# Validation Voucher Technical Report

## VV ID [VV105]

## Project title [DeSludge – Micrbiologial treatment for fish farming effluents and hydroponic culture]

Period covered by the report: from [19/09/2019] to [19/06/2020]

## Company name

| | |
|---|---|
| Project beneficiary (SME) | **Landing Aquaculture BV** |

## Contact person (responsible for reporting)



| | |
|---|---|
| Family name | **Espinal** |
| First name | **Carlos** |
| Phone number | **+31 0 612769754** |
| Email address | **Carlos@landingaqauculture.com** |



By signing the document the beneficiary confirms that the provided information concerning this report is correct and complete.

| | |
|---|---|
| Signature | |
| Name | Carlos Alberto Espinal |
| Position | Managing Director |
| Date | 2nd June 2020 |

*Disclaimer:*

*Please note that the project summary for publication shall be published on the VIDA website and through other communication and dissemination tools, such as the CLOU5 and the European Cluster Collaboration Platform (ref to the signed VIDA Grant Agreement for Beneficiaries).*

*Images for supporting the summary for publication can be attached in the Annex. Please specify if you give the permission for publication for each image by adding "publishable" in its caption.*


The VIDA project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement nº 777795.

# 1. Summary for publication

Aquaculture is the fastest-growing food production sector in the world. A rising technology in this industry is recirculating aquaculture, which comprises land-based fish farms fitted with filtration equipment that allow the fish culture water to be recycled. Recirculating aquaculture systems (RAS) are becoming popular as they allow intensive production of fish with minimal water use, away from coastlines and with a good degree of control over the organic pollutants produced during the farming process. However, RAS can be a source of nitrogen and phosphorous emissions to the environment, if their effluents are not treated.

Traditionally, RAS farms have been able to dipose sludge and water in constructed wetlands, as soil conditioners or simply by connecting the farm to existing wastewater treatment infrastructure. However, due to the increase in intensity, size and number of farms, proactive proactive approaches are required to reduce nutrient emissions. On the other hand, aquaculture sludges are a rich source of nutrients – mostly N and P-. Moreover, the microbiota found in rearing waters of recirculating aquaculture systems has been found to have unspecified growth-promoting effects on plants

Reduction of the nutrient loads and sludge volumes in RAS can be achieved with denitrification – a classic wastewater treatment process. In the denitrification process, heterotrophic, facultative anaerobic bacteria convert nitrate – which has already been oxidised from ammonia by the RAS –, to nitrogen gas. This process requires an energy source for the bacteria in the form of organic carbon. Classic carbon sources for this process are methanol and ethanol, which are expensive to the farmer and are potentially unsafe to use. As denitrification reactors require specific operating conditions (anoxia, sufficient carbon, sufficient contact between the water and the bacteria) they tend to be relatively complex and expensive.

In this Validation Voucher project, we embarked to produce a simple, low-cost denitrification reactor which uses the fish faeces generated within the RAS to fuel the denitrification process. The reactor design would require minimal input by an operator, would require little to no moving parts and would use minimal monitoring and control equipment, all aiming to reduce cost and complexity. At the same time, we analysed the reactor effluents in search for compounds with known effects on plant growth.

The results of these findings provided us with a glimpse of the possibilities to use DeSludge reactors in commercial fish farming, as well as in combination with hydroponic horticulture operations. ***After this project, the TRL of this technology has been increased to 8.***

These type of reactors can be a valuable addition to reducing the environmental impact and water use requirements of land-based fish farms by a factor of 5-10 over conventional RAS.This has important implications in how the future of the European aquaculture sector will be able to expand in the future. For the food value chain, this means higher potential to reduce the EU's seafood trade deficit and new opportunities for circular use of resources – in this case, between the fish farming and the horticulture sectors.

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*Our key findings:*

- *The DeSludge reactor's performance, in terms of its capacity to remove nitrogen from the water on a daily basis, was close to double the initial estimates (peak removal rates were 504mgNO3/m3 reactor /day compared versus initial estimated values of 250mgNO3/m3 reactor /day.*
- *The sludge coming from the RAS was concentrated from 0.1% dry matter to 0.5% dry matter.*
- *More than 3000 compounds were found in the sludge. A few of them have been identified with potential use in hydroponic culture.*
- *The reactor has been proven maintenance-free and requires no input from an operator.*
- *The reactor is best operated in batch-fed mode instead of continuous mode.*
- *The reactor can be automated with economical, off-the-shelf timers and level switches. No PLC or control programming needed.*
- *DeSludge requires an additional solids treatment step when used as an in-line reactor in a recirculating aquaculture system.*

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# 2. Technical report / Validation report

## Project timeline

The final project timeline is presented in the figure below. The timeline represents the main events occurring during the project, with the task carried out during each event. The task numbers are per the task table of the signed Grant Agreement.

1. Project kickoff – 19th of September 2020
2. Reactor maturation 19th September 2020 until end of December 2020
3. Temporary reactor shutdown during the 2020 Christmas holidays
4. First reactor trials (Tasks 1.1,1.2 and 1.3 of the GA) until early February 2020
5. COVID19- related shutdown until April 2020.
6. Reactor modifications during April 2020.
7. Final reactor trials (Tasks 1.1, 1.3), performance benchmarking during May and early June 2020.
8. Project closing on the 19th of June 2020

The sequence of events of the DeSludge project is as follows:

1. **Initial reactor design and configuration:** before starting the DeSludge project, the DeSludge reactor was designed to fit into the Geofood RAS. The connection was made to the reactor would receive fish sludge from the system's mechanical filter (HEX F1-2 drum fitler, CMAqua, Denmark) and a flow of 12 lpm of clean, nitrate-rich waste from the RAS. The sludge/water mixture will be kept under intermittent mixing by an airlift inside the reactor. The reactor was designed to keep the majority of the solids in, allowing them to ferment and provide the denitrifiers with fermentation products that are used as a carbon source for denitrification. Excess treated water, containing some solids, would overflow the reactor and return to the inlet of the mechanical filter, completing the circuit.

