LRTAP
Long-range Transboundary Air Pollution

UK Centre for Ecology & Hydrology

ICP VEGETATION

33rd Task Force Meeting

27 - 30 January 2020

Riga, Latvia

UNIVERSITAS LATVIENSIS
SCIENTIAE ET PATRIAE

University of Latvia

Programme & Abstracts

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

Organisers:

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

Dr. Harry Harmens, Dr. Felicity Hayes
Dr. Katrina Sharps, Dr. Amanda Holder

Local organiser:

University of Latvia

Dr. Guntis Tabors

Local financial support is provided by

University of Latvia

PROGRAMME

Venue: ***Academic Centre, The House of Nature, University of Latvia, Jegavas street 1***

Monday 27th January, 2020

17:00 – Registration and putting up posters in Academic Centre, The House of Nature

18:30 – Welcome reception

Tuesday 28th January, 2020

- ***Plenary sessions in room 106 (Magnum)***
- ***Ozone sessions in room 108 (Dextrum)***
- ***Moss survey sessions in room 106 (Magnum)***
- ***Poster session in foyer***

08:00 **Late registration and putting up posters**

Session 1: **9:00 – 10:45** **Plenary** **Chair: Guntis Tabors**

09:00 Welcome address:

Silvija Nora Kalniņš - Ministry of Environmental Protection and Regional Development of the Republic of Latvia, Deputy Director of the Department of Environmental Protection

Didzis Elferts - Dean Faculty of Biology

09:15 *Harry Harmens et al.* – Achievements of the ICP Vegetation in 2019 and future work plan.

09:40 *Eiliv Steinnes & Marina Frontasyeva* – An overview of the 2015 European moss survey and recommendations for the 2020 survey.

10:00 *David Simpson et al.* – Updated semi-natural vegetation calculations in EMEP MSC-W model.

10:20 *Ilia Ilyin* – Contribution of anthropogenic and secondary emission sources to heavy metal pollution in the EMEP region: Results of the model simulations and moss surveys.

10:40 General 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** **Chair: Viki Bermejo**

11:30 *Håkan Pleijel et al.* – Does ozone sensitivity depend on nitrogen application rate and how is nitrogen efficiency affected by ozone in crops?

11:50 *Felicity Hayes et al.* – Impacts of ozone on growth and yield of tropical (African) crops.

12:10 *Ignacio González Fernández et al.* – Soil moisture modelling effects on dose-based ozone risk assessment under water-limited climatic conditions.

12:30 *Katrina Sharps et al.* – Mapping ozone impacts on crops at a range of scales: focusing on developing regions.

12:50 General discussion

Session 2b: **Moss survey** **Chair: Pranvera Lazo**

11:30 *Guntis Tabors et al.* – Heavy metal concentrations in moss (*Pleurozium schreberi*) and forest soils in Latvia.

11:50 *Zaida Kosonen* – Emissions in Switzerland in relation to the results of the Swiss moss monitoring - a time-series 1990-2015.

12:10 *Marina Frontasyeva* – Moss biomonitoring in Russia: Past, present and future.

12:30 *Claudia Stihi et al.* – Temporal trends of metals pollution in Romania studied by analysis of naturally growing moss samples.

12:50 General discussion

13:00 – 14.00 Lunch

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

Session 3a: **Ozone** **Chair: Ane Vollsnes**

14:00 *Pierre Sicard, Valda Araminiene et al.* – Urban trees - Effective solutions to reduce increasing ozone levels in cities.

14:20 *Valda Araminiene et al.* – Air pollution removal by urban trees in Kaunas, Central Lithuania.

14:40 *Lina Fusaro et al.* – An integrated approach to assess the effects of particulate matter on functional traits of *Quercus ilex* L. in an urban area.

15:00 *Lina Fusaro et al.* – Discussion on chapter on 'Ozone removal by vegetation in urban areas' for Scientific Background Document B.

15:20 Short summary presentations on Chapters for Scientific Background Document B:

Yasutomo Hoshika et al. – Critical levels for ozone-sensitive clones of poplar.

Sabine Braun and Per Erik Karlsson – Improved phenology for ozone flux modelling in trees.

Session 3b: **Moss survey** **Chair: Marina Frontasyeva**

14:00 *Alexander Uzhinskiy* – 1) How to manage your UNECE ICP Vegetation data; 2) UNECE ICP Vegetation data versus satellite image data.

14:30 *Stefano Loppi* – On the way of expressing bioaccumulation data: does the choice of the metric really determine the outcome?

14:50 *Winfried Schröder* – Relevance of site-specific and regional characteristics on element concentrations in moss specimens collected 1990-2015 across Germany.

15:10 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 – Discussion session on updates for Chapter 3 of Modelling and Mapping Manual and new developments - Chapters for Scientific Background Document B** **Chair: Felicity Hayes**

16:00 Discussion on additional parameterisations required for large-scale modelling.

16:20 Short summary presentations and discussions on:

Felicity Hayes et al. – Guidelines for gap filling in data required for ozone flux modelling.

Victoria Bermejo et al. – Guidelines for assessing ozone-induced foliar damage and yield loss of horticultural crops.

Klaudia Borowiak et al. – Ozone-induced injury guidance for educational and awareness raising purposes.

Felicity Hayes et al. – Impacts of ozone on pasture quality.

Lisa Emberson, Harry Harmens et al. – Ozone flux-effect relationships and methodology for net annual increment (NAI) of trees.

Håkan Pleijel, Felicity Hayes et al. – Interactive impacts of ozone and nitrogen on vegetation

Valda Araminiene et al. – Ozone impacts on insects.

Session 4b: **Moss survey** **Chair: Mira Aničić Urošević**

16:00 *Yulia Koroleva et al.* – Trace elements atmospheric deposition study in Kaliningrad region.

16:20 *Omar Chaligava et al.* – Evaluation of air quality based on moss analyses using different analytical techniques: A case study in Georgia.

16:40 *Konstantin Vergel et al.* – Monitoring of atmospheric deposition of inorganic pollutants in Moscow region using terrestrial moss: preliminary results.

17:00 *Nikolajs Filipenoks et al.* – Geoecological assessment of the Great Moss Swamp (Bolshoye Mokhovoye swamp), accumulation of heavy metals in bioindicates (peat and moss), transboundary transfer of heavy metals through precipitation.

17:20 General discussion.

Wednesday 29th January, 2020

Session 5: 08:30 – 10:30 (Two parallel sessions: Ozone and Moss survey)

Session 5a: Ozone **Chair: Katrina Sharps**

08:30 *Stefanie Falk et al.* – Surface ozone concentrations in northern Scandinavia and implications on local vegetation: A case study.

08:50 *Ane Vollsnes et al.* – Responses to experimental ozone exposure in some native plant species from Northern Scandinavia.

09:10 *Valda Araminiene et al.* – Biogenic volatile organic compounds and insect dynamics under ozone pollution.

09:30 *B. Vazquez de Aldana, Victoria Bermejo et al.* – Endophytic fungi as tools to confer tolerance to ozone in wild and cultivated grass species.

09:50 *Melissa Chang-Espino et al*. – Effect of ozone on the isotopic signal of Mediterranean wheat.

10:10 *Andrea Vannini et al.* – Understanding the resistance of lichens (and mosses) to elevated ozone concentrations.

Session 5b: Moss survey **Chair: Stefano Loppi**

08:30 *Winfried Schröder* – Mapping percentile statistics of element concentrations in moss specimens collected 1990-2015 across Germany.

08:50 *Pranvera Lazo et al.* – The effects of anthropogenic factors to sea spray elements studied by moss biomonitoring in inland and coastal areas of Albania.

09:10 *Vladislav Svozilík et al.* – Air pollution mathematical modelling verification using biomonitoring.

09:30 *Mira Aničić Urošević* – How to overcome the lack of mosses in agricultural and urban areas? Moss bag biomonitoring for the ICP Vegetation moss surveys.

09:50 *Dellal Abdelkader et al.* – Chemical composition in heavy metals of PM2.5 aerosols in the city of Tiaret (Algeria).

10:10 General discussion

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

Session 6: **11:00 – 12:45 (Two parallel sessions: Ozone and Moss survey)**

Session 6a: **Empirical nitrogen critical loads + discussions on work plan for ozone**
Chair: Felicity Hayes

11:00 *Christin Loran et al.* – Roadmap for the review and revision of empirical critical loads for nitrogen in Europe.

11:20 *Rocio Alonso, Ignacio González Fernández et al.* – Revision of effects of atmospheric deposition in Spanish ecosystems: suitability for proposing empirical critical loads.

11:40 *Sabine Braun et al*. – Nitrogen effects on forest vitality in Switzerland.

12.00 Discussion on contribution of ICP Vegetation to review and revision of empirical critical loads for nitrogen in Europe and ICP Vegetation as a forum for dissemination of nitrogen experimental work on (semi-)natural vegetation.

12.20 Discussion on ozone work plan items and feedback to plenary.

Session 6b: **Moss survey** **Chair: Zaida Kosonen**

11:00 *Stefano Loppi et al.* – Accumulation of microplastics in lichens from a landfill dumping site.

11:20 *Luca Paoli et al.* – Problems and possible solutions during repeated biomonitoring surveys around point sources of pollution.

11:40 *Stefano Loppi, Stefan Fränzle et al.* – Linking results on chitin-based biomonitoring to each other: ants, lichens vs. grafted chitin - environmental analytics in another manner.

12:00 *Fabrizio Monaci et al.* – Bryophytes and lichens for monitoring atmospheric mercury: recent insights, challenges and opportunities.

12:20 General discussion and feedback to plenary.

12:45 – 13.45 Lunch

Session 7: **13:45 – 15:30 Final plenary session** **Chair: Felicity Hayes**

- Reporting back from ozone and moss survey sessions: decisions and actions
- Medium-term work plan ICP Vegetation 2020 – 2022 and beyond
- Decisions and recommendations of the 33rd Task Force Meeting
- 34th ICP Vegetation Task Force Meeting;
- Other business.

15:30 – 16:00 Coffee/tea and taking down posters

16:00 Walking tour Riga

19:00 Conference Dinner

Thursday 30th January, 2020

Excursion to Bauska Castle and Rundale Palace tour.

LIST OF POSTERS

GENERAL

Author(s)	Title
Nadia, B. et al.	Remote sensing and ground based assessment of distribution of land cover parameters in the catchment area of Wadi el K'sob M'sila (Algeria)

OZONE

Author(s)	Title
Hayes, F. et al.	Ozone flux-effect relationships for tropical crops
Hoshika, Y. et al.	Monitoring ozone injury for seTTing new critical LEvelS: A novel long-term monitoring strategy to produce new critical levels for forest protection against O_3
Melece, I.	Bioindication studies of ground- level ozone in Latvia
Mills, G., Sharps, K., et al.	Ozone pollution compromises efforts to increase crop production
Neirynck, J.	Long-term trends in ozone concentrations, indices and fluxes above a suburban mixed forest.
Yadav, P. et al.	Response of nutraceutical crop *Amaranthus hypochondriacus* cultivars to ozone stress

MOSS SURVEY

Author(s)	Title
Bekteshi, L. et al.	The study of crustal and lithogenic elements in atmospheric deposition of Albania evaluated by moss biomonitoring
Borowiak K. et al.	Differences between accumulation of trace elements in plants collected in Poznan (Poland) and Brno (Czech Republic)
Bukharina I.L. et al	Moss monitoring in the study of the accumulation of trace elements in the Udmurt Republic, Russia
Cakaj A. et al.	Heavy metals accumulation in plants collected from different sites in Pristina, Kosovo.
Ene, A. et al.	Nuclear and related techniques used for the assessment of heavy metals in crops
Ene, A. et al.	Study of the impact of metallurgical industry on metal accumulation in plant tissues and health risk assessment
Gorelova S.V. et al.	The effect of atmospheric deposition on soil pollution
Gretarsdottir, J. et al.	Monitoring of heavy metals and sulphur in moss (*Hylocomium splendens*) in Iceland 1990-2015. Effects from industry and volcanic activity.
Ievinsh, G. et al.	Coastal wetland plant species as models in heavy metal and nitrogen accumulation studies
Ilic, M. et al.	*Hypnum cupressiforme*-notes on ecology and distribution patterns (a case study in Serbia).
Isak, N. et al.	Moss biomonitoring of trace metal deposition in south of Albania.
Kaupe, D	Effects of vegetation variability on the amount of biologically active nitrogen in the soil.
Lisiak M. et al.	Bioaccumulation of heavy metals in plants in relation to land use - a case study
Madadzada A.I. et al.	The moss technique and neutron activation analysis for trace element atmosphetic deposition study in Goygol district, Azerbaijan
Maňkovská, B., Borovská, J.	Spatial and time trends of accumulation of heavy metals and nitrogen in mosses in Slovakia
Omarova N. et al.	Mosses as bioindicators of trace elements in the environment of Central Kazakhstan
Qarri, F. et al.	The study of anthropogenic elements in atmospheric deposition of Albania evaluated by moss biomonitoring
Radulescu, C. et al.	Seasonal variability of particulate matter composition and microclimate in cultural heritage area
Vladislav, S. et al.	Evaluation of air pollution mathematical modelling using by various methods

PLENARY

ACHIEVEMENTS OF THE ICP VEGETATION IN 2019
AND FUTURE WORKPLAN

Harmens, H.(1), Hayes, F.(1), Sharps, K.(1), Holder, A.(1)
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. 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: i) Quantifying the risks to vegetation posed by ozone pollution and collating field-based evidence of ozone impacts; ii) The atmospheric deposition of heavy metals, nitrogen and persistent organic pollutants (POPs) to vegetation. The ICP Vegetation encourages outreach activities to other regions such as Asia, Africa and South America and has established an ICP Vegetation-Asia network.

At the 33rd Task Force Meeting we will report on the achievements in 2019, including:

- Further evidence of ozone impacts on vegetation, including developing regions, and interactions with nitrogen;
- Ozone risk assessments: new developments and potential additions to Scientific Background Document B of the Modelling and Mapping Manual [1];
- Future risk of ozone impacts on crops globally;
- Heavy metals, nitrogen and persistent organic pollutants (POPs): Final report of 2015/2016 moss survey;
- Contributions to workplan items of the WGE and collaboration with the European Monitoring and Evalution Programme (EMEP) and other ICPs;
- Outreach activities beyond the UNECE region.

We will also discuss the future workplan, including:

- Evidence of ozone impacts on crops in developing countries;
- Large-scale risk assessment of ozone impacts in soil moisture limited areas (collaboration with EMEP/MSC-West);
- Contribution to review and potential revision of empirical critical loads for nitrogen (collaboration with Coordination Centre for Effects of ICP Modelling and Mapping);
- Preparations for the 2020 moss survey: call for data.

For further details, see our website http://icpvegetation.ceh.ac.uk

Acknowledgement
We thank the UK Department for Environment, Food and Rural Affairs (Defra, project AQ0846) for funding the ICP Vegetation Programme Coordination Centre. Further financial support was provided by the UNECE.

Reference
[1] https://icpvegetation.ceh.ac.uk/get-involved/manuals/mapping-manual

UPDATED SEMI-NATURAL VEGETATION CALCULATIONS IN THE EMEP MSC-W MODEL

Simpson, D., Emberson, L.D., Gonzalez Fernadez, I.A., Harmens, H., Hayes, F.J.

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Calculations of AOT and POD from the EMEP MSC-W chemical transport model (Simpson et al., 2007, 2012, 2019) have so far focused on forests and crops (e.g. Mills et al., 2018). The EMEP model is currently being updated to harmonise better with the latest Mapping Manual, and as part of this work additional land-cover categories and POD calculations are being introducted for seminatural vegetation. This talk will outline progress, present some preliminary calculations, and discuss some questions associated with these new land-cover calculations. For example, although the mapping manual makes suggestions concerning stomatal conductance parameters, large-scale modelling also requires information on leaf-area indices and phenology that are not defined in the manual.

References

Mills, G., Sharps, K., Simpson, D., et al., Ozone pollution will compromise efforts to increase global wheat production, Global Change Biol., 2018, 24, 3560-3574

Simpson, D., Emberson, L., Ashmore, M. & Tuovinen, J., A comparison of two different approaches for mapping potential ozone damage to vegetation. A model study, Environ. Poll., 2007, 146, 715-725

Simpson, D., Benedictow, A., Berge, H. et al., The EMEP MSC-W chemical transport model - technical description, Atmos. Chem. Physics, 2012, 12, 7825-7865

Simpson, D., Bergström, R., Tsyro, S. & Wind, P. Updates to the EMEP/MSC-W model, 2018--2019 Transboundary particulate matter, photo-oxidants, acidifying and eutrophying components. EMEP Status Report 1/2019, The Norwegian Meteorological Institute, Oslo, Norway, 2019, 145-155

AN OVERVIEW OF THE 2015 EUROPEAN MOSS SURVEY AND RECOMMENDATIONS FOR THE 2020 SURVEY

Steinnes E.[(1)] and Frontasyeva M.[(2)]

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An overview of the moss survey 2015-2016 carried out in the framework of the UNECE ICP Vegetation in 36 countries of Europe and some selected areas in other continents is given. The primary target of the survey is the atmospheric deposition of selected toxic elements over the studied areas and corresponding temporal trends. The geographical distributions in some countries of other air pollutants such as oxidised nitrogen and selected organochlorine compounds are also presented. Strong and weak points of the current program are discussed and some modifications are suggested for the next European moss survey planned for 2020 - 2021.

OZONE SESSIONS

BIOGENIC VOLATILE ORGANIC COMPOUNDS AND INSECT DYNAMICS UNDER OZONE POLLUTION

Araminiene V. (1), Agathokleous E. (2), Sicard P. (3)

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Ground-level ozone is an air pollutant which induces oxidative stress in plants with a negative impact on the nutritional quality of leaves for insects. The relationship between ozone and volatile organic compounds (VOCs) is highly complex because they both have a reciprocal influence. VOCs are very important for plant–insect interactions. Here, we review the current literature on ozone effects on VOCs and subsequent implications to insects. Reactive ozone molecules can modify or degrade VOCs, and this may impair the communication between plants and their pollinators by affecting the olfactory system of pollinators. Despite the knowledge on the effects of atmospheric pollutants on volatile signals, it unknown whether these compounds can directly affect the olfactory system of insects. There is also a lack of studies on how changes in VOCs composition and amounts may affect insect diversity, although there are studies showing that insect communities can be altered, urging for more studies toward this end. The current understandings will be discussed in relation to ecological implications.

