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. Ramtha WWTP, Jordan

Responsible partner: NARC

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ABBREVIATIONS AND ACRONYMS

Acronym	Description
CENTA	Spanish Fundación Pública Andaluza Centro de las Nuevas Technologies del Agua
BOD	Biological Oxygen Demand
TSS	Total Suspended Solid
COD	Chemical Oxygen Demand
DN	Diameter Nominal
DO	Dissolved Oxygen
MAR	Managed Aquifer Recharge
TDS	Total Dissolved Solids
TWW	Treated Wastewater
WP	Work Package
WWTP	Wastewater Treatment Plant
NARC	National Agricultural Research Center

1. Background

This technical report has been written in the context of the third Work Package (WP3) of the MENAWARA project on Non-conventional Water Re-use in Agriculture in Mediterranean countries and more specifically for **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).

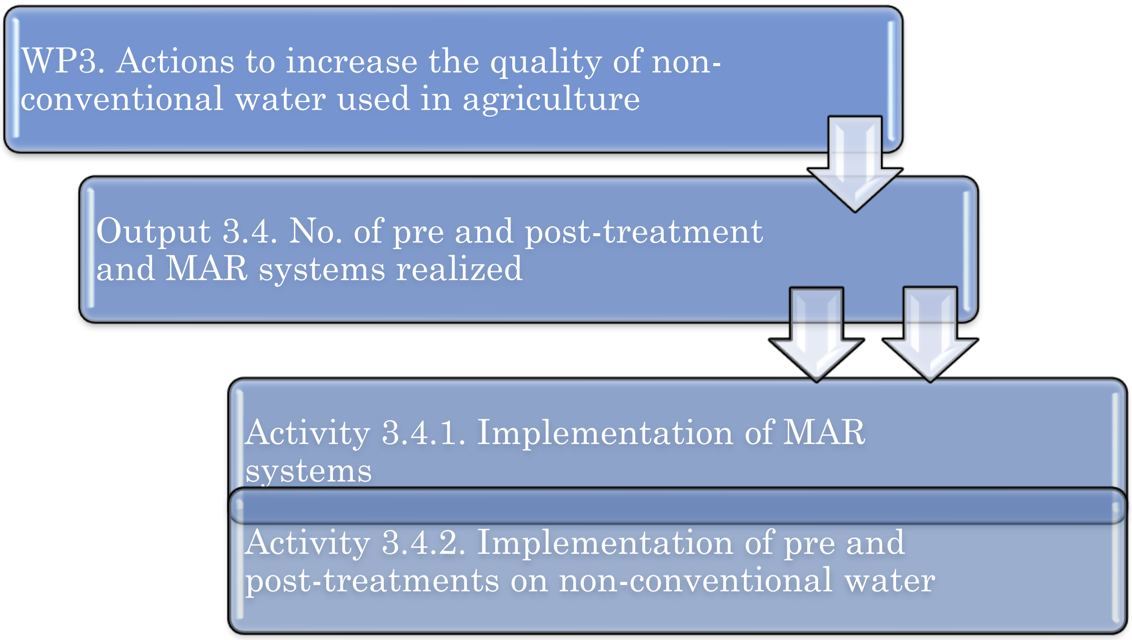


Figure 1. Infographic on the context of this technical report.

This is the third technical report for the intervention in Ramtha Wastewater Treatment Plant (WWTP), after the technical report written for the minor interventions (Activity 3.2.1) of November 2022 and the preliminary report written on the design of these minor and major interventions by Spanish Fundación Pública Andaluza Centro de las Nuevas Technologies del Agua (CENTA) of July 2020.

More specifically the 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 major interventions realised on the WWTP site of Ramtha City in Jordan, under this output 3.4 over the period of August 2023 as part of Activity 3.4.2 “Implementation of the post-treatment on non-conventional water” and complimentary to Activity 3.2.1 “Minor interventions on waste water treatment plants to improve efficiency” under output 3.2 “Efficient infrastructures and technical reports”.

Before the start of the interventions on Ramtha WWTP, several field visits and technical meetings were performed to verify the technical needs to support CENTA in elaborating the technical design for the improvement of the performance of the WWTP in Ramtha. During the implementation, due to unforeseen circumstances and budget changes, some interventions were adapted from those drafted by CENTA in the preliminary technical report. The technical interventions, a major and minor solutions aim to enhance the processes of water quality improvement in the intervention site of Ramtha TWW Research Station, Jordan; The technical needs were split into two interventions, a major and minor one:

- The minor intervention included the installation of: chamber for filters, pipes, pressure group and pumps, storage tank, Chlorination labyrinth, pipe.
- The major intervention consisted of pressure sand filters and disc filters, subsequent disinfection stage by application of ultraviolet radiation and maintenance disinfection by adding sodium hypochlorite.

