Complement to Deliverable 3.1

LEAKAGE AND DRAINAGE WATER AS A SORCE OF HEAVY METALS IN HÖÖR/HÖRBY

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INTRODUCTION

Heavy metals are pollutants which follow the wastewater through the sewage system to the wastewater treatment plants (WWTP). In the WWTP there are processes in place to remove the heavy metals from the waste stream in order to avoid having heavy metals ending up in the recipients. Removed heavy metals end up in the sludge and high concentrations of these heavy metals in the sludge can be a problem if one may want to reuse the sludge in for example agriculture.

Heavy metals may origin from point pollution sources such as industries or highly trafficked areas but may also show up in a more diluted manner with origin from for example the piping system or underlying bedrock. For example, in Sweden nickel, lead and copper are common metals in the water piping system, and it is plausible that these metals follow the wastewater into the sewage system and further on to the WWTP.

In the municipality of Höör the bedrock, at places, have a high abundance of cadmium and lead. A hypothesis is that drainage and leakage water leach the soil and bedrock bringing cadmium and lead into the sewage system.

In this case study flow measurements together with metal and nutrient sampling has been conducted. This in order to see whether drainage and leakage water may be a source of heavy metals in the wastewater in the municipality of Höör.

Initially this case study was planned to be conducted in collaboration with the STEP project partners using a mobile sampling unit (MSU) to get similar and comparable analysis data from all different countries and to try out the MSU equipment. The MSU could take samples of the wastewater and measure flow on spot at different locations in the sewer system – a seemingly efficient and straightforward method for sampling of wastewater. Unfortunately, due to Covid-19, there was no possibility to transport the MSU between the partner countries and use it for this part of the project. Instead flow measurements and analysis were carried out in accordance to this report.

FLOW MEASUREMENTS – TO DETERMINE LEAKAGE AND DRAINAGE WATER

In an ideal and sealed sewer system, the only water should be wastewater from households and industrial plants which are connected to the sewer system. However, this is most often not the case. Ground water and rainwater (leakage and drainage water) find its way into the sewage system through for example cracks and joints, manholes and stormwater or drainage pipes that are wrongfully connected to the wastewater system. Leakage and drainage water dilute the wastewater and changes its composition.

To measure the amount of drainage and leakage water one can do flow measurements over a period and look at night flows during the hours when people do not use the water and wastewater system – approximately between 02.00-05.00.

Flow measurements in Höör

Flow measurements were conducted for two months (mid-October to mid-December) 2020 at 6 spots in the municipal sewage system of Höör (which wastewater is treated at Ormanäs WWTP). The points of measurement are seen in figure 1 (an extra spot is present in the figure and no measurements were conducted here. This spot is for area Nyby). Each measurement point represents one catchment area.

- Frostavallen
- Holma
- Åkersberg
- Fogdaröd
- Centrum
- Nyby
- Ormanäs

All areas contribute sequentially with wastewater to the next coming area except the Centrum area, which is a standalone area and, as the area Åkersberg, contributes with wastewater to the Fogdaröd catchment.

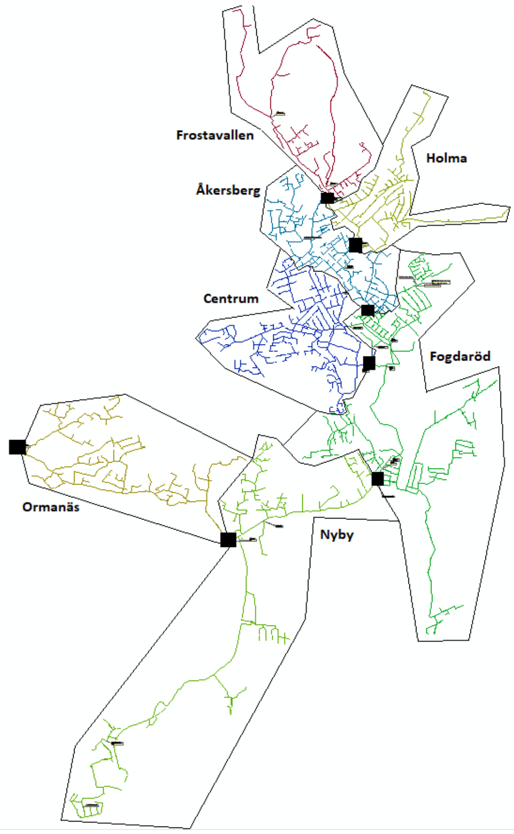

Figure 1 Points for measurement, all representing a specific catchment area..

