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MENAWARA

WP3. ACTIONS TO INCREASE THE QUALITY OF NON CONVENTIONAL WATER USED IN AGRICULTURE

Output 3.4. No. of pre and post-treatment and MAR systems realized.

A 3.4.2 Implementation of pre and post-treatments on non-conventional water. Choutrana II, Borj Touil, Beni Hassen, Tunisia

Responsible partner: ONAS

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ABBREVIATIONS AND ACRONYMS

Acronym	Description
CRDA	Commissariat Régional au Développement Agricole
CW	Constructed Wetland
GDA	Groupe D'aménagement Agricole
ONAS	Office National de l'Assainissement
TWW	Treated Wastewater
WP	Work Package
WWTP	Wastewater Treatment Plant

1. BACKGROUND

This technical report has been written in the context of the MENAWARA project on Non-conventional Water Re-use in Agriculture in Mediterranean countries.

The joint challenges of the MENAWARA project consist in providing additional resources by recycling drainage and wastewater, rationalizing water use practices and setting operational governance models in line with national and international plans. The project is designed to enhance access to water through the treatment of wastewater to be re-used as complementary irrigation and to strengthen the capacity of governmental institutions, non-state actors operating in the sector, technicians, and farmers.

The document reports the activities carried out in the third Work Package (WP3) of the MENAWARA project on *Non-conventional Water Re-use in Agriculture in Mediterranean countries* and, in particular, is related to the **Output 3. 4 "Number of pre and post treatment and Managed Aquifer Recharge systems realized"** and **Activity 3.4.2 "Implementation of pre and post-treatments on non-conventional water"** as described in infographic below (Figure 1).

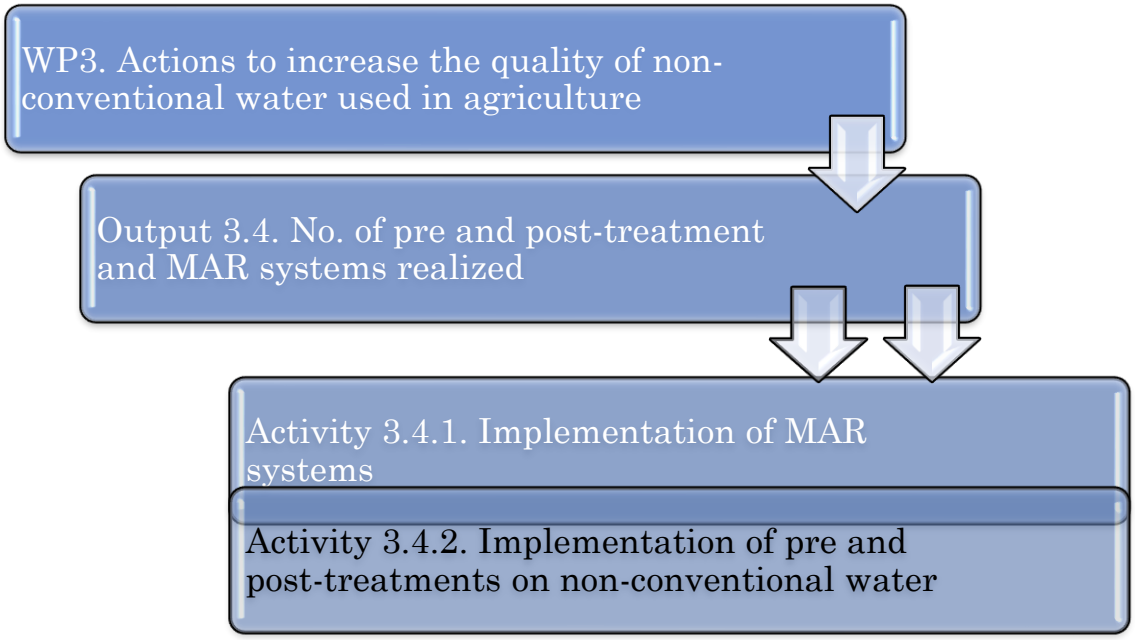

Figure 1. Infographic on the context of this technical report. MAR: Managed Aquifer Recharge.

This is the second technical report for the intervention in the WWTPs in Choutrana II, Borj Touil and Beni Hassen, Tunisia, after the technical reports written on the design of major interventions by the Spanish Public Foundation Center for New Water Technologies (CENTA) of June 2020, currently fully incorporated into the Environment and Water Agency of Andalusia (AMAYA).