DOES OZONE SENSITIVTY DEPEND ON NITROGEN APPLICATION RATE AND HOW IS NITROGEN EFFICIENCY AFFECTED BY OZONE IN CROPS?

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We investigated the interactive effects of tropospheric ozone and nitrogen on crops from two perspectives based on existing literature. In the first step, the focus was the effect of ozone on protein yield, reflecting N fertilizer efficiency, comparing the responses in soybean, wheat and rice. In the second step, we investigated whether the crop sensitivity to ozone depends on N application rate. For this part, the amount of available data was considered sufficient only for wheat.

We extracted data on seed yield, protein concentration and protein yield in soybean, rice and wheat from existing literature. We identified 30, 10, and 32 data sets, for soybean, rice and wheat, respectively, meeting the requirements of the study. Data for each crop were combined in response regressions for seed protein concentration, seed protein yield and seed yield. Although seed yield in rice was less sensitive to ozone than in wheat, there was a statistically significant positive effect on seed protein concentration of the same magnitude in both crops. Soybean, a high-protein crop with symbiotic N fixation, responded differently. Despite the effect on seed yield being similar to that in wheat, there was no indication of any effect of ozone on seed protein concentration in soybean. The negative influence of ozone on seed protein yield was statistically significant for soybean and wheat. This ozone effect was larger for soybean (slope of response function: -0.58% per ppb [O_3]) than for wheat (slope: -0.44% per ppb) and especially compared to rice (slope: -0.08% per ppb). The different response of protein concentration in soybean, likely to be associated with ozone effects on N fixation, has larger implication for global protein production because of the much higher absolute protein concentration in soybean (Figure 1).

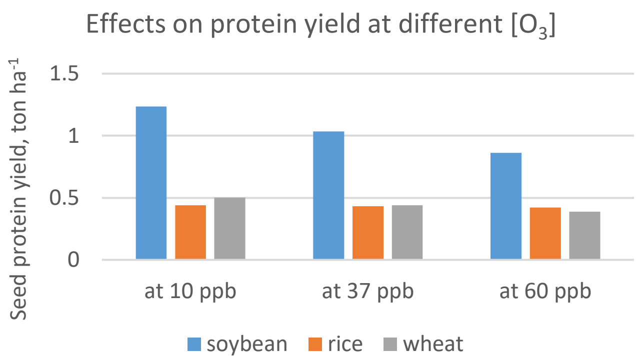

Figure 1. Estimated seed protein yield in soybean, rice and wheat at three different levels of [O_3] based on global average yields of the three crops collected from the data base of FAOstat, protein concentrations observed in and response functions derived from ozone experiments.

For the second part, 89 data points from 29 data sets could be extracted from the literature. These data covered a broad range of N application rates. However, the relationships between the effect of ozone on grain yield, grain protein concentration and grain protein yield were very weak, non-significant and did not indicate that the response to ozone in any of the variables was sensitive to N application rate.

EFFECT OF OZONE ON THE ISOTOPIC SIGNAL OF MEDITERRANEAN WHEAT

Chang, M.[(1)], Elvira S.[(2)], Araus J.L.[(1)], Sanz J.[(2)]., Bermejo-Bermejo V[(2)].

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Several studies have highlighted the negative effects of ozone on wheat development and productivity (early senescence, lower grain and protein yield), caused by physiological effects on the different processes of carbon assimilation (gas exchange, photosynthesis, translocation) which are difficult of measuring and time consuming; thus, only sporadically this physiological parameters can be measured throughout the plant cycle in an experimental design. However, leaf isotopic measures can help integrating the ozone effects on carbon assimilation over the plant lifespan.

This particular study focuses on the effect in which the photosynthesis, productivity and quality parameters of wheat are related to carbon and nitrogen isotopic signatures under chronic ozone exposure. An OTC experiment was designed to analyze the ozone effects of 12 Spanish wheat cultivars considering modern and traditional cultivars. Four ozone treatments were considered. Gas exchange measurements were carried out during anthesis, and yield and quality parameters were taken at maturity. Carbon and nitrogen isotopic compositions samples were measured by EA-IRMS.

Results indicate that both δ15N and δ13C isotopes strongly correlate with the ozone effects on grain quantity and quality, as well as photosynthetic activity. The average grain yield decrease in the modern cultivars under stressed ozone environments, meanwhile traditional cultivars keep and stable production across ozone levels. Grain nitrogen increased in modern cultivars and decreased in traditional ones. Ozone increased the δ13C/δ12C, this negative correlation between stomatal conductance and carbon composition indicates a chronic stress during the growing season associated with ozone exposure, in agreement with the instantaneous gas exchange measures.

Given that δ15N and δ13C are strongly correlated with the main ozone effects, they could be potentially used as indicators of chronic ozone exposure.

Funding provided by AGRISOST-3 (P2018/BAA-4330), OZOCAM (G.Os. IMIDRA, CAM), ERANET-SUSCROP SUSCAP (PCI2019-103521) projects, and the Agreement between MITECO and CIEMAT for Advice on CLRTAP Convention (Exp.nº17-CAES0009).

SURFACE OZONE CONCENTRATIONS IN NORTHERN SCANDINAVIA AND IMPLICATIONS ON LOCAL VEGETATION: A CASE STUDY

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The Arctic biosphere is subject to comprehensive changes induced by climate change. The highly specialized subartic vegetation will be challenged by both, changing environmental conditions as well as further interference through human activity. Permission of exploitation of natural resources in the Artic is likely to increase the levels of air pollutants which are precursors to ozone.

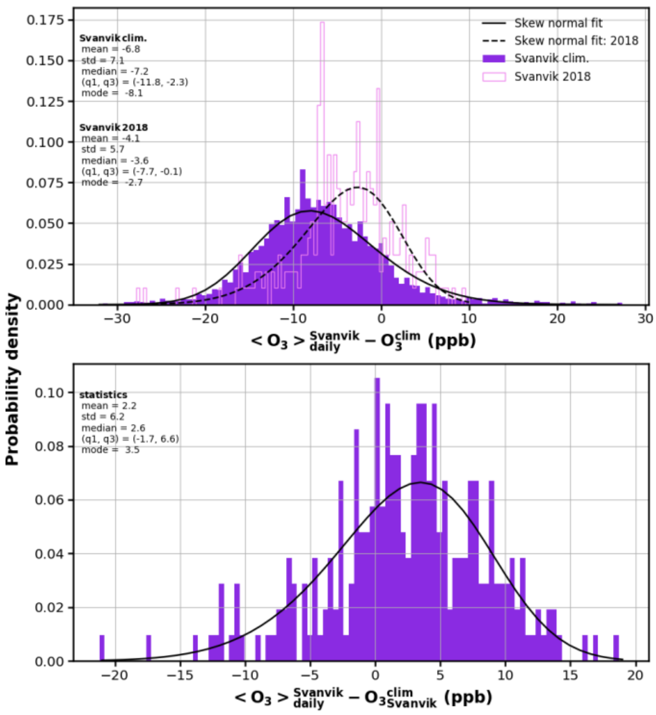

Fig. 1: Ozone anomaly 2019 in Svanvik with respect to climatological means (Svanvik, regional).

In the course of our project (OzoNorClim: The Double Punch), we had an ozone monitor installed at the Norwegian Institute for Bioeconomic Research (NIBIO) Svanhovd Research Station operated by the Norwegian Institute for Air Research (NILU). In 2018, a long-lasting heatwave accompanied by extensive forest fires across Europe and Scandinavia enhanced surface ozone concentrations by about 2 ppt above the climatological mean in Northern Scandinavia. Ozone sensitive glover species in the ozone garden at Svanhovd showed clear signs of ozone damage in 2018 but not in 2019.

We study these two years as example for probable future scenarios in which both heat stress and ozone stress affect vegetation negatively. We look at the corresponding surface ozone concentrations, accumulated ozone dose, and implications on natural and semi-natural vegetation especially in the Pasvik valley in Northern Norway, put these in a larger regional context, and give an outlook on further modelling work.

AN INTEGRATED APPROACH TO ASSESS THE EFFECTS OF PARTICULATE MATTER ON FUNCTIONAL TRAITS OF QUERCUS ILEX L. IN AN URBAN AREA.

Fusaro L.[(1)], Winkler A.[(2)], Salvatori E.[(1)], Macrì P.[(2)], Frezzini MA.[(3)], Canepari S.[(3)], Manes F.[(1)]

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Increasing attention has been given to the ameliorating the role of air quality exerted by Green Infrastructures (GI), which can play a relevant role as Nature Based Solutions for removal.
Green Infrastructures (GI) can play a relevant role in ameliorating air quality in urban areas, adsorbing atmospheric pollutants like particulate matter (PM).
On the other hand, PM can affect the functionality of vegetation and, accordingly, its capacity to provide Ecosystem Services. This work aims to evaluate how the functional traits of *Quercus ilex* L., selected as a target species for its widespread use in the urban green of Mediterranean regions, are affected by PM exposure. Leaves of *Q. ilex* were sampled in eight sites of the metropolitan area of Rome (Italy), selected as different GI elements and characterized by different levels of vehicular traffic, including peri-urban forests as a control site. Physiological traits derived from chlorophyll *a* fluorescence (ChlF) were assessed together with leaf magnetic properties, used to characterize the magnetic fraction, of anthropogenic origin, of the PM accumulated by leaves. Oxidative potential assays were also performed on aqueous extracts of the PM adsorbed together with metals concentration to identify the main anthropogenic emission sources to PM deposition.
ChlF highlighted that photosynthetic functionality decreases with increasing magnetic susceptibility in the sites with a higher level of vehicular traffic, sites where the oxidative potential of PM reached the highest values. Among the considered functional traits, the effective energy dissipation by active reaction centers of Photosystem II, and the photosynthetic Performance Index (PI) could be used as a functional marker of oxidative pressure due to PM. Our results suggest that this integrated approach is a promising tool for monitoring the air quality in urban areas and that PM can impair the functionality of plants in urban areas, affecting the regulating Ecosystem Services provisioning.

SOIL MOISTURE MODELLING EFFECTS ON DOSE-BASED OZONE RISK ASSESSMENT UNDER WATER-LIMITED CLIMATIC CONDITIONS

González-Fernández, I.(1), Marzuoli, R.(2), Calatayud, V.(3), Simpson, D.(4),(5), Alonso, R.(1), Gerosa, G.(2), Carrara, A.(3), Rábago, I.(1)

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(2) Dipartimento Matematica e Fisica, Università Cattolica del Sacro Cuore, Brescia, Italy

(3) Fundación CEAM, Paterna, Valencia, Spain[1]

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Soil moisture is currently one of the dominant drivers of ozone stomatal deposition to rainfed vegetation in many areas across Europe, and future climatic scenarios show that this influence may change in the coming decades. However, modelling the influence of soil moisture on ozone stomatal fluxes is still challenging for applying flux-based ozone risk assessment methodologies at the European scale.

Recent developments of the EMEP MSC-W chemical transport model, which is used within the Convention on Long-Range Transboundary Air Pollution to provide ozone stomatal fluxes to vegetation receptors at the European scale for ozone risk assessment, includes the influence of soil moisture on dry deposition through a soil moisture index (SMI) dataset provided by the European Centre for Medium Range Weather Forecast (ECMWF). But its suitability and parameterization has not been tested under field conditions to date.

A joint ICP-Vegetation – EMEP collaborative exercise is being developed aiming at improving current flux-based ozone risk assessment applications for large scales (IAM), especially at soil moisture limited areas and other regions of Europe under future climate change scenarios. Modelled and site-specific 5-year-long records of SMI have been compared and sensitivity analysis of the SMI parameterization have been performed at six Mediterranean sites for different vegetation types (crops, forest and semi-natural vegetation) from Italy and Spain. Analyses will be presented with a view to testing the SMI index at these sites and discussing the next steps of the exercise.

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IMPACT OF OZONE ON GROWTH AND YIELD OF TROPICAL (AFRICAN) CROPS

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Ozone pollution is a growing problem in Africa, however, effects of ozone on subsistence agriculture crops and those grown on smallholder farms are largely unknown. We exposed varieties of several crops that are commonly grown in tropical regions to ozone in the 'solardomes' air pollution facility in Bangor, UK in 2019. An episodic ozone profile with peak ozone concentrations of approximately 30, 80 and 110 ppb were used and additional heating was applied to the solardomes in order to better represent tropical conditions.

Visible-leaf injury due to ozone was observed throughout the growing season on several crops including maize, bean and squash. Distinctive ozone injury was observed initially for sweet potato, and although the symptoms were only visible after the initial ozone exposure, newly produced leaves from the higher ozone treatments continued to senesce faster than those in the lowest ozone treatment, so that these plants had fewer leaves throughout the duration of the growing period. No ozone-specific leaf-injury symptoms were observed for ginger, but the leaves in the highest ozone treatments were noticeably less 'green' and more 'yellow' than those of the lowest ozone treatments.

Reductions in yield due to ozone were found for several crops including bean, sweet potato and ginger. These crops also showed a decline in both chlorophyll content and stomatal conductance with increasing ozone exposure. Data on the flux-response relationship for bean fitted well with data from experiments in 2017 and 2018. The yield reduction observed for sweet potato based on ozone concentration fitted with existing published data. The DO_3SE model was parameterised for sweet potato, but no additional data from existing experiments was found to run through the DO_3SE model in order to improve the robustness of the flux-response relationship derived from this dataset.

Ozone induced visible leaf injury on squash

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MAPPING OZONE IMPACTS ON CROPS AT A RANGE OF SCALES: FOCUSING ON DEVELOPING REGIONS.

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Global scale mapping has indicated a negative effect of ozone on the yield of several staple crops, including wheat, soybean, maize and rice (Mills *et al.,* 2018). Building on this work, further mapping is being carried out at a range of scales, focusing on ozone impacts in ODA countries, including countries in Sub-Saharan Africa and India. There are few sources of measured data on ozone concentrations in Africa, however model simulations suggest that ozone increased over the last four decades in central Africa. Currently, there is little known about the potential impact of ozone on crops in Sub-Saharan Africa. In India, crop yield losses due to ozone have been estimated (in the range of 5 – 30%), however these results have mostly come from global studies, and/or using concentration based metrics.

To investigate the impact of ozone on wheat, bean and cowpea across Sub-Saharan Africa, ozone flux was calculated using the EMEP-WRF Africa model, which is based on the official EMEP MSC-W model. The EMEP Africa model was parameterised using data from experiments carried out on African crop cultivars in the 'solardomes' air pollution facility in Bangor, UK in 2017-19. The model provided daily ozone flux values (POD_3IAM and POD_6SPEC) for the year 2015 at 0.11 x 0.11 degree grid cell resolution for the whole of SS Africa. For each crop, information on growing seasons per country was taken from the FAO crop calendar and used to calculate accumulated flux per grid cell. Yield loss due to ozone was calculated using flux response relationships from the 2017/18 Bangor experimental data.

For India, the EMEP-WRF Asia model will be used to investigate the impact of ozone on wheat. Model parameterisations (including gmax, and crop growing period) were taken from a literature review of experimental data on Indian wheat (Jamir 2011). The model will provide seasonal ozone flux values (POD_3IAM) for the year 2015 at 0.11 x 0.11 degree grid cell resolution. Indian government data will be used to estimate the effect of ozone on wheat production. While there are a number of areas of uncertainty related to the methodology used, this is the first time that potential ozone impacts on crops have been mapped for Sub-Saharan Africa and India using such fine-scale ozone data.

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URBAN TREES – EFFECTIVE SOLUTIONS TO REDUCE INCREASING OZONE LEVELS IN CITIES

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Outdoor air pollution is considered as the most serious environmental problem for human health, associated with some million deaths worldwide per year. Cities have to cope with the challenges due to poor air quality impacting human health and citizen well-being. According to an analysis in the framework of this study, the annual mean concentrations of tropospheric ozone (O_3) have been increasing by on average 0.16 ppb year^{-1} in cities across the globe over the time period 1995-2014. *Green urban infrastructure* can improve air quality by removing O_3. To efficiently reduce O_3 in cities, it is important to define suitable urban forest management, including proper species selection, with focus on the removal ability of O_3 and other air pollutants, biogenic emission rates, allergenic effects and maintenance requirements. This study reanalyzes the literature to i) quantify O_3 removal by urban vegetation categorized into trees/shrubs and green roofs; ii) rank 95 urban plant species based on the ability to maximize air quality and minimize disservices, and iii) provide novel insights on the management of urban green spaces to maximize urban air quality. Trees showed higher O_3 removal capacity (3.4 g m^{-2} year^{-1} on average) than green roofs (2.9 g m^{-2} year^{-1} as average removal rate), with lower installation and maintenance costs (around 10 times). To overcome present gaps and uncertainties, a novel Species-specific Air Quality Index (S-AQI) of suitability to air quality improvement is proposed for tree/shrub species. We recommend city planners to select species with an S-AQI>8, i.e. with high O_3 removal capacity, O_3-tolerant, resistant to pests and diseases, tolerant to drought and non-allergenic (e.g. *Acer* sp., *Carpinus* sp., *Larix decidua, Prunus* sp.). Green roofs can be used to supplement urban trees in improving air quality in cities. Urban vegetation, as a cost-effective and nature-based approach, aids in meeting clean air standards and should be taken into account by policymakers.

UDERSTANDING THE RESISTANCE OF LICHENS (AND MOSSES) TO ELEVATED OZONE CONCENTRATIONS

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Lichens have been reported as unsuitable indicators of environmental ozone (O_3) pollution since during periods of maximal O_3 concentrations (summer) they face metabolic inactivity and thus limited sensitivity to this oxidizing pollutant (Lorenzini et al., 2003; Nali et al., 2007). However, short fumigations of 1 h at 3 ppm O_3 of the lichen *Xanthoria parietina* highlighted the susceptibility of this pollution-tolerant lichen to high O_3 concentrations (Vannini et al., 2018). The results showed ultrastructural and physiological effects both in the photobiont and in the mycobiont of this lichen, already after few hours from the fumigation, irrespective of the hydration state (dry and wet samples) and of the presence of the main antioxidant compound, parietin (samples whit or without parietin). After one week only dry fumigated samples with parietin showed some recovery, suggesting the importance of this molecule and of the hydration state.

