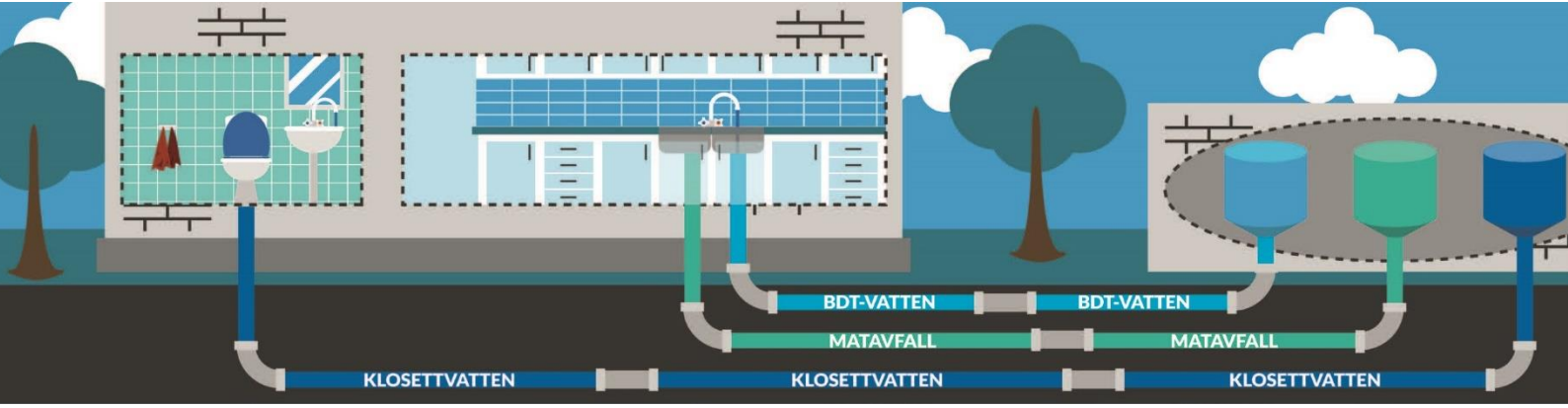


Follow-up of the workshop on

Replication of source separation wastewater systems

Answers to questions raised during the Menti Q&A session

Thursday 25th of November 2021

- **Helsingborg, Sweden – Physical interactive workshop and guided tour**
- **Online – Online viewing of a livestream from Helsingborg**

On November 25th 2021 the final workshop of the Horizon 2020 project Run4Life took place, at the RecoLab in Helsingborg. The workshop was organised by project partner NSVA, in cooperation with project partner LeAF and invited moderator Mats Johansson of Ecoloop. Five European sites where source separated wastewater systems are implemented shared their experiences to ease similar implementation at other locations. Together, the houses, offices and other buildings at the five locations include around 3500 users. The aim of the workshop was to bring interested stakeholders directly into contact with the site managers, and highlight the circular advantages of taking the source-separation approach. The short time in which the workshop was fully booked is a sign of great interest in the use of this kind of wastewater management systems.

In total just over 70 people attended the workshop physically and 10 people joined the online streaming.
To all the participants: thank you very much for joining us in Helsingborg and online!

The workshop programme was as follows:

- 12-13h: Lunch and coffee, guided tour of RecoLab.
- 13h: Presentations by the site managers of Helsingborg (SE), Vigo (ES), Ghent (BE), Sneek (NL) and Hamburg (DE), followed by a moderated round of questions.
- 14h: Coffee break.
- 14.30h: Moderated panel debate about the economic feasibility, legal aspects, technical results, etc.
- 16h: End of the program, possibility for socialising and free discussion.

Questions raised on Menti and answers by demo-site representatives

Throughout the workshop an online Menti board was available on which all participants in Helsingborg and online could post all their questions related to source-separation in general and the five sites in particular. All of the posted questions have been gathered and analysed. The questions that had not been answered during the workshop have been distributed among the site managers and the communications manager of the Run4Life project. Duplicate or very similar questions have been grouped. Below and on the next pages you find the answered questions.

