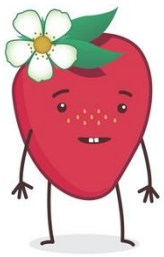
University of Antwerp

BIOVEINS



STRAWBAIRIES 2019:
AIR QUALITY RESULTS

The project

Within the scope of the European BIOVEINS project (BiodivERsA – Horizon2020), the strawbAIRies citizen science project was set up. It was based on the already existing AIRbezen concept, with which the lab of Environmental and Urban Ecology (Departments of Bioscience Engineering, University of Antwerp) already had a lot of experience. In this strawbAIRies project, it was the first time active biomonitoring with strawberry plants in the scope of a citizen science project was done simultaneously in four different European countries. Furthermore, the project was extended with the use of bird's-foot trefoil plants to assess the pollination success of urban insects.

In the period of May to July 2019, 266 strawberry (*Fragaria sp.*) and bird's-foot trefoil (*Lotus corniculatus* var. Leo) plants were distributed to citizens in four European cities (Antwerp, Poznan, Tartu and Zürich). On the map (Fig. 1) you can see the spreading of the locations over Europe.

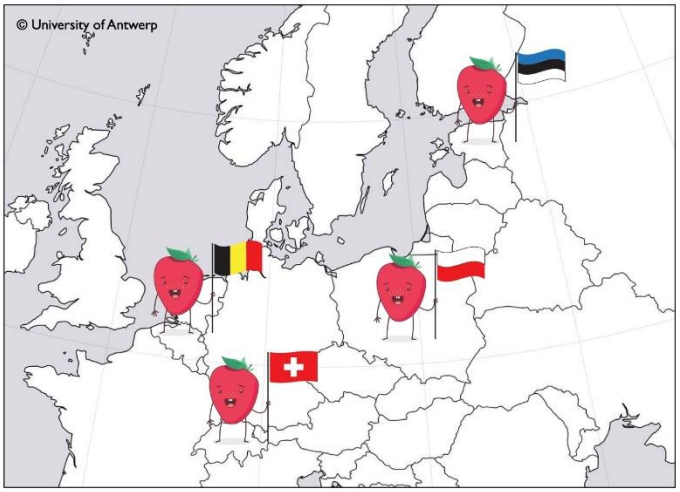


Fig. 1. Map with locations of participating cities: Antwerp (Belgium), Poznan (Poland), Tartu (Estonia) and Zürich (Switzerland).

The aim of the project was to measure local air quality and to get an idea about the pollination success of urban insects. In this report we focus on the results for the first part of the project, air quality.

Previous AIRbezen projects showed that air quality varies strongly at local levels. We see higher particulate matter concentrations in cities, compared to its rural surroundings, with local increases near roads (Fig. 2).

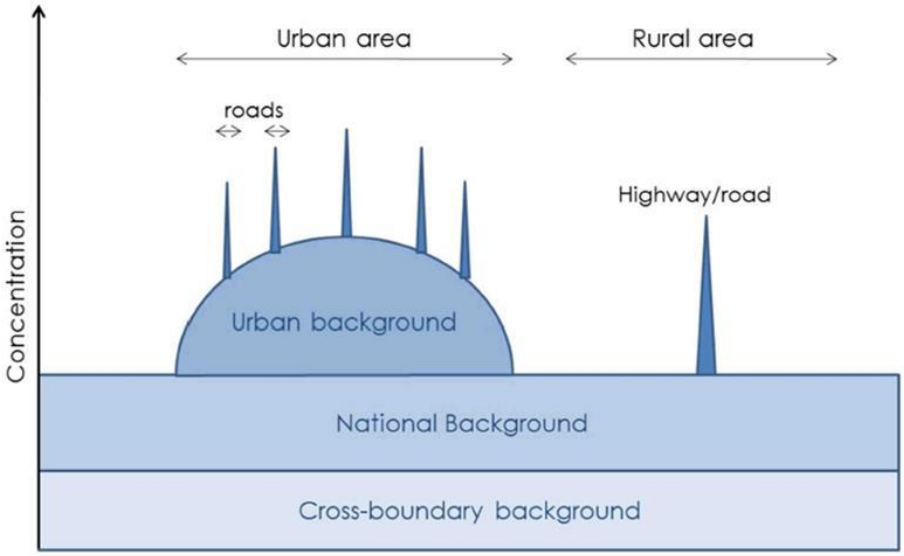


Fig. 2. Schematic overview of air quality in urban environments.

Every participant received two plants, one strawberry plant and one bird's-foot trefoil plant, for which they cared during the time of the experiment, which was May to July 2019. Plants were placed outside in the first week of May and leaf samples were collected at the end of June according to the protocol. During this period, particulate matter could be accumulated on the plant leaves. All leaf samples were send to and dried by the local project partners in each city, after which they were send to Antwerp, to be analysed in the lab of Environmental and Urban Ecology (EUREC-Air) at the department of Bioscience Engineering of the University of Antwerp.

Participants

Table 1 gives an overview of the number of registrants, participants and participants who delivered leaf samples for each city. Most of the participants who send in the samples, delivered a sample for both the strawberry and the bird's-foot trefoil plant, four participants from Poznan delivered only one of the two samples.

Table 1. Numbers of registrants, participants, and received samples for each city.

	registrants	participants	samples
Antwerp	74	65	45
Poznan	85	54	53
Tartu	140	87	81
Zürich	140	60	57
Total	**439**	**266**	**236**

For one third of the responding participants, the age of participating adults was between 31 and 40 years old. For more than two third of the responding participants, the adults have a university degree or higher. More than half of the responding participants had no children living (partially) at home. The other group had mostly one or two children of varying ages. For more than a quarter of the responding participants, at least one family member has encountered health problems related to the airways. In approximately half of the cases it is asthma and it was confirmed by a medical doctor. In 37% of these cases, the doctor made a link with air quality.

People participated for multiple reasons such as the importance of the topic of air quality (19%), they like to participate in scientific projects (17%), out of sympathy for the organizing research institutions (15%), because it is important to have enough flowers in the city for insects (14%), because they are concerned about the air quality in general (11%), because they want to show the importance of air quality to policy makers (10%), because they are concerned about local air quality (9%) or because they like to have free plants and strawberries (2%). The participants indicated that they wanted to learn more about the air quality in their city and in Europe.

Lab work and analysis

The amount of traffic-related particulate matter on the leaves can be estimated via a biomagnetic monitoring technique. In this technique, leaves are magnetised and the remaining magnetic field is measured. In this way the SIRM (saturation isothermal remanent magnetisation) can be determined which is a measure for the amount of traffic-related particulate matter. This sort of measurements cannot be compared directly to measurements of classical air monitoring stations because they measure particulate matter in another way.

To avoid mold on the samples, samples were dried by each project partner before sending them to Antwerp for further analysis. This is why we could not work with the leaf area directly as was done in previous projects. We had to use a conversion factor to convert dry weight into fresh leaf area for each species grown in every city (Table 2). To obtain the final normalized value (nSIRM), the magnetic signal was divided by the calculated fresh leaf area of the sample.