The document is structured considering as follows:

1. A general introduction of the area of intervention (Section 2);
2. A general overview of the WWTP design (Section 3) after the implementation of both the minor and major intervention.
3. Detail of the major intervention, its technical specifications and pictures from the field (Section 4) and
4. Concluding remarks (Section 5).

2. Area of intervention

Ramtha is a city located north of Jordan, in the Irbid Governorate near the border with Syria as shown in Figure 2. The city's population reached about 164 thousand with 90% of households connected to the sewer network. It covers 40 km^2 on a plain 30 km northeast of the Jordan River and Irbid. Ramtha experiences a Mediterranean climate. The summer is hot and long (four months in average), but it has cool nights.

Temperatures range in summer from 27 °C – 33 °C. Spring and fall temperatures are ideal for a human's body, they range from 17 °C – 23 °C. Al-Ramtha WWTP was constructed in 1988 on gently sloping plateau about 4km northwest of Al-Ramtha city, near the road leading to Turra. The treated wastewater (TWW) is used to irrigate surrounding agricultural lands, which are cultivated with olives, almonds, alfalfa, grapes and lemons.

The plant receives wastewater from the Ramtha city sewer collection network, but no trucked septage is discharged to the facility. In 2018, the estimated average month influent flow was 4,485 m3/d and average dry weather (May to October) flow was 4,875 m3/d, with the maximum month flow of 5,009 m3/d occurring in August. The existing plant's design hydraulic capacity is average dry weather flow of 5,400 m3/d, and the plant is currently operating below the design hydraulic capacity for the biological treatment processes. The influent 5-day Biological Oxygen Demand (BOD5) measured during the sampling program averaged 991 milligrams per liter (mg/l) which was the same as the design average influent BOD5 of 1,000 mg/l. The settling tank effluent BOD5 averaged 14 mg/l during the sampling, and a BOD5 removal efficiency of 99% was achieved. Total suspended solids (TSS) measured in the influent during the same period averaged 578 mg/l which was lower than the design average influent for TSS of 950 mg/l. The settling tank effluent TSS averaged 13 mg/l during the sampling, well below the design criteria of 30 mg/l. The plant effluent is not currently meeting effluent discharge standards for irrigation of cooked vegetables (Category 3A) Jordanian Standard JS893/2006 primarily because the plant effluent is not chlorinated sufficiently to kill *E. Coli*. The treated wastewater (TWW) is used to irrigate surrounding agricultural lands for forage crops such as alfalfa, sorghum, barley, etc…, the irrigated area with treated wastewater estimated about 120 ha.