General Run4Life information

Questions answered by Iemke Bisschops (LeAF).

- *What technologies are used at the different Run4Life sites?*
  On the Run4Life project website you find dedicated pages that contain descriptions of the four demonstration sites. On these webpages you will also find different factsheets that are available for download, containing flow charts of the applied processes, descriptions of the resource recovery technologies and information about the recovered fertilisers. Direct links to the four site pages are:
  - Nieuwe Dokken – Ghent, Belgium
  - Oceanhamnen & RecoLab – Helsingborg, Sweden
  - Porto do Molle – Vigo, Spain
  - Lemmergweg – Sneek, the Netherlands

  Information about the site in Hamburg, Jenfelder Au, can be found on the website of Hamburg Wasser.

- *Do you have information about the capital and operational costs of the systems? And information comparing the costs to those of centralised systems?*
  An economic analysis was part of the Run4Life activities. These have been reported in the project report "Deliverable 5.5 - Benefit Cost Analysis" prepared by project partner Universidad de Santiago de Compostela (USC). This report has been submitted to the European Commission and is currently undergoing review. As the deliverable is a public report, it will be made available for download on the project website after it has been approved by the EC.

- *What were the main drivers, the primary selling points, for implementing source separating systems instead of conventional ones?*
  During the workshop the drivers and selling points have been discussed. In addition information can be found on the project website, or will be made available in the near future as more reports are approved. During the Run4Life project, under the lead of project partner WE&B, an analysis has been made of the stakeholders, their expectations, and different governance aspects. Project report "Deliverable 6.1 - Mapping of Stakeholders and expectations" is available for download. Other deliverables related to stakeholders and governance have been submitted to the European Commission and are currently undergoing review.

The project website contains information about the four sites and the work that has been done in the project. The publications section provides access to scientific publications, public project reports (deliverables), different sets of factsheets and a video collection. In addition, presentations given at several of the different events have been made available. Not all of the public project reports are already available, those submitted towards the end of the project are currently under review and will be uploaded after they gave been approved by the EC.

Demo-site Helsingborg

Questions answered by Hamse Kjerstadius (NSVA).

- *What did the Reco Lab cost?*
  The cost of process equipment was 3 M euro, The entire building (everything from engineering and construction to finalized interior) was another 12 M euro. Please note that the show room and test bed area is also included in this cost.

- *How is food waste transported from the grinders to Recolab?*
  There is gravity piping in each building down to the basement. In the basement there is a collection tank with a screw pump that a few times per day pumps the food waste to the municipal sewer net. If the pump should not work for any reason the food waste is instead entering the greywater gravity sewer by means of an overflow from the collection tank (i.e. if the pump malfunctions you can still use the food waste system). NSVA is reading the signals from the pump in each building, so we get an alarm if the pump is not working or pumps less than once very 24h. In that way we can inform the houseowner they need to fix the pump. So far it happened once that one pump stopped working, but it was simply an error in the control system. None the less it meant we could test the system live and it works well with the alarms.

Recovered fertilisers

- *What is the recovery rate for the treatment steps Eco-P and Eco-N (incoming vs outgoing from just this step)?*
  For struvite precipitation you can expect >90% phosphate P recovery. From the digester we have around 110 mg tot-P/L and around 90 mg PO4-p/L so approx >80mgP/L is recovered as struvite.
  For the ammonia stripper it is more of a question of the height of the stripper towers and the pH/temp. We are aiming at 80-90% ammonia-N recovery since we like to keep the NaOH dosing as low as possible (pH regulation with NaOH is expensive relative to the value of the recovered N). From the digesters we have approx 1300mgtot-N/L and 1200 mgNH4-N/L so a recovery of just over 1gN/L.

- *I´m very interested in the fertilizer pellets. Is there a link to information on this technology?*
  Sadly not really. In Helsingborg we are still talking to 3 different companies about where to commercialise long term. The pellets we have made so far for the field trials were made by the Swedish company Ekobalans Fenix AB and you can find very little information on their web page: Kretsloppsgödsel - gödsel och jordförbättringsprodukter - Ekobalans Fenix There is however already 3 pelletization units active in Sweden from wastewater residual products. The companies Scandinavian biogas and Biototal has pelletization units running and Ekobalans Fenix AB is now building a new commercial scale plant. I can't find any information about these on the net though so please contact me (Hamse) if you want contact details to the companies.