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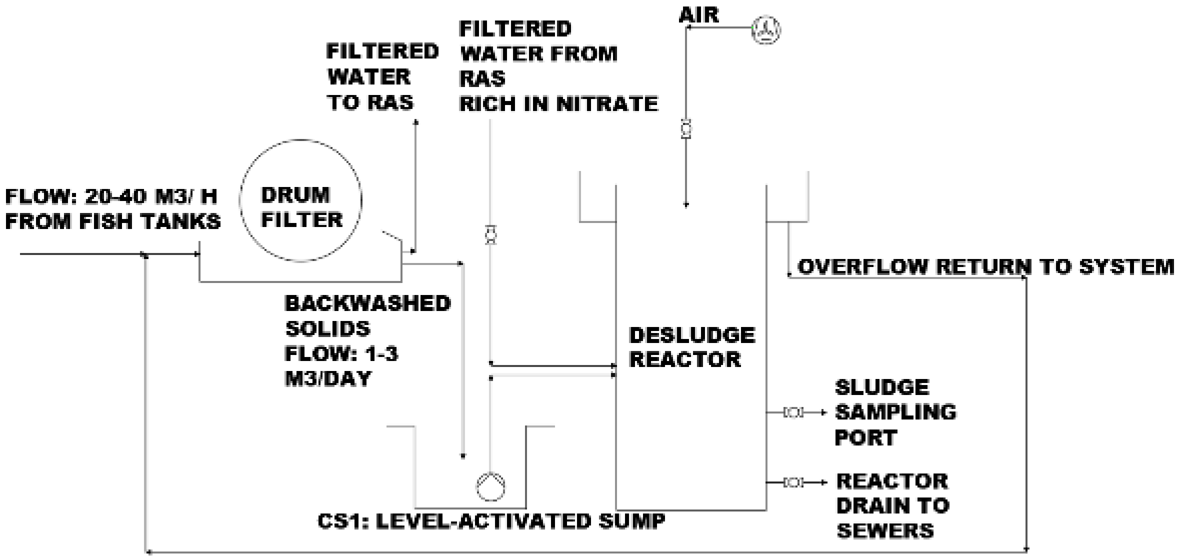


*Figure 1: initial reactor setup*

*Figure 2: the DeSludge reactor being prepared for installation in early 2019.*

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2. **Project kickoff**: The project kicks off at the end of September 2019. By the time of the project kickoff, the DeSludge reactor had been installed in the Geofood Recirculating Aquaculture System (www.geofood.eu) earlier in 2019. By the time the project started, the Geofood was stocked with red tilapia (*Oreochromis niloticus*) fed less than 2 kg of fish feed per day. This amount of feed was deemed too low to test the reactor's performance. Therefore, a maturation period begins as the same time that the fish biomass in the Geofood RAS is able to take 8-10 kg of feed per day.

3. 

*Figure 3: reactor installed*

4. **Reactor maturation:** two months were given to 1) allow denitrifying bacterial populations to develop and 2) increase the nitrogen load in the system as more fish feed was given to the growing fish biomass. Once the initial denitrifying activity was observed in the reactor, the first attempts to connect it to the RAS were made. Bringing the reactor online caused instability in the RAS for three reasons:
    a. The water stream coming out of DeSludge and into the drum filter (figure 1) was relatively solids-free, but contained oils from the fish feed and some bacterial activity. This caused the mechanical filter (drum filter) to clog after a few days of operation. The clogged filter would attempt to continuously backwash, eventually overwhelming the DeSludge reactor, causing in turn an excess of sludge loss from it.
    b. The solids captured by DeSludge reactor would quickly from a floating scum blanket on top of the reactor, this blanket would effectively carry most of the denitrifying bacteria out of the water column, hampering performance.
    c. Bringing the DeSludge system online meant the net loss of solids from the RAS was close to zero. The accumulation of the organic matter in the RAS would eventually lead

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to "blooms" of heterotrophic bacteria in the system, with subsequent deterioration of water quality.

*Figure 4: initial reactor configurations showed an excess of solids buildup at the top. This provided excellent solids capture, but little $NO_3$ removal.*

Despite these challenges, the reactor's denitrifying activity was established and a plan was made to improve the reactor's performance in early 2020.

5. **Temporary shutdown:** the reactor was kept offline during the holidays of December 2019. During this time, the bacterial community was kept alive by bringing the reactor online for brief periods of time.

6. **Offline denitrification (batch) trials:** experiments during early February found out the correct amount of sludge mixing frequency and intensity to avoid the formation of the floating scum layer. The sludge in the reactor, from this point forward, was kept in successfully. During this period, the reactor was operated online and offline intermittently to test its performance without compromising water quality in the RAS. During this period, tasks 1.1 and 1.3 were carried out.

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The nitrate removal capacity of the system was assessed during batch experiments. The reactor in this trial was able to remove around 100 mg/l of nitrate over the course of approximately 90 minutes. This information was used to include upgrades to the reactor design.

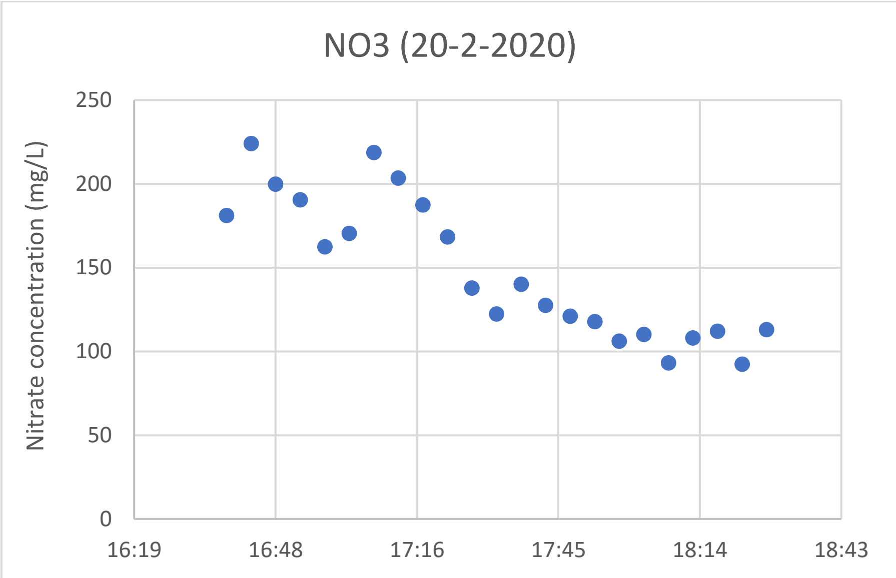


*Figure 5: NO3 concentrations sampled from the reactor during a batch experiment*

During the experiments, it was found out that the DeSludge reactor was extremely sensitive to small oxygen concentrations coming in from the RAS water stream: any small amounts of oxygenated water would gradually stop the denitrifying activity. In turn, the denitrifying activity would quickly resume as soon as the flow of oxygenated water stopped. This information was also useful as the design upgrades were carried over.