Recent investigations, carried out fumigating the pollution-sensitive lichen *Evernia prunastri* for 1 h at 3 ppm O_3, confirmed the sensitivity of lichens to very high O_3 concentrations even if in this case the investigated lichen showed greater photosynthetic impairments in wet fumigated samples, which however showed some recovery after 1 week from the fumigation.

Although there are conflicting opinions on the mechanism of action of ozone, different lichen species may differ in their sensitivity to O_3 depending on their ecology and physiological properties. In fact, diffusion of O_3 through the lichen cortex to penetrate the thallus is limited when samples are hydrated, but O_3 reactivity should be higher when samples are wet since being O_3 a polar molecule, it has higher affinity for water than for the hydrophobic regions of the thallus.

Mosses, despite their poikilohydric nature and their sensitivity to air pollution, usually have received less attention than lichens as indicators of environmental O_3. For this reason, ozone fumigation of samples of the mosses *Brachythecium* sp. was run to investigate the response to a high ozone exposure (1 h at 3 ppm). The results showed photosynthetic impairment especially for wet fumigated samples, with some recovery after one week. Despite the similar response, *Evernia* and *Brachythecium* however showed a remarkable difference in the antioxidant response immediately after the exposure, which further increase after 1 week of recovery, with moss showing a much higher antioxidant content.

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ENDOPHYTIC FUNGI AS TOOLS TO CONFER TOLERANCE TO OZONE IN WILD AND CULTIVATED GRASS SPECIES

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Tropospheric ozone is a widely recognized pollutant that has detrimental effects on vegetation (Fuhrer *et al*., 1997). Furthermore, many climatic models predict that ozone will increase over the next decades causing negative effects on major staple crops and on food security (Fuhrer, 2009; Sicard *et al*., 2013; Mills *et al*., 2018).

It is a well-recognized fact that plants live in symbiosis with many organisms such as fungi, bacteria and yeast and they play an important role on plant performance (Singh *et al*., 2011). It has been shown that symbiotic endophytic fungi can be beneficial to plants as they are a source of functional secondary metabolites and they can decrease soil and water pollution (Khan *et al*., 2015; Watson *et al*., 2019). Recent studies have shown that endophytic fungi can confer tolerance to several abiotic stresses such as drought, heat and metals (Singh *et al*., 2011; Lata *et al*., 2018).

Although some works have been published regarding the effects of ozone on the growth and development of endophytic fungi (Duckmanton & Widden, 1994; Magan *et al*., 1995), few insights have been done on the effects of those endophytic fungi on ozone tolerance. According to Wang *et al*. (2017), arbuscular mycorrhiza can increase grain yields under O_3 stress. However, the influence of endophytic fungi on plant responses to O_3 stress is completely unknown.

Epichloë is an endophytic fungus that infect several grasses systematically and is present in many Mediterranean pastures. *Festuca rubra* plants infected by *Epichloë* have shown to be tolerant to several biotic and abiotic stresses and to produce many beneficial alkaloids and phenolic compounds (Vázquez de Aldana *et al*., 2015). An OTC-experiment was recently done to test the effects of the endophytic fungus *Epichloë* on the O_3 tolerance of two plant species: *Festuca rubra* and *Tritordeum*, which is an hybrid created by crossing comercial wheat and barley. An overview of the experiment as well as the preliminary obtained results will be presented.

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RESPONSES TO EXPERIMENTAL OZONE EXPOSURE IN SOME NATIVE PLANT SPECIES FROM NORTHERN SCANDINAVIA

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The northernmost parts of Scandinavia are within the subarctic region and constitute the western border of the Eurasian (Sub-)Arctic tundra. The high latitude vegetation has been subjected to pronounced climate changes, including higher summer temperatures and thinner snow cover, increasing the risk of winter frost damages. The length of the growing season has also increased over the three past decades (Park et al., 2016), due to both an earlier start and a later end. On top of these climate effects, vegetation in these areas are subjected to air pollution, including ozone. Although the ozone levels are low and rarely exceed the critical levels for vegetation, visible injuries have been observed in the field in Norway at as high latitudes as 69 °N (Manninen et al., 2009). In the future, ozone precursor emissions from ships in the area may increase as the polar ice sheet melts, facilitating the passage between the Atlantic Ocean and the Pacific Ocean along the northern coast of Russia. We study the current and future interactions between climate, ozone and vegetation in these areas. Thus, we need more knowledge about the native plant species' responses to ozone.

Some of the plant species growing in the subarctic areas in Norway can also be found in other parts of Europe, and some are of the same genus as species found further south. For our experiments we have chosen, from the subarctic flora, three widespread species that could be expected to display visible injuries due to ozone exposure, i.e. *Rubus arcticus*, *Salix phylicifolia* and *Trifolium repens* (Fig. 1). They have been cultivated under controlled conditions and exposed to ozone in laboratory conditions. The plants were exposed to 70 ppb ozone for six hours per day, four days a week for 2.5 to 5 weeks. Responses to ozone from these three experiments will be presented.

Figure 1. Experimental plants. Left: *Rubus arcticus*, center: *Salix phylicifolia*, right: *Trifolium repens*.

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NITROGEN EMPIRICAL CRITICAL LOAD SESSION

REVISION OF EFFECTS OF ATMOSPHERIC N DEPOSITION IN SPANISH ECOSYSTEMS: SUITABILITY FOR PROPOSING EMPIRICAL CRITICAL LOADS

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The Mediterranean basin is one of the biodiversity hotspots for conservation priorities; particularly some of the most valuable areas are located in mountain areas. While conservation plans have been implemented in many protected areas, valuable Mediterranean ecosystems are still threatened by air quality and climate change. Tropospheric ozone (O_3) and atmospheric nitrogen (N) deposition are two of the main air pollutants affecting natural and semi-natural ecosystems of the Mediterranean basin, according to risk assessments based on exceedances of empirical critical loads and levels. While O_3 critical levels and associated parameterizations for O_3 deposition modelling have been extensively developed in the last decades for major vegetation groups, although important vegetation types still lack of sufficient empirical data, empirical N critical loads are still lacking for important ecosystems in the Mediterranean area (Bobbink and Hettelingh, 2011, CCE). Moreover, atmospheric N deposition in Spain still presents an increasing trend compared to the decreases detected in other European areas.

Preliminary studies show that empirical N critical loads in Natura 2000 sites in Spain are exceeded in rich and valuable mountain habitats (García-Gómez et al. 2014 Sci.Tot.Env., 485-486). However, these assessments are limited by (i) scarce regular air quality monitoring and N deposition levels in natural and semi-natural protected areas; (ii) methodological challenges to monitor and/or model dry N deposition; and (iii) scarcity of empirical information about the sensitivity of Mediterranean ecosystems to atmospheric N deposition.

In the framework of the revision of empirical N critical loads, a review of evidences of N effects and experimental studies on the sensitivity of Mediterranean ecosystems from Spain is being conducted. A summary of recent advances with this review will be presented.

Consideration of the establishment of a permanent group within the ICP-Vegetation to present and discuss advances in experimental studies of N effects on natural and semi-natural vegetation should be proposed and publicized at the WGE level.

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MOSS SURVEY SESSIONS

HOW TO OVERCOME THE LACK OF MOSSES IN AGRICULTURAL AND URBAN AREAS? MOSS BAG BIOMONITORING FOR THE ICP VEGETATION MOSS SURVEYS

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Moss biomonitors are a ubiquitous organism, present in all ecosystems, except marine ones. Specific morpho-physiological adaptations of mosses recommend them for the application in biomonitoring of air pollution. They are particularly suitable for long-term biomonitoring across large areas, and, thus, applied in the European(-Asian) international Moss survey program. However, in anthropocene, mosses have vanished from some ecosystems, such as urban with predominantly paved and landscaped surfaces, and agricultural where dominate tillage and melioration. These areas make approximately one-quarter of the terrestrial surface, belongs to highly contaminated areas. Moreover, in some countries, the agricultural areas can be predominant scenery in some countries. The moss bag technique can be a valuable alternative for the biomonitoring of air pollution in the absence of naturally growing mosses in agricultural and urban areas. The technique has been developed and well-defined for the urban conditions while in agricultural areas just a few studies were performed (Aničić Urošević and Milićević, 2019; Milićević et al., 2017; Capozzi et al., 2016a). The results of these studies suggest that the moss bag technique can be successfully used for air pollution assessment in both areas. Agricultural areas represent diffuse pollution sources with more spatial homogeneity of air pollution than in urban areas. Still, in the agricultural areas, there are temporal fluctuations of air pollution, which coincide with the agrochemical treatments. Thus, in an agricultural area, the minimum recommended period of the moss bag exposure − six weeks (Capozzi et al., 2016b), does not guarantee a measurable moss load with pollutants if the exposure period of the bags does not involve the time of agrochemical applications (Milićević et al., 2017). To conclude, the goal of a survey implies a definition of the moss bag exposure time in a particular ambient.

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EVALUATION OF AIR QUALITY BASED ON MOSS ANALYSES USING DIFFERENT ANALYTICAL TECHNIQUES: A CASE STUDY IN GEORGIA

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The present work was conducted to give the first comprehensive baseline data on the air quality based on the moss biomonitoring technique in Georgia for the period from 2014 to 2017. A total of 41 elements were determined in 120 samples collected for three different species of moss (*Hylocomium splendens, Hypnum cupressiforme,* and *Pleurozium schreberi*). The moss samples were analyzed by two complementary techniques: instrumental neutron activation analysis (INAA) and atomic absorption spectrometer (AAS). The obtained results were compared with those published in the literature and normalized relative to the corresponding values of the Reference plant (Markert et al., 1998). Univariate and multivariate statistical analyses were implemented. The obtained elements are in a good matching with the corresponding ones in the Reference plant except Al, Sc, Ti, V, Cr, Fe, As, Se, Zr, Ta, Th, and U, which are slightly above the corresponding values in the Reference plant. It was observed that the moss *Hypnum cupressiforme,* in general, accumulated higher concentrations of elements in comparing to the other species. However, the mean values of the three species in each sampling do not show significant differences. The statistical analysis demonstrates that the samples were slightly influenced by soil weathering. The enrichment factor of the elements of the species for the study period was less than unity, which suggests that there are no anthropogenic impacts. The ecological risk index of selected potentially toxic elements (Cr, Ni, Cu, Zn, As, Pb, and Cd) is considerably high for these elements in *Hypnum cupressiforme* and *Pleurozium schreberi*. Pollution load index (PLI) was calculated and mapped using GIS technology. PLI reveals some localized contaminated areas as machine-building factory in Kutaisi, Zestaponi Ferroalloy Plant, production of inert and construction materials near Telavi, old mining of arsenic in Uravi and Tsana, coal mining in Tkibuli, Chiatura mine complex, and Sakdrisi gold mine. The obtained data might be used as a baseline data for the air pollution deposition and follow up any possible dynamics of the air quality in Georgia.

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GEOECOLOGICAL ASSESSMENT OF THE GREAT MOSS SWAMP (BOLSHOYE MOKHOVOYE SWAMP), ACCUMULATION OF HEAVY METALS IN BIOINDICATES (PEAT AND MOSS), TRANSBOUNDARY TRANSFER OF HEAVY METALS THROUGH PRECIPITATION

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The paper describes the characteristics of accumulation of trace elements - manganese (Mn), nickel (Ni), zinc (Zn), bromine (Br), strontium (Sr), rubidium (Rb), iron (Fe) and calcium (Ca) in mosses and peat in the Bolshoye Mokhovoye swamp. The method employed to determine elemental composition of mosses and peat is X-ray fluorescence spectrometry. To explain the variations in the experimental data, the primary results were processed using descriptive statistics, correlation analysis and principal component analysis. The correlation and principal component analysis revealed three (in mosses) and four (in peat) factors. This may be owing to the effects of atmospheric deposition, water migration of chemical elements and leaching from plant residues.

MOSS BIOMONITORING IN RUSSIA: PAST, PRESENT AND FUTURE

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The use of mosses as biomonitors of atmosphertic deposition of heavy metals and radionuclides in Russia started more than 40 years ago in connection with the development and problems of the nuclear and military-industrial complexes in Siberia and the Urals. In the 1990s, within the framework of UNECE ICP Vegetation programme, systematic studies using moss were carried on in north-western Russia (Karelia, Kola Peninsula, Kaliningrad, Pskov and Leningrad regions), and the results were presented in the European Atlas Atmospheric Heavy Metal Deposition in Europe – Estimations Based on Moss Analysis. In 1998–2002, JINR participated in the IAEA-coordinated research project "Biomonitoring of air pollution in the Chelyabinsk region (South Ural Mountains, Russia) through trace elements" in one of the most contaminated areas of the world experiencing strong ecological stress from heavy metals and radionuclides. A combination of instrumental ENAA at the IBR-2 reactor at JINR, Dubna, and AAS at counterpart laboratories provides data on concentrations of about 40 chemical elements (**Al, As,** Au, Ba, Br, Ca, **Cd,** Ce, Cl, Co, **Cr,** Cs, **Cu**, Dy, Eu, **Fe,** Hf, **Hg**, I, In, La, Lu, Mg, Mn, Na, Nd, **Ni, Pb,** Rb, **Sb,** S, Sc, Se, Sm, Ta, Tb, Ti, Th, **V,** W, Yb, **Zn**), which substantially exceeds the number of elements requested by the European Atlas (given in bold). Distribution of the determined elements over the sampled areas is illustrated by the contour maps produced by the Russian software package GIS-INTEGRO with raster and vector graphics. Starting from 1995, JINR takes part in the European moss surveys reporting data on some areas of Central Russia (Moscow, Tula, Yaroslavl, Ivanovo, Kostroma, Leningrad and Tver regions), as well as on the Republic of Udmurtia, Yekaterinburg (The Urals), Crimea and Yamal peninsulas). It was shown that moss as natural planchette can be used for tracing deposition of cosmic dust in peat bog cores in Western Siberia and some mountainous areas of Russia. The moss technique was successfully used for assessing sequences of the Fukushima disaster in the Far East of Russia (Kamchatka). Besides passive (terrestrial) moss biomonitoring, the active moss biomonitoring (moss-bag technique) was used to study air pollution in street canyons of the intensely growing megalopolis of Moscow. The perspectives of applying moss techniques in the coming moss survey 2020/2021 are described.

CHEMICAL COMPOSITION IN HEAVY METALS OF PM2.5 AEROSOLS IN THE CITY OF TIARET (ALGERIA)

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In the atmosphere, aerosols are one of the main routes of pollutant transfer. Particles with a characteristic size of less than a few microns make up the majority of the atmospheric aerosol and are therefore the most likely long-distance transfer route.

In Algeria, the problems of air pollution accumulated over the past decades are just like those big cities whose industrial development, automobile traffic and household waste suffocate their environment.

The objective of this work is to evaluate the current state of air pollution by PM2.5 aerosols in educational establishments of the city of Tiaret "Algeria". To achieve this expected goal we chose 23 primary schools as sampling sites. PM2.5 collection was conducted in the presence and absence of students in winter and summer periods. The aerosol mass concentrations were quantified by using a two-stage Dekati® PM10 impactor. It was also determined the dispersion of these particles by detailed mapping.

The determination of concentrations of some metals has been made by ICP-MS, this method is generally recommended for PM10 and PM2.5 heavy metals analyzes.

The results found showed a concentration gradient of PM2.5 and its composition by site typology; The heavy metal content in PM2.5 particles was determined by ICP-MS. The maximum concentrations of Si, Pb, Zn, Cu, Al and Ni are observed in areas with heavy traffic in winter, in the south-east of the city, which are respectively 21.53 ± 7.87ng / m3, 63.26 ± 32.25 ng / m3 × 10-4, 54.32 ± 468 ng / m3 × 10-3, 3.61 ± 0.21 ng / m3 × 10-2, 24.87 ± 9.98 ng / m3 and 3.48 ± 1.11 ng / m3 × 10-5. Whose main sources are car traffic. low and medium concentrations are recorded in areas close to forests, on the other hand, slightly low values are recorded in summer. We also find that the dominance of heavy metals has been observed in the vicinity of major traffic arteries.

The maps present information from the results obtained by the automatic classification and pollution classes, they aim to meet a need for spatialized knowledge of the problem of particulate pollution in urban areas in the city of Tiaret.

Keywords: *Air Pollution, PM 2.5 Aerosols, Heavy metals, Road traffic, Schools, Algeria.*

TRACE ELEMENTS ATMOSPHERIC DEPOSITION STUDY IN KALININGRAD REGION

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The biomonitoring technique was applied to air pollution studies in the West region of Russia (Kaliningrad region). Samples of the terrestrial moss *Pleurozium schreberi* have been collected every 5 years, from 2000 in accordance with the sampling strategy of the European moss survey program. Moss samples have been collected on regular network of 10x10 km during the August – September in 2000, 2005, 2010, 2015. From 2000 – 2010 only eight metals were determined (Pb, Cd, Cr, Ni, Cu, Fe, Mn, Ag) by AAS technique. In 2015 year 33 elements were investigated by epithermal neutron activation analysis (ENAA) at the IBR-2 pulsed fast reactor FLNP JINR Dubna, Russia [1].

Statistical processing of data included the calculation of these descriptive statistics: mean content, standard deviation, minimum and maximum content, median, variance, and coefficient of variation. The Pearson and Kolmogorov criterions were applied to test the hypothesis of normal distribution of the elements in the sample. For normal distribution, the Pearson correlation coefficients were used to characterize the ratio of two chemical elements. Different pollution sources were identified and characterized with the help of multivariate statistics (factor analysis). Principal component analysis was used. QGIS and ArcGiS software package was applied for spatial distribution mapping and factor load maps. There were three factors: airborn transport, soil dust, leaching from leaf litter. Airborne transport with deposition plays a dominant role, which led us to prefer visualizing the surface distribution in mosses using a continuous (interpolated) spatial distribution rather than individual data points.