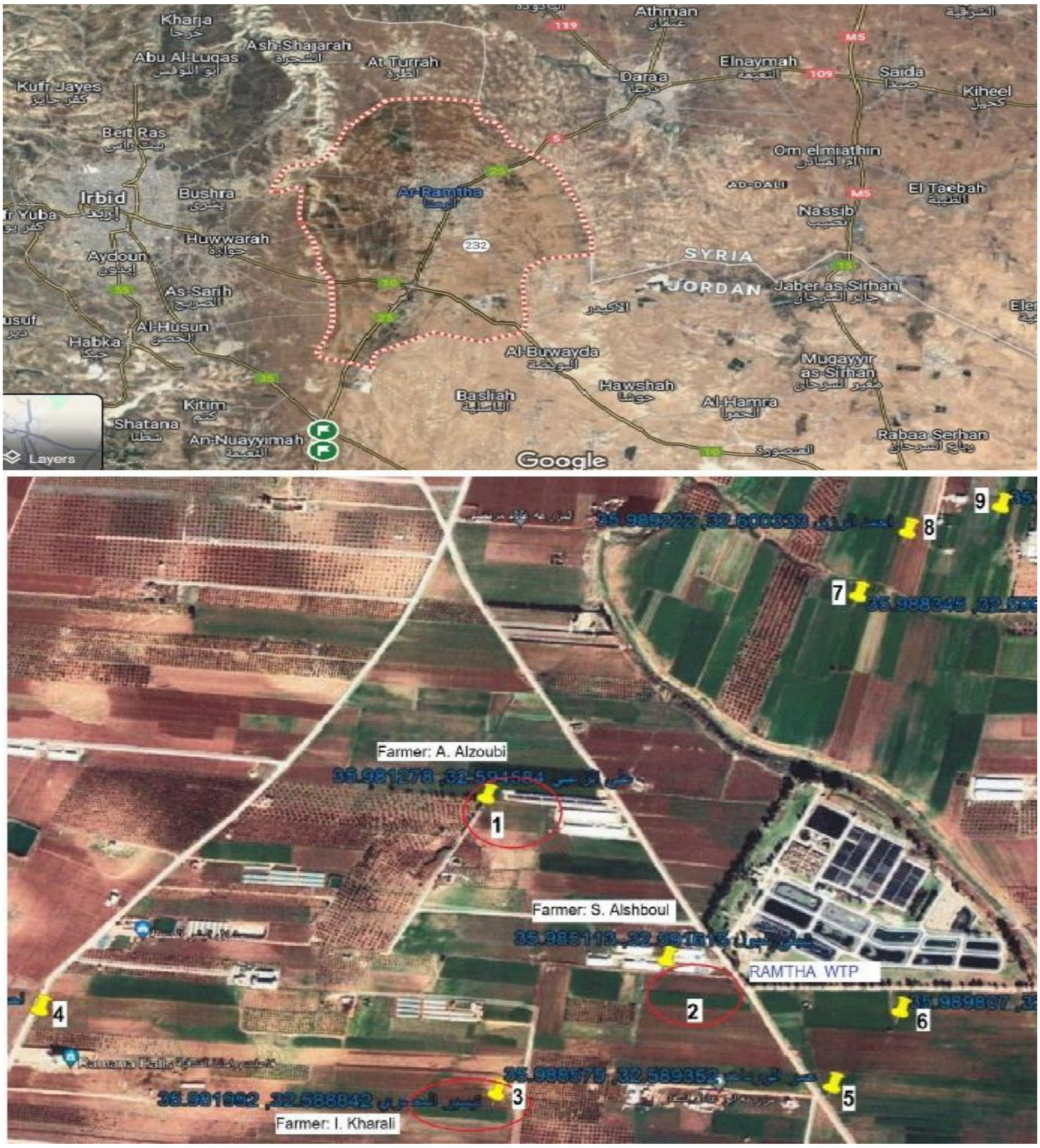


Figure 2. Map to illustrate border and location of Ramtha City, its wastewater treatment plant (WWTP), the main pipelines of the installed irrigation network and the 9 farmer plots irrigated with treated wastewater (TWW).

3. Ramtha WWT design pre-interventions

- The wastewater generated in Ramtha City is treated at the Ramtha WWTP located seven km north of city.
- Ramtha WWTP started work in 1987 as stabilization ponds (design capacity was 2.700 m³/d, three stages were used: (i) two anaerobic ponds, followed by (ii) six facultative ponds and (iii) four shallow maturation ponds.

- Upgrade in 2002 as a mechanical activated sludge with design capacity 5,400 m³/d with influent daily now is 4,268 m³/d. In the following Table 1 Table 1. Characteristics of the treatment train (components) of Ramtha WWTP, Jordan

Component	Dimension (m)			Existing Number	Remarks
	Width/ diameter	Length	Depth		
Coarse Screen				1	
Fine Screen				3	
Girt Chamber	5		3	2	
Equalization Ponds	25	70	3	2	
Lifting Station				1	4 pumps
Aeration Tank	33.4	50.1	4.5	2	
Final Sedimentation Tank	22		3	2	
Rock Filter				1	
Polishing Pond	30-36	70-94	2	10	
Disinfection (Chlorine Contact)	1.4	52.5	3.5	2	
Sludge Thickener	9		4	2	
Sludge Drying Bed	6	25		100	
Irrigation Reservoir	43	63.2	3.5	1	

Figure 3. Overview of Ramtha WWTP, including treatment units

Figure 4. General view of the Preliminary treatment and automatic Screen

Figure 5. Overview of one of the two Equalization Ponds

Figure 6. Overview of one of the two Aeration Tanks

Figure 7. Overview of one of the two Sedimentation Tanks

Figure 8. Overview of one of the ten Polishing Ponds

Figure 9. Overview of the Rock Filter for microalgae removal

Figure 10. Overview of the Irrigation reservoir with presence of Lemna sp.