Table 2. Conversion factors for each species in every city, to convert dry weight (DW) into fresh leaf area (LA). N is the number of leaves used to calculate the conversion factor.

	strawberry	N	bird's-foot trefoil	N
Antwerp	LA = 5.6414 * DW	26	LA = 3.3958 * DW	30
Poznan	LA = 5.3197 * DW	21	LA = 4.4933 * DW	31
Tartu	LA = 6.0471 * DW	30	LA = 5.5794* DW	30
Zürich	LA = 4.9632 * DW	17	LA = 3.2495 * DW	30

Results

In this report we show results not normalised for the actual exposure time. On an exposure of approximately two months it will not make a difference if the actual exposure time between the samples of participants deviated a few days. For further statistical analysis, the exact duration of exposure will be taken into account. In the maps in this report (Fig. 4 and 5 and Fig. A1 – A8) we will only show values of participants who filled in the final project survey (N=234). Later on we will try to complete the dataset and make maps with the data from the other participants as well.

Table 3. Overview of nSIRM data for strawberry plants in all cities (Antwerp, Poznan, Tartu and Zürich) and for all cities together (Europe).

strawberry nSIRM (µA)	*Antwerp*	*Poznan*	*Tartu*	*Zürich*	*Europe*
Mean	22.19 µA (± 18.69)	15.61 (± 15.60)	4.69 (± 3.23)	18.44 (± 28.41)	15.23 (± 7.53)
Median	16.97	10.31	3.91	8.34	8.19
Percentile 0%	3.98	2.24	0.74	2.68	0.74
Percentile 20%	10.81	7.90	2.03	4.56	3.91
Percentile 40%	13.54	8.87	3.61	7.05	6.43
Percentile 60%	19.30	14.33	4.50	9.04	9.71
Percentile 80%	27.12	20.32	6.39	20.64	18.29
Percentile 100%	88.75	102.10	18.30	157.46	157.46

Table 4. Overview of nSIRM data for bird's-foot trefoil plants in all cities (Antwerp, Poznan, Tartu and Zürich) and for all cities together (Europe).

Bird's-foot trefoil nSIRM (µA)	*Antwerp*	*Poznan*	*Tartu*	*Zürich*	*Europe*
Mean	5.85 (± 3.13)	6.29 (± 6.07)	2.08 (± 3.48)	3.84 (± 5.11)	4.51 (± 1.94)
Median	5.38	4.67	1.20	2.11	2.62
Percentile 0%	1.86	1.17	0.08	0.29	0.08
Percentile 20%	3.13	2.88	0.53	1.22	1.09
Percentile 40%	4.35	4.05	1.02	1.79	2.11
Percentile 60%	5.89	5.39	1.62	2.37	3.66
Percentile 80%	7.75	7.47	2.54	5.31	5.93
Percentile 100%	16.27	37.70	28.71	30.79	37.70

In almost all measuring locations considered (N=221), the magnetic value of the strawberry leaves (red in Fig. 3) was higher than that of the trefoil leaves (blue in Fig. 3).

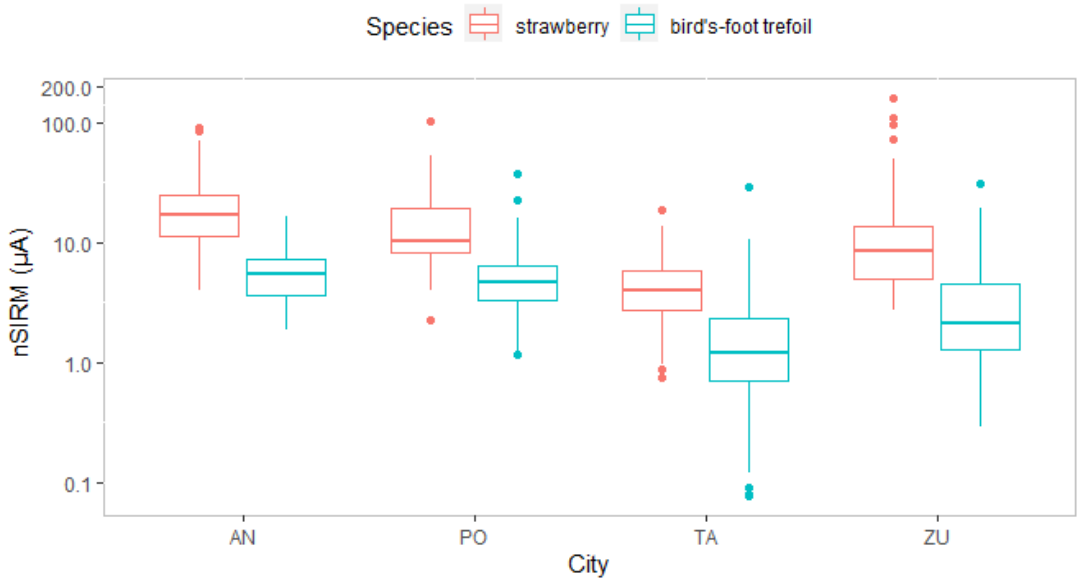


Fig. 3. Boxplots showing the distribution of nSIRM data for both species (strawberry in red, bird's-foot trefoil in blue) for each city (AN= Antwerp, PO = Poznan, TA = Tartu and ZU = Zürich).

On average, the magnetic values of the strawberry leaves were more than four times higher than the magnetic value of the leaves of the co-located trefoil. This means that **strawberry leaves are more effective at accumulating particles than bird's-foot trefoil leaves**. This can be explained by the presence of so-called "trichomes", forming a densely hairy surface of the strawberry leaves, while the trichomes on the trefoil leaves are sparser. These hair-like protrusions on the leaf surface are very effective at "trapping" particulate matter, by increasing the leaf's exposed area upon which the particles can be deposited as well as by hindering the removal of deposited particles from the surface by rain and wind.

The considered locations in Antwerp and Poznan did not significantly differ in magnetic signal of the leaves, but Antwerp and Poznan locations had significantly higher magnetic values than the locations considered in Zürich and Tartu. The locations in Tartu showed the lowest leaf magnetic values, which were significantly lower than those of the plants sampled in the three other cities. The same ordering and differences between locations from different cities emerged for both species studied in this citizen science project. With the precondition that the main source of particulate matter in these cities considered is similar (i.e., traffic emissions), these results indicate that **the plants in Zürich and particularly in Tartu are exposed to lower levels of particulate matter in the atmosphere than the plants in Poznan and Antwerp**. If, however, significant emissions of metal-processing industries or railway traffic in the near vicinity of the sampling locations cannot be excluded, such conclusions regarding PM exposure are not valid. Railway traffic (i.e., by abrasion of wheels, brakes, tracks, pantograph and overhead line from trams and trains) may lead to a disproportionate increase in leaf magnetic values within a 50 to 100 m distance from the tracks. Results of locations within near vicinity of railway traffic or metal-processing industry should be interpreted with care. Keep in mind that the results of this citizen science campaign cannot provide conclusions on the comparison of entire cities, but it does provide an indication that a location in Zürich and Tartu in particular has a bigger chance of having lower particulate matter concentrations than a location in Poznan or Antwerp.