More specifically output 3.4 is described as follows: "Low-cost pre and post-treatments for each WWTP in the intervention areas realized and high-quality TWW supplied to irrigation distribution networks adopting more rational irrigation techniques compared to the pre-project situation. MAR systems (FIA) realized in Arborea by using improved non-conventional water to recharge the phreatic sandy aquifer exploited for agricultural purposes"

This document details the technical aspects of the pre and post-treatment implemented in the WWTPs of Choutrana II, Borj Touil and Beni Hassen in Tunisia, under this output 3.4 over the period of June 2022 and September 2023 as part of Activity 3.4.2 "Implementation of the post-treatment on non-conventional water"

The document is structured considering as follows:

1. A general introduction of the areas of intervention and WWTPs short description (Section 2);
2. Detail of the pre and post-treatment interventions and technical specifications (Section 3);
3. Concluding remarks (Section 4).

2. AREAS OF INTERVENTION

In Tunisia, the MENAWARA project has 3 intervention areas: Choutrana II, Borj Touil and Beni Hassen. The intervention site of Beni Hassen (Monastir) replaced the initially proposed sites of Kelibia and Korba, after having been cancelled in the major amendment approved by the Managing Authority on August 23rd, 2022. In the following, a short description of each area is reported.

2.1. CHOUTRANA II

The Choutrana WWTP is located 20 km northward from the centre of Tunis, in a flat swampy area at an elevation close to the sea level. It gathers the sewerage system of Tunis city, serving more than 1 million inhab. eq., occupying a large surface of 40 ha (Fig. 2). The effluent is already partially utilized for irrigation by the Commissariat Régional au Développement Agricole (CRDA).

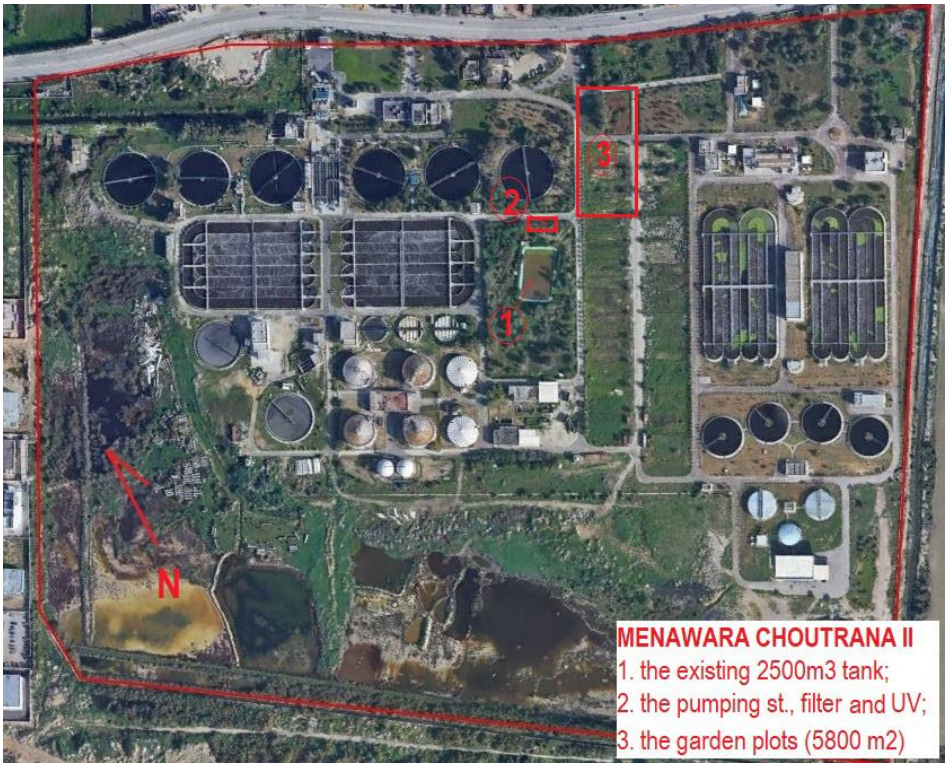

Figure 2. Location of the Choutrana WWTP (Tunis)

Choutrana II, on the contrary, is a small portion of that area, utilized by MENAWARA for renovating totally the existing WWTP feeding an experimental irrigated garden of 0.6 ha, named the Living lab. The main

characteristics of this WWTP which is used for wastewater treatment for urban and agricultural use are as follows (Fig. 3):

- primary and secondary treatment (low-load activated sludge);
- 16% of the treated wastewater is diverted to Borj Touil for agriculture use;
- the daily capacity of the plant is 40,000 m^3;
- the plant produces 20,000 kg of organic matter daily;
- pretreatment: grit removal, coarse screen;
- pumping of wastewater to another pretreatment: grit removal, screens, grease removal;
- four aeration basins (fine bubble diffused aeration) with a capacity of 60,000 m3/day, connected to 10 suppressors of 560 kgO_2/h;
- 04 secondary clarifiers with a unit volume of 2,920 m^3;
- sludge treatment:
    - recirculation to biological reactors.
    - excess sludge:
        - 02 thickeners with a unit volume of 2000 m^3;
        - mechanical dewatering of sludge thickened by 03 units of 20 m^3/h band filter each. Coagulation-flocculation process before the band filters.