Figure 11. Overview of the Disinfection unit (Chlorination Channel) and chlorine gas containers

Figure 12. Drying Beds

4. Ramtha WWT post intervention and technical specifications

The technical interventions included design, operation and dimensioning of the post- treatment line in the Ramtha TWW Research Station, based on filtration processes using pressure sand filters and disc filters, a subsequent disinfection stage by application of ultraviolet radiation and maintenance disinfection by adding sodium hypochlorite. The facilities are planned with a treatment capacity of 500 m^3/d. The design was adequate to allow the reuse of the treated water for irrigation of agricultural crops. Therefore, its main objective was to define its necessary processes, facilities and equipment.
The following requirements have also been considered as basic objectives when designing and projecting this project:

- ❖ Provide a quality of execution to civil works, equipment and facilities that allow a value for money that fits this type of works, paying particular attention to the task that they are going to perform.
- ❖ Provide facilities with sufficient flexibility to facilitate operating manoeuvres and achieve low O&M costs.

In the sections below the interventions are described.

4.1. Installation of eight Sand filters

- ❖ The basic objective of filtration in the water reclamation processes is focused on reducing the concentration of suspended solids, turbidity and the size of solids in the previously treated waters, to facilitate the subsequent disinfection stage.
- ❖ The filtration process improves the quality of the effluents, by circulating the water through porous beds, made up of materials that retains solid particles, on its surface or well incorporated into its structure. The size threshold of he removed materials is 10 μm, which allows the removal of helminth eggs.
- ❖ The most common filtration processes in water reclamation are pressure sand filters.
- ❖ The filter material (sand / anthracite that rests on a layer of gravel) is placed inside a closed container under pressure. The water to be treated is pumped to the top of the filter, passes through the filter material in a downward direction, and is collected in a perforated

lower pipe, which carries the filtered water to the outside. When the filtration occurs, the filtering substrate is cleaned, circulating the water upwards, opening and closing the relevant valves. The backwash of the granular media is needed to remove the entrapped particles and adequately clean and fluidize the bed.

- ❖ In this kind of filters, the backwash is generally much higher than the hydraulic loading rate, in values typically between three up to ten times higher than the hydraulic loading rate.
- ❖ Concerning the removal performance of TSS and turbidity achieved in this type of treatment the values are shown in the following Table 2.

Table 2. Removal performance of TSS and turbidity in the pressure sand filtration

Parameter	Output values
Suspended solids	Up to 3.5 mg / L
Turbidity	Up to 0.6 UNT

