM slides from Marina Frontasyeva.
- – Further outreach activities, including Asia, South America and Africa.
- – Schedule for data submission, including for moss reference material, and schedule for finalisation of report.
- – Future moss reference material, including some slides from Sébastien Leblond.

13:00 – 14.00 Lunch

Session 3: 14:00 – 15:30 (Two parallel sessions: Ozone and Moss survey)

Session 3a: Ozone – Revision of Chapter 3 of the Modelling and Mapping Manual (part 2) **Chair: Håkan Pleijel**

14:00 *Patrick Büker et al.* – Ozone critical levels for trees for inclusion in the Modelling and Mapping Manual.

14:15 *Giacomo Gerosa, Rocio Alonso et al.* – Ozone critical levels for Mediterranean deciduous broadleaved and evergreen tree species for inclusion in the Modelling and Mapping Manual.

14:30 General discussion – critical levels for trees and other suggested changes to the chapter.

Session 3b: Moss survey **Chair: Eiliv Steinnes**

14:00 *Yulia Aleksiayenak et al.* – Ten year biomonitoring study of atmospheric deposition of trace elements in the territory of Belarus: trends and tendencies, optimization of the sample sites number for upcoming moss surveys.

14:20 *Hilde Thelle Uggerud et al.* – Atmospheric deposition of organic contaminants in Norway.

14:40 *Zaida Kosonen et al.* – PAH in Switzerland – results of the 2015 moss survey.

15:00 *Maria Zielińska et al.* – Execution of the biomonitoring research conducted within grants (OP CR-RP, JINR, POL-NOR) in selected areas in Poland and Norway

15:20 General discussion.

15:30 – 16.00 Coffee/tea and poster viewing

Session 4: 16:00 – 17:30 (Two parallel sessions: Ozone and Moss survey)

Session 4a: Ozone: (Semi-)natural vegetation and crops Chair: Patrick Büker

16:00 *Felicity Hayes et al.* – An overview of recent ozone experimental work at CEH Bangor.

16:20 *Håkan Pleijel et al.* – Current surface ozone significantly affect several aspects of wheat growth, yield and quality on three continents.

16:40 *Sabine Braun et al.* – Phenological models for budbreak calculation.

17:00 *Per Erik Karlsson et al.* – Estimated ozone sensitivity periods for trees in northern Europe.

17:20 General discussion.

Session 4b: Moss survey: Chair: Marina Frontasyeva

16:00 Discussion:
– Analysis of data, moss reference data, mapping.
– On line data availability: summary data and maps? Requests for original data per site via data access protocol?
– Recent and future joint publications.

16:30 *Alexander Uzinskiy et al.* – Data management of the UNECE ICP Vegetation monitoring network.

16:50 *Alexander Uzinskiy* – Training use data management system.

Thursday 16th February, 2017

Session 5: 09:00 – 10:30 (Two parallel sessions: Ozone and Moss survey)

Session 5a: Ozone Chair: Per Erik Karlsson

09:00 *Klaudia Borowiak et al.* – Ozone gardens in Poland in 2016 season.

09:20 *Kent Burkey et al.* – Potential impacts of ambient ozone on wheat rust diseases and the role of plant ozone sensitivity.

09:40 *Alexandra de Marco et al.* – Latest update of modelling ozone fluxes over Europe.

10:00 *Stan Cieslik et al.* – Total and stomatal ozone surface fluxes recorded during 3.5 years over a deciduous subalpine forest.

10:20 General discussion

Session 5b: Mosses Chair: Pranvera Lazo

09:00 *Helena Danielsson* et al. – Results from the national Swedish moss survey in 2015.

09:20 *Gunilla Pihl-Karlsson et al.* – Heavy metals, sulphur and nitrogen - correlation between concentrations in mosses and deposition.

09:40 *Lotti Thöni et al.* – Nitrogen concentration in moss compared with N load in precipitation and "total" N deposition in Switzerland.

10:00 *Stefan Nickel et al.* – Re-structuring the German Moss Survey Network.

10:20 General discussion.

10:30 – 11:00 Coffee/tea and poster viewing

Session 6: 11:00 – 12:30 (Two parallel sessions: Ozone and Moss survey)

Session 6a: Ozone Chair: Gina Mills

11:00 Gina Mills – Introduction to working groups.

Working groups: Theme – Extending the outreach activities of the ICP Vegetation.

Session 6b: Moss survey Chair: Zvonka Jeran

11:00 *Julian Aherne et al.* – Moss biomonitoring in Ireland: 2015 survey.

11:20 *Guntis Tabors et al.* – Assessment of atmospheric pollution with heavy metals and nitrogen using *Pleurozium schreberi* mosses as bioindicator in Latvia.

11:40 Discussion:
- – Preparations for 2020 survey, including improved monitoring manual. Set up working group to draft new manual?
- – Any further outstanding discussion points.

12:30 – 13.30 Lunch

Session 7: 13:30 – 15:00 (Two parallel sessions: Ozone and Moss survey)

Session 7a: Ozone Chair: Felicity Hayes

13:30 *Giacomo Gerosa et al.* – Ozone flux-effect relationships for durum wheat and lettuce in Mediterranean conditions.

13:40 *Rocio Alonso et al.* – O_3 sensitivity of Spanish wheat cultivars: preliminary results.

13:50 Gina Mills – Update on the Tropospheric Ozone Assessment Report (TOAR).

14:05 Working groups session 6a report back.

14:30 General discussion of ICP Vegetation work plan for ozone activities.

Session 7b: Moss survey Chair: Sebastien Leblond

13:30 *Irena Pavlikova et al.* – Atmospheric deposition of heavy metals in Czech-Polish border region studied by moss survey, neutron activation analysis and GIS.

13:50 *Evdoxia Tsakiri et al.* – *Hypnum Cupressiforme* HEDW. as bioindicator of ^{137}Cs radionuclide in Northern Greece.

14:10 *Stefan Franzle et al.* – How do chitin adsorption-based data compare to biomonitoring using mosses?

14:30 *Oldrich Motyka et al.* – NAA and ICP-AES: comparison of approaches in biomonitoring campaign.

14:50 General discussion

15:00 – 15:30 Coffee/tea and poster viewing

Session 8: 15:30 – 17:00 (Two parallel sessions: Ozone and Moss survey)

Session 8a: Ozone: decisions ozone critical levels Chair: Gina Mills

15:30 Finalise decisions on ozone critical levels – to be presented in plenary on Friday morning for consideration by the Task Force.

Session 8b: Moss survey Chair: Marina Frontasyeva

15:30 Final discussions on moss survey, workplan for coming year, decisions and actions to be reported back to plenary on Friday morning for consideration by the Task Force.

17:00 Departure to Poznan city centre by tram and sightseeing with guide (Poznan old town, old market, Cathedral)

19:00 **CONFERENCE DINNER** in the old town area – *Tumska restaurant* (near the Cathedral, Tumska 5a street).

Friday 17th February, 2017

Session 9: 08:45 – 10:30 Plenary session Chair: Harry Harmens

- Reporting back from ozone and moss sessions: decisions and actions
- Medium-term work plan ICP Vegetation 2017 – 2020
- Decisions and recommendations of the 30th Task Force Meeting
- 31st ICP Vegetation Task Force Meeting
- Other business

10:30 **Excursion Poznan area.**

POSTERS

OZONE (AND PM)

1. **The problem of the local conditions on the smog phenomena on the example of Krakaw city.**
   Bedla D.

2. **Changes of photosynthesis activity of pine trees cultivated in different water regimes in relation to tropospheric ozone concentrations.**
   Borowiak K., Biniak-Pieróg M., Żyromski A., Budka A.

3. **Changes of ozone-caused injuries of bean and tobacco plants in 2016 season.**
   Borowiak K., Stasik R., Zbierska M., Lisiak M., Achtenberg K., Adamska A.

4. **Bean as a simultaneous bioindicator of ozone and trace elements in different environmental conditions.**
   Borowiak K., Wasik J., Niewiadomska A., Wolna-Maruwka A., Ławniczak A., Urbaniak J.

5. **Geispan project: GHG balance and ozone fluxes in relevant Spanish ecosystems.**
   Calatayud, V., Calvo, E., Carrara, A.

6. **Microscopic analysis of ozone-caused injuries in selected plant species.**
   Drapikowska M., Drapikowski P., Borowiak K., Gmur A.

7. **Using of *Trifolium repens* to assessment of air contamination in the Sambia peninsula (Kaliningrad region, Russia).**
   Koroleva Y., Shleivis A., Kumichyova S., Raicis E.

8. **The influence of climate change, particularly temperature increase and precipitation reduction in wetlands – short term experiment in climate manipulation in the western Poland.**
   Leśny J.,_ Juszczak R., Silvennoinen H., Urbaniak M., Chojnicki B.,, Lamentowicz M., Basińska A., Gąba M., Stróżecki M., Samson M., Józefczyk D., Hoffmann M., Olejnik J.

9. **"End of clean air in ..." – problems of the cities from Polish Green Lungs.**
   Panfil M.

MOSS SURVEY

1. **Cl, I and Br, and trace metal assessment on atmospheric deposition of Albania evaluated by ENAA Analysis.**
   Allajbeu S., Qarri F., Kane S., Lazo P., Frontasyeva M.

2. **Trace elements accumulation in *Taraxacum officinale* collected from city area.**
   Borowiak K., Kanclerz J., Lisiak M., Budka A., Janicka E., Mleczek M., Niedzielski P.

3. **Toxic metals and metalloids in the environment and possibility to neutralize with dendroremediation.**
   Budzyńska S., Mleczek M., Niedzielski P., Gąsecka M., Goliński P.

4. **Atmospheric deposition of major and trace elements by the moss biomonitoring technique in Istanbul/Turkey.**
   Erenturk S., Haciyakupoglu S.

5. **Moss monitoring of trace elements in the republic of Udmurtia, Russia.**
   Bukharina, I.L., Zhuravleva, A.N., Volkov, N.A., Vasileva, N.A., Shvetsova, M.S., Frontasyeva, M.V.

6. **Moss biomonitoring in Canada: 2014-2016.**
   Cowden, P., Aherne, J.

7. **Shifts of Sphagnum and brown mosses populations vs pollutions in Harz Mts. (Germany) over the last 2700 years.**
   Gałka M., Szal M., Broder T., Knorr K.-H.

8. **Assessment of changes in radioisotopes activity concentrations in mosses during subsequent growing seasons.**
   Godyń P., Ziembik Z., Dołhańczuk-Śródka A.

9. **Analysis of mosses to monitor radioactivity from the atmosphere (Istanbul, Turkey).**
   Haciyakupoglu S., Erenturk S., Gungor N., Bayulken S., Karahan G.

10. **Moss biomonitoring in Central Russia: Tula Region case study.**
    Gorelova S.V., Frontasyeva M.V., Vergel K.N., Babicheva D.E., Ignatova T.Yu.

11. **The 2015 moss monitoring in Poland.**
    Kapusta P., Szarek-Łukaszewska G., Stanek M., Godzik B.

12. **The use of moss *Pleurozium schreberi* (Brid.) Mitt. as bioindicator of radionuclides contamination in industrial areas of Upper Silesia.**
    Kosior G., Dołhańczuk-Śródka A., Ziembik Z., Brudzińska-Kosior, A.

13. **Phytoextraction of rare earth elements using *Betula pendula* Roth and *Pinus sylvestris* L. growing on highly polluted mining wastes.**
    Kozubik T., Mleczek M., Niedzielski P., Magdziak Z, Goliński P.

14. **A comparison of various methods for air pollution characterization of industry influenced areas.**
    Krakovska A., Svozilik V., Lackova E., Bitta J., Jancik P.

15. **Trends of heavy metal accumulation in mosses in Slovakia (1990 -2015).**
Maňkovská B. . Oszlányi J., Izakovičová Z., Frontasyeva M.V.

16. **The use of lichens and mosses in passive biomonitoring.**
Marciniak M., Kłos A., Rajfur, M.

17. **Phytoextraction of selected rare earth elements in herbaceous plant species growing near roads.**
Mikołajczak P., Borowiak K., Niedzielski P.

18. **Phytoextraction of some arsenic forms in selected willow taxa - pot experiment**.
Mleczek M., Budzyńska S., Goliński P., Gąsecka M., Magdziak Z., Rutkowski P., Niedzielski P.

19. **Biomonitoring of atmospheric depositions of heavy metals and radionuclides in Kazakhstan.**
Nurkasimova, M.U., Omarova, N.M, Chepurchenko, O., Frontasyeva, M.V.

20. **Analysis of nitrogen concentrations in mosses in Czech-Polish border region in 2015**.
Pavlíková I., Tomšejová K., Hladký D.

21. **Atmospheric deposition of trace metal in Albania (2015 moss survey) evaluated by moss biomonitoring and ICP-AES analysis.**
Qarri, F., Kane, S., Allajbeu, Sh., Lazo, P., Stafilov T.

22. **Moss monitoring of trace elements in the Republic of Udmurtia, Russia**.
Shvetsova M.S., Frontasyeva M.V., Zhuravleva A.N., Bukharina I.L., Volkov N., Vasileva N.

23. **Air pollution biomonitoring with moss in Republic of Georgia.**
Shetekauri S., Chaligava O., Shetekauri T., Kvlividze A., Kalabegishvili T., Kirkesali E.I., Frontasyeva M.V., Chepurchenko O.E., Tselmovich V.A., Steinnes E.

24. **Temporal trends of metal concentrations in mosses collected in Romania in 2010 and 2015.**
Stihi C., Ene A., Radulescu C., Dulama I., Iacoban C., Frontasyeva M.V., Culicov O., Zinikovscaia I.

25. **Establishing moss monitoring network of atmospheric deposition of trace elements in Armenia: a pilot study in 2016.**
Tepanosyan G.H., Sahakyan L.V., Yarmaloyan K.V., Chepurchenko O., Yushin N.S., Saghatelyan A.K., Frontasyeva M.V.

26. **Biomonitoring of heavy metals and trace elements in central Russia: Moscow case study.**
Vergel K.N., Frontasyeva M.V., Zinicovscaia I.I., Goryainova Z.I.

27. **Web-Based geoinformatic system for modeling and assessment of the environmental status of the South-Eastern Baltic (Russia Federation).**
Zhegalina L., Bryksin V., Kungurtsev S., Koroleva Y., Pukhlova I

PLENARY

OVERVIEW OF THE ACHIEVEMENTS OF THE ICP VEGETATION IN 2016 AND FUTURE WORKPLAN (2017 – 2019)

Harmens H., Mills G., Hayes F., Sharps K.
and the participants of the ICP Vegetation

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The ICP Vegetation is an international programme that reports on the effects of air pollutants on natural vegetation and crops [1]. It reports to the Working Group on Effects (WGE) of the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP). In particular, the ICP Vegetation focuses on the following air pollution problems: quantifying the risks to vegetation posed by ozone pollution and the atmospheric deposition of heavy metals, nitrogen and persistent organic pollutants (POPs) to vegetation. The ICP Vegetation also studies the impacts of pollutant mixtures (e.g. ozone and nitrogen), impacts on ecosystem services and biodiversity, and interactions between air pollutants and climate change.

At the 30th Task Force Meeting we will report on the achievements of the ICP Vegetation in 2016 [1], including:

- Field evidence of ozone impacts on vegetation in ambient air (2007-2015) [2];
- Impacts of ozone pollution on biodiversity [3];
- New developments of ozone critical levels for vegetation and revision of Chapter 3 of the Modelling and Mapping Manual [4];
- Progress with the European moss survey 2015/2016;
- Outcome of survey on usefulness of ICP Vegetation outputs;
- Contributions to common workplan items of the WGE.

We will also discuss the future workplan (2017 – 2019), including:

- Further outreach activities to developing countries;
- Evidence of ozone impacts on vegetation in Europe and developing countries;
- Application of ozone risk assessment methodology in Europe and beyond;
- Impacts of ozone on global food production;
- Report on the outcome of the 2015/2016 moss survey;
- Preparations for the 2020 moss survey.

Acknowledgement
We thank the UK Department for Environment, Food and Rural Affairs (Defra) for funding the ICP Vegetation Programme Coordination Centre. Further financial support was provided by the UNECE and the UK Natural Environment Research Council (NERC).

References

[1] http://icpvegetation.ceh.ac.uk/publications/documents/ICPVegetationannualreport2015-16.pdf
[2] http://icpvegetation.ceh.ac.uk/publications/documents/CEH_EVIDENCE_SINGLES_HIGH.pdf
[3] http://icpvegetation.ceh.ac.uk/publications/documents/CEH_BIODIVERSITY_SINGLES_HIGH.pdf
[4] http://icpvegetation.ceh.ac.uk/publications/documents/Ch3-MapMan-2016-05-03_vf.pdf

PRESENT STATUS OF THE MOSS SURVEY IN 2015/2016

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A summary of the present situation in the moss survey 2015/2016 is given. In agreement with the long-term strategy of the LRTAP Convention to enhance participation and improve air quality in Eastern Europe, the Caucasus, Central Asia and South Eastern Europe, efforts to extend the moss survey to former republics of the USSR were successfully undertaken in countries such as Armenia, Azerbaijan, Georgia, Kazakhstan, Moldova, and Tadjikistan. In the current moss survey the following territories of the Russian Federation were sampled: Moscow, Tver, Tula, Ivanovo, Leningrad (Tikhvin district), Bryansk, and Kaliningrad Regions, Voronezh Reserve, Yamal Penisular, Republic of Udmurtia, and Far East (Kamchatka). Up-to-date results are reported by Austria, Latvia, Norway, Poland, Serbia, and Sweden. Norway, in addition to the requested 12 elements (Al, As, Cd, Cr, Cu, Fe, Hg, Ni, Pb, Sb, V, Zn), have reported data on Li, Be, B, Na, Rb, Sr, Y, Nb, Rh, Ag, Tl, Cs, Ba, La, Ce, Pr. Nd, Sm, Eu, Gd, Tb, Dy, Er, Yb, Ir, Pt, Te, Bi, Th, U, Mg, S, Ca, Sc, Ti, Mn, Co, Ga, K, and Se, whereas Serbia extended the request list of elements to include Ba, Ca, Ce, Co, In, Ga, K, Mg, Mn, Mo, Na, Rb, Sr, Sm, Y, and W. Switzerland reported extra data for S, Ag, Bi, Co, Se, and Tl. Sector of NAA and Applied Research of FLNP JINR (Dubna) continues to support the moss survey programme in some of its member states: Bulgaria, Czech Republic, Mongolia, Poland, Romania, Slovakia, Vietnam, as well as in some non-member states: Albania, Hungary, Thailand, South Korea, and China. In spite of the growing interest in assessment of the deposition of persistent organic pollutants (PAHs, PCBs, PBDEs, dioxins, PFOS, etc.) using moss, only a limited number of the Western European countries determine POPs. Many countries will also report nitrogen concentrations in moss samples. Some countries will report results on radionuclides of technogenic origin in Europe. The relevance of these studies to the UN Convention on Long-range Transboundary Air Pollution (LRTAP) is emphasized. Some details are given on the newly established database for storage of information about the European and Asian moss survey, conducting and storing analytical results on heavy metals, nitrogen, persistent organic compounds, and radionuclides (^{137}Cs, ^{210}Pb, etc) based on moss analysis. Potentialities of using moss planchettes for search of cosmic dust deposition are illustrated with images obtained using microanalysis (SEM and TEM).