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EMISSIONS IN SWITZERLAND IN RELATION TO THE RESULTS OF THE SWISS MOSS MONITORING – A TIME SERIES 1990-2015

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Switzerland has been participating in the moss monitoring program of the ICP vegetation since 1990 and has collected samples every five years up to 2015. The sample sites have been distributed as equally as possible over the entire country to account for the different geographical regions. Whenever possible, identical sampling sites were kept in the survey from period to period and so far, 73 sites were consequently sampled.

As part of the Convention on Long-Range Transboundary Air Pollution, Switzerland reports on its yearly emissions to the UNECE. The report includes different pollutants (e.g. heavy metals, VOC, POPs and ammonia) and for many of them the data provided starts already in 1980.

As mosses are used to estimate the deposition of pollutants, it is worth comparing these immission data with the reported emissions to investigate if changes in emissions are also reflected in the deposition data. For Switzerland a comparison of the reported emissions with the results of the moos monitoring survey show that overall emission and deposition follow the same pattern (Figure 1).

The changes in emissions are reflected directly in the data gained with the moss monitoring survey. These observations confirm that mosses are suitable bioindicators and, that the moss monitoring provides a valuable tool for long term monitoring of the deposition of pollutants.

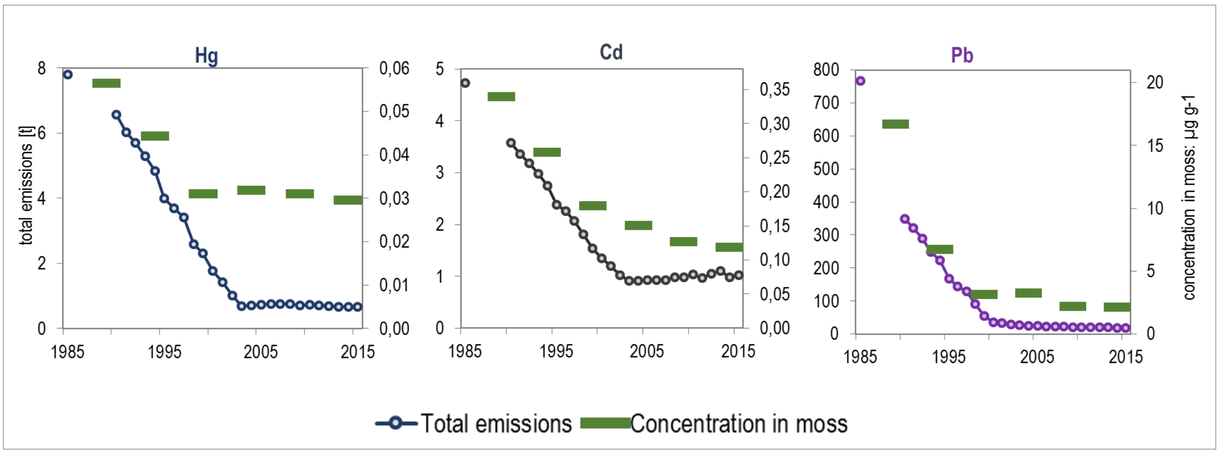

Figure 1: Comparison of the deposition data based on the moss monitoring survey (green bars) and the reported emissions for Switzerland (dashed line) for the elements mercury (Hg), cadmium (Cd) and lead (Pb). Emission data are from Switzerland’s Informative Inventory Report 2017, FOEN.

THE EFFECTS OF ANTHROPOGENIC FACTORS TO SEA SPRAY ELEMENTS STUDIED BY MOSS BIOMONITORING IN INLAND AND COASTAL AREAS OF ALBANIA.

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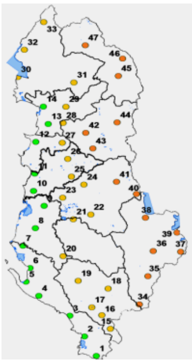
Since 2010, Albania had contributed to the data onto the European Moss Survey (EMS), which is repeated at five-yearly intervals. This study was conducted under the framework of ICP Vegetation Programme in order to provide an assessment of air quality throughout Albania. Albania is exposed to high levels of trace metals particularly for elements linked with geological factors, mining operations, and mineral mine waste damps. The country has been appointed as a "*hotspot of heavy metal contamination in Europe*" (Lazo et al., 2018; Harmens et al., 2015). The effects of anthropogenic elements onto sea spray emitted elements are discussed in this presentation. The data collected from 2010 moss survey, ICP-AES and INAA are presented. Moss samples (Hypnum cupressiforme) were collected during autumn 2010 and July 2011from 47 sites, distributed over the entire country. Sampling was performed in accordance with the LRTAP Convention–ICP Vegetation protocol (Frontasyeva and Harmens, 2015) and sampling strategy of the European Programme on Biomonitoring of Heavy Metal Atmospheric Deposition. The data of 3 different transects positioned in three different parallel lines positioned in different distances from the coastal areas, i.e. 2-8 km (the 1st Line), about 50 km (the 2nd Line), and approximately 120 km, the 3rd Line are investigated.

Sampling map of Albania



The presence, the behavior and the relations between the most important marine tracer elements, Cl and Na, in moss samples may indicate the effects of the sea spray and seawater of Adriatic and Ionian coastal areas positioned in the western part of Albania. Beside the important contributions of sea sprays and seawater for Na^+ and Cl^- in coastal regions, the natural sources of Na^+ and Cl^- that include the atmospheric deposition, interactions between water and soil, rocks, brines and salt deposits showed a strong affect derived by different local factors such as anthropogenic sources and geogenic factors which could contribute to the increase of Na content in moss samples. The molar Na/Cl ratio in precipitation is a typical sea salt parameter with a value of 0.857and it was proved to be useful in sites far from the sea. On the other hand, the heterogeneous reactions with acidic gaseous and other reactive species in the marine environment, may contribute to the decline of Cl content in moss samples, and/or in geographical positions of sampling sites.

The differentiations founded at the distributions of the sea spray elements (Na, Cl, K, Br, I, Mg, and P) in moss samples indicate the effects of geographical position of the moss sampling sites, and the local natural and anthropogenic contributions of these elements. On the other hand, the decreased contribution of sea-salt aerosols as the distance from coastal line is increased and as an increasing contribution of tropospheric aerosol, and/or the effect of weather condition on wet or dry deposition was reflected on the distributions patterns of the elements in moss samples.

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ACCUMULATION OF MICROPLASTICS IN LICHENS FROM A LANDFILL DUMPING SITE

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The term microplastic is fairly new, dating back only to 2004. It refers to small pieces of carbon and hydrogen atoms bound together in polymer chains, less than 5 mm in length, that occur in the environment as a consequence of plastic pollution. Microplastics are divided into two types: primary and secondary: the former the environment directly, like microfibers, the latter from the breakdown of larger plastics (fragments). Although the marine and freshwater environments have widely been investigated for microplastic pollution, it is now clear that the atmosphere is also largely polluted by microplastics, even at remote sites.
Similar to monitoring other important persistent air pollutants, such as trace metals, living organisms may be very useful for investigating the atmospheric deposition of microplastics, but so far studies on this topic are very scanty. Only one study to-date has evaluated the use of bryophytes (*Hylocomium splendens*) as a biomonitor for airborne microfibers (Roblin and Aherne, 2020).
In this study we have investigated the accumulation of microplastics in lichens from a landfill dumping site for the disposal of industrial waste in central Italy. Lichen (*Flavoparmelia caperata*) samples were collected according to three concentric sampling zones at increasing distance from the landfill: (1) close, sites directly facing the landfill; (2) intermediate, sites located at about 200 m from the landfill; (3), remote, sites located at about 1500 m from the landfill.
Lichen samples were digested using a wet peroxide oxidation method, the digestate was vacuum filtered onto glass-fibre filter papers and analysed for the presence of microplastics using a stereomicroscope and following a five criteria visual identification method.
The results showed a much greater number of microfragments and microfibers and hence total microplastics per gram of dry lichen at sites close to the landfill, while numbers were comparably low at the intermediate and remote sites. These results were consistent with those of other lichen studies (Paoli et al., 2015) showing a significant change in the epiphytic biodiversity, in the bioaccumulation of trace elements (As, Cd, Cr, Cu, Fe, Ni, Pb, Zn), and in physiological stress parameters (membrane lipid peroxidation, ergosterol content, dehydrogenase activity, photosynthetic efficiency, chlorophyll integrity, production of secondary metabolites), with the worst situation around the landfill.
It can be concluded that in addition to the classical biomonitoring outputs, lichens can be profitably used also to monitor the deposition of microplastics and are valid bioindicators of environmental quality around landfills.

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ON THE WAY OF EXPRESSING BIOACCUMULATION DATA: DOES THE CHOICE OF THE METRIC REALLY DETERMINE THE OUTCOME?

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The evaluation of pollution by trace metals is usually expressed in terms of deviations from reference ("normal") concentrations, which are (rarely) established by law or (more often) referred to generic background values. These deviations may be either expressed in terms of difference or ratio with such reference values. If the bioaccumulation occurs mostly as simple particle deposition, the former may be appropriate, but this poses the question if biomonitoring has to be preferred over passive samplers. Living organisms tend to reach an equilibrium with their surrounding environment, which in terms of trace metals is determined by their ionic uptake, which in turn, besides element characteristics, is determined by a wide array of factors, including cell wall cation exchange properties, intracellular translocation, environmental concentration, element competition. In the case of ionic exchange (wet deposition), the ratio to reference or starting concentrations may be appropriate. The latter allows also for interspecific and temporal comparisons.

However, irrespective of the way of expressing bioaccumulation data, the sensitivity of a given biomonitor to environmental changes is given by its reference conditions, i.e. by its element background concentration: the higher the background ("noise"), the lower the sensitivity (i.e. the ability to detect a "signal"). Thus, setting accurate background values is mandatory for any biomonitoring study. It will be shown that in the framework of the interpretation of bioaccumulation data, the choice of the metric is less important than the correct definition of background values.

LINKING RESULTS ON CHITIN-BASED BIOMONITORINGTO EACH OTHER: ANTS, LICHENS VS. GRAFTED CHITIN – ENVIRONMENTAL ANALYTICS IN ANOTHER MANNER

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Chitin does strongly bind metal ions from aq. or organic media down to the ≤ 1 nM/l level and thus was previously (Muzzarelli et al. 1972, Pinto et al. 2011) employed for retaining the broad range of fissiogenic radionuclides and actinoids except of Cs or for wastewater purification purposes. We (Fränzle 2016, Fränzle et al. 2019, Bauer 2014) applied this property to withhold both environmental analytes or photocatalysts (Blind 2018, Fränzle et al. 2019) to living creatures and isolated chitin. Studying the chitin-metal ion interaction in the open environment not only gives an opportunity to use that material – grafted on an inert support (e.g., glass) rather than applying living animals, lichens, or fungi – for intercepting and quantifying amounts of analytes from the immediate surrounding (chitin-modified surfaces can be placed in either water, sediment, wood cracks or directly on minerals) but additionally affords pieces of information on element transport processes across the boundary layer. The latter processes which release or bind trace metals may occur several tens of cm apart from a water-sediment interface (bottom of a pond or river, shore, circumference of an island). Possible causes include all biochemical activities (vertical drift of Ni in bog pools then "reporting" on methanogenesis, of Mo on nitrate reduction or N_2 fixation), precipitation, airborne or water-connected pollution/deposition, eventually even photochemical release of REE europium from solid phases. If, conversely, some hardly soluble phase in the ground (alkaline earth sulfates, MnO_2) is dissolved by reduction, metal ions are driven from sediment into water, thereby passing chitin flakes located on either side of the phase transition. Either way round, non-equilibrium and drift of metal ions can be observed, with increased readings and (chitin;sedim. vs. chitin/water) partition coefficients in the former case (underground or in-body take-up and lower values in sediment release of metals by reduction of themselves or of S (it is more straightforward to analyze partition data than understanding absolute concentrations seen on the chitin flakes, besides of the information contained in this partition, using a calibration line-set produced by biochemically innocuous di- and trivalent ions).

Because Dy does not bind to chitin, it will not then either be found in chitin covers of ants, while other REEs are present. When Dy is yet found in a total analysis of some animal (e.g., an ant or spider) that means this element was absorbed by feeding. This could be corroborated by a multi-step procedure of dissolution and analysis, first removing the waxy cuticle, then the uppermost chitin layer by appropriate solvents and analyzing the metal contents after each step before taking the rest of the ant and analyzing it by total digestion. Elements which do bind to chitin, like Cd, can be assigned to either pathway of uptake in this manner for organisms also; corresponding studies on aquatic arthropods are underway.

Thus element transport thermodynamics in ecosystems and at their borders (the same holds for a forest edge towards grassland because woody plants, scrubs and graminees, lichens on rocks do deliver different ligands into the soil, producing different adsorption behavior towards chitin) can be studied. Current work deals with the question whether data from grafted chitin (obtained from peeling Arctic swimming shrimp *Pandalus borealis*) can be replaced or supplemented with those from local lichens which also are covered by chitin. Accordingly, most of their thalli do also dissolve in dimethyl formamide/Li^+ such that sorbates can be analyzed without digestion following the established procedure.

Yet lichens are distinguished by: a) very high levels of oxalate ligands attacking bedrock and mobilizing metal ions by complexation to bind to chitin (solid Ni oxalate and several oxalate complexes of REEs were already shown to adsorb to grafted chitin); and b) display a pronounced response to chemical stress, namely release of ethylene and other hydrocarbons (Garty 1989) which is insensitive to agents which would block the common C_2H_4 formation from aminocyclopropane-1-carboxylate in flowering plants, like Pb. Obviously some component of a lichen – alga/cyanobacterium or fungus – behaves differently, taking another biochemical pathway for C_2H_4 formation which may or may not exert an effect on chitin binding of the said metal ions (from "inside"). Anyway, the said stress response implies HMs to penetrate through the chitin shroud and get into the lichen´s symbiotic metabolism (some, e.g. Fe, can reach very high levels); hence the situation with respect to transport through a water- or mineral/sediment- or organic interface is comparable to that previously studied at ecotones (Fränzle et al. 2019), with a certain chance to produce diffusion fronts in the chitin layer after one-time exposure (Gebauer 2017). Except for very high SO_2 levels, lichens are superior to arthropods in enduring very extreme weather and climate conditions (also live in Antarctica, f.e.); however, at real disaster sites grafted chitin should be placed on drones or rovers sent to sampling sites by remote control.

BRYOPHYTES AND LICHENS FOR MONITORING ATMOSPHERIC MERCURY: RECENT INSIGHTS, CHALLENGES AND OPPORTUNITIES

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Atmospheric pollution by mercury (Hg) is a global concern since this metal is ubiquitous and highly toxic. Addressing this pollution problem requires emission reductions and monitoring, as it has recently been stipulated by the Minamata Convention. Presently, the reliable estimation of emissions from contaminated sites and quantification of atmospheric Hg is very challenging and impaired by large uncertainties, mainly because of instrumental constraints. Mosses and lichens are known to accumulate Hg and since pioneering works carried out in the 1970s and 1980s, they have been used as a proxy for atmospheric concentrations to obtain information about the dispersal of Hg in proximity of emission sources. In the last decade, Hg biomonitoring by mosses and lichens has greatly increased worldwide, using either native or transplanted samples, to trace and often to map Hg contamination, as well as to quantify atmospheric Hg deposition even at remote sites. Although a direct correlation with atmospheric Hg levels has been experimentally demonstrated for lichens [1], the major cause of inconclusive results of studies aiming at converting Hg concentrations in the biomonitors into estimates of atmospheric Hg values remains the lack of reliable, long-lasting, spatially-resolved data concerning atmospheric Hg concentrations.
Recently, a new passive monitoring sampler (PAS) [2] has being developed and made available, disclosing unprecedented possibilities for gaseous Hg monitoring and for supporting biomonitoring studies. Being very effective, discriminating even very small concentration differences on the order of 0.2 ng/m^3, the PAS was successfully used in early applications for detailed characterization of spatial and temporal variability of Hg concentration in different environments, including the former Abbadia San Salvatore Hg Mine (ASSM; Central Italy) [2]. Notwithstanding the cessation of mining operations and recent remediation works, the ASSM remains a notable point source of Hg and represents an invaluable open-air lab for establishing quantitative relationships between the atmosphere and biomonitors. At ASSM, we are currently deploying side by side transplanted lichen and moss samples along with the new PAS within a wide array of environmental conditions, from background up to very high concentrations. Here we present preliminary data of the ongoing research and discuss the perspective offered by the integrated PAS-biomonitor approach for improving the current knowledge of the processes controlling Hg cycling in terrestrial ecosystem, as well as for supporting the management of contaminated areas.

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PROBLEMS AND POSSIBLE SOLUTIONS DURING REPEATED BIOMONITORING SURVEYS AROUND POINT SOURCES OF POLLUTION

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Lichens and mosses are of primary importance as biomonitors of atmospheric pollution and are often included in long-term monitoring programmes of environmental quality, especially around point sources. The interactions of lichens with heavy metals are complex: the uptake and release of trace elements from a lichen thallus are reversible processes and can be influenced by concentration and type of pollutants in the environment, duration of the exposure, microclimatic conditions and thallus characteristics, such as morphology, age, physiological status, interactions between heavy metals on the thallus. The use of native lichens as bioaccumulators during repeated surveys carried out in the same sampling points may pose further problems, namely: exploitment of local populations (which can be scarse in polluted sites); low quality of the native material seletcted for the analysis (bias of the results); failure to apply a desired sampling design. The use of transplants may overtake some criticisms: e.g., the selected lichen material has known pre-exposure concentrations and similar physiological conditions, the duration of the exposure is known, an appropriate sampling design can be applied in the field, higher amounts of material are available for the analysis, etc.
In a series of long term transplants of the lichen *Flavoparmelia caperata* from an unpolluted remote area and exposed to different intensities of pollution around a landfill in Central Italy, the content of several elements of toxicological concern (As, Cd, Cr, Cu, Fe, Pb, Zn) has been investigated in both transplanted and autochthonous samples. The results after 12 months pointed out a relevant accumulation of heavy metals, so that transplanted thalli gained up to 80% of the level of heavy metals respect to native lichens and 24 months were safe to reach, by means of transplanted thalli, the concentrations of native lichens. This is particularly helpful in long-term monitoring programmes, to extend the advantages of the transplants to biomonitoring studies with native samples. Furthermore, data interpretation could benefit of naturality/alteration scales available for native lichens.