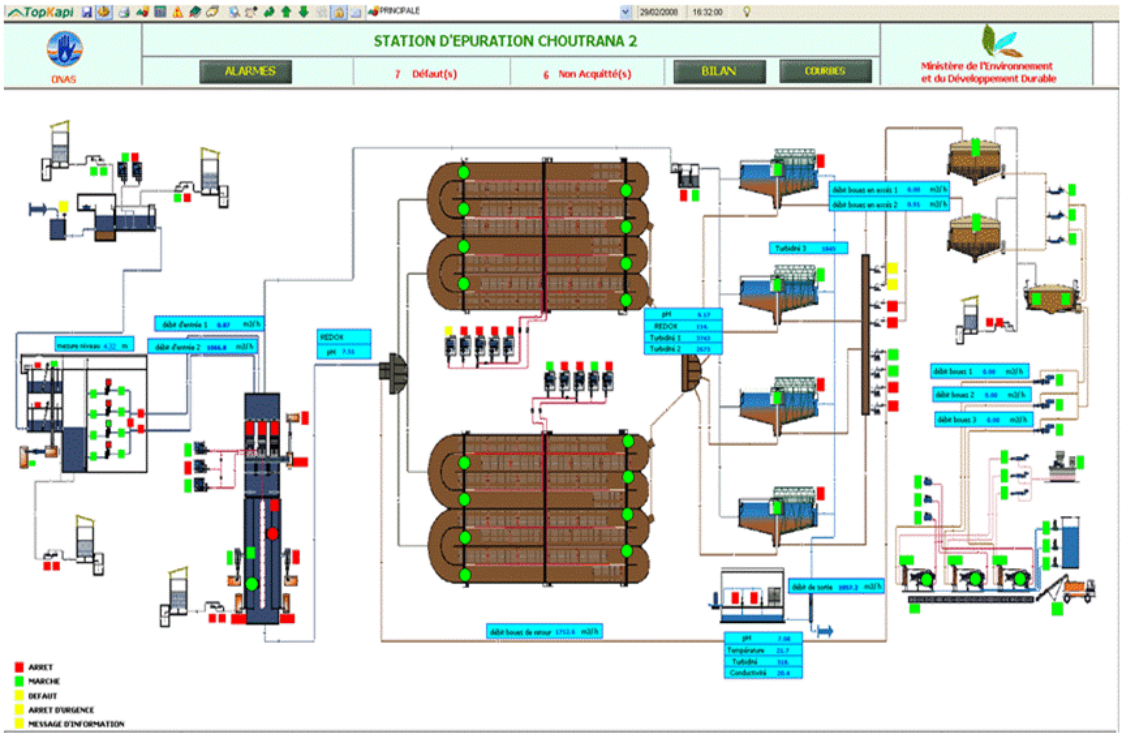

Figure 3. Scheme of the Choutrana II WWTP

2.2. BORJ TOUIL

The Borj Touil intervention area is located in the Governorate of Ariana, northward from Tunis (Fig. 4).

Figure 4. Location of the Borj Touil intervention area

Treated wastewater is conveyed to Borj Touil scheme (and Ben Amor) from Choutrana plant, through Borj Touil pumping station, in the recent past, after the treatment water was conveyed through an open channel and thus was subject to heavy re-contamination. ONAS has undertaken the substitution of the open channel by a piped convey. Ben Amor GDA has its own treatment plant which by gravity receives 500-600 m^3/day from an accumulation tank (160.000 m^3). The WWTP is composed by:

- two horizontal filters (constructed wetlands-CW), working in parallel. The first CW treats 2/3 of the flow and the 2nd CW the other 1/3;
- treated water is pumped to one maturation pond with Lemna sp. with a capacity of 600 m^3/day;
- water is pumped to the farms located down the hill.

The main crops in Borj Touil are fodder and trees: furrow and drip irrigation are practiced. There are 500-600 ha under modernization. The target is 3,000 ha.

2.3. Beni Hassen

The Beni Hassen Municipality is located 18 km southward of Monastir city, house of the ONAS directorate premises. Located in the flat rural area of the arid Tunisian Sahel, the main economic resource is the cultivation of the olive trees. Due to the lack of surface water resources and the high level of salinity of the groundwater (> 6-7 g/l), it is a rainfed area that is suffering nowadays for the severe rainfall reduction caused by the climate change effects. According to the Country Water Policy, in order to (partially) alleviate the shortage of water, the utilization of the TWW is incentivized by the Ministry of Agriculture.

The WWTP managed by ONAS is located 2.6 km NNW from the centre of the town of Beni Hassen. It is sized for a design flow of 21,700 inh.eq. with a maximum production of 1,654 m^3/day, namely 18.5 L/s (Fig. 5).

