Towards Sustainable Treatment and Reuse of Wastewater in the Mediterranean Region

Establishment of demonstration units

(Output 4.2, A.4.2.2)

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Towards Sustainable Treatment and Reuse of Wastewater in the Mediterranean Region

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Contributors

Pedro Jose Simon Andreu, Roman Lopez (Editors)

Entidad de Saneamiento y Depuración de la Región de Murcia (ESAMUR), Spain

http://www.esamur.com/

Ahmad El Moll, Mohamad Khalil, Tawfik AL-Naboulsi, Fatima Yahya

Faculty of Public Health & Doctoral School of Science & Technology, Lebanese University (UL), Lebanon

https://www.ul.edu.lb/

Fadel M'Hiri, Khitem Mensi, Anis Ghattassi, Safa Chaabane

Centre International des Technologies de l' Environnement de Tunis (CITET), Tunisia

http://www.citet.nat.tn

Isabel Oller Alberola, Inmaculada Polo López, Samira Nahim Granados

Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas, Plataforma Solar de Almeria (CIEMAT-PSA), Spain

http://www.psa.es/

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INDEX

LIST OF FIGURES

LIST OF TABLES

Executive Summary

The present Output explains the entire construction process from contract award to commissioning, including plant performance. The details of the construction are presented to provide the next developers of other APOC facilities with a visual guide to help them replicate the APOC eco-innovative system for municipal wastewater treatment and reuse in small to medium-size communities.

This activity has been split into three parts, one for each demo site, as there are differences between the designs. It will enrich knowledge even more as it can help to compare the different variants of APOC systems.

1 ESTABLISHMENT OF BLANCA DEMO-SITE

1.1 Design of the unit

The existence of an earlier anaerobic reactor was utilised in the Blanca demonstration plant. It was built a few years ago as part of another European research project called LIFE RAMSES. The capacity of this anaerobic reactor is 700 m^3/day and the typology was UASB (Upflow Anaerobic Sludge Blanket). According to the APOC system model, the other parts of the treatment system in this demo plant are constructed wetlands and a solar reactor.

Two constructed wetlands with different typologies were selected. Both constructed wetlands can be connected in series or they can work independently. The first is a vertical flow constructed wetland. Due to the excellent oxygen transfer of this type of wetlands, they are very efficient and the required surface area is smaller than other types of constructed wetlands, which is a significant advantage for the implementation of large units. They can also nitrify and are needed for discharge requirements. The second constructed wetland is a Subsurface horizontal flow constructed wetland selected for the removal of nitrates from the water. The main objective of this design was to remove as much of the nutrients in the treated water as possible to prevent or limit algae formation in the solar reactor. These algae can interfere with the solar radiation, making the solar process less effective.

With anaerobic treatment, followed by treatment in constructed wetlands, we obtain treated water with excellent water quality for discharge into the environment.

However, one of the main objectives of the APOC system is to utilise this treated water for reuse, especially for crop irrigation. To this end, the final part of the APOC system is a continuous flow pond reactor. With this treatment and with the help of some chemicals, we are able to achieve good disinfection and also remove many emerging compounds with acceptable retention times.

Figure 1 shows the flow diagram in the Blanca demo plant.

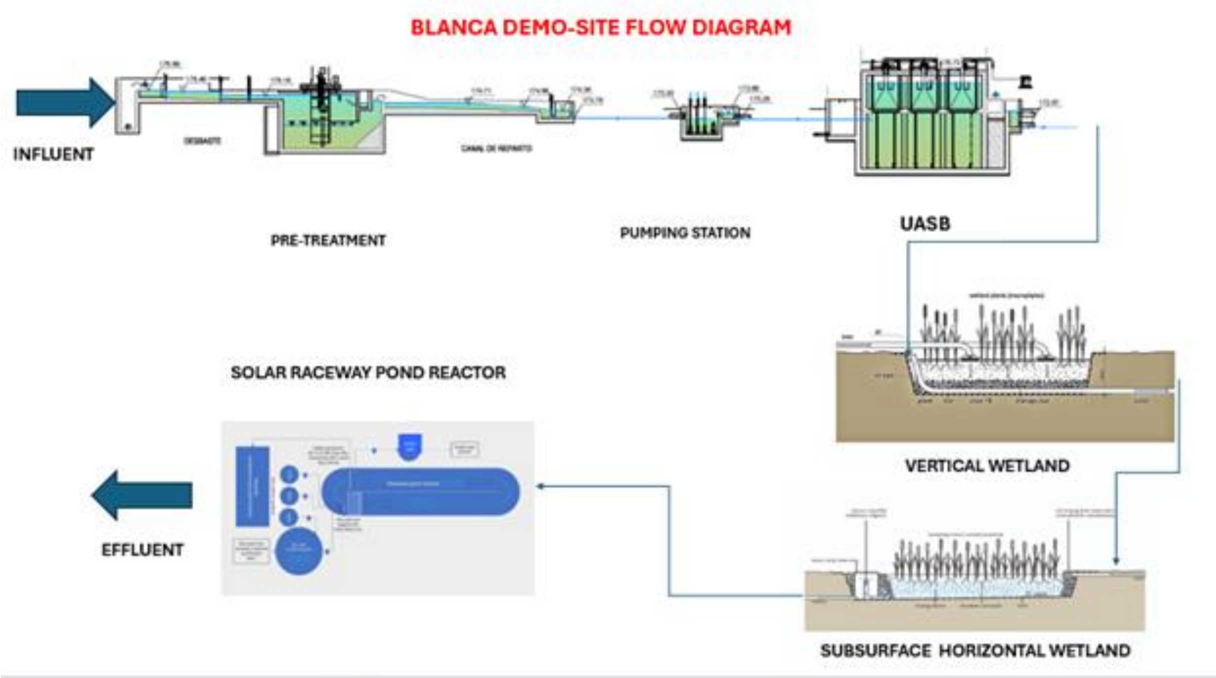


Figure 1. The flow diagram in Blanca demo-site.

Figures 1 and 2 show the real demo system.

Figure 2. The real demo-site plant.

1.2 Starting Data

Before planning the various components of the plant, we need to know the physicochemical properties of the raw water, the quality of the wastewater and the design flow rate.

In the case of the Blanca demo site, we had data on both the raw water and the outlet of the anaerobic reactor. This is an advantage for the planning of the constructed wetlands because we have real data.

In Figure 3 a diagram is shown with the previous information on the performance of the anaerobic reactor.

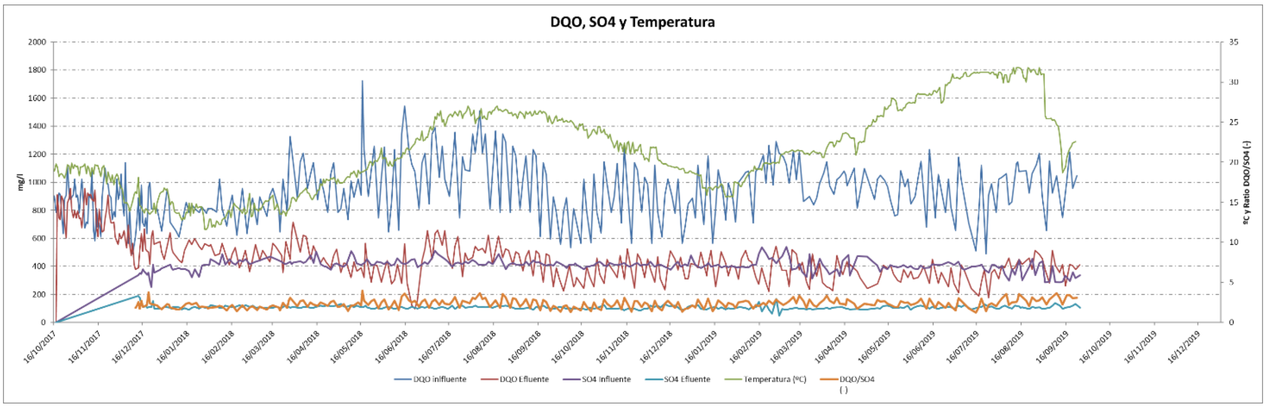


Figure 3. Previous information of anaerobic reactor performance.

Based on the available area and the AQUACYCLE budget, a flow rate of 5 m3/day was agreed.

The water properties were determined based on the performance data of the anaerobic reactor. As the maximum BOD5 value was 354 mg/l, the BOD5 value was used for the calculations:

BOD5 design value: 400 mg/l

In accordance with the calculation system for vertical wetlands that we can see in the APOC Technical Guide, the required area is 100 m^2 with the recommendations for length and width given in the guide.

For horizontal wetlands, the required area is 25 m^2 to achieve a 40% reduction in nitrate concentration, as indicated in the APOC Technical Guide.

Since the reuse of water is one of the most important points of the project, the main objective for the solar raceway pond reactor is to remove pathogens, in accordance with the requirements of the validation for Type A of Regulation EU 741/2020. This means that the next objectives are to achieve the removal of indicators related to the values at the entrance:

E. Coli ≥ 5.0 LRV

Total coliphages/F-specific coliphages/somatic coliphages ≥ 6.0 LRV

Clostridium perfringens spores ≥ 4 LRV

In addition to the removal of pathogens, it is also about the removal of newly emerging compounds. One of the points to be investigated in this project is the ability of this technology to reduce the contamination of the treated water with these parameters in order to avoid possible negative effects in the irrigation of agricultural products.

1.3 Tender information

Due to the special nature of the Solar Raceway Pond reactor, a special PSA-sponsored tender was organised. Therefore, two tenders were developed for the Blanca demo site. The first tender, subsidised by ESAMUR, was for the construction of the constructed wetlands and the connections with the anaerobic reactor and the solar reactor, as well as the ancillary facilities. The second tender, subsidised by PSA, was for the construction of the solar reactor and the storage and dosing of chemicals.

The key dates of the public tender for the wetlands were:

- Tender submission for construction : 01/02/2021
- Start of the construction works : 03/05/2021
- Completion of the construction works : 05/11/2021

1.4 Construction: Development, figures and construction details

As we have already mentioned, the anaerobic reactor, one of the key points of the APOC system, was built before the AQUACYCLE project (Figure 4).

Figure 4. The anaerobic reactor.

Figure 5. The initial situation of the plot.

A view of the plot without vegetation can be seen in Figure 5.

In Figure 6 the initial situation of the plot is shown on which the wetlands and the solar reactor were built.

Figure 6. The start of excavation.

The start of excavation can be seen in Figures 7 and 8.

Figure 7. The excavation of vertical wetland.

Figure 8. A detail of the excavation of vertical wetland.

A detail of the excavation of vertical wetland can be seen in Figure 9.

Figure 9. Water drainage collection box.

A detail of installation of geotextile and polyethylene sheet is shown in Figure 10.

Figure 10. Installation of geotextile.

The test to check the impermeability of the wetland can be seen in Figure 11.

Figure 11. Test to check the impermeability of the wetland.

Figure 12. Installation of second sheet of geotextil and the protection wall of perimeter.

Figure 12 shows the installation of the second geotextile layer and the protective wall of the site.

Figure 13 shows a detail of the filling process of the granules in the vertical wetland.

Figure 13. A detail of the granular material filling process in the vertical wetland.