References

[1] M. V. Frontasyeva, E. Steinnes and H. Harmens. Monitoring long-term and large-scale deposition of air pollutants based on moss analysis. Chapter in a book “Biomonitoring of Air Pollution Using Mosses and Lichens: Passive and Active Approach – State of the Art and Perspectives”, Edts. M. Aničić Urošević, G. Vuković, M. Tomašević, Nova Science Publishers, New-York, USA, 2016.

[2] G. Ososkov, M. Frontasyeva, A. Uzhinskiy, N. Kutovskiy, B. Rumyantsev, A. Nechaevsky, V. Trofimov, K. Vergel. Data Management of the Environmental Monitoring Network: UNECE ICP Vegetation Case. Proceedings of XVIII International Conference «Data Analytics and Management in Data Intensive Domains» DAMDID/RCDL'2016 (October 11-14, Ershovo, Moscow, Russia). ISBN 978-5-94588-206-5, Moscow: FRC IM RAS Publ., 2016. pp. 309-314.

ACTIVITIES UNDER ICP FORESTS WITH REFERENCE TO ICP VEGETATION

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The International Co-operative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) follows both, an ecosystem approach in its intensive monitoring programme on selected forest plots (Level II monitoring) and a large scale inventory of mainly tree condition within a representative network (Level I monitoring). On approximately 200 open-field sites nearby Level II plots from 20 countries, ozone concentration measurements by passive samplers – at some sites in combination with active ozone concentration measurements – are conducted and ozone-like visible symptoms are being assessed towards the end of each season on approximately 285 species from 169 plots in 19 countries across Europe. On many Level II monitoring plots and nearby forest openings throughfall deposition, open field deposition and air quality measurements are being performed since approximately 1995. At a number of these sites also moss samples for biomonitoring are collected.

Data from the long-term monitoring campaigns at Level II sites offer opportunities for joint evaluations between ICP Forests and ICP Vegetation. In respect to ozone risk assessment, currently developed ozone concentration maps may be validated by ICP Forests data for ozone concentrations from the very forest sites. Data from ozone-like symptoms from woody species grown at the forest edge closest to Level II monitoring plots, contribute to effect-based risk assessment for forest ecosystems. Additional data on soil condition, meteorology and other ecosystem-related data should support a more integrated view on ozone risk for forest ecosystems across Europe. Along these lines, a recently launched initiative on 'Predicting Ozone Fluxes, Impacts, and critical Levels on European forests' (PROFILE) integrates the ozone flux modeling expertise from ICP Vegetation and EMEP with the available long-term and large-scale data as collected, harmonized and evaluated by ICP Forests experts.

Element analysis of moss samples from some Level II sites have already been evaluated regarding relationships between N content in moss and N concentrations in the open-field and throughfall deposition. Also, within-plot relationships between stand-structural features and element content in mosses have been studied at some Level II plots in Slovenia. Well established ICP Forests infrastructure (Level I and Level II plots) with numerous environmental variables measured in the open-field and forest stands, could serve as backbone for ICP Vegetation field surveys. With gathering different data at the same locations, more sophisticated modelling could enhance both, a better understanding of small-scale variation of moss and deposition element concentrations of nitrogen and heavy metals on one side and improved modelling approaches at larger spatial and temporal scales.

OZONE

O_3-SENSITIVITY OF SPANISH WHEAT CULTIVARS. Preliminary results

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Wheat is currently considered the most sensitive cereal to the increasing levels of surface ozone (O_3). Accordingly, the exposure and dose-response functions developed for this crop are currently used for assessing the risk of O_3 effects on agricultural production at European scale (CLRTAP, 2010). To date, the response functions are based on experiments developed under central and north-European climate and using cultivars adapted to these latitudes. Thus, risk analyses present high uncertainty in the Southern European countries, with a Mediterranean climate profile and specific cultivars adapted to the water limited conditions characteristic of the area.

Since 2015 until 2018, new OTC experiments funded by the AGRISOST-CAM project will be performed to determine the relative sensitivity to O_3 of the most abundant modern wheat cultivars in Spain, to compare them with the O_3 sensitivity of old cultivars typically used during the XX century, and to evaluate how water availability affects their response to O_3.

The first experiment was developed in 2015, testing 15 cultivars, five from each of the three groups considered (old, medium and modern cultivars) under four O_3 treatments. In order to grow cultivars in homogeneous conditions for finding the main traits related with O_3-sensitivity, plants were grown in pots. Biomass, yield and physiological parameters related to gas exchange and water stress tolerance were measured.

The results of the first experiment have allowed selecting the most sensitive cultivar for the next 2016 experiment, when plants grew in natural soil. The 2017 experiment will consider ozone and water stress interactions in plants growing in natural soil. Joining all the experiments, together with other available Mediterranean wheat data sets, will allow determining whether different wheat response functions should be considered for O_3 risk analysis in the different European agroclimatic zones.

This study is funded by the AGRISOST project (P2013/ABI-2717, Comunidad de Madrid) and by the Agreement between CIEMAT and the Spanish Ministry of Agriculture, Food and Environment for stablishing critical levels and loads for vegetation.

References

[1] CLRTAP, 2010. Chapter 3 of the CLRTAP Mapping Manual: Mapping Critical Levels for Vegetation. Available at: http://icpvegetation.ceh.ac.uk/manuals/mapping_manual.html

OZONE CRITICAL LEVELS FOR MEDITERRANEAN EVERGREEN FORESTS

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Ozone (O_3) is the most important and pervasive air pollutant in the Mediterranean region where climatic conditions favor O_3 photochemical formation and persistence. O_3-induced effects have been reported on the physiology and growth of Mediterranean forest species. However, discrepancies exist between the observed and the predicted O_3 effects on Southern European forests based on current O_3 critical levels. This discrepancy is likely to be explained by the inadequacy of the critical level and/or the inherent higher O_3 tolerance of Mediterranean vegetation. A review of O_3 exposure experiments performed with Mediterranean evergreen tree species has been carried out to address this issue. A database of 8 experiments including 6 different tree species and 3 experimental sites was used to derive exposure- and flux-based response functions for evergreen species. The species considered were: one conifer (*Pinus halepensis*) and 5 broadleaf evergreen species (*Quercus ilex* ssp *ilex*, *Q. ilex* ssp *ballota*, *Q. coccifera*, *Ceratonia siliqua*, *Olea europea*). All the experiments were performed with seedlings growing in open top chambers exposed to different O_3 treatments using charcoal-filtered air as control treatment. Four experiments included water stress treatments. Only those experiments providing information on O_3-induced effects on biomass of tree species growing under Mediterranean climate conditions have been considered. The length of the experiments varied between 0.4 to 3 years. Both local and species parameterizations of the Mapping Manual were used to model stomatal conductance. The reduction of biomass (RY) for each O_3 treatment (and water treatment if available) was estimated for each experiment relative to the hypothetical biomass at an AOT40 and POD_1 equal to zero. Each data point included in the response functions represents a single value for each species, treatment and experiment. Ozone critical levels were calculated based on exposure- and dose-response relationships for a 4% effect. Those effects were calculated starting from a reference biomass estimated for an average POD_1 using 10 ppb of O_3 as constant concentration (POD_1_10). The results indicate that Mediterranean tree species are more tolerant to O_3 than species from more humid biomes, yielding higher O_3 critical levels than those reported in the Mapping Manual. The results indicate that different O_3 critical levels should be used for damage risk assessment in Europe depending on vegetation types.

OZONE GARDENS IN POLAND IN 2016 SEASON

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There were three ozone gardens conducted simultaneously in three locations in Poland in 2016 season. The first one was located in the city of Poznan (Central-Western part of Poland), the second one in Wroclaw city suburbs area within rural land use (West-Southern part) and the last one was located in the suburbs of Krakow city (Southern part of Poland). Four plant species were cultivated in all three locations: bean (ozone-sensitive and resistant genotype), tobacco (ozone-resistant and –sensitive cultivar), wheat (ozone-sensitive) and clover (ozone-sensitive). Plants were firstly cultivated in pots in the greenhouse of Poznan University of Life Sciences, for several weeks to obtain strong plants for exposure. Afterwards, plants were transported to the experimental sites.

Plants were exposed from the beginning of July 2016. Every week visual observations were made and recording of visible ozone injuries was also conducted. All of ozone-sensitive plants revealed some injuries. However, the biggest were noted at tobacco ozone-sensitive cultivar. The second plant with high injury was bean and the lower sensitivity for ozone was noted for clover. The size of injuries increased during the season. However 2016 year was very windy and some of plants were mechanically destroyed. This was noted for all of analysed locations. The relations to ozone concertation are currently conducted and the results will be presented during the meeting. Recommendations for the next year – to protect plants again bad weather conditions it is recommended to use some protection screens or cultivate plants between higher plants (but not too high).

POTENTIAL IMPACTS OF AMBIENT OZONE ON WHEAT RUST DISEASES AND THE ROLE OF PLANT OZONE SENSITIVITY

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The resurgence of rust diseases and the continued rise in tropospheric ozone (O_3) levels have the potential to limit global wheat production. We conducted a series of experiments to understand the potential interactions between these two stress factors.

Both stem rust (Figure 1) and leaf rust (data not shown) were increased on a rust-susceptible, moderately O_3-sensitive winter wheat cultivar exposed to O_3 concentrations near current ambient levels (50 ppbv). Enhancement of disease was observed only when plants were pre-exposed for 3 weeks or continuously exposed to 50 ppbv O_3. This intermediate treatment did not result in foliar injury, suggesting that changes in leaf chemistry in what appear to be healthy leaves were a contributing factor. No differences in disease were observed between low O_3 controls and much higher O_3 levels typical of past studies, suggesting the need to re-evaluate the consensus that elevated O_3 suppresses wheat rusts.

The results suggest that present day air pollution may be impacting wheat production in areas where O_3 and rust disease co-occur. This phenomenon was reduced for cultivars with greater rust resistance, suggesting an interaction between O_3 sensitivity, rust resistance, and the resulting disease pressure. This interaction is dynamic because cultivar rust resistance may be overcome by pathogen evolution causing the inherent O_3 sensitivity to be a critical factor.

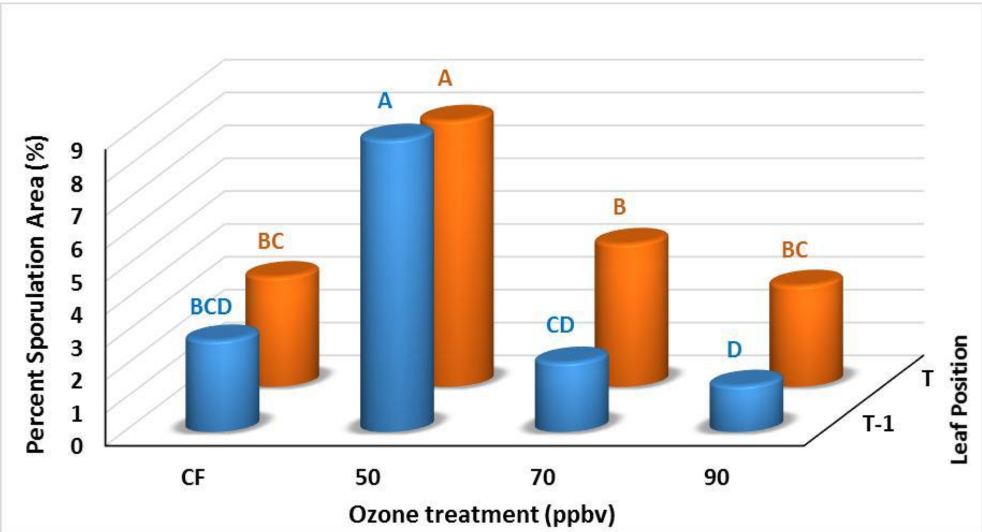

Fig. 1. Ozone effects on percent leaf sporulation area for winter wheat infected with stem rust (race QFCSC). Data are for the rust-susceptible, moderately O3 sensitive cultivar Coker-9553. Plants were grown for 4 weeks (Zadoks stage 21-22) under charcoal-filtered air (CF) followed by exposure to O3 treatments for 3 weeks [CF(<10), 50, 70, and 90 ppbv 12hr average]. Plants were then inoculated with spores and the O3 treatments continued. Disease severity was assessed at 21 days post inoculation at two leaf positions [top leaf (T) and second top leaf (T-1)] on the main stem. The treatments were conducted in custom-built outdoor plant environment chambers at 50% RH, 25/16 °C (day/night), and 400 ppmv CO2.

TOTAL AND STOMATAL OZONE SURFACE FLUXES RECORDED DURING 3.5 YEARS OVER A DECIDUOUS SUBALPINE FOREST

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Quantification of ozone fluxes from atmosphere to vegetation is essential in assessing damage to trees due to ozone uptake by leaf tissues. This work is devoted to a long-term series of micrometeorological observations including ozone fluxes over a forest site located in Northern Italy, mostly consisting of deciduous trees (*Quercus robur*,80%, *Alnus glutinosa*, 10%, and other).
Total ozone fluxes were derived from micrometeorological recordings, using an ultrasonic anemometer mounted on a 37-m high tower, operated together with fast-response sensors for ozone, water vapour and CO_2. Total ozone fluxes were obtained by correlating the instantaneous (recorded at a 10 Hz acquisition frequency) value of the vertical wind vector component and ozone concentration. The plant physiologically relevant parameter is not the total ozone flux however, but the stomatal ozone flux, which expresses the quantity of ozone molecules penetrating the leaf tissues through the stomatal cavities. Stomatal uptake is generally considered as the major ozone penetration process. As no direct measurement method exists nowadays to determine the stomatal flux of ozone, this work makes use of an algorithm based on the similarity between stomatal fluxes of ozone and water vapour, through the Penman-Monteith formulation and the measurement of water vapour fluxes.
Results show that the stomatal ozone fluxes over the forest under investigation are sensitive to the wetness state of the soil, to solar radiation, but are less correlated to ozone concentration. Flux and concentration often show different behaviour. Usually, ozone stomatal fluxes values are less than half the total ozone fluxes. Dependence of stomatal ozone fluxes with various atmospheric and plant physiological variables will be discussed.
Time-integrated stomatal ozone fluxes (POD) are presented on a yearly basis, such as to give indications to potential damage to trees.

DOSE-RESPONSE RELATIONSHIPS FOR OZONE EFFECT ON ABOVEGROUND BIOMASS OF DECIDUOUS BROADLEAVED TREE SPECIES IN MEDITERRANEAN ENVIRONMENT

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Ozone (O_3) is the most phytotoxic air pollutant in the Mediterranean region, where climatic conditions favor its formation and persistence during spring and summer. The negative effects of O_3 on the physiology and biomass growth of several forest species have been well documented in the last decades. However, some divergences exist between the effects observed on Southern Europe forests and the expected effects estimated with the current flux-based dose-response (D-R) relationships. This discrepancy is likely to be explained by the inadequacy of the current D-R functions, which have been defined with experiments conducted in Northern and Central Europe, to estimate the effect on the Mediterranean forest trees and/or their higher O_3 tolerance.

In order to address this issue, this study presents a reanalysis of the available O_3 exposure experiments performed on deciduous broadleaved tree species in the Mediterranean area and the proposal of new critical levels to improve the O_3 risk assessment in this region.
A database of 5 different experiments, performed in Spain and Italy, including 5 tree species was collated. The studied species were: *Q. pyrenaica*, *Q. faginea*, *Q. robur*, *P. nigra* ("Jean Pourtet" clone) and *P. maximowiczii* Henry×*P. berolinensis* Dippel (Oxford clone). All the experiments were performed with seedlings or cuttings growing in Open-Top Chambers exposed to different O_3 levels (with charcoal-filtered air as control treatment). The length of the experiments varied between a minimum of 2 months and a maximum of 1.5 years.
Two different parameterization were used for the stomatal conductance (g_s) model: one species-specific based on the *"local"* g_s measurements performed in each experiment, and the other *"generic"* based on the "Deciduous Mediterranean broadleaved" parameterization described in the Mapping Manual of the UN/ECE.

The two different parameterizations (*local* and *generic*) were used to calculate the Phytoxic Ozone Dose (POD_1) and to derive the D-R functions for the aboveground biomass. The D-R function built with the generic parameterization of g_s was not statistically significant, while the local parameterization yielded a statistically significant (p=0.0057) relationship. According to this result different POD_1 critical levels were calculated on the latter D-R relationship considering an effect threshold of 2%, 4% and 5% decrease in the annual relative yield (RY) of shoots biomass. The effects were calculated starting from a reference biomass estimated for an average POD_1 using 10 ppb of O_3 as constant concentration (POD_{1_10}). Fluxes with constant 10 ppb O_3 were calculated for each experiment and averaged, and the corresponding RY was used as the reference RY for defining critical levels. The obtained values (9, 16 and 19 mmolO_3 m^{-2}, for 2, 4 and 5% biomass loss, respectively) indicate that the Mediterranean deciduous trees could be more tolerant to O3 than trees growing in more humid biomes, and that different O3 critical levels should be used for ozone risk assessment in Europe depending on vegetation types.

AN OVERVIEW OF RECENT EXPERIMENTAL WORK AT CEH BANGOR

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The experimental systems at CEH Bangor are used to quantify impacts and feedbacks between elevated ozone, nitrogen deposition, and the above and below ground ecological community. The systems are used to identify and quantify critical feedbacks between greenhouse gas, hydrological and ecological processes across a range of sensitive ecosystems.

The current systems include:
Bangor-FAOE, which uses computer controlled pollutant release dependant on windspeed to ensure that target concentrations are achieved.
Solardomes and controlled chambers, where ozone concentrations are precisely delivered using a custom made solenoid delivery system.
Heating of two of the solardomes, which allows temperature increases of up to 10°C, either for the duration of the growing season or for short critical time periods such as grain fill in wheat.

This presentation will include an overview of some of the recent experimental work using these facilities, including interactions between ozone and nitrogen in grassland species, effects of ozone on carbon and nitrogen dynamics in wheat, impact of ozone, heat and drought on grainfill in wheat, and the influence of duration of ozone exposure and flooding on resilience of pasture grassland.


New: Heating to +10°C in 2 solardomes.


9 field release rings

OZONE DOSE-RESPONSE RELATIONSHIPS FOR DURUM WHEAT IN MEDITERRANEAN CONDITIONS

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The aim of this study was to define an ozone (O_3) dose-response function and identify a critical level for the protection of *Triticum durum* in Mediterranean conditions. 'Colombo' and 'Sculptur' are two modern durum wheat cultivars that in previous studies proved to be very sensitive to O_3 stress at both eco-physiological and agronomical level. Two consecutive experiments on these cultivars were carried out in 2013 and 2014 at the Open-Top Chambers facility of Curno (Northern Italy). Plants of durum wheat were exposed to 2 and 4 different levels of O_3 in 2013 and 2014, respectively.

