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NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH

Pesticides are all Around us

a Case Study from Orchards in Western Norway

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Why?

Pesticides are widely used in conventional agriculture, yet their environmental distribution in orchard systems remains poorly characterized. In Norway, pesticide monitoring is conducted through the Norwegian Agricultural Environmental Monitoring Programme (JOVA) but limited to five catchments, primarily representing cereals, potatoes, vegetables, and grass production, with orchard systems largely excluded. To address this gap, targeted studies have been conducted since 2019 in a major orchard area in Western Norway. Multiple environmental compartments—including water, soil, vegetation (wildflowers), air, and insects—have been systematically sampled at several locations, included in one organic orchard. Samples have been analyzed for pesticides and metabolites using LC-HRMS (Q-Orbitrap, modell Q Exactive) for water analyses and LC-MS/MS for other analyses. Here, we show some of the methods used and present a selection of results from these projects.



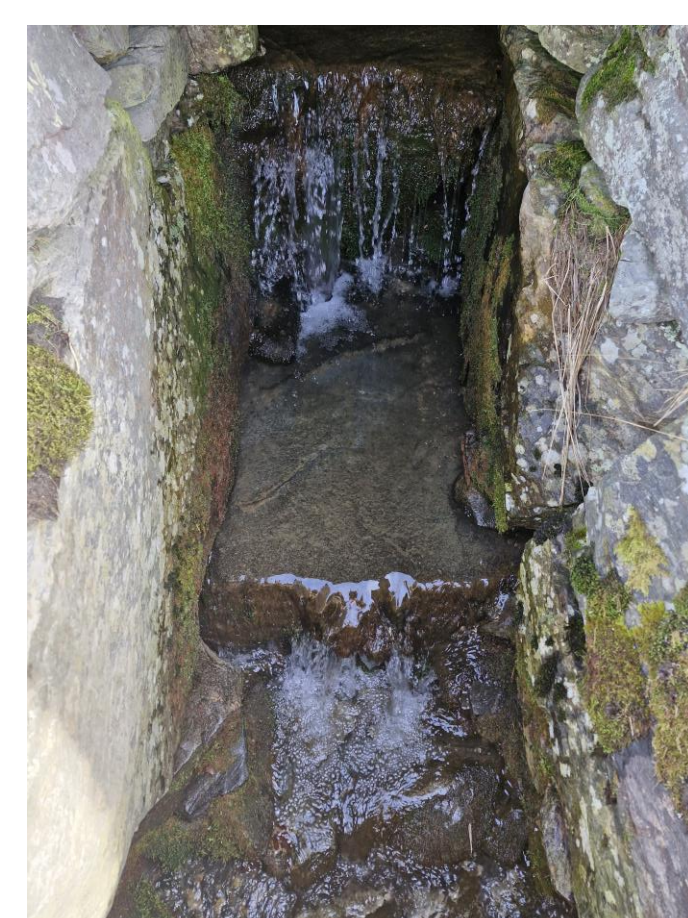
Study area. Four locations along Sørfjorden in Hardanger.

What did we do?

Water sampling



Daily water samples were taken from two small streams running through the orchards. Sampling was done daily with an ISCO sampler, but weekly mixed samples were analyzed. Sampling was done from April to October/November over two years.



A drain outlet was sampled manually.



Benthic animals were collected to assess the ecological status of the streams. Results not shown.

Sampling of soil, vegetation and hoverflies



Topsoil, flowering plants and hoverflies (Syrphidae) were sampled in 3-4 plots in 4 locations.