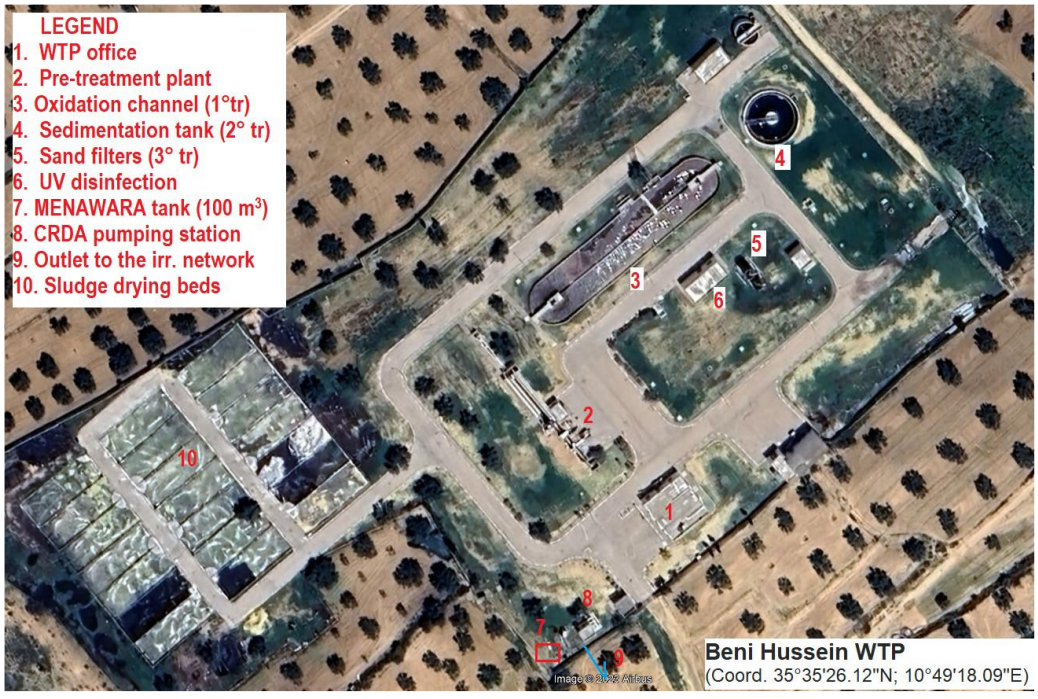

Figure 5. Location of the Beni Hassen WWTP

The plant has a traditional biological treatment system composed by: i) Pre-treatment, ii) Primary treatment (Oxidation channel); iii) Secondary treatment (Sedimentation tank); iv) Tertiary Treatment (Sand filtration + UV disinfection) as given by the synoptic board of the remote control system in Fig. 6.

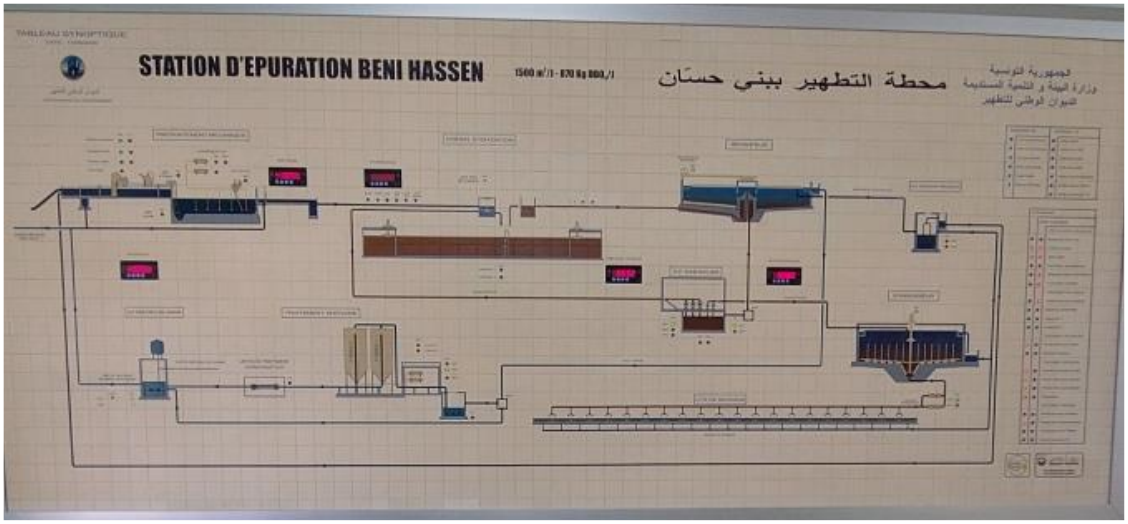

Figure 6. Beni Hassen WWTP: synoptic board of the Remote Control System

The existing tertiary treatment plant was out of order since the beginning of the MENAWARA project, because of the clogging of the sand filters and of the burning of the 8 UV lamps. Despite it, facing the 2021-2023 drought, with an emergency decree, ONAS was authorized to distribute the secondary treated water to the farmers only for the olive cultivation, by-passing the out-off order tertiary treatment. The MENAWARA project has foreseen the rehabilitation of this tertiary plant.