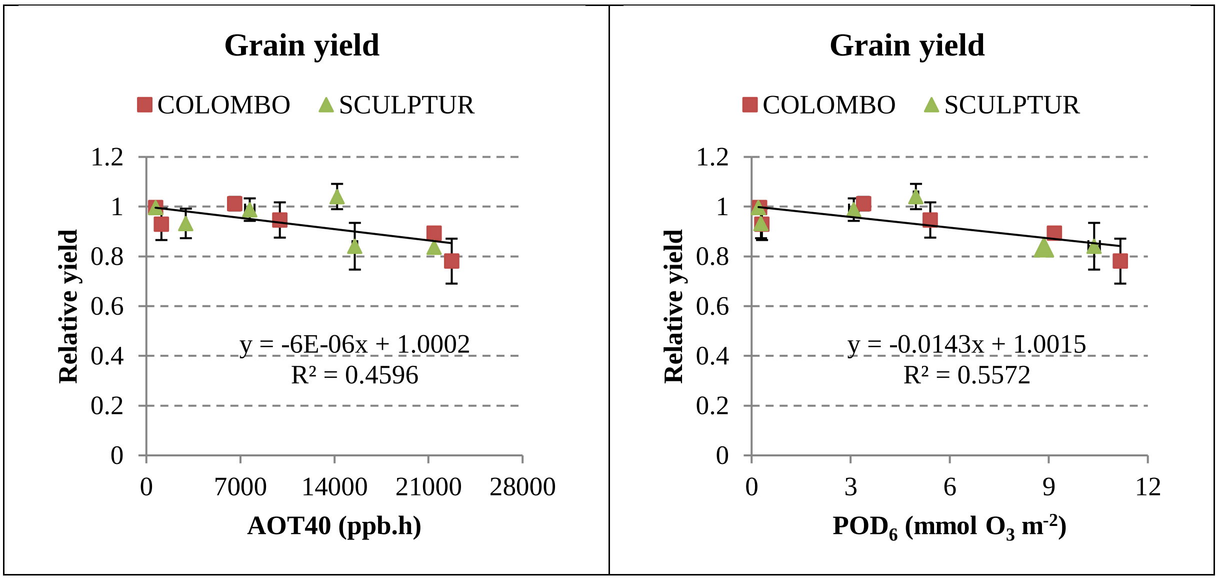
The seasonal accumulation of Phytotoxic Ozone Dose (as POD_6) and O_3 exposure (as AOT40) were correlated with the reduction of grain yield, total aboveground biomass, stems, number of spikes and hectolitre weight.

'Colombo' resulted more affected by O_3 than 'Sculptur' in both years of the experiments, with a significant decrease in yield and growth parameters. 'Sculptur' showed significant negative effects only in the highest O_3 level treatments.

Regression analysis on grain yield were performed using both the AOT40 and the POD_6, and the relative effects were calculated on the basis of the mean values of plants grown in Charcoal-Filtered OTC (-50% of ambient ozone). According to this study the POD_6 value causing a 5% of decrease in relative grain yield was around 3 mmol O_3 m^{-2} for cv 'Colombo' and 4 mmol O_3 m^{-2} for cv 'Sculptur'.

Considering the two cultivars together, we can propose a critical level of POD_6 of 3.5 mmol O_3 m^{-2} for a 5% reduction of grain yield to be used in the Mediterranean countries for *Triticum durum*. Analogously the AOT40 critical level could be set to 8'000 ppb.h. The critical level based on POD_6 is 3.5 times higher than that proposed in the Mapping Manual for *Triticum aestivum* (1 mmol O_3 m^{-2}).

Results of this study demonstrate clearly that both relationships based on the O_3 exposure and POD_6 proposed in the Mapping Manual could overestimate the O_3 effects on durum wheat under Mediterranean conditions.



A DOSE-RESPONSE RELATIONSHIP FOR MARKETABLE YIELD REDUCTION OF TWO LETTUCE (*LACTUCA SATIVA* L.) CULTIVARS EXPOSED TO OZONE

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The present study investigated the response to ozone (O_3) of two cultivars (cv.'Romana' and cv. 'Canasta') of irrigated lettuce grown in an Open-Top Chambers (OTCs) experiment performed in Northern Italy (Curno, BG). Two different levels of ozone were applied: ambient O_3 in Non-Filtered OTCs and -40% of ambient O_3 in Charcoal-Filtered OTCs. These ozone treatments were applied during 4 consecutive growing cycles. At the end of each growing cycle the marketable yield (fresh biomass) of lettuce plants was assessed while during the growing periods measurements of the stomatal conductance (g_s) at leaf level were performed and used to define two cultivar-specific and a generic g_s model for calculation of the Phytotoxic Ozone Dose (POD) absorbed by the plants.

Results showed that ozone caused statistically significant yield reductions in the first and in the last growing cycle. In general, the marketable yield of the NF-OTCs plants was always lower than the CF-OTCs plants for both cultivars, with mean reductions of -18.5% and -14.5% for 'Romana' and 'Canasta', respectively. On the contrary, there was no statistically significant difference in marketable yield due to the cultivar factor or to the interaction between ozone and cultivar in any of the growing cycle performed.

Dose-response relationships for the marketable relative yield based on the POD_Y values were calculated according to different flux threshold values (Y). The best regression fit was obtained using an instantaneous flux threshold of 6 nmol O_3 m^{-2} s^{-1} (POD_6); the same Y threshold value was obtained also for other crops. According to the generic lettuce dose-response relationship an O_3 critical level of 1 mmol O_3 m^{-2} of POD_6 for a 15% of marketable yield loss was found.

REVISION OF OZONE EXPOSURE EXPERIMENTS OF ANNUAL MEDITERRANEAN PASTURES FOR SETTING OZONE CRITICAL LEVELS

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Ozone (O_3) exposure- and flux-response relationships and their associated critical levels (CLe) for (semi-)natural vegetation in the Mapping Manual of the Convention on Long Range Transboundary Air Pollution only cover a small fraction of the wide range of plant communities found across Europe (CLRTAP, 2010).

Dehesas are one of the most characteristic habitats of the central and South-Western Iberian Peninsula, typically composed of an open tree canopy with an understorey of species-rich annual pastures. Dehesa annual pasture species are also present in other annual Mediterranean pastures widely distributed in the Mediterranean region of Europe but they have not been considered so far for flux-based ozone critical levels derivation.

New O_3 exposure- and flux-response relationships have been established for Mediterranean annual Dehesa pastures following a revision of open-top chamber (OTC) experiments conducted in Spain (Sanz et al., 2016). The new response relationships for aboveground biomass and seed biomass of sensitive annual Mediterranean pastures are based on 5 independent OTC experiments performed at one site in Eastern Spain, including data for 7 legume species and covering a range of competition and nitrogen fertilization sub-treatments (n=51). For seed biomass, 3 experiments and 3 species were considered (n=15). New exposure- and flux-based CLe for aboveground biomass and seed biomass of sensitive annual Mediterranean pastures have been derived for a 10% effect above a reference O_3 flux, following the methodology adopted by the ICP-Vegetation (Table 1).

Tab. 1. Exposure and flux-response functions and critical levels for annual pastures.

Response variable	Function	Reference flux	Critical level
Aboveground biomass	= 100 - 0.0032·AOT40		3.1 ppm.h
	= 97.3 - 0.0098·POD_1	4.2 mmol m^{-2}	14.4 mmol m^{-2}
Seed biomass	= 100 – 0.0050·AOT40		2.0 ppm.h
	= 92.5 - 0.0182·POD_1	3.9 mmol m^{-2}	9.4 mmol m^{-2}

The growing conditions of the plants considered for CLe derivation represent the optimum conditions for plant development, with plants growing in well-watered pots with artificial substrate and little intra- and inter-specific competition. The response relationships were compared with another set of 2 experiments conducted at a site in central Spain in 2011 and 2012 in natural soil, subjected to soil water stress and intra- and inter-specific competition (González-Fernández et al., submitted; Calvete-Sogo et al., 2017) showing that they were also applicable to describe O_3 effects under sub-optimum growing conditions, more representative of natural growing conditions.

References:

[1] Calvete-Sogo et al., 2017. Env.Pol. 220, 186-195.
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[3] Sanz et al., 2016. Sci.Tot.Env. DOI: 10.1016/j.scitotenv.2016.07.035
[4] CLRTAP, 2010. http://icpvegetation.ceh.ac.uk/manuals/mapping_manual.html

ESTIMATING OZONE SENSITIVITY PERIODS FOR TREES IN NORTHERN EUROPE

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The aim of this presentation was to describe the significance of climate induced changes in the phenology of tree species for the methods to estimate the ozone sensitivity periods for forest trees in northern Europe, i.e. Fennoscandia, and to make suggestions for improvements. some conclusions will be made:

- Methods used within the Mapping Manual to estimate the onset and end of the ozone sensitivity period for deciduous and coniferous tree species in northern Europe clearly needs revision
- The latitude model had a limited capacity to predict yearly values for the timing of the onset of budburst of birch in Finland and Sweden, compared to what has been observed.
- A temperature sum model, accumulating daily mean temperatures above 5°C up to a limit of 45 degree*days, predicted budburst of birch in Finland and Sweden well.
- The two-stage Kramer model, used with default parameterisation, gave a good prediction of the range of day-of-year (doy) for the budburst of birch in Finland and Sweden, but the model overestimate the doy for budburst by 20-30 days, i.e. it predicted a far later timing for the budburst compared to observations.
- For Fennoscandia, it might be appropriate to use the simple temperature sum model parameterized for birch in order to predict the timing of start of the ozone sensitivity period for deciduous forests.
- The start of the gas exchange of mature Norway spruce trees in stands in Northern Sweden started well before the estimated start of growing season, predicted either as when 24-h mean temperatures exceeded 5oC or as predicted with the latitude model
- For predicting the timing of the end of the ozone sensitivity period during autumn, there is currently no satisfactory methods available either for coniferous or for deciduous tree species.

CURRENT SURFACE OZONE SIGNIFICANTLY AFFECT SEVERAL ASPECTS OF WHEAT GROWTH, YIELD AND QUALITY ON THREE CONTINENTS

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To test the effect of reducing present surface ozone concentrations on a range of agronomically important response variables in wheat 33 (10 countries, 3 continents, 18 cultivars) open-top chamber experiments with field-grown wheat using filtered and non-filtered air treatments were combined in a meta-analysis (Figure 1). Non-filtered air had a significant negative effect compared to filtered air on grain yield (-8.4%), grain mass (-3.7%), grain number (-3.2%), harvest index (-2.4%), total above-ground biomass (-5.4%), starch concentration (-3.0%), starch yield (-10.9%), and protein yield (-6.2%). The significant negative effect on starch concentration and the larger effect on starch yield compared to grain yield indicate that the production of food energy is more strongly affected than the biomass yield as such, starch being the quantitatively dominating component of wheat grain. For protein concentration a small, non-significant positive effect (+0.5%) of exposure to non-filtered air was noted. Average filtration efficiency was 62% reducing the ozone concentration from 35.6 ± 11 ppb to 13.7 ± 9 ppb, the latter being in the range of estimated preindustrial ozone concentrations: 10-15 ppb. The average yield loss per 10 ppb O_3 removed was 3.6%. It did not vary systematically, neither with year of experiment (ranging from 1982 to 2010), nor with the non-filtered level of ozone concentration in the experiments. A significant relationship was found between the effect of air filtration on grain yield and the reduction in ozone concentration by air filtration, further highlighting the sensitivity of wheat yield to ozone concentrations below present ambient. Although there are many sources of variation influencing the detailed outcome in the individual experiment, such as genotype variation, degree of ozone pollution of the site and year, nutrient and soil condition as well as filtration efficiency, our study provides strong evidence that several aspects of wheat growth, yield and quality are significantly affected by current ozone pollution over large areas of the Earth.

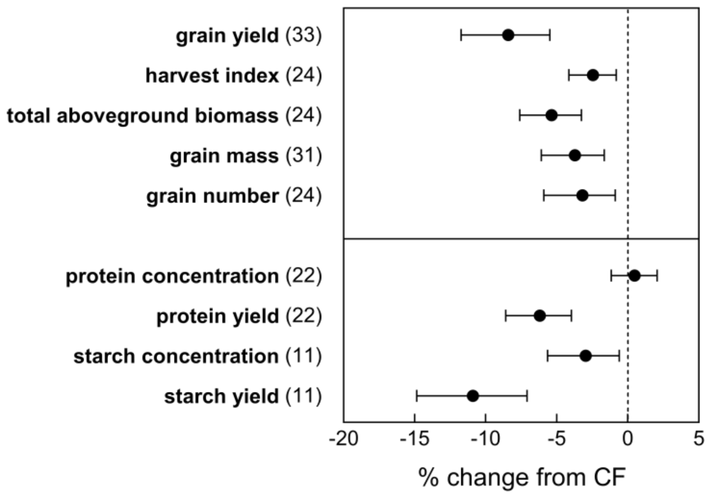

Fig. 1. Meta-analysis of the effect of non-filtered air vs. charcoal filtered (CF) air for a range of agronomically important variables in wheat. Values within brackets denote the number of experiments contributing data. Confidence limits represent p = 0.95.

MOSS SURVEY

MOSS BIOMONITORING IN IREAND: 2015 SURVEY

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During 2015, Ireland participated in the European moss biomonitoring survey organised under the UNECE Convention on Long-range Transboundary Air Pollution. The land area of Ireland was divided into 25 km × 25 km grids (Figure 1), with the objective of collecting one composite moss sample per grid to ensure national coverage of study sites. Moss tissue was collected during two field campaigns (27 May–05 June and 28 July–05 August) following survey protocols described in the 'monitoring manual' (see URL: icpvegetation.ceh.ac.uk). More than 170 sites were surveyed; moss tissue was collected at 115 sites, dominated by the species *Hylocomium splendens* (n = 112). In contrast, *Pleurozium schreberi* was only found at 16 sites (with both species at 13 survey sites). In the laboratory, unwashed samples were stored in paper bags and oven-dried at 57°C for 70 hrs. Dried samples were pulverized using a hand mill, and analysed for carbon (C), nitrogen (N) and sulphur (S) content (%) using an Elementar vario Marco CNS analyzer. Heavy metal concentrations were determined using a Triple-Quad ICP-MS analyzer following acid digestion (Mars 6 microwave digester). Total mercury was determined using a mercury analyzer (Milestone DMA-80), and radionuclides were analysed at a sub-set of the study sites (n = 24) by the Office of Radiological Protection Ireland (Figure 1). In addition, moss tissue samples (n = 9) collected from three ICP Waters catchments were analysed for Persistent Organic Pollutants and total and monomethyl mercury.

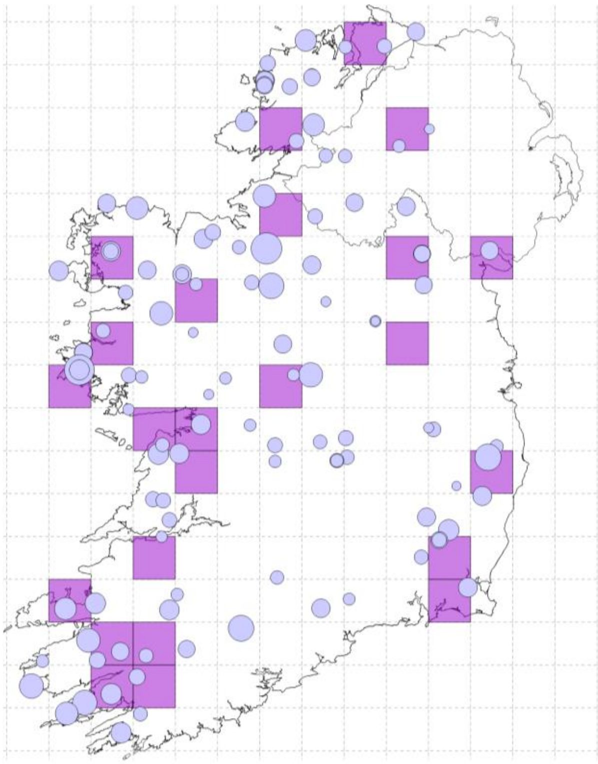

Fig. 1. Location of moss tissue sampling sites with observations of total mercury (n = 125) ranging from 0.02–0.7 µg g^{-1}. In addition, filled squares indicate the 25 km × 25 km sampling grids where moss tissue was analysed for radionuclides (n = 24).

A TEN-YEAR BIOMONITORING STUDY OF ATMOSPHERIC DEPOSITION OF TRACE ELEMENTS AT THE TERRITORY OF BELARUS: TRENDS AND TENDENCIES, OPTIMIZATION OF THE SAMPLE SITES NUMBER FOR UPCOMING MOSS SURVEYS

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For the third time Belarus is participating in the moss survey carried out in the framework of the UNECE ICP ICP Vegetation. In 2015, we collected 30 samples in the previously studied areas, as well as in some new regions. In general, moss was sampled at 250 sites evenly distributed over nearly the whole territory of the country. At present, there is enough data for sampling network optimization because previously it was too dense in some areas. Optimized network will allow completing moss survey over the whole country during a one-year period. Trends in atmospheric elemental concentrations from 2005 to 2015 were examined. In spite of the increase of metal concentration at some sampling sites, comparison of the results for Belarus with the analogous data for the other European countries showed relatively low contamination levels for most of heavy and toxic elements.

HOW DO CHITIN ADSORPTION DATA COMPARE TO BIOMONITORING USING MOSSES?

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Chitin adsorption values of both metals and non-metals in submerged sediments and overlying water layers should each obey mutual equilibrium criteria and thus be equal. However, biological activation and -use of some – e.g. Ni (methanogenic Archaea), Mo (nitrate reductase, nitrogenase) or Fe (in iron-oxidizing bacteria) – element does increase readings obtained on chitin exposed inside sediment substantially. The same holds for some toxicologically significant elements such as Pb and Sb. Chitin is very robust towards oxidation (common sugar cleavage reagents like periodate or Pb(IV) do not attack), enabling electroanalytical studies in both native and analyte-loaded states of this biopolymer in chitin DMF solutions obtained by adding Li^+.· Adsorption is completed within 10 min; this permits dislocation and retrieval of sample carriers in one run and avoids a) photochemical effects in uranium and silver adsorptions and b) changes of binding modes caused by partial surface hydrolysis of chitin (→ chitosan; occurs after several days of submersion at some 10°C). The analytical procedure does not require either oxidative digestion or neutron activation of sample (thus one can choose whether to return chitin-based samples as obtained or already dil. HNO_3 solutions ready for ICP/MS analysis from the field) while chitin retention does tolerate radionuclide levels; data for U retention at crab chitin are available and binding of components from high-level radioactive waste (^{106}Ru, ^{144}Ce, ^{90}Sr, ^{95}Zr) to chitin was investigated elsewhere before. Metal elements (e.g., Ni) are fixed to chitin a) as "free" hydrated cations, b) in complexes formed with ambient ligands like glycinate, malate, citrate, hydroxamates or caffeinate (modeling humic acids), and c) also within particles of oxides, solid salts and other minerals. In addition metal carbonyls or biomethylation products present in landfill gas bind to chitin readily without extensive decomposition/ligand replacement at realistic levels (ppbv) omitting cryosorption. Generally speaking, chitin is a superior sorbent to moss surfaces (roughly, cellulose). Recovery of chitin-fixed metals from solutions by means of ion exchanger resins was measured by model experiments. Of course, relative contributions of a) – c) depend on kind of metal, with significant differences also observed among REE metals, and chitin can be readily dissolved for retrieving the analytes, both features due to carboxamide sidechains of the polysaccharide.

Particle- and polysaccharide-related metal ion retentions directly compare to moss monitoring, with parallel studies including both chitin plates and (dried aquatic) mosses were conducted at Jedlica Creek, Kowary/Poland. Very high levels of either Al (clayey river beds) or Fe (pig iron deposits and their direct precursors [ochre in water-filled ditches]) do not preclude meaningful determinations of other elements. The analysis is being combined with biological data on the system, especially on abundances and species patterns of arthropods, e.g. caddisfly larvae, flatworms and mollusks. The gross statements from chitin adsorption agree well with evidence from aquatic biodiversity studied in Mongolia (fishes were rarely seen or retrieved).

