THE ASSESSMENT OF ANTHROPOGENIC AIR POLLUTION IN URBAN ECOSYSTEM USING LICHENOINDICATION AND SNOW SAMPLINGS

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INTRODUCTION

More than 70% of human population will live in urban areas after 2050 (UNESCO, 2008) and air pollution is one of the biggest environmental problems in urban areas. The anthropogenic sources of air pollution such as transport, energetics, household heating and industry generate different trace element footprint in the urban ecosystems. It's very important to identify the threats connected with air pollution in time, so the risks of environmental well-being could be eliminated by the choice of the right actions. Lichens are great indicator organisms of air pollution because they are very sensitive to air pollution: lichens receive the water mainly from atmospheric precipitation, and the metabobolism occurs in the whole surface of the lichen.

The different air pollution sources give different chemical trace elements footprint. The waste burning is associated with many trace elements such as Ag, Al, Ca, K, Fe, Ti, Zn, S, Pb, Cu, Cd, Mn, P, Cr, Sn. The burning of oil and fossil materials pollute the air with Pb, Zn, Cr, Co, V, Ni, Sb, Fe, Mn, Cu, Sn, As, Cd but the wastewater treatment and sewage sludge utilization are associated with Pb, Zn, Cu, Cd, Cr, Ni. The transport gives non-point source pollution in the city and accumulates around transport corridors. The trace elements of air pollution by transport are Pb, Cu, Cr, Sn, Sb. The industrialization generates air pollutants trace elements such as Pb, Zn, N, Cu, Cd. The additional air pollution source is firework especially in big cities after New Year and other events.

The aim of the research is to determine air pollution in Jelgava city, Latvia, using lichenoindication and snow sampling.

MATERIALS AND METHODS

City of Jelgava was divided in 104 sample plots (in the central part of the city 500 x 500 m and in outer part of the city ~ 1 km x 1 km) (Figure 1 and 2). In each sample plot on 10 tree trunks the number of epiphytic lichen species was identified and the percentage of the covered area of each species was determined. The index of air purity I.A.P. has been determined.

The snow samplings were collected during January and February 2017. The snow samples were analysed using inductively coupled plasma spectrometer (ICP-OES).

Figure 1. The location of Jelgava city, Latvia.

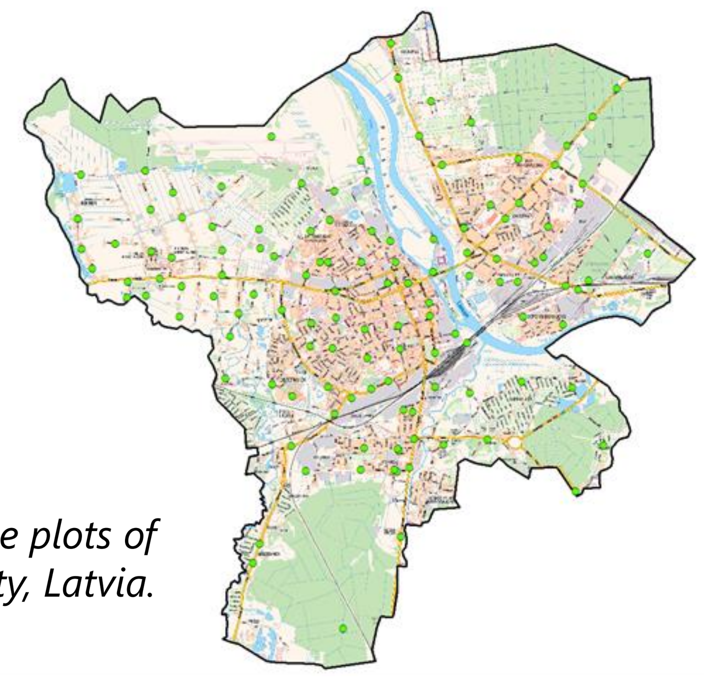

Figure 2. The sample plots of lichenoindication in Jelgava city, Latvia.

Air purity index or I.A.P is calculated for each sampling plot. I.A.P. consists of all values of lichen species toxicotolerance factor Q and the surface area occurance degree f multiplication sum.

Hierarchical Agglomerative Cluster Analysis was used to classify snow samples into groups using similarities. Totally 12 Hierarchical Agglomerative Cluster Analysis was made. The cluster analysis results for each analyzing group were divided into three pollution levels according to cluster centroid coordinates:
Low pollution – 1 (green) if total sum of standardised centroid coordinates is < 0;
Middle pollution – 2 (yellow) if total sum of standardized centroid coordinates is 0 < 5;
High pollution - 3 (red) if total sum of standardized centroid coordinates is > 5.
The weights of each monitoring point were summarised and according to the total sum of clustering results were divided risk groups of air pollution with trace elements:
Clean air - total sum of clustering results equal to 12 (green);
Low risk - total sum of clustering results 13 to 17 (yellow);
Middle risk - total sum of clustering results 18 to 23 (orange);
High - risk total sum of clustering results 24 and higher (red).
The GIS map with risk areas was created to show air pollution risk level in analysed areas of Jelgava.

