LIFE DENTREAT

LABORATORY PILOT PLANT TESTS

THE LIFE DENTREAT PROJECT

What is the problem?

Digital textile printing (DTP) has recently become a widely used printing technology in many European textile districts. Although it brings certain environmental advantages, DTP requires dipping the entire fabric in urea, which is then completely washed out after printing and ends up as nitrogen residue in wastewaters.

Certain European textile districts experience nitrogen-rich wastewater in concentrations not efficiently supported by the local wastewater treatment plants.

How can DeNTreat address the problem?

Life DeNTreat technology aims at reducing the amount of nitrogen content in urban wastewater in a sustainable and cost-efficient way using an on-site wastewater treatment module based on the anammox microbial process (PN/Anammox process).

WASTEWATER CANDIDATES FOR LIFE DENTREAT ADOPTION

Four different wastewaters (WWs) discharged by digital textile printing (DTP) companies have been investigated with the PN/Anammox laboratory pilot plant. The characteristics of the four wastewaters are shown in **Table 1**. *While the organic fraction was the main contribution of total nitrogen in WW 1 and 2, urea in WW 3 and 4 was almost totally converted to ammonia before the lab-scale pilot tests.*

Laboratory pilot plant tests

The PN/Anammox tests with the four wastewaters have been carried out with the lab-scale reactor shown in **Figure 1**.

In the SBR reactor the treatment cycle is divided into 4 distinct time periods, which correspond to the different phases of the process: feed, reaction, sedimentation and discharge. During the feeding phase the wastewater is fed into the reactor, where it is mixed with the residual biomass from the previous cycle. When the maximum set level is reached (2 L), the mixing-aeration phases, which started during the feeding period, are completed in the reaction phase. As in the feeding period, even in the reaction phase, anaerobic, anoxic and aerated phases can alternate, by setting properly the aeration system. Once this phase is over, the sedimentation phase begins, which is accomplished by deactivating the aeration-mixing systems, which allows settling the granules on the bottom of the tank leaving the treated wastewater above. The duration of the sedimentation time is kept low, to allow the settling of the granules, but not that of the suspended solids, that are mostly made of undesired fast-growing heterotrophic biomass. At the end of the sedimentation the clarified effluent is discharged.

Characteristics	WW 1	WW 2	WW 3	WW 4
pH	8.8	8.9	9.2	9.2
Conductivity (uS)	1537	300	2410	2430
COD (mg/L)	891	395	329	1001
TN (mg/L)	728	508	220	311
NH4+-N (mg/L)	17.5	33.4	196	273
NO3--N (mg/L)	1.3	4.9	0.8	2.7
NO2--N (mg/L)	< 1	< 1	< 1	< 1
Organic N (mg/L)	709.2	468.8	23.2	35.3
TSS (mg/L)	70	33	NA	200

Table 1 – Characteristics of the four wastewaters studied.