Methanogenesis requires some minimal levels of Ni (and Co) in the substrate; Ni is deposited on top of an ombrotrophic bog (Mt. Sniezka, Poland) mainly via atmosphere after release (besides of V, Mn, Ba, Ge…) from lignite or black coal burned omitting flue-dust filters. CH_4 emissions from bogs thus indicate former Ni inputs which made it downward to levels sufficiently reducing to permit CO_2 reduction by Archaea. The "patchy" pattern of CH_4 release at Rownia pod Sniezką (PL/CZ border) implies this – 35 cm level from upper groundwater edge was reached by Ni only recently and at contrived spots, dating Ni inputs to several decades ago,

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which fully agrees with times of maximum emissions from “Black Triangle” located westward in principal wind direction. Accordingly ecosystems and “switches” in their gross behavior due to pollution and pollution-induced biochemical activities can be identified by non-equilibrium behavior of elements observed on chitin. As e.g. Sb and Bi trimethyls or volatile halides readily bind to chitin, as do homoleptic metal (Fe, Mo, W) carbonyls from landfill gas vents, additional pollutants subjected to biomethylation can be recovered from gas flows. Thus there is a unique mode of view into operation of certain ecosystems. A likely mechanism is given in the lecture.

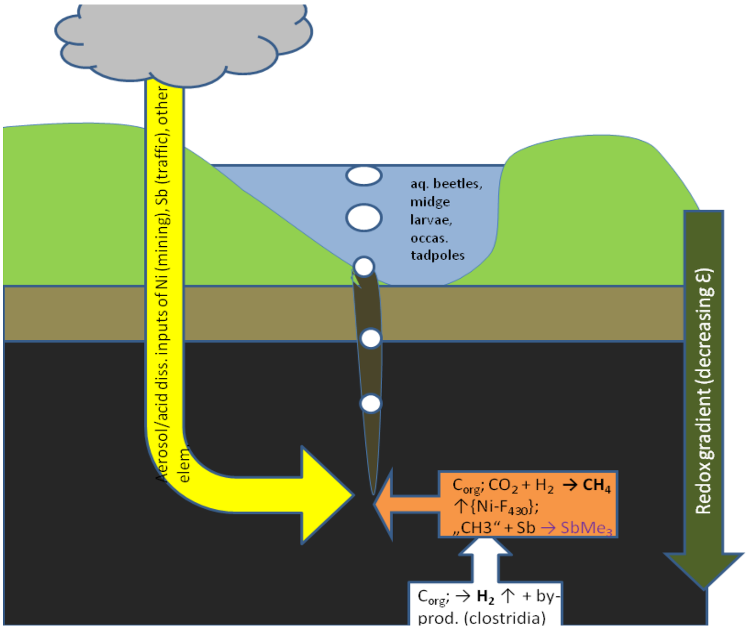

Fig. 1. Reasons of co-release of other pollutants (Sb) which thus get accessible to chitin-based (headspace) GC/MS-analysis once nickel got deep enough into peat bog sediments as to cause methanogenesis.

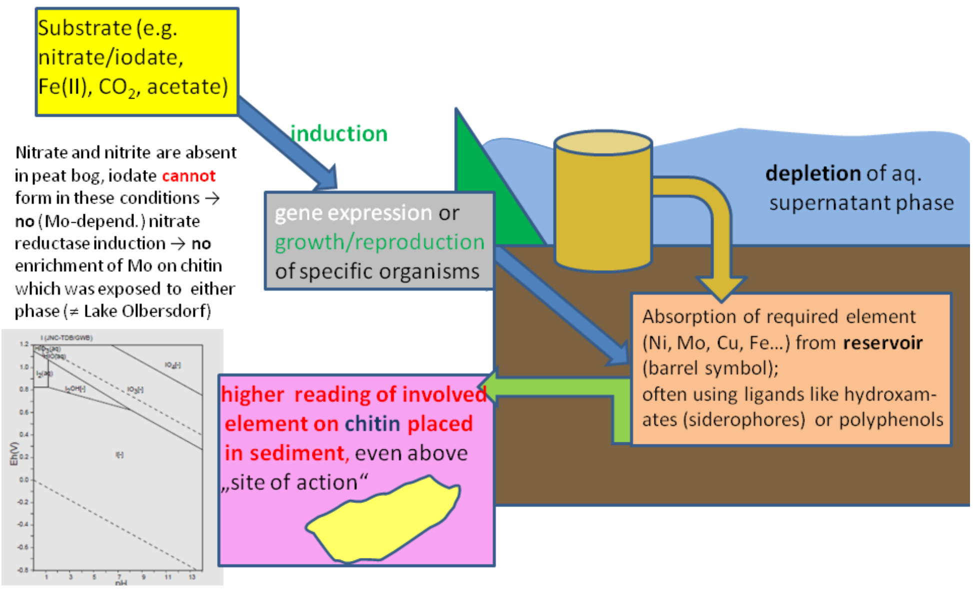

Fig. 2. Application of chitin adsorption for surveys of trace-element-related induction of certain metabolic pathways, like N (both N_2- and nitrate) reductions (increased Mo reading from sediment).

PAH IN SWITZERLAND – RESULTS OF THE 2015 MOSS SURVEY

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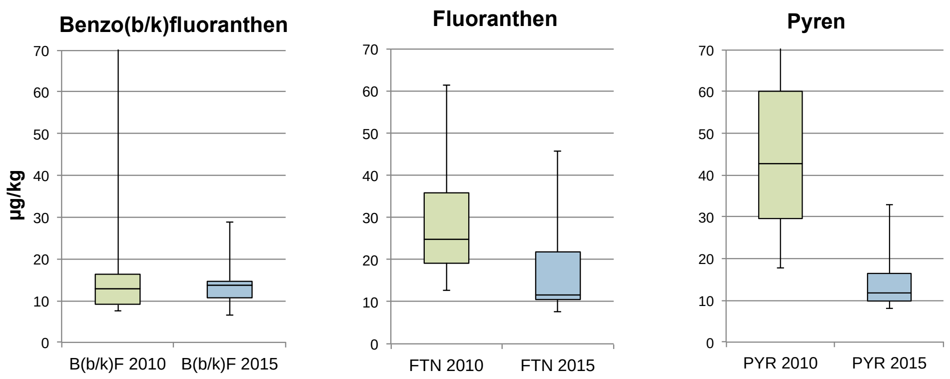
Monitoring PAH (Polycyclic Aromatic Hydrocarbons) has reached interest especially because of their slow degradation and toxicity. For example, PAH have been shown to affect the human health by being carcinogenic and influencing foetal development.
PAH in the environment has traditionally been measured in ambient air as well as in soils. Also mosses has been used as bioindicators to assess PAH pollution in the environment. In the framework of the ICP moss survey several PAHs at different study sites in Switzerland in 2010 (n=20) and 2015 (n=22) were analysed. The 2015 results show that currently the amount of all PAH measured in moss is mostly low and close to detection limit. These results are in agreement with the PAH values reported for other countries in close proximity. The total PAH concentration does not show any particular pattern even though a certain local variation can be observed. The variation is possibly mainly based on local sources (in the plateau area) and on topography (Central Alps).

A comparison between the survey years 2010 and 2015 shows that in general the PAH concentrations in moss has decreased. This result is supported by the decrease of PAH measured in PM10 in Switzerland. In moss the decline is not statistically significant for every PAH (Fig 1) and not constant throughout Switzerland. All but one study site show a decrease in the total PAH concentration. However, the decrease at study site level is not constant for each PAH when examined separately.

In summary, the PAH concentrations in Switzerland have decreased within the last 5 years and have reached a low level close to detection limits of the method used. Based on the pattern of PAH concentration throughout Switzerland it seems that the PAH pollution is quite constant across the whole country.



p = 0.454 p = 0.064 p = 0.008

Fig. 1. Change over time of three different PAH at 11 study sites sampled 2010 and 2015.

MINERAL PARTICLES DUST IMPORTANT SOURCES OF TRACE METAL IN ATMOSPHERIC DEPOSITION IN ALBANIA

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Trace metal atmospheric deposition is studied by using moss biomonitoring (*Hypnum cupressiforme* and *Pseudoschleropodium purum*) collected in 48 stations distributed over the whole territory of Albania. 46 elements were determined by ICP-AES and ENAA analysis, but only 37 are presented in this study. The presence of lithofile elements, and the variations in Al, Ti and Ca are mostly associated with local and long- term emitting of wind blowing mineral dust particles that is considered as main contributor of trace metal in atmospheric deposition in Albania. Spatial distributions and relationships between elements present in moss, the geochemical interpretation of the data and the secondary effects, such as redox conditions generated by the origin of rocks in local and long-distance migration of the pollutants, are discussed. Based on Al_2O_3 and CaO variations and Al_2O_3 vs. TiO_2 plot, the depositional environment of parent soils were discussed. To interpret the geochemical classification and to show the origin of elements present in current moss samples considered with respect to different types of rocks of local area and the anthropogenic input of elements, Spearman correlation coefficients, distribution pattern of elements, Zr normalized data and the ratio of the redox sensitive elements were used. Spearman correlation and factor analysis are used to identify the most significant association of the elements and their probable sources of origin. Four dominant factors were extracted from concentration matrix data that represent the atmospheric deposition of elements associated with mineral and industrial local emission. Spearman correlation and factor analysis are good tools to identify the most significant association of the elements and their probable sources of origin that represent the atmospheric deposition of elements associated with mineral dust and industrial and/or traffic local emissions.

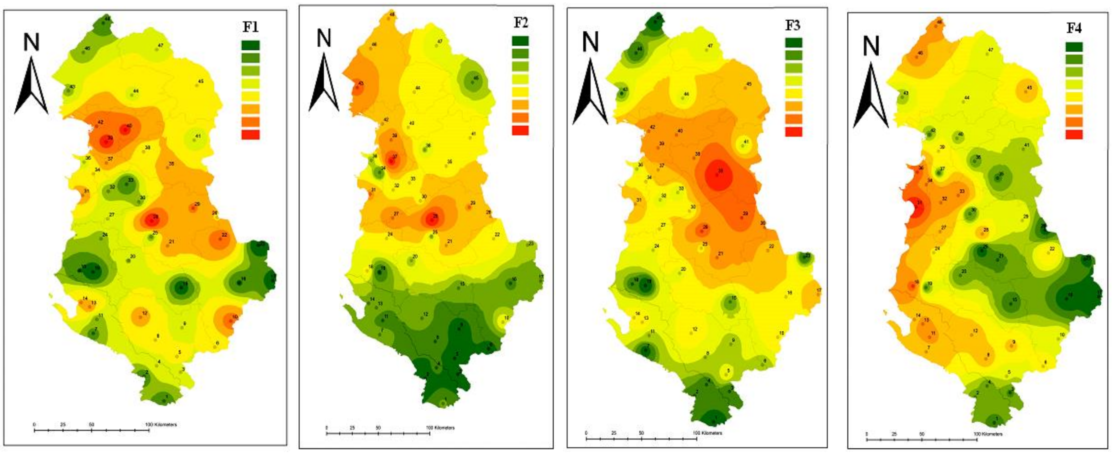

Fig. 1. GIS maps of factor loadings: a. *F1* – Al, Mn, V, Ti, Fe, Co, Hf, Zr, W, Sc, La, Ce, Yb, Th, U, Ba, Sr and Li; b. *F2* – Cu, Pb, Zn, Hg, Sb, Mo, Rb and Ca; c. *F3* – Cr, Ni, Co, Fe, Mg and K; *F4* - Al, Na, K, Sr and P.

RE-STRUCTURING THE GERMAN MOSS SURVEY NETWORK

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For the German moss survey 2015, the biomonitoring network applied in the 2005 campaign should be reorganized. The aim was to reduce the number of samplings sites without statistical significant loss of data quality in terms of eligible statistical criteria. Across Europe, the national networks contributing to the European Moss Survey (EMS) should comply with the requirements defined by [1]: At least 1.5 moss samples / 1000 km2 should be sampled. For the German territory this would result in 536 sites. If this is not feasible, a sampling density of at least two moss sample sites per EMEP grid (50 km by 50 km) is recommended. In Germany, this would correspond to 404 moss sampling sites which should be regarded as target number for the German moss survey 2015. A denser sampling network is recommended in areas where steep gradients in the deposition of heavy metals are to be expected based on previous surveys. To enable the analysis of temporal trends, it is recommended to collect specimens from the same sites as in the previous surveys. Regarding the determination of POPs, a lower sampling density may be performed due to potential financial limits. To assess a statistically valid number of sampling sites for a given ecoregion, country or whatever spatial unit, the respective minimum sample sizes (MSS) should be calculated. Only pleurocarpous mosses should be sampled. In addition to the above mentioned standard requirements of the EMS [1], the Federal Environment Agency of Germany defined national requirements. This presentation concentrates on explaining a method enabling to reduce the number of sampling sites compared to previous surveys and the potentially associated loss of spatial validity of the monitoring results as far as possible.

For operationalising the criteria mentioned above, a multi-step approach with an integrated decision support model was developed, implemented and applied for the re-organisation of the German moss survey network. By this, the MSS could be calculated for different spatial categories (territory of Germany as a whole, the German federal states, and ecological land classes covering Germany) and the sampling density in specific areas could be determined. Furthermore, the sampling sites for the survey network 2015 could be selected and its performance tested based on the data collected in 2005.

Minimum numbers of sample size for the estimation of mean values with a pre-defined precision were calculated and differentiated for federal states and ecological landscape classes as presented by [2]. A multi-criteria decision model was developed, which allows a computer-based investigation of numerous variants of parametrisation with high efficiency and reproducibility. The moss monitoring network for the survey in 2015/16 was thinned out from 726 to 402 sampling sites in Germany without significant change in the statistical validity and a limited loss of geostatistical representativity of the measurement values. The re-organised monitoring network is harmonised with other environmental monitoring networks (ICP Forests, ICP Integrated Monitoring, German Environmental Specimen Bank).

References:

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[2] Schröder W et al 2016. Spatially valid data of atmospheric deposition of heavy metals and nitrogen derived by moss surveys for pollution risk assessments of ecosystems. *Environmental Science and Pollution Research*, 23:10457-10476.

NATIONAL METAL SURVEY BY MOSS: LONG-TERM INTEGRATED MONITORING OF ATMOSPHERIC METAL LEAD (2000-2015)

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Bio-monitoring by mosses has certain advantages in comparison to the direct measurement of atmospheric metals from the environment because (i) moss reactions to environmental changes is quicker and more direct than those of the majority of vascular plants (ii) provide data of short period, (iii) and there is no need of number of instruments to run simultaneously to monitor at many place which is expansive and no need of man and power to run the same (Janice and Saxena,1991).

Longest running metal monitoring program was initiated in 1996 in India by inducting widely distributed moss *Hypnum cupressiforme* and *Barbula tenuirostris* . Tolerant (validated by using PEA) and widely distributed moss species was identified and moss-bags of standard size were transplanted on annual basis. Exposed moss-bags were sampled at the end of each year for metal analysis during 2000-2015 from Garhwal, Himanchal, Jammu & Kashmir, Karnataka, Kumaon, Maharastra, Uttar Pradesh and from West Bengal. Analysis of annually exposed moss transplants harvested from selected metro towns of seven states exhibited high lead values in moss from Dehradoon in 2000 and from Moradabad in 2015. Trend for low lead values was measured from Manesar in 2000 and as well as in 2015 too. Contrary to high values of lead analysed in year 2000 from Dehradoon, lead value was measured high in moss from Moradabad during 2015, could be due numerous metal industries, big junk yard of electronic e-waste and heavy traffic congestion on narrow roads. Present study reports widespread exceedance of the critical load for lead. It is quite interesting to record that the lead is declining in most of the European countries, while an increasing trend for lead is still observed in different towns of India (Harmens et al 2015).

References:

[1] Janice M Glime and D K Saxena, 1991. Uses of bryophytes. Today and Tomarrow Printers, India
[2] H. Harmens, et al. 2015. Heavy metal and nitrogen concentrations in mosses are declining across Europe whilst some "hotspots" remain in 2010 *Environ. Poll.*, 200: 93-104.

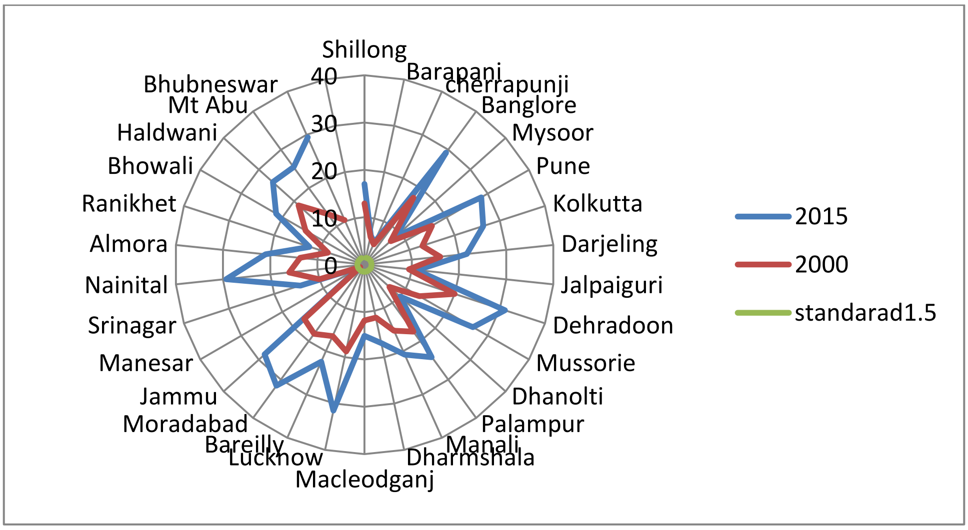

Fig. 1. Trend of lead in different towns during 2000 and in 2015.

MONITORING OF ATMOSPHERIC DEPOSITION OF METALS: WHERE DO WE STAND AFTER FORTY YEARS OF EXPERIENCE?

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Monitoring of atmospheric deposition of metals started in Scandinavia, where conditions are especially favorable because suitable moss species are found all over the territory and mostly grow on an organic-rich soil surface layer. Temporal and spatial trends have been mapped at regular intervals and results show good correspondence with bulk deposition measurements. Some problems and artifacts have been identified, but so far not sufficiently serious to question the usefulness of moss surveys.

Extension of the moss-based monitoring to areas farther south and gradually extending the number of participating countries has raised several questions and concerns with respect to the feasibility and usefulness of the European moss survey, such as:

- comparability of results obtained by different analytical techniques.
- contamination of the moss surface by mineral matter from the substrate and/or from wind erosion of totally or partly barren areas, *i.e*. geogenic influence.
- Applicability of new moss species.

Given the extension of the moss survey to territories that are in several ways strongly different from those originally subject to metal deposition monitoring using moss sampling the feasibility of this approach under different physical conditions needs to be discussed to avoid misinterpretation of monitoring data.

Currently, an increasing number of countries are using instrumental neutron activation analysis for determination of most of the target elements of the moss survey. What is positive about that is that the samples from these countries are presently analyzed in the same very experienced laboratory. The interpretation of the analytical data with respect to atmospheric deposition, however, must consider the greater likelihood of geogenic influence to the moss samples in some areas. This is particularly important in the case of analytical techniques measuring the total content of elements in the sample, also including any fraction contained in geogenic material. Elements present in mineral matter are generally sparingly soluble in strong acids and thus only partly recorded by the analytical methods depending on this approach. Using analytical techniques measuring the total element content, *e.g.* INAA, may lead to an overestimation of the amounts of these elements derived from air pollution if geogenic material is present in the sample.

The future of the present moss survey as well as of biomonitoring using naturally growing moss in general depends on full recognition of this problem. Possibly possible the moss monitoring approach must be abandoned e.g. in areas with high wind erosion. The current extension of the moss survey to new countries and geographical territories must therefore be accompanied by critical assessment of the results obtained.