RESULTS

The territory of Jelgava consists of three long term air pollution zones: high air pollution zone makes up 2,75% of the city, medium zone - 44% but clear air zone - 53,25% of the city. In the central part of the city the medium zone dominates because of intensity of traffic in the main streets furthermore this zone has a tendency to increase.

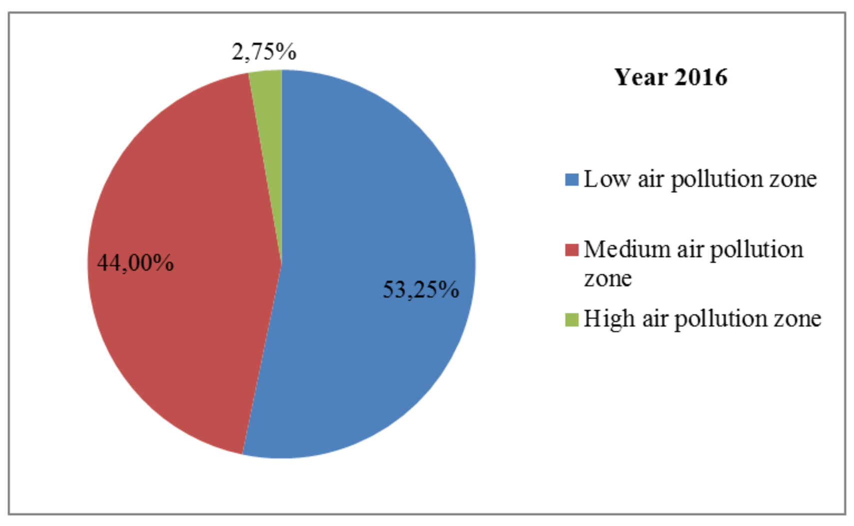

Figure 3. The proportion (%) of long term air pollution zones in Jelgava city, Latvia.

The results of clusters of snow samplings were analysed using GIS, and the areas with different air pollution risks were identified. In Jelgava, there were identified six possible sources of trace elements: waste burning; burning of oil and fossil materials; wastewater treatment and utilization of sewage sludge; transport; metal industry and fireworks (Table 1).

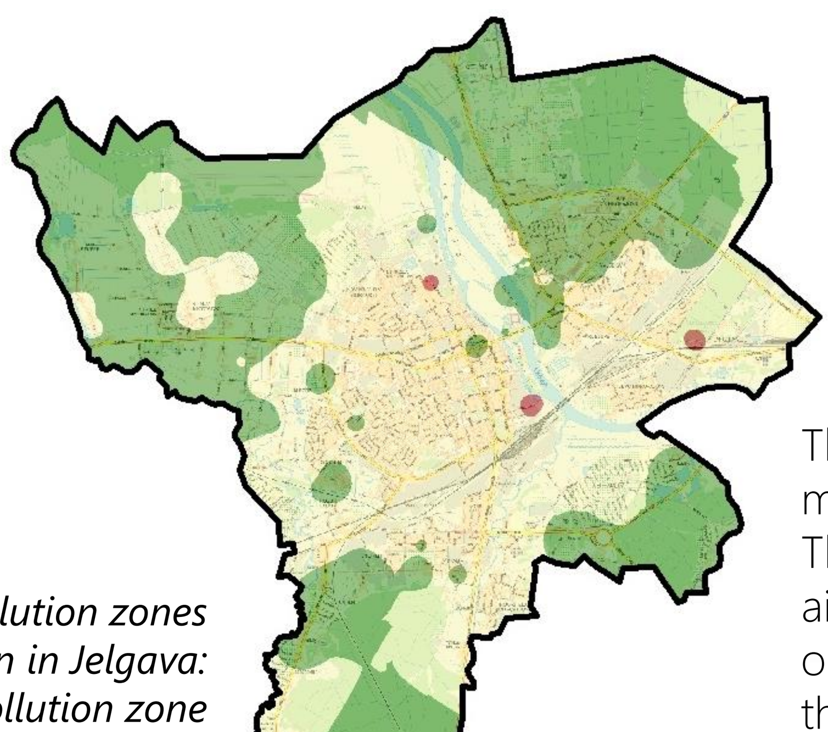

Figure 4. The distribution of long term air pollution zones determined by lichenoindication in Jelgava: high air pollution zone (red), medium air pollution zone zone (yellow) and clear air zone (green).