Figure 14 shows a section of the filling process of the granules in the horizontal wetland.

Figure 14. A detail of the granular material filling process in the horizontal wetland.

The vertical wetland after completion of the filling can be seen in Figure 15.

Figure 15. The vertical wetland once the filling process has finished.

Figure 16 shows the delivery collector and the plants of the vertical wetland.

Figure 16. The vertical wetland with crop plants.

And in Figure 16 we see the horizontal wetland after the filling process is complete. We can recognise the delivery collector.

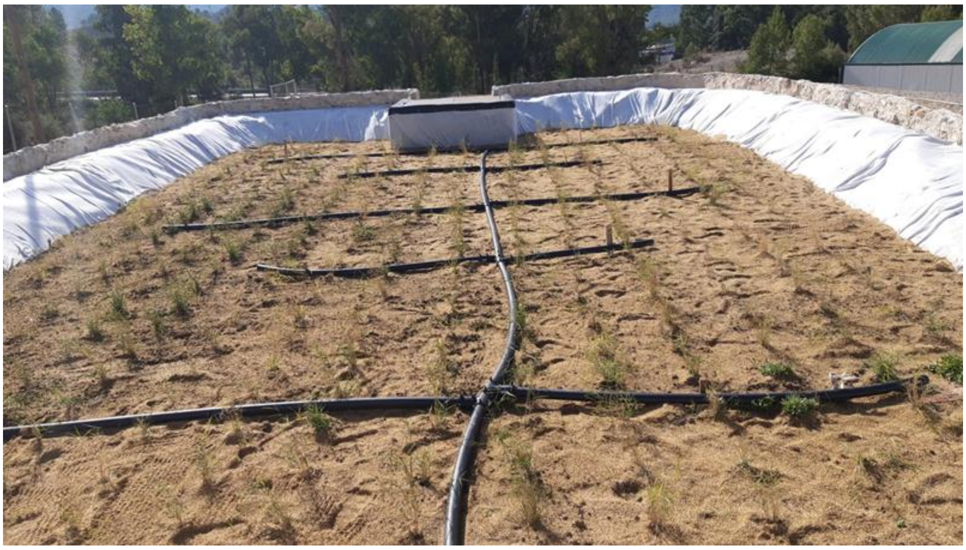


Figure 17. The horizontal wetland.

Figure 18. The completely installed solar raceway pond reactor and auxiliary systems.

Figure 18 shows the fully installed Solar Raceway pond reactor and the auxiliary systems.

A general view can be seen in Figure 19 (aerophotograph).

Figure 19. A general view.

1.5 Performance data

The construction of the APOC system was completed on 05 November 2021. During the project, an analytical control for the main physico-chemical and microbiological variables was developed. In the next figures (Figures 21, 22, 23, 24, 25, 26 and 27) the respective results are illustrated.

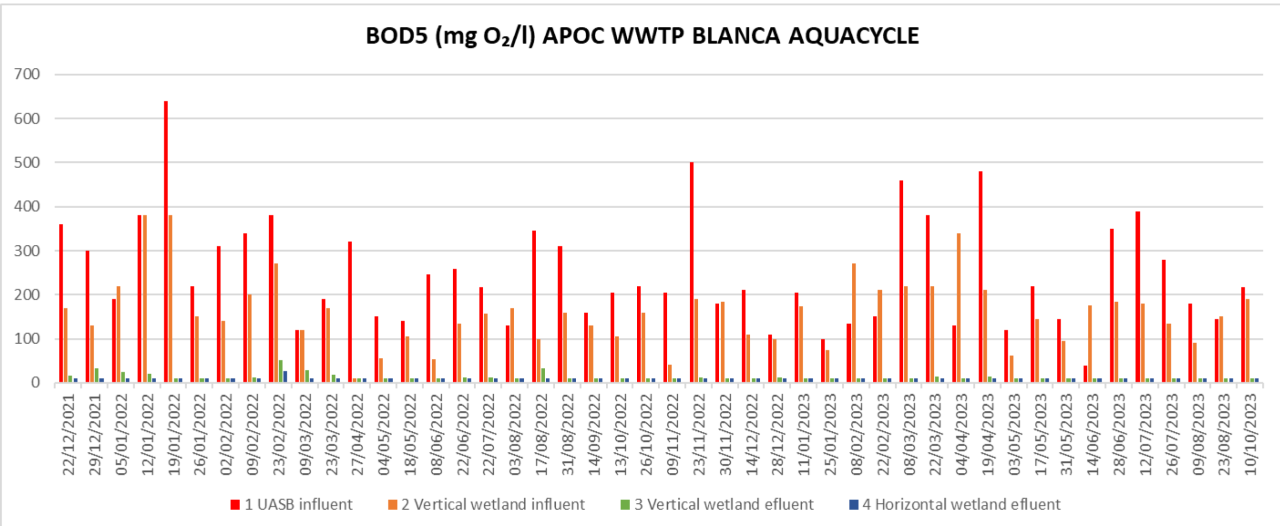


Figure 20. BOD_5 APOC WWTP Blanca.

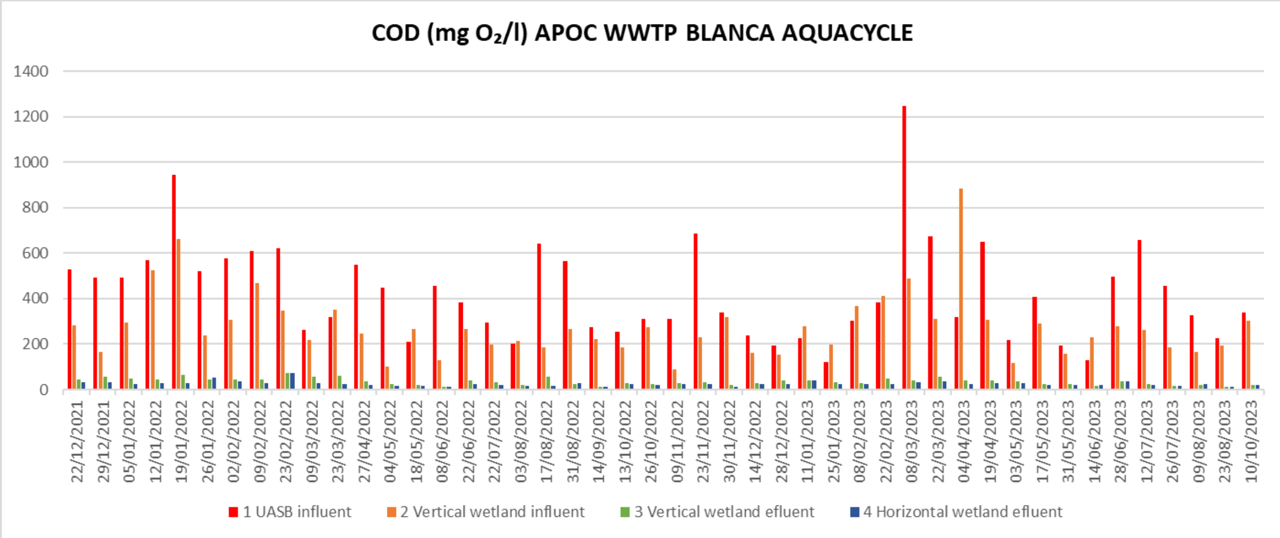


Figure 21. COD APOC WWTP Blanca.

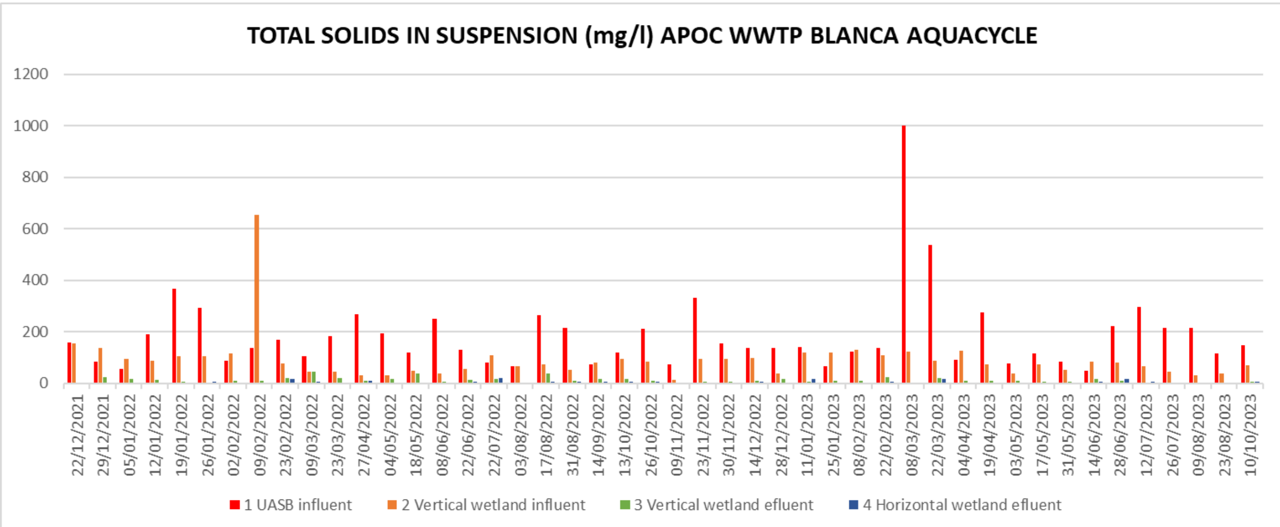


Figure 22. Total solids suspension APOC WWTP Blanca.

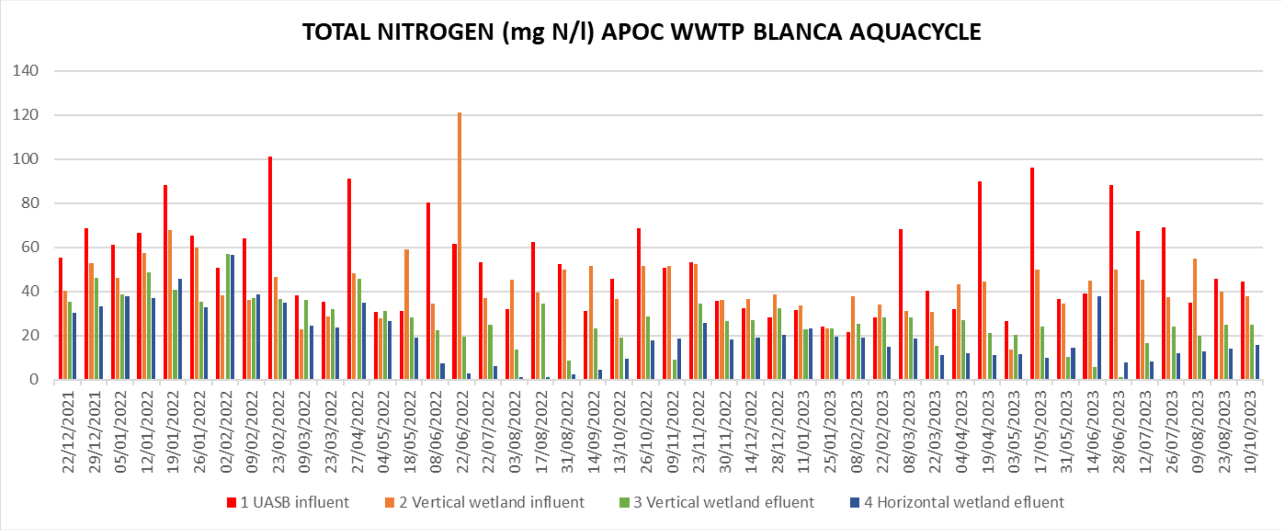


Figure 23. Total nitrogen APOC WWTP Blanca.