ASSESSMENT OF ATMOSPHERIC POLLUTION WITH HEAVY METALS AND NITROGEN USING *PLEUROZIUM SCHREBERI* MOSSES AS BIOINDICATOR IN LATVIA

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Biomonitoring is a technique of using organisms or biomaterials to determinate air quality. Moss was used as a bioindicator to assess the concentration of heavy metal in atmosphere because of its ability to adsorb heavy metals. Mosses provide inexpensive and effective monitoring for the identification of atmospheric deposition fluxes of heavy metals. The main aim of this research was to determine the environmental pollution with heavy metals and N using feather moss *Pleurozium schreberi* to provide spatial information and identify main polluted areas in Latvia. The concentrations of 8 metals (Cd, Cr, Cu, Fe, Ni, Pb, Zn and V) were determined by using moss *Pleurozium schreberi* samples collected from 101 sample plots and N from 40 sample plots. Moss sampling time was from middle August to middle October, 2015. The main results show that the concentrations of heavy metals are clearly associated with local emission point sources in Liepāja (Cd, Cr, Cu, Fe, Pb, V, Zn), Brocēni (Ni), Rīga (Cr, Cu) and Daugavpils (Cr, Cu, Fe, Ni, Zn). Raised concentrations in the western part of Latvia (Cd, Cr, Cu, Ni, Pb, V, Zn) are due to long range transport from Europe and Liepāja city (local metallurgical and boiler house source). Higher concentrations near the Lithuanian border are associated with pollution impact from Naujoji Akmenes cement factory (Cu, Fe, Ni) and Mažeikiai oil refinery (Ni, V). In general concentrations of heavy metals (Table 1) are lower in Latvia compared with background levels in Europe. In comparison to the previous monitoring results (year 1990, 1995, 2000 and 2005), the concentration of heavy metals in moss has decreased in Latvia.

Tab. 1**.** Mean, maximum and minimum concentrations of heavy metals (mg/kg) and N (%) in *Pleurozium schreberi* moss in Latvia

	V	**Cr**	**Ni**	**Cd**	**Pb**	**Zn**	**Cu**	**Fe**	**N**
	mg/kg								%
Mean	0.56	0.35	0.57	0.11	1.43	34.17	5.45	157.61	1.21
Max.	2.54	1.04	1.67	0.55	9.20	99.79	12.31	587.82	1.83
Min.	0.17	0.01	0.20	0.04	0.41	22.40	2.37	36.91	0.75

At the European scale the mean concentrations of nitrogen in mosses in years 2005 and 2010 were respectively 1.26% and 1.19%. Our analysis of 2015 shows that the mean concentrations of N in Latvia are 1.21% and that corresponds to the background level of the European countries. The higher N concentrations are in the south-western area of Latvia due to the long range transboundary transport of pollution as well as in the territories with intensive agriculture and areas close to the industrial cities.

NITROGEN CONCENTRATION IN MOSS COMPARED WITH N LOAD IN PRECIPITATION AND „TOTAL“ N DEPOSITION IN SWITZERLAND

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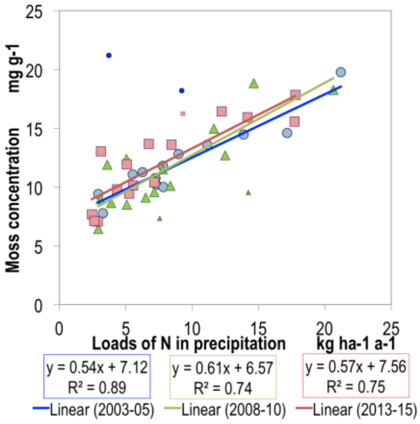

Fig. 1. N conc. in mosses compared to N deposition in precipitation

In various studies N in moss has been compared with N deposition through precipitation (e.g. Harmens et al. 2014). In 2015, for the third time after 2005 and 2010, this comparison was done at 17 background sites in Switzerland, where relatively low depositions could be expected. The results show that the linear regression lines for all three periods are similar and no fundamental changes could be detected (Fig.1).

In addition, a study measuring N deposition from precipitation as well as from other N components (N in aerosols, gases) was carried out in 2014. We compared these data with the moss samples collected in 2015 near the measuring stations. This comparison shows that, when taking only N from precipitation into account, the correlation for N deposition with N in moss is already good (R^2=0.72) although there is an “outlier” VIS (a station in the Central Alps with low amounts of precipitation, Fig. 2). The correlation becomes even stronger when comparing concentration in moss to “total” N input (7 components, Fig. 3) or even only to N input from precipitation and ammonia (Fig. 4). The station VIS now also lays within the expected correlation.

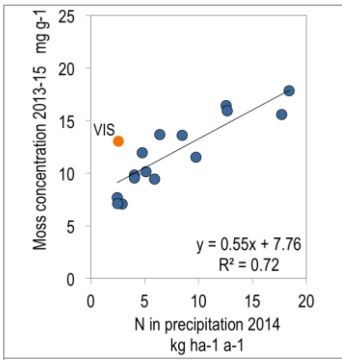

Fig. 2. N in moss vs. N in precipitation

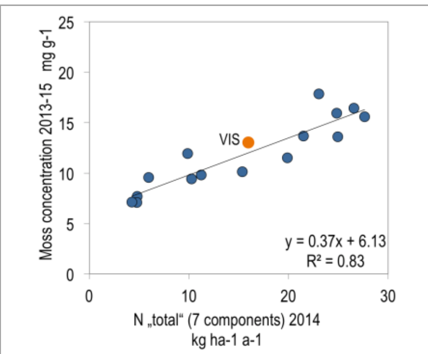

Fig. 3. N in moss vs. N from precipitation, gases and aerosols

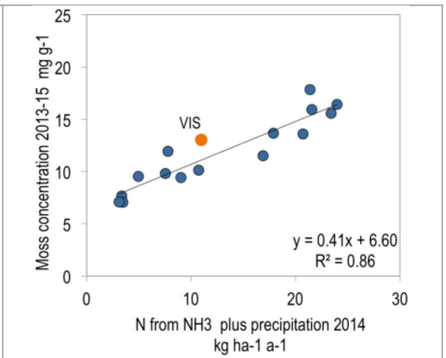

Fig. 4. N in moss vs. N in precipitation and ammonia

Conclusion: No fundamental change has been found in the correlation between N in moss and N in precipitation since 2005 in Switzerland at background stations. The correlation is improved when also taking N in gases and aerosols, especially NH_3, into account.

- At background stations, it is possible to estimate the N deposition by analysing the N concentration in moss.
- Measurement of N conc. in moss can be applied to identify areas of risk for N deposition, e.g. bogs.

References:

[1] Harmens H., Schnyder E., Thöni L., Cooper D.M., Mills G., Leblond S., Mohr K., Poikolainen J., Santamaria J., Skudnik M., Zechmeister H.G., Lindroos A-J., Hanus-Illnar A. 2014: Relationship between site-specific nitrogen concentrations in mosses and measured wet bulk atmospheric nitrogen deposition across Europe. Environmental Pollution 194, 50-59.

HYPNUM CUPRESSIFORME HEDW. AS BIOINDICATOR OF ^{137}CS RADIONUCLIDE IN NORTHERN GREECE

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The artificial radionuclide ^{137}Cs was mostly released in the atmosphere during nuclear weapon testing and the Chernobyl nuclear accident. After that, the atmospheric ^{137}Cs was exposed to physical decay as well as wet and dry deposition, with only significant ^{137}Cs emission being that of the recent Fukushima accident, which contributed to the release of radionuclides in the atmosphere but with minor influence in regions far from Japan. This study aimed to present the levels of concentrations of ^{137}Cs in Northern Greece, 30 years after the Chernobyl accident using mosses as bioindicators.

Samples of *Hypnum cupressiforme* Hedw. were collected from 93 sampling sites in Northern Greece, covering the Regions of West, Central and East Macedonia and Thrace, with sampling taking place from mid August till mid of October 2016. The specific activity of ^{137}Cs was determined by gamma-ray spectrometry, measured in a low-background HPGe detector with 36% relative efficiency.

The information obtained using the moss *Hypnum cupressiforme* as biomonitor, provided the spatial distribution of the ^{137}Cs over Northern Greece. Activity concentrations of ^{137}Cs in moss samples vary from 1.8 to 590 Bq kg^{-1}. The highest observed values are relatively higher than typically observed values over Europe nowadays. This is probably due to the high ^{137}Cs contamination of most areas in Northern Greece due to the Chernobyl accident, when heavy rainfall events during May 1986 in site of investigation coincided with the passage of air masses from Chernobyl area over Northern Greece that had as a result high ^{137}Cs concentrations at the ground level. Additionally, preliminary results of ^{137}Cs data obtained from the analysis of *Hypnum* samples collected on different growth substrates (soil, rock, etc) in comparison with ^{137}Cs in soil samples collected at the same sampling sites will be presented.

ATOMOSPHERIC DEPOSITION OF ORGANIC CONTAMINANTS IN NORWAY

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The geographical distribution of atmospheric deposition of heavy metals in Norway has been monitored every fifth year since 1977 by analysis of moss samples (*Hylocomium splendens*) from sites distributed all over mainland Norway. In 2010, determinations of selected persistent organic pollutants (POPs) were for the first time included in the survey, as a contribution to the evaluation of terrestrial moss as a sample medium for these compounds. Based on the results from 2010, it was decided to continue with determination of POPs in moss samples in the 2015 survey. Sampling was done in the period May-August 2015 and the moss samples were collected at the same sites as in 2010.

In the present talk, concentrations and spatial distribution of selected POPs will be presented. The results will be compared with the results obtained in the 2010 survey. In addition, results from statistical treatment of selected POPs concentrations with heavy metal data from 2015 will be shown.

DATA MANAGEMENT OF THE UNECE ICP VEGETATION MONITORING NETWORK

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A cloud platform, which was developed for the data management of the UNECE ICP Vegetation monitoring network, is described. Modern statistical, programming and organizational methods were used to provide the UNECE ICP Vegetation community with a unified system of gathering, storing, analyzing, processing, sharing and collective usage of monitoring data. This system consisting of a set of interconnected services and tools developed and hosted in the JINR cloud. Basic principles, architecture and web-interface of the platform are presented.

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EXECUTION OF THE BIOMONITORING RESEARCH CONDUCTED WITHIN GRANTS (OP CR-PR, JINR, POL-NOR) IN SELECTED AREAS IN POLAND AND NORWAY

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Mechanisms of bioaccumulation and translocation of heavy metals in the environment have been the subject of research for several decades now, including the possibility of using mosses as biomarkers and biomonitors of environmental quality.

The work concerns the comparison of the accumulation levels of selected heavy metals (Mn, Ni, Cu, Zn, Cd, Pb and Hg) in samples of epigeic moss *Pleurozium schreberi* collected in areas of different intensity of anthropogenic impacts during implementation of grants: *Propagation of research on environment quality of Polish-Czech cross-border area* financed by the Operational Programme of Cross Border Cooperation Czech Republic - Republic of Poland, *Ecosystem stress from the combined effects of winter climate change and air pollution - how do the impacts differ between biomes?* (WICLAP), which was a part of Polish Norwegian Research Programme and a study conducted in collaboration with the Joint Institute for Nuclear Research, Dubna RU.

The studies were mainly focused on the assessment of the sources (primary and secondary) of contaminants accumulated in moss, the contamination impact on ecosystems and seasonal changes in the concentrations of heavy metals in the studied samples.

The general results indicate that the mean values of metals concentrations are different, depending on the analyzed area, type of sorbed metal and season. The highest lead and cadmium concentrations were found in samples collected in Beskidy. Comparison of Zn, Cd and Pb mean concentrations indicates Beskidy and then the Karkonosze Mountains as the most vulnerable on these metals deposition. Also, high concentrations of lead and cadmium were determined in moss collected in the Bory Niemodlińskie. Samples with the lowest contamination level were collected in north-western areas of Poland. It should also be noted, that the accumulation of heavy metals in the moss is a result of wet and dry deposition. The atmospheric aerosol, however, may be re-enriched with secondary contamination elevating from soil with dust. The transport from soil can also be accessed via water wetting the moss surface [1]. Elevated concentrations of heavy metals, especially cadmium and lead, in samples collected in spring may indicate the significant contribution of low emission.

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OZONE (AND PM) POSTERS

THE PROBLEM OF THE LOCAL CONDITIONS ON THE SMOG PHENOMENA ON THE EXAMPLE OF KRAKOW CITY

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Krakow is the second most largest city in Poland, with a population about 850 thousand. Its geographical localization in the area of highly diverse relief within latitudinal course of the Vistula River valley causes specific conditions of the local climate. Most are subject to modification as a result of the strong interaction between topographic conditions and urbanization. Typical for urban environment are changes of the natural weather conditions (including e.g. the occurrence of heat islands). Not only the localization has an adverse affects on the unsatisfactory air quality, but also the way of heating of premises, especially in the old housing, based mainly on low-quality coal, burned in outdated furnaces. It is also worth mentioning that according to estimates, about 20% of pollution is coming from neighboring communities. As a result, during the winter season are recorded multiple alarm levels of PM10 and PM2.5 and other impurities. According to studies (Government research 2016), in 2015 more than 200 days in with exceeded permissible concentrations of suspended material (PM 10) were observed, which shows the scale of the problem.

CHANGES OF PHOTOSYNTHESIS ACTIVITY OF PINE TREES CULTIVATED IN DIFFERENT WATER REGIMES IN RELATION TO TROPOSPHERIC OZONE CONCENTRAITIONS

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The aim of the study was to evaluate an effect of tropospheric ozone on gas exchange parameters of pine trees cultivated in two different water conditions (with and without groundwater availability). Both, water supply and tropospheric ozone, are important to proper tree growth and physiological activities. However, in the case of water this is necessary component of environment to proper plant growth, while exceeded levels of ozone can negatively influence on physiological status of plants, including trees.
Plants were cultivated with two water regimes – the first one was limited to rain water, while the second one was with possibility to absorb water from the ground. Investigations were carried out in 2016 growing season, beginning from the July in the area of the Faculty Agro- and Hydrometeorology Observatory belonging to Wrocław University of Environmental and Life Sciences. The object is located in the south-western part of Poland, in the region of Lower Silesia. It is situated at an elevation of 120 m a.s.l., geographic latitude 51°07' and longitude 17°07'. It is separated from the centre of the city of Wrocław by a complex of parks and stadiums, the riverbed of the Oder, meadows and fields. Every moth photosynthesis activity parameters were analysed with the aid of photosynthesis activity handheld system Ci 340aa (CID BioSciences, Inc., USA). The following parameters were analysed: net photosynthesis rate (P_N), stomatal conductance (g_s), transpiration rate (E) and intercellular CO_2 concentration (C_i). Obtained results were related to tropospheric ozone concentration, automatically measured nearby the experiment site, and to air temperature. It seems that photosynthesis activity is negatively related to tropospheric ozone accumulated values, and positively related to water supply. However, stronger relation was noted to water supply.

CHANGES OF OZONE-CAUSED INJURIES OF BEAN AND TOBACCO PLANTS IN 2016 SEASON

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The aim of presented work was to examine the time-course of ozone-caused injuries. For this purpose two plant species were selected – tobacco (*Nicotiana tabacum* L.) and common bean (*Phaseolus vulgaris* L). Investigations were carried out during 2016 growing season. Tobacco ozone-sensitive cultivar (Bel W3) and bean ozone-sensitive genotype (S 156) were cultivated for 4 and 6 weeks. Afterwards were exposed to ambient air conditions. Every 3rd day plants were investigated on level of visible ozone-injuries for 4 weeks. To analysis of time changes the same leaves were chosen and documented. To achieve a good quality and comparability of photography documentation a source of light from the leaf bottom was used as well as the same camera and focal length of lens was used.
The results revealed the differences in time of occurrence and size of visible ozone injuries between examined plant species. Concerning the methodology it is important to remember about proper scale and data analysis. The level of ozone injuries will be further analysed with the aid of GIS tools to investigate the tendency of injuries spreading on leaves. Moreover, the obtained results will be related to real tropospheric ozone concentrations.

BEAN AS A SIMULTANEOUS BIOINDICATOR OF OZONE AND TRACE ELEMENTS IN DIFFERENT ENVIRONMENTAL CONDITIONS

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The aim of the work was to evaluate a possibility of use common bean (*Phaseolus vulgaris* L.) as bioindicator for monitoring air pollution for trace elements and tropospheric ozone. For this purpose two common bean genotypes were chosen: ozone-sensitive S 156 and ozone-resistant R 123, provided from CEH, Bangor.

Seeds of both genotypes were sown and cultivated in the greenhouse conditions for 4 weeks. Afterwards were transported to exposure sites located in urban, suburban and forest areas. Three samples collections were conducted during the experimental time – in 0th, 14th and 28th day of experiment.

The obtained results were collected and statistically analysed. Here we present visible ozone injuries of leaves and selected trace elements content: cadmium, lead, arsenic, nickel and chromium. Investigations revealed, that meteorological parameters has the strongest effect on tropospheric ozone creation, and in turn were also related to visible ozone injuries. Visible ozone injuries were only noted at ozone-sensitive genotype S 156. Trace element contents in leaves were mostly related to the day of experiment, and in some cases to experimental site. The range of trace elements content between genotypes did not differ significantly. This indicates on possibility of usefulness of both genotypes for identification of trace elements level. Presented results revealed possibility of using the common bean (genotypes S 156 and R123) as bioindicators of tropospheric ozone and trace elements in ambient air.

GEISPAIN PROJECT: GHG BALANCE AND OZONE FLUXES IN RELEVANT SPANISH ECOSYSTEMS

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Project GEISPAIN (CGL2014-52838-C2-2-R, MINECO, Spain) has been launched with the general objective of quantifying the GHG balance of different relevant Spanish ecosystems. Target types of vegetation and crops are: rice paddy field, olive orchard, Holm oak dehesa, and Mediterranean shrub. Specific objectives of the project are: 1) To quantify the real C balance (CO_2, CH_4) and natural drivers in the agro-Mediterranean sites. 2) To determine the relevance of soil emission of N_2O in the agro-Mediterranean sites. 3) To evaluate the effectiveness of the EC technique for measuring CH_4 fluxes in sites with low expected fluxes (such as semiarid-Mediterranean). 4) To provide for the first time in Spain direct eddy covariance measurements of ozone fluxes at ecosystem level in relevant Mediterranean ecosystems. 5) To quantify the partitioning between stomatal and non-stomatal ozone deposition and its variation along the day and seasonally. 6) To parameterize DO_3SE model, including its photosynthetic component, for olive tree and rice for the first time. 7) To test the soil moisture module of DO_3SE under Mediterranean conditions. 8) To validate modeled stomatal ozone fluxes (DO_3SE) with measured ozone fluxes by eddy covariance technique.

During 2016, measurements of O_3 fluxes with a fast O_3 analyzer (FOS, Sextant) in combination with eddy covariance technique were carried out in a rice paddy in Sueca (eastern Spain) during all the vegetative period of the crop. Complementarily, gas exchange leaf measurements under ambient conditions were carried out with a LICOR-6400 in order to parameterize the DO_3SE model and to model stomatal O_3 fluxes in rice. The first results of this study will be presented.