- *Are source-separated nutrients accepted for fertilization use? Have there been any discussion regarding the harmful substances in black water?*
  The pellets are made of 50% mineral fraction (recovered struvite and ammonium sulphate) and 50% organic material (dewatered sludge from anaerobic digestion of food waste or blackwater). First of all the recovered struvite and ammonium sulphate will undergo the End of Waste process and thus be covered by product legislation and not the waste legislation. The organic fraction (sludge from digestion of either blackwater or food waste) are still legally a waste, however they can be certified as biofertilizer in Sweden using the national certification system SPCR120 (for food waste sludge) or SPCR178 (for blackwater sludge). Both sludges have no problem reaching the legal requirements for what is allowed to spread (in fact blackwater sludge is cleaner than food waste sludge in regards to the ration between heavy metals over nutrients). But the legal requirements does not take in to account pharmaceutical residues which we know are present in blackwater.

However keep in mind that i) most pharmaceuticals are found in the water phase and does not transfer to either the sludge or struvite and ii) the soil biota have a much greater rate of decomposing organic pollutants than the aquatic biota due to the greater concentration of biomass (there is a study on the fate of pollutants in BW application to farmland by Leven et al that you can read on the topic: Läkemedel i kretsloppet via humangödsel (slu.se)).

Black water

- *What would be the most efficient way to sanitize black-water in a large tank? Say 3500m3. Urea? Concentration? Amount? Time?*
  Yes if you want to hygienise blackwater urea hygienisation is likely the most economic way (unless you are neighbor with a large producer of waste heat that you can buy at a low cost). Urea also increases the N concentration and make the final blackwater sludge a more valuable fertilizer. Keep in mind however that most farmers want at least 5% N in the liquid to make it worthwhile spreading and that the initial N-concentration of blackwater is just 1,2 - 1,5%. Thus blackwater as a fertilizer without addition of urea to dope the N concentration likely has limited value. That being said: we do have several cases in Sweden were blackwater treated with urea to lower concentrations than 5% are being spread on farmland, so apparently you can find a local off set in some areas.

- *Does anyone have experience of using sanitized blackwater directly in agriculture or forestry or ecosystem restoration?*
  In Sweden there are a few cases of this in agriculture. For more information I recommend contacting Marie Strand who leads the network called “decentralised sewage in circularity” (my own translation) in Sweden: Kretsloppsnätverket – små avlopp i kretslopp | VA-guiden (vaguiden.se)
  I have never heard of blackwater in forestry, however there were a lot of experiments with growing Salix from wastewater in Sweden some 20 years ago. I do not know how many of these projects are still alive.

Demo-site Ghent

Answers by Lieven Demolder (CEIP/DuCoop)

- *How big amount of effect in kWh/kvm per year can approximately be recovered/lowered from foodwaste, blackwater and greywater per unit/flat/office/hotel/commercial/service ?*
  Biogas: about 4,8 Nm^3 of biogas (6-7kWh/Nm^3) per m^3 of black water & kitchen waste (we mix it together before anaerobic digestion). You have to take into account the loss of heat to heat up the black water to mesophilic temperatures, heat that we will recover from the effluent (heat pump).
  Waste heat recovery: using a heat pump on the water treatment effluent we have a remaining temperature of about 21-27°C in the effluent. For an average effluent temperature of 24°C and 3,5 m^3/h (1250 PE) you can expect an average heat production of 100kWth (bruto).

- *After recovery, how are nutrients reused in practise for the Ghent example Nieuwe Dokken? What is the value of nutrient products?*
  At full operational capacity of our designed water treatment plant (1250 PE) our installation is expected to produce about 1,5 tons of struvite ($(NH_4)Mg_2PO_4$) per year. We have this product in pot trials (on strawberry plants) and they showed the same nutritional value as traditional fertiliser products. To use them commercially, we would need an end-of-waste certificate, which we have not received to-date. At this moment we only produce limited amounts of nutrient recovery products, and we store them for research purposes (samples for pot trials, chemical analysis, etc.).