MAPPING PERCENTILE STATISTICS OF ELEMENT CONCENTRATIONS IN MOSS SPECIMENS COLLECTED 1990-2015 ACROSS GERMANY

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This paper presents air quality data in terms of heavy metals and nitrogen concentrations in moss specimens collected across Germany. The calculation of quantiles of the distribution of measured values enables their statistically meaningful scaling as well as their measurement campaigns integrating and specific mapping, the mapping of spatial differences even with strongly decreasing element contents as well as the mapping of the spatial structures of a Multi Metal Index covering all chemical elements.

Background. Monitoring and mapping of atmospheric deposition can be achieved by use of chemical transport models, technical sampling devices and bio-accumulators such as moss. Within the European moss survey programme, since 1990 every five years moss have been sampled at up to about 7312 sites in up to 34 countries, among them Germany. Sampling, chemical determination of heavy metals (since 1990), nitrogen (since 2005), and persistent organic pollutants (POPs since 2010) in moss specimens, quality control and statistical evaluation were conducted according to an harmonized methodology. Mapping the percentile statistics of heavy metals and nitrogen concentration in moss sampled in forests across Germany is the focus of this paper.

Methodology. To this end, element- and survey-specific as well as heavy metals and surveys integrating statistical evaluations and GIS-mapping were performed based on data collected in five (1990-2005, 2015) of the six (additionally 2010) European Moss Surveys in which Germany participated. The number of moss sampling sites ranged between 4499 and 7312 in 20 to 34 European countries. In Germany, mosses were sampled at 592 (1990), 1026 (1995), 1028 (2000), 726 (2005) and 400 (2015), respectively, sites. The reduction of monitoring sites since 2005 was conducted using a statistical methodology ensuring the validity of monitoring results.

Results. The results encompass a) maps on element- and survey-specific quantiles (ten percentile classes: 0-10, > 10-20, , …, > 90-90) depicting the spatial structure of the ten percentile classes for each element and monitoring campaign and changes in the geographical position of relative hot spots of element concentrations (Figure 1 top); b) maps on element-specific and surveys integrating ten percentile classes (Figure 1 bottom) depicting the spatial structure of up to ten percentile classes for each element integrating survey data of all monitoring campaigns, where the number of percentiles depends from the decrease or increase of element concentration across time; c) maps on the spatial structure of a Multi Metal Index integrating several heavy metals by transforming their measurement values into 1 to 10 scores according to the percentile classes.

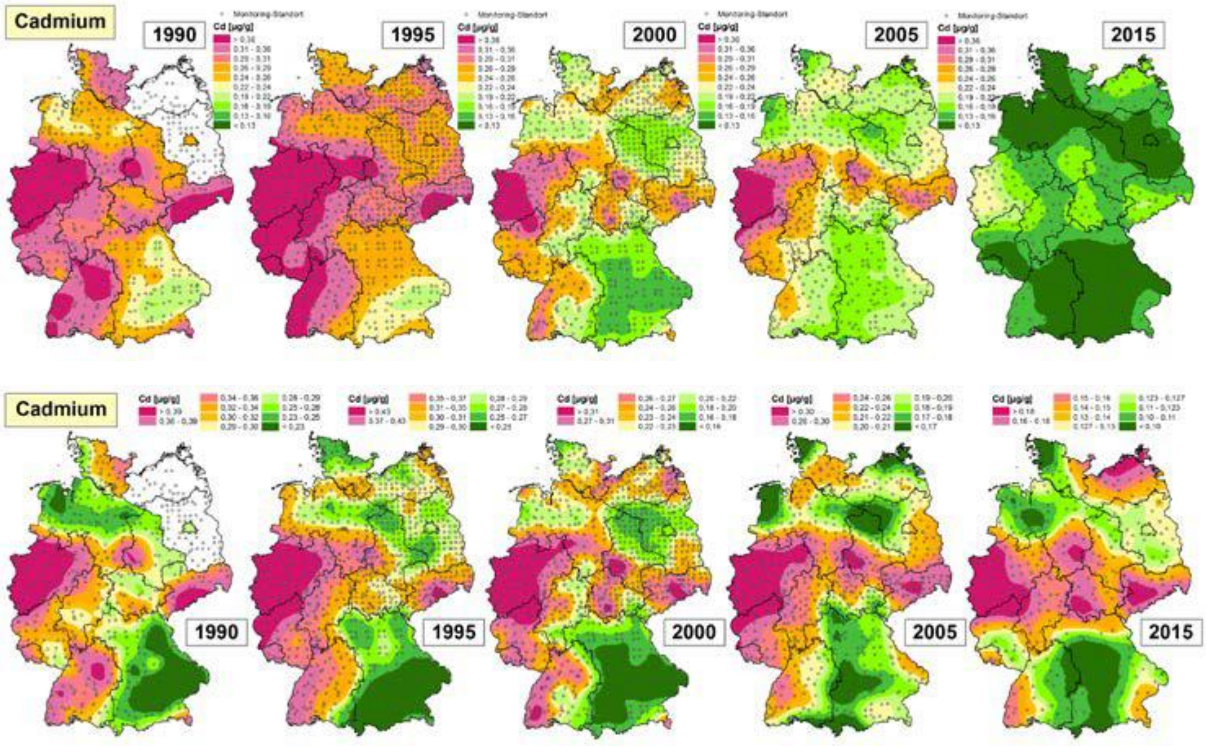

Figure 1: Spatial patterns of percentile classes integrating the surveys 1990-2015 (top) and of the 10 survey-specific percentile classes (bottom) of Cd-concentrations in moss specimens.

Conclusion. Cr, Hg, Sb and Zn show, contrary to Fe and Pb, no constant decrease of element concentrations, but an intermediate increase between 2000 and 2005, which did not continue until 2015. Al, As, Cd, Cu and V stagnated between 2000 and 2005, Hg from 2005 to 2015. Therefore, Cr, Sb and Zn are focused in this paper together with Cd, Hg, Pb and N which are of priority according to the Convention on Long-range Transboundary Air Pollution. Survey-specific statistical analyses corroborate that the spatial patterns of element concentrations in moss are changing across time.

RELEVANCE OF SITE-SPECIFIC AND REGIONAL CHARACTERISTICS ON ELEMENT CONCENTRATIONS IN MOSS SPECIMENS COLLECTED 1990-2015 ACROSS GERMANY

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Background and Aim. This article presents statistical analyses of elements concentrations in mosses which were collected in 1990, 1995, 2000, 2005 and 2015 throughout Germany at 592, 1026, 1028, 726 and 400 sites, respectively, and chemically analysed according to harmonised methods throughout Europe. The evaluations intended, amongst others, to examine whether the element concentrations are specific to moss species and whether conversion factors should be used. Such observations and recommendations have so far been limited to spatially confined areas with relatively few moss samples and were derived from studies without methodological harmonisation.

Methods. To examine the element accumulation of moss species used in moss surveys, comparative studies between *Pleurozium schreberi (P.s.), Scle-ropodium purum (S.p.; synonym: Pseudoscleropodium purum)* and *Hypnum cupressiforme (H.c.)* were carried out at the same moss sampling sites across Germany. The elements considered were, amongst others: Cd, Cu, Cr, Fe, Ni, Ti, Pb, V and Zn in 1990 as well as As, Cd, Cu, Cr, Fe, Ni, Ti, Pb, V, Zn, Sb and Hg in 1995, 2000, 2005 and 2015. N concentrations were measured in 2005 and 2015. The data analyses applied encompassed median statistics, regression analysis and Commonality Analysis. The latter one allows for identifying and ranking factors associated with the element concentrations in mosses. In the multivariate analyses measured concentrations of 12 heavy metals and N in the mosses were set as target variables and the following potential predictors: Atmospheric deposition, meteorology, geology, soil, topography, sampling, vegetation structure, land use density, population density and potential emission sources. In addition to a correlation analysis of the relationships between the predictors and the target variables, a regression analysis was performed using Random Forest Regression and Multiple Linear Regression combined with Commonality Analysis.

Results. The strongest predictor for Cd, Cu, Ni, Pb, Zn and N in moss was the sampled moss species. In 2015, the atmospheric deposition showed a lower predictive power compared to earlier campaigns. The mean precipitation (2013-2015) is a significant factor influencing Cd, Pb and Zn. Among the topographical parameters, altitude (Cu, Hg, and Ni) and slope (Cd) are the strongest predictors. With regard to 14 vegetation structure measures studied, the distance to adjacent tree stands is the strongest predictor (Cd, Cu, Hg, Zn and N), followed by the tree layer height (Cd, Hg, Pb and N), the leaf area index (Cd, N, Zn), and finally the coverage of the tree layer (Ni, Cd and Hg). For forests, the spatial density in radii 100-300 km predominate as significant predictors for Cu, Hg, Ni and N. For the urban areas, there are element-specific different radii between 25 and 300 km (Cd, Cu, Ni, Pb and N) and for agricultural areas usually radii between 50 and 300 km, which are important. The population density in the 50 and 100 km radius is a variable with high explanatory power for all elements except Hg and N.

Conclusions. In order to derive statistically verified accumulation trends from *P.s.*, *S.p.* and *H.c.*, it is actually necessary to compare the elements concentrations of moss samples taken in parallel at the same site. However, the samples compared in the analyses described above are never spatially identical, i.e. they do not fulfil this precondition. Samples of the same moss species collected at the same site may have different elements concentrations due to factors such as atmospheric deposition and vegetation structure (site variability) and different adsorption and accumulation properties of mosses (moss species variability). Since the site and moss species variability are in the same order of magnitude, conversion factors should not be used.

TEMPORAL TREND OF METALS POLLUTION IN ROMANIA STUDIED BY ANALYSIS OF NATURALLY GROWING MOSS SAMPLES

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A biomonitoring and analytical techniques network was developed for a nationwide moss survey in 2010/2011 and 2015/2016, to achieve the pollution database with metals in Romania. The concentrations of metals in mosses collected in Romania were high compared to other (Eastern-) European countries.

High loads of some heavy metals, related to industrial areas in the western part of Romania were found based on the calculated concentration factors and geochemical indices.

The temporal trends based on the reported and obtained values for the mean concentration of selected metals have revealed a decrease in 2015 for most of the elements, excepting As, Fe, V and Cr.

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AIR POLLUTION MATHEMATICAL MODELLING VERIFICATION USING BIOMONITORING

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Background

European Grouping of Territorial Cooperation (EGTC) Tritia includes the Moravian-Silesian Region (Czech Republic), Opole Voivodeship, Silesian Voivodeship (Republic of Poland) and the Žilina Region (Slovak Republic). These regions suffer by common exceeded air pollution due to high heavy industry concentration, high population density and natural disposition. Air pollution is undesirable, which requires systematic monitoring and consequently rationally decide on the steps to elimination of this phenomenon. In order to evaluate the air quality are used mathematical air pollution models. The credibility of the modelling results can be confirmed by verification. Moss biomonitoring was chosen for modelling results verification based on the previous research.

Mathematical modelling

Analytical Dispersion Modelling Supercomputer System (ADMoSS) system has been developed at VSB - Technical University of Ostrava (VSB-TUO) for modelling relations between emissions and concentrations in widespread areas. The ADMoSS system uses routines which control Geographic Information Systems (GIS), mathematical model and computing clusters. The modelling itself is currently performed using the SYMOS'97 methodology. Individual source groups are modelled separately. Consequently, it is possible to determine the predominance and influence of individual source groups.

Mathematical model verification

Research performed by the VSB-TUO team applied the moss biomonitoring for verification of air pollution mathematical model of Tritia region. The sampling mesh was designed based on the previous modelling results. The sampling mesh is consists of a regular 20x20 km collection network, which is concentrated in the areas of the expected higher gradient of pollutant concentrations by a 7x7 km network. The 285 samples were collected in the area of AIR TRITIA[1] project during the years 2015, 2016 and 2017. Collected samples were analysed by Instrumental Neutron Activation Analysis (INAA). The INAA provides information on the mass concentration of individual chemical elements in the examined samples. Relations between individual chemical elements were investigate using correlation analysis of the INAA results. Then was applied Correlation Matrix Based Hierarchical Clustering (CMBHC) analysis. Cluster containing elements Cr, Fe, Mo, As, W was identified using the CMBHC. Consequently, correlation analysis was performed to investigate relations of biomonitoring results and results of ADMoSS modelling system. The results suggest that the Cr, Fe, Mo, As, W elements were among the group of elements whose values correlated most with mathematical model calculation. Consequently, Principal Component Analysis (PCA) and then Hierarchical Clustering on Principal Components (HCPC) were performed for separate individual bryophyte samples into clusters. There were identified three clusters. Resulting three clusters were interpreted using the mathematical modelling results. Points in the first cluster are influenced mostly by natural sources, second cluster is influenced by anthropogenic sources with greater influence of industrial sources. Third cluster is influenced by anthropogenic sources with greater influence of domestic heating[2].

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HEAVY METAL CONCENTRATIONS IN MOSS (*PLEUROZIUM SCHREBERI)* AND FOREST SOILS IN LATVIA

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Mosses and soils are used as effective bioindicator that assess pollution concentration of heavy metals in atmosphere. The main aim of this research was to determine the environmental pollution with heavy metals using feather moss *Pleurozium schreberi*, soil O horizon (combined OL+OF+OH layers), and upper mineral horizon from 0 to 10 cm, in Ah, E and / or B horizon, and to provide spatial information about pollution, as well as to identify the main pollution sites in the territory of Latvia. The concentrations of 8 heavy metals (Cd, Cr, Cu, Fe, Ni, Pb, Zn and V) were determined using moss, and soil samples were collected from 101 sample plots, and the sampling period was from middle August to middle October, 2015. A high sampling density provided the information for the elemental deposition from the atmosphere to terrestrial ecosystems over the territory of Latvia (the territory of Latvia is 64 589 km^2). Currently the environmental atmospheric pollution level in Latvia has decreased significantly (Tabors et al., 2017), while historical pollution in the soil has remained. In the moss, the order of the median concentration of heavy metals was following: Fe > Zn > Cu > Pb > V > Ni > Cr > Cd, in soil O horizon: Fe > Zn > Pb > Cu > V > Ni > Cr > Cd, and in mineral soil horizons: Fe > Zn > Pb > V > Cu > Cr > Ni > Cd. (Table 1).

Table 1. Median values of heavy metals' (mg/kg) concentrations in *Pleurozium schreberi* moss, in soil O horizon and in soil mineral horizons in Latvia.

	V	Cr	Ni	Cd	Pb	Zn	Cu	Fe
Moss	0.49	0.33	0.48	0.10	1.26	33.13	5.17	133.02
O horizon	4.18	1.86	2.24	0.41	21.78	41.00	4.52	1213.64
Soil mineral horizons	2.51	1.79	1.22	0.09	7.46	13.26	1.81	1228.13

The results of this study show that using all three parameters, it is possible to assess in detail the amounts of environmental pollution in the territory of Latvia, as well as the distribution of pollution trends in time and space.

Keywords: air pollution, biomonitoring, heavy metal, moss, soil, Latvia

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HOW TO MANAGE YOUR UNECE ICP VEGETATION DATA?

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Data management is an important part of environmental monitoring. Any program faces problems of collection, storing and processing of the data. The proper organization of the data management process is critical for the quality and effectiveness of the research. The data management system (DMS, moss.jinr.ru) for ICP Vegetation program was developed at the Laboratory of Information Technologies of the Joint Institute for Nuclear Research using modern analytical, statistical, and organizational methods to provide the ICP Vegetation community with a unified system of gathering, storing, analysing, processing, sharing and collective usage of biological monitoring data. DMS consists of a set of interconnected services and tools developed, deployed and hosted in the JINR cloud infrastructure. Users communicate with the DMS through web-portal, the Android mobile application or web-services. There are two parts of the portal – public and private. The private part can be accessed only by authorized contributors and is used for data management and analysis. Data can be imported from and exported to Excel files. Participants can get some basic and advanced statistic parameters of their data, calculate correlations between element concentrations, calculate contaminations factors, geo-indexes, perform cluster analysis. Data can be represented as a different type of maps. Contributors can share their maps or statistic metrics so it can be accessed with no credentials. Mostly participants can access only their own data, but in some cases, they can use special tools to get general information from other contributors. For example, it is useful to execute mean values comparison of median elements concentration between neighboring countries and regions. It is possible to get historical reports and build historical charts and graphs. Coordinators of the program can access any contributor’s data, get some general information about completeness and quality of the data, export any type of data, execute group operation and build special combined maps.
For 2020 - 2021 Atlas, we offer the mobile application (Moss ICP Vegetation, at Google Play) for collecting meta-data about the sampling sites. The application automatically insert coordinates and allow specify all required by manual data and also allows to set MossMet data. All the data from the App could be imported to the DMS. Sampling site names should be unique. After processing of samples, information about concentration should be imported to the DMS.
An example of the workflow for management your ICP data starting from sampling and finishing with creation of reports will be presented.

UNECE ICP VEGETATION DATA VERSUS SATELITE IMAGES DATA

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Indexes from satellite images and data from ICP Vegetation were combined with machine learning to predict concentrations of heavy metals in some regions [1]. Models for Sb in Norway, Cu in Serbia and U in Romania showed prominent tendencies good and were used for fulfilling gaps in the data.
For several decades, researchers approved that there is a connection between heavy metal contamination of surface materials (soils, biomass) and electromagnetic radiation [2, 3]. In addition, field spectroscopy may give reliable results in the detection of some heavy metals [4, 5]. Many researchers use data from field spectroscopes or satellite programs (e.g. Landsat) to create a model that predicts soil contamination [6, 7]. These investigations show that heavy metals contribute to the reflectance in some spectra better or worse and that connection varies from many geological, biological and anthropogenic factors.
Massive research was conducted over the whole ICP Vegetation moss data for 2015-2016. More than 1M records with satellite data of 21 satellite programs for 4855 sampling sites were calculated. After processing more than 30K indexes with r>0.35 and r<-0.35 were selected as potential candidates for modelling. For each country or region that provided data for 2015-2016 Atlas several elements correlated with a number of indexes were found. Some numbers, analysis, and assumptions will be presented.