MICROSCOPIC ANALYSIS OF OZONE-CAUSED INJURIES IN SELECTED PLANT SPECIES

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The aim of this study was to evaluate the degree of leaf tissue injury of ozone-sensitive and -resistant tobacco plants and an ozone-sensitive bean, caused by tropospheric ozone. Plants were exposed at two different sites varying in ozone level, within Poznań city and in a remote forestry area. The ozone concentrations were higher at the forest site than in the city; cumulative ozone concentrations (AOT 40) were from 4312 ppb h^{-1} and 2914 ppb h^{-1} respectively. To validate O_3 symptoms at the microscopic level, Evans blue staining together with an image processing method for the removal of distortions and calculation of dead leaf areas was applied.

It was found that both resistant and sensitive tobacco and bean plants were damaged by ozone; however, the size of necrotic and partially destroyed leaf area in the sensitive bean was bigger - 2.9%, than in the resistant one – 1.5%. In sensitive tobacco, necrotic areas covered 2.8% examined area and in resistant tobacco - 1.5%.

USING OF TRIFOLIUM REPENS TO ASSESSMENT OF AIR CONTAMINATION IN THE SAMBIA PENINSULA (KALININGRAD REGION, RUSSIA)

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It is known the contamination of ambient air is one of the causes of variety of damage to vegetation. The appearance of yellow and brown spots on plants leaves and premature drying out and withering away of the damaged leaves indicates the environmental pollution.

Trifolium repens was chosen as a bioindicator of an atmospheric contamination. Monitoring was conducted from June to September. There were nine plots with different antropogenic load: five plots in the city (regional center) two of them near the roads, tree plots in the parks in the different parts of the town. There were four plots in native conditions: in the costal of Baltic sea, in the Curonian speat, in the forest and meadow. The damage leaf clover plate were visually recorded, the color of the leaf plates, the degree of damage of the leaves and their edges, the presence of faint spots were evaluated. The area of damaged plants was calculated every month.

Maximal damages were fixed in the city plots, near roads, 45-55%, in the park zones in the city - 25-35%, in the forest on the Noth of Sambia - 0-5%, in the meadow (ib.) - 10%, in the pasture in the south - east - 20% and in the meadow in the Curonian speat - 30%.

It was found that the maximum damages of *Trifolium repens* there were in the open areas and near permanent and strong sources of the pollution emission such as an automobile transport.

THE INFLUENCE OF CLIMATE CHANGE, PARTICULARLY TEMPERATURE INCREASE AND PRECIPITATION REDUCTION ON WETLANDS – SHORT TERM CLIMATE MANIPULATION EXPERIMENT IN THE WESTERN POLAND

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Wetlands in Central Europe under the influence of climate change, particularly higher temperature and drought, are prone to become a potential source of carbon emission into the atmosphere. In order to study how this process may occur, the climate manipulation experiment was designed to be conducted on Rzecin wetland in Poland. The experiment was intended to test how the above mentioned changes influence the carbon balance, plant vegetation and water chemistry. In order to do so, four surfaces were designated, i.e. control, heated surface, limited precipitation surface and heated surface with limited precipitation. The heating was obtained by using infrared radiators, and precipitation was reduced with an automatic curtain which opened during rain at night. As a result of these activities, in 2015, temperature was successfully increased by 0.4^{o}C for air and by 1.0^{o}C for soil, and precipitation was reduced by 35%. The measurements of carbon dioxide, methane and water vapour fluxes were conducted with a special automatic system of closed dynamic chambers. This work presents the results obtained in 2015 during climate manipulation experiment. It was an extremely dry year and probably due to that the surface was a net carbon emitter into the atmosphere (80 gC·m^{-2}yr^{-1}) which was confirmed in the control surface, while the heated surface with limited precipitation emitted smaller amount of carbon net (7 gC·m^{-2}yr^{-1}). It was probably a result of lower respiration (only 610 gC m^{-2}yr^{-1}). On the other hand, the heated surface without limited precipitation emitted more carbon (680 gC·m^{-2}yr^{-1}). Higher temperature in the heated surface also led to higher gross production of the ecosystem (-620 gC·m^{-2}yr^{-1}) than the surface with limited precipitation without heating (-550 gC·m^{-2}yr^{-1}).

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"END OF CLEAN AIR IN ..." – PROBLEMS OF THE CITIES FROM POLISH GREEN LUNGS

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In the era of globalization and the common progressive unification it is becoming increasingly important areas with unique features of the natural environment and cultural heritage. Uniqueness becomes a value in itself that must be protected, but also used skillfully, and the Polish Green Lungs are a unique area.

Functional area Polish Green Lungs are highly territorial compactness having strategic importance for its development. It is situated in the north-eastern part of the country. From the north it borders with the Kaliningrad Oblast of the Russian Federation, Lithuania and to the east of Belarus. The surface of the functional area of 60 759 km^2, which represents 19.4% of the country, and is inhabited by 3.7 million people (9.6% of the population).

The administrative structure form the province: the whole Podlasie, Warmia-Mazury (without one municipality), the northern part of the Mazowieckie province, as well as part of the region of Pomorskie (6 municipalities) and Kujawsko-Pomorskie (9 municipalities). Within the limits of the functional area is a 49 administrative districts and 6 cities with the county, 355 municipalities, including 35 municipalities and 68 urban-rural. The municipalities belonging to the Polish Green Lungs decided by the special qualities of the natural environment and the will of local governments.

According to the World Health Organization (WHO) every year as a result of inhaling the polluted air in the world die 2 million people. Of the 65 cities in Poland that were tested, only 6 is in norm (Gdańsk, Elbląg, Koszalin, Zielona Góra, Olsztyn and Wałbrzych. But for several days (8.01.2017) in Olsztyn We do deal with surge in air pollution. January 8 concentration of PM10 in the air exceeded the norm by more than 300 percent, of the Law of PM2.5 600 Percent.

MOSS SURVEY POSTERS

Cl, I AND Br, AND TRACE METAL ASSESSMENT ON ATMOSPHERIC DEPOSITION OF ALBANIA EVALUATED BY ENAA ANALYSIS

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Atmospheric deposition of Cr, V, Ni, Co, Zn, As, Cl, Br, I, Cu and Pb is studied by using moss biomonitoring (*Hypnum cupressiforme*) collected from 30 sampling sites of three vertical axes parallel to coastal line of Albania (the average distance of each axis is 10, 41 and 83 km). Cr, V, Ni, Co, Zn, As, Cl, Br and I were done by using *neutron activation analysis* (NAA) at IBR-2 fast pulsed reactor in Joint Institute for Nuclear Research (JINR) Dubna, Russia, while Cu and Pb were done by ICP/AES at the Institute of Chemistry, Faculty of Science, Sts. Cyril and Methodius University, Skopje, Macedonia. Cd foil was used to absorb thermal neutrons during the determination ^{51}Cr, ^{58}Ni, ^{60}Co, ^{65}Zn, ^{76}As and ^{82}Br (Ch 1), while ^{52}V, ^{38}Cl and ^{128}I were analyzed by thermal neutrons in Ch2. The distribution of the elements as a function of distance from the coast line are investigated in this study. The order of the distribution of mean concentrations of the V, Cu and Pb is decreased as the distance from coast line is increased (Fig. 2). These elements close to coast line are highly affected from shipping emission, ash, oil and gas burning (Viana et al. 2014). It is a typical carbonate area rich in oil, gas and coal minerals, and is under the effect of shipping emission by providing good conditions for V enrichment. The order of the distribution of halogen elements was Cl > Br > I. The respective values of their mean concentrations were decresed as the distance from the coastal line is increased [the slopes of linear regression lines were: $b_{(Cl)}$=-4.1; $b_{(Br)}$=-0.03; $b_{(I)}$=-0.01] (Fig. 2) that is strongly indicating the atmospheric supply from the marine environment is the predominant source of these elements in the air. It is in the same line with the results of similar publications (Frontasyeva and Steinnes, 2004).

The concentrations for Cr and Ni increases as a function of distance from the seaside increased. The higher concentration is found on Axis 3 that is affected by geochemical factors of this zone.

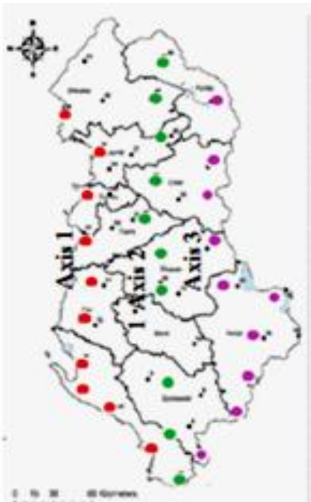

Fig. 1 The map of sampling sites

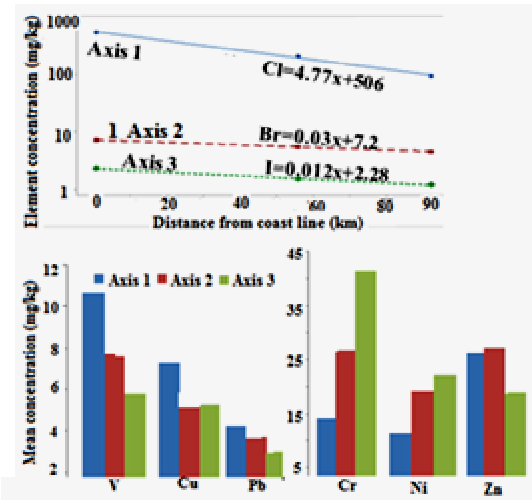

Fig. 2 The diagrams of element mean content

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TRACE ELEMENTS ACCUMULATION IN *TARAXACUM OFFICINALE* L. COLLECTED FROM CITY AREA

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The aim of the study was to examine *Taraxam officinale* as potential indicator of selected trace elements level in the city area. For this purpose the samples of leaves were collected from the Poznan city area, which was divided into squares with 4km^2 area. Four trace elements are here presented: Cd, Pb, Cr and Ni. All elements were analysed by inductively coupled plasma optical emission spectrometry followed by microwave-assisted sample digestion by concentrated nitric acid. For graphical data presentation, GIS tools were used.

Cadmium level was between 0.15 to 3.52 ng g^{-1} DM, lead from 0.13-5.32 ng g^{-1} DM, Ni 0.14-8.33 ng g^{-1}, 0.09-4.08 ng g^{-1}. The highest level of Pb was noted in the city centre, but also in areas close to main roads. Similarly, the highest cadmium accumulation was also recorded in central part of the city, while the rest squares with high level of Cd were rather spread on the whole city area. Chromium accumulation was also the highest in the city centre, but also plants collected from the northern part of the city revealed higher accumulation than plants from the southern part. Similar observation was made for nickel.

The next step of investigations will be relation of trace elements accumulation to land use, type of buildings and road density of certain squares. This analysis can pointed on certain sources of these elements in plants. However, based on diverse in elements contents in *Taraxacum officinale* we can conclude, that this species can be treated as indicator of trace elements accumulation in plants at city area. This is especially important, that this species is widely occurred almost in every city in Poland.

TOXIC METALS AND METALLOIDS IN THE ENVIRONMENT AND POSSIBILITY TO NEUTRALIZE WITH DENDROREMEDIATION

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Anthropogenic activity is the greatest cause of the production and disposal of wastes with possible high contents of toxic metals and metalloids. One of the methods to address this issue is phytoremediation which offers a promising solution to the global problem of the abundance of toxic elements in the environment. This biological method utilizes plants for decontamination of organic and inorganic pollutions from soils, sewages, sediments and also air. Especially promising is dendroremediation, which is phytoremediation with the use of tree species characterized by great biomass, developed root system and low environmental requirements, as plants able to undertake effective phytoextraction of toxic elements.

The key to achieving a satisfactory degree of efficiency in this process is to select suitable tree species, depending on the kind and concentration of pollution as well as the specific requirements of the used trees. Selection of trees is a long process that demands numerous hydroponic experiments, pot experiments using different substrates and field trials (the best directly in polluted environments). The first and most important aspects to bear in mind are the survivability of trees and their rapid adaptation and growth, after which high phytoextraction of toxic elements should be considered. Knowledge of interactions between elements, both their total amounts but also particular chemical forms is another important criterion.

The aim of the study was to test the phytoremediative potential of the native tree species, able to grow on mining sludges extremely polluted with trace elements. We were focused especially on arsenic and its metalloid forms (As(III), As(V) and cacodylic acid (DMA)) but also copper (Cu), lead (Pb) and zinc (Zn). Tree species selected in our previous studies were: *Acer platanoides* L., *Acer pseudoplatanus* L., *Betula pendula* Roth., *Quercus robur* L., *Tilia cordata* Miller and *Ulmus laevis* Pall. Analysis of elements and their chemical forms indicated that tree species such as *Acer platanoides* L. are able to survive in the above mentioned conditions. Moreover, these studies confirmed that phytoextraction of the analysed elements does not only depend on their bioavailable form but in a significant way on the interactions between their chemical forms.

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MOSS MONITORING OF TRACE ELEMENTS IN THE REPUBLIC OF UDMURTIA, RUSSIA

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Results on atmospheric deposition of trace elements in the moss survey in the summer of 2016 in the Republic of Udmurtia, Russia, are reported. Udmurtia is an industrial region allocated in the east of the East-European Plain, where it goes to the Western Urals. An important role in its economy belongs to enterprises of the military-industrial complex, machine tools and automotive, building materials and mining. Samples of moss were collected uniformly over the territory of central and southern part of the Republic in accordance with the guidelines of the Moss Manual 2015/2016 of the UNECE ICP Vegetation. Coordinates of the sampling sites were very close to those used in the first moss survey in Udmurtia carried out in 2005-2006 (Pankratova et al., 2007, 2008). A total of 39 elements were determined by neutron-activation analysis and atomic absorption spectrometry (Pb, Cd, and Cu). Multivariate statistics (factor analysis) and geochemical mapping were applied for data interpretation.

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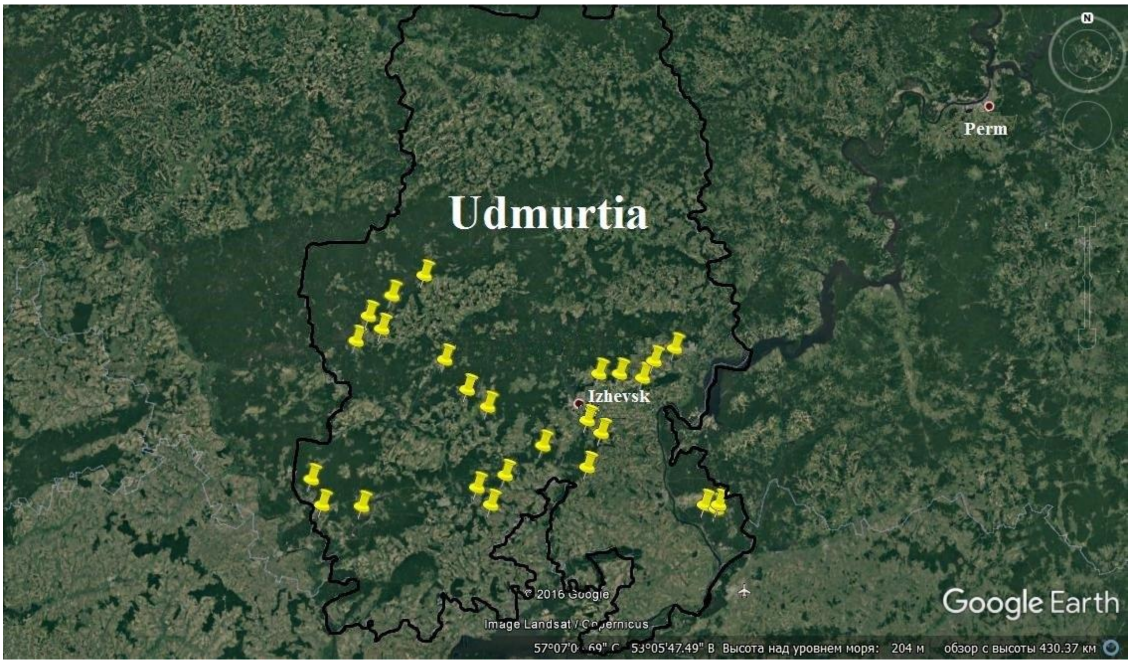

Fig. 1. Moss monitoring network in Udmurtia, Wester Urals, in 2016.

MOSS BIOMONITORING IN CANADA: 2014–2016

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Moss biomonitoring is widely used in Europe to monitor spatial and temporal tends in atmospheric pollutants. In contrast, few studies have been carried out in North America.

Motivated by the 2015 European moss survey (organised under the UNECE Convention on Long-range Transboundary Air Pollution), moss tissue for chemical analysis was collected from focused study regions across Canada during 2014–2016. In total, moss tissue was collected from > 340 sites (Figure 1), with the majority in Alberta (n = 129), followed by Ontario (n = 99), British Columbia (n = 90), Nunavut (n = 40), Saskatchewan (n = 16) and Northwest Territories (n = 8). Moss species (by sample number) were more-or-less equally split between *Hylocomium splendens* and *Pleurozium schreberi*; notably moss tissue for both species was obtained from approximately 60 sites in Alberta. The survey regions were selected under ongoing studies to assess the impacts of anthropogenic emissions from various sources, such as an Aluminum smelter in Kitimat, British Columbia, a Nickel smelter in Sudbury, Ontario, and Oil Sands emissions in Alberta. Similarly, moss tissue samples on Baffin Island (n = 60) were collected under a study to evaluate the potential impacts of ship-source emissions on Arctic ecosystems. All survey and laboratory methods followed the 'monitoring manual' (see URL: icpvegetation.ceh.ac.uk); tissue samples were analysed for trace metals (by Triple-Quad ICP-MS), total mercury (Milestone DMA-80 mercury analyzer) and carbon, nitrogen and sulphur content (Elementar vario Marco CNS analyzer).

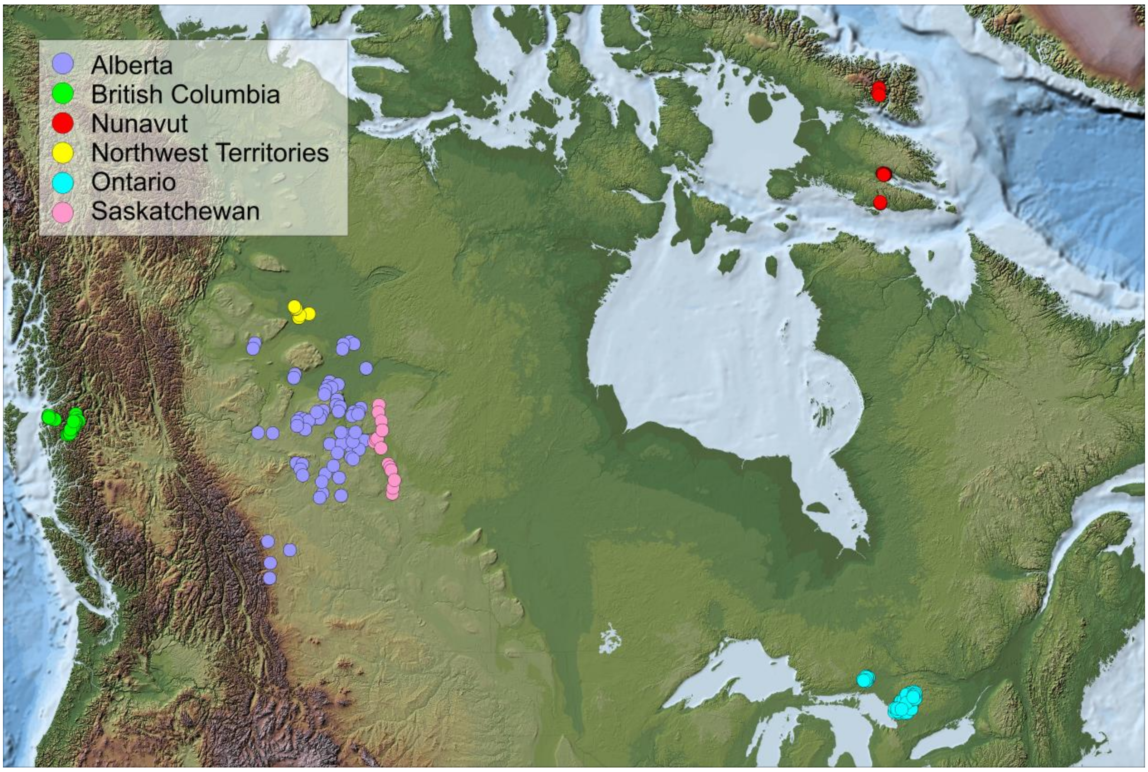

Fig. 1. Location of moss tissue study sites (n = 402) across Canada sampled during 2014 (n = 117), 2015 (n = 68) and 2016 (n = 167).

