

Under the Patronage of the Minister of Environment Water & Agriculture
Eng. Abdulrahman bin Abdulmohsen Al Fadhili

منتدى المياه السعودي
saudi water forum SWF



"Sustainable Water.. for Sustainable Development"

وزارة البيئة والمياه والزراعة
Ministry of Environment Water & Agriculture
Kingdom of Saudi Arabia المملكة العربية السعودية



رؤية
2030
المملكة العربية السعودية
KINGDOM OF SAUDI ARABIA

swforum.sa

Twitter Facebook LinkedIn /SaudiWaterForum

17-19 MARCH 2019

Fairmont Hotel Riyadh - Business Gate
Kingdom of Saudi Arabia

Treated Water Technologies

MAIN PARTNERS

المؤسسة العامة لتحلية المياه المالحة
Saline Water Conversion Corporation



شركة المياه الوطنية
National Water Company



المؤسسة العامة للري
Saudi Irrigation Organization
المملكة العربية السعودية



شركة الماء والكهرباء ذ.م.م
WATER & ELECTRICITY LLC.

EXECUTED BY

مجموعة
EXICON
International Group
مجموعة إكزيكون الدولية في.م.م
International Business Unit

TECHNICAL ADVISOR

QWi
WATER & RISK CONSULTING

Under the Patronage of the Minister of Environment Water & Agriculture
Eng. Abdulrahman bin Abdulmohsen Al Fadhili

منتدى المياه السعودي
saudi water forum SWF



"Sustainable Water.. for Sustainable Development"

وزارة البيئة والمياه والزراعة
Ministry of Environment Water & Agriculture
Kingdom of Saudi Arabia المملكة العربية السعودية




رؤية
2030
المملكة العربية السعودية
KINGDOM OF SAUDI ARABIA

swforum.sa

Twitter Facebook LinkedIn /SaudiWaterForum

Selection Criteria for Treated Water Technologies Depending on the Final Use of the Water

Carlos Varela
Engineering department of  aqualia
Head of Waste Water Treatment

- 1 .- TREATED WATER TECHNOLOGIES**
- 2.- SELECTION BASED ON USE AND QUALITY OF THE TREATED WATER**
- 3 .- SELECTION BASED ON THE REQUIRED AREA**
- 4 .- SELECTION BASED ON CAPEX & OPEX**
- 5 .- TECHNOLOGY SELECTION EXAMPLES**

Under the Patronage of the Minister of Environment Water & Agriculture
Eng. Abdulrahman bin Abdulmohsen Al Fadhili

منتدى المياه السعودي
saudi water forum SWF



"Sustainable Water.. for Sustainable Development"

وزارة البيئة والمياه والزراعة
Ministry of Environment Water & Agriculture
Kingdom of Saudi Arabia المملكة العربية السعودية