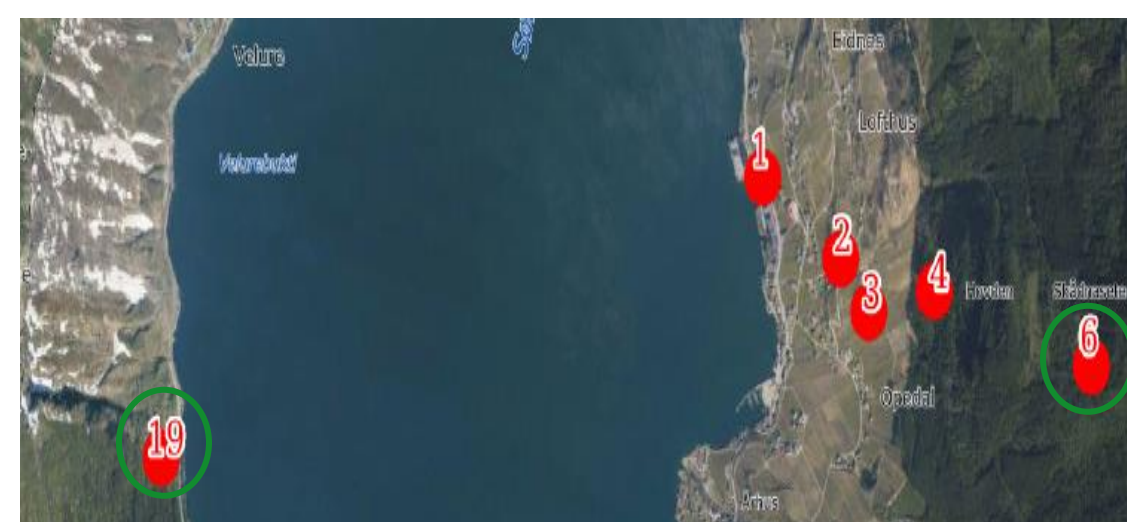


Sampling of air



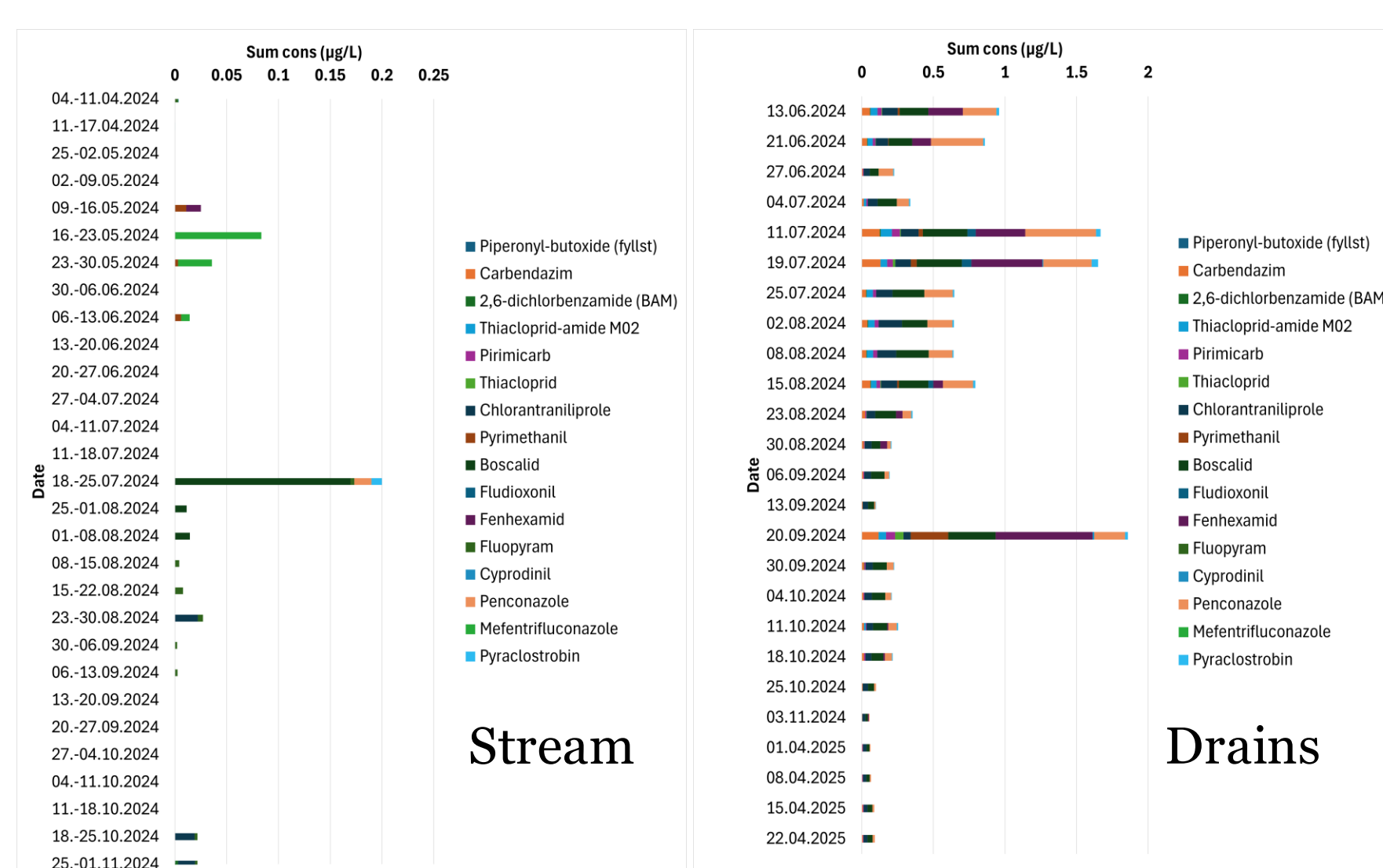
Passive sampling with PUF through the growth season (ca. 3 months) along transects through the orchards in the 4 locations.