ATMOSPHERIC DEPOSITION OF MAJOR AND TRACE ELEMENTS BY THE MOSS BIOMONITORING TECHNIQUE IN ISTANBUL/TURKEY

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Air pollution is a major environmental and public health problem all over the world caused by different anthropogenic and natural emission sources from industries, traffic, fuel combustion, fires and accidents. Atmospheric pollution with metal, trace elements and radionuclides has been increasingly recognized as a serious threat to human health and ecosystem integrity worldwide. Over the past several decades, biomonitoring has been developed as an alternative method to instrumental air pollutant monitoring. Biomonitoring is regarded to assess major and trace element contamination in aerosols and deposition.

The overall aim of the study is to assess the ecological impacts of atmospheric deposition for major and trace elements contamination based on moss analysis around Istanbul. Istanbul is the most crowded city in Turkey. The current rapid industrialisation in Istanbul and the contributory relationships with the original pollution sources can cause serious environmental problems within the city. The present study conducted a survey on the air pollution on both the European and Asian sides of Istanbul, and the contributory relationships with the original pollution sources.

Moss sampling sites were selected from the urban, suburban, industrial and green zones and references sites on both the European and Asian sides of Istanbul. Terrestrial moss samples were collected from all sites for assessment of metal contamination level. To measure the element content in the mosses, each sample was dried. Then the samples were digested in acid solution. Digested samples were diluted with distilled water to a total volume of 100 mL. Metal concentrations of Al, As, Cd, Cr, Cu, Fe, Hg, Ni, Pb, Sb, V and Zn on the moss samples and standard reference materials was determined by ICP–AES. The concentrations of air pollutants on European sides of Istanbul were found higher than Asian sides of Istanbul. Multiple linear regression on a data set was performed. The air contamination from pollutants was assessed based on enrichment factor, geoaccumulation factors, and ecological risk indices. The results were compared with the data from each site of Istanbul.

SHIFTS OF SPHAGNUM AND BROWN MOSSES POPULATIONS VS POLLUTIONS IN HARZ MTS. (GERMANY) OVER THE LAST 2700 YEARS

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Local shifts in vegetation communities of ombrotrophic bogs can be determined by various factors e.g. climatic and hydrological changes, human activity (e.g. grazing, deforestation and fires) or competition among local plants populations. However pollution and deposition of external inputs triggered by the industrial activity and the erosion of mineral soil caused by increasing of open area may also impact bog ecosystems development.

To determine the influence of pollution and human activity on *Sphagnum* and brown mosses assemblages in a mountain bog we collected a peat core (280 cm long) in Odersprungmoor located in Harz Mts. (Central Germany). We carried out radiocarbon dating (AMS) of nine samples to reconstruct chronology. High-resolution (1-cm peat slice) plant macrofossils analysis was used to reconstruct local plant succession. Results of pollen analysis gathered knowledge about climate changes and human impact reflected by the plant cover in regional scale. Geochemical analysis of the peat samples allowed to reconstruct pollution and deposition of external material (eg. dust) over the last ca. 2700 years.

The peat-forming process in Odersprungmoor in sampling site started ca. BC 700 after a fire documented by a high amount of macro-charoal and burned plant remains. *Polytrichum strictum* and *Sphagnum magellanicum* were pioneer mosses that appeared on the burned soil which was apparently still connected with local groundwater. Increase of some elements eg. titanium, silicon caused by the erosion of mineral soil trigged changes in plant populations (Hölzer and Hölzer, 1998). Appearance of *Sphagnum magellanicum* was linked to intermittent increases of titanum and silicon, indicating dust from an increase of human activity and more open area.

Since ca. AD 1000 there is repeated increase of trace metals such as Cu, Zn, and Pb, coinciding well with medieval increase of industrial activity. This increased disturbance was related to disappearance of *Sphagnum angustifolium* in the sampling site.

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[1] Hölzer A. and Hölzer A., 1998. Silicon and titanium in peat profiles as indicators of human impact. The Holocene 8: 685–696.

ASSESSMENT OF CHANGES IN RADIOISOTOPES ACTIVITY CONCENTRATIONS IN MOSSES DURING SUBSEQUENT GROWING SEASONS

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The aim of the study was to describe the concentration of radioisotopes in mosses and their bedding during subsequent growing seasons. In the study common in central Europe moss.species *Pleurozium schreberi* was used.

Samples of moss and bedding were collected in forest areas in Karkonosze Moutains. After manual removal of impurities the collected material was dried to constant mass in temperature of 105 ˚C. The determinations of activity concentrations of gamma radioisotopes (among others:Cs-137, Pb-210, K-40, Pb-214, Bi-214) were carried out by means of a gamma-spectrometer with a germanium detector HPGe (Canberra) of high resolution. Statistical analysis was conducted using environment of R language.

In the measurement results interpretation the methods of compositional data analysis (CoDA) were utilized. Cluster analysis in samples shows significant influence of growing season on isotopes concentrations in moss. Clustering process was less affected by, among others, sampling site or material used: green parts of moss, brown parts of moss and bedding. In addition, the analysis showed a higher concentration of radionuclide Pb-210 in spring. This concentration gradually decreased during subsequent seasons. This phenomenon may be related to the low deposition escalating during the heating season. Unlike Pb-210 of potentially anthropogenic origin, concentration of Bi-214 in the studied seasons showed no significant changes.

MOSS BIOMONITORING IN CENTRAL RUSSIA: TULA REGION CASE STUDY

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Using the method of passive moss biomonitoring atmospheric deposition of trace elements was studied in Tula region, one of the major industrial regions of Central Russia. A comparison of different moss species with those recommended by Moss Manual 2015/2016 was undertaken by epithermal neutron activation analysis (ENAA). Such species as: *Oxyrrhynchium hians, Eurhynchium angustirete, Orthotrichum speciosum, Brachythecium rutabulum, Atrichum undulatum, Brachythecium salebrosum, Abietinella abietina, Rhytidiadelphus triquetrus* showed similar accumulative characteristics as the recommended ones or even surpass them. Sampling of mosses was carried out at 82 sampling points in the forest, forest-steppe, steppe and marsh phytocoenosis of the Tula region. A total of 42 elements were determined. Retrospective comparative analysis of the atmospheric deposition of trace elements in 2000–2015 showed an increase since 2000 of Fe, Cr, Co, As, Cd, Sr, and Sm concentrations determined by ENAA. In comparison with the other regions of Russia, the air of Tula region is polluted by such elements as V, Fe, Co, As, Sr, La, Ce, Tb, Hf, Ta, Th, U, and Sm. These elements are of technogenic origin associated with the activity of the enterprises of metallurgical, metalworking, defense, coal mining in the region. These elements can be transferred by air masses to neighboring areas. Concentrations of V, Cr, Fe, Zn, As, and Cd in atmospheric deposition for Tula region are 1.5-7 times higher than those for Belarus, Ukraine, UK, and EU (fig.1).

Study was supported by RFBR (Grant 15-45-03252 - r_centre_a)

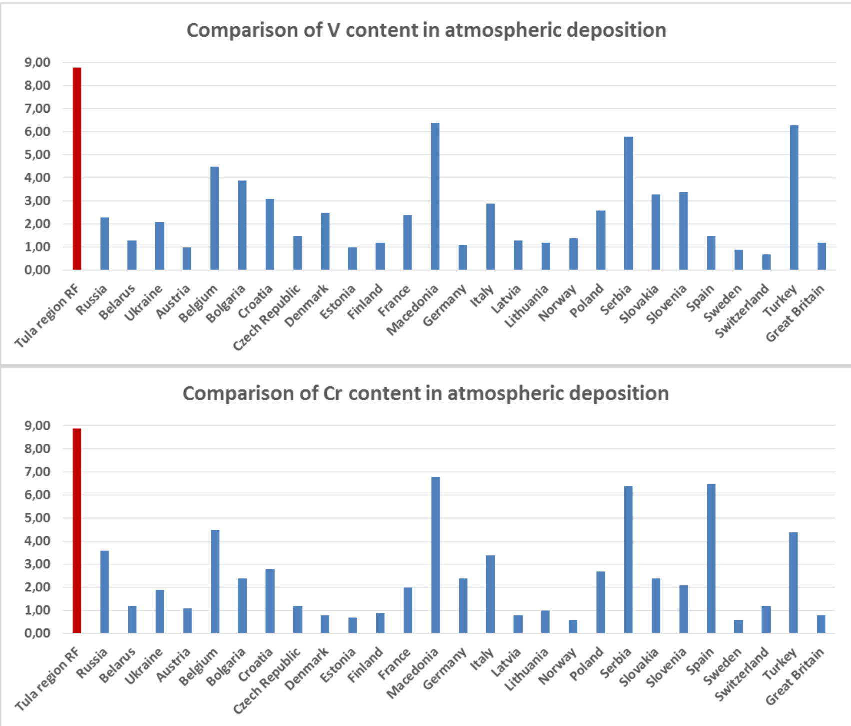

Fig. 1. Comparison of atmospheric deposition (V, Cr) in Tula region with average data in RF, Belarus, Ukraine, EU, UK.

ANALYSIS OF MOSSES TO MONITOR RADIOACTIVITY FROM THE ATMOSPHERE (ISTANBUL, TURKEY)

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Moss have been used commonly as bioindicators of fallout radionuclides. Nuclear weapon tests and nuclear reactor accidents are main sources to release artificial radionuclides such as ^{137}Cs, ^{90}Sr and Pu which have long physical half-lives into the atmosphere. Terrestrial radionuclides such as ^{40}K, ^{238}U and ^{232}Th present also in the environment. Part of all radionuclides are deposited in mosses.

The present study was undertaken in order to determine the radionuclide activity concentrations in moss samples of Istanbul. For this reason, moss samples were collected from urban and rural areas of Istanbul. Radiation levels of samples were measured using a gamma multichannel analyser equipped with a high purity germanium detector. The concentrations of radionuclides were compared with those obtained from similar studies related to Turkey reported in the literature as well as earth's crust average values.

THE 2015 MOSS MONITORING IN POLAND

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The aim of the study was to assess the air quality (by moss monitoring) in four Polish regions, differing in the degree of urbanization and industrialization, and compare it with the state recorded in the past (2001). The study regions were: 1) the Legnica-Głogów Copper District (*LG)*, 2) the Silesian-Cracow Industrial District (*SC*), 3) the central region covering the Warsaw agglomeration, and 4) the reference area (SE Poland). We collected a total of 117 moss samples in 2015, from the same sites as in 2001. In green parts of *Pleurozium scherberii* the concentration of 13 elements (N and As, Cd, Co, Cu, Cr, Fe, Hg, Mn, Mo, Ni, Pb, Zn) was determined. Only Cd, Cu, Fe and Pb were analysed in both years. The content of heavy metals in mosses significantly differed between 2001 and 2015. The levels of Cd, Cu and Pb decreased, while Fe showed the opposite trend. Significant differences were also found between the study regions. As expected, the most contaminated were industrial regions, i.e. *SC* (high concentrations of Cd, Fe and Pb) and *LG* (high concentrations of Cu and Pb), while the reference area was the cleanest. In the case of Cu, Cd and Pb, we found the interaction of factors (year × region). This suggests that air quality has improved only in areas that were relatively clean in the past; on the contrary, in areas characterized by high levels of pollution in 2001, the poor condition of the environment persists. Other elements (N and As, Co, Cr, Hg, Mn, Mo, Ni, Zn) were compared only between regions. Significant differences were found for all with the exception of Co. The lowest levels were always observed in the reference area. As for the other regions, the pattern was element-specific. For example, the central region surpassed other regions in terms of the level of N and Ni, while As and Hg levels were highest in the industrial regions.

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THE USE OF MOSS *PLEUROZIUM SCHREBERI* (BRID.) MITT. AS BIOINDICATOR OF RADIONUCLIDE CONTAMINATION IN INDUSTRIAL AREAS OF UPPER SILESIA

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Mosses are good bioaccumulators of radionuclides and from the 60 of the last century, they are used as bioindicators of radioactive contamination in the environment. Concentration of impurities in moss represent the accumulation in mosses during the past 2-3 years. As a result, the moss composition analysis provides information on an average contamination within a few vegetation seasons.

During our survey the measurements of radionuclide activity concentrations in *P. schreberi* transplanted from places relatively clean to heavily contaminated areas of Upper Silesia were carried out. An increase in the radionuclides activity concentrations in *P. schreberi* transplants may indicate not only deposition of the radionuclides itself, but also an influx of other pollutants. The results showed no relationship between the Pb-210 activity concentration and activity concentrations of Pb-214, Bi-214, also belonging to the uranium-radium decay series. The increased concentration of Pb-210 in *P. schreberi* may be the result of the radionuclide atmospheric deposition, which appears in the environment as a result of fossil fuels burning. Excess, allogeneic Pb-210 can be used as marker of environmental pollution. In the areas with its higher activity concentration increased pollution can be expected delivered, for example, by local industry.

Acknowledgement: The Project received financial assistance from the funds of the National Science Centre, granted by the decision no. UMO-2013/09/B/NZ8/03340 (NCN).

PHYTOEXTRACTION OF RARE EARTH ELEMENTS USING *BETULA PENDULA* ROTH AND *PINUS SYLVESTRIS* L. GROWING ON HIGHLY POLLUTED MINING WASTES

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Phytoextraction of trace elements is one of the biological methods whose importance is constantly increasing because of the low cost and the use of plants capable of effectively collecting pollutants from soils and sediments. A particularly important issue is the use of tree species commonly found in Poland for the purification of post-flotation waste, which is bulky waste from the non-ferrous metal industry. For establishments not indifferent to corporate environmental responsibility the issues of remediation are one of the basic foundations of business.

One type of pollutant now becoming more and more common are rare earth elements (REEs). REEs, also found in post-flotation sediments, due to their increasing importance in modern technologies can be taken up by herbaceous plants, among others, as previously described in literature. Owing to their accumulation in the deeper layers of deposited waste, tests have been carried out on pines (*Pinus sylvestris* L.) and birches (*Betula pendula* Roth) of different ages growing within one of the settling tanks located in the south-western part of Poland (the village of Iwiny). In our studies the REE content in plant organs was categorised as belonging to Light Rare Earth Elements (LREEs) or Heavy Rare Earth Elements (HREEs). Additionally, plant age and biomass, and creation of low molecular weight organic acids (LMWOAs) were analysed.

Plants growing within the unused post-flotation sediment tank in Iwiny were characterised by high phytostabilization of rare earth elements. The analysis of trunks and leaves in the case of birch, as well as trunks and needles in the case of pine did not demonstrate the existence of any specific relationship between the age of the trees and their ability to phytoextract REEs. It is worth emphasising that the dominant LREEs were neodymium (Nd) and cerium (Ce), while in case of HREEs, the content of all elements belonging to this group was similar. It is likely that the reason for the absence of any correlation between plant age and phytoextraction of REEs was diversity in plant access to water. The level of REEs present in plant organs indicated a limitation of their accumulation in the aerial plant parts and additional analysis of LMWOAs confirmed phytostabilization of elements in the rhizosphere.

Acknowledgement

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A COMPARISON OF VARIOUS METHODS FOR AIR POLLUTION CHARACTERIZATION OF INDUSTRY INFLUENCED AREAS

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Moravian-Silesian region in the Czech Republic is one of the most polluted areas in the Europe. In this region is concentrated big amount of heavy industry which is mainly focus on metallurgy processes and associated industries. Department of Environmental Protection in Industry, which also deals with the protection of the environment in relation to industrial systems is focused on the relationship between resources and the pollution exposition. The research was focused on the comparison of various methods for air pollution characterization such as modelling, moss biomonitoring and air pollution monitoring. During the research the analytic dispersion modeling supercomputer system (ADMOSS) was developed. This model is capable to modeling these relationships using the parallel clusters computing and geographic information systems. Results of modeling and air pollution monitoring stations in Czech-Polish industrial area where are cities Ostrava, Rybnik, Katowice and Krakow were verified using the moss biomonitoring. Biomonitoring was carried out in the mesh of monitoring sites covering core of the polluted area which include two large industrial complexes. Results of moss biomonitoring show that some heavy metal pollution (vanad, titan, aluminium dysprosium, magnesium) is approximately correlated with influence of large pollution sources. Despite to results of Gaussian model the moss biomonitoring show that pollutions is dispersed more orthogonally to dominant wind direction. These results are probably caused by thermal inversion and low wind velocity and calm. During high concentration the pollution is spread equally to all directions. Researches are still in progress, one of innovations is former coal mine tower named “František” in the center of the study area which will be used for air pollution monitoring by special equipment for sampling.

TRENDS OF HEAVY METAL ACCUMULATION IN MOSSES IN SLOVAKIA (1990 -2015)

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The use of mosses as biomonitor of atmospheric deposition of heavy metals in Slovakia started more than 30 years ago in connection with the problems of the forest dying in Slovakia.1990s, within the framework of UNECE ICP Vegetation programme, systematic studies using moss were carried on in Slovakia (net 16x16 km), and the results were presented in the European Atlas *Atmospheric Heavy Metal Deposition in Europe – Estimations Based on Moss Analysis*. It is assumed that in the Slovakia (SK) a large gradient of the atmospheric deposition load of elements exists because part of the SK territory belongs to the most polluted areas in central Europe known as the 'Black Triangle II'. In order to recognise the distribution of element deposition in the SK, the moss monitoring technique, also known as biomonitoring, was applied to the whole territory in 1990, 1995, 1996, 1997, 2000, 2005, 2010 and 2015. The application of mosses as biomonitors of trace elements in selected Slovak industrial areas, mining country, and National parks affected by anthropogenic activity is reviewed. Moss was successfully used also to study temporal and spatial deposition of N and S. A combination of analytical data (NAA, and AAS in our case) with principle component analysis and correlation factor allowed pollution source characterization and apportioning in the sampled areas: Central Spiš (effect of heavy metals); Aluminium plant Žiar nad Hronom; Thermal power plant Horná Nitra; Central Slovakia (mining area of Staré Hory, Ľubietová, Špania dolina); Beskydy (north part of Slovakia- influence of Poland and Czech pollutants); High Tatra National Park (TANAP) and Low Tatra National Park (NAPANT).

THE USE OF LICHENS AND MOSSES IN PASSIVE BIOMONITORING

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In recent decades, the instrumental methods of pollution assessment are more often complimented with biomonitoring methods consisting of assessing the anatomical, morphological and physiological changes occurring in plants due to contaminants emitted into the environment [1]. Among the so-called biomonitoring stands biomonitors of accumulation, having the capacity to accumulate contamination [2]. One of the most commonly used are the mosses and lichens that nutrients, but also pollution, consume their entire surface. The popularity of these methods is the fact that they are successfully used in most European countries, including Poland. Examples are studies carried out since 1990 in the framework of ICP Vegetation - International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops, involving the measurement of concentrations of heavy metals accumulated in mosses [3, 4].