Results - flow measurements

The flow measurements showed to follow the same general pattern at all measurement spots. A clear decrease in flow is seen during the hours 02.00-05.00, see figure 2 below, and peaks in flow are seen during the morning around 08.00 and during the evenings between 18.00 and 21.00. The peaks indicate that the wastewater mainly origins from households which usually generate wastewater during the morning hours before people leave for school and work and during the evenings when people get back home, make dinner etc. before going to sleep. Therefor the seen pattern was expected.

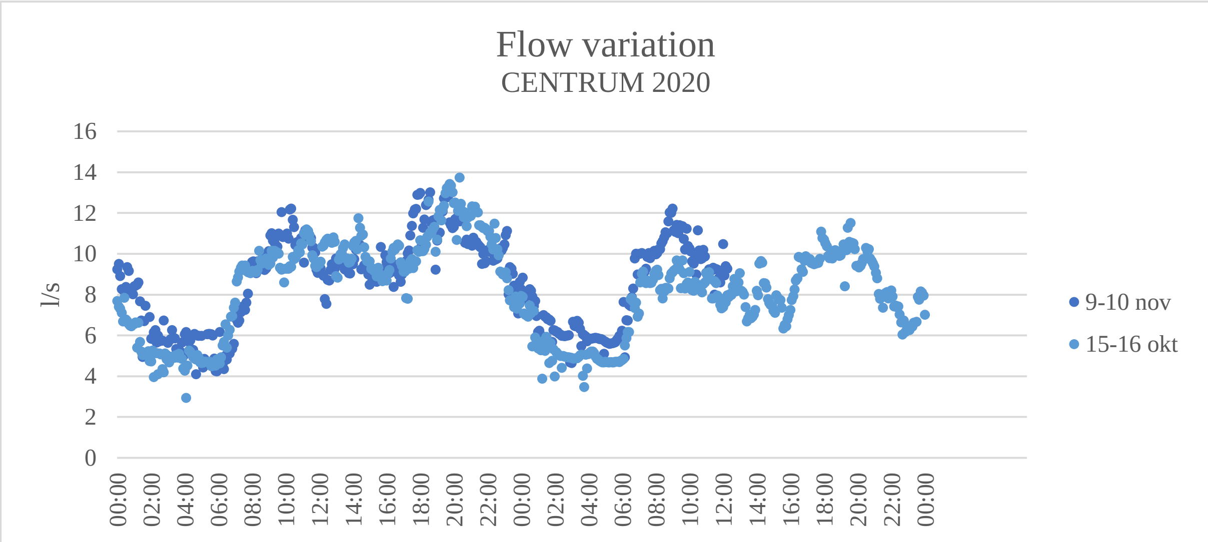

Figure 2 24- hour flow variation at measurement spot for catchmenta area Centrum.

The registered flows at each measurement point is seen in table 1, and the net flow added from each catchment is seen in figure 3.