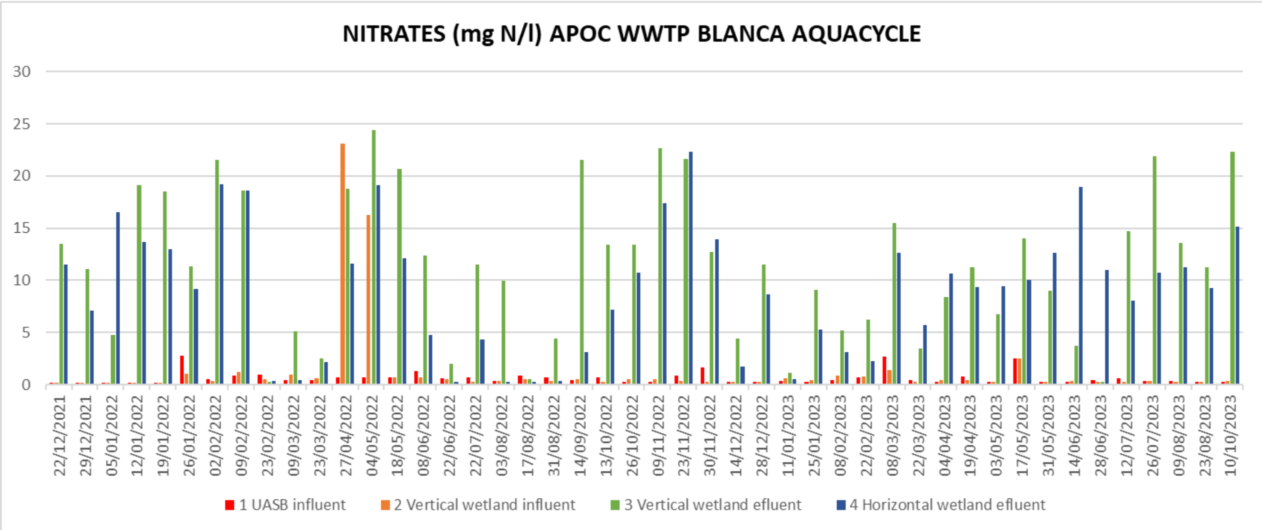


Figure 24. Nitrates Apoc WWTP Blanca.

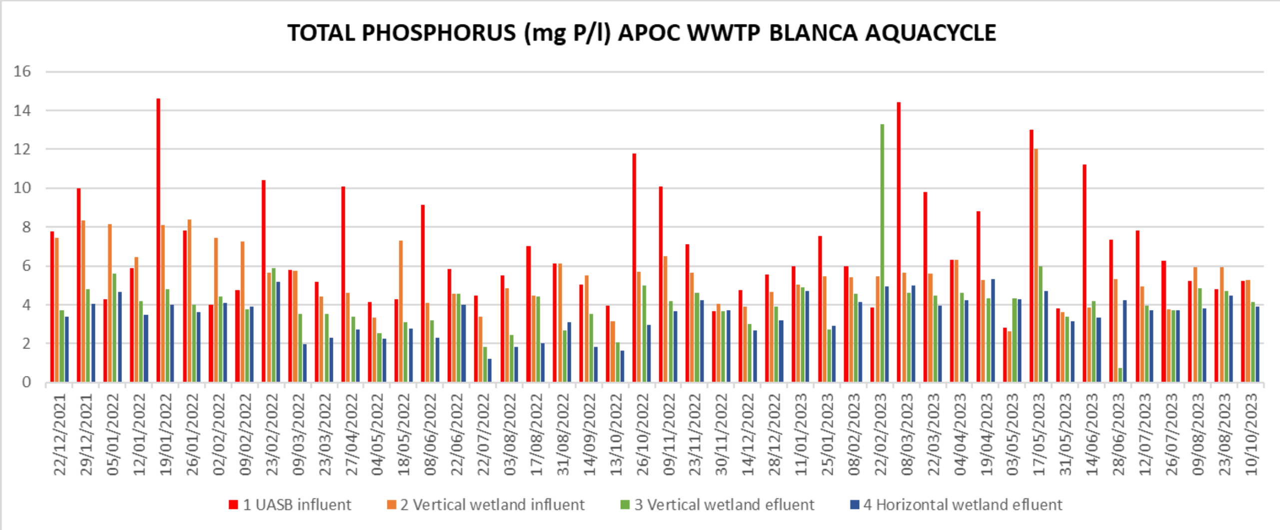


Figure 25. Total phosphorus APOC WWTP Blanca.

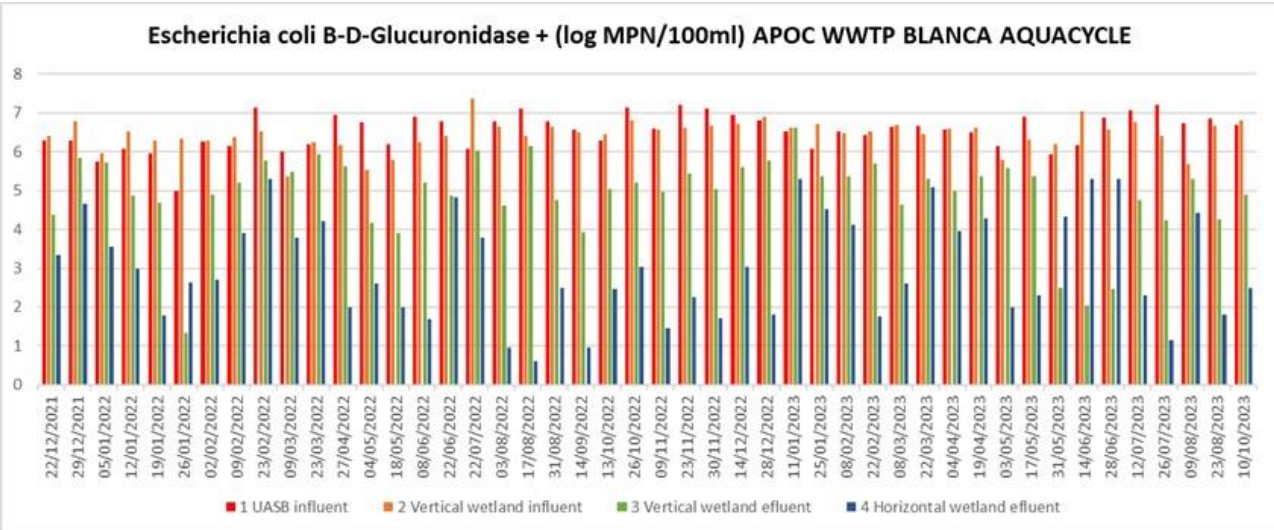


Figure 26. Escherichia coli APOC WWTP Blanca.

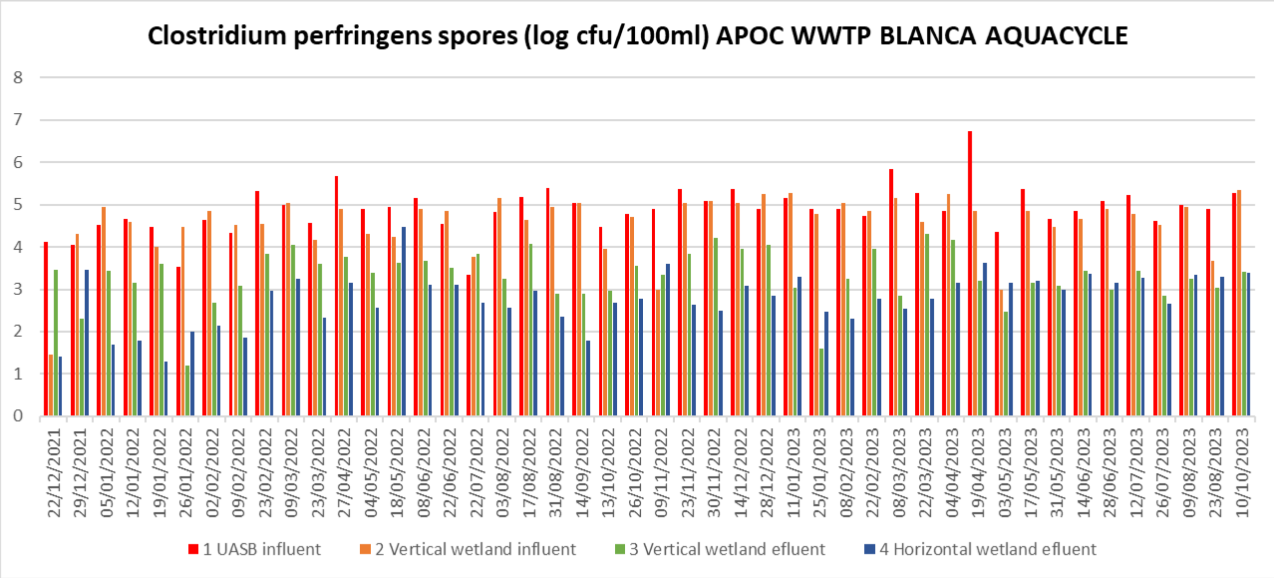


Figure 27.Clostridium perfringens spores APOC WWTP Blanca.

In the following tables and figures the most important statistical values of the measured variables for the APOC system are summarized.

Table 1. Descriptive statistics of BOD_5 APOC WWTP Blanca.

AQUACYCLE- APOC			UASB influent	Vertical wetland influent	Vertical wetland efluent	Horizontal wetland efluent
BOD5 (mg O_2/l)	Statistical	N	46	46	46	46
		Minimum	40	11	10	10
		Maximum	640	380	52	26
		Average	249,22	161,37	13,61	10,41
	Standard error	Average	18,268	11,643	1,193	0,348

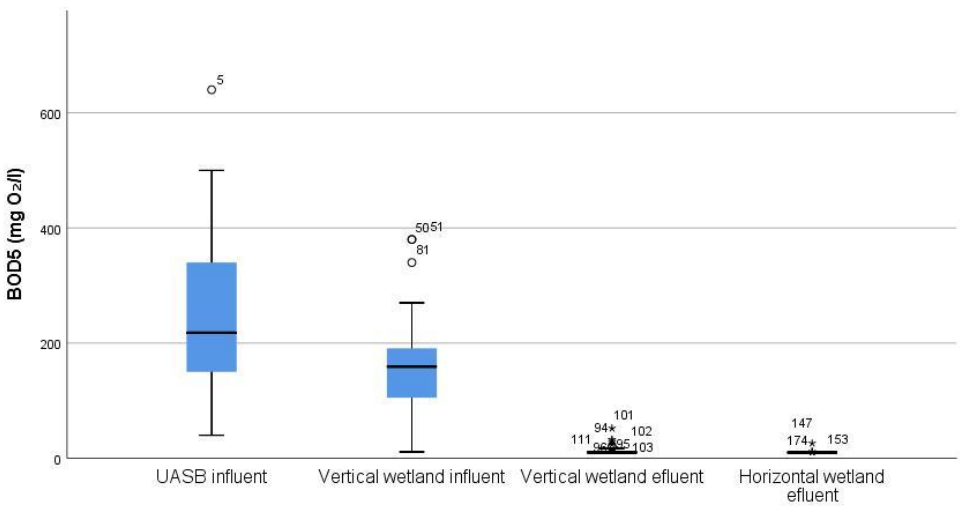


Figure 28. Box plot BOD_5 APOC WWTP Blanca.