***Note: The work at this point in the project has interrupted due to COVID19. As precautionary measures, access to the testing facilities was restricted until the end of April 2020.***

7. **Reactor modifications:** to prevent oxygen contamination and to ensure continuous denitrifying activity, the reactor had to undergo modifications:
    a. The reactor's operation had to be changed from a continuous mode to a batch-fed mode, to prevent oxygen from disrupting denitrifying activity.
    b. The batch-fed cycles had to be at least 90 minutes long (figure 5). To achieve this, a larger sludge collection tank was installed upstream of the reactor. This collection tank

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would take up to two hours to fill, effectively controlling the length of the batch feeding cycles.

c. A batch sequence of reactor filling, mixing and decanting had to be used, with the filling flow being low enough to prevent the loss of sludge due to excessive water velocities.

d. The mixing had to be long enough to allow proper mixing of the reactor and to prevent the formation of a floating scum layer, but short enough to reduce oxygen intrusion as much as possible.

e. We included the option to operate the reactor as an "end of pipe" treatment device. This means that the reactor's outlet could be sent directly to the sewers instead of returned to the RAS. This was done to have better control of organic build-up in the RAS.

*Figure 6: modified reactor*

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## 8. Modified reactor re-start and final reactor trials

With the reactor modified, the bacterial community -already established in the reactor- was quick to resume activity. During this trial period, the GeoFood system was operating close to its maximum design capacity. This facilitated loading the reactor with sludge and testing its performance in a short period of time. The control of the batch-fed process and the trials were carried out successfully over a period of three weeks. The final reactor performance was documented over three sampling days.

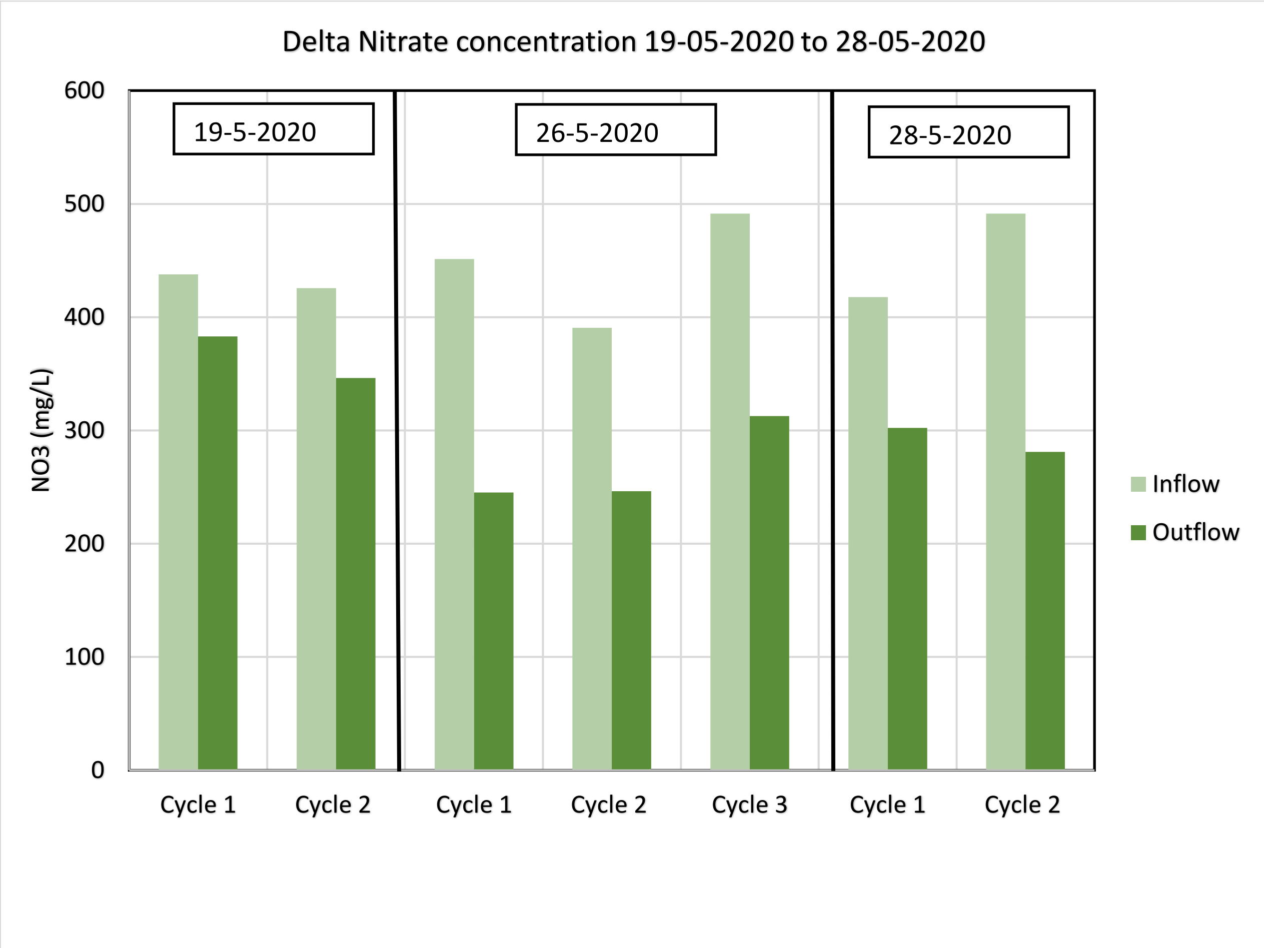


*Figure 7: differences in nitrate concentration at the inlet and outlet of the reactor sampled in several batch cycles.*