Nearby the Beni Hassen WWTP, the CRDA of Monastir realized, in the year 2017, a piped irrigation networks serving a command area of 60 hectares, at an elevation of around 40 m asl. Within this area, only a part of the farmers, owned 30 ha only (50%), accepted to irrigate their plots with the TWW.

3. Technical specifications of the interventions on the WWTPs

3.1. Choutrana II

The principle of operation of the tertiary treatment unit is based on the following flow diagram described in Fig. 7.

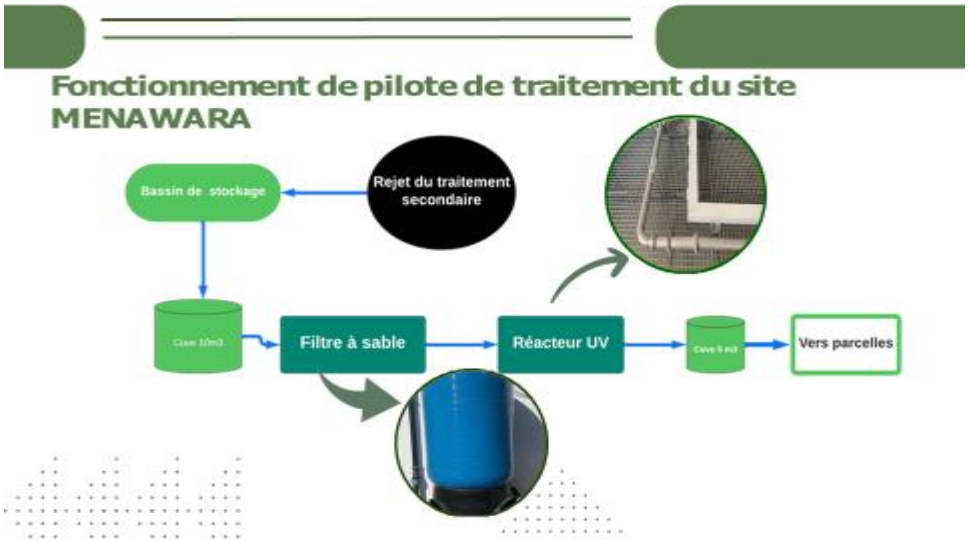

Figure 7. Flow diagram of the tertiary treatment implemented in the Choutrana II WWTP

The tertiary treatment line utilizes the secondary treated flow filling the existing 2.500 m^3 basin in Fig. 8.

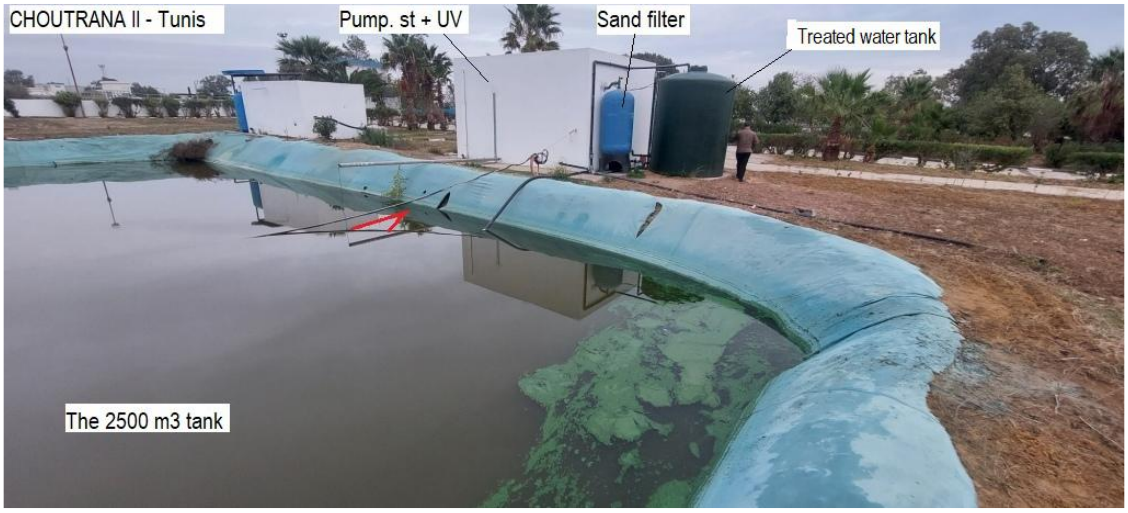

Figure 8. View of the existing 2500 m^3 tank in the Choutrana II WWTP

The technical specifications of the implemented tertiary treatment line are:

- n. 1+1R submergible pump sets inside the existing 2,500 m^3 tank: Q= 6,5 m^3/h=1.8 l/s; H=8.5 m;
- n. 1 main raisins pipe HDPE De 50 mm ;
- n. 1 PENTAIR PE vessel for raw water PN 10, Vol= 1020 l (Treated water tank);
- n. 1+1R horizontals pump sets (pression group) (Movitec V6/3 B: 0.75 kW; Q=6.31 m^3/h =1.75 l/s;
- H=22 m) inside the existing chamber;
- n. 1 Sand filter with filtration and counter washing circuits PN 3 bar;
- n.1 UV disinfection unit connected with the drip irrigation network.