Table 2. Descriptive statistics of QOD APOC WWTP Blanca.

AQUACYCLE- APOC			UASB influent	Vertical wetland influent	Vertical wetland efluent	Horizontal wetland efluent
QOD (mg O_2/l)	Statistical	N	46	46	46	46
		Minimum	120	87	10	10
		Maximum	1246	883	74	72
		Average	427,13	277,67	35,00	25,28
	Standard error	Average	32,166	21,393	2,217	1,620

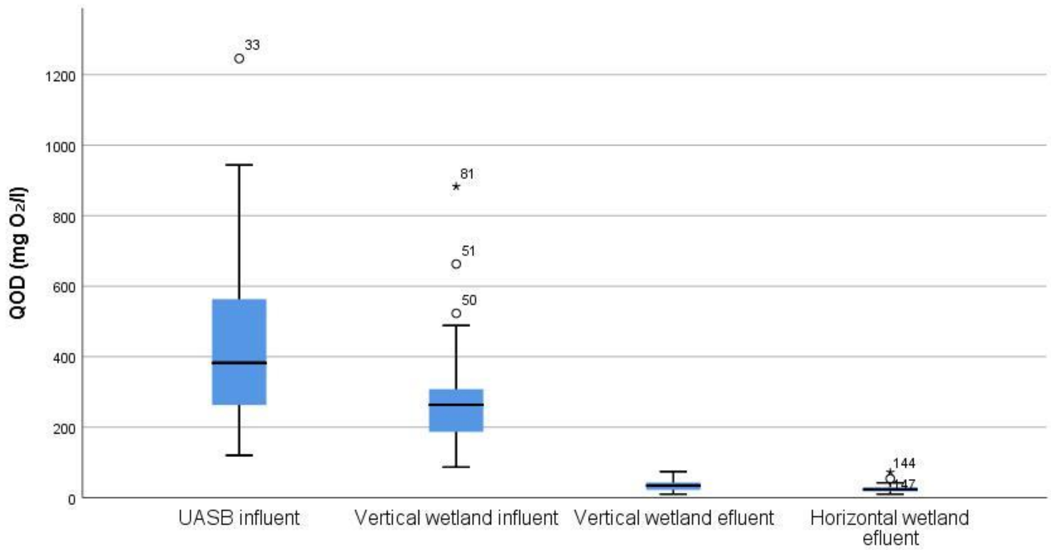


Figure 29. Box plot QOD APOC WWTP Blanca.

Table 3. Descriptive statistics of TSS APOC WWTP Blanca.

AQUACYCLE- APOC			UASB influent	Vertical wetland influent	Vertical wetland efluent	Horizontal wetland efluent
TSS (mg/l)	Statistical	N	46	46	46	46
		Minimum	48	12	2	2
		Maximum	1000	654	44	20
		Average	186,46	91,59	12,21	5,38
	Standard error	Average	22,992	13,413	1,426	0,687

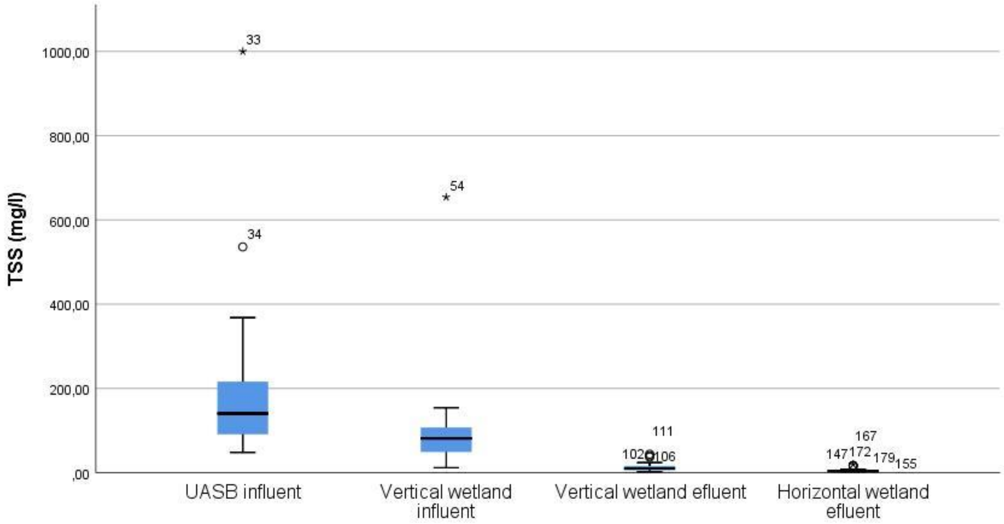


Figure 30. Box plot TSS APOC WWTP Blanca.

Table 4. Descriptive statistics of Nt APOC WWTP Blanca.

AQUACYCLE- APOC			UASB influent	Vertical wetland influent	Vertical wetland efluent	Horizontal wetland efluent
Nt (mg/l)	Statistical	N	46	46	46	46
		Minimum	22	14	1	1
		Maximum	101	121	57	57
		Average	52,63	43,55	26,94	19,76
	Standard error	Average	3,186	2,330	1,680	1,865

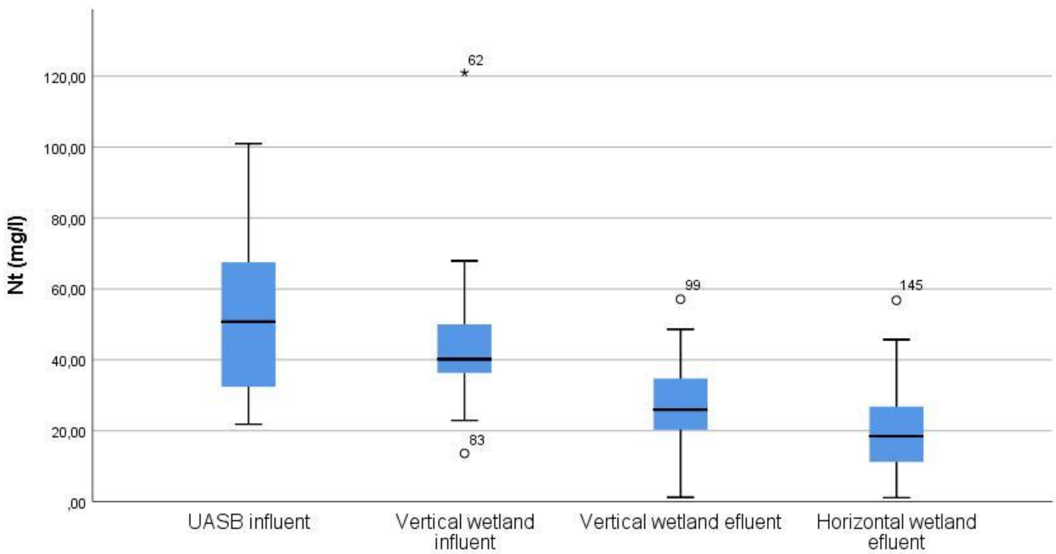


Figure 31. Box plot Nt APOC WWTP Blanca.

Table 5. Descriptive statistics of NO_3 APOC WWTP Blanca.

AQUACYCLE- APOC			UASB influent	Vertical wetland influent	Vertical wetland effluent	Horizontal wetland effluent
NO_3 (mg/l)	Statistical	N	46	46	46	46
		Minimum	0	0	0	0
		Maximum	3	23	24	22
		Average	0,63	1,33	11,52	9,03
	Standard error	Average	0,091	0,596	1,041	0,900

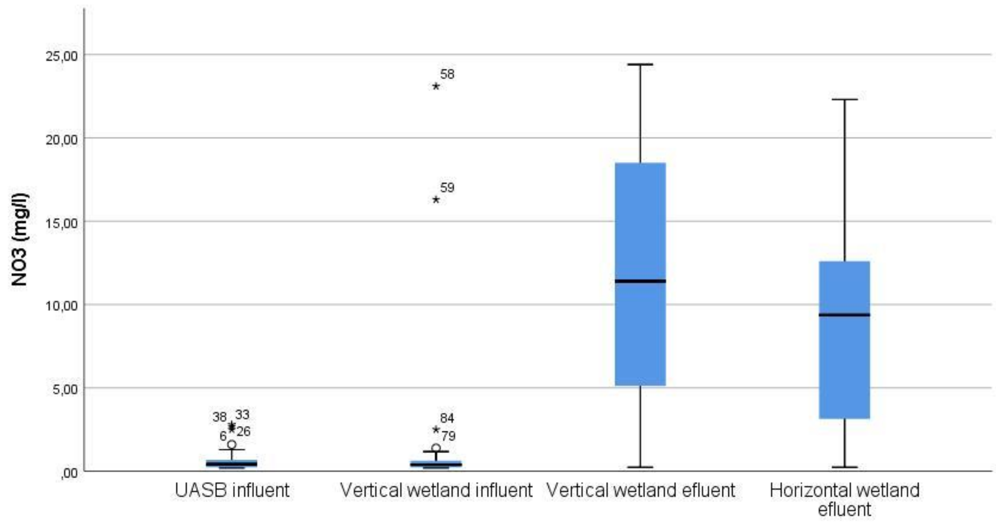


Figure 32. Box plot NO_3 APOC WWTP Blanca.

Table 6. Descriptive statistics of Pt APOC WWTP Blanca.

AQUACYCLE- APOC			UASB influent	Vertical wetland influent	Vertical wetland efluent	Horizontal wetland efluent
Pt (mg/l)	Statistical	N	46	46	46	46
		Minimum	3	3	1	1
		Maximum	15	12	13	5
		Average	6,94	5,58	4,13	3,51
	Standard error	Average	0,431	0,255	0,254	0,149

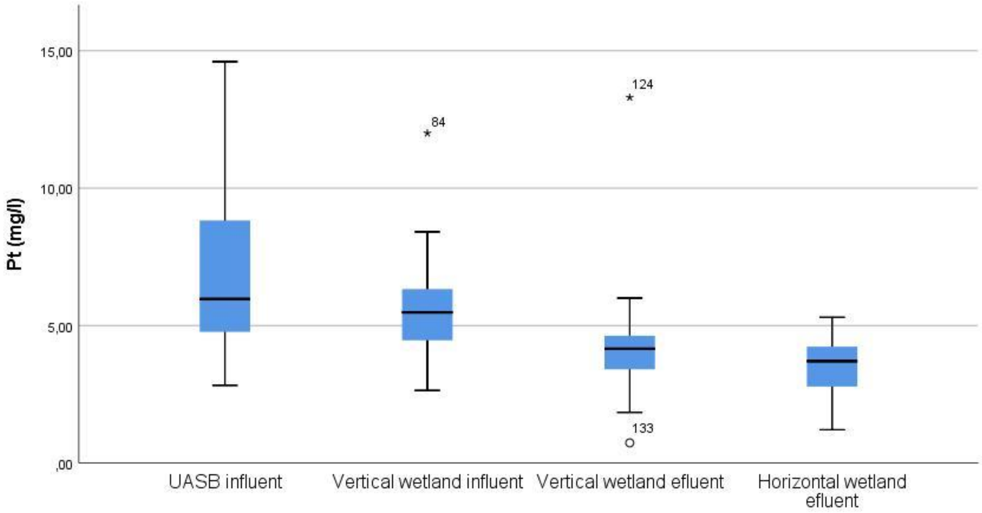


Figure 33. Box plot Pt APOC WWTP Blanca.