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## Explanation of the work carried per Work Package

*WP1 – T1.1- sampling analysis of N, TOC, TSS and proximate composition.*

N sampling

- $NO_2$ and $NO_3$ samples were taking routinely through the project using Sigma-Aldrich Quantofix $NO_2/NO_3$ test strips analysed by a Sigma-Aldrich Quantofix Relax analyser.
- Sampling frequency:
    - Daily in the RAS during the whole duration of the project.
    - Daily in the DeSludge reactor during at the reactor's inlet, outlet and sampling port during reactor maturation (once or twice per day) and during the trials (several times per hour each trial, by triplicate).
    - Ammonia was tested during the final trials using a Tetra colorimetric test kit.
- Main results
    - $NO_2$ values varied between 20 mg/l and 0 mg/l. Higher values were observed in moments where the denitrification reaction was interrupted by oxygen intrusion. Lowest values were recorded where batch fed cycles were longest or when the reactor was allowed to stand for 2h+
    - $NO_2$ was kept >10 mg/l in most cases. This concentration was safe to handle by the nitrifying biofilter, which kept $NO_2$ concentrations below detectable limits during the whole duration of the experiments.
    - $NO_3$ was reduced by 100-200 mg/l on a single pass through the experiments as long as the reactor was able to react for at least 1.5 h per cycle. The $NO_3$ removal rate of the reactor was calculated to be 500 g $NO_3$ per $m^3$ of reactor volume per day or 113 g $NO_3$-N per $m^3$ of reactor volume per day. This is in line with other sludge reactors studied in the literature (Klas et al., 2006; Meriac, 2014). The reactor, being 1.2 $m^3$, could remove as much as 115 g $NO_3$-N per day.

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## TOC, TSS and proximate composition sampling

- TOC, TSS and proximate composition were sampled during the final trials and analysed by WUR.
- Sampling frequency:
  - Once a day for 2 weeks by taking sludge samples from the reactor's sampling port.
  - Settable sludge was also sampled frequently with a jar and inspected to check for its presence and consistency.
- Main results:
  - Total suspended solids were kept, on average, at around 1000mg/l. However, the results are highly variable due to the intermittent mixing of the sludge not matching with the frequency of sampling events.

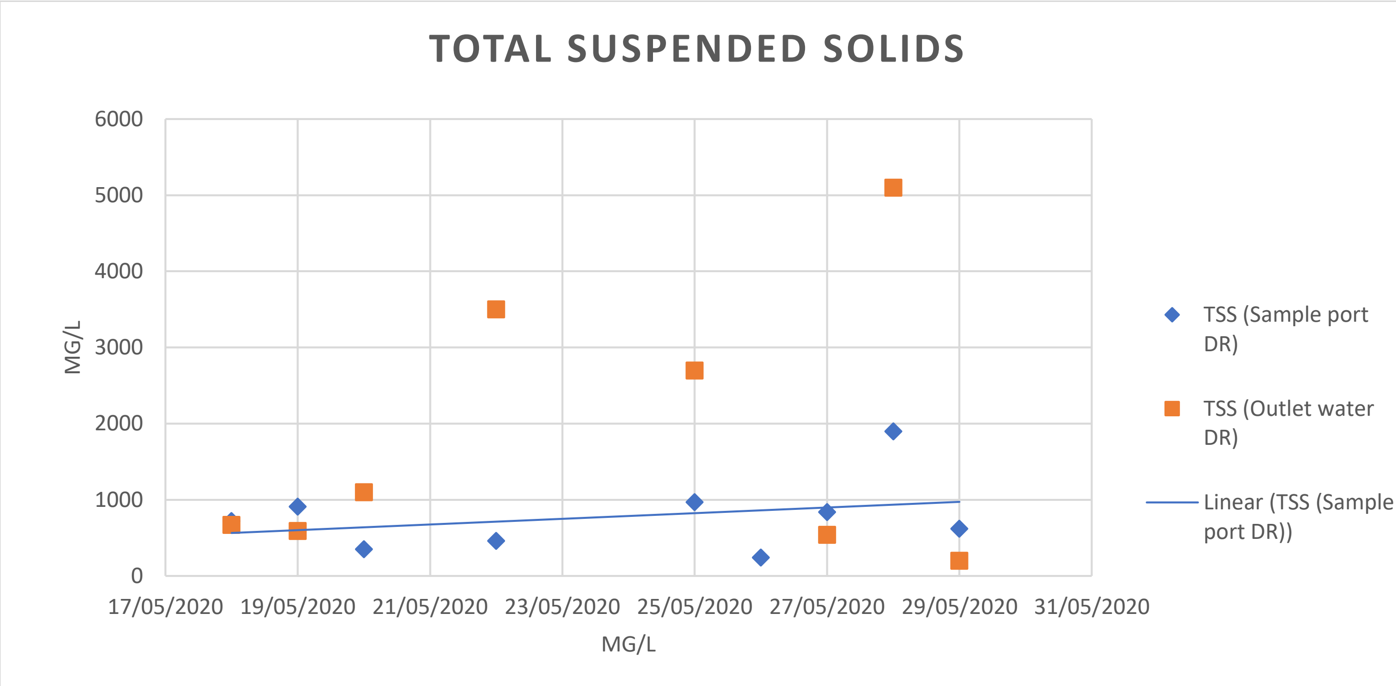


*Figure 8: TSS readings sampled*

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- Total organc carbon showed accumulation over time. This was likely due to accumulation of organic matter that is not readily available for the bacteria to consume (Meriac, 2014)

