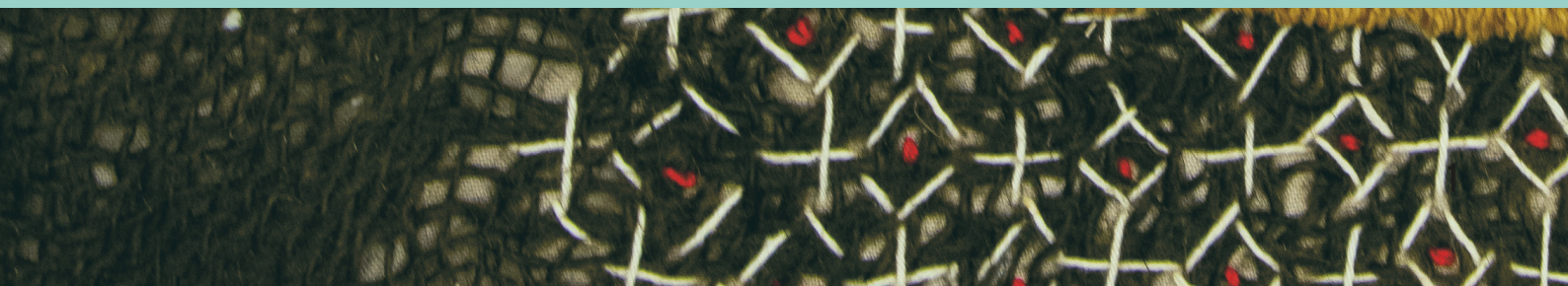


# Flowing through urban agriculture

- Art and science explorations of nutrient  
movement from Linköping's gardens



# ABOUT THIS BOOKLET

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**This document accompanies an art & science collaborative exhibit exploring how urban agriculture can contribute to sustainable resource flows to support food production, recreation, and water quality.**



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A photograph showing two people, a man and a woman, working in a garden bed. The man, with long reddish-brown hair, is wearing a purple jacket and yellow gloves, and is reaching into the soil. The woman, with long brown hair, is wearing a teal jacket and yellow gloves, and is holding a small blue container. They are both looking down at the soil. The garden bed is filled with dark, rich soil and some small plants. In the background, there are more garden beds, a black plastic basket, and some garden tools.

# Why look at nutrient flows?

All plants need nitrogen and phosphorus to grow. These are essential building blocks of life and a key input to a healthy and productive garden. However, when too much of these nutrients reach water, some algae can benefit and grow quickly, which disrupts healthy and diverse ecosystems. Good nutrient management requires there to be enough for plants to be healthy while minimizing the risk of losses.

Urban agriculture has been proposed as a way to tighten urban residents' connection to food systems and provide diverse social and environmental benefits as a type of green infrastructure. Sweden has a long history of allotment gardening, which attests to the fact the cities know it's value. As Sweden urbanizes further, and tackles key sustainability challenges, air and water pollution, biodiversity loss, and natural resource depletion, cities need their green infrastructure, including urban agriculture, to be as multifunctional as possible.

Sustainable nutrient management is required to meet Swedish food strategy goals and Sweden's responsibility to meet EU Water Quality Directives (in lakes but also in the Baltic Sea where we find the world's largest nutrient-induced dead-zone).

Urban agriculture provides many opportunities to alter historically linear nutrient flows through the city to recycle more organic resources that contain essential nutrients (including food and landscaping waste, along with human excreta) locally.

In fact, gardeners favor recycled nutrients over synthetic sources in most gardens. However, all agricultural practices can contribute to losses of nutrients to waters, because all crops require nutrients to grow. Nutrients can leave a garden via runoff and erosion (movement of water and particles on top of the land), via leaching (movement of water through the soil), and via drainage or stormwater pipes. How much, and when this happens however is not well quantified.

This project examines nitrogen and phosphorus flows through selected gardens in Linköping and explores ways to keep nutrients where they are needed.

# RESEARCH PROCESS

We started collecting data in the spring of 2020, and over three years we worked with 22 gardeners, creating over 40 nutrient input estimates and soil samples, and taking more than 3 500 leachate water samples across four gardening areas in Linköping, Sweden.

Interviewing gardeners each year to determine what and how much nutrient inputs (e.g. compost, soil, manure) they use and what they grew. With this information we could approximate how much nitrogen and phosphorus each garden was getting every year.