رؤية
VISION
2030
المملكة العربية السعودية
KINGDOM OF SAUDI ARABIA

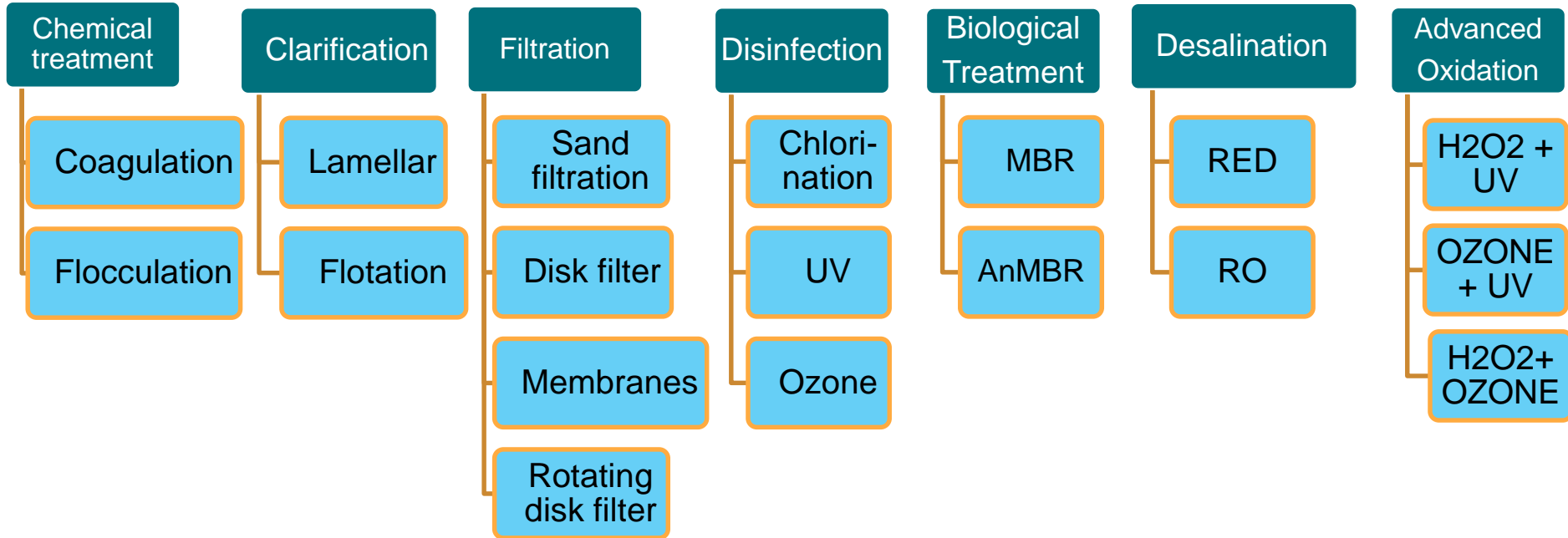
swforum.sa



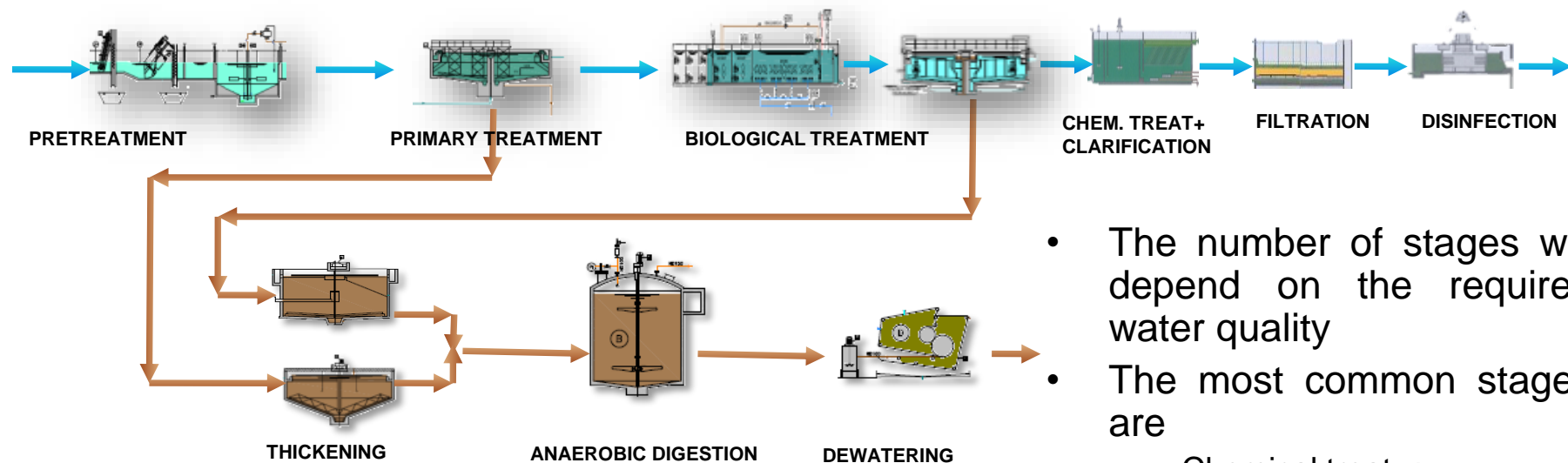
/SaudiWaterForum

1.- TREATED WATER TECHNOLOGIES

SELECTION CRITERIA FOR TREATED WATER TECHNOLOGIES