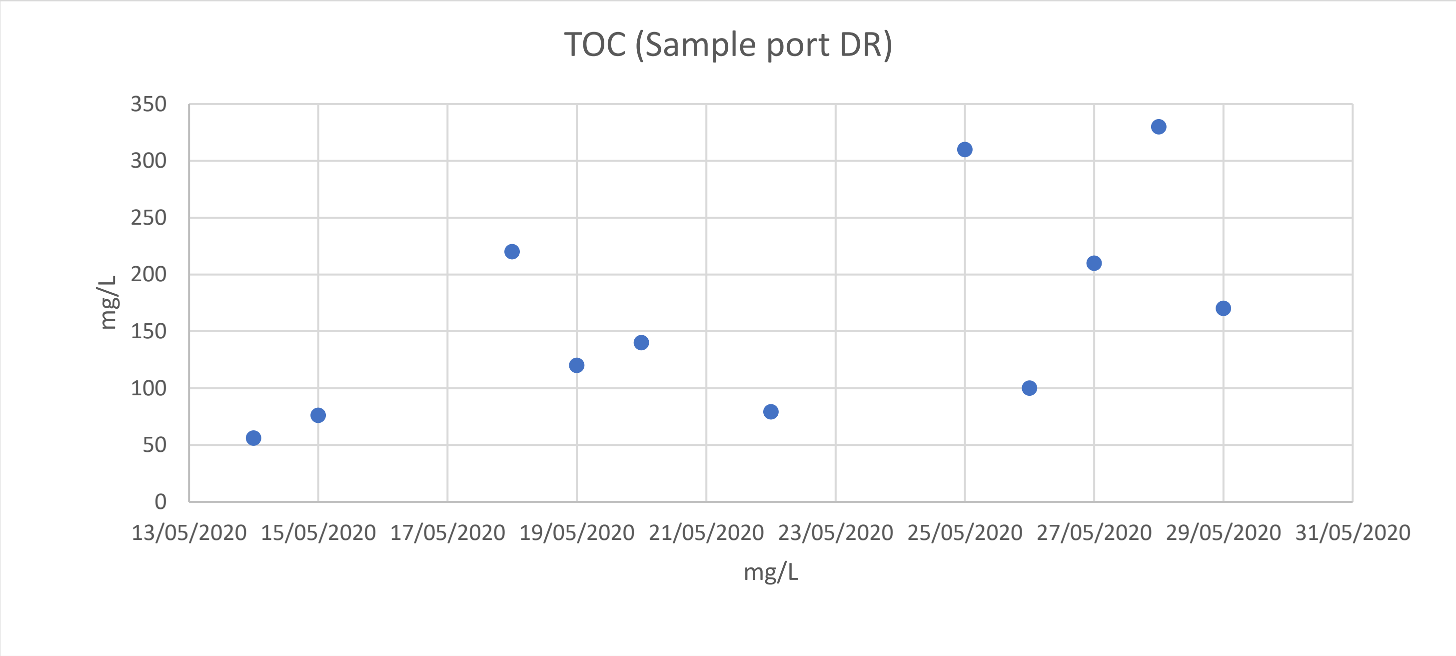


*Figure 9: TOC analysis*

- Proximate composition analysis showed that DeSludge effluents may partially replace standard recirculating hydroponic solutions. DeSludge effluent was particularly rich in Mg, K, Ca and B.
- The denitrifying activity in the reactor removes some of the NO3 needed for plant growth, in practice, extra NO3 can be dosed directly to hydroponic cultures from fish tanks whilst DeSludge reactors can be used to remove excess nitrogen when the amount of plant biomass relative to fish biomass is too small.

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*Tabel 1: proximate composition of sludge coming out of DeSluge reactors on the last day of sampling.*

| | | DeSludge outlet | Standard recirculating lettuce hydroponic solution | % substitution possible | Target value in lettuce root | % substitution possible |
|---|---|---|---|---|---|---|
| **EC** | mS/cm | 1,60 | 2,6 | 61,5 | 2,5 | 64,0 |
| **pH** | | 7,40 | | | 5,5 | |
| **NH4** | mmol | 0,10 | 1,25 | 8,0 | 0,1 | 100,0 |
| **K** | mmol | 6,70 | 11 | 60,9 | 6 | 111,7 |
| **Na** | mmol | 3,20 | | | <8 | |
| **Ca** | mmol | 0,50 | 1 | 50,0 | 1,5 | 33,3 |
| **Mg** | mmol | 0,70 | 1 | 70,0 | 1,5 | 46,7 |
| **NO3** | mmol | 6,20 | 19 | 32,6 | 19 | 32,6 |
| **Cl** | mmol | 3,70 | | | <10 | |
| **SO4** | mmol | 0,50 | 1,125 | 44,4 | 2 | 25,0 |
| **HCO3** | mmol | 0,80 | | | <1 | |
| **P** | mmol | 0,43 | | | | |
| **Si** | mmol | 0,05 | 0,5 | 10,0 | 0,5 | 10,0 |
| **Fe** | µmol | 1,20 | 40 | 3,0 | 40 | 3,0 |
| **Mn** | µmol | 0,20 | 4 | 5,0 | 5 | 4,0 |
| **Zn** | µmol | 0,60 | 4 | 15,0 | 5 | 12,0 |
| **B** | µmol | 12,00 | 30 | 40,0 | 50 | 24,0 |
| **Cu** | µmol | 0,20 | 0,75 | 26,7 | 1 | 20,0 |
| **Mo** | µmol | 0,10 | 0,5 | 20,0 | 0,5 | 20,0 |

### *Task 1.2 – Metabolomic analysis of the sludge*

The metabolomics analysis was performed by WUR. In this section, a extract of their report (enclosed with this report) is provided:

#### Sludge sampling, storage and analysis (by WUR)

- 18 x 10 ml samples in 50 ml tubes, freeze-dried for transport and storage
- 0.5 ml of 75% methanol+0.1% formic acid added to residue
- sludge samples had larger dry residue: 2 ml added
- 15 min sonication, 15 min centrifugation at 5,000 g
- supernatant transferred to 1.5 ml Eppendorf tubes
- 15 min centrifugation at 20,000 g
- 180 µl of protein-free, clear supernatant transferred to HPLC vial

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- LCMS profiling in both positive and negative ionization modes

## Metabolomic analysis

Untargeted metabolomic analysis was performed by processing the unbiased data. Metalign software was used for peak picking and alignment (243,356 signals in pos. ionization mode and 89,870 signals in neg. mode). MSClust was used to group all signals originating from the same compound (1,816 compounds in pos. mode and 1,184 compounds in neg. mode).

Finally, unsupervised multivariate statistics (PCA) with both positive and negative data sets was applied to identify differences between and within sample groups.