Table 1 Night flows at the different measurement points

Site	Nightflow l/s
Frostavallen	1
Holma	4,4
Åkersberg	10
Centrum	5,5
Fogdaröd	27,7
Ormanäs+Nyby	30

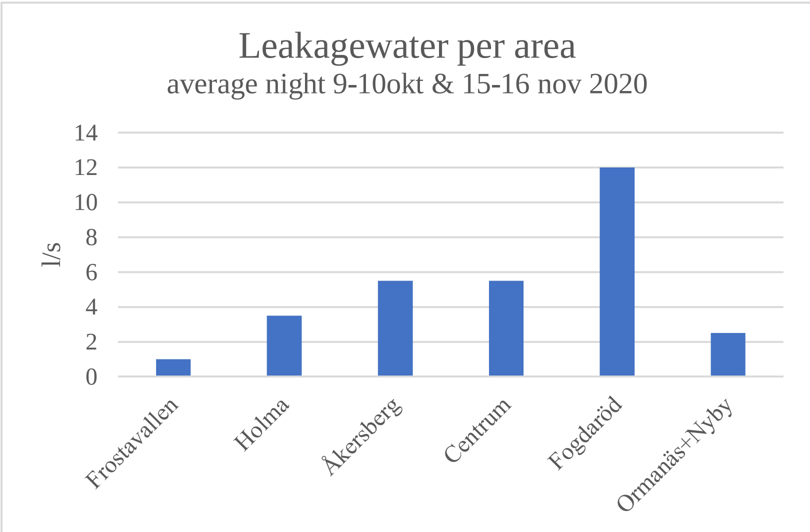

Figure 3 Net leakage and drainage water added at each catchment area.

As seen in figure 3, the Fogdaröd catchments seems to be the main contributor to leakage and drainage water with up to 12 l/s. Holma, Åkersberg and Centrum catchments contribute with approximately 4-6 l/s, Ormanäs/Nyby contributes with approximately 2,5 l/s and Frostavallen with 1 l/s. In total the drainage and leakage water adding to the wastewater at Ormanäs WWTP was approximately 30 l/s during the two nights that the measurements for this analysis was carried out. Looking at a longer time period would give a more accurate representation of the drainage and leakage flows. However in order to compare these values with the results when looking at nutrient and metal content of the water the scope had to be limited to the same two nights as when the nutrient and metal samples were collected (see coming chapters for further information on the nutrient and metal analysis).

Nutrient and metal analysis

Twice during the period for flow measurements, the nutrient (ammonium NH_4-N and phosphorous PO_4-P) and metal (lead, cadmium, chromium, nickel, zinc and copper) content of the wastewater was measured. Metals were measured once during night and once during day at two occasions in order to be able to compare the day and night values. Nutrients were only measured during day since the nutrient content during night should be low since the activity from households should be low during this period. Measurements were carried out between 9-10th November and 15-16th October (measurements at night between the two days and measurements at day during the second day of each occasion). No night measurements were carried out at Ormanäs due to limited access during night. Instead a 24-hour average was collected from this sampling point.

Since nutrients origin from the wastewater it was assumed that the nutrient concentration should decline on the way through the sewage system as the increasing amount of leakage and drainage water should dilute the wastewater.

For metals the aim was to compare concentrations during day and night. Some metals are prominent components of water installations in households and it was assumed that these metals would appear in higher concentrations during day than during night since this would be when household activities take place. On the contrary, metals that origin from the bedrock was assumed to appear in higher concentrations during night since they are rather a component brought into the system by leakage water then by the wastewater and therefor being more diluted during night. Metals that are prominent components of wastewater installations are for example copper, lead and nickel and metals known to appear in high concentrations in the soils of Höör are lead and cadmium. To be mentioned is that some households have private water wells instead of using the municipal water but still use the municipal wastewater system. From these households a higher contribution of metals from the bedrock should also be seen since these are brought from the bedrock through the water well, further on through the household installations and into the sewer system. Although the fraction of households with this type of solution is low some effect should be expected.

