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PREVALENCE OF LONG-TERM AND SHORT-TERM POLLUTION OF CHEMICAL ELEMENTS IN THE CITY OF JELGAVA

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Abstract
Air pollution is a global environmental problem. More than 92% of the world's population lives in areas where air pollution exceeds limit values. The aim of the research is to analyse the pollution of chemical elements and their distribution in the environment of Jelgava city, using long-term and short-term pollution detection methods. City air quality is a critical factor in ensuring the quality of life in the city.
Methods for the identification of contamination of chemical elements can be divided into two broad groups: 1. for the determination of short-term pollution and 2. for the determination of long-term pollution. Temporary pollution is determined using two methods: the analysis of snow samples and the placement of lichen transplants in the city. Long-term pollution is determined by analysing the chemical composition of lichen (*Xanthoria parietina*) and determining the air purity index I.A.P.
During the work, snow samples were collected on 10 January and 14 February 2017 to detect temporary contamination; samples were collected in 20 sampling areas of the urban area and one sampling area of the natural site with three repetitions. Chemical elements were identified in 120 snow samples and 60 lichen samples (*Xanthoria parietina*) from the city and six snow samples and three lichen samples (*Xanthoria parietina*) from the forest, which is on the southwest side of the city and represents background pollution with chemical elements.
Preliminary results vividly reflect the effect of transport corridors on the chemical composition of snow samples. Snow analyses indicate pollution from heat supply and road transport.
Key words: environment, pollution, heavy metals in the city, snow.

Introduction

Air pollution is one of the most significant environmental problems, as well as it is the biggest environmental threat to health (She *et al*., 2017). People living in cities, especially large cities, face serious health threats from urban air pollution (Shi, Ka-Lun Lau, & Ng, 2017). Industrial development and urbanisation worldwide have led to chemical pollution of the environment. About 92% of the world's population lives in places where the level of air pollution does not meet the permissible limits (Battista & de Letto Vollare, 2017). Pollution in the air causes various diseases or even death in many parts of the world. The number of premature deaths due to air pollution in the world has risen from 0.22 million in 2010 to 3.7 million in 2012, highlighting the high health risk. For example, air pollution has become the fourth most significant risk factor for deaths in China (She *et al*., 2017).

Economic activity increases every year, and it promotes the intensive use of natural resources. The use of chemicals in agriculture, households, mineral extraction and industrial use cause significant air pollution with various chemical elements (Tchounwou, Yedjou, Patlolla, & Sutton, 2014). Several studies use snow as an indicator of urban air pollution (Dossi *et al*., 2007; Engelhard *et al*., 2007).

The idea that lichen is affected by air pollution was first expressed in 1790 by studying lichen at metal foundries in North Wales (Nimis, Scheidegger, & Wolseley, 2002). The environmental monitoring method, based on the viability of lichen, is based on various environments. The development phase of lichen indication developed most rapidly in the 20th century. In the 1960s and 1970s, when the theoretical bases for lichen indications were formed, essential methods of lichenoindiation were developed, such as the Index of Atmospheric Purity – I.A.P. (LeBlanc & DeSloover, 1970). The benefits of lihenoindication are the low cost and ability to characterise long-term pollution. The objective of the research is to analyse the pollution and distribution of chemical elements in Jelgava city's environment using long-term and short-term pollution detection methods.

Tasks of the research are:

1. To get acquainted with the experience of previous research to identify chemical element pollution in the urban environment;
2. To develop a methodology for chemical element pollution identification and to select a pilot site for conducting a study;
3. To carry out sampling and sample analysis;
4. Analyse the prevalence of pollution of chemical elements and provide proposals to limit pollution.

Materials and Methods

Jelgava has more than 59,000 inhabitants (Office of Citizenship and Migration Affairs Republic of Latvia) and it is located in the middle of Latvia next to the Lielupe (Figure 1). It is located in the temperate climate zone. The average annual rainfall is 180 mm in autumn, 117 mm in winter, 124 mm in spring and 217 mm in summer. The snow typically ranges from November to March, and the length of the snow

Figure 1. The geographical location of Jelgava city (created by the author).

exposure period is affected by local meteorological conditions, such as the effects of urban heat islands. The region is dominated by westerly and south-westerly winds (LEGMC).

The territory of Jelgava city (60.32 km^2) for air quality mapping depending on the building density, location of highways and production companies is divided into 104 plots (green dots in Figure 2) – centre 500 m x 500 m (52 plots) and the rest area – 1 km x 1 km (52 plots). The sample plots were established in 1996, where repeated research was carried out according to a standard methodology also in 2006 and 2016. Considering the intensity of construction and the development trends of the city of Jelgava, 21 additional sample plots (read dots in Figure 2) have been created in this study (Figure 2).