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MONITORING OF ATMOSPHERIC DEPOSITION OF INORGANIC POLLUTANTS IN MOSCOW REGION USING TERRESTRIAL MOSS: PRELIMINARY RESULTS

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In the framework of the International Cooperative Program on Effects of Air Pollution on Natural Vegetation and Crops (UNECE ICP Vegetation, the third moss survey was performed in the Moscow region. Previous moss surveys conducted in 2009 and 2014 covered only the territory of north and north-east part of Moscow region. In the third survey, during summer 2019,156 samples of *Pleurozium schreberi* and *Hylocomium splendens* were collected all over the region. Epithermal neutron activation analysis allowed to determine Al, V, Mg, Mn, Ti, Cl based on short-lived isotopes in moss samples. The goal of the present study was to evaluate the atmospheric pollution and to reveal possible pollution hot-spots in the Moscow region, as well as to compare obtained data with those from the previous surveys.

GENERAL POSTERS

REMOTE SENSING AND GROUND BASED ASSESSMENT OF LAND COVER PARAMETERS DISTRIBUTION IN THE CATCHMENT AREA OF WADI EL K'SOB M'SILA (ALGERIA)

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Remote sensing approaches application was made to estimate two land cover parameters (elevation and soil moisture) at first stage. An effects of altitude and physico-chemical properties of soil on soil microflora communities in the catchment area of Wadi El K'sob M'sila (Algeria) were investigated at second stage.
The purpose of this investigation was to estimate the impact of the gradient altitude and physico - chemical properties on soil microflora communities. The present work enumerated three groups of microorganisms in the soil samples collected from 7 locations situated in the catchment area of Wadi El K'sob M'sila (Algeria) at 398-1081m, along with 11 physico-chemical characteristics in spring 2017.
Statistical tests showed that actinomycetes, fungi and mesophilic bacteria were positively correlated to the altitude. The results revealed that the microflora communities was very dependent on soil physico-chemical characteristics, the main parameters were texture, pH, electrical conductivity, organic carbon, organic matter, total azote and available potassium. Generally, the parameters analyzed in this study, indicated a change in the soil microflora community according to the altitudinal and soil physico-chemical variations.

Keywords: remote sensing, land cover, catchment area, physico-chemical properties, soil microflora communities.

OZONE POSTERS

Monitoring ozone injury for seTTing new critical LEvelS: A novel long-term monitoring strategy to produce new critical levels for forest protection against O_3

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Current European directives for the protection of vegetation from the phytotoxic ozone (O_3) are based on atmospheric exposure (AOT40) that are not always representative of the actual field conditions. Such discrepancy is known to be related to the fact that O_3 effects on forests depend on gas uptake through stomata (stomatal fluxes). MOTTLES is an EC LIFE project establishing a permanent network of forest sites based on active monitoring in areas at highest and medium risk of ozone injury, in order to define new standards based on stomatal fluxes, i.e. POD_Y (Phytotoxic Ozone Dose above a threshold Y of uptake). In the present analyses, based on the first year of MOTTLES data, we describe the typical monitoring station, together with measure protocols and index calculation methods. AOT40 and POD_Y, computed with different approaches, are then compared and correlated with plant-response indicators (radial growth, crown defoliation, leaf visible injury). For 2017, the average AOT40 calculated according with the European Directive was almost twice the EC legislative standard of 5,000 ppb h. The metrics obtained following European protocols (Directive, ICP) resulted well correlated to those calculated on the basis of the real duration of the growing season (MOTTLES method) and are thus representative of the actual exposure/flux. AOT40 showed an opposite trend compared with PODY, hence it cannot be recommended as an optimal metric for forest protection from O_3. Visible foliar injury appeared as the best plant-response indicator of tree responses to O_3 under field conditions and more easily detected at the forest edge than inside the forest. The present work may help the set-up of further long-term forest monitoring sites dedicated to ozone assessment. Such experience is fundamental in Europe where stomatal O_3 fluxes shall now be monitored at different habitats according with the new National Emission Ceiling directive.

BIOINDICATION STUDIES OF GROUND- LEVEL OZONE IN LATVIA

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In the framework of the ICP Vegetation several biomonitoring experiments have been conducted to study effects of ambient ozone in Europe and in the USA. Latvia participated in biomonitoring of ozone impacts on white clover (T*rifolium repens cv* Regal) in 2006 and in biomonitoring of ozone impacts on snap been (*Phaseolus vulgaris* L.) in 2012.
In 2006, two batches of cuttings of ozone-sensitive (NC-S biotype) and ozone-resistant (NC-R biotype) white clover (T*rifolium repens cv* Regal) clones were received from the Coordination Centre of the ICP Vegetation at the Centre for Ecology and Hydrology, Bangor (UK) and were grown according to the ICP Vegetation protocol. The experiments were performed at five meteorological stations (Rūjiena, Zosēni, Dobele, Mērsrags and Rucava) located in rural areas of different climatic regions of Latvia from 27 June until 3 October 2006. Multiple regression analysis of dependence of percent of ozone damage from AOT40, mean relative air humidity (RAH) and sums of temperature (TS) performed on the data from Rucava (R2adj=0.405; P<0.001) showed that pure ozone effects explained only 13-16% of the injury data variation, while the RAH explained 23-25% and TS – 3-6% of the data variation. This can be explained by increase of diffusion of ozone through stomata during the periods of increased RAH. Extent of leaf injuries of white clover (*Trifolium repens* L cv Regal) in rural area of Latvia did not exceeded 10%.
Ozone sensitive (S156) and ozone tolerant (R123) genotypes of snap bean *(Phaseolus vulgaris* L.) was firstly used as a bioindicator plant in Latvia during the summer of 2012 at two rural sites Rucava (at the territory of the meteorological station) and Taurene (nearest meteorological station Zosēni) located in different climatic regions of the country. The seeds were sawn on June 11, 2012, plants were transplanted into the large pots on June 26 (day 0 of the experiment). The experiment lasted until September 27. Visible injury occured on the ozone sensitive genotype at both experimental sites, while ozone resistant type didn't show any signs of injuries. At the end of August at Rucava site (coastal site with marine climate) ozone injuries on plants was over 25%, at Taurene (inland site with more continental climat) ozone injuries did not exceed 5-25%. At the end of the growing season significant diferences were observed between ozone-sensitive and ozone resistant genotypes. All R123 plants were green, the signs of aging was just at some lower plant leaves, while all sensitive plants were senesced and dried. Therefore, despite of relatively low ozone levels, it caused significant damage and rapid aging of leaves. The yield biomass ratio evaluation showed that ozone sensitive genotypes of snap beans have higher number of seeds and matured pods than resistant genotypes, while mean weight of seeds is almost the same. It could be explained by adaptive reaction to environmental stress for plant species with R- strategy.
Despite the relatively small territory of Latvia it has a pronouced west-east climatic gradient. The continentality increases with increasing the distance from the Baltic sea. Climatic gradient over the territory of Latvia from the coast of the Baltic sea to the continent affects seasonal mean temperature, air humidity and therefore affects extent of ozone injuries.

LONG-TERM TRENDS IN OZONE CONCENTRATIONS, INDICES AND FLUXES ABOVE A SUBURBAN MIXED FOREST

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Ozone concentrations and fluxes have been monitored for more than two decades over a suburban mixed forest, situated in the deposition plume of Antwerp port.

The increase in ozone levels over the period 1995-2019 is especially marked during the spring months March and April (slope resp. 0.9 and 0.7 µg m^{-3} a^{-1}). During autumn and winter, the increase is also evident but the slope is less steep compared to the spring months. No distinct trend is shown during the months June, July and August.

The AOT40-index for forest trees exhibits maximum values during the years 1995, 2003 and 2006 (resp. 15.0, 16.3 and 16.7 ppm.h). During the heat waves of 2018 and 2019, AOT40-index were resp. 13.6 and 13.1 ppm.h. The critical AOT40 level, set to 5 ppm.h for protection of forests, was exceeded during the entire period.
The hourly threshold of 200 µg m^{-3}, implemented by the Council directive 92/72 (air pollution by ozone) for protection of vegetation was still exceeded in recent years. The daily threshold value of 65 µg m^{-3} for protection of vegetation was more frequently exceeded during recent years, because of increasing background concentrations, sometimes by a factor of two.

Monthly ozone fluxes, calculated using the aerodynamic gradient method, were following increasing trends over the period 2000-2018, with the highest slope recorded in the month of June. Linear trends could, however, not be substantiated by statistics to date. The deposition velocity (ʋd) of ozone was subjected to a strong interannual variability, with higher ʋds measured during the working-week.

MOSS SURVEY POSTERS

THE STUDY OF CRUSTAL AND LITHOGENIC ELEMENTS IN ATMOSPHERIC DEPOSITION OF ALBANIA EVALUATED BY MOSS BIOMONITORING

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Since 2010, Albania had contributed to the data onto the European moss survey (EMS), which is repeated at five-yearly intervals. Sampling was performed in accordance with the LRTAP Convention–ICP Vegetation protocol (Frontasyeva and Harmens, 2015) and sampling strategy of the European Programme on Biomonitoring of Heavy Metal Atmospheric Deposition. Beside the ten priority elements (V, Cr, Fe, Ni, Cu, Zn, As, Cd, Hg, Pb) 41 additional elements were investigated on 2010 moss survey. The presence of lithogenic and crustal elements (Yb, Sc, Ta, Ce, La, Th, Nd, Hf, U, Sm, Zr, Mn, W, Co, Ti, Al, Li, Sr, V, Fe, Ba and As) in moss samples indicate the effect of long-range transport of the pollutants combined with local geochemical factors of wind blowing soil dust fine particles that produce some local differentiation of these elements along the country.

Most of the crustal elements (Li, Al, Fe, Hf, Ta, W, Sc, Ce, Cs, Ba and Na, as well as Ni, Co ($r=0.6-0.7$, $p<0.01$) that are soil dust derived elements) show moderate variations (25% <CV% < 75 %) by indicating that the data are relatively stable and are derived mostly from long-range transport of the pollutants.

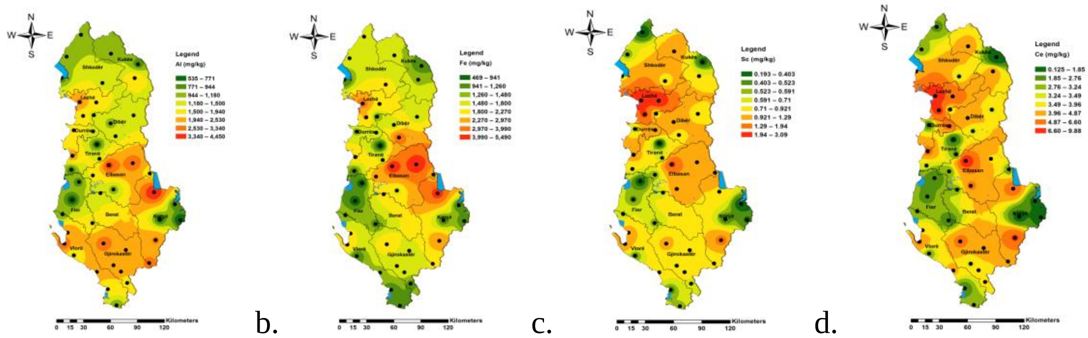

Figure 1 GIS maps of a. Al, b. Fe, c. Sc and d.Ce, typical crustal elements

Trend Analysis of different elements (linear model) indicates stable distribution over the country. The local anomalies distributed geographically, indicate a substantial contribution from local factors.

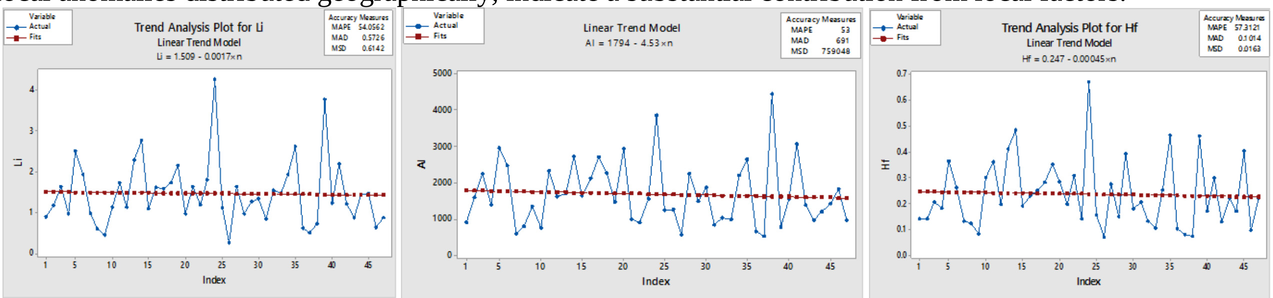

Figure 2: Linear Trend Analysis plot for Li, Al and Hf

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DIFFERENCES BETWEEN ACCUMULATION OF TRACE ELEMENTS IN PLANTS COLLECTED IN POZNAN (POLAND) AND BRNO (CZECH REPUBLIC)

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Developing civilization and industry have led to the development of transport, which is one of the sources of trace elements. Transport itself and the whole infrastructure are the source of many trace elements (such as Pb, Cd, Ni and Cr). These elements can accumulate plants, which can further be applied for detection of the environmental contamination. *Taraxacum officinale* is a herb species which commonly known as "dandelion". This perennial plant is a widespread weed, which can occur in various habitats. These features make possible to apply it as a good bioindicator.

Dandelion (*Taraxacum officinale)* was collected from 10 sites varied in environmental characteristic in two cities - Poznan, Poland, and Brno, Czech Republic. Leaves, roots and soil samples were analysed for cadmium, copper, lead and nickel accumulation.

Variation in four elements concentration was recorded and differences between two analysed cities was found. In most cases the higher concentration was noted for soil samples. Variation in results confirmed the usefulness of dandelion as a bioindicator of trace elements in urban areas.

MOSS MONITORING IN THE STUDY OF THE ACCUMULATION OF TRACE ELEMENTS IN THE UDMURT REPUBLIC, RUSSIA

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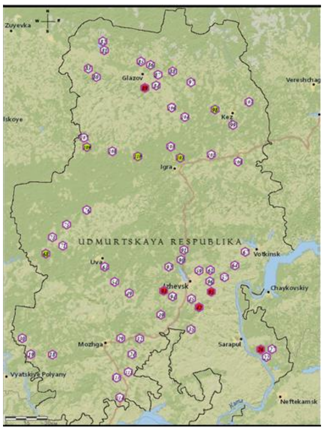
The results of atmospheric deposition of trace elements in the moss survey in the summer of 2016 and 2017 in the Republic of Udmurtia, Russia, are reported. Coordinates of the sampling sites were very close to those used in the first moss survey in Udmurtia carried out in 2005-2006 (Pankratova et al., 2007, 2008). Conducted research supplements the information on the moss surveys in Udmurtia in 2005, 2006 and 2016, 2017 (Pankratova et al, 2007, Bukharina, etc., 2017, 2018). A total of 39 elements were determined by neutron-activation analysis and atomic absorption spectrometry (Pb, Cd, and Cu).Comparative analysis of distribution maps of the concentration of chemical elements in the biomass of mosses *Pleurozium schreberi* (Brid.) Mitt. and *Hylocomium splendens* (Hedw.) Bruch et al. in the territory of the Udmurt Republic revealed a high, relatively background, the content of chemical elements such as Mg, W, Mo, Cr at points 89, 42, 93, 95, 26; low content of chemical elements is noted at points 109, 110, 68, 98.



Moss monitoring network in Udmurtia, Wester Urals, in 2016-2017

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HEAVY METALS ACCUMULATION IN PLANTS COLLECTED FROM DIFFERENT SITES IN PRISTINA, KOSOVO

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Heavy metals can accumulate in living organisms and their concentration depends on different factors, such as source, land use, meteorological conditions. There are several bioindicators of heavy metals, dandelion is among them very promising, due to its common occurrence almost in every habitat, including urban areas.

We have analysed the accumulation of selected heavy metals (cadmium, chromium, copper, lead, nickel, zinc) in dandelion (*Taraxacum officinale)* in Pristina city, Kosovo. For this purpose ten samples of leaves, roots and soil were collected from 10 research sites. Experimental sites were selected nearby typical facilities for big cities like: airport, old town, motorway, high-density housing areas, lake, park, rural areas, low-density housing areas, big river and train station. After the preparation of the samples, chemical analyses were carried out and graphic and statistical elaborations of the obtained results were made.

The highest concentrations (peaks) of all elements were noted in soils (excluding Pb – in roots) at various sites. The highest values of Zn, Cu and Cd were found in roots and soils collected from site near train station. While the Cr and Ni accumulation was the highest in soils and roots of plants sampled near the airport, while the leaves revealed highest accumulation in plants collected from the park. Lead revealed different tendency with the highest concentration in all analysed samples collected from the old town site.

MONITORING OF HEAVY METALS AND SULPHUR IN MOSS (*HYLOCOMIUM SPLENDENS*) IN ICELAND 1990–2015. EFFECTS FROM INDUSTRY AND VOLCANIC ACTIVITY

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In Iceland, airborne pollution has been monitored since 1990 by measuring heavy metals in the moss *Hylocomium splendens* every five years. Mosses have been collected all over Iceland, but the concentration of elements in moss has also been specifically measured close to aluminum smelters and on a small scale near geothermal power plants. In 2015, monitoring also began in the vicinity of two silicon metal production plants. From the beginning of the project, concentrations of Cd, Cr, Cu, Fe, Ni, Pb, V and Zn have been measured and from 1995 also As, Hg and S; in 2015, the elements B and Sb were added.

The concentration of elements has varied between years and regions. Since monitoring began in Iceland in 1990, the concentration of copper (Cu) in moss has decreased. The same is true for the concentration of cadmium (Cd) and lead (Pb) which, however, has slightly increased again in recent years. The concentration of chromium (Cr) has increased slightly, but the concentration of arsenic (As) has remained relatively stable. The concentration of other substances (Hg, Fe, Ni, S, V, Zn) has varied over time.