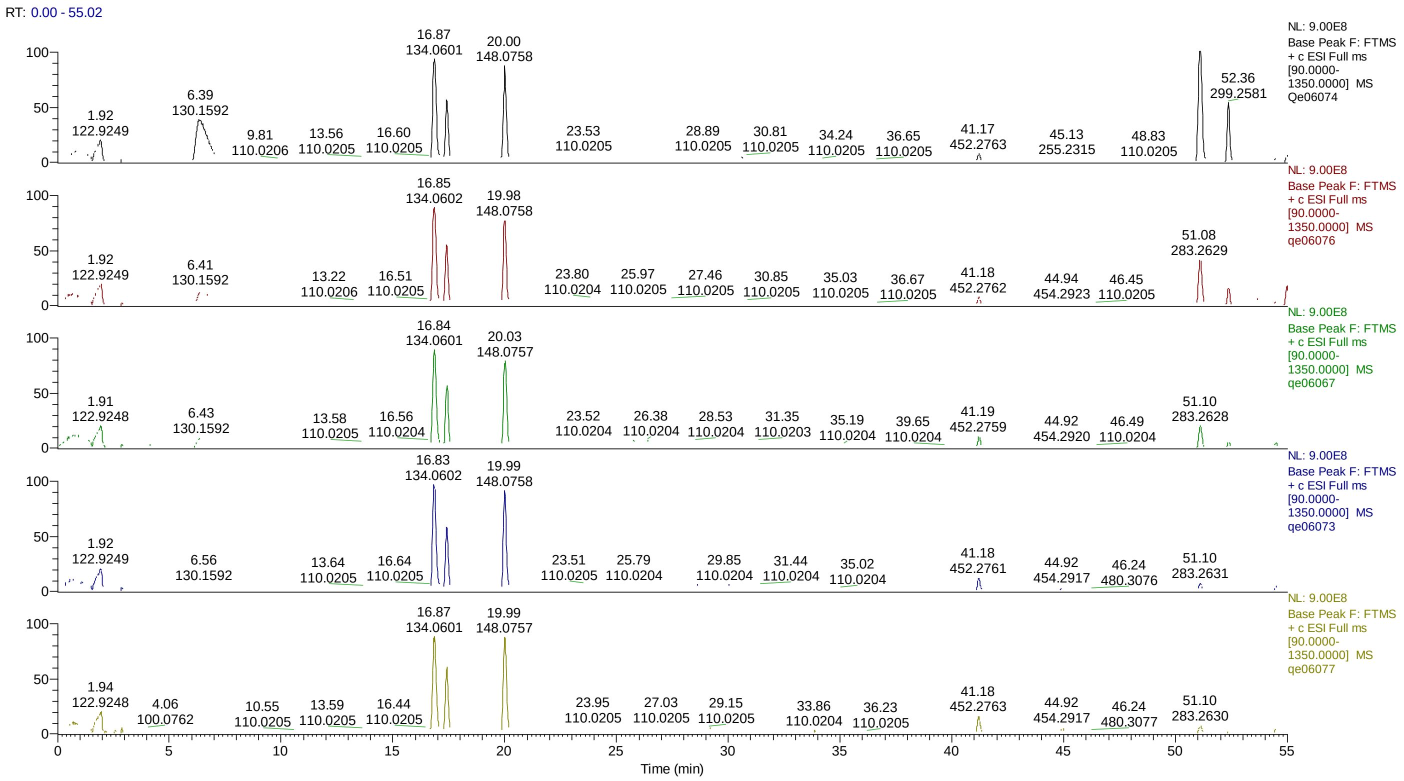


*Figure 10: results of chromatography analysis*

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Results

- 3004 compounds were detected in the DeSludge reactor samples. All compounds have been stored in a database, pending further analysis.
- A preliminary assessment of the data has pointed out at some interesting compounds:
    - Penitrem B, a mycotoxin with insecticidal properties which has also been shown to have anti-tumoral effects in humans (Reddy et al., 2019).
    - Indole-3-carboxaldehyde, an antifungal metabolite (Brucker et al., 2008)
    - Choline, an essential nutreint for animals
    - Myristic acid, a long-saturated fatty acid used in the costmetics and nutrition industries
    - Proline, an aminoacid which enhances stress tolerance in plants when supplied in low concentrations (Hayat et al., 2012)

## Task 1.3 – Daily sludge sampling and reactor control

- Reactor was sampled almost daily for the duration of the project. Exception were 1) Christmas holiday period 2) reactor shutdowns during fixes
- Once the reactor operated in its final form, reactor control was not necessary.

## Task Project management

- Reactor control and liaising with the contractor was done on a weekly basis during the course of the project
- Data was collected and analysed by both Landing and WUR

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## Technical Success criteria

| Criterion | Result | Deviation | Fix |
|---|---|---|---|
| **Nitrate removal rates above 250 mg $NO_3/L_{reactor}$/day.** | Rates achieved around 500 mg$NO_3/L_{reactor}$/day. | No comment | |
| **Sludge concentrated to 2% dry matter** | Maximum sludge concentrations achieved 0.5% dry matter | A typo in the grant agreement document: target should have been 0.2% dry matter instead of 2%. | |
| **<3 mg/ ammonia nitrogen at the reactor outlet** | Ammonia nitrogen was <1mg/l when tested | No comment | |
| **2 mg/l $NO_2$ at the reactor outlet** | $NO_2$ varied between 0 and 20mg/l | Batch-fed cycle times need to be longer than 1.5h to reach $NO_2$ target. | Increasing batch-feeding cycle duration to 3-4h and/or pass effluent through nitrifying biofilter or ozonation process |
| **Reactor operation requires less than 30 mins per day** | The reactor operated without user input | No comment | |
| **Water quality in the fish tanks connected to the reactor is acceptable** | Water quality deteriorated when connected to the fish tanks | Excess organic matter escaping the reactor | A solids treatment step between the reactor and the RAS is needed |
| **Baterial metabolites and trace elements are detected** | 3004 compounds detected. Presence of macro and micronutrients used in hydroponics also detected. | | |

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# 3. Impacts

## Overall impact - VIDA Scope

*Vida Challenge tackled: closing loops in* ***sustainable aquaculture***

- The DeSludge reactor has been proven to reduce nitrogen emissions from recirculating aquaculture systems without the need of complex equipment or expensive chemicals.
- The reactor seems to produce a very large range of chemical compounds that could be used in circular production / biorefinery concepts. This requires further research, explained in section 5 of this document.
- Recirculating aquaculture systems farms fitted with denitrification reactors – DeSludge among them- can reduce their water consumption to about 100 litres per kg of feed delivered (Martins et al., 2010) – this is one hundred times less than classic flow-through farms.