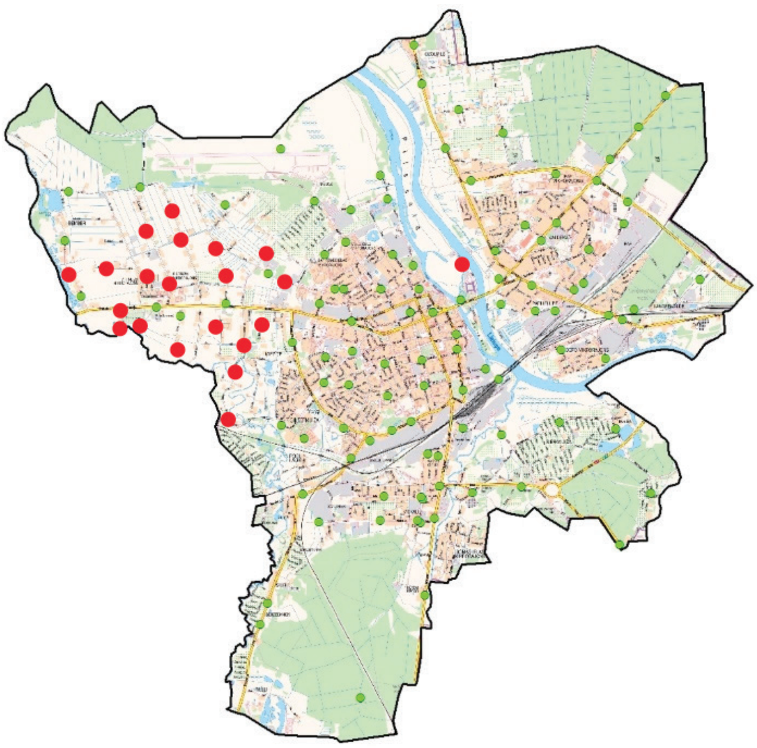

Figure 2. Location of lichen indication plots in Jelgava city, added plots in read (created by the author).

Quantitative assessment of lichen diversity is one of the simplest and most effective methods for lichen indication. Air purity index I.A.P. (Index of Atmospheric Purity) method (LeBlanc & De Sloover, 1970) is considered the most popular bioindication solution globally for air quality assessment obtained data reflect the long-term level of pollution. An inventory of all lichen species was made on ten tree trunks at the height of 30 cm to 2 m in each plot. The percentage of lichens by species is estimated on the side of the trunk where the most lichens are found.

The air purity index or I.A.P. is determined for each plot and consists of the sum of the product of the toxicological tolerance factor Q for all lichen species and the values for the degree of coverage f.

It is calculated by the following equation:

$$IAP = \sum_{l}^{n} \frac{(Q \times f)}{10} \quad (1)$$

where: I.A.P. – air purity index; n – number of lichen species in the study area; Q – toxic tolerance factor (constant for each lichen species) (1).

$$Q = {}^{n_1}/_{n_2} \quad (2)$$

where: n_1 – the total number of all lichen species in all plots containing the species of interest; n_2 – the sum of the sample plots in which the species of interest is found; f – degree of cover occurrence, which is determined by the combination of the percentage cover of the lichen species and the frequency of occurrence of the lichen species in each plot (2).

f values:

1 – species rare, with little cover; 2 – species rare or with 1-5% coverage; 3 – species not common or with 5-10% coverage; 4 – species often or with 10-20% coverage; 5 – species widespread with a coverage of more than 20%.

The study selected 1250 deciduous trees, possibly with similar ages, crown shapes and exposures, and similar growing sites, mainly on the side of streets and roads.

Analysis of snow samples is one of the methods for monitoring pollution with chemical elements in urban areas. As part of the work, snow samples were collected on 10 January and 14 February 2017 to determine transient chemical contamination. Samples were collected at 20 urban sampling sites and one natural site sampling site with three replicates, averaging from 1.0-1.5 kg of snow. The average snow depth was 6-10 cm. Inductively coupled plasma-optical emission spectroscopy (ICP-OES) method was used to determine chemical elements in melting snow water.

In order to determine the long-term pollution in the city area, lichen samples were collected. They were harvested from deciduous trees, about 1.3-1.5 m above the ground. Preparation of the samples to determine the chemical elements: (a) The lichens are dried and then weighed in a 50 ml glass beaker with an analytical balance of 0.3000 ± 0.0002 g. (b) Add 10 ml of concentrated HNO_3 and 5 ml of concentrated H_2O_2 (analytical reagents); (c) after 12 hours, the solutions were extracted by heating in a block at 160 °C; (d) After cooling the extract (7.5 ml), filter the sample solutions and makeup to 20 ml with ultrapure deionised water in polypropylene tubes. Metal concentrations and chemical elements were measured with an ICP-OES spectrometer. Chemical elements were determined in 120 snow samples and 60 lichen samples (*Xanthoria parietina*) from the city, six snow samples, and three lichen samples (*Xanthoria parietina*) from the forest outside the city.