The monitoring in Iceland has revealed that the major sources of heavy metals and sulphur are related to volcanic activity (As, S), soil dust from sparsely vegetated areas (Cr, Cu, Fe, Ni, V), aluminium smelters (As, Ni, S, Sb), other industries (Cr, Cu, Fe, Pb, V, Zn) and geothermal power plants (As, S). Heavy metals are also transported from abroad with air currents but on a rather small scale (Cd, Pb).

Following a large eruption in Holuhraun in northeast Iceland 2014–2015, where around 11 Mt of SO_2 were released from the eruption and the cooling lava flow field (84 km^2), the concentration of sulphur in moss rose, and damaged moss was found in large parts of the country. Damages on moss were also found close to all aluminium smelters, and in some places, moss had disappeared altogether, probably due to chemical stress. In Reyðarfjörður, in eastern Iceland, where aluminum plant was started in 2007, the concentration of arsenic (As) and nickel (Ni) increased significantly. There was a considerable pollution at an industrial area in Hafnarfjörður, close to Reykjavik, as there was a relatively high concentration of many substances (Cr, Cu, Fe, Pb, Zn) which can probably be traced to metal industry in the area. Substantial input of pollutants (As, Ni, Sb, S) from an aluminium smelter close by in Straumsvík was also detected.

The most powerful sources of air pollution in Iceland are volcanic eruptions, which can temporarily affect large parts of the country. Other sources of pollution are aluminium smelters, other industries and geothermal power plants that all have rather local but persistent effects.

COASTAL WETLAND PLANT SPECIES AS MODELS IN HEAVY METAL AND NITROGEN ACCUMULATION STUDIES

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Wetland plant species have long been known as targets for accumulation of environmental contaminants, including heavy metals. In addition, many wetland species are nitrophilous, being well adapted to nitrogen-rich deposits trough high growth rate and efficient photosynthesis-dependent nitrate reduction system. Another ecophysiological group of species interesting in respect to their accumulation abilities are halophytes, plants tolerant to highly saline conditions. Wetland habitats on a sea coast are especially heterogeneous regarding soil chemical constituents. Typical coastal wetland species are well adapted to chemical heterogeneity due to different physiological and cellular mechanisms of tolerance as well as an ability to induce efficient uptake and storage processes. Therefore, the focus of the present study was on plants from sea-affected coastal wetland habitats as models in heavy metal and nitrogen accumulation studies.

As a first step, during field studies on electrolyte accumulation in leaves of coastal plants, promising candidate species having an ability to accumulate relatively high concentration of Na^+ in their aerial parts were identified. Both coastal-specific species and widespread species with accessions in coastal wetlands were considered. Selected species were propagated in controlled conditions either by seeds or by vegetative propagules in the case of clonal species. To examine heavy metal tolerance and accumulation capacity, plants were cultivated in presence of variable increased substrate concentration of biogenous (Mn, Zn) and non-biogenous (Cd, Pb) heavy metals, and metal concentration was analyzed in different plant parts. To assess nitrogen response, plants were cultivated in presence of elevated substrate nitrogen in a form of either nitrate or ammonia.

Ranunculus sceleratus plants from coastal lagoons were extremely tolerant to presence of NaCl and heavy metals in substrate with no growth reduction up to 1 g L^{-1} Mn, Zn or Pb, and 0.1 g L^{-1} Cd. According to the established criteria, coastal accession of *R. sceleratus* was hyperaccumulator of Zn (7.0 g kg^{-1}), Cd (0.1 g kg^{-1}), and Pb (2.4 g kg^{-1}), and accumulator of Mn (8.0 g kg^{-1}). Plants were highly nitrophilous, with growth stimulation by nitrates (even in a form of Na and Pb salts) on the background of optimum mineral nutrition. Together with a high flooding tolerance of *R. sceleratus*, these plants are extremely good candidates for phytoremediation systems of contaminated waters.

An accession of *Rumex hydrolapathum* from a sea-affected coastal marsh showed high tolerance to Pb (up to 1.0 g L^{-1}) and Cd (up to 0.1 g L^{-1}) and relatively good tolerance to Zn and Mn in substrate. Plants accumulated 0.8 g kg^{-1} Pb, 60 mg kg^{-1} Cd, 6.5 g kg^{-1} Mn and 1.8 g kg^{-1} Zn. Coastal accessions of *R. hydrolapathum* and related species *Rumex longifolius* and *Rumex maritima* were highly nitrophilous with growth stimulation by nitrate and ammonia.

Other tested species relatively tolerant to chemical contamination were coastal accessions of *Armeria maritima, Atriplex glabriuscula, Mentha aquatica, Sedum maximum, Triglochin maritimum, Tripleurospermum maritimum*, and *Veronica beccabunga*.

HYPNUM CUPRESSIFORME-NOTES ON ECOLOGY AND DISTRIBUTION PATTERNS (A CASE STUDY IN SERBIA)

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Bryophytes are suitable and commonly used for passive biomonitoring of air quality. Among pleurocarpous bryophytes, *Hypnum cupressiforme* is the most frequently used biomonitor of air quality in Southeastern Europe due to its abundancy in various habitats in comparison to other widely used “carpet” mosses (e.g. *Pleurozium schreberi*, *Hylocomium splendens*, etc.) in rest of Europe.

Field sampling of *H. cupressiforme* frequently implies a plenty of difficulties. Among various problems, finding “perfect” places according to the Monitoring Manual (e.g. 3 m away from tree canopy in forest, finding a sufficient amount of plant at same place etc.) can be very complicated. Further, there is a high risk for misidentification, since this species can often be replaced with similar species, such as *H. andoi* or with other from *Hypnum* genus, even with some non-related species, consequently leading to wrong conclusions. Overcoming these problems is based on good knowledge on morphology, habitat preferences, and distribution patterns.

H. cupressiforme is pleurocarpous moss, irregularly branched with shoots up to 2 cm long with strong curved leaves, without (or poorly developed, sometimes double) costa. It is polyedaphic species, very common on acidic and slightly base-rich bark and siliceous rocks.

In this research we attempt to define the major ecological factors associate to *H. cupressiforme* distribution, as well as to identify bryophyte community composition and species richness.

The research was performed on Fruška gora mountain (Northern Serbia). Bryophytes have been colected from different habitat types (forest, epiphytic and open habitats), where several environmental factros were measured (forest floor: soil pH, temerature and moisture, stream distance, tree and bushes number, herbaceous and litter cover; open habitats: soil pH, temperature and moisture, forest distance and herbaceous cover; epiphytic habitats: phorophyte type, tree height and diameter, bark pH). CCA analysis was performed in order to determine major factors that drive bryophyte abundance, while Label propagating community detection analysis was used for bryophyte communities detection.

Major factors that play important role on *H. cupressiforme* abundance are as follows: stream distance, soil moisture and pH on ground habitats (forest and open habitat soil) and phorophyte species for epiphytic habitats (it prefers *Quercus* spp., *Tilia* spp. and *Sambucus* spp.). Analyse of bryophyte communities showed that *H. cupressiforme* can be occurred together with 24 bryophyte species in forest floor (where it has highest abundance), with 20 species in epiphytic communities (where it has similar percentage cover as *Amblystegium serpens, Rhynchostegiella tenella*, *Pseudoscleropodium purum* and *Leucodon sciuroides*), with 10 species at rotten trunks (with similar abundance as *Brachytheciastrum velutinum*), with 3 species on open habitats ground (it has the highest abundance) and with one species on rocks (with the highest abundance).

The results of this study can be used as a framework for further ecological research of this species.

MOSS BIOMONITORING OF TRACE METAL DEPOSITION IN SOUTH OF ALBANIA

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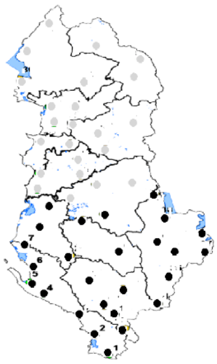
Since 2010, Albania contributes to the data of European moss survey (EMS). The use of mosses as biomonitors of heavy metal deposition has been extensively applied in numerous studies in the last years. This study takes place in the South region of Albania, and it presents the results obtained from 27 sites in the area. The aim of this survey is the comparison of air pollution in the different sites, based on the contamination derived by trace metals of anthropogenic origin.



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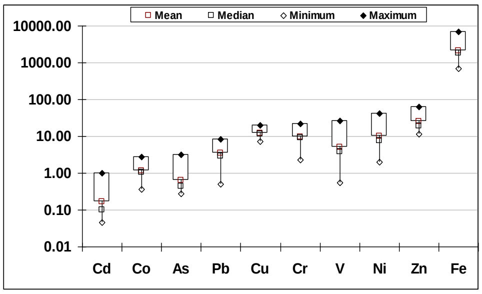

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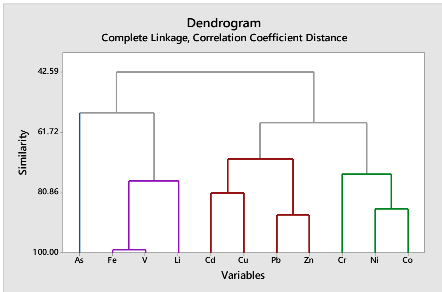

b.Box-plot and c. Cluster analysis of concentration data

27 samples of Hypnium cupressiforme were collected and the concentration of As, Cd, Cr, Cu, Fe, Ni, Pb and Zn was determined for each sample. Sampling was performed in accordance with the LRTAP Convention–ICP Vegetation protocol (Frontasyeva and Harmens, 2015) and sampling strategy of the European Programme on Biomonitoring of Heavy Metal Atmospheric Deposition. Heavy metals (Cu, Pb, Zn, Fe and Cd) were determined by atomic absorption spectrometry by using flame/and or electrothermal system.

High concentration levels of anthropogenic elements (Pb, Cu, Cr, Ni, Zn, and Fe) were detected affected by geogenic factors and mining industry:

- Arsenic shows maximum concentration at St.2; Cadmium at St.13 and St.26, Chromium at St.13, 18 and 19, Iron at St.27 (Alarup) and Nickel at S.26 Memlisht.

Low concentration levels were detected at:

- Copper shows the minimal concentration at St. 13, Lead at St.4, 13, 26 and 27, Vanadium at 27.

High concentration of Fe in all the sites, especially in Alarup was expected, because of the industry of iron extraction of its mineral that has been there for years. Emissions of zinc in the air come as a result of mining, steel production, purifying of zinc, coal burning, and burning of wastes.Cr is released in the atmosphere due to coal and oil combustion, mostly at diesel-fed vehicles.

Atmospheric particulates with trace metals have an important impact on human health. This is why we have to focus on analysing their levels, study their sources and find solutions for decreasing their concentration on air.

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EFFECT OF VEGETATION VARIABILITY ON THE AMOUNT OF BIOLOGICALLY ACTIVE NITROGEN IN THE SOIL

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Ellenberg's indicator values of the ecological factors of are used to assess the conditions of the site by species. The survey of vegetation in Latvia at Rucava Peši site in the extra-urban mesotropic pine forest has been performed in a semi-natural environment since 1994 within the framework of the collection of data for Integrated Monitoring. The values of the ecological factors of H. Ellenberg (Ellenberg et al., 1992) were calculated for the characterisation of critical climatic (light, temperature, continentality) and edaphic (humidity, reaction and nitrogen) factors in the forest fire-affected (area A) and undisturbed (area B) area. The values of Ellenberg ecological factors on each plot are calculated for each 3 x 3 m area (hundred 3 x 3 m plots per plot). The average values for Ellenberg ecological factors for each plot are then calculated (Laiviņš et al., 2019). The species of pine forest of a boreal nature are indifferent to changes in ecological factors, particularly as regards the amount of nitrogen in the environment. Therefore, the smallest changes in species coverage in the small areas of 3 x 3 m may have a significant impact on the value of the Ellenberg's ecological factors. The aim of this research was to determine the effect of vegetation variability over a 12-year period on the amount of biologically active nitrogen in the soil.

Analysis of Ellenberg's indicator values over the twelve-year observation period reveals differences between the forest affected and non-affected stands, as well as changes over several years. Changes in species composition indicate that the forest stand affected by the forest fire has richer growing conditions and higher amounts of biologically active nitrogen. Changes in species composition over the long term observation period indicate a slightly warmer climate than that observed at the start of the observations in 1994, as well as less light, higher humidity, and nitrogen enrichment of the soil during the observed period.

Nitrogen enrichment of the soil has led to statistically significant increases in the cover of *Deschampsia flexuosa, Maianthemum bifolium, Rubus idaeus* and *Trientalis europaea* species, while the cover of *Melampyrum pratense* has decreased significantly since 1994.

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BIOACCUMULATION OF HEAVY METALS IN PLANTS IN RELATION TO LAND USE - A CASE STUDY

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Heavy metals (HMs) have been a worldwide problem due to toxicity, abundant sources and bioaccumulative potential. The variations of heavy metal concentrations in urban areas might be related to natural backgrounds and anthropogenic activities and associated with land use type, soil type and its parameters, as well as demographic factors. In urban environment the human exposure to HMs increased significantly due to low air quality, high number of pollution sources and unsuitable urban planning. The aim of the study was to examine relations between HM plant and soil accumulation (Pb, Cd, Ni and Cr) and land use structure.

Taraxacum officinale was collected from city areas in Poland: Poznan, Warsaw and Wroclaw. Ten research sites were selected in each city. Research sites were located nearby typical facilities for big cities, such as: residential areas, roads, parks.

The level of Cd accumulation in soil in all cities were higher than previously observed in other cities. The Cd concentration in plant was different at sites depending on the city. The highest level of Cd in Poznan was at site located near river, in Warsaw was at site located in park and in Wroclaw was at site near high-density residential areas. The concentrations of Cr detected in soil in all cities were similar to levels reported in other research. Cr concentration in Poznan was higher in all soil samples in comparison to plant samples. The level in Warsaw was the highest with the peak at site near to the lake. The highest level of Cr in plants in Wroclaw was observed again at site near high-density residential areas. The obtained mean nickel contamination in soil was lower than previously. In Poznań and Warsaw Ni accumulations were higher in all roots samples than in soil. In Poznań the highest levels were recorded at sites located at old town and rural areas. In Warsaw peaks were in such sites as rural areas and near airport. In Wroclaw the highest accumulation of Ni was found in root samples of plants collected near the lake and near the river. The distribution of Pb concentrations in soil and plants in all cities were diverse, which may be mostly associated with anthropogenic origin and historical industrial activities. The Pb content in roots and leaves were at similar level.

The HM concentration was mostly related to the land use type and accumulation in leaves was mostly related to the location of sample site in the particular city.

THE MOSS TECHNIQUE AND NEUTRON ACTIVATION ANALYSIS FOR TRACE ELEMENT ATMOSPHERIC DEPOSITION STUDY IN GOYGOL DISTRICT, AZERBAIJAN

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The Goygol National park is a protected area because of its advantages, mainly outstanding natural value for the environmental, scientific, social, cultural and educational reasons. Natural resources of the national parks are one of the Azerbaijan strategic natural resources. Nowadays, alarming amount of pollution enters into the environment due to anthropogenic activities, lessen of natural habitats. Because of the environmental pollution there is an increased attention on the potentially toxic elements and on the dangers related to heavy metals. Detailed and intensive examinations are necessary in order to avoid extensive contaminations. A lot of information is needed about different environmental elements to understand the fast changes in environment and to control the environmental laws. Therefore, it is important to evaluate different studies in the environment the deposition of heavy metals. Some plants, can be very useful as bioindicators in order to obtain information about heavy metal concentration data derived from the air pollution monitoring. For the investigations there were selected different type of moss, because they have a big surface and can adsorbed the deposition from the air.
Our study thus examines the view that special care should be taken in regional comparisons of bryophyte concentrations of trace elements and radioactive elements. The 50 samples of moss *Pleurozium schreberi* were collected in different regions of the Goy-Gol district in compliance with the UNECE ICP Vegetation guidelines. The concentration of elements in the moss *P. schreberi* samples was determined by a multi-element instrumental neutron activation analysis using epithermal neutrons (ENAA) at the IBR-2 reactor, FLNP JINR, Dubna. A total of 44 elemental concentrations were determined by ENAA. The total content of Cd, Cu and Pb was determined by ASS method. Along with metals (Al, Sc, V, Cr, Mn, Fe, Co, Ni, Zn, Sr, Rb, Mo, Cd, W), halogens (Cl, Br, I), abiogenic elements (As, Se, Si), rare-earth elements (Ce, Nd, Sm, Eu, Gd, Tb, Dy, Tm, Yb, Lu), as well as U and Th were determined. The obtained data are used to construct coloured maps of the distribution of elements over the investigated territory.

SPATIAL AND TIME TRENDS OF ACCUMULATION OF HEAVY METALS AND NITROGEN IN MOSSES IN SLOVAKIA

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Use of mosses for biomonitoring of atmospheric deposition of heavy metals in Slovakia started more than 30 years ago. Based on the UNECE ICP Vegetation Program the systematic collection of selected species of mosses in a network of 16 x16 km is being done. Sampling of mosses Pleurozium schreberi, Hylocomium splendens and Dicranum sp. has been performed on the same sampling points since 1990.

In 1990-2015 we found temporal and spatial trends of concentrations of Cu, Cr, Fe, Ni, Pb, S, Zn. Concentration of Cu, Cr, Fe, Ni, Pb, S, Zn in mosses decreased between 1990 and 2015; but increased for Cd and Mn. To determine possible elementary sources factor analysis was used for moss deposition.

In Slovakia, comparing to Norwegian limit data (middle Norway – like relatively cleanest region in Europe) we found exceedances of levels for Ag, Al, As, Au, Ba, Br, Ca, Ce, Cd, Cl, Co, Cr, Cs, Cu, Dy, Eu, Fe, Gd, Hf, Hg, I, In, K, La, Lu, Mg, Mn, Mo, N, Na, Nd, Ni, Pb, Rb, S, Sb, Sc, Se, Sm, Sr, Ta, Tb, Th, Ti, U, V, W, Yb, Zn and Zr.