Sharing soil, water, and nutrient input values to gardeners via information sheets.

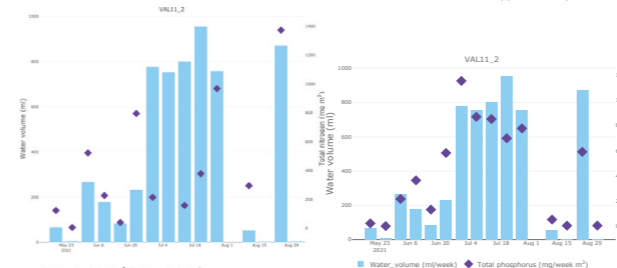
Preliminary results -  
Nutrients in Linköping urban agriculture



March 2022

## Water results

In your garden we took water leachate samples (which represent water loss) at two different points, indicated as VAL\_11\_1 (measuring point 1) and VAL\_11\_2 (measuring point 2). We have analyzed the water samples for their phosphorus (P) and nitrogen (N) content. We took water samples between May and October in both 2021 and 2020. Below we present the results of the total nitrogen (Figure 1) and total phosphorus (Figure 2) for measuring point 2. The amount of measured water and nutrient losses varied a lot between different weeks. As you can see in the figures below, **most losses happened in July**.



↑ Figure 1. Water volume and total nitrogen flux in mg per week per m² at measuring point 2.

We have also calculated the average total nitrogen (TN) and phosphorus losses (TP) for your garden for the period between May-October 2021. We calculated the average based on both measuring points. The total nitrogen loss from May till October in 2021 for your garden was on average **5,8 g per m²**. The average of the other gardens in Valla where we took samples was **3,3 g per m²**. So, the total nitrogen loss of your garden was higher than the average losses in Valla. The total average total phosphorus loss in your garden was **536 mg per m²**. This was also a bit higher than the average total phosphorus loss of Valla, which was **470 mg per m²**.

Preliminary results -  
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March 2022

Thank you for participating in our study. We are excited to share some preliminary results about the soil and water sampling we've done in 2021!

## Soil results

Table 1 shows the results of the soil sample analysis from your garden plot. You can compare them to the *low*, *optimal* and *high* reference values for mixed vegetable garden with different plants, of which *optimal* represents the value for optimal crop yield. Nutrients are presented as the amount available to plants. For example, an average of 65,5mg/100g P-AL means that there is 65,5mg phosphorus available for plant uptake per 100g soil.

The C/N ratio of your garden is 20, which is good. The target for the C/N ratio is 13 to 24. The lower the C/N ratio, the more rapidly nitrogen will be released into the soil for immediate crop use. A C/N ratio > 35 results in

microbial immobilization, which means the plant cannot access and use the nitrogen. Low C/N ratios may be raised by adding wood chips or dry leaves. High C/N ratios can be lowered by adding manures or grass clippings.

Some of the soil values fall in the high range. This indicates that, even though your plants might grow well, the soil contains more nutrients than the plants can take up. **Be careful not to apply too much mineral fertilizer or compost containing phosphorus and magnesium.** Also try to **limit calcium application**. Your soil pH is good for growing most type of plants, therefore you do not need to change anything about the acidity of your garden soil.

ID	pH	P-AL mg/100g	K-AL mg/100g	Mg-AL mg/100g	Ca-AL mg/100g	Al-AL mg/100g	Fe-AL mg/100g
VAL_11_1	6,7	70,6	19,4	54,8	1058	25	56
VAL_11_2	7	72,8	58,5	75,7	1136	22	27
Low	< 5,8	< 2	< 4	< 5	< 100	0 - 30	< 20
Optimal	5,8 - 7,2	2 - 16	4 - 32	5 - 30	100 - 300	0 - 30	20 - 45
High	> 7,2	> 16	> 32	> 30	> 300	> 30	> 45

↑ Table 1. Soil Analysis in your garden compared to reference values for mixed vegetable gardens

P = phosphorus, K = potassium, Mg = magnesium, Ca = calcium, Al = aluminium, Fe = iron

- AL refers to the method used which looks for plant available forms of the nutrient.
- Mull is a well-mixed layer of humus, which is the slowly degradable part of organic matter in the soil.
- The soil reference values are derived from Eurofins, Jordbruksverket and SLU.
- The optimal ranges large because different plants require a different physical and chemical soil content. Other important factors that influence crop yield are the ground water level and soil life (300 earthworms per m² is OK!).