Sampling also further away from orchards, on the other side of the fjord as well as higher up in the mountain sides.



Active air sampling for 1 week-long periods every month during the growth season to get the general background concentrations.

What did we find?

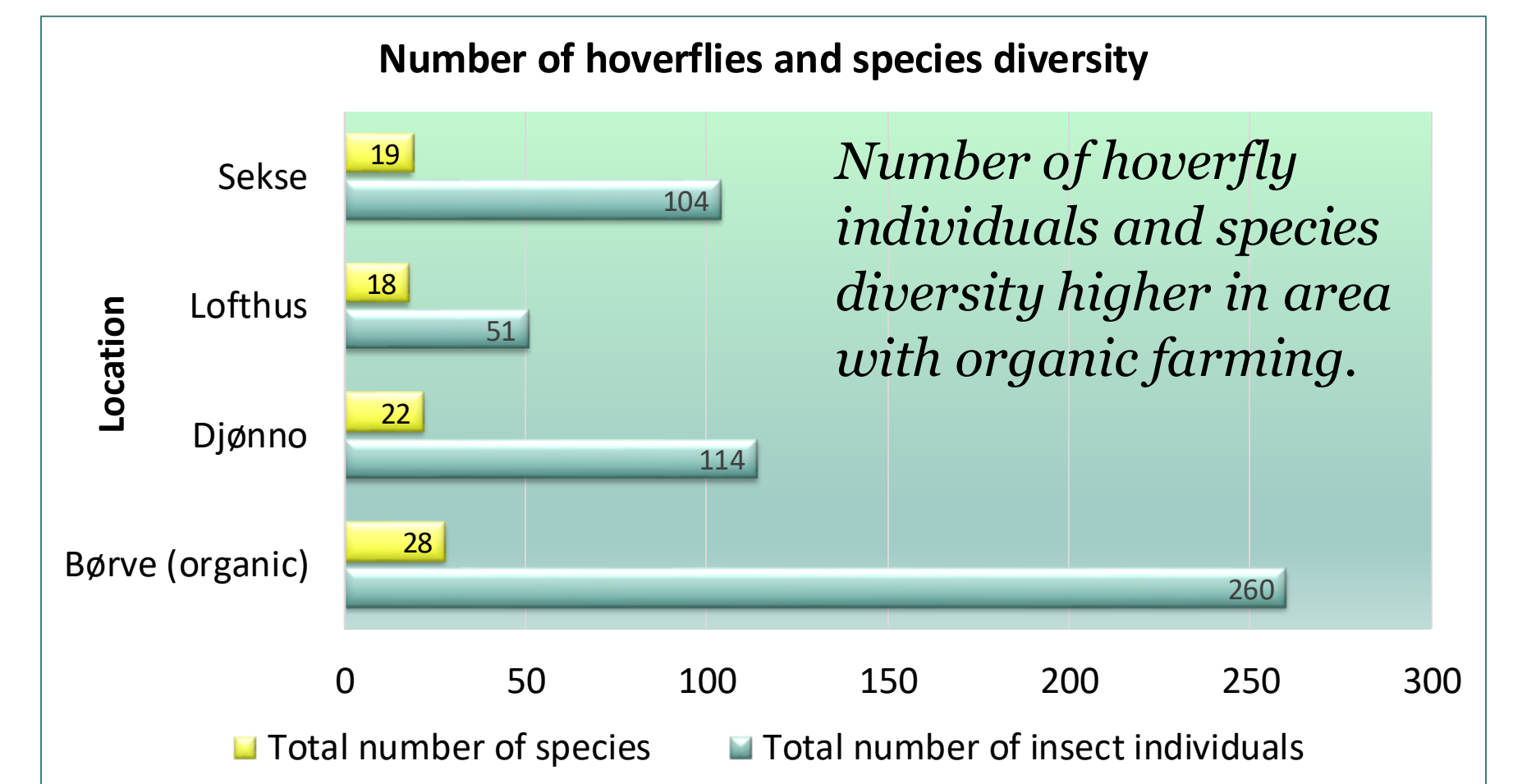


Generally, low concentrations were detected in surface water compared to other monitoring sites in areas with annual crops, and rarely in levels toxic to aquatic organisms. At least 10x higher concentrations in drainage water from orchards. Results from only one of the streams are presented here.

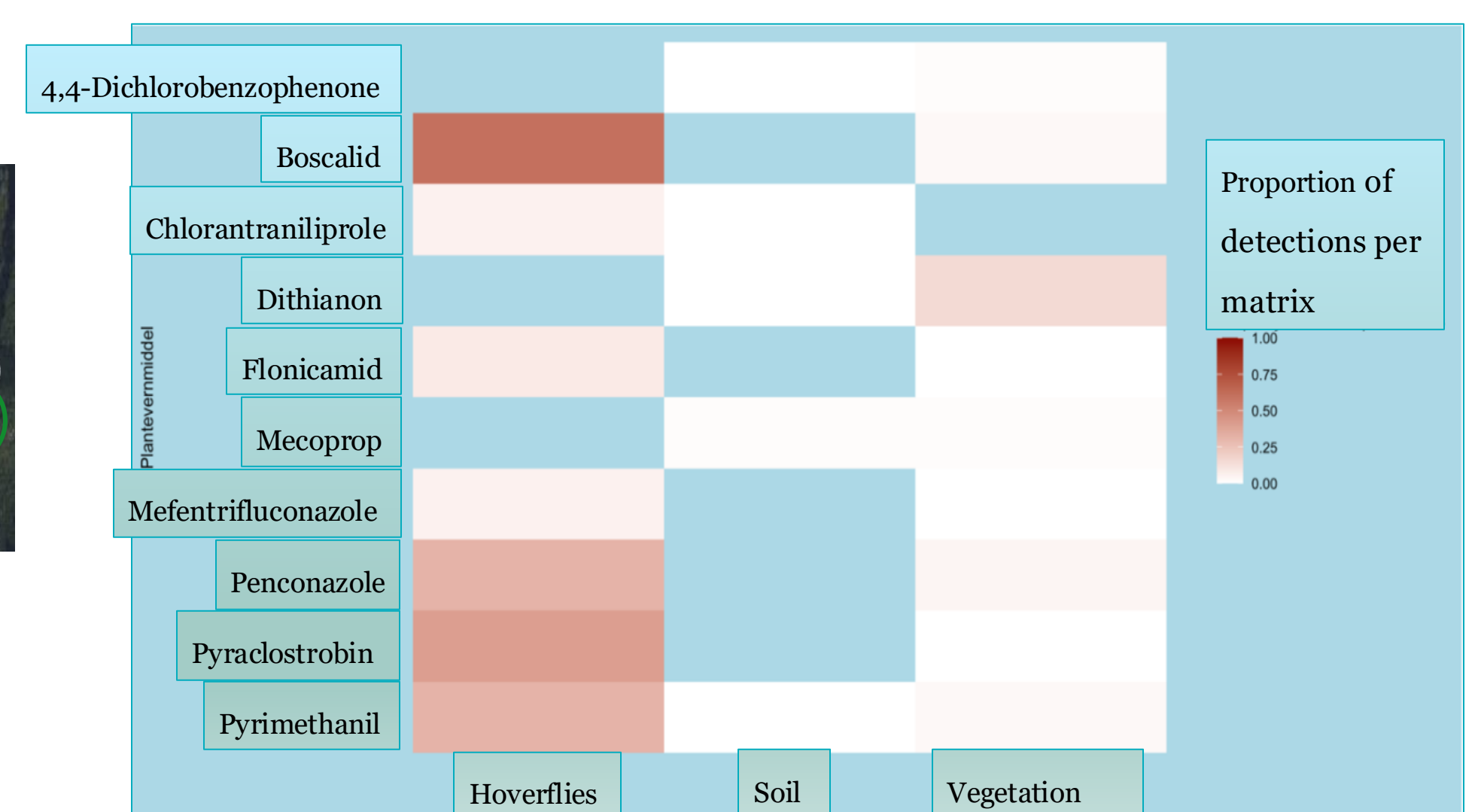