## Test Scope

In this project, the nitrate removal capacity of DeSludge from RAS waters was found. Other important design and operating parameters such as hydraulic loading rates, operating mode (continuous vs batch), length of reacting cycles and frequency of sludge mixing cycles were also identified. With this information, the sizing and design of DeSludge reactors in commercial applications will be possible.

The 1.2 $m^3$ DeSludge achieved removal rates of about 115 g $NO_3$-N (504 mg/l $NO_3$) per day on a 50$m^3$ RAS producing about 700 g $NO_3$-N per day. To remove most of the $NO_3$-N in the system a reactor of 7.2 $m^3$ (14-15% of the total system volume) would be needed. However, RAS systems are preferably run with some $NO_3$-N left in the water to prevent the formation of toxic $H_2S$. In practice, DeSludge reactors would be sized to be >10% of the total volume of a RAS.

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## TRL

The initial 2018 DeSludge concept was considered to be TRL 6. With the reactor prototype validated, the TRL has been increased to 7 or 8 depending on the case:

- The reactor can be considered TRL 8 – system completed and qualified in warmwater aquaculture applications where fish are fed with high-protein diets. This is because the reactor performance will be highly dependent on temperature and the nitrogen / carbon content of the ish feeds.
- The reactor should be considered TRL 7 for applications where the environmental conditions could affect reaction performance such as
    - Cold water aquaculture (trout, Atlantic salmon)
    - Seawater aquaculture (Kingfish, seabass, seabream)

## Road to market

The following table estimates the possible market penetration opportunities that lie ahead for the technology

| Application | Potential clients | Market readiness | Sales projections | Sales channels | Territories |
|---|---|---|---|---|---|
| DeSludge as end of pipe treatment systems | Small / medium scale recirculating aquaculture farms (10s to 100s of tons per year) and laboratories | Ready to market | 1-3 units per year | Direct sales to Landing's customers and inclusion of the technology in turnkey projects | EMEA |
| DeSluge in coldwater and seawater systems | Large scale recirculating aquaculture systems | Industrial validation required. Landing to conduct further development | No sales projected until 2022 | Direct sales to Landing's customers and inclusion of the technology in turnkey projects | EMEA and the Americas |

The short-term market opportunities are comprised by upcoming and running farms which can benefit from the low cost entry barrier of the DeSludge system. However, in the long term, very large scale fish farming operations producing fish on the tens of thousands of tons per year will require large and possibly more complex treatment systems. To this end, Landing will continue development work to offer solutions to this future market.

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## Penetrating the horticultural market

There are possibilities to enter the horticultural market, however, the risk of using new technologies is a barrier for entry. To enter the market, further validation and demonstration – ideally by the hand of WUR as a reptutable scientific partner- will be crucial. Questions remain on the true benefit of using DeSludge reactors in for horticulture despite the initial findings. To find what is possible, Landing will extend their efforts in waste valorization and integrated production systems via three main ways:

- Landing will open an industrial PhD position on circular production systems from 2021 onwards as part of the EASYTRAIN project from the programme H2020-MSCA-ITN-2020.
- Landing is aiming to start a new research project on circular production systems using salmon RAS and horticulure by the end of 2020. Although the project has not been officially started, the opportunity would be used to further validate the technology.
- Landing will take part in the dissemination and exploitation efforts of the Geofood Project,as it reaches its end by mid 2021. The project serves as a great platofrm to communicate the findings of the work carrier out in the Geofood RAS, which also include the DeSludge project.

## Closing the loops -other benefits

- DeSludge was found to concentrate and/or produce 3000 compounds. The preliminary assessment finds plant stress management, insecticidal and antifungal properties.
- In other experiments (outside the scope of this project), sludge from the DeSludge and water mixtures were employed successfully in hydroponic lettuce production.

# 4. Description of deviations from project plan (if applicable)

- Deviation 1: testing was delayed due to oxygen contamination in the reactor.
  - Solution: the reactor design was modified to run batch-fed instead of continuously. Sludge mixing cycles were reduced in duration and frequency.
  - Outcome: the DeSludge reactor successfully removes nitrate from water.
- Deviation 2: testing was delayed due to COVID19.
  - Solution: final reactor trials had to be delayed until the testing facilities were able to accept workers again.
  - Outcome: trials were undertaken successfully.
- Deviation 3: personnel costs higher than planned
  - The calculated salary for the employees (base salary + overhead) have been adjusted
  - The hourly allocation for Carlos Espinal was increased due to the extended duration of the project. The hourly allocation was divided into one hour per week for the worker to

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visit the facilities during the whole duration of the project plus 5 full days where the worker remained in the facilities for experiments and modifications to the reactor.

- The hours for Rob van den Ven remain unchanged
- The hours for Timo Wolfswinkel remain unchanged.

## 5. Description of further planned activities

The DeSludge reactor, as tested and validated in this project is already being offered to the market and its included as an optional treatment device in Landing's offers for recirculating aquaculture systems. The system is currently offered as:

- End-of-pipe- treatment device for RAS plants that require to reduce their nitrogen load.
- Sludge treatment / wet composting reactor for aquaponic projects. In this version, landing offers the options to run the reactor anaerobically or aerobically.

To the writing of this report, Landing is offering one turn-key recirculating aquaculture system that uses the technology and one turn-key recirculating aquaculture system that could use the technology in the future. Landing is also responding to customer enquiries about the technology on a constant basis.