Results – nutrient sampling

The nutrient sampling showed a decrease in concentration of both ammonium and phosphorous from Frostavallen to Holma to Åkersberg (see figures 4 and 5) which implied an increased dilution caused by intrusion of leakage and drainage water to the wastewater

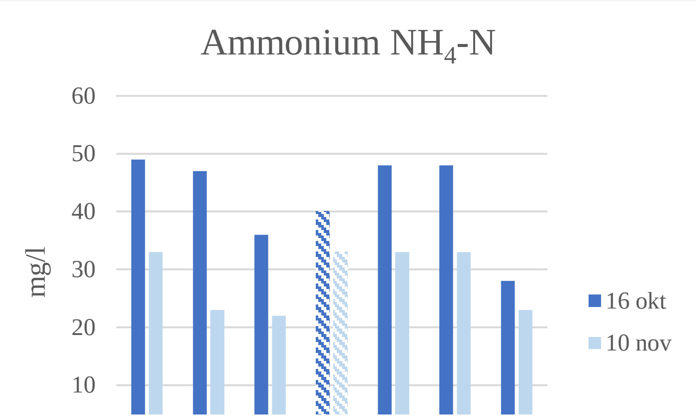

Figure 4 Ammonium concentration at sampling points on the 16th oktober and 10th november 2020. Centrum catchments is a standalnone catchment with no upstream contribution and is therefore marked in the graph. The other catchments follow each other sequentially.

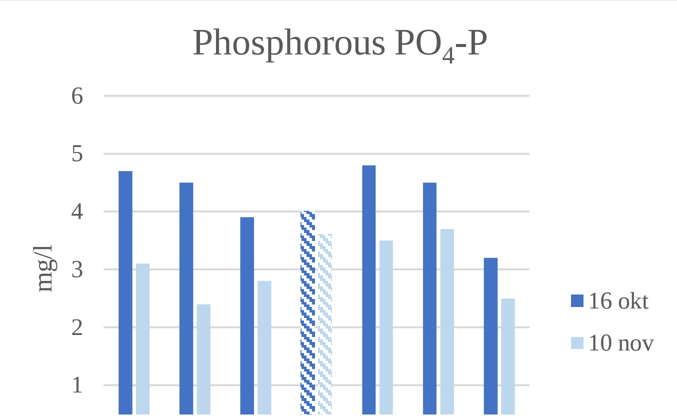

Figure 5 Phosphorous concentration at sampling points on the 16th oktober and 10th november 2020. Centrum catchments is a standalnone catchment with no upstream contribution and is therefore marked in the graph. The other catchments follow each other sequentially.

system. The centrum catchment area is a standalone area with no upstream contribution. The nutrient concentrations here were a little higher than the concentrations seen at Åkersberg, although not much higher, indicating that the dilution in the Centrum area alone is almost as high as in the Frostavallen, Holma and Åkersberg together.

An increase in nutrient concentrations was seen between Centrum and Fogdaröd on the first measurement occasion. This implies that the wastewater from Fogdaröd has a very high nutrient concentration and thereby isn´t extensively affected by dilution of leakage and drainage water. On the second measurement occasion the nutrient concentration at Centrum, Fogdaröd and Nyby were quite uniform implying that these areas are equally affected by leakage and drainage water. However, comparing these findings with the night flows gives a bit contradicting result. The night flows imply a very high leakage and drainage flow from Fogdaröd catchment whilst the nutrient concentrations imply the opposite. One explanation may be that sediments, by mistake, were collected and analyzed in the nutrient measurements – giving a higher nutrient concentration than seen in just the wastewater. On both occasions there is a seen decline in concentration at Ormanäs from the preceding catchments, again implying an increased dilution from drainage and leakage water. One way to avoid influence of sediments on the samples could for example be to filter the samples prior to analysis.

Mentioned should be that the nutrient samples were taken within a limited time span, and during this time span the wastewater did not have time to flow through the whole system. This meaning that the effect of the dilution in the first catchment areas will not be seen for the same time span in the last catchments. It is therefore possible that at the time of measurement a high nutrient load in one catchment is not affected by the potentially more diluted water from a previous catchment.

Results – metal sampling

Having obtained a first overview of the metal sampling results, it was seen that during the first night measurements, the concentration of all measured metals reaches a maximum in Nyby (see figure 6). The concentrations are very high in comparison to the rest of the sites and the rest of the measurement occasions. Therefore, it could be plausible to believe that there might have been sediments in the sample giving higher concentrations in the sample than in just the wastewater. This measurement occasion was therefore kept out of the further analysis. Again, it might have been a solution to filter the sample prior to the analysis in order to avoid this type of problem.