Table 7. Descriptive statistics of E. Coli APOC WWTP Blanca.

AQUACYCLE- APOC			UASB influent	Vertical wetland influent	Vertical wetland efluent	Horizontal wetland efluent
E. Coli (MPN/100ml)	Statistical	N	46	46	46	46
		Minimum	98000	240000	22	4
		Maximum	16000000	24000000	4100000	200000
		Average	5281260,87	3858913,04	327031,35	26201,17
	Standard error	Average	659297,405	546331,572	94881,830	8595,381

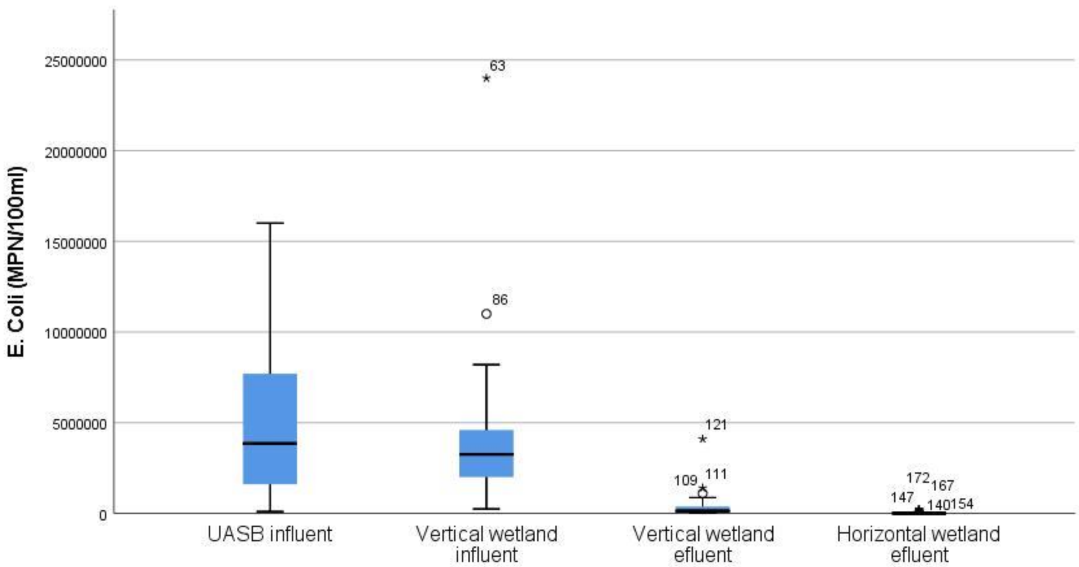


Figure 34. Box plot E. Coli APOC WWTP Blanca.

Table 8. Descriptive statistics of Clostridium perfringens spores APOC WWTP Blanca.

AQUACYCLE- APOC			UASB influent	Vertical wetland influent	Vertical wetland efluent	Horizontal wetland efluent
Clostridium perfringens spores (cfu/100ml)	Statistical	N	46	46	46	46
		Minimum	2200	28	16	20
		Maximum	5500000	220000	20000	30000
		Average	232513,04	69168,00	4187,96	1665,13
	Standard error	Average	118501,864	8070,083	686,776	646,609

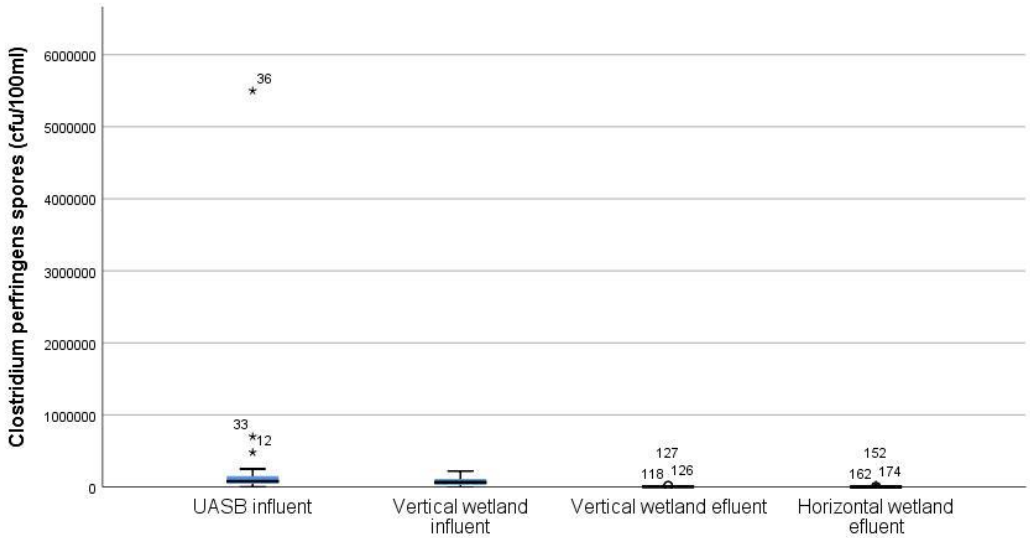


Figure 35. Box plot Clostridium perfringens spores APOC WWTP Blanca.

Regarding the results for the raceway pond reactor, several studies were carried out with different water heights (5, 10 and 15 cm) in the reactor and with different chemicals (different concentrations of H2O2 (100 mg/l, 150 mg/l or 200 mg/l) or none). The targets were microbiological parameters (E. Coli, Enterococcus, Salmonella or Total Coliforms) or emerging compounds. Figure 36 shows the efficiency at 5 cm for several microbiological parameters.

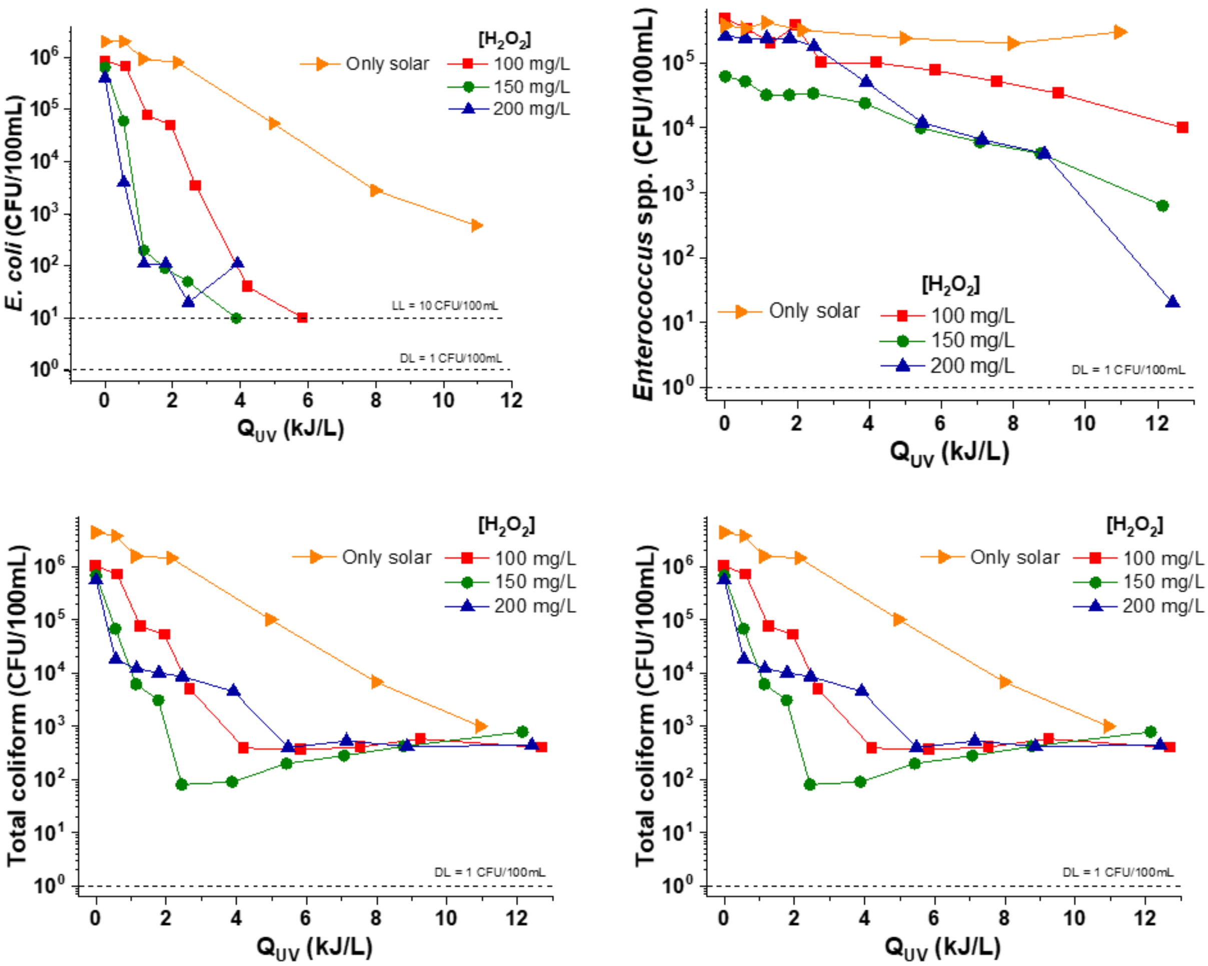


Figure 36. Efficiency with 5 cm of height, for the microbiological parameters.

Table 9. Efficiency with 5 cm of height, for the emerging compounds.

RPR 5 cm entrada	**H_2O_2**			**PMS**	**Only sol**
Swiss Regulation	**100 mg/L**	**150 mg/L**	**200 mg/L**	**1 mM**	
Amisulpride	-	15	100	100	100
Benzotriazole	10	17	19	-	4
Candesartan cilexetil	n.d.	n.d.	n.d.	n.d.	n.d.
Carbamazepine	67	48	49	-	-
Citalopram	n.d.	n.d.	n.d.	n.d.	n.d.
Irbesartan	-	7	18	-	-
Metoprolol	23	15	15	n.d.	n.d.
Venlafaxine	-	-	4	-	64
Clarithromycin	-	-	-	n.d.	n.d.
Hydrochlorothiazide	73	58	80	73	43
Diclofenac	90	81	100	91	79
Total (%)	**12**	**-**	**9**	**16**	**7**

Table 9 shows the efficiency at a height of 5 cm for a multitude of emerging contaminants. Figure 37 shows the efficiency at a height of 15 cm for the microbiological parameters.