When comparing values for strawberry and bird's-foot trefoil samples in each city (Fig. 4), we found that in general more or less the same patterns occurred for both species. When the magnetic signal (nSIRM values) for strawberry samples are located in the lower percentiles, we see that the magnetic signal for bird's-foot trefoil also tend to be located in the lower percentiles. The same is true for the higher magnetic signals.

There can be large differences in magnetic signals of leaves between locations, even on a very small scale. The air quality can vary a lot within one city. This is due to a large amount of local sources of particulate matter and the limited ventilation and dilution of air pollution within cities. Especially in high traffic roads with little ventilation (often street canyons) high nSIRM values can be expected.

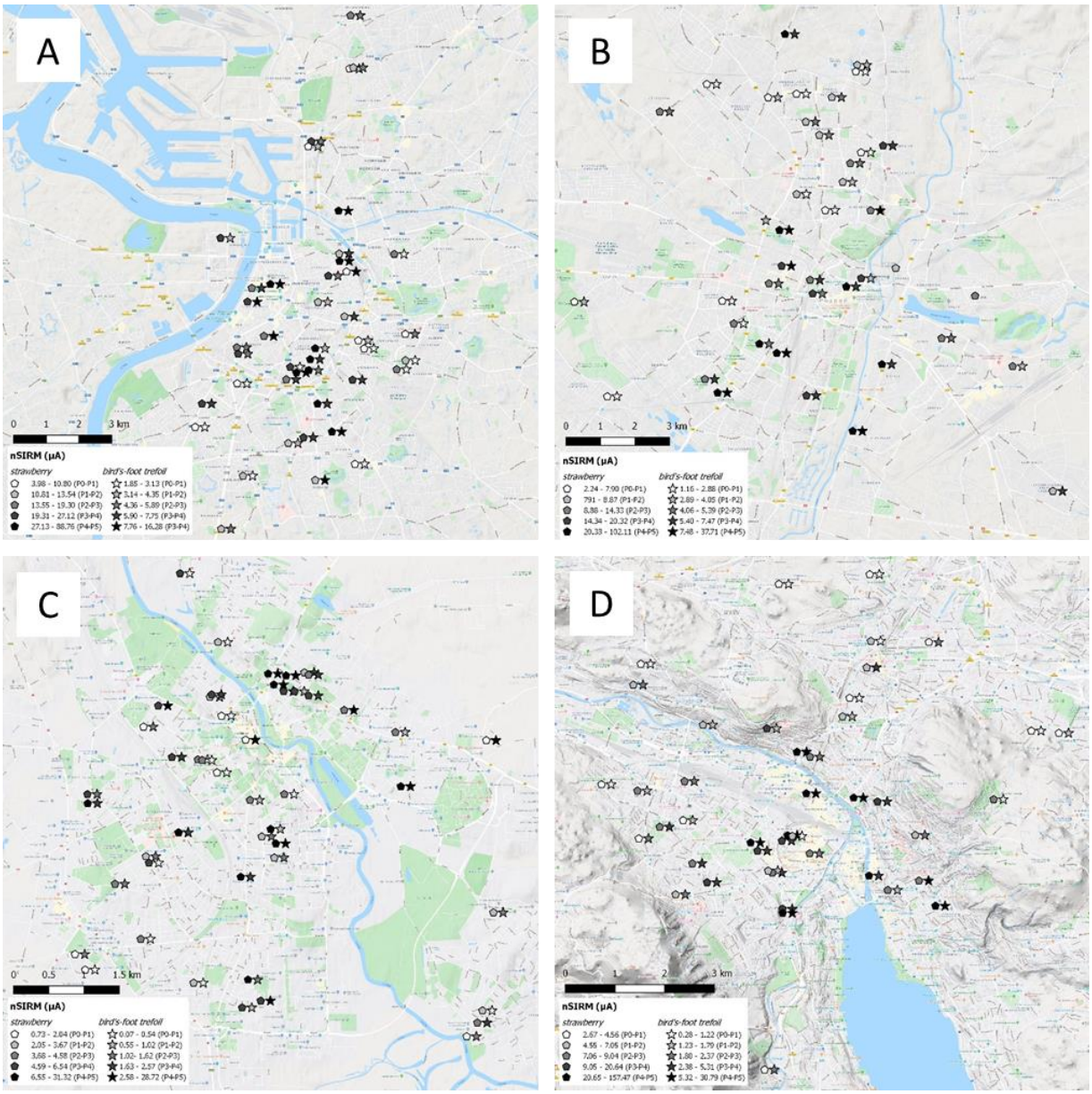


Fig. 4. Maps with results for each city. Values are divided in bins of equal amount of values. Values are compared for each city separately. A = Antwerp, B = Poznan, C = Tartu and D = Zürich. Larger images are available in the appendix (Fig. A1 – A4).

When we consider nSIRM values of both strawberry and bird'-foot trefoil for each city in comparison with all values (referred to as values for Europe, Fig. 6), we see clear differences between the cities. For Antwerp, most of the values (for both strawberry and bird's-foot trefoil) are at the upper half of the values for Europe. The same applies to the values for Poznan. For Tartu, most of the values (for both strawberry and bird's-foot trefoil) are at the lower half of the values for Europe. For Zürich, nSIRM values of both species have a wide range, with values going from very low as compared to other values in Europe to the highest values in Europe. On the map of Zürich, we see a gradient with higher nSIRM values in the center of the city and lower nSIRM values going to the city border.