Results and Discussion

The air purity index in the territory of Jelgava was calculated using data from 104 plots, and air pollution zones were divided into three groups:

I High pollution zone: With a minimal lichen population or lichen survival zones (I.A.P. from 0-110); II Medium pollution zone: With limited lichen population or transition zone (I.A.P. = 111 – 200); III Low Pollution Zone: Lichen-rich or natural environment zone (I.A.P.> over 200).

The high air pollution zone in Jelgava in 2016 occupied 1.66 km^2 or 2.75% of the entire city territory: it was found in 4 sample plots: in the centre of Jelgava – in 3 sample plots (part of wastewater treatment plants; the territory of LTD. Larelini, Palīdzības street) and outside the centre - in one sample plot (near Langervalde park).

The average air pollution zone in Jelgava in 2016 occupied 26.54 km^2, or 44.0% of the total area. Compared to the previous results in 1996, its area had slightly increased – from 25.76 km^2 or 44.0% to 26.54 km^2 or 44.0%, respectively, but compared to the results of 2006, it had decreased from 29, respectively, 26 km^2 or 48.51%, 26.54 km^2 or 44.0%.

In 2016, the low air pollution or clean air zone in the city of Jelgava occupied more than half of the city territory – 32.12 km^2 or 53.25%. Compared to the previous results in 1996 and 2006, in general, it had slightly increased in Jelgava: in 1996 – 32.11 km^2 or 53.23% and 2006 – 29.56 km^2 or 49.01%. However, compared to the previous results in the city centre, the clean air area now occupies only 3 km^2 or 23.08% of the area; moreover, it tends to decrease (5.75 km^2 or 44.25% and 5 km^2 or 38.46% respectively in 1996 and 2006).

The KL_SM_4 cluster is characterised by extremely high pollution, where the primary source is transport exhaust. The KL_SM_3 cluster is characterised by

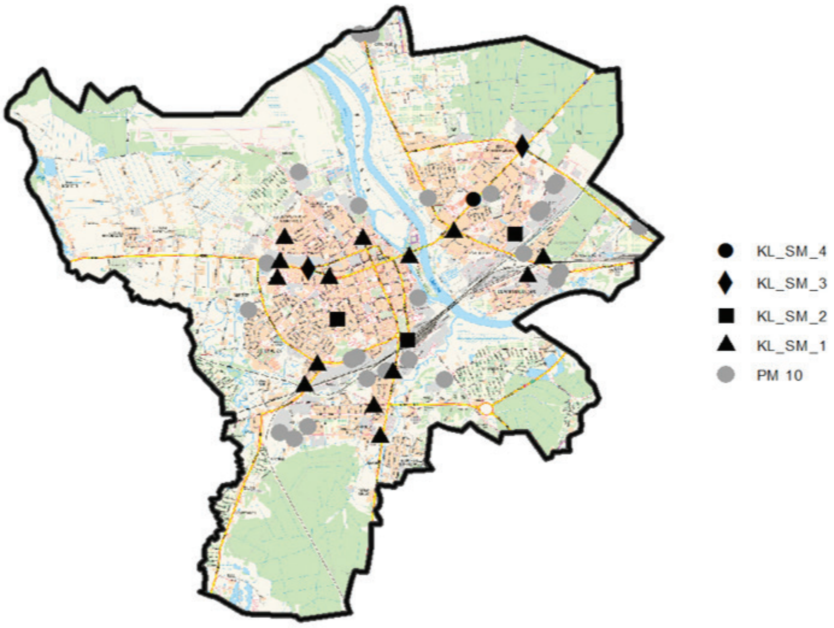

Figure 3. Cluster analysis results of short term air pollution by chemical composition of snow samples collected 14.02.2017 (created by the author).

high levels of pollution from transport exhaust. The KL_SM_2 cluster is characterised by high pollution resulting from industrial processes. The KL_SM_1 cluster is characterised by relatively clean air, with little pollution from transport (Figure 3).

Conclusions

According to the long-term air pollution monitoring data, there is 2.75% high pollution zone, 44.0% medium pollution zone and 53.25% low pollution zone in the territory of Jelgava city. According to the long-term air pollution monitoring data, there is 2.75% high pollution zone, 44.0% medium pollution zone and 53.25% low pollution zone in the territory of Jelgava city. According to short-term air pollution monitoring data, 2 points have very high transport pollution, but surprisingly high air pollution, the primary source of transport exhaust, is at one point.

For further research, it is recommended to establish a more uniform sampling network to obtain more detailed information on the spatial variability of chemical element concentrations.

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