Table 1
The trace elements used in Hierarchical Agglomerative Cluster Analysis

Air pollution source	Used trace elements in January	Code of January cluster analysis	Used trace elements in February	Code of February cluster analysis
Waste burning	Cu; Pb; Ca; Fe; Zn; Cr; Mn; Ti; Al; P; K	J_W_B	Cd; Cu; Pb; Ca; Fe; Zn; Cr; Mn; K; Ti; Al; P	F_W_B
Burning of oil and fossil materials	Cu; Pb; Fe; Zn; Ni; Cr; Mn; Co	J_F	Cd; Cu; Pb; Fe; Zn; Ni; Cr; Mn; As; Co; V; Sb	F_F
Wastewater treatment and utilisation of sewage sludge	Cu; Pb; Zn; Ni; Cr	J_W_W	Cd; Cu; Pb; Zn; Ni; Cr	F_W_W
Transport	Cu; Pb; Cr	J_TR	Cu; Pb; Cr; Sb	F_TR
Metal industry	Cu; Pb; Zn; Ni	J_M	Cd; Cu; Pb; Zn; Ni	F_M
Fireworks	Cu; Pb; Ca; Mg; Na; Fe; Zn; Ni; Mn; Sr; Ba; Al; K	J_FW	Cu; Pb; Ca; Mg; Na; Fe; Zn; Ni; Mn; K; Sr; Ba; Al	F_FW

The spatial distribution of air pollution risk level of monitoring points in Jelgava is presented in Fig. 5. There are four monitoring points with a high risk of air pollution with trace elements. The train station is one of high risk area, the intensive cargo flow through Jelgava city and road infrastructure intensify the risk of air pollution with trace elements. The Tervetes street and Pavasara street area is characterised by the individual housing and closed landscape, as well as individual heating systems with different burning materials from wood and coal to plastic and paper can intensify air pollution with trace elements. The Aviacijas street and Lacplesa street monitoring point are situated between industrial and living area and show a high risk of air pollution with trace elements.

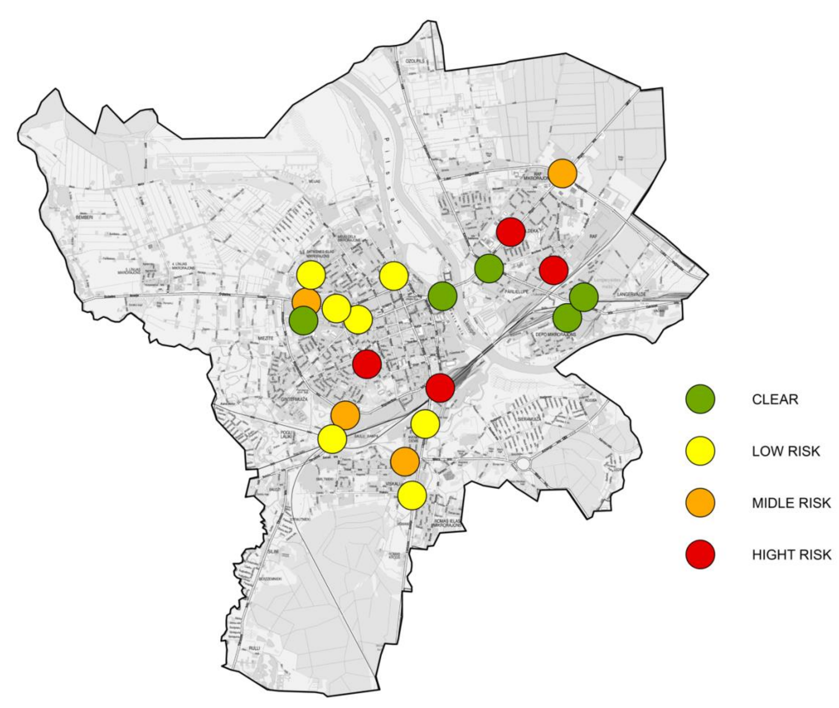

Figure 5. The map of Jelgava with risk intensity of air pollution with trace elements

The Institute street and Riga street monitoring point show high air pollution risk with trace elements during February, it can be explained by intensive fireworks during Ice Sculpture festival. The cleanest areas are situated in open landscape with open water bodies. For example, monitoring point of Rigas street and Brivibas street is situated close to gasoline station between two main streets in Jelgava with intensive transport flow, but there is relatively clean air because of open landscape and a short distance to Lielupe and Driksa river.

CONCLUSIONS

The research results highlight the temporal and spatial multidimensionality of air pollution with trace elements in the urban environment.

The results show strong evidence of transport and household impact on air quality.
The results show the positive impact of open urban areas and open water bodies on air quality: relatively good air quality has been found in places where the pollution is being dispersed by nearby open spaces or urban parks and forests, and also nearby rivers – Driksa and Lielupe.
The air pollution risk with trace elements is higher in urban street "canyons" and lower - in opened areas.