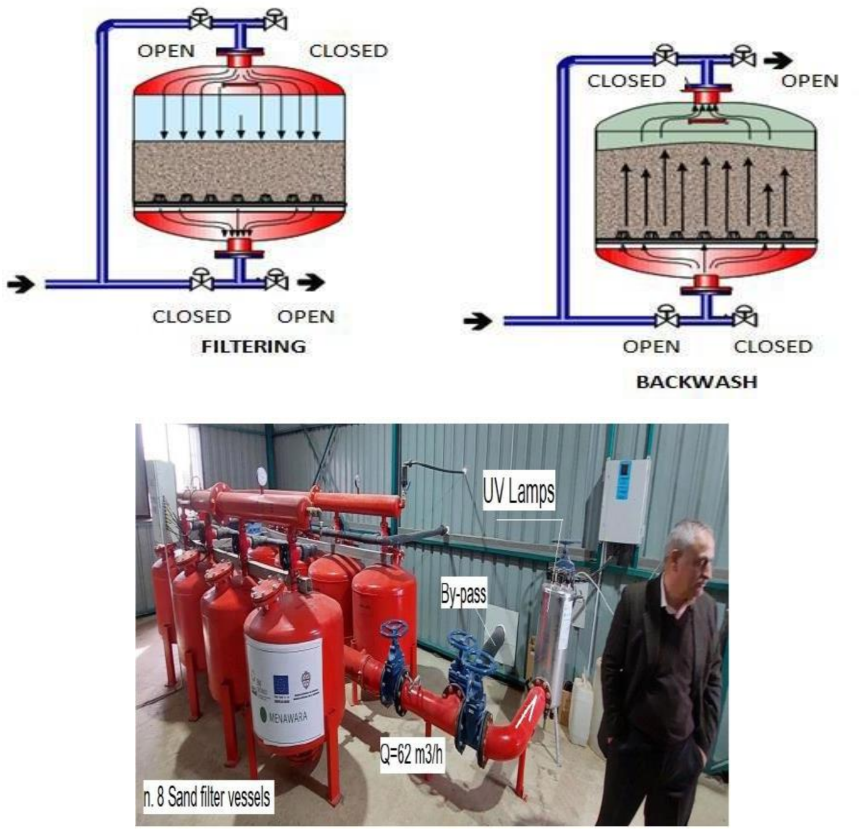


Figure 13. Filtering and backwash processes in a pressure sand filter

4.2 Installation of three disc filters

- In this technology a mixture of surface and depth filtration takes place through flat plastic discs with grooves. Said discs are placed one on top of the other and compressed, forming the filter element. The crossings between the grooves of each pair of adjacent discs form water passages, the size of which varies according to the discs used and the relative location of the discs.
- They are usually designed for a maximum pore size of 25µm. The circulation of the water is from the outside to the inside, crossing the width of the disc in a radial direction.
- The pressure drops with a clean filter, for its operating flow, must be of the order of 10-15 m.c.a. and it must be cleaned when said value reaches around 5m.c.a, for an approximate time of 15-30 seconds.

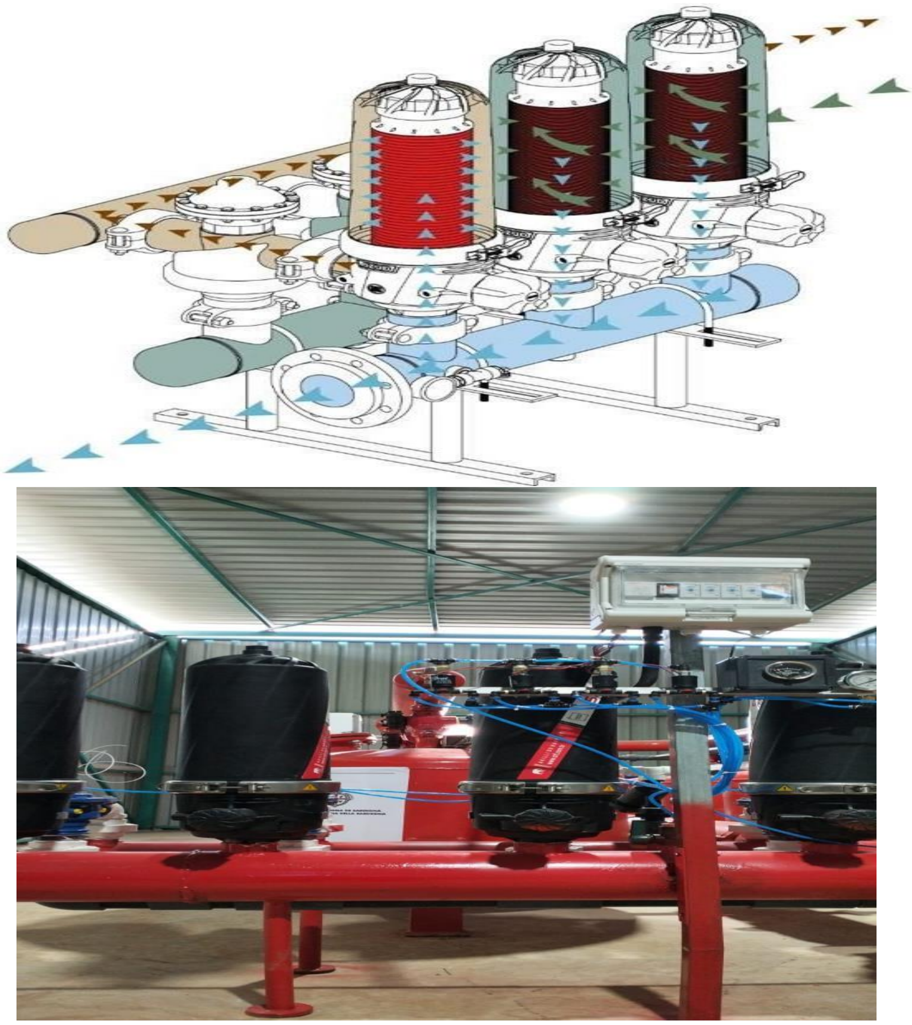


Figure 14. Operating scheme for disc filter

The main characteristics of this filtration technology are shown below:

- Real average filtration speed around 2.5 m/h.
- Performance in terms of quality: Elimination of less than 60% of
- Particles larger than 15 µm.
- The conversion rate is above 95%.
- The energy costs are higher when circulating pressurized water. They tend to form preferential paths due to the self-cleaning system.