A hypothesis was that lead and cadmium, which are metals prominent in the bedrock in Höör, would show higher concentrations during night than during day due to the fact that they enter the wastewater through leakage and drainage water. Night one showed higher concentrations of cadmium than day one, whilst night two showed equal or lower concentrations of cadmium than day two. For lead the night concentrations where consequently lower than the day concentrations with exception to Frostavallen during the second measurement occasions.

Since lead is also a metal prominent in water installations, one could conclude that the contribution of lead to the wastewater stream was, during the measurement occasions, mainly from the wastewater and not from leakage and drainage water. On the other hand, for cadmium the results were more supportive of the hypothesis and it is plausible to believe that a larger fraction of the cadmium that enters the wastewater origins from leakage and drainage water than from the wastewater itself.

For the remaining metals the concentrations were mainly seen to be higher during day than during night. At four occasions the night concentrations were slightly higher than the day concentrations. All occurred during the night two /day two measurement session, and were seen for lead, chromium and nickel at Frostavallen and for nickel also at Holma. Only copper concentrations showed to be consequently higher during day than during night, and since copper is very prominently used in water installations, this was an expected result.

To be mentioned is that the night measurements were conducted according to table 2. At these hours there might still have been some household activities going on which may contribute with metals from water installations. A clearer result would have been given if the night measurements were conducted between 02.00 and 05.00 when the minimal amount of household activities take place.

Table 2 Hours of night sampling

Site	Sample night 1 taken at	Sample night 2 taken at
Frostavallen	01:10	00:31
Holma	01:20	00:38
Åkersberg	01:30	00:46
Centrum	01:35	00:51
Fogdaröd	01:45	00:59
Nyby	02:00	01:10