The aim of the study was to evaluate the level of contamination with selected heavy metals: Zn, Ni, Cd and Pb in forest areas of Twardogóra community. City of Twardogóra is located in the north-eastern part of the Lower Silesian province (south-western Poland), where forests account for 44% of the total community area. *Pleurozium schreberi* moss and *Hypogymnia physodes* lichens were collected from 32 sites located near the Gola, Goszcz, Grabowno Wielkie and Sosnowka villages. Selected heavy metals (Ni, Zn, Cd and Pb) were determined using atomic absorption spectrometry.

The study results were interpreted using, i.a. Comparison Factor (*CF*), which is a difference in concentration of analyte accumulated in lichens and moss, relative to its average content in lichens and mosses. Obtained results indicate a non-uniform deposition of heavy metals on the studied area, especially of Zn, Pb and Cd, which is confirmed i.a. with the designated values of *CF*. It has been shown that mosses and lichens can be an important source of information about pollution.

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PHYTOEXTRACTION OF SELECTED RARE EARTH ELEMENTS IN HERBACEOUS PLANT SPECIES GROWING NEAR ROADS

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Rare Earth Elements (REEs) is one of the most interesting group of elements present in environment and the subject of numerous studies last years. The development of modern technologies and use of these elements in creation of new materials with improved traits, is the main cause of their concentration increase in many components of environment. It is worth to underline that this group of elements was omitted long time, what was an effect of limitation in analytical chemistry (no proper equipment and methods of results validation). At this moment, development of analytical methods allows to REEs analysis in majority kind of samples.

The genesis of these studies was related with information about differences in REEs content in soil near German roads last years and over 20 years ago. Information present in sporadically published data pointed at general increase of this group of elements in soil, therefore probably also in plants and finally increase the risk of their transport to food chain. For this reason, the aim of study was to show how effective is the phytoextraction of REEs in commonly present near the roads herbaceous plant species. The choice of just this group of plant was purposal, because content of REEs was analysed in mosses, lichens or vascular plants but in case of hearbaceous plant species, data are extremely poor. The experimental material were 5 plant species: *Achillea millefolium* L., *Artemisia vulgaris* L., *Papaver rhoeas* L., *Tripleurospermum inodorum* (L.) Sch. Bip. and *Taraxacum officinale* F.H. WIGG, collected from 4 places near the same road. Places were diverse regards the traffic intensity and the experiment was performed within the next two years. Analysis of REES was divided into two groups: light rare earth elements (LREES) and heavy rare earth elements (HREES).

Generally, the concise correlation between traffic intensity and LREE, HREE and REE content in soil was observed. On the other hand, there was not positive correlation between content of each of these elements groups in soil and their phytoextraction in soil. Effective phytoextraction of REEs in *A. vulgaris and P. rhoeas* leaves was stated. *P. rhoeas* leaves and *T. inodorum* roots were organs with the highest content of REEs. Phtoextraction of this group elements to aboveground plant parts suggested their effective translocation. In case of LREEs, elements included for this group were accumulated mainly in *T. inodorum* roots and *T. officinale stems. Phytoextraction of HREEs was mainly in T. inodorum* and *T. officinale stems and also P. rhoeas* roots and leaves.

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PHYTOEXTRACTION OF SOME ARSENIC FORMS IN SELECTED WILLOW TAXA - HYDROPONIC EXPERIMENT

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Phytoextraction of inorganic pollution, especially toxic trace elements such as arsenic (As) is one of the most promising ways to decontaminate polluted ecosystems. However, to achieve the greatest possible efficiency in this process the selection of suitable plant species is essential. The selected plants should be able to easily adapt to new area conditions, have low environmental requirements, high phytoextraction efficiency and a potentially high biomass crop. In literature, there are extensive data on plants that have traits that can be applied in particular phytoremediation strategies among which are fast growing plant species such as willows. Willows, common in many European countries are significantly diverse with respect to their ability to take up elements through phytoextraction, while growing in the same places. Accumulation of toxic metals and metalloids e.g. As depends on many environmental factors such as: soil pH, redox potential, conductivity, organic matter, amount of bioavailable forms of elements and especially amount of water. One factor, probably the most important with the exception of those mentioned above, is the form of elements.

In the case of As, forms such as As(III), As(V), MMA or DMA are particularly important as regards their toxicity for living organisms. In plants their presence can cause numerous negative reactions. For this reason, we analysed the influence of particular As forms in hydroponic pots on 5 willow taxa. Two-year-old seedlings of *Salix viminalis*, *Salix purpurea* and *Salix alba* were studied over a 28 day hydroponic experiment in fully controlled conditions (phytotrone), where each plant was grown in modified Knop solution enriched with 0.5 mM L^{-1} of each of the above mentioned As forms separately.

The obtained results revealed significant differences in total As phytoextraction, not only between *Salix* taxa but also their organs. As was accumulated mainly in roots and shoots, whereas the amount of this metalloid in young shoots and leaves was significantly lower. Both As(III) and As(V) were accumulated in all organs of each of the tested *Salix* taxa. At a concentration of 0.5 mM L^{-1} MMA or DMA caused limitation of plant growth. Signs of withering, particularly of leaves were clearly visible. All the obtained results suggest that the form of As present in Knop solution plays an important role in plant response and phytoextraction of As in the analysed willow taxa.

ATMOSPHERIC DEPOSITION OF HEAVY METALS AND RADIONUCLIDES IN IRTYSH AREAS OF KAZAKHSTAN

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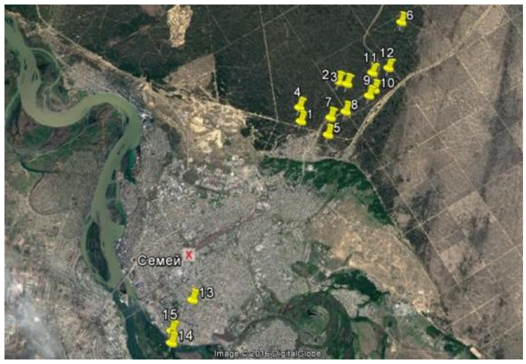
The method of moss biomonitoring of atmospheric deposition of trace elements was applied for the Southeastern, Northeastern and Central parts of the Republic of Kazakhstan to assess the environmental situation in these regions. The ninety moss samples were collected in summer of 2014-2015 growth periods. Also, the thirty moss samples were collected in autumn and summer of 2015-2016 growth periods. A total of 42 elements (Na, Mg, Al, Cl, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Ni, Co, Zn, As, Se, Br, Rb, Sr, Zr, Nb, Mo, Ag, Cd, Sb, Ba, La, Ce, Nd, Sm, Eu, Gd, Tb, Dy, Tm, Hf, Ta, W, Au, Th, and U) were determined by epithermal neutron activation analysis. Multivariate statistical analysis of the results obtained was used to assess the pollution sources in the study area of the Almaty, Pavlodar, Oskemen, Shymkent and Semey regions (sampling sites are shown in the map below).

Sampling map (2014-2015)



Sampling map (2015-2016)

Multivariate statistical analysis of the results obtained was used to assess the pollution sources in the study areas. The descriptive statistics of the 22 analysed elements in all collected moss samples in median values and minimum-maximum ranges for the contents of all elements were compared with the data obtained in Republic of Macedonia (Barandovski, et al., 2010), and the data obtained from Georgia moss survey in 2014 and the data Norway considered as a pristine area of Europe (Shetekauri, et al., 2015). The data obtained in Kazakhstan in 2014-2016 growth periods were compared with each other.

A comparison of concentrations Kazakhstan-Norway showed the increased values for most of heavy metals (Fe, Mn, Ti, V, As, Mg, Al, Ca, etc) in the studied samples that apparently are due to the state of the industrial pollution in these regions.

ATMOSPHERIC DEPOSITION OF TRACE METAL IN ALBANIA (2015 MOSS SURVEY) EVALUATED BY MOSS BIOMONITORING AND ICP-AES ANALYSIS

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Trace element concentrations in moss provide complementary, spatial resolution and time integrated data on atmospheric deposition. The study of moss biomonitoring is conducted every 5 years in European countries. Albania joined this study for the first time on 2010 moss survey. The study of 2015 is presented in this study. Moss samples (*Hypnum cupressiforme*) were collected during the August and September 2015 from 58 sites, evenly distributed over the country. Moss biomonitoring technique and inductively coupled plasma-atomic emission spectrometric (ICP-AES) were applied to study multi-element atmospheric deposition in Albania. Sampling was performed in accordance with the LRTAP Convention-ICP Vegetation protocol and sampling strategy of the European Programme on Biomonitoring of Heavy Metal Atmospheric Deposition. ICP-AES and AAS analysis made it possible to determine concentrations of 19 elements including key toxic metals such as Pb, Cd, As, and Cu. The study of 2010 show median values of the elements in moss samples of Albania were high for Al, Cr, Ni, Fe, and V and low for Cd, Cu, and Zn compared to other European countries, but generally were of a similar level as some of the neighboring countries such as Bulgaria, Croatia, Kosovo, Macedonia, and Romania. The decline in emission and subsequent atmospheric deposition of HM across Europe has resulted in decreasing HM concentrations in moss between 1990 and 2010 (Harmens et al. 2015, Schröder et al. 2016). In contrast, the level of most toxic elements, such as As, Ni, Cr, Cu, Zn and Cd is increased in 2015 compared to 2010 in moss samples of Albania. Beside the high level of mineral particle dust emission, the atmospheric conditions of 2015 (after a long rainy period of 2015) should be another important factor of this increase.
This study was conducted in the framework of ICP Vegetation in order to provide a reliable assessment of air quality throughout Albania and to produce information needed for better identification of contamination sources and improving the potential for assessing environmental and health risks in Albania, associated with toxic metals

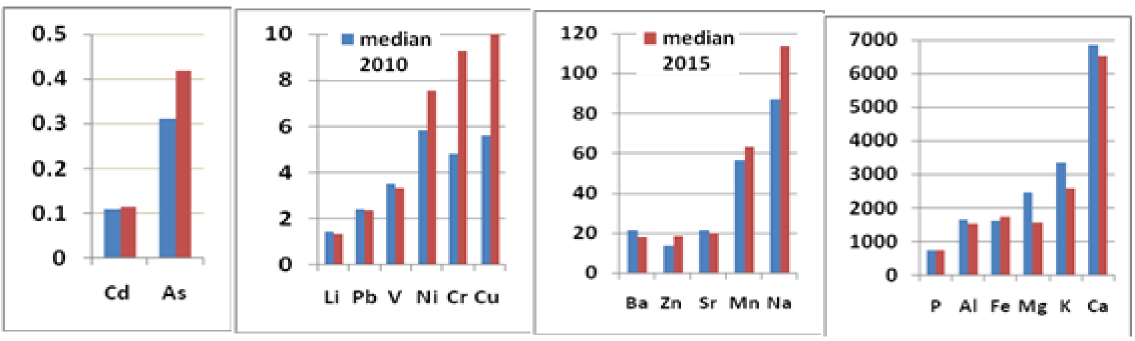

Fig. 1. Metal conentration (mg/kg, DW) in moss samples of Albania (2010, 2015 moss survey)

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TEMPORAL TRENDS OF METAL CONCENTRATIONS IN MOSSES COLLECTED IN ROMANIA IN 2010 AND 2015

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Biomonitoring of heavy metal atmospheric deposition using terrestrial moss is a well-established technique in Europe. Nationwide moss surveys undertaken in Romania in 2010/2011 and 2015/2016 comprised the common sampling sites evenly distributed over 75% of the Romanian territory. The metals concentrations in moss samples were determined by three complementary analytical techniques: instrumental epithermal neutron activation analysis (ENAA) at the IBR-2 reactor in the Joint Institute for Nuclear Research in Dubna, Russian Federation; graphite furnace/flame atomic absorption spectrometry (GFAAS /FAAS) in 2010/2011 and inductively coupled plasma mass spectrometry (ICP-MS) in 2015/2016 carried out in the Institute of Multidisciplinary Research for Science and Technology, Targoviste, Romania. The site specific temporal trends for many elements were observed between two moss surveys.

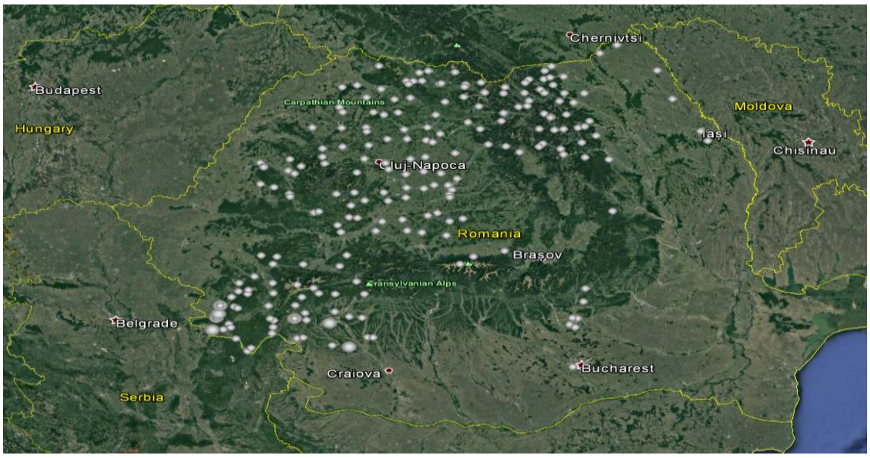

Fig. 1. Moss monitoring network in Romania in 2015.

ESTABLISHING MOSS MONITORING NETWORK OF ATMOSPHERIC DEPOSITION OF TRACE ELEMENTS IN ARMENIA: A PILOT STUDY IN 2016

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It is well recognized that terrestrial mosses are among the most effective biomonitors of atmospheric trace element deposition. In September-November of 2016 moss samples were collected (Fig. 1) for the first time across different landscape/geochemical zones of Armenia in the framework of the UNECE ICP Vegetation. The selected moss monitoring network covered the spatial distribution of known air pollution sources. Sample collection and pretreatment for analysis was carried out following the guidelines of the Moss Manual 2015/2016. Two complementary analytical techniques were used for determination of elements in moss samples: multi-element neutron activation analysis (35 elements including heavy metals, lanthanides and actinides) and atomic absorption spectrometry (Pb, Cd, and Cu). To characterize the deposition patterns and to identify the spatial distribution features of elements from natural and anthropogenic sources, multivariate geostatistical analysis and geochemical mapping were performed.

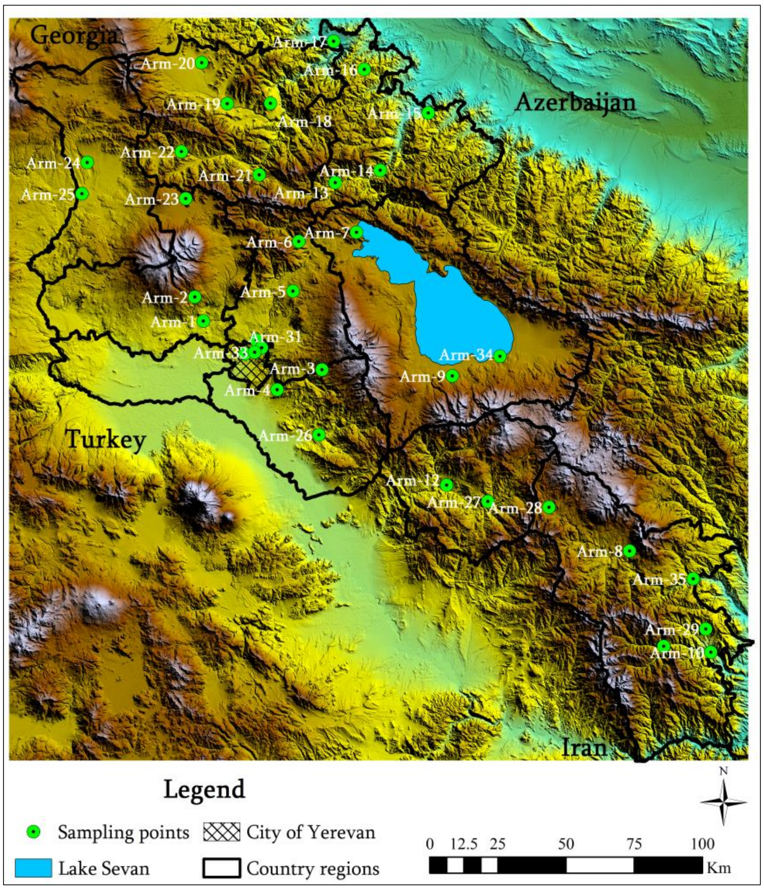

Fig. 1. Moss monitoring network in Armenia in 2016.

BIOMONITORING OF HEAVY METALS AND TRACE ELEMENTS IN CENTRAL RUSSIA: MOSCOW CASE STUDY

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The data obtained on 40 elements including heavy metals and rare earth elements determined by instrumental neutron activation analysis in 39 moss samples collected in the northern part of Moscow region (Central Russia) in summer 2014 are presented. Principal component analysis was used to identify and characterize different pollution sources. Distribution maps were prepared to point out the areas most affected by pollution and to characterize the deposition patterns of pollutants. The median concentrations of all heavy metals in the sampled area are similar those obtained for the other parts of the Russian Federation [1, 2]. The obtained data were also compared with the data from the previous moss survey in 2009 [2]. As in 2009, transport and industrial enterprises are the main pollution sources in the satellite towns around Moscow.

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WEB-BASED GEOINFORMATIC SYSTEM FOR MODELING AND ASSESSMENT OF THE ENVIRONMENTAL STATUS OF THE SOUTH-EASTERN BALTIC (RUSSIA FEDERATION)

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Simulation-based modules of ArcGIS geographic information system has been applied to study of spatiotemporal dynamics of pollutants distribution and accumulation in forest biogeocenoses of the South-Eastern Baltic (Russia Federation, Kaliningrad region); identification of pollution sources (definition of contribution of transboundary transport and regional sources); forecasting the quality of atmospheric precipitation (based on multi-year research, including ICP-vegetation).

The content of pollutants were determined in some species of higher and inferior plants and in the surface soil. Species of the growing carpet and side-fruiting mosses such as *Pleurosium shrebery, Hylocimium splendens and Scleropodium purum* have been collected to assess the atmospheric deposition of trace elements in Kaliningrad region (the South-Eastern Baltic) every 5 year from 1994 until now. There were used a three years growth. Epiphytic lichens *Hypogimnia physodes* were sampled to estimate the ambient air quality of for shorter exposure, 1-2 year. There were other criteria of shot and long-term exposure, the basidium fungi were used as the markers of the short-term trace elements contamination, and the top soil - as the long-term index.

ArcGIS Geostatistical Analyst Extension module is used to perform the following tasks: interpolation of measurements data of pollutants concentrations in mosses and lichens; assessment of the statistical properties of spatial data, such as the variability of spatial data, spatial data dependence and global trends; assessment of impact of environmental (climatic, edaphic, orographic) factors, especially rainfall, topography, wind direction.

The multi-year measurements have been used to model variograms. Surface interpolation is implemented using cokriging (an improved method of surface modeling which is one of ArcGIS Geostatistical Analyst Extension tools).

The simulation results are presented both in the form of static raster map charts and are also published on the Internet using the AgcGIS Server or the freeware package GeoServer. The Geoportal can be created using the free OpenLayers package.