Digging holes to install the lysimeters in gardens

Once a week during the summer (and for eight gardens year-round), we would come and empty the lysimeter with a syringe to determine the amount of water that leached in one week. One person would input this information on a tablet and take a picture of the garden. We would sample some of the water by putting it into bottles (as in the picture) to bring back to the lab and test for concentrations of nitrogen and phosphorus.



Measuring how deep the hole is to put the bottle below 30 cm

Lysimeter with shovel for size



Tube that goes all the way down into the bottle is sampled with a syringe every week



# ARTIST PROCESS

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I have been struggling to find a more sustainable gardening practice, so when I saw an advertisement about Gen Metson's research project on nutrients in urban agriculture it immediately caught my attention. I hoped to learn more about urban gardening and possibly develop an Art & Science project in collaboration with the researchers.

During this project I learned that my allotment site is located on former agricultural land. It means that I have "inherited" the previous farmer's soil and its nutrients. This information completely changed my perspective on gardening and put me in a historical context: I am important and what I do matters!

## MY PROCESS

Art & Science projects can be done in many ways, be it science illustration, computer visualization, or illustrations of key terms. My approach is to leave a lot of room for emotional and symbolic interpretations and inspire to action.

## THE QUILTS

One of the results of this study is that the nutrient leachate is largest in winter. The recommendation is to cover the soil with leaves and other organic litter. I dig deeper into the meaning of the word "cover". I associate it with quilts, care and nurture, thinking of our soils, our waters, and our planet.

I create four quilts, 70 x 100 cm, from recycled jute, linen, cotton, silk and wool. All textiles are eco-dyed by me. The form is inspired by Japanese patching techniques, Boro. I also employ Japanese sashiko stitches, originally used for mending or strengthening materials. The quilts are composed around a symbolic cross - a symbol for both death and crossroad/ new paths. While working with the quilts, I imagine myself laying naked, without a cover. This is not a pleasant feeling. Suddenly I come up with the title for this body of work: "Cover me, I don't want to be left bare".



Elizabeth Carlsson, gardener and artist



Scan QR code to open Instagram



# FINDINGS

Here, we present three selected research findings and artistic representations of those results. We have three tips from these findings.

1

## Test your soil

Soil phosphorus levels are generally high, and this means that more inputs will not necessarily result in higher yields.

2

## Not too much fertilizer

Often people use more inputs than crops can use, even if it is mostly coming from plant composts.