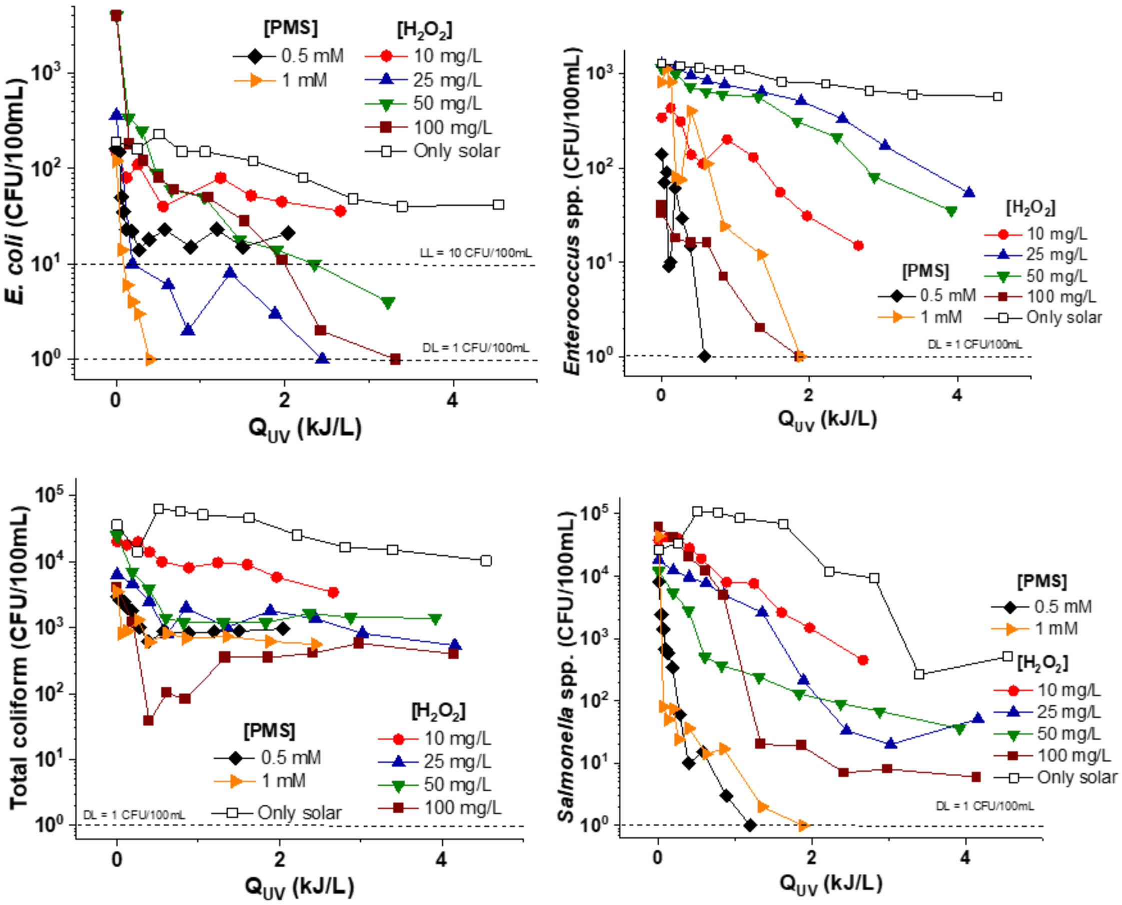


Figure 37. Efficiency with 15 cm of height, for the microbiological parameters.

Table 10 shows the efficiency at a height of 15 cm for the target emerging contaminants.

Table 10. Efficiency with 15 cm of height, for the emerging compounds.

	H_2O_2				PMS		Only sol
Swiss Regulation	**10 mg/L**	**25 mg/L**	**50 mg/L**	**100 mg/L**	**0,5 mM**	**1 mM**	
Amisulpride	23	38	38	64	85	95	33
Benzotriazole	-	10	4	37	-	0	10
Candesartan cilexetil	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Carbamazepine	9	18	16	62	20	53	4
Citalopram	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Irbesartan	79	6	0	84	-	74	0
Metoprolol	5	n.d.	n.d.	14	36	n.d.	n.d.
Venlafaxine	5	0	10	40	54	98	0

Clarithromycin	-	n.d.	n.d.	9	-	n.d.	n.d.
Hydrochlorothiazide	54	56	83	87	49	100	78
Diclofenac	76	68	69	100	48	98	71
Total (%)	**13**	**20**	**41**	**22**	**27**	**70**	**31**

Figure 38 shows the efficiency at a height of 10 cm for the microbiological parameters.

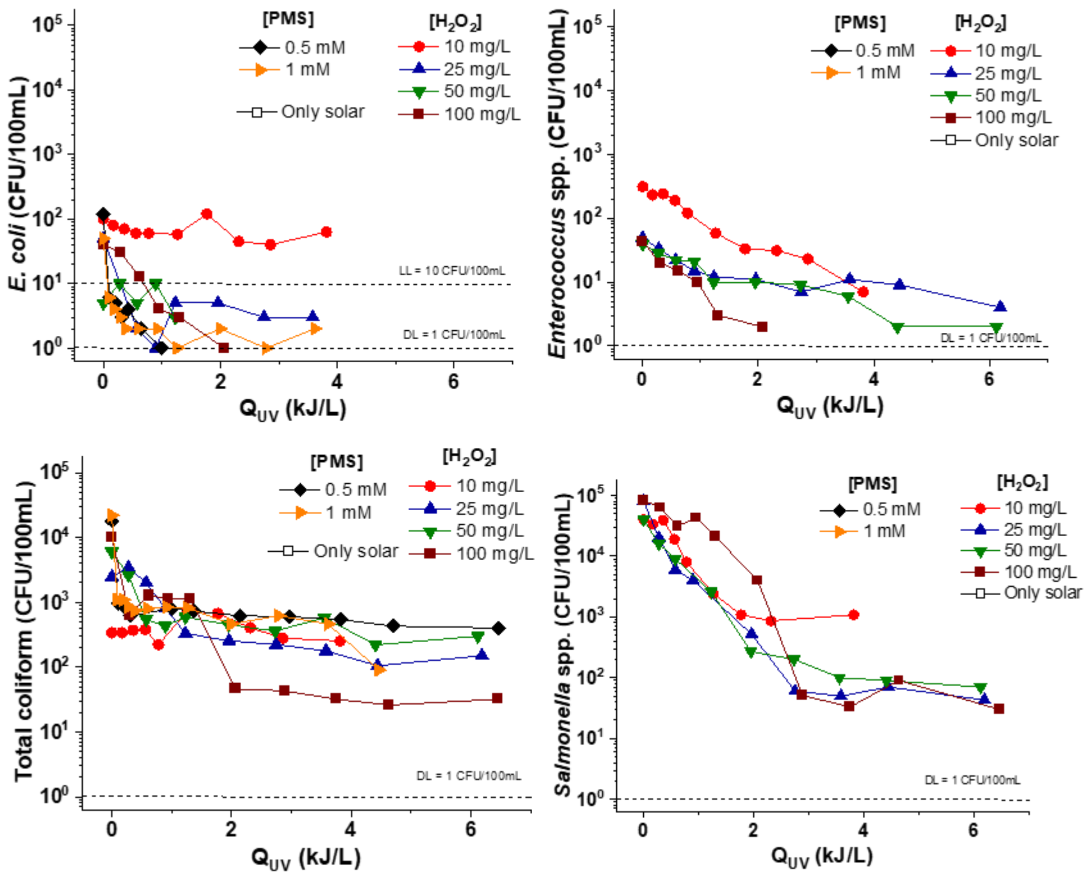


Figure 38. Efficiency with 10 cm of height, for the microbiological parameters.

Table 11 shows the efficiency at a height of 10 cm for the emerging contaminants.

Table 11. Efficiency with 10 cm of height, for the emerging compounds.

	H_2O_2				PMS		Only sol
Swiss Regulation	**10 mg/L**	**25 mg/L**	**50 mg/L**	**100 mg/L**	**0,5 mM**	**1 mM**	
Amisulpride	23	40	100	61	100	100	
Benzotriazole	-	16	16	20	100	100	
Candesartan cilexetil	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	
Carbamazepine	9	24	60	50	100	100	
Citalopram	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	
Irbesartan	79	-	10	89	100	100	
Metoprolol	5	22	17	24	100	100	

Venlafaxine	5	20	20	35	100	100	
Clarithromycin	-	-	3	32	n.d.	n.d.	
Hydrochlorothiazide	54	82	82	-	n.d.	n.d.	
Diclofenac	76	100	100	100	100	100	
Total (%)	**9**	**14**	**21**	**1**	**80**	**95**	

From the above it becomes clear that the results in the Blanca demonstration plant are excellent in terms of overall parameters, both physicochemical and microbiological. This means that the APOC system is a viable technology for wastewater treatment and water reuse.

2 ESTABLISHMENT OF DEDDEH DEMO-SITE IN LEBANON

2.1 Design of the unit

The design of the APOC demo plant in Lebanon is very functional, with several accumulation tanks which can add versatility to the system. Several bypasses have been installed to treat the wastewater in different ways. The electrical energy is supplied by a photovoltaic system with 22 PV solar panels 600 WP and a fuel generator of 9 KVA, as the power consumption in the APOC system is very low.

The possibility of aerating the wetland, if necessary, is also an interesting novelty in this project.

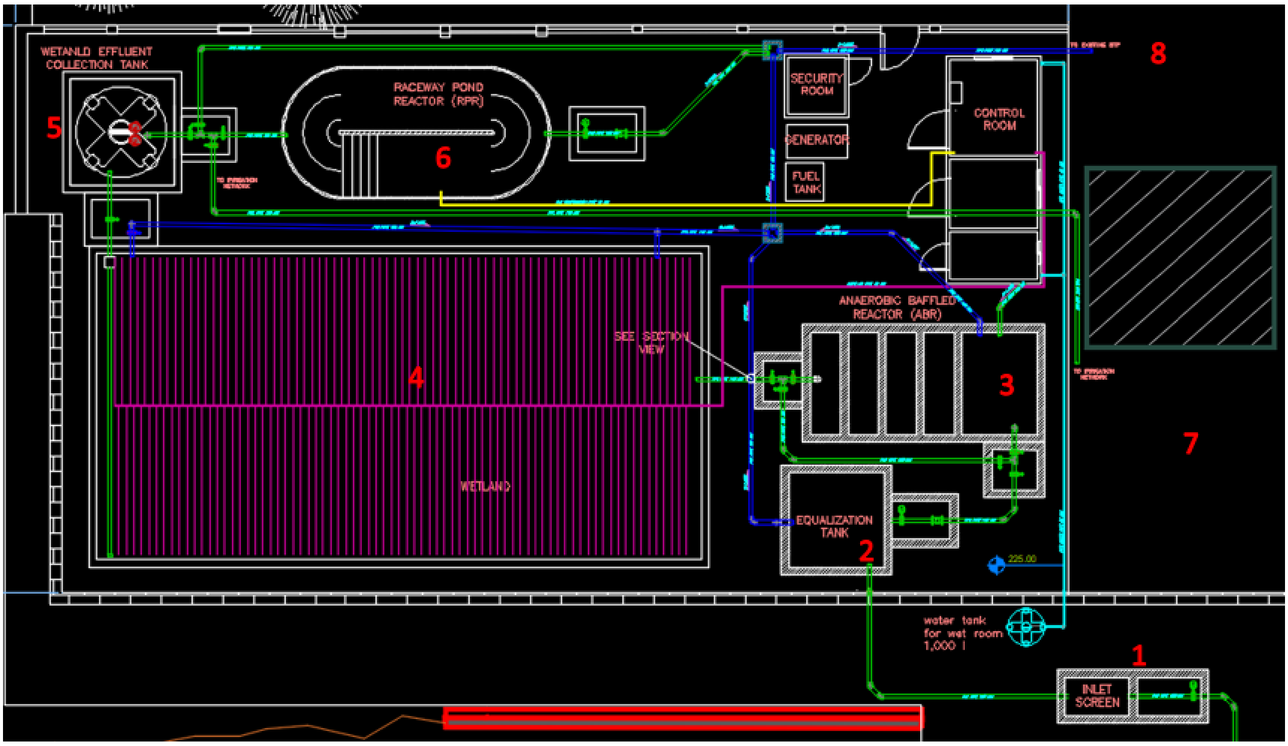
The planting of different types of plants to be irrigated with the treated water is an interesting point of this project.