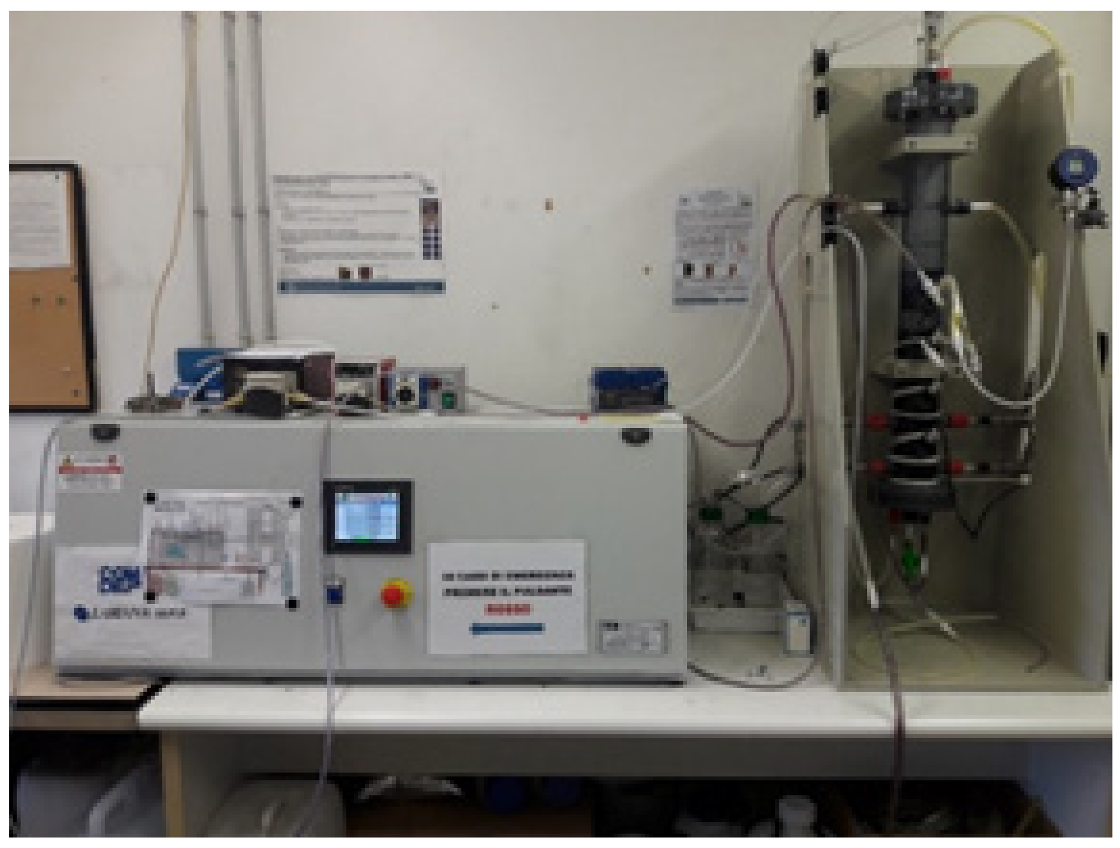

Figure 1- SBR reactor (on the right) and control unit (on the left).

Operating conditions	WW 1	WW 2	WW 3	WW 4
Duration of experiment (days)	5	7	5	5
Cycle duration (hours)	6	6 - 8	4 - 3	4 - 3
Volume exchanged (L/cycle)	0.45	0.45	0.50	0.50
Biomass concentration (gVSS/L)	8.0	8.0	8.0	8.0
pH	7.2 - 7.6	7.2 - 7.6	7.6 - 7.8	7.6 - 7.8
DO (ppm)	0.2 - 0.4	0.2 - 0.4	0.4 - 0.7	0.4 - 0.7

Table 2 – Operating conditions of the PN/Anammox lab-scale reactor with the four WWs.

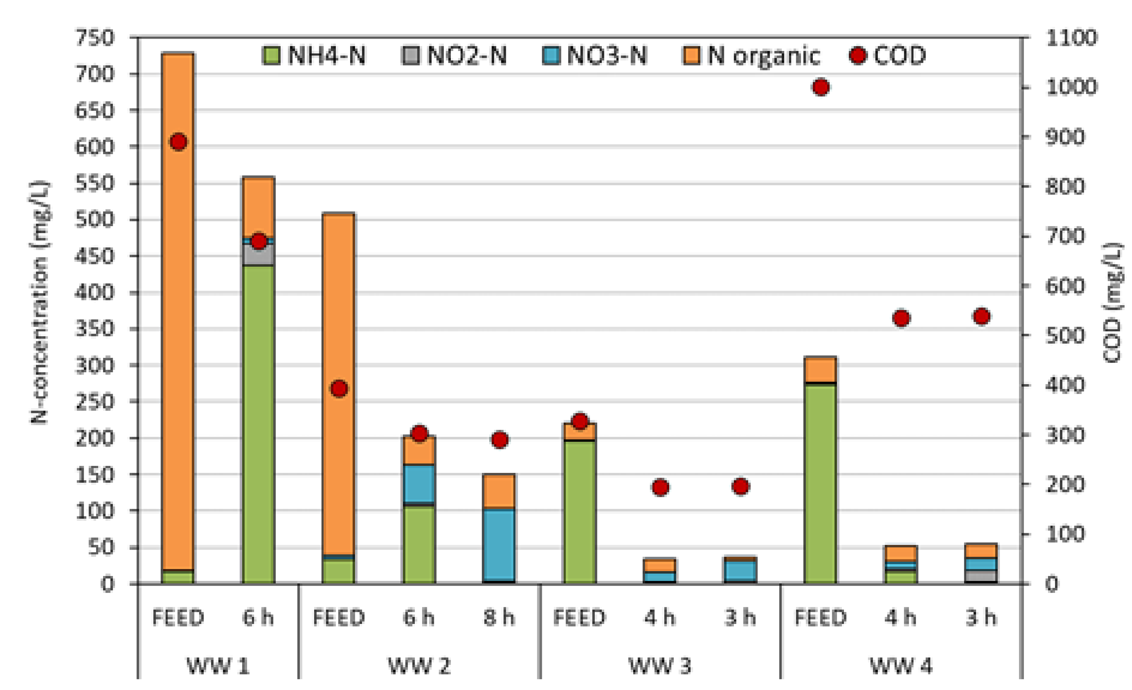

Figure 2 – Composition of the total nitrogen and COD concentration in the influent and at the discharge from the PN/Anammox lab-scale reactor in the four WWs.