3

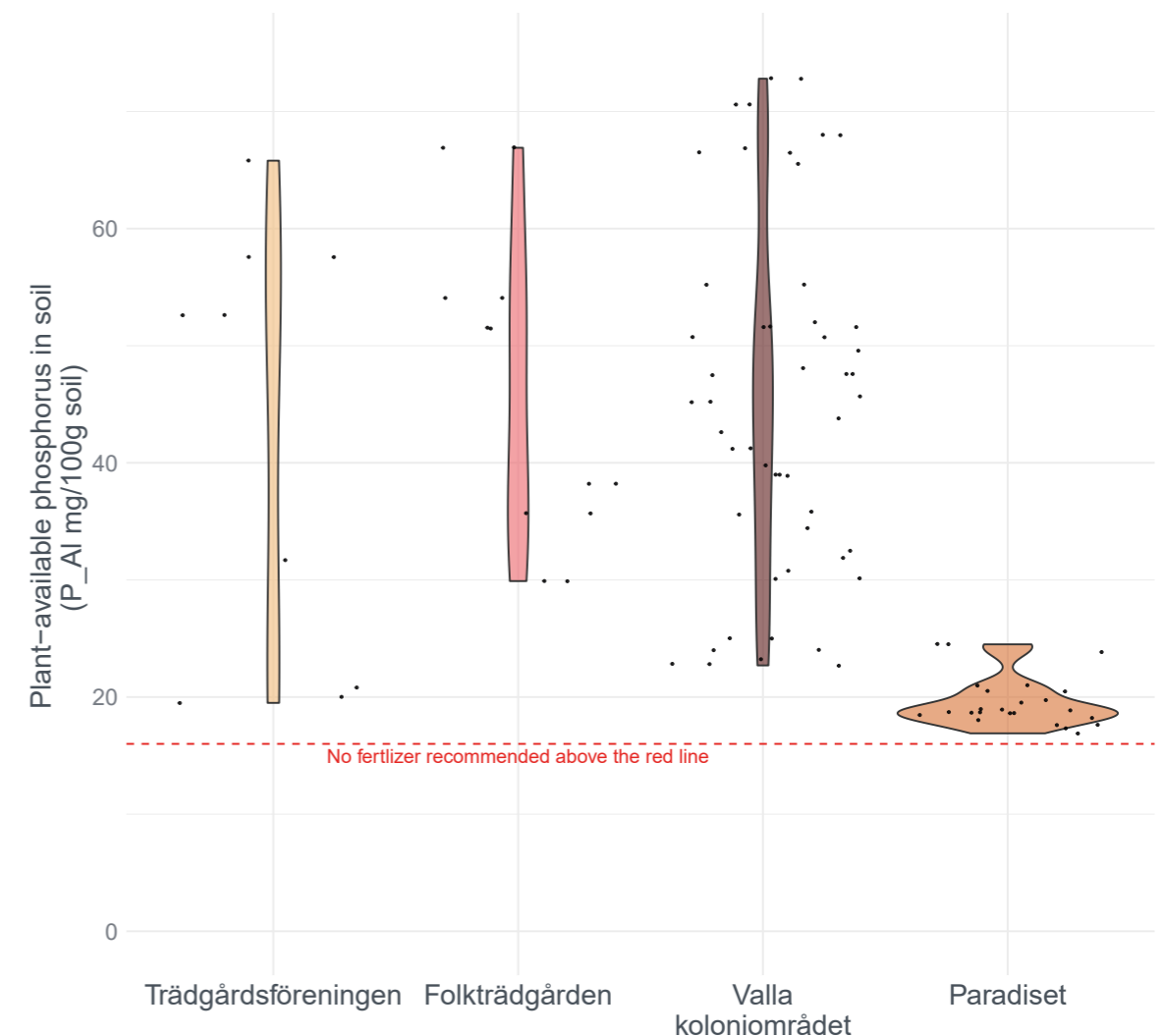
## Cover the soil

More than half of the leaching we measured happens in the non-growing season. Avoiding bare soil might help.

1

## Soils have large amounts of phosphorus

Each dot represents a soil sample taken between 2020 and 2022. The colored shapes are a visual representation of the distribution of those dots for each of the four areas we sampled.