The main units of the system are:

- Anaerobic Baffled Reactor (ABR)
- Aerated Horizontal Constructed Wetland (ACW)
- Raceway Pond Reactor (RPR)

An irrigation area is also provided.

Figure 39 shows a general layout of the plant.



1. Intake structure, 2: Equalization Tank (EQ), 3: Anaerobic Baffled Reactor (ABR), 4: Aerated Horizontal Constructed Wetland (ACW), 5: ACW effluent collection tank, 6: Raceway Pond Reactor (RPR), 7: Irrigation area, 8: effluent flow to the existing wastewater treatment plant (WWTP).

Figure 39. General layout of the APOC demo plant.

Figure 40 shows a diagram of the general flow of this plant.

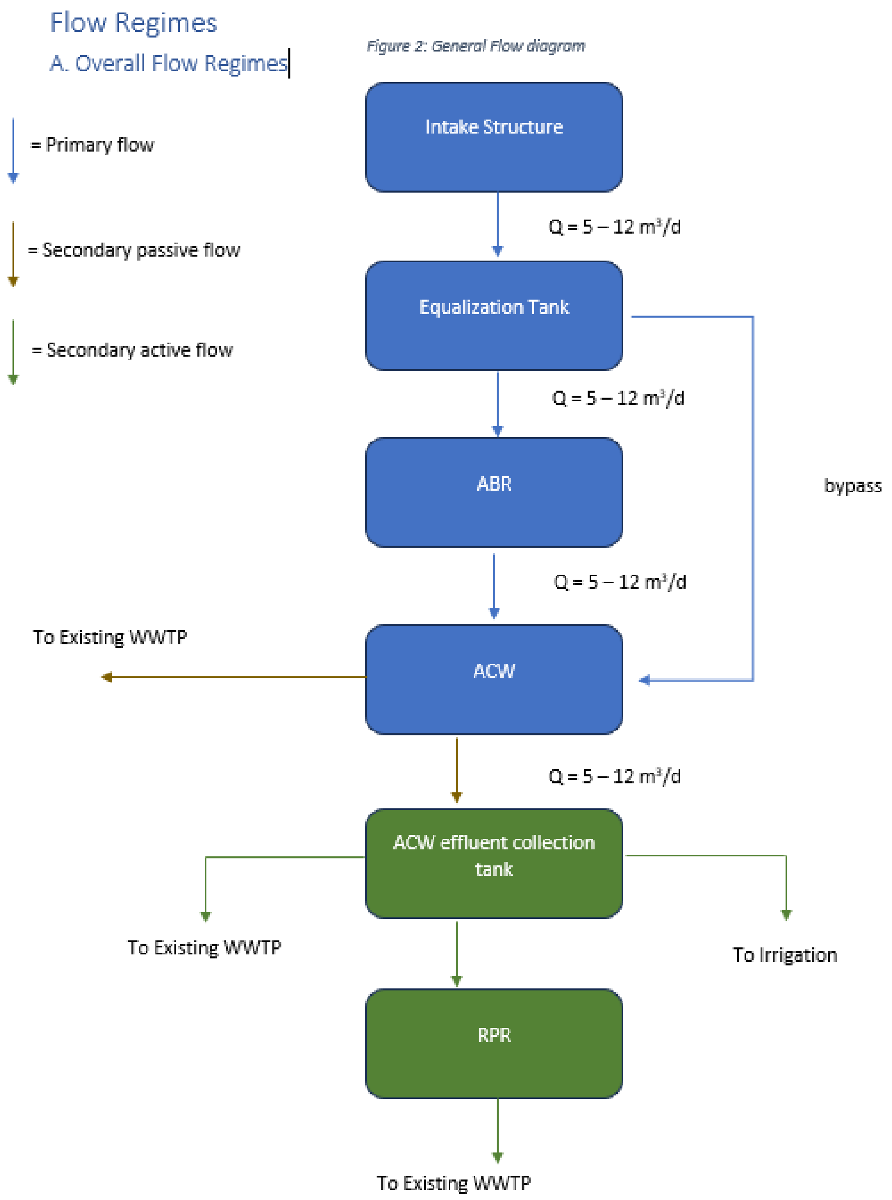


Figure 40. Scheme of the general flow of the plant.

2.2 Starting Data

The Deddeh plant is designed for a flow range of **5 m^3 to 12 m^3 per day** of domestic wastewater in a batch flow process. The daily volume of wastewater is collected at the start of the plant and then immediately discharged into the plant's network. There is no continuous flow during the initial phase of operation.

Table 12. Influent characteristics of the wastewater.

PARAMETER	SYMBOL	INFLUENT CONCENTRATION (MG/L)
CHEMICAL OXYGEN DEMAND	COD	240
FIVE-DAY BIOCHEMICAL OXYGEN DEMAND	BOD_5	90
TOTAL SUSPENDED SOLIDS	TSS	75
TOTAL KJELDAHL NITROGEN	TKN	59
TOTAL NITROGEN	TN	62
AMMONIUM NITROGEN	NH_4^+-N	54
TOTAL PHOSPHORUS	TP	14
NITRATE NITROGEN	NO_3^--N	5

Table 13. Expected effluent characteristics of the treated wastewater.

PARAMETER	SYMBOL	EFFLUENT CONCENTRATION (MG/L)
CHEMICAL OXYGEN DEMAND	COD	< 40
FIVE-DAY BIOCHEMICAL OXYGEN DEMAND	BOD_5	< 10
TOTAL SUSPENDED SOLIDS	TSS	< 5
TOTAL KJELDAHL NITROGEN	TKN	13
TOTAL NITROGEN	TN	14
AMMONIUM NITROGEN	NH_4^+-N	1
TOTAL PHOSPHORUS	TP	5
NITRATE NITROGEN	NO_3^--N	10

In the case of a passive secondary flow path, if no irrigation or RPR operations are performed, the treated effluent would have the following characteristics.

Table 14. Characteristics of treated effluent.

Parameters	Class II*
Temperature (°C)	-
pH	6 - 9
Turbidity (NTU)	-

TSS (mg/L)	< 200
COD (mg/L)	< 250
BOD$_5$ (mg/L)	< 100
TP (mg/L)	-
NO$_3$ (mg/L)	< 30
NH$_3$-N (mg/L)	-
TN, as N (mg/L)	-
TC (CFU/100 mL)	-
FC (CFU/100 mL)	< 1000

2.3 Tender information

Construction of the Deddeh APOC system began on 27 December 2022 and was completed at the end of October 2023.

2.4 Construction: Development, figures and construction details

Figure 41 shows the location of the pilot plant, and Figure 42 the first steps of the construction.

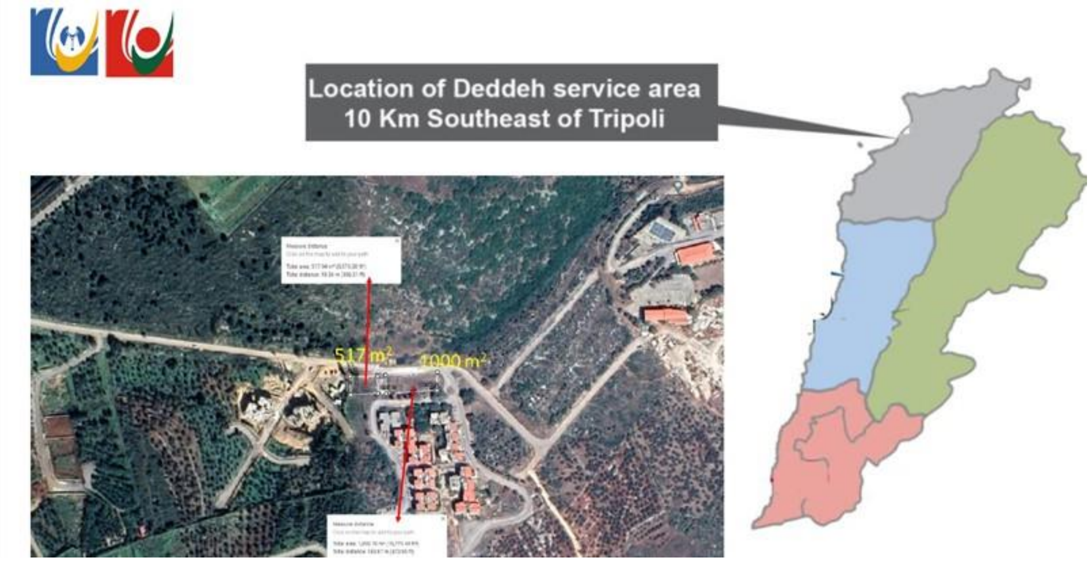


Figure 41. Location of the pilot plant.

Figure 42. First steps of the construction.

A detail of the tank for the pre-treatment elements can be seen in Figure 43. A bar screen is installed inside it.

Figure 43. Detail of the tank for the pretreatment elements.

In Figure 44, an equalising tank has been installed to laminate the flow.

Figure 44. Equalization tank.

Figure 45 shows one of the main parts of the APOC system, the Anaerobic Baffled Reactor (ABR), with the main holes for inspecting and removing the settled solids in the various compartments.

Figure 45. A detail of constructed wetland.

A general view can be seen in Figure 46, where the regulation tank for the solar system can also be found.

Figure 46. General vision of some elements of APOC system.

A detail of the regulation tank for the solar system with a volume of 10 m^3 can be seen in Figure 47.

Figure 47. Regulation tank for the solar system.

The work of filling the ground and applying the bitumen colour can be seen in Figure 48.

Figure 48. Some detail of the construction.

Figure 49 shows the completion of land filling and the construction of a slab for the installation of the solar reactor, and the installation of the membrane for the wetland can be seen in Figure 50.

Figure 49. Land filling completion.

Figure 50. Installation of the wetland membrane.

Another view of the APOC system treatment is the wetlands. Here we can see some details of the construction of these elements in Figures 51 and 52.

Figure 51. Anaerobic Baffled Reactor.

Figure 52. Constructed wetland.