- *I am wondering how the private business model cooperates with the "normal" wastewater and waste and energy providers in Ghent?*
  The regional water supplier and sewer utility company 'Farys' is a member of the board of DuCoop (co-investor) and participated in the design and operation of the sewage infrastructure and the pilot wastewater treatment plant at the Nieuwe Dokken. The sewage and sanitation system is funded by a tariffication structure which is based on 'polluter pays' principle. In this case, Flemish local municipalities, who carry the responsibility of organising the sewage system (through regional semi-public utility companies), charge end-users with a 'municipal contribution' on the consumption of tap water. Wastewater sanitation is a regional competence and charged through a 'supralocal contribution'. This system of end-user contributions has led to increasing cost for the consumers (approx. 4.3 EUR/m^3 (VMM, 2018) including water supply, sanitation and sewage contribution. The sewage and sanitation contribution of the tap water that is being consumed at the Nieuwe Dokken is passed on to the DuCoop, because the company takes over this role from the respective utility companies. Same is accounted for DuCoop's role in the collection and treatment of food waste (city of Ghent waste company 'IVAGO').

Demo-site Sneek

Answers by Paraschos Chatzopoulos (DeSaH)

Vacuum toilets and black water

- *In comparison with regular water-flushing WC, how does the installation of vacuum toilets compare in terms of cost - say if you were building a new house?*
  A vacuum toilet costs around 700 euro. The overall increased cost per household amounts to approx. 2500 euros. This includes toilets, vacuum generation and collection.

- *Are there any comments from the vacuum toilet users on that they need to flush several times to get everything flushed down (my personal experience)?*
  There is a slightly higher need for double flush, mainly to ensure toilet bowl cleaning. But based on water consumption measurements that doesn't have any effect on the water saving. The reason is that even when double flushing, vacuum toilets use 2 litres of water instead of 6-7 litres and sometimes also normal toilets may need double flush (resulting in at least 12 litres of water use).

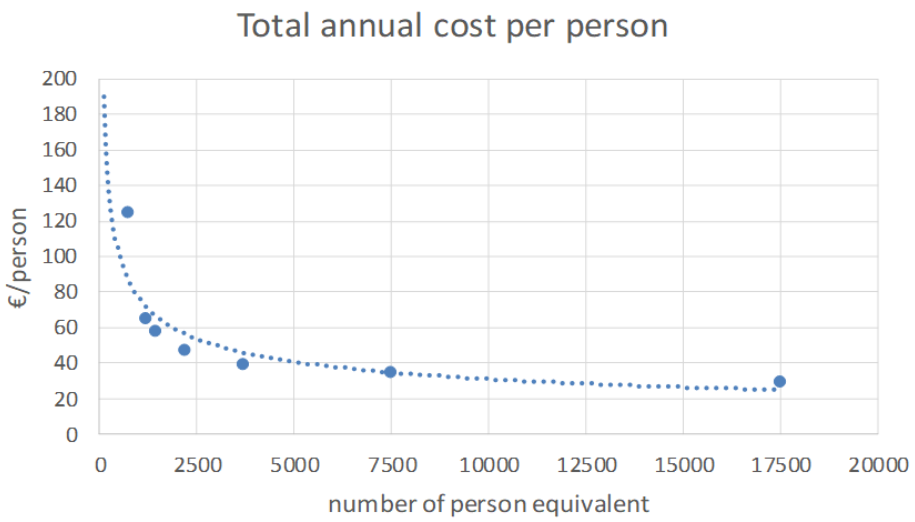
- *Can someone share nutrient analyses on blackwater from vacuum toilets?*