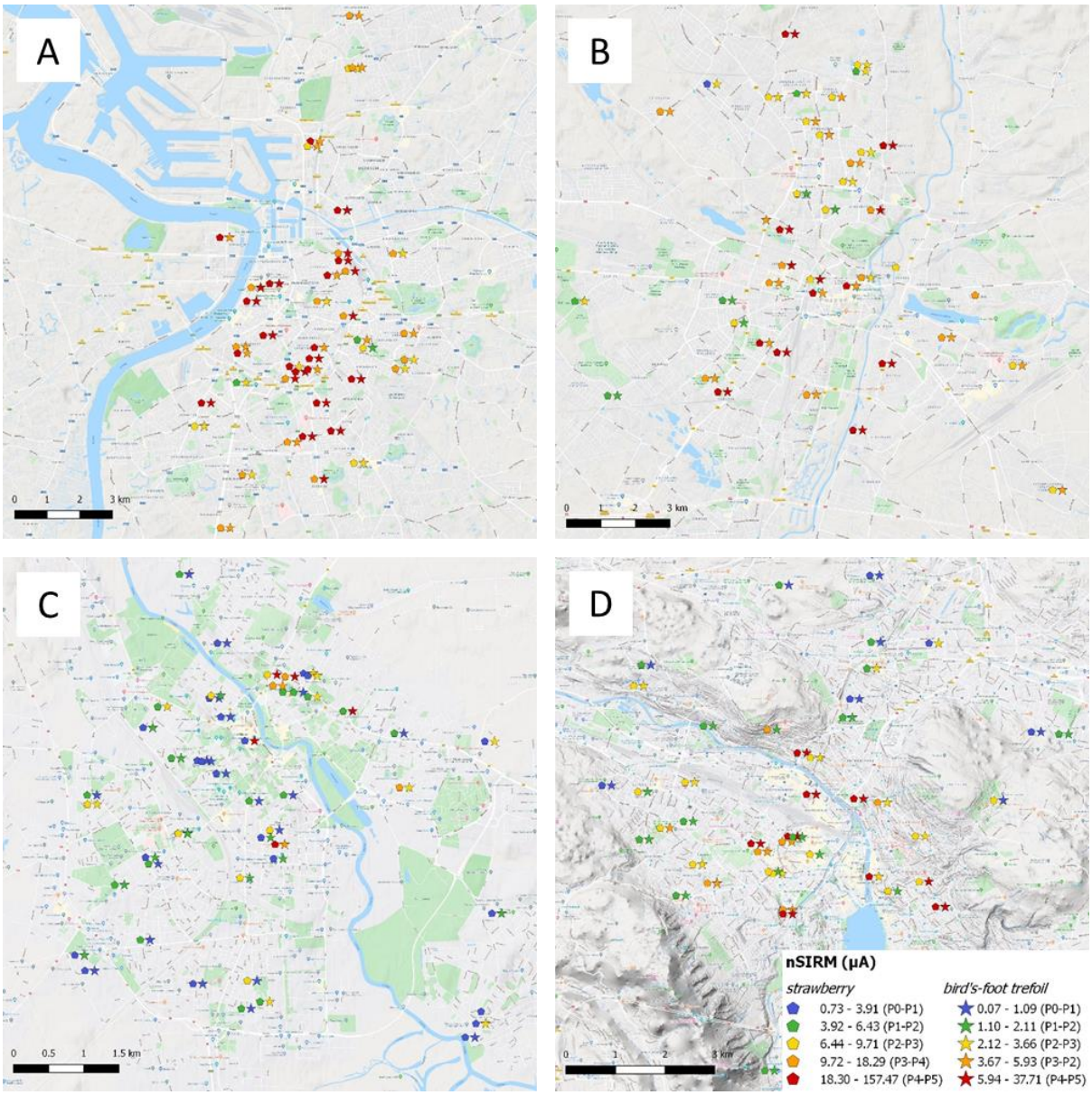


Fig. 5. Maps or results for each city. Values are divided in bins of equal amount of values. Values for each location are compared with all the values in Europe. A = Antwerp, B = Poznan, C = Tartu and D = Zürich. Larger images are available in the appendix (Fig. A5 – A8).

Funding and project partners

The strawbAIRies project took place in the scope of the BIOVEINS project. The BIOVEINS project was funded by the Horizon 2020 BiodivERsA call.
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Appendix

Here you can find larger images of the figures that were already shown in the results section.

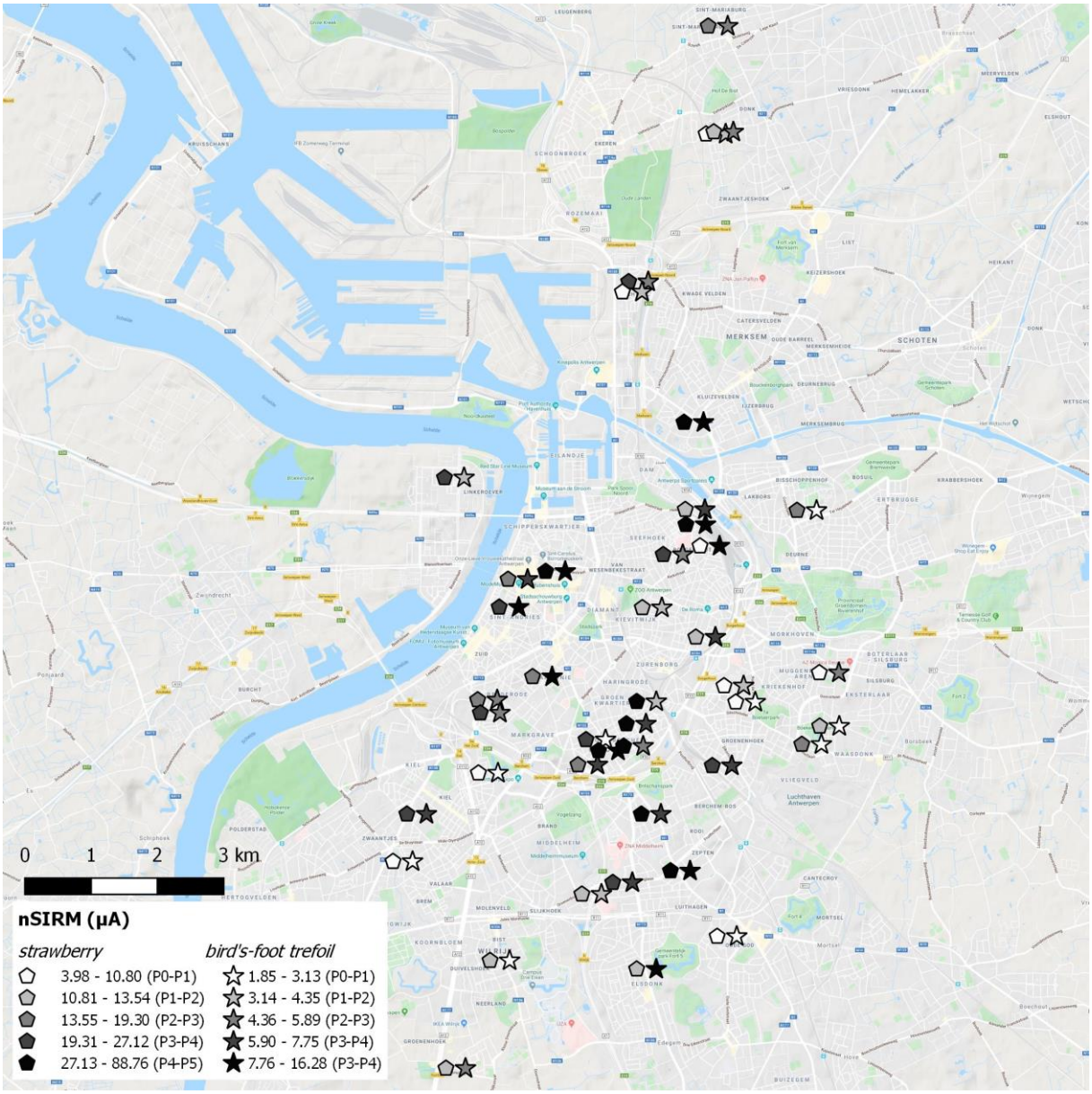

Fig. A1. Results of nSIRM values for Antwerp. Values are divided in bins of equal amount of values. Pentagons represent values for strawberry and stars represent values for bird's-foot trefoil.