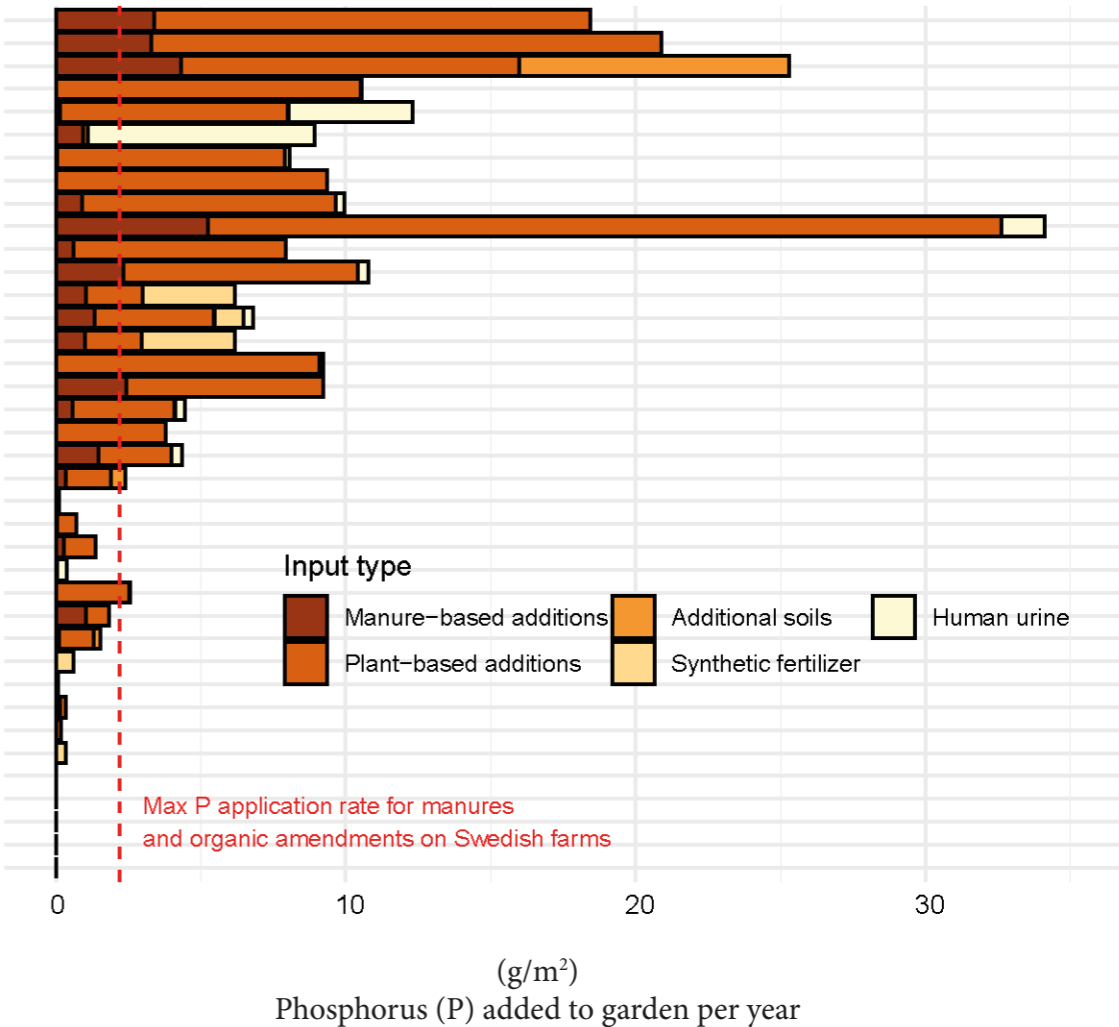
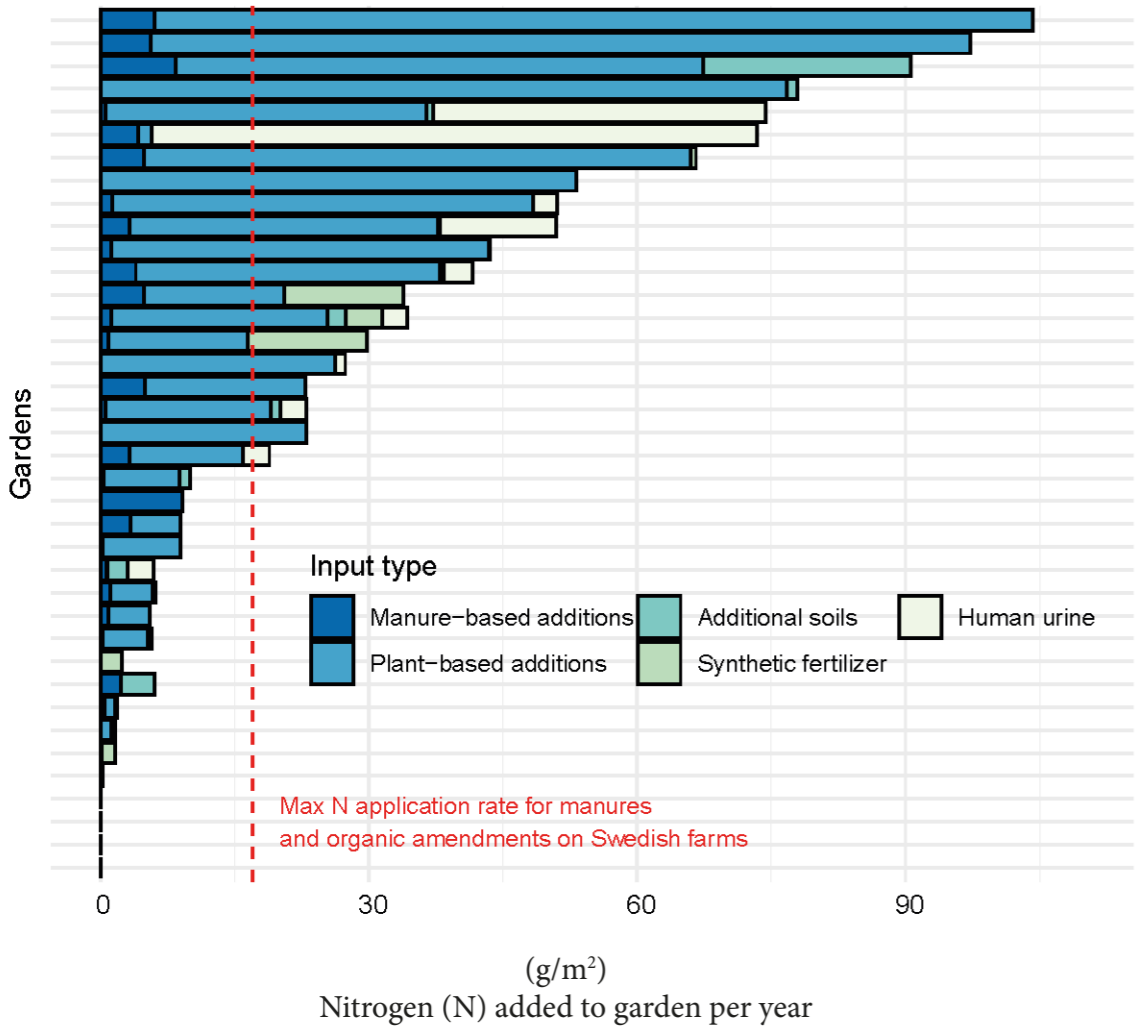