Location	Matrix/Compartment	Pesticide detected	Pesticide type	Reg. in Norway	Max conc. (mg/kg)
BØR**	Vegetation	-	-	-	-
BØR**	Soil	DDT (sum)	Insecticide	No	0.13
DJØ	Vegetation	Fonicamid	Insecticide	Yes	0.018
DJØ	Soil	DDT (sum)	Insecticide	No	4.9
DJØ	Soil	4,4-Dichlorobenzophenone	Insecticide*	No	0.012
DJØ	Vegetation	Boscalid	Fungicide	Yes	0.29
DJØ	Vegetation	Dithianon	Fungicide	Yes	25.7
DJØ	Vegetation	Fenhexamid	Fungicide	Yes	1.2
DJØ	Vegetation	Penconazole	Fungicide	Yes	0.24
DJØ	Vegetation	Pyraclostrobin	Fungicide	Yes	0.032
DJØ	Vegetation	Pyrimethanil	Fungicide	Yes	4.5
DJØ	Soil	Dithianon	Fungicide	Yes	0.019
DJØ	Soil	Pyrimethanil	Fungicide	Yes	0.024
LOF	Soil	Antraquinone	Insecticide	No	0.046
LOF	Soil	DDT (sum)	Insecticide	No	0.83
LOF	Vegetation	Boscalid	Fungicide	Yes	0.042
LOF	Vegetation	Dithianon	Fungicide	Yes	0.15
LOF	Vegetation	Mefentrifluconazole	Fungicide	Yes	0.018
LOF	Vegetation	Pyraclostrobin	Fungicide	Yes	0.011
LOF	Vegetation	Pyrimethanil	Fungicide	Yes	0.038
SEK	Soil	Chlorantraniliprole	Insecticide	No	0.019
SEK	Soil	DDT (sum)	Insecticide	No	3.6
SEK	Vegetation	4,4-Dichlorobenzophenone	Insecticide*	No	0.11
SEK	Soil	4,4-Dichlorobenzophenone	Insecticide*	No	0.013
SEK	Vegetation	Penconazole	Fungicide	Yes	0.011
SEK	Vegetation	Mecoprop	Herbicide	Yes	3.5
SEK	Soil	Mecoprop	Herbicide	Yes	1.3