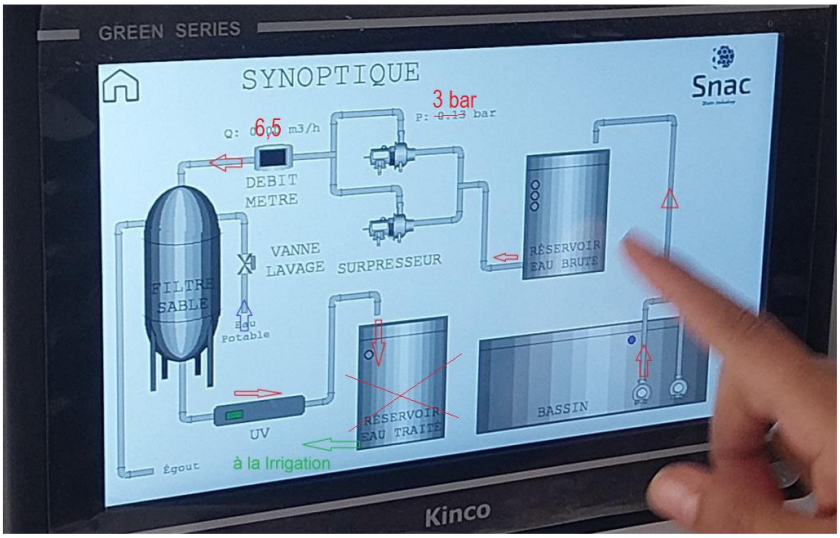

Figure 9. Choutrana II WWTP, Synoptic board

Figure 10. Overview of the pumping station

Figure 11. Details of the pumping station

3.2. Borj Touil

The intervention implemented in the WWTP of the GDA Sidi Amor in Borj Touil consisted in the construction of the RCC settling tank with 150 m^3 of volume (n. 1 in Fig. 12) and the rehabilitation of the Wet Land treatment plant of the Sidi Amour GDA (n. 2, 3, 4 in Fig. 12).

The RCC settling tank (n. 1) with 150 m^3 of volume at an elevation of 98 m asl is gravity fed by the pipeline coming from the upper 3,000 m^3 CRDA reservoir at an elevation of 112 m asl. This hydraulic infrastructure is realized in reinforced concrete. It is 12 m long, 3.2 m wide and 3 m total height (useful height 2.5m).