Other planned activities include:

- Further reactor testing and optimization for Atlantic salmon farming: the reactor will be tested in cold water conditions in a salmon RAS.
- Post-treatment of reactor effluents to achieve full recirculation. The reactor will be tested with an aggressive solids capture step so its effluent can be added back to the RAS without increasing the organic matter loading.
- A upscaled, 9m$^3$ reactor installed in the Geofood system will be tested in late 2020 and 2021.
- Further research will be planned to survey the database *of 3004 compounds found during the metabolomic analysis of the sludge.*
- Studying the feasibility of using these reactors in combination with microalgae cultivation

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## 6. Summary of dissemination and communication activities

Project dissemination was done through Landing Aquaculture's social media channels, where constant updates about the setup and the recirculating aquaculture system were made. In addition, two magazine articles making reference to the technology were publised in the International AquaFeed Magazine.

December 2019 - https://issuu.com/international_aquafeed/docs/iaf1912_w1

May 2020 - https://issuu.com/international_aquafeed/docs/iaf2005_w1

Social media updates:
https://www.linkedin.com/feed/update/urn:li:activity:6674307495978135552

https://www.linkedin.com/feed/update/urn:li:activity:6607931655715897345

https://www.linkedin.com/feed/update/urn:li:activity:6559417079693402113

| Communication and Dissemination Activities | Nº |
|---|---|
| Organisation of a Conference | |
| Organisation of a Workshop | |
| Press release | 0 |
| Non-scientific and non-peer-reviewed publication (popularised publication) | 2 |
| Exhibition | |
| Flyer | 0 |
| Training | |
| Social Media | 4 |
| Website | |
| Communication Campaign (e.g. Radio, TV) | |
| Participation to a Conference | |
| Participation to a Workshop | |
| Participation to an Event other than a Conference or a Workshop | 1 |
| Video/Film | |
| Brokerage Event | |
| Pitch Event | |
| Trade Fair | |
| Participation in activities organized jointly with other EU project(s) | |
| Other | |

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Most of the stakrholders reached were general public and aquaculture enthusiasts following our social media pages, which generated in total more than 2000 impressions. Members of the scientific community have approached Landing eniquiring about the technology and one supplier of RAS has initially shown interest in the technology.

| Stakeholders' groups | Nº |
|---|---|
| Scientific Community (Higher Education, Research) | 20 |
| Industry | 4 |
| Civil Society | |
| General Public | 2100 |
| Policy Makers | |
| Media | 1 |
| Investors | |
| Customers | 1 |
| Other | |

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## Annex

*Please include here images for supporting the summary for publication, and specify if you give the permission for publication for each image by adding "publishable" in its caption. You shall include at least one publishable image as supporting evidence of the Validation project.*

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*Figure 11: publishable*

The VIDA project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement nº 777795.

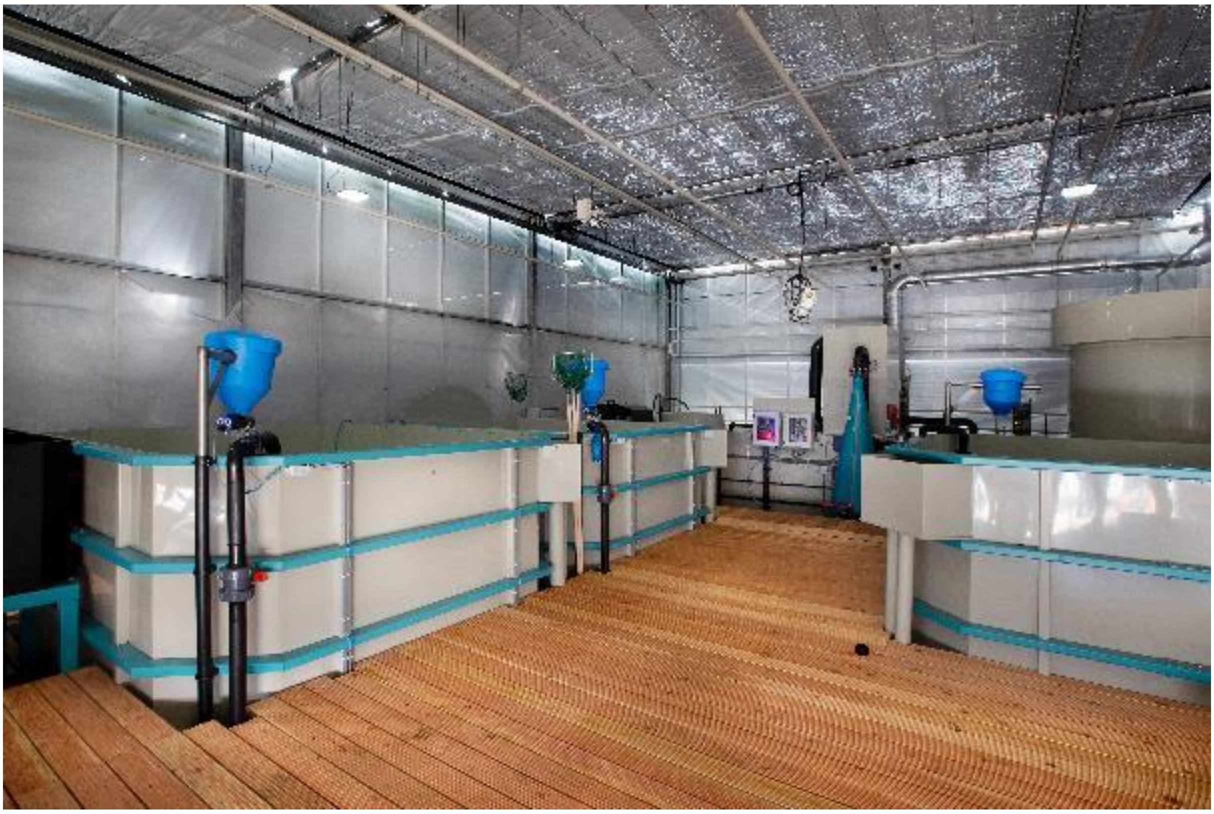
*Figure 12: publishable*

The VIDA project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement nº 777795.

*Figure 13: publishable*

The VIDA project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement nº 777795.

*Figure 14: publishable*

The VIDA project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement nº 777795.


*Figure 15: reactor sampling. Alexander Boedijn, project manager of the DeSludge validation work in WUR Greenhouse Horticulture. Publishable.*

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*Figure 16: running reactor. Publishable*

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