According to the Swedish board of agriculture, none of these soils requires extra phosphorus applied (red line).

# 2

Nutrient inputs are mostly organic, amounts vary a lot per garden, and are high sometimes

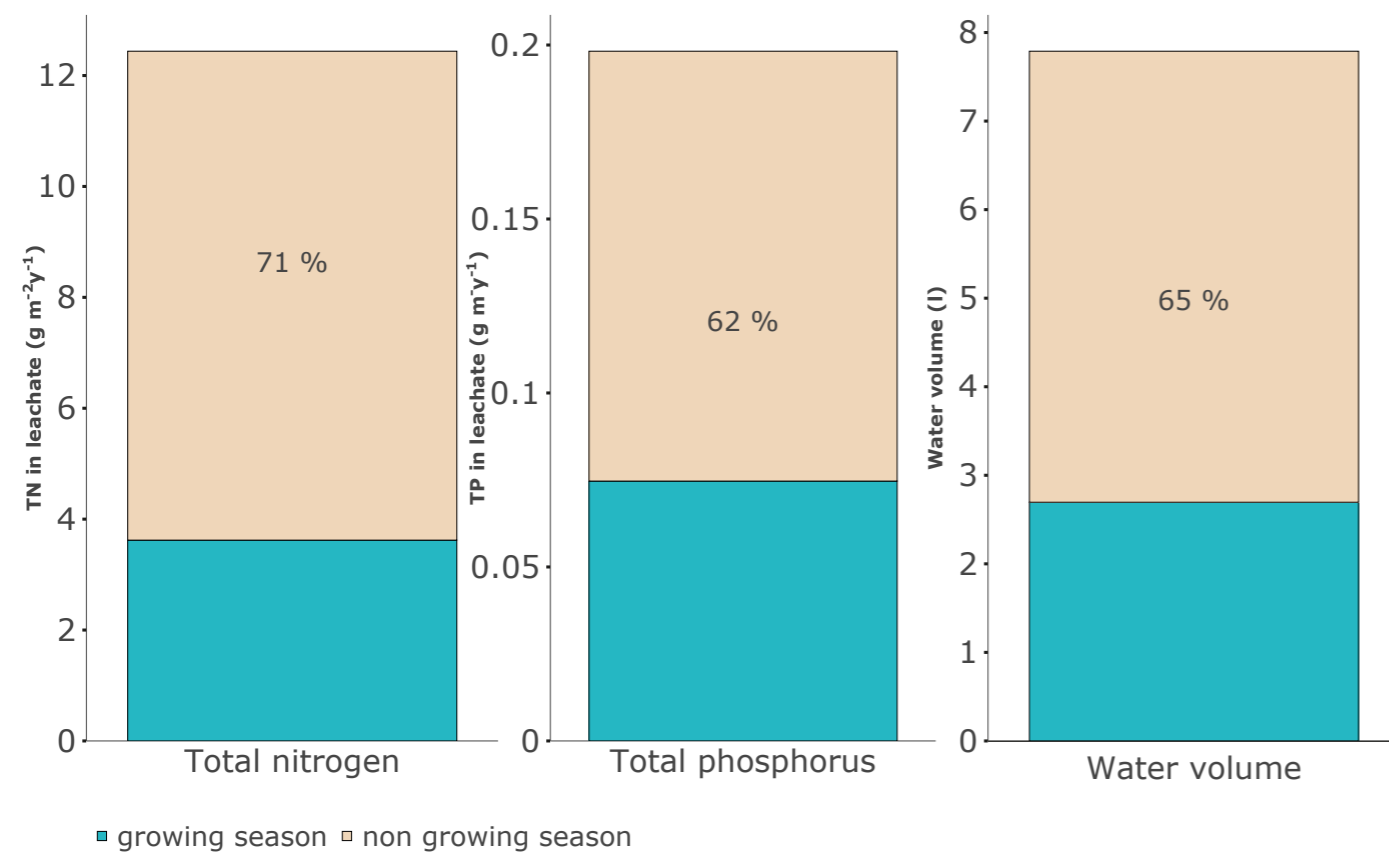
Each bar in the graphs below represents what a gardener used in one year (data from 2020 to 2022). Gardens are ordered from largest to smallest total nitrogen input. The order of gardens matches on the left and the right.