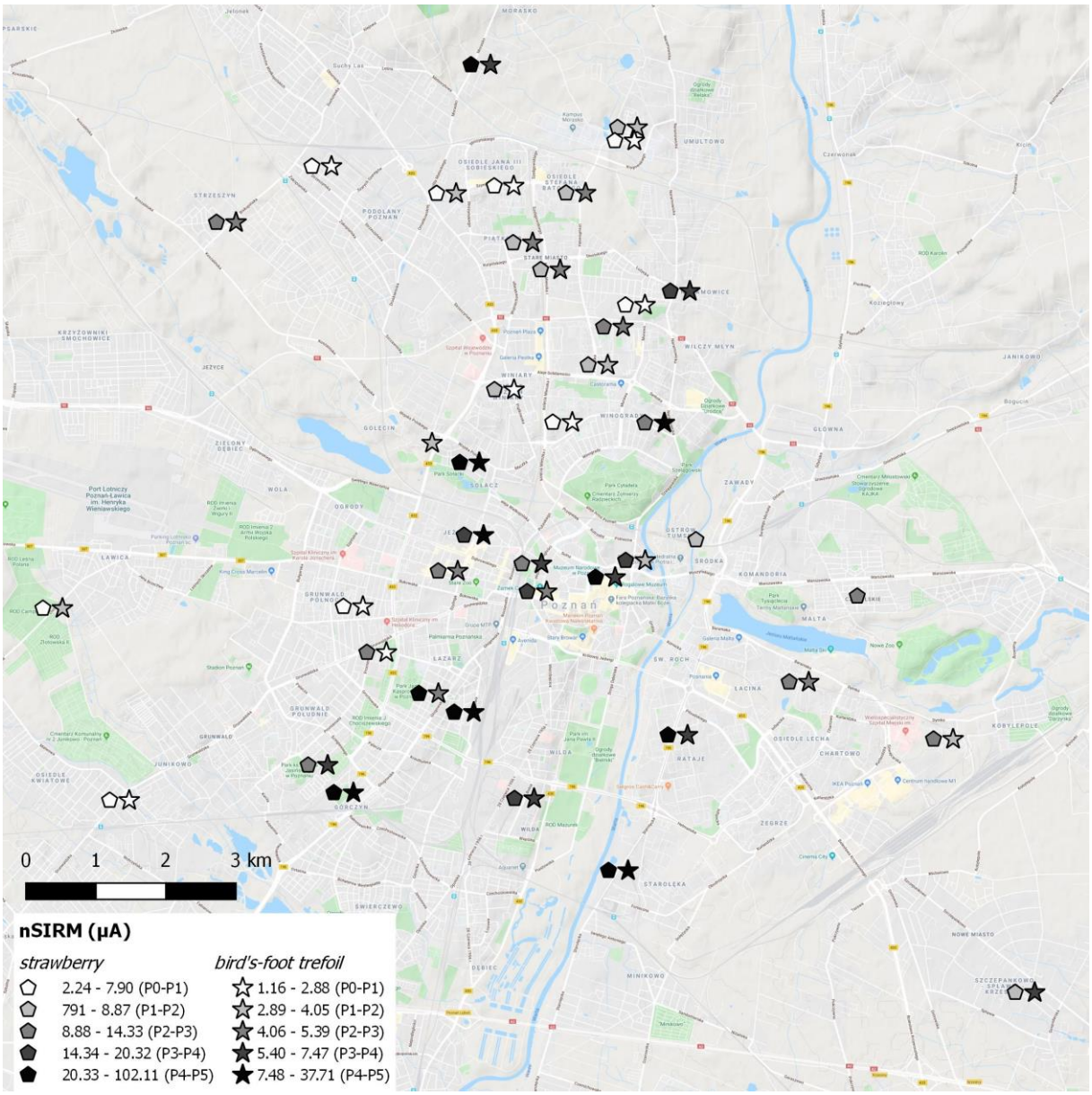

Fig. A2. Results of nSIRM values for Poznan. Values are divided in bins of equal amount of values. Pentagons represent values for strawberry and stars represent values for bird's-foot trefoil.

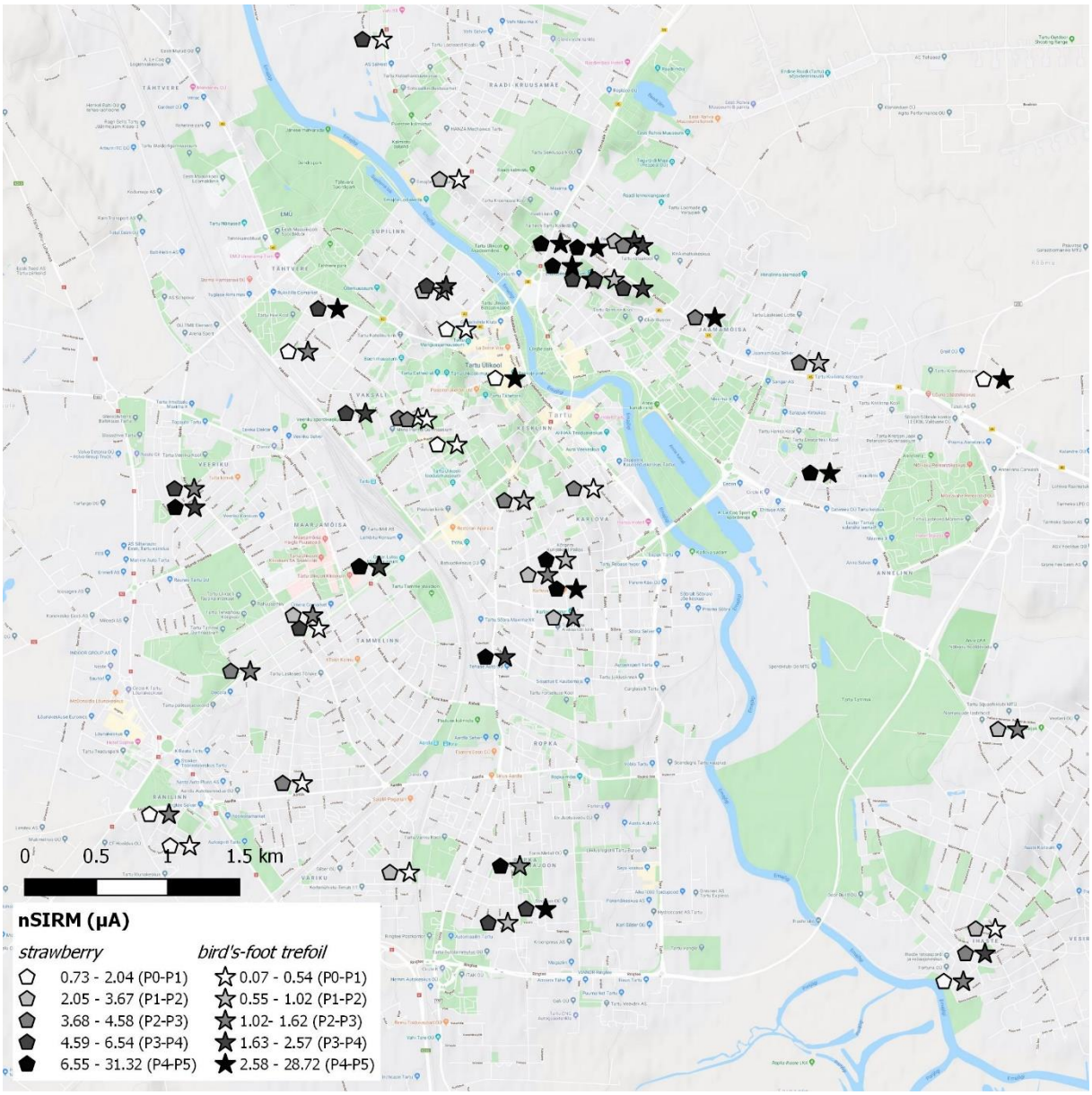

Fig. A3. Results of nSIRM values for Tartu. Values are divided in bins of equal amount of values. Pentagons represent values for strawberry and stars represent values for bird's-foot trefoil.