3 ESTABLISHMENT OF BENT SAIDANE DEMO-SITE IN TUNISIA

3.1 Design of the unit

The design of this demo plant is very versatile, with a very wide range of capacity (5 to 25 m3/day). The current pre-treatment of an existing plant makes it possible to focus on the other parts of the process. Installing a settling tank after the anaerobic reactor is an excellent idea to avoid blockages in the wetlands and pipes, especially in the early stages of the process when there is not yet too much sludge in the anaerobic reactor. And the design of the wetlands is excellent, with both anaerobic and aerobic phases. The aerobic phase makes it possible to significantly reduce the organic matter and nitrify the water after the anaerobic process. In addition, the use of two lines makes the process more versatile and adaptable, as it offers the possibility of working with very different flows. And the underground, horizontal flow constructed wetland makes it possible to remove some of the nitrogen from the system when necessary. The Solar Raceway pond reactor will be able to disinfect the water and remove the emerging compounds using chemicals. The ability to use the treated water in an irrigation area adjacent to the plant is an excellent opportunity to demonstrate the benefits of the APOC system. A schematic of this design is shown in Figure 53.

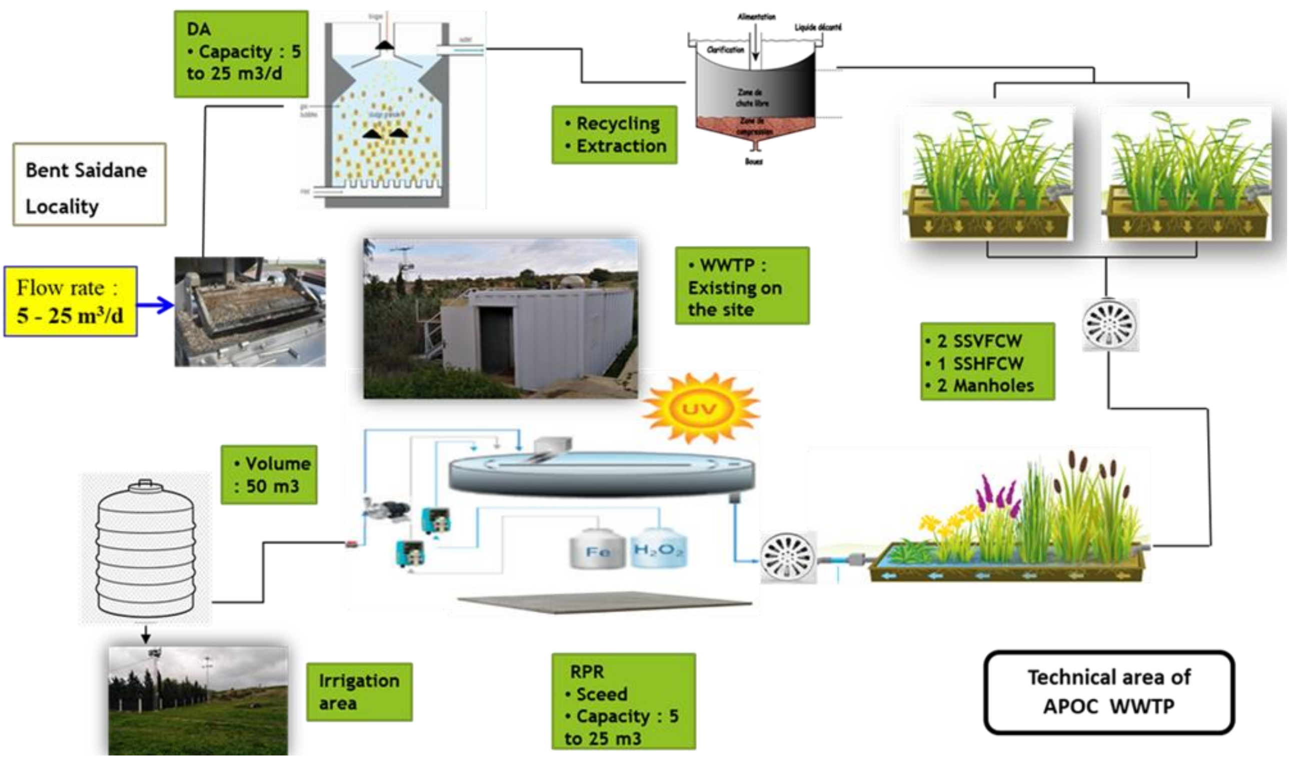


Figure 53. Design scheme

Figure 54 shows a diagram of the lay out of the plant, in which the distribution of the different parts of the process can be seen.

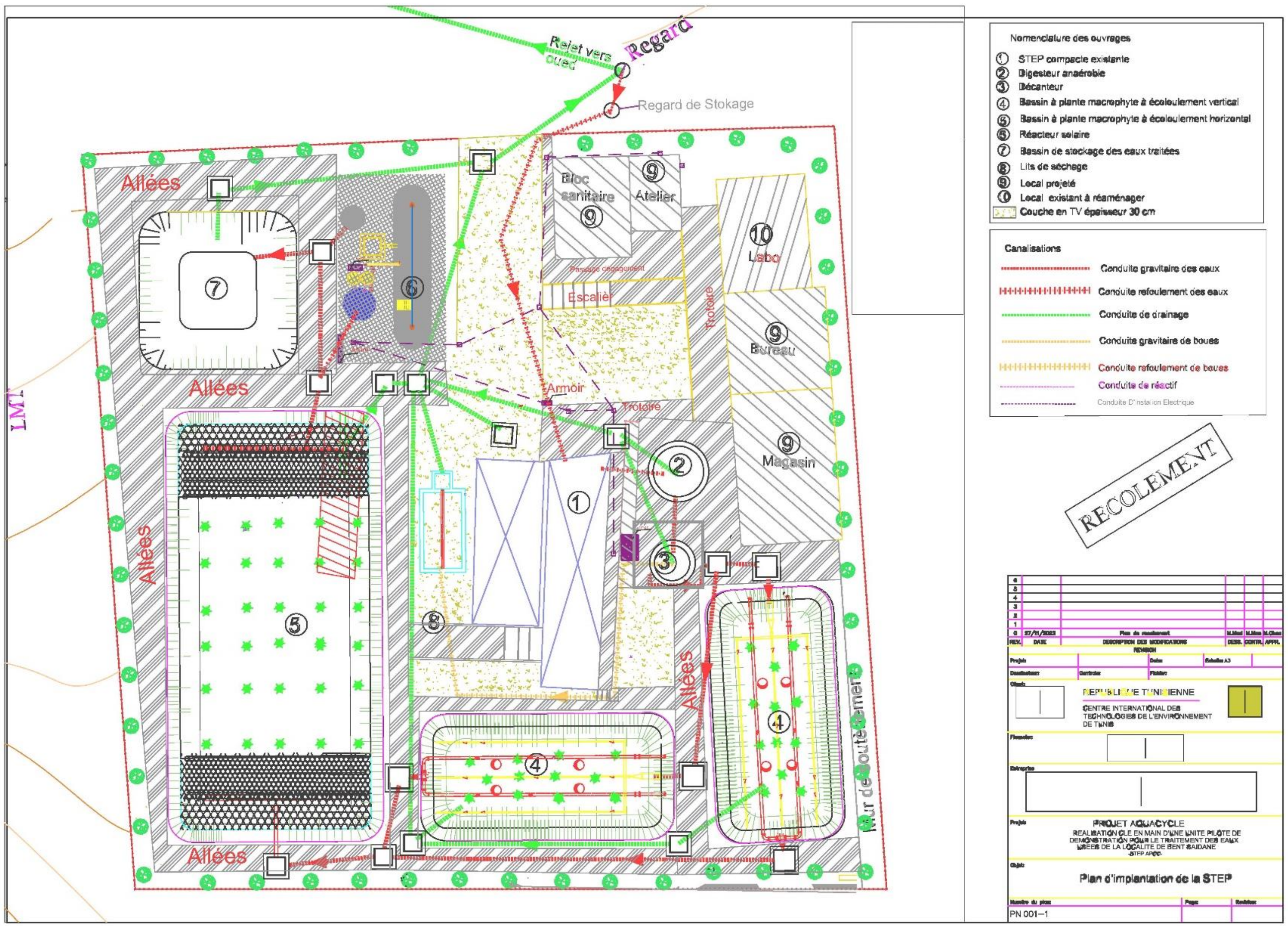


Figure 54. Lay out of the plant.

3.2 Starting Data

In the next table we can see the characteristics of the influent. We can see that the organic load and the nutrients are very high, as it corresponds to an arid zone where, due to the scarcity of water, the concentrations are high. Another interesting parameter is the sulphate concentration. In this case, it is not very low, but due to the high concentration of organic matter, the anaerobic process can function properly.

Table 15. Influent characteristics.

Parameter	Value
Temperature (°C)	**16**
pH	**7.5**
Suspended solids **(***SS*) mg/l	**400-500**
Chemical oxygen demand (COD) (mgO_2 / l)	**1000-1500**
Biochemical Oxygen Demand (mgO_2 / l)	**500-600**
Chlorides (Cl^-) (mg/l)	**220**
Sulphate SO_4 (mg / l)	**300**
Nitrates NO_3 (mg/l)	**< 0.5**
Nitrites NO_2 (mg/l)	**0.12**
Organic nitrogen and ammoniacal NH_4 (mg/l)	**50-150**
NTK mgN/l	**70-200**
Total phosphorus (mg / l)	**10 to 30**
Fluorides F (mg / l)	**10**
Iron (Fe) (mg / l)	**0.5**
Copper (Cu) (mg / l)	**< 0.05**
Manganese Mn (mg / l))	**< 0.05**
Zinc Zn (mg/l)	**0.8**
Arsenic As (mg/l)	**0.2**
Aluminium Al (mg/l)	**0.179**
Cadmium Cd (mg/l)	**0.005**
Lead Pb (mg / l)	**<0.05**
Nickel Ni (mg/l)	**<0.05**
Chromium Cr (mg/l)	**0.05**

3.3 Tender information

After several attempts, the final launch was on 31 October 2022. Construction work began on 18 July 2023 and was completed on 31 October 2023.

3.4 Construction: Development, figures and construction details

Figure 55 shows the plot of land on which the APOC plant has been built.

Figure 55. Location of demo site plant

A detail of the plot can be seen in Figure 56.

Figure 56. Detail of the plot

Figure 57 shows the existing pre-treatment equipment.

Figure 57. Pre-treatment.

The first part of the APOC system, anaerobic reactor, is shown in Figure 58.

Figure 58. Anaerobic reactor.

The settlement tank after the UASB reactor is shown in Figure 59.

Figure 59. Settlement tank.

A detail of the vertical wetlands can be seen in Figure 60.

Figure 60. vertical wetlands detail

A detail of the sowing of plants in the horizontal wetland can be seen in Figure 61.

Figure 61. Sowing of plants in the horizontal wetland

Both constructed wetlands, vertical and horizontal, can be seen in Figure 62.

Figure 62. Vertical and horizontal wetlands

The Raceway Pond reactor is located in the last part of the APOC system. Figures 63 and 64 show images of the respective system.

Figure 63. Solar raceway pond reactor

Figure 64.

A storage basin, for the treated water, can be seen in Figure 65.

Figure 65. Storage basin, for the treated water

Finally, a global Figure of the overall APOC demo plant is shown in Figure 66.

Figure 66. global figure of all the system