# 3

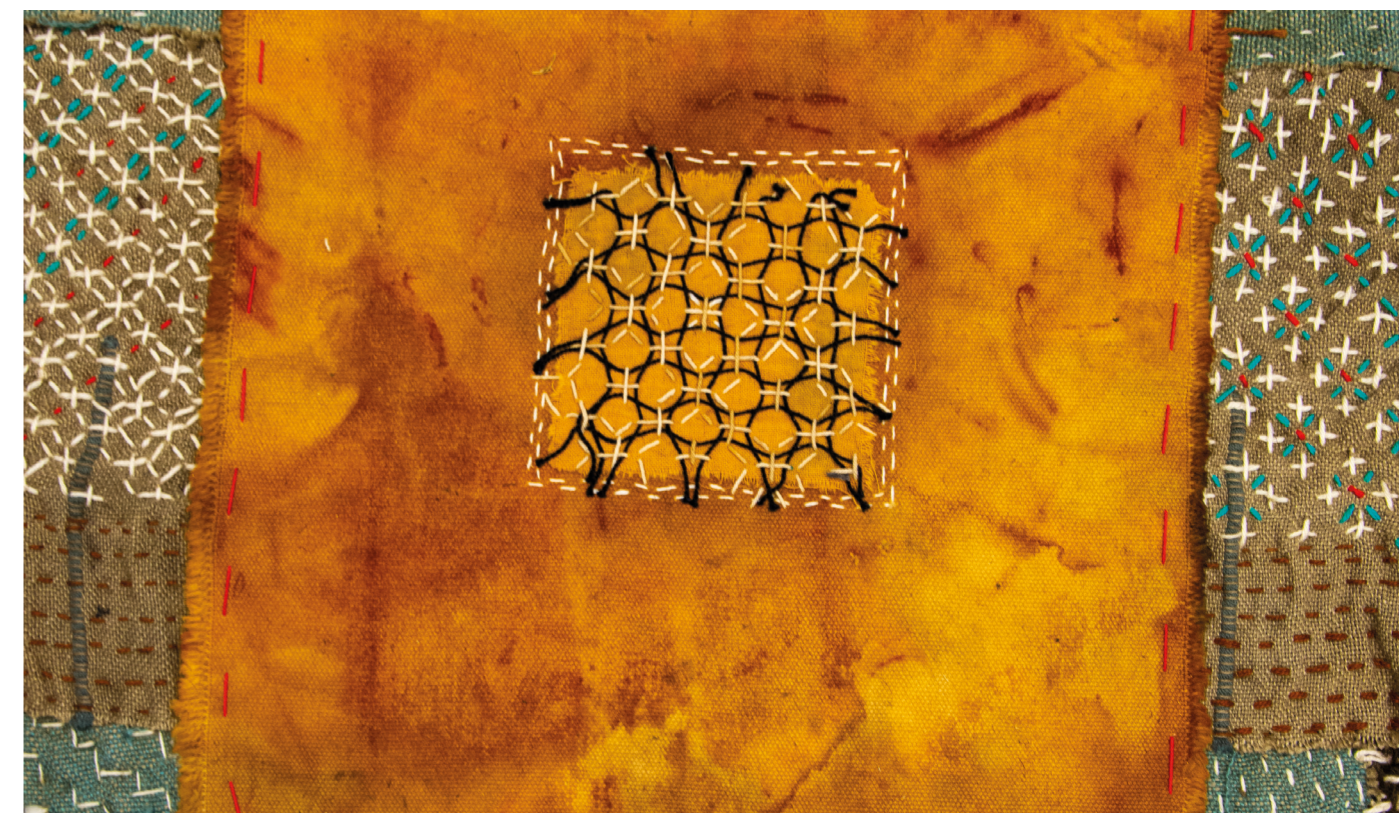
Even if people are not in the gardens over winter, that is when most leaching happens