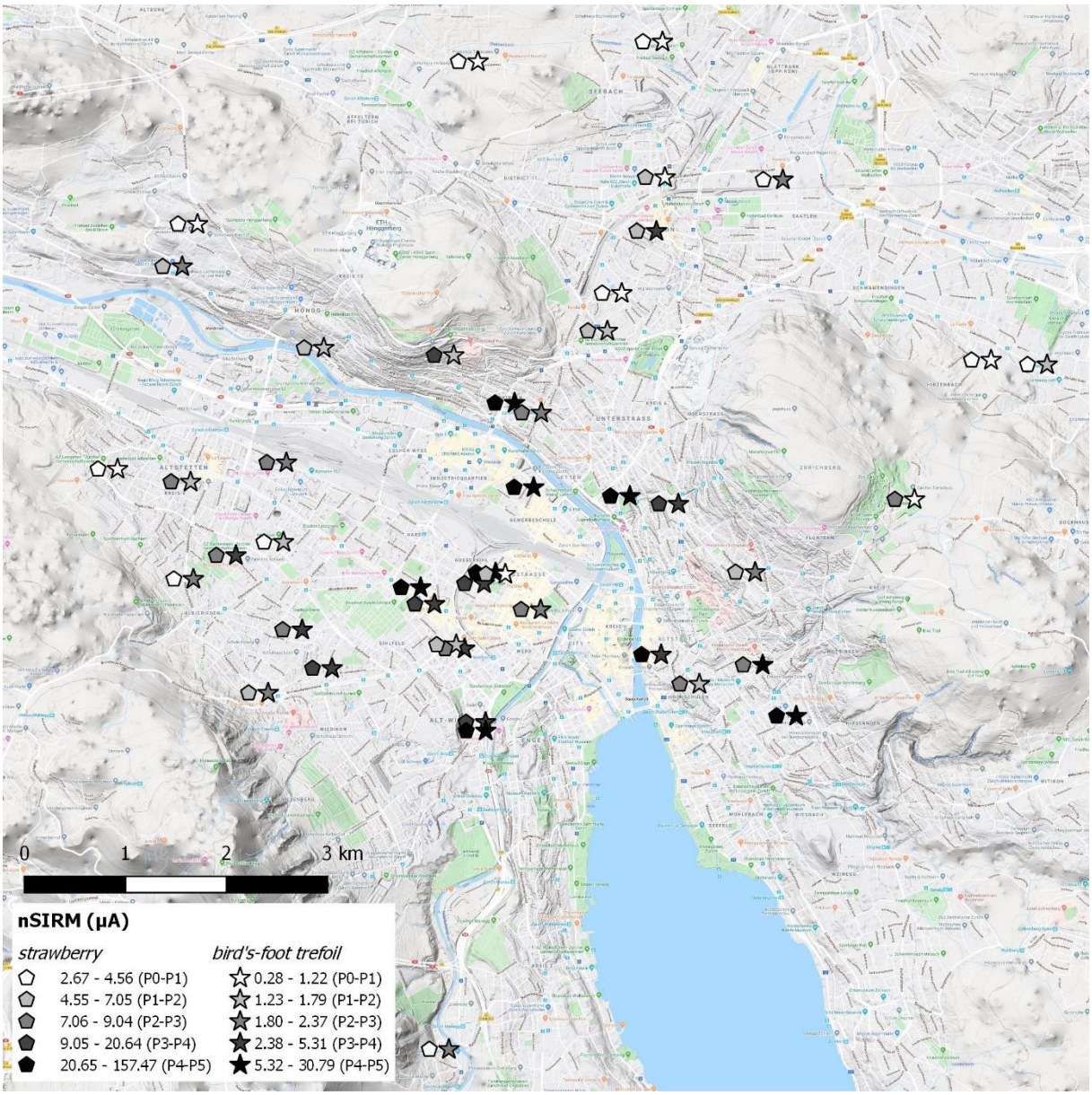

Fig. A4. Results of nSIRM values for Zürich. Values are divided in bins of equal amount of values. Pentagons represent values for strawberry and stars represent values for bird's-foot trefoil.