Parameter	Unit	Gravity toilets (Vigo Demo site)	Normal vacuum toilets	Low flush vacuum toilets (Desah office)	Low flush vacuum toilets (Demo site)
Blackwater generated	L/PE/day	36	6	3.5	3.5
COD_T	g COD_T L^{-1}	0.7-1.5 ± 0.9	8.2 ± 1.4	34.5 ± 9.5	23.7 ± 2.0
COD_f	g COD_f L^{-1}	-	4 ± 0.7	15.9 ± 2.3	11.1 ± 5.2
VFA	g VFA L^{-1}	-	1.2 ± 0.1	5.2 ± 2.1	5.8 ± 0.2
Total Nitrogen	g TN L^{-1}	0.12-0.2 ± 0.06	1.1 ± 0.2	2.6 ±0.3	2.6 ± 0.3
NH_4-N	g NH_4-N L^{-1}	0.07-0.13 ± 0.04	0.7 ± 0.1	1.75 ± 0.1	1.4 ± 0.1
Total Phosphorus	g TP L^{-1}	0.11-0.22 ± 0.04	0.12 ± 0.04	0.43 ±0.16	0.25 ± 0.07
PO_4^{3-}	g PO_4^{3-} L^{-1}	-	0.05 ± 0.02	0.28 ± 0.11	0.11 ± 0.01

Treatment system and costs

- *About Noorderhoek: what is the end product used for?*
  Biogas: Heat the UASB and heat the houses
  Greywater recovered heat: Used to heat the houses
  Struvite: Not used commercially due to small amounts produced, given for free to locals
  Effluent water: Not used so far, plans to create a communal washing machine that uses treated greywater after nanofiltration

- *OPEX EUR/pe?*
  Depends on the size and system configuration. For the Noordhoek design for Dutch market values se table below.



  Values in the graph are without taking into consideration any income from selling heat/water/nutrients.

- *Amount of chemicals for 500 PE Greywater Per year? kg and cost?*
  No chemicals for UASB and GW treatment. Around 2 euros/ p.e./y for anammox and struvite.

- *What is the water price (EUR/m^3) in Sneek?*
  It is 1.30 euros/m^3

Demo-site Porto do Molle

Answers by Eva Martinez (Aqualia)

- *Do you think that users are willing to pay more provided that they perceive an environmental benefit?*
  In Porto de Molle in Vigo, the client is a public administration, offering a sustainable, green and modern building for companies to hire offices. The image of sustainable activity is very important as part of an advanced and holistic philosophy of smart and sustainable sites and where the environmental benefits are as important as the costs. In further replications, where the potential client is the industry, at larger scale, we will be able to recover and use biogas, therefore obtaining environmental benefits while able to recover energy and therefore adjusting the costs and making the system more efficient.

- *How does the Vigo/Aqualia project work with the problem of micropollutants and pharmaceuticals in treated blackwater? (Used for irrigation)*
  To evaluate the potential use of the treated blackwater in fertigation, the AnMBR permeate produced in Vigo demo site was categorized according to the requirements for water reuse in (EU)2020/74. Since contamination of urban wastewater with pathogens is usually considered already as a high-priority risk in water reuse, pathogenic bacteria (intestinal nematodes, E. coli, Legionella spp), and viral indicators (Norovirus GI and GII, Sapovirus and Sars-Cov-2) were assessed by the University of Santiago de Compostela. Also, emerging micropollutants of special interest were subject to analysis. The fertigation potential of the AnMBR effluent was assessed by pot-test performed by project partners SLU and ASB, and toxicity essays were performed by Leitat. Results show the AnMBR permeate always complies class D requirements for water reuse, and after adjustments in the operation even class A requirements are achieved.

Demo-site Jenfelder Au

Answers by Wenke Schönfelder (Hamburg Wasser)

Vacuum system

- *How has the vacuum pipe system worked? Any special challenges?*
  - The Vacuum system works well overall. Due to the successive completion and occupation, automatic aerator stations were installed because of the risk of blockages → would not have been necessary
  - Installed pressure switches prone to failure and delivered undifferentiated collective disturbances, decision to install pressure probes (in process at the moment)
  - Special attention has to be payed towards the installations in the houses. Therefore we prepared a handbook (in English and German), that is currently translated into Swedish.
  - It is very important to advice and guide the builders, technical planners and installers from the very beginning on
  - Maintenance and emergency concept should be developed and in place for the public as well as for the private vacuum system including vacuum toilets.