Each bar represents the average leaching observed in eight lysimeters over two years (data from 2020 to 2022). The percentages show how much of that flow happened in the winter.





Quilts



# GRAPHS AND THE EMBROIDERIES

I find Gen's graphs very aesthetically pleasing and fascinating. They are all almost like small pieces of art, and some of them even look like embroideries!

I read the captions and try to understand, both intellectually and emotionally. Some words stick in my mind: saturation, leaching, and too much nutrients. They touch me deeply and a question keeps coming back over and over again: What is the feeling of having a nutrient imbalance?

As a gardener, I contribute to this imbalance, and knowing that creates a feeling of guilt. The relief comes when I start working with self-compassion and empathy – the tools that I have learnt from art therapy and ecopsychology.

I get a strong desire to return to my sashiko-needles; this time with more intuition and deeper intensity. I work almost subconsciously, with lots of emotions. It is my hand, not my mind that leads the work. The results look like emotional graphs. Their abstract language reflects the emotional mood of the artist and the gardener.

# HOPE

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I study graph #1 (see page 13), and in particular the small figure to the right of the graph. I feel a strong desire to place this figure as an appliqué on the opposite side of the embroidery. From an art therapeutic perspective the left part of the image can symbolize past times, and suddenly the appliqué makes me think of the Ark of Noah. It gives me a vague sense of hope.



# RELIEF

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I am curious to look at the graph #2 (see page 14-15) from different angles. I turn it and see vertical bars. They look like small sashiko-stitches, falling from top to bottom like rain washing out nutrients, or like tears of sorrow rolling down a cheek. I feel relief.



# TRUST

Graph #3 (see page 16) shows peaceful, broad areas, which make me think of resting winter farm fields. The aesthetic expression of this graph creates a sense of calmness, which I want to recreate.

My sashiko-stitches form horizontal patterns that cover a large part of the image. Small stitches by the side of the main shape are almost like snowflakes. They create a slow movement. I sense a feel of trust in life.





# OTHER PROJECT OUTPUTS

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## Scientific papers

Siezko, van de Vlasakker, Tonderski, and Metson (2023). **Seasonal nitrogen and phosphorus leaching in urban agriculture: Dominance of non-growing season losses in a Southern Swedish case study.** Urban Forestry & Urban Greening 79: 127823

Van de Vlasakker, Tonderski and Metson (2022). **A review of nutrient losses to waters from soil- and ground- based urban agriculture – more nutrient balances than measurements.** Frontiers in Sustainable Food Systems 6

Small, Martensson, Janke, Metson (2023). **Potential for high contribution of urban gardens to nutrient export in urban watersheds.** Landscape and Urban Planning 229: 104 602

Small, Shrestha, Zeiner, Metson (in review). **Phosphorus recycling and loss from compost-amended urban gardens: results from a seven-year study.** Urban Agriculture & Regional Food Systems

van de Vlasakker, Tonderski, Small, Metson (in review). **Annual total nutrient inputs in Swedish urban food gardens are not good predictors of growing-season leachate.** Journal of Urban Ecology



# ACKNOWLEDGMENT

This work would not have been possible without the gardeners and garden organizers who talked to us and gave us access to their beautiful spaces. We are also thankful to the students and staff who contributed to data collection and dissemination of research results.

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