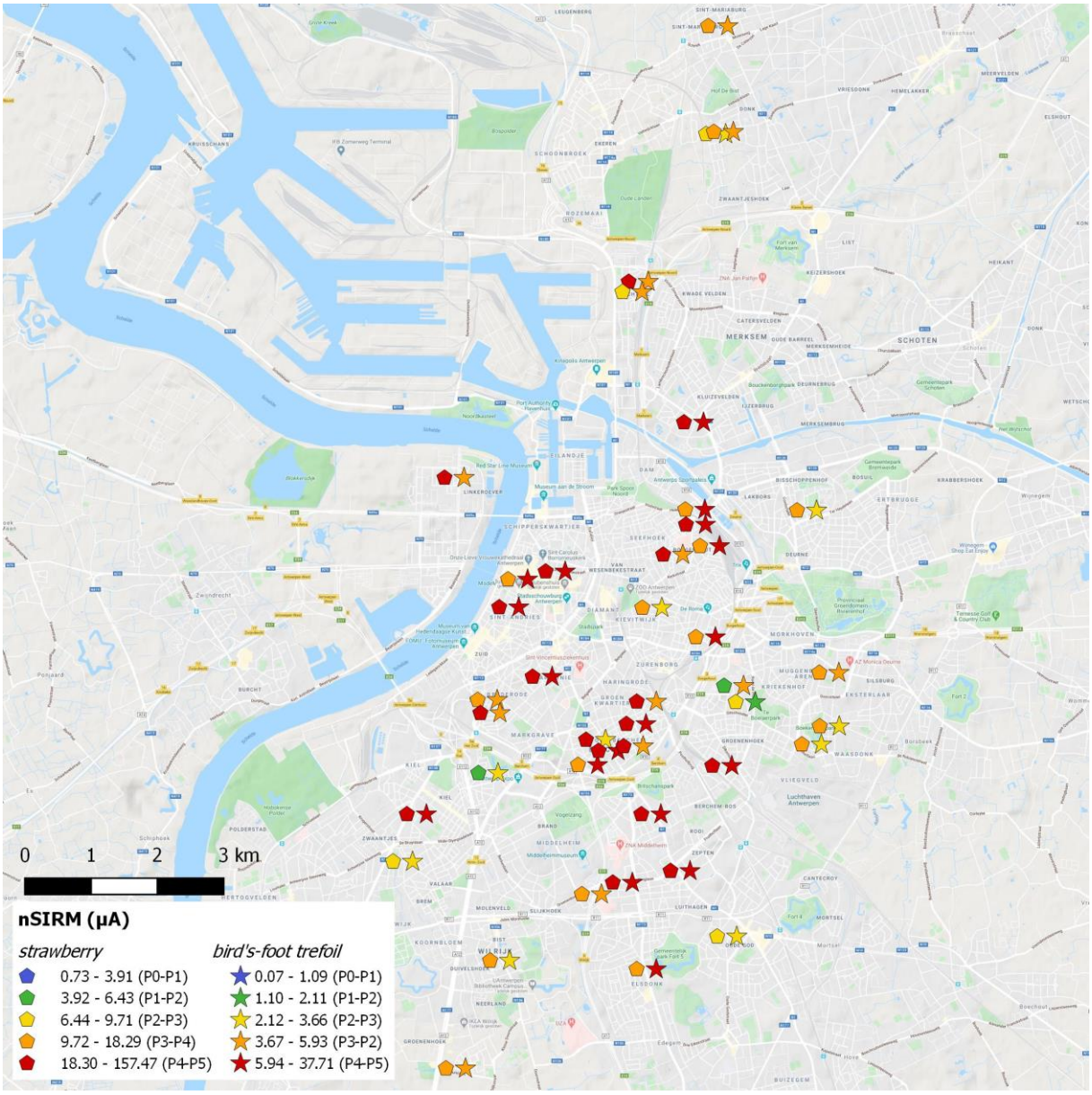

Fig. A5. Results of nSIRM values for Antwerp. Values are divided in bins of equal amount of values. Values are compared with all the values in Europe. Pentagons represent values for strawberry and stars represent values for bird's-foot trefoil.

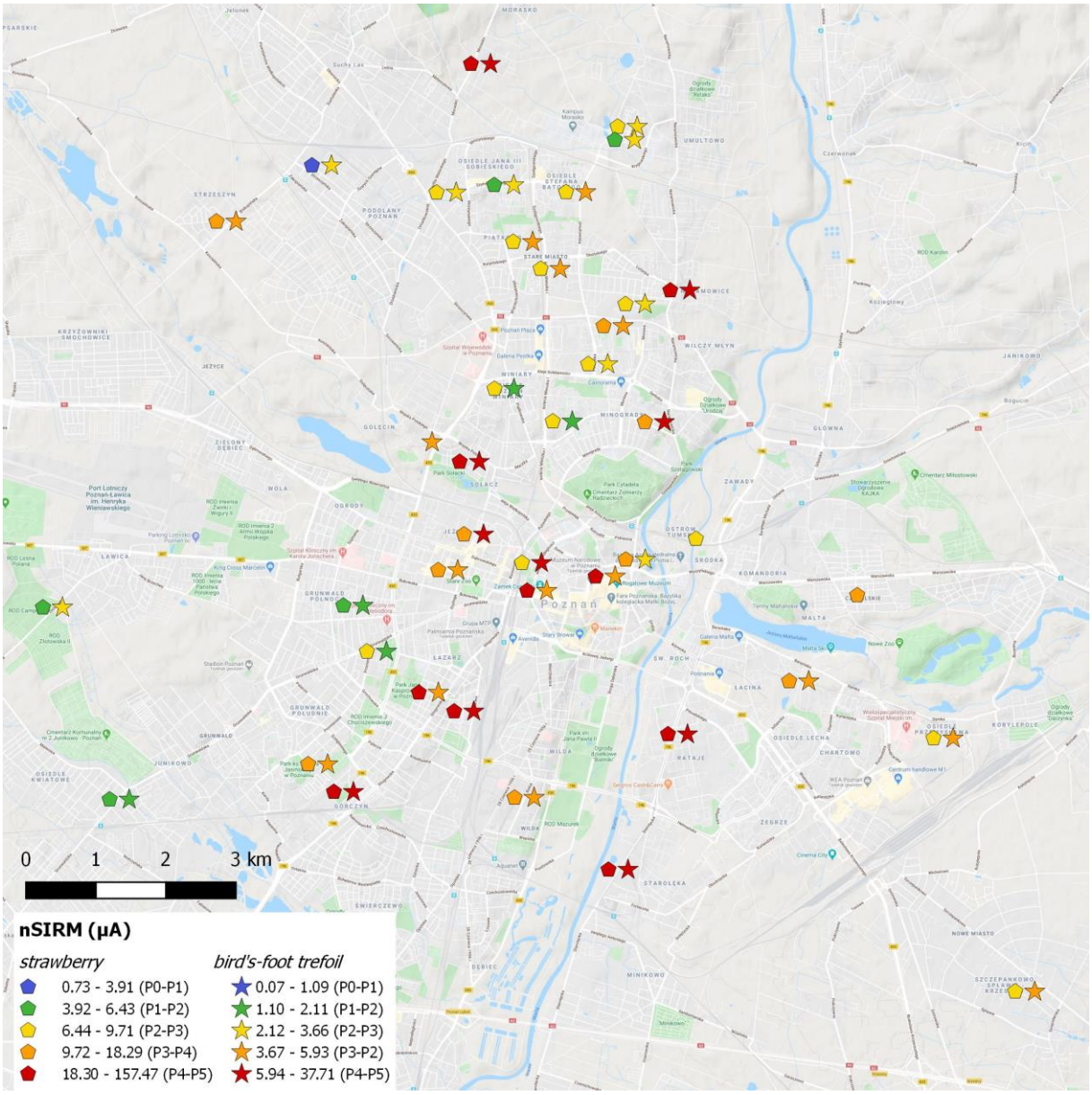

Fig. A6. Results of nSIRM values for Poznan. Values are divided in bins of equal amount of values. Values are compared with all the values in Europe. Pentagons represent values for strawberry and stars represent values for bird's-foot trefoil.