- *Could the system be built in a different way to avoid the risk that the whole or big parts of the vacuum system shut down for buildings in an area instead of only the building or dwelling that are the source of the problem?*
  - There already is the possibility to shut down every building and even disconnect every toilet so in case of a malfunction not the whole area needs to be shut down

- *What type of aspects were taken in consideration when choosing the manufacturer/brand for the vacuumsytem/toilets? How were they compared with each other in order to make the most suitable choice for the project?*
  - HAMBURG WATER did not carry out the installation of vacuum toilets, this was done by the building companies
  - There were two prerequisites for the installation of vacuum toilets: Firstly, they had to meet the construction requirement and, in addition, only direct vacuum toilets were permitted
  - Due to these prerequisites only two providers were left: Roediger and Jet
  - The toilets by Roediger are known to meet the sound insulation requirement

Grew water

- *Is there a regulation existing of what levels the greywater can be treated to depending on use?*
  - In Germany, there are no statutory minimum requirements for the quality of service water for private use. Only the construction, commissioning and decommissioning of systems, for example for recycling greywater, must be reported to the local health authorities in accordance with the amendment to the Drinking Water Ordinance.
  - Stricter hygienic quality requirements are set for industrial water according to DIN 19650, which is used for irrigation purposes in agriculture, horticulture, landscaping and in parks and sports facilities. There is a total of four different suitability classes, which determine the hygienic requirements depending on the defined area of application.
- *Is the grey water treatment only indoors? Is it ejected into a local water body? How clean is the water when ejected regarding N, P? Legislative problems with that?*
  - We are still testing in pilot plants what we can achieve and what use will be possible. No decision has been made yet.

Black water

- *what is the COD load ratio between BW and fat?*
  - Blackwater has an average COD 9000 mg/L:

- Fatwater varies a lot, average COD in fat depending on study: approx. 65,000 mg/L, see table

Tabelle 9: Charakterisierung von Fettwasser der TUHH und Vergleich mit Literaturwerten

Parameter	Einheit	Eigene Untersuchung Anzahl Proben	AWW[1] Mittel ± S[2]	Min.	Max.	Literatur (Fachagentur Nachwachsende Rohstoffe e.V. (FNR))Min.-Max. Werte	Deegener 2012 Mittel ± S
TR	%	9	3,23 ± 2,75	1,84	10,52	2-70	4,52 ± 4,03
oTR	% DM	9	85,53 ± 11,32	66,11	97,38	75-93	88,4 ± 10,5
CSB	mg/L	9	67245 ± 40282	30359	170360	-	63900 ± 56500
TOC	mg/L	9	9926 ± 3480	6197	17302	-	16100 ± 13600
TC	mg/l	9	9828 ± 3689	6250	17346		-
TN	mg/L	9	632 ± 264	253	1007	0,1-3,6 %TR	540 ± 520
NH_4^+/NH_3-N	mg/L	5	152 ± 87	92	297	0,02-1,5 %TR	-
TP	mg/l	2	165 ± 113	85	245	0,1-0,6 %TR	-
pH	-	7	4,4 ± 0,6	3,4	5,1	-	4,1 ± 0,7

- *what do inhabitants think about the trucs bringing the fat?*
  - As the work yard is not located directly in the quarter the trucks are not really noticed by the residents
  - Didn't receive any complaints in our surveys

Treatment system

- *is the produced electricity enough to drive all pumps and all equipment? Is the heat enough? What is the digestion temperature?*
  - not all households are connected yet, so the final monitoring processes haven't been performed
  - it is planned that the electricity and heat that is produced is enough to run all pumps and the entire plants for BW and GW as well as to produce a surplus of electricity and heat for approx. 50-100 households
- *what is done with effluent from digester? And the sludge?*
  - Still in progress, Nutrient recovery will maybe implemented in the next years
  - Maybe usage as fertilizer