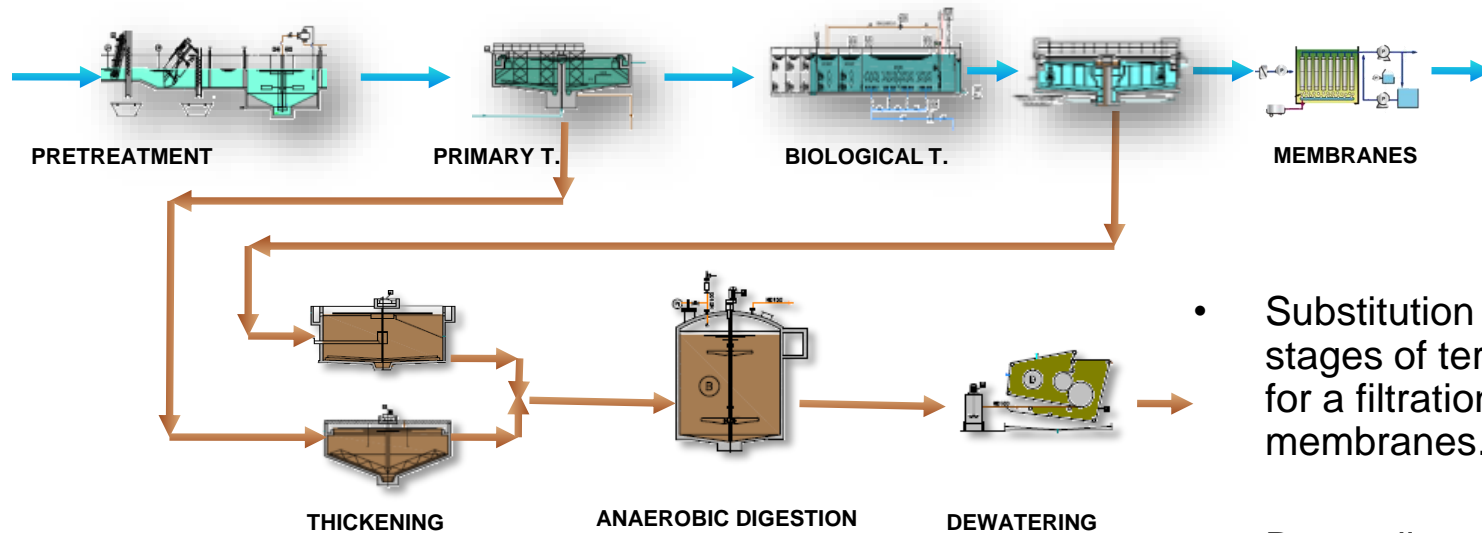


CONVENTIONAL REUSE TREATMENT



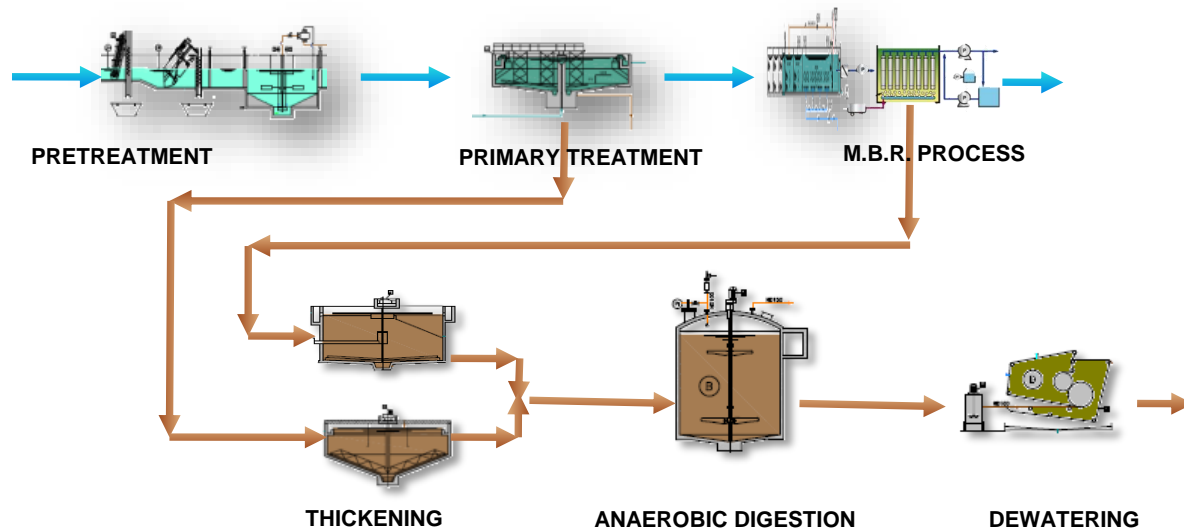
- The number of stages will depend on the required water quality
- The most common stages are
 - Chemical treat. + clarification
 - Filtration
 - Disinfection.