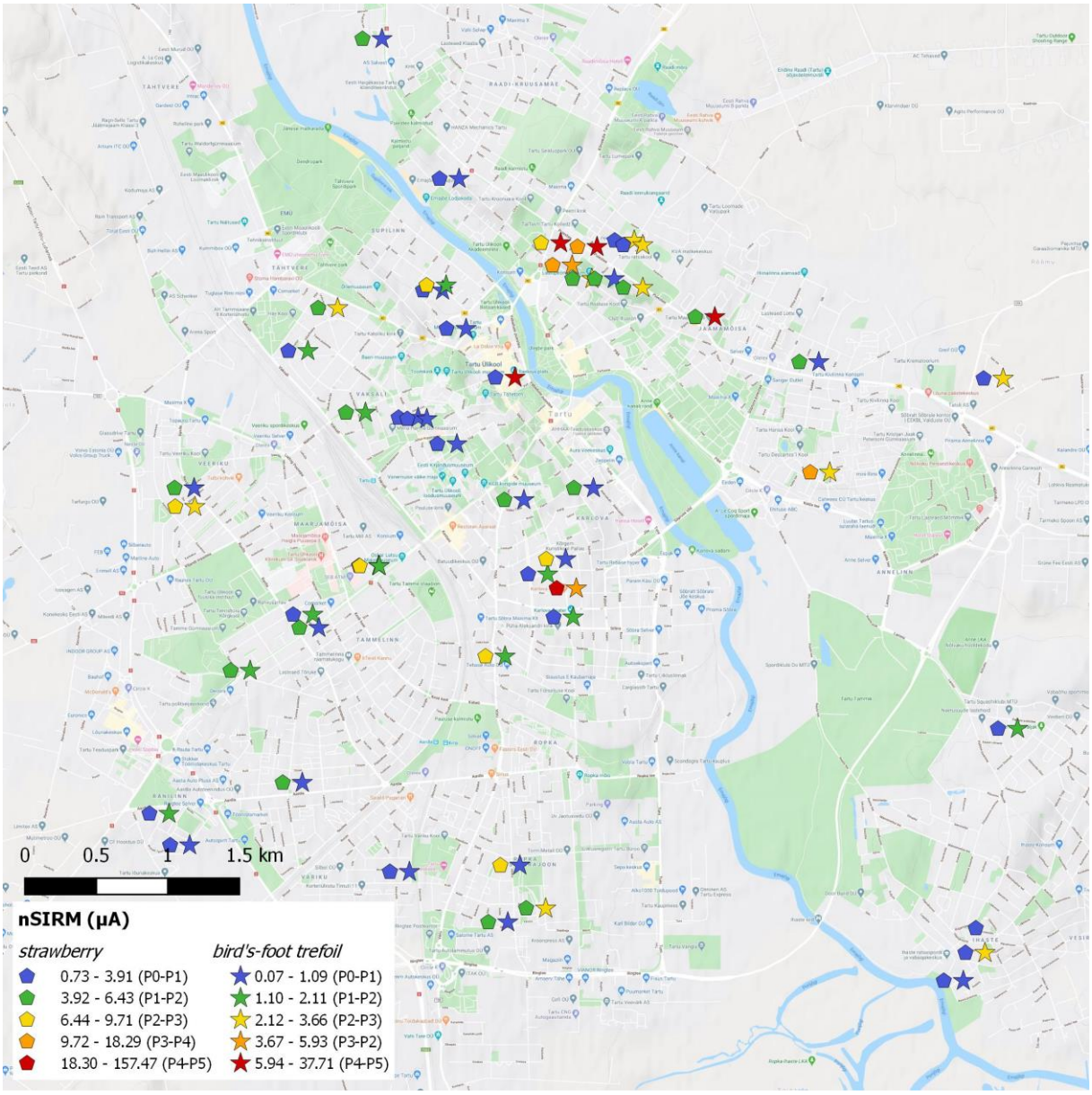

Fig. A7. Results of nSIRM values for Tartu. Values are divided in bins of equal amount of values. Values are compared with all the values in Europe. Pentagons represent values for strawberry and stars represent values for bird's-foot trefoil.

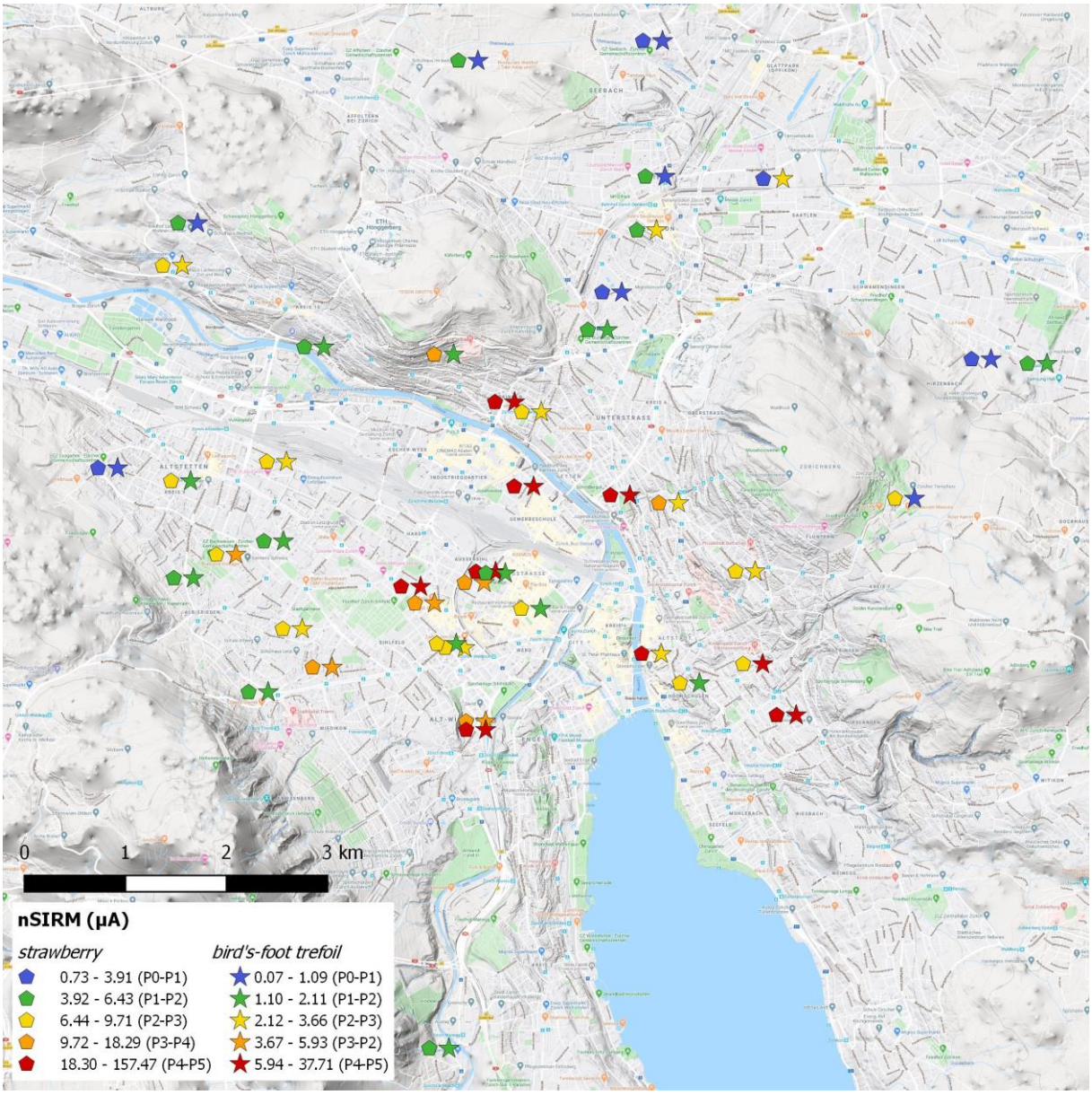

Fig. A8. Results of nSIRM values for Zürich. Values are divided in bins of equal amount of values. Values are compared with all the values in Europe. Pentagons represent values for strawberry and stars represent values for bird's-foot trefoil.