*Metabolite of insecticides dicofol. and DDT. ** Organic production in recent years.

Generally, low concentrations were detected in soil and vegetation, compared to soils under annual crops seen in other studies in Norway. The old "sin" DDT was more frequently detected at higher concentrations than many of the currently used pesticides.



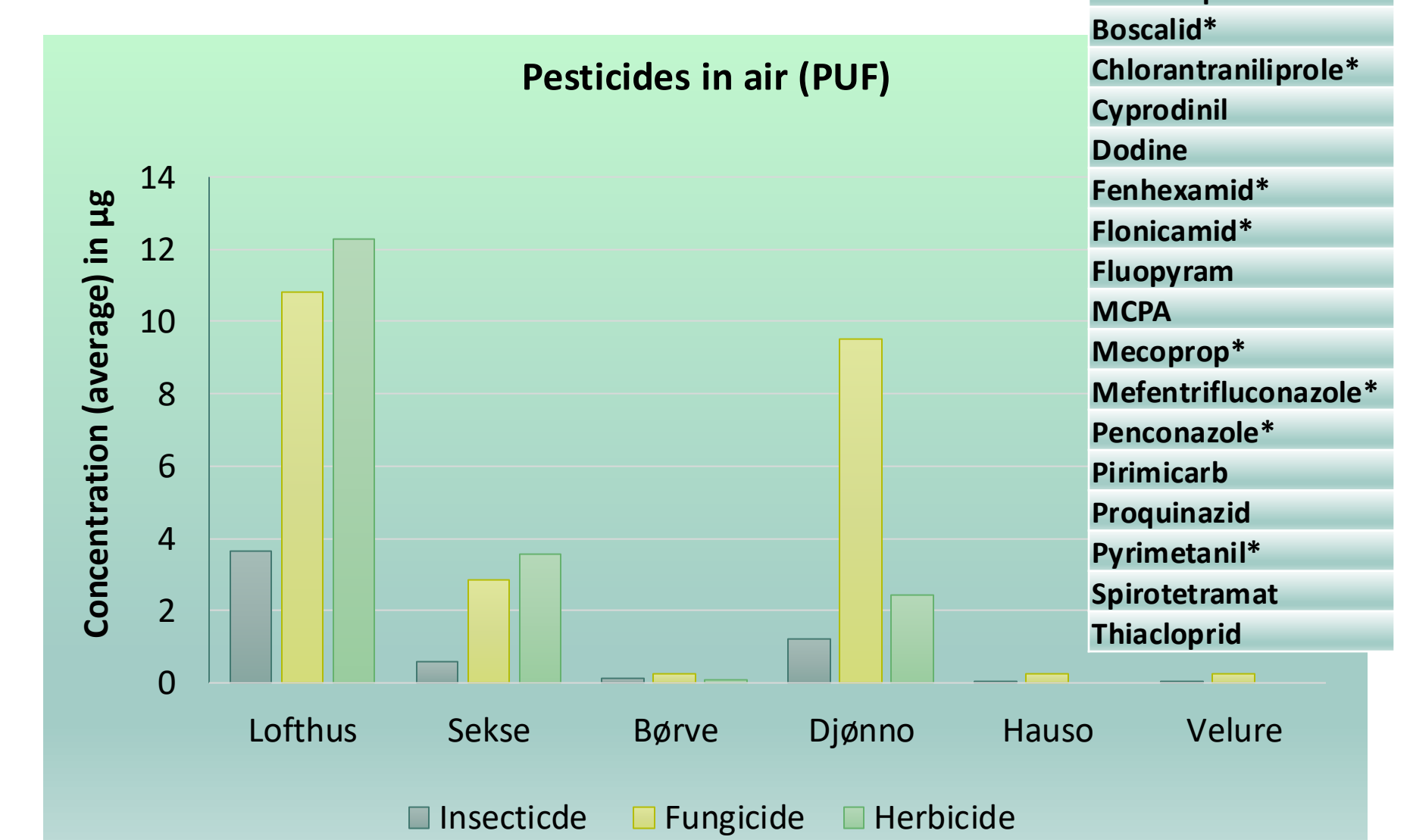
Number of hoverfly individuals and species diversity higher in area with organic farming.



Heat map showing pesticides detected in at least two of three compartments; hoverflies, soil or vegetation. Darker red indicates more frequent detections. White indicates very few detections and blue no detections. The fungicide boscalid is found frequently in hoverflies, infrequently in vegetation and not at all in soil. The fungicide pyrimethanil is the only pesticide detected in all three compartments.

	Børve (organic)	Djønno	Lofthus	Sekse
Samples with at least one detection, %	93	100	100	100
Average number of pesticides per sample	3.7	4.8	4.5	4
Average concentration per sample, ng/g	4	41	885	162

Slightly fewer samples of hoverflies sampled in organic fields contained pesticides as well as lower average number of pesticides and lower total concentrations detected per sample.



This figure shows the summarized amount of pesticides based on the average amount detected across the PUF samplers at the different locations. Included are also two "control" locations; Hauso and Velure across the fjord from the other sites. We can clearly see the differences between locations, with the most intensive orchard area, Lofthus, showing the highest amounts. Pesticides detected are listed in the table.

Main conclusions

- Pesticides were detected across multiple compartments, showing they disperse beyond the application area.
- Surface water generally showed low concentrations, while drainage water had around 10x higher levels.
- Air monitoring captured background and seasonal presence, with highest detections in conventional and intensive run areas and less in organic orchards and across the fjord.
- Hoverflies contained pesticides more often than soil or vegetation, indicating exposure of beneficial insects.
- Organic areas had higher hoverfly abundance/diversity and fewer pesticide detections and lower overall loads per sample.
- Legacy compounds (e.g., DDT) still appear in soils, consistent with historical use ("old sins").

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