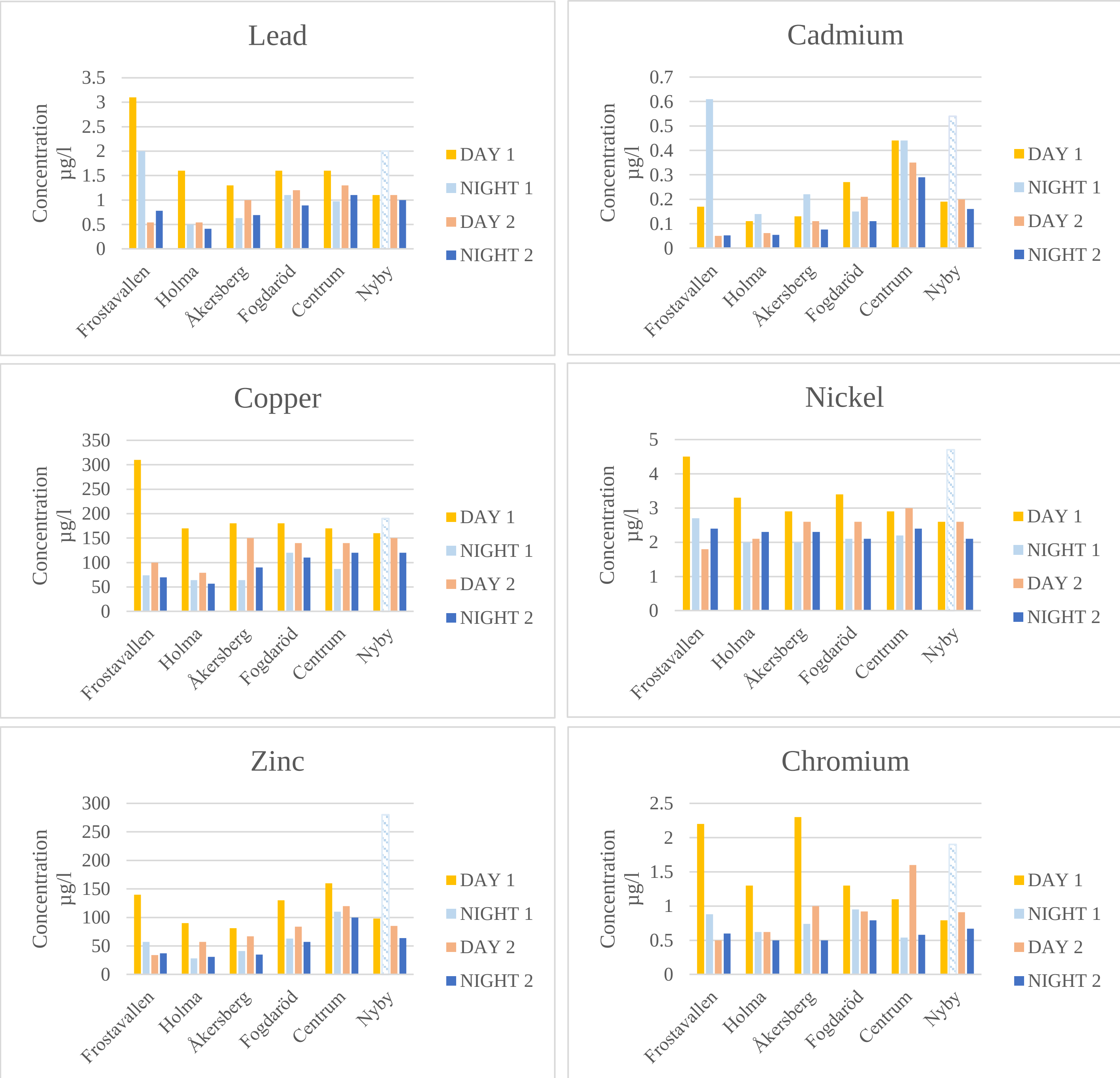

Figure 4 Concentrations of lead, cadmium, copper, nickel, zinc and chromium at six different measurement sites throughout the sewage system. Measurements were carried out during four ocassions, twice during night and twice during the following days. Nyby, night one sediments considered in sample and therefore marked in graphs.

CONCLUSIONS

The overall takeaway from the nutrient sampling was the seen trend of nutrient concentrations decreasing towards the end point of the sewage system implying increased effect of leakage and drainage water. However, further analysis and more data would be needed in order to draw any more detailed conclusions regarding nutrient concentrations as an indicator for leakage and drainage water. It would also be interesting to look further at smaller catchment areas and to determine the origin of leakage water on a more detailed level. Results from such an analysis could be used as basis for renovation planning for the sewer system in order to reduce the amount of excess water.

The overall takeaway from the metal sampling was that it is plausible that cadmium in the wastewater origins from leakage and drainage water in Höör. For metals that might origin from both bedrock and water installations a measurement session during the later night hours would have been needed in order to possibly determine which source was most prominent. For the majority of the measured metals it was evident that the source was water installations rather than leakage and drainage water. Looking at heavy metals in a similar manner to what is done in this analysis is a way to detect leakage and drainage water however, one then needs to look specifically at metals that origin only from the bedrock and not from households, industries or similar in order to draw any clear conclusions, and such metals may not be present. Additionally, this type of analysis will always be comparative. Since the water in the sewer system always will be a mix of wastewater and leakage and drainage water – even during night hours – it will not be possible to determine exact concentrations of metals with origin from the different sources. However, with a comparison it will be possible to determine which source is most prominent.

It is important to keep the origin of different metals in mind when looking at effects further down the system. For example, metal amounts affect the possibility of reuse of sludge from the wastewater treatment plants. Diffuse sources such as dilutes from the bedrock may be hard to tackle at the source, whilst other metals from point sources may be easier to prevent. To prevent metals such as copper from the water installations may be difficult but due to the non-natural origin it is possible if there is a great need of limiting that specific metal. Of course, an investigation showing fractions of metals from households versus industries or other spaces generating wastewater with high concentrations of heavy metals such as parking lots etc., should be carried out in order to find the most efficient point to tackle in order to limit the amount of metals reaching the wastewater treatment plants.