MEMBRANES REUSE TREATMENT



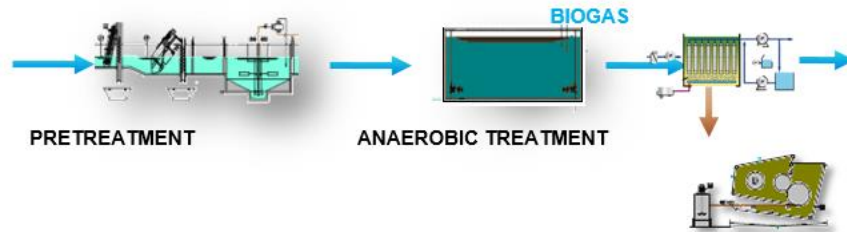
- Substitution of the first two stages of tertiary treatment for a filtration process with membranes.
- Depending on the required quality, ultrafiltration membranes can also replace disinfection

AEROBIC MBR PROCESS



- Incorporation of the filtration process with membranes in the biological process of the WWTP, replacing secondary settlement.
- It allows to reduce the size of the biological treatment and therefore of the wastewater treatment station.

ANEROBIC MEMBRANE PROCESS AnMBR

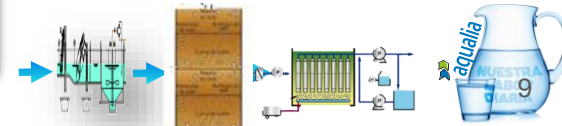
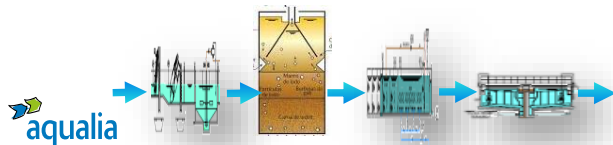


- Anaerobic biological process instead of aerobic followed by membranes.
- Significant reduction in operating costs
- It does not remove nutrients which can be beneficial in irrigation.

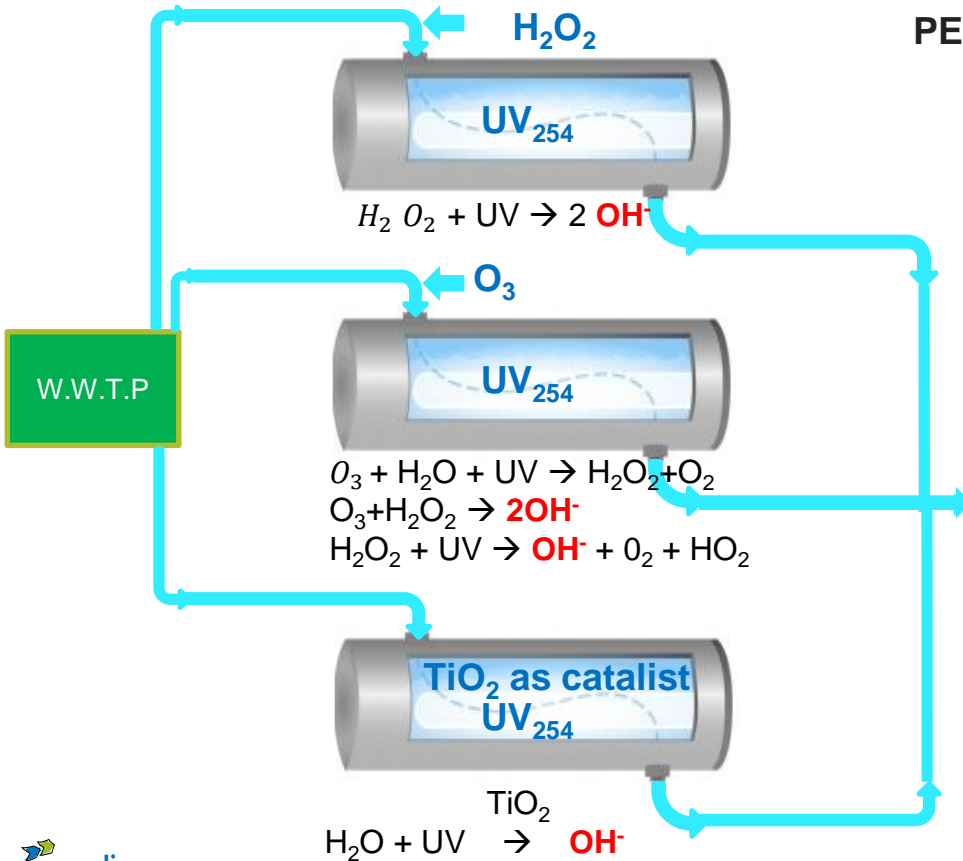
- Low production of sludge with a high degree of stabilization
- Low energy demand
- Biogas production



- Full retention of the biomass
- It allows a biomass of greater biodiversity
- Very good quality of treated water