4.4 Installation of ultraviolet disinfection unit

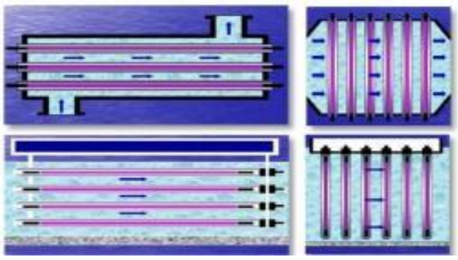
In the disinfection processes through the application of radiation, it is usual to resort to the application of ultraviolet (UV) light, which is part of the electromagnetic spectrum in the wavelength range that ranges from 100 to 400 nanometres (nm), and that falls between visible light and X-rays. The bactericidal properties of this type of radiation were discovered in 1877, and nowadays, the development of cheaper and more effective UV light sources, coupled with growing concern about the possible toxic effects of other disinfecting agents, have led to its use has been notably increased in the disinfection of treated wastewater, being used for the inactivation of bacteria, viruses, protozoa, fungi, and spores (Huffman et al., 2000)1. In the following Figure 4 are shown the ranges of radiation covered by the UV spectrum.

A disinfection system using UV radiation is made up of the following elements: (figure 15):

a. Lamps.
b. Electronic ballasts and the control center.
c. Reactor or rack.
d. Flow and/or level control systems

A. Lamps

B. Electronic ballasts and the control center



C. Reactor or rack

D. Flow and/or level control systems

Figure 15. Ultraviolet Disinfection Unit and components

4.5 Installation of chlorination unit

Chlorination is the most widely used disinfection method of treated wastewater worldwide, destroying pathogenic organisms by oxidation of their cellular material. Chlorine could be applied to water mainly in the form of: chlorine gas, chlorine dioxide, calcium sodium hypochlorite. For the field of application of this technical proposal, we will focus on sodium hypochlorite.

Sodium hypochlorite is marketed in powder or granule form, requiring 0.75 gr. of dry chlorine to obtain 100 l. of solution with a concentration of 5 mg/l. of available chlorine. It can be applied to the waters to be disinfected, either directly in solid form or in liquid form, after dissolving in water and it is especially applied in WWTP that serve small populations. For its part, sodium hypochlorite usually occurs in solutions with 10-15% richness, since at this concentration it degrades more slowly, increasing its storage period. This reagent is added directly to the waters to be disinfected, using dosing pumps.

Figure 16. Dosing pump for the addition of hypochlorite.

4.6 Installation of two water pumps

The pressure group is made up of two main pumps consisting of a vertical multicellular centrifugal pump. A centrifugal pump feed filter. Another pump with the same characteristic will remain inactive.

Main unit characteristics of pumps are:

Brand: LOWARA.
Model: 66SV2/2AG075T.
Nominal flow rate: 62.50 m3/h.
Nominal pressure: 8 bar.
Pump body: AISI 304 stainless steel.
Impulsion: AISI 304 stainless steel.
Aspiration: AISI 304 stainless steel.
Shaft: AISI 304 stainless steel.

Axis covering: Tungsten Carbide.
Mechanical seal: Silicon Carbide / Carbon / EPDM.
Three-phase squirrel cage electric motor of size IEC 112 in a V18/B14 construction, IE3 efficiency, manufactured according to EN 60034-1, directly coupled to the vertical of the pump.
Engine Power: 7.50 kW.
Voltage: 400 V.
Frequency: 50 Hz.
Rated current: 14.10 A.
Speed: 2,900 rpm
Maximum ambient temperature: 40°C.
Protection class: IP 55.
Insulation class: F.

Figure 18. Two pump groups

5. Conclusion

Through the MENAWARA/WP3, post treatments for Ramtha wastewater effluent improved the quality of TWW supplied to farmers. Treated wastewater were treated for tertiary treatment after post treatment to achieve and meet the water quality to irrigate forage crops using sprinkler irrigation system without health hazard on workers or near inhabitants. TWW can also be used to irrigate forage using surface drip and/or subsurface drip irrigation avoiding clogging and saving more water especially by using subsurface drip irrigation compared to other irrigation techniques. The post treatment was able to guarantee the quantity of water necessary for the subsurface irrigation in an area of 4.5 ha belonging to 9 farmers.