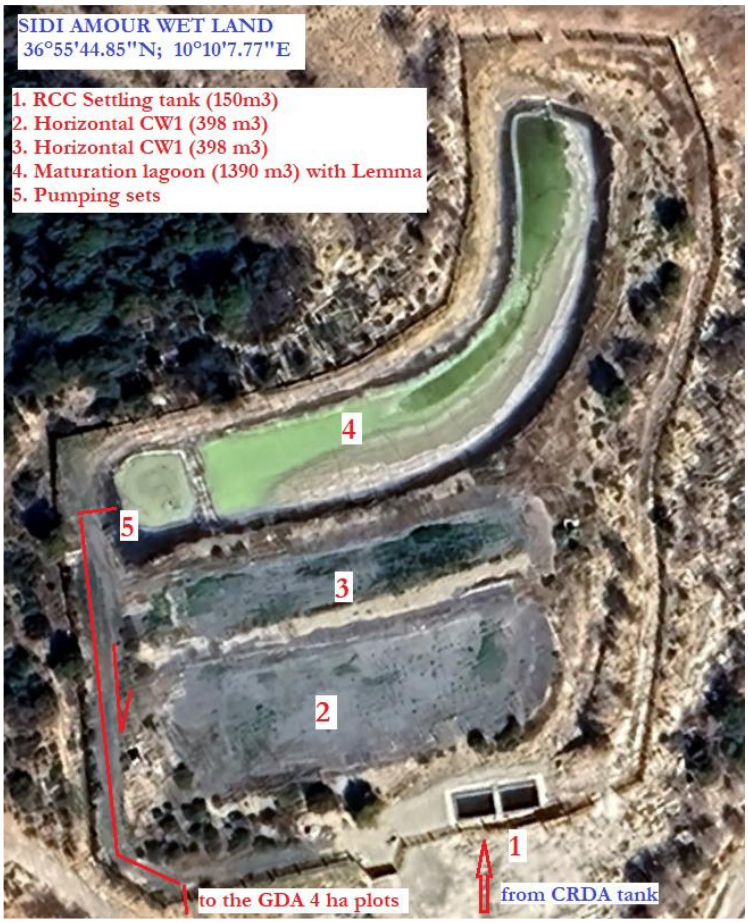

Figure 12. Overview of the intervention in the WWTP of Borj Touil

Table 1. Main characteristics of the RCC settling tank

Average daily flow	500 m^3/day
Average hourly flow	20,83 m^3/h
Width	3.2 m
Length	12 m
Useful Height	2,5 m
Total Height	3 m
Volume	96 m^3
Hydraulic retention time (HRT)	4,57 h

Before the start of the work, the awarded company provided with an execution study consisting of a detailed reinforced concrete calculation including the execution plans of the settling tank work and various networks, considering the nature of the soil and the topographical survey. Summarizing, the implementation work of the settling tank consisted of the following steps:

- topographic survey and implementation of works and connection networks;
- earthworks in excavations and embankments with a width of 0.50m compared to the initial exterior dimensions, possibly including the shielding and maintenance of the slopes, preparation and compaction of the base for the installation of the clean concrete;
- placement of B1 clean concrete (150 kg/m^3 dosage of HRS cement) including a width of 0.50 m on either side of the structure and a thickness of 0.15 m;
- shaping and installation of the reinforcement of the raft and the walls including the smooth formwork and necessary shoring, covering blocks, dust removal;
- the concreting of the raft and the walls in B5 concrete (dosage 400 kg/m^3 of HRS cement) with intersecting layers of flintkote for protection on the outside of the walls;
- connection work to the settling tank (inlet and outlet) using HDPE PN6 pipes requiring a survey of the existing pipe, including supply and installation of pipes, elbows, gate valves and any necessary accessories, and development of existing manholes;
- backfilling work all around the tank structure with execution of a 1.00 m pedestrian walk (sidewalk) all around the tank attached to the structure to avoid settling and subsidence of the sidewalk;
- manufacturing and installing hot-dip galvanized steel gratings according to requested dimensions;
- restoration of the premises.

From the settling tank, the wet land reservoirs are fed with the secondary treated effluent pumped from the Choutrana WWTP. The two wet tanks (n. 2, 3 in Fig. 12) are horizontal CWs, built halfway up, in step, due to the steep slope of the hill where they are located (Fig. 13), and the maturation lagoon (n. 4: 1390 m^3) as tertiary treatment located at the toe of them. According to the AMAYA design, both the CWs are too small and it was proposed for an enlargement but for the steep and rocky site and even for the high costs for the construction, this proposal was abandoned, maintaining the existing volume but, on the contrary, increasing the risk of clogging as AMAYA stated

in the Output 3.3. The gravel filters inside the CWs were completed clogged, and have been replaced utilizing a bigger granulometry, according to the design specifications (Fig. 14). The maturation reservoir (4) has been cleaned and planted with floating grass, named Lemma, in order to increase the tertiary treatment process to break down the residual organic load (Fig. 15). This solution was adopted according to the experiments carried out at the AMAYA centre in Spain. At the outlet, a new submersible pump was installed to lift the TWW to the upper GDA 4 ha plots.

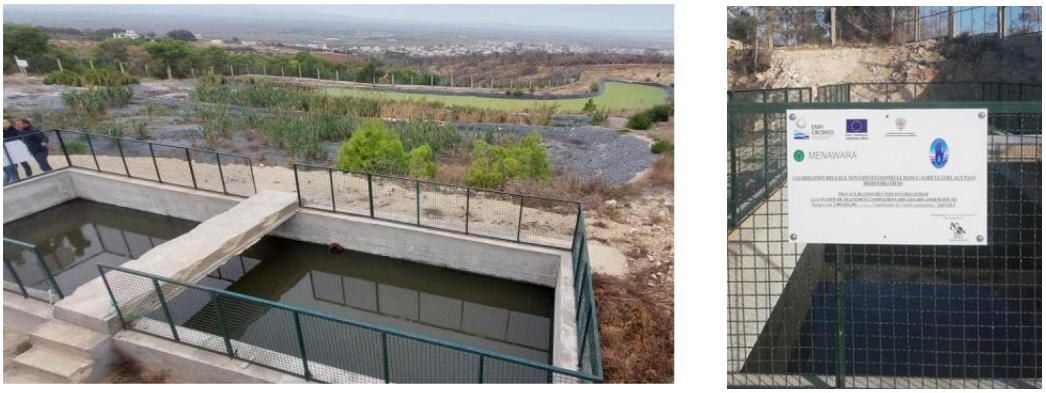

Figure 13. The settling tank and the CWs

Figure 14. The constructed wetlands CWs

Figure 15. The maturation lagoon

3.3. Beni Hassen

An emergency affected the Beni Hassen area due to the rainfall reduction in the last years, especially in the 2022-23 winter seasons, with zero rain in 2023, and more than 50% of reduction in 2022. This was the main reason why the MENAWARA project decided to rehabilitate the tertiary system (Sand filter +UV disinfection) and to build, in addition, a RCC tank of 100 m^3 for improving the functioning of the CRDA pumping station at the outlet of the WWTP feeding the d/s piped irrigation network.