ADVANCED OXIDATION



PERSISTENT ORGANIC POLLUTANTS

Pesticides	Industrial Chemicals
<ul style="list-style-type: none">• Aldrin• Chlordane• DDT• Dieldrin• Endrin• HCB• Heptachlor• Mirex• Toxaphene	<ul style="list-style-type: none">• Hexachlorobenzene (HCB)• Polychlorinated biphenyls (PCBs)
	Unintentionally Produced by-Products
	<ul style="list-style-type: none">• Dioxins• Furans• HCB• PCBs



Under the Patronage of the Minister of Environment Water & Agriculture
Eng. Abdulrahman bin Abdulmohsen Al Fadhili

منتدى المياه السعودي
saudi water forum SWF



"Sustainable Water.. for Sustainable Development"

وزارة البيئة والمياه والزراعة
Ministry of Environment Water & Agriculture
Kingdom of Saudi Arabia المملكة العربية السعودية



رؤية
VISION
2030
المملكة العربية السعودية
KINGDOM OF SAUDI ARABIA

swforum.sa

Twitter Facebook LinkedIn /SaudiWaterForum

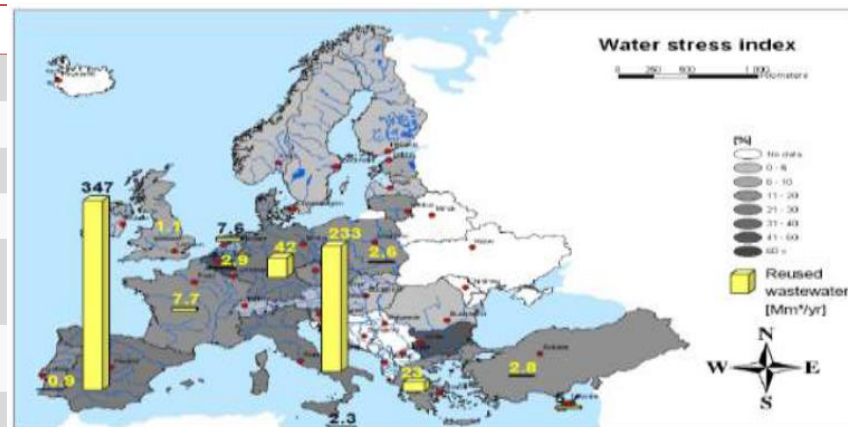
2.- SELECTION BASED ON USE AND QUALITY OF THE TREATED WATER

USES AND QUALITY OF THE TREATED WATER

Differences in maximum limit values for selected parameters considered in national quality requirements for water reuse

Parameters	Cyprus	France	Greece	Italy	Portugal	Spain
E coli (cfu/100ml)	5-10 ³	250-10 ⁵	5-200	10	-	0-10,000 ²⁴
Faecal coliforms	-	-	-	-	100-10 ⁴	-
TSS	10-30	15	2-35	10	60	5-35
Turbidity (NTU)	-	-	2-no limit	-	-	1-15
Biochemical oxygen demand (BOD 5) (mg/l)	10-70	-	10-25	20	-	-
Chemical oxygen demand (COD) (mg-l)	70	60	-	100	-	-
Total nitrogen (mg/l)	15	-	30	15	-	10

Source: Reproduced from JRC, 2014. '-' indicates that there is no value set for the parameter in the national legislation



Reuse of reclaimed water in Europe (Hochstrat et al., 2006)

USES AND QUALITY OF THE TREATED WATER

The Spanish R.D 1620/2007 defines 14 water qualities and five different uses of the treated water: **

MUNICIPAL USE

AGRICULTURE

INDUSTRIAL

RECREATIONAL USE

ENVIRONMENTAL USE

** New regulations that will be more restrictive than the current ones are under development.

USES OF TREATED WATER



MUNICIPAL USE

- RESIDENTIAL (Quality 1.1)
- SERVICES (Quality 1.2)



AGRICULTURAL USE

- CROP IRRIGATION FOR FRESH HUMAN CONSUMPTION (Q2,1)
- CROP IRRIGATION FOR CONSUMPTION WITH TREATMENT (Q 2.2)
- CROP IRRIGATION WITHOUT HUMAN CONSUMPTION (Q 2.3)



INDUSTRIAL USE

- PROCESS WATER (Quality 3.1)
- PROCESS WATER IN FOOD INDUSTRY (Quality 3.2)
- REFRIGERATION TOWERS (Quality 3.3)



RECREATIONAL USE

- GOLF COURSES IRRIGATION (QUALITY 4.1)
- PONDS O WATER LAKES, WITHOUT HUMAN ACCES (Q 4.4)



ENVIRONMENTAL USE

- AQUIFERS RECHARGED BY INFILTRATION (Quality