In Slovakia we found a high gradient of atmospheric load of heavy metals. The most burdened are the Volovské Hills (middle Spiš), Kremnické and Štiavnické vrchy (production of non-ferrous metals and aluminium works) and surroundings of Snina, Strážské, Stropkov (boundary PL, SK and U). Comparing years 2000 and 2015 a decrease of N was found out.

MOSSES AS BIOINDICATORS OF TRACE ELEMENTS IN THE ENVIRONMENT OF CENTRAL KAZAKHSTAN

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The moss-biomonitoring technique in combination with instrumental neutron activation analysis and atomic absorption spectrometry were used for assessment of air pollution in the Central Kazakhstan. Contents of 39 major and trace elements including heavy metals, rare-earth elements, uranium, and thorium were determined in 38 moss samples. GIS technology was used to construct distributions maps of heavy metals and other toxic elements over the investigated territory. A significant environmental pollution of the industrial Karaganda region was documented. The main pollutants are copper, zinc, iron, manganese and lead. High concentrations of these elements are of great hazard to human health. This indicates the need in regular biomonitoring of their atmospheric deposition. The analytical part of this investigation was performed at the FLNP JINR.

THE STUDY OF ANTHROPOGENIC ELEMENTS IN ATMOSPHERIC DEPOSITION OF ALBANIA EVALUATED BY MOSS BIOMONITORING.

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Albania had contributed to the data onto the European Moss Survey (EMS), conducted under the framework of ICP Vegetation Programme. The data of ten priority toxic metals (Al, As, Hg, Cd, Pb, Ni, Co, Cr, Fe and V) are reported to EMS. The elements under investigation were determined by using ICP-AES analytical technique performed in the Institute of Chemistry, Faculty of Science, Sts. Cyril and Methodius University, Skopje, North Macedonia. Moss species Hypnum cupressiforme (Hedw) sps. and Scleropodium purum (Hedw.) Limpr., were used as bioindicators of trace metal atmospheric deposition. Hypnum cupressiforme (Hedw), a carpet-forming bryophyte is the dominant moss species in this study area. The goal of this study was to identify factors leading to the high levels of the certain trace metals in atmospheric deposition in Albania identified by 2010/2011 and 2015 moss biomonitoring surveys, and to extend the study to the associations and the relationships between the elements content. It may help to identify the most probable sources of the origin and the areas at risk to humans and environmental ecosystems.

Sampling map of Albania

The elements Al, Fe, Cr, Ni and V exceeded the corresponding median values of European moss. The background (BC) of the elements was calculated, and high BCs particularly of Al, Fe, Cr, Ni, V, As, Cd, Pb and Hg on moss samples are probably affected by the historical industrial and mining emissions that may indicate a high anthropogenic effect on the air quality in Albania. The predicted trends of the distribution were calculated by using time series (linear model) and the areas with high concentration of certain metals were suggested for monitoring and to be under control. Wide ranges of metal concentrations were found for Al, As, Hg, Cd, Pb, Ni, Co, Cr, Fe, V, Eu, Tm, Lu, and Mn. The highest content of Fe, Cr, Ni, Zn and V was found in the eastern part of the country. The median concentrations and statistical parameters of elements were discussed by comparing the respective concentration data between the results of other European countries.

The air quality of Albania is comparable with the neighboring countries. The factors affecting to the high concentration level of Cr, Ni, V, Al, Fe have been identified and presented. The investigated levels of the contamination, and the local emitters like iron and chromium metallurgy, cement industry, oil refinery, mining industry, and transport were distinguished as main contributors of trace metals in atmospheric deposition of Albania. In addition, the natural sources, from the accumulation of these metals in mosses caused by metal enriched soil dust, associated with wind blowing fine mineral dust particles were pointed as another possibility of local emitting factors. It was found that the local emitting sources had shown higher contribution than the long-range transport of these elements.

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SEASONAL VARIABILITY OF PARTICULATE MATTER COMPOSITION AND MICROCLIMATE IN CULTURAL HERITAGE AREA

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This study is the first attempt to decipher the effect of PM composition on tourist's health and historical objects correlated with daily and seasonal microclimate monitoring indoor and outdoor of Roman Mosaic Edifice museum area (port of Constanta, Romania). More specifically, increased of metal concentrations of particulate matter during the summer of 2018 and spring of 2019, in the investigated museum could possibly be associated with microclimate of both seasons, coastal factors as well as anthropic activities specific port of Constanta. FTIR and ICP-MS techniques, used for investigation of $PM_{2.5-10}$ samples, revealed high concentrations of Fe, Al-rich and soluble particle indoor of investigated museum area. The high values of the measured RH in outdoor area (till 99% in the monitoring campaign of the autumn of 2018 and spring of 2019), and over 50% in indoor area, in all seasons, correlated with temperature influenced the chemical composition of $PM_{2.5-10}$ samples. Statistical analysis showed that the chemical composition of particulate matter indoor and outdoor of investigated Roman Mosaic Edifice area was influenced by microclimatic conditions, mainly temperature and RH. In this respect, a perfect relationship between Cr, Ni, Cu, Cd and Pb concentrations, temperature and AT in indoor Roman Mosaic Edifice area was found. On the other hand, a high correlation was found between Al concentrations, temperature and AT. A low correlation between Al concentrations, temperature and AT in outdoor of the Roman Mosaic Edifice area was observed, as well as high correlation between Mn and Cu concentrations, temperature and AT. With this respect, a perfect relationship between Cr, Fe, Ni, Zn, Cd and Pb concentrations, temperature and AT in outdoor of investigated area was remarked. The order of the analyzed metals in terms of abundance in cold seasons (i.e. autumn and winter, when temperature are ranged between 10 °C and 0 °C) indoor and outdoor of investigated area it's the same. However, the rise of temperature has led to a change in the order of the metals, indoor of Roman Mosaic Edifice area. The obtained data indicated that with temperature increasing (i.e. summer and spring seasons), the Pb concentrations, both indoor and outdoor of investigated area, are much higher than expected, mainly due to the anthropic activities conducted by port of Constanta. In conclusion, even if an outdoor confined environment may not be suitable for conservation of the original heritage materials, depending on the climatic region, several solutions can be proposed in order to reduce the impact of the external climatic risk. Consequently, the thermo-hygrometric variation indoor of the museum may has harmful effects on historical materials and visitors health. A potential risk health for the tourists is the thermal and humidity conditions together with the toxic components of the particulate matter. Through this research, suggestions for improving the indoor environmental conditions in Roman Mosaic Edifice area are mentioned usefully to increase the health safety of visitors and also, to protect museum exhibits from possible future deterioration.

TRENDS OF SPATIAL AND TEMPORAL DISPERSION PATTERN OF ATMOSPHERIC METAL (Pb) DURING 2000-2015 BY MOSSES.

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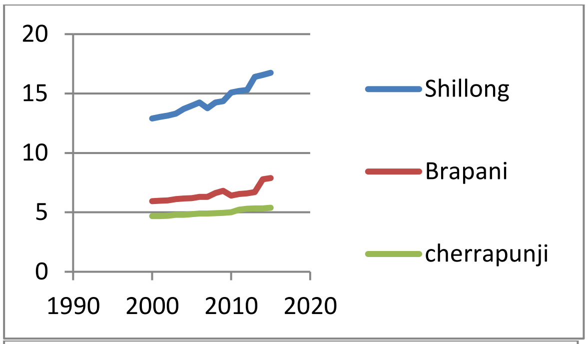
An organism or part of an organism or community is used in qualitative determination of environmental pollutions is referred to as bioindicator, whereas an organism or part of an organism or a community of organisms that contains the quantitative aspects of the environment is referred to as biomonitor (Wolterbeek, 2002). Presence of excessive concentration of metals is generally harmful and being non-biodegradable, and tend to accumulate in living system or in soil. Through plants metals enter the food chain, they can lead to morphological and physiological change (high affinity for the –SH group of some enzyme systems, free radical production, Goyer and Clasen, 1995). Lead is a silent killer is affecting human health and it has no role in human physiology, but its toxicity affects almost all functions of body. Approximately 90% of absorbed lead is reported to be stored in bones with half life of 600-3000 days. The remaining 10% is stored in soft tissues like kidney, brain and liver. Lead passes through the placenta easily and fetal blood has almost same lead concentration as maternal blood. Chronic toxicity is more common and can be described in three stages of progression: *(i)* The early stage is characterized by loss of appetite, weight loss, constipation, irritability, occasional vomiting, fatigue, weakness, lead line of gums and anemia; *(ii)* The second stage is marked by intermittent vomiting, irritability, nervousness, tremors and sensory disturbances in the in the extremities, most often accompanied by stippling of red blood cells; and *(iii)* A severe stage of toxicity is characterized by persistent vomiting, encephalopathy, lethargy, delirium, convulsions and comma.

Present study discusses the spatial and temporal dispersion pattern of atmospheric metal lead, studied over last 15 years from selected towns of eight states (Uttranchal, Punjab, Jammu and Kashmir, Uttar Pradesh, West Bengal, Meghalaya, Karnataka and Rajsthan) of India with the help of two mosses *Isopterygium distichaceum*, *Rhynchostegium herbaceum* using active monitoring approach. Undertaken moss transplants were harvested after exposure of every four months (covering each season i.e. winter, summer and monsoon) as per protocol at different distances across the city as well as in suburbs. Moss samples were brought to the lab for analysis for metal lead by using Atomic Absorption spectrophotometer after digestion. An increasing trend of Pb was found almost in all the study stations except at Manesar (see Figures). Pb values were persistent low at Manesar. Studies also confirmed that the high concentrations of lithogenic elements in analysed in moss transplants are associated with high levels of deposition from airborne soil dust (Fe, Cd, Cr, Ni). Its source can not be ruled out from excavation works, burning of the dumping ground and due to emissions spewed out from automobiles, traffic dust, abrasion of automobile parts and same is magnified in areas with high traffic congestions.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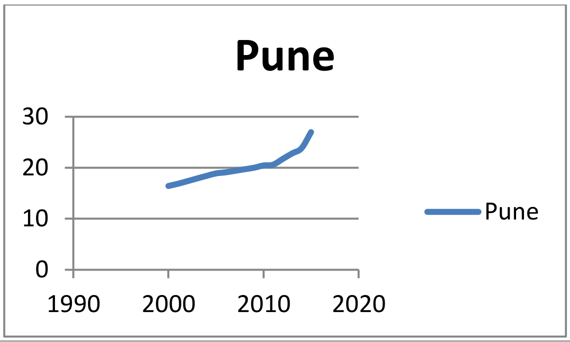
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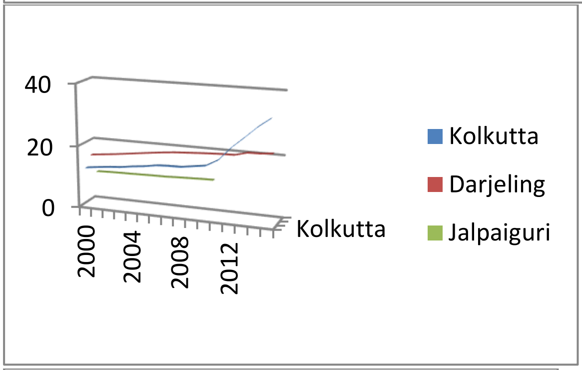
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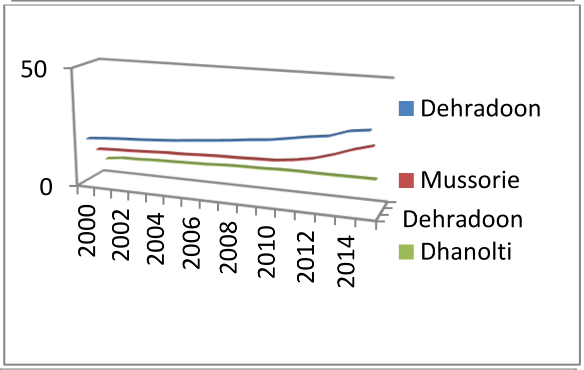
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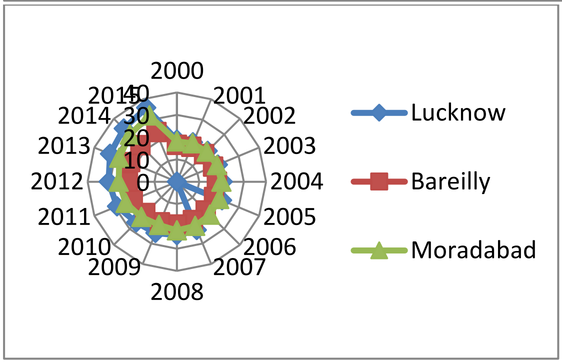
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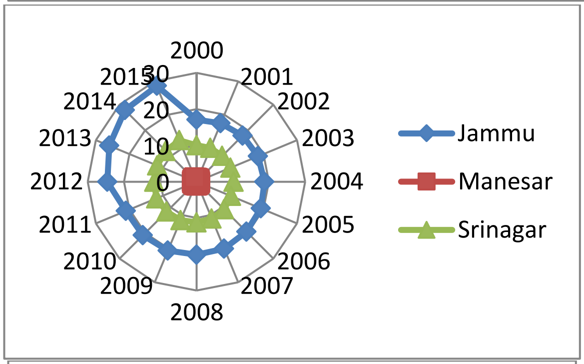
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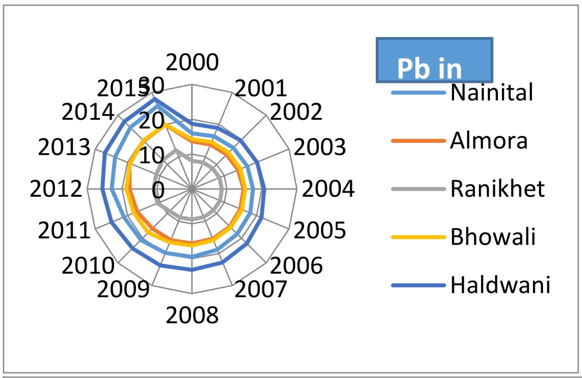
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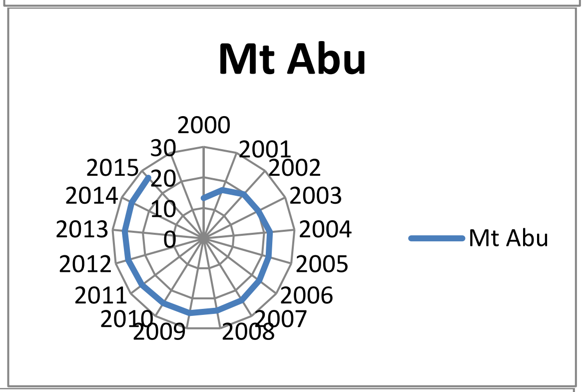
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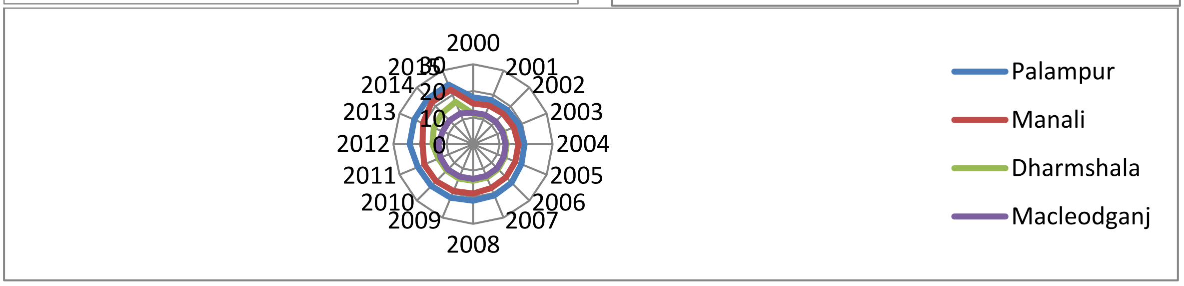
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EVALUATION OF AIR POLLUTION MATHEMATICAL MODELLING USING BY VARIOUS METHODS

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The research deals with the European Grouping for Territorial Cooperation (EGTC) Tritia in frame of AIR TRITIA project. The region includes the Czech Republic, Republic of Poland and Slovak Republic. Specifically, the Moravian-Silesian Region, Opole Voivodeship, Silesian Voivodeship and the Žilina Region. The regions combine common environmental and social problems, air pollution and intensive socio-economic relations.
Mathematical modelling is a suitable method for assessing the influence of specific pollution sources in a particular place. In order to assess the air quality in large area, Analytical Dispersion Modelling Supercomputer System (ADMoSS) has been developed at VSB – Technical University of Ostrava. The ADMoSS uses geographic information systems, a mathematical model and computing clusters. The modelling itself is currently performed using the SYMOS'97 methodology. SYMOS'97 is a Gaussian dispersion capable of evaluation the degree of air pollution by gases and solid pollutants.
Biomonitoring using moss samples was used for verification of mathematical modelling. In 2015 a regular network of 41 sampling sites was established, in 2016 area was extended by another 44 sampling points and in 2017, the last 244 moss samples took place.
The correlation between individual chemical elements was investigated in the instrumental neutron activation analysis results of the moss samples. The result was a correlation matrix, grouping of elements from industries was identified. Then, the Correlation Matrix Based Hierarchical Clustering, where three major clusters were identified. The subgroup of third group consisting of Nd, Na, Sr, Cr, Fe, Mo, As, W, Cs, Ni and Ba probably involves the impact of human activity. Cr, Fe, Mo, As and W were chosen for a detailed study of the spatial distribution.
Furthermore, the interdependence between the INAA results and the results of mathematical modelling using the ADMoSS system was investigated. Correlation analysis identified similar clusters as correlation between individual chemical elements. Mo, Sb, Zn, W, Fe and U showed the highest degree of dependence with the overall model and the model for each group of pollutant source[3].
Calculating the contamination factor[4] ensures better result interpretation. The contamination factor determines whether a specific element indicates pollution or not. The contamination factors were calculated by dividing each value by the corresponding background level of that element[5]. First, the contamination factor (CF) was calculated for chosen elements (Cr, Fe, Mo, As, W) where pollution was confirmed. Further, the contamination factor was calculated for individual samples. The sampling sites with highest values of contamination factor corresponded with the most polluted areas.

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