The RCC tank is characterized by a dimension in plan of 10x5 m^2 with a gross depth of 5 m, for a volume of 100 m^3, as shown in Fig. 16.

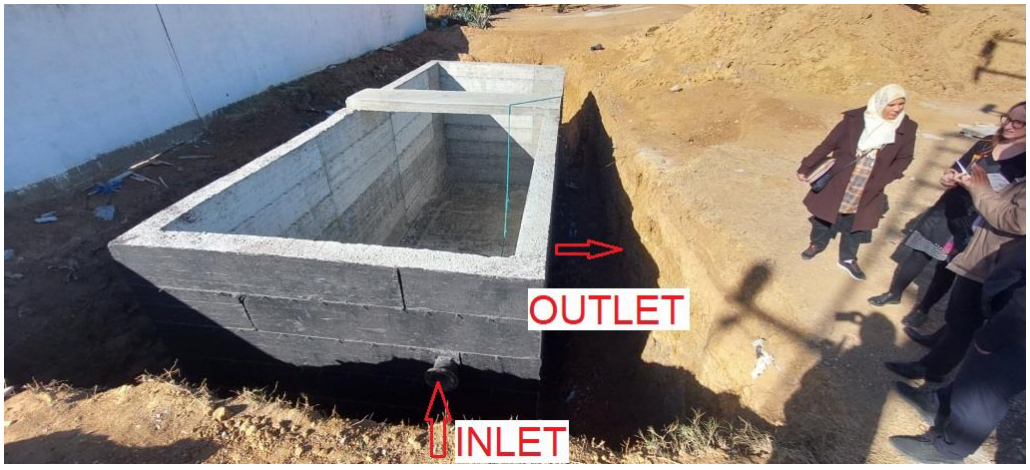

Figure 16. The RCC tank

The RCC tank is not still hydraulically connected because the CRDA didn't complete the tank piping works as visible in Fig. 15. The piping works, up to CRDA, must connect the d/s pumping station before connecting the network.

Concerning the rehabilitation of the tertiary treatment system, the two sand filter vessels were properly painted and the sand, inside both, replaced (Fig. 17).

Figure 16. Sand filter, relining of the steel vessels

Regarding the UV disinfection system, the contractor supplied n. 8 UV lamps by the end of the project (30th September 2023) but the electronic chips of the lamps to be inserted in the existing electric board (Fig. 18), which were not available on the local market and required a special order, took several months out of time to manufacture and transfer them to Tunisia. For this reason and, in addition to a blocking of the 2nd tranche of financing at the Central bank since July 2023, the electronic chips were provided and installed by the company only in February 2024.

Figure 18. UV disinfection, the level meter for P.S., the sampler and the electronic board of the UV lamps

4. CONCLUSION

Concerning the interventions on the WWTPs of Choutrana II and Borj Touil, compared to the original proposed design in the preliminary technical reports, there were no deviations done for the pre and post-treatment implementation.

The intervention implemented on the WWTP in Beni Hassen replaced, after the major amendment approval in 2022, the ones initially designed for the Korba and Kelibia sites. Although the delay in the implementation of the UV disinfection system, due to the long time needed to have the availability of electronic chips for the lamps in Tunisia and the blocking of the 2nd tranche of financing at the central bank since July 2023, the rehabilitation works in the WWTP were completed in February 2024. This intervention allowed us to give an initial response to farmers in the Beni Hassen area who, in recent years, have been suffering the effects of climate change in terms of increasingly intense drought periods which make their activity more and more complex. The rehabilitation of the tertiary treatment of the Beni Hassen WWTP will allow irrigating with better quality TWW on approximately 30 hectares owned by farmers, which represent 50% of the irrigation area, who asked to use this non-conventional water. This intervention paves the way for further actions that could very shortly satisfy the needs of all 60 hectares of the Beni Hassen district.

Thanks to these interventions within the MENAWARA project, ONAS was able to demonstrate that TWW, with an improved quality obtained through the implementation of post-treatments especially at the tertiary level in the WWTPs, can represent a precious alternative resource to the freshwater for irrigation purposes, allowing farmers, who are facing issues related to water shortages and climate change impacts, to ensure adequate water volume to satisfy the crop requirements and possibly increase crop yields and incomes.