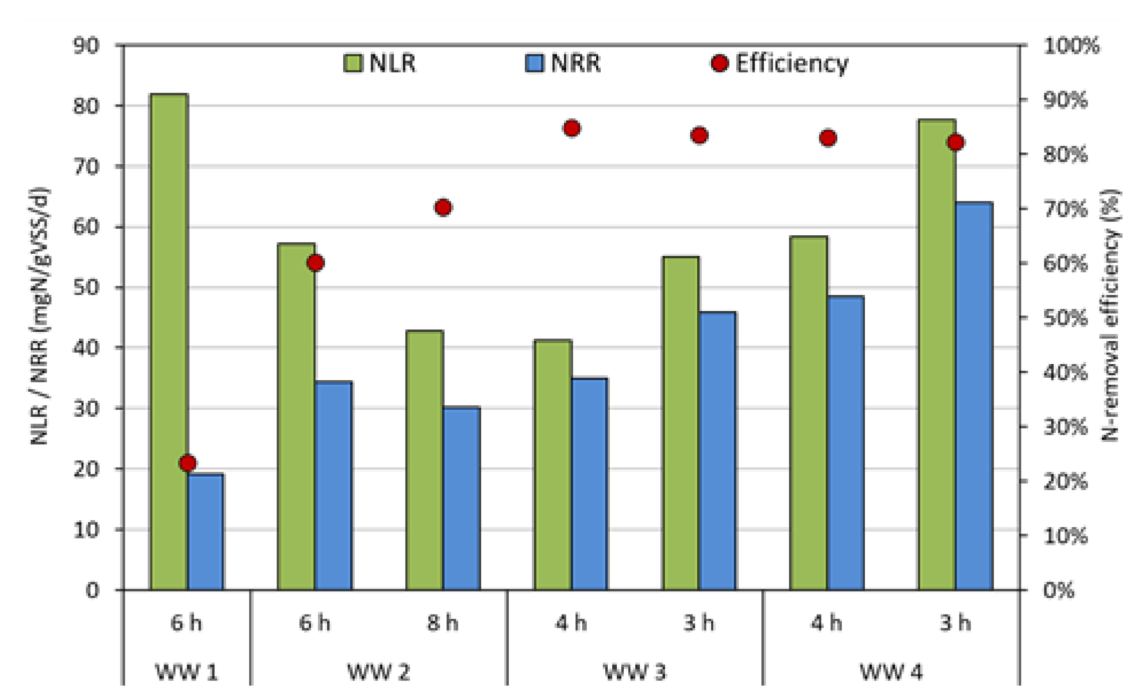

Figure 3 – NLR e NRR in [mgN/gVSS/d] for the four WWs.

The operating conditions of the quick clinic tests on the four WWs are reported in **Table 2**. *From preliminary experiments, the ranges of pH and DO have been set in order to favour Anammox bacteria over other species (NOB) and enhance the Anammox activity. On the other hand, the duration of the cycles has been varied according to the WW characteristics.*

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The composition of the total nitrogen and the concentration of COD in the effluents from the PN/Anammox lab-scale reactor are shown in **Figure 2**.

Considering WW 1, despite low total nitrogen removal, it is important to notice that a very high ammonification occurred and most of the organic nitrogen was converted into ammoniacal nitrogen. Indeed, bacterial populations in the reactor were able to convert urea into ammonium and also a large proportion of the ammonia was removed via PN/Anammox and not via nitrification/denitrification. These results evidenced that the condition "NH4+-N/total N ratio > 30%", previously considered for the selection of WW candidates, was excessively conservative, as the process starts even with very low ratios.

Similar results have been achieved with WW 2, where the bacterial consortium was able to convert organic nitrogen into ammonium and 60% of total nitrogen was removed through the PN/Anammox process. Since a still high portion of ammonia (106 mg/L) was present at the discharge at the end of the 6 h-cycles, the duration of each cycle was increased up to 8 h. The results showed that about 90% of the organic nitrogen was ammonified and almost 100% of the ammonia was removed.

On the other hand, the organic fraction in WW 3 and 4 was already converted to ammonia before the PN/Anammox test, without any pretreatment. The lab-scale experiments allowed to remove 82-85% of total nitrogen at the discharge, independently from the duration of the cycles, with average concentrations of 34 and 54 mg/L for WW 3 and WW 4, respectively. These results showed that the nitrogen load might be furtherly increased, with shorted cycles, without any strong effect on the nitrogen removal efficiencies.

Figure 3 *shows the nitrogen loading rate (NLR) and the nitrogen removal rate (NRR) with the four WWs. Nitrogen removal efficiencies were higher than 80% for WW 3 and 4, while it was 23% for WW 1 due to the too short cycles duration. Moreover, NLR values were in the range 41-55 mgN/gVSS/d and 58-78 mgN/gVSS/d for WW 3 and 4, respectively, and may have been increased further.*

In conclusion, WW 3 and 4 have been demonstrated that can be treated by the PN/Anammox process with high efficiencies. On the other hand, WW 2 and WW 1 need longer duration of the cycles and lower nitrogen loads to be treated, allowing first the time needed for the conversion of organic nitrogen to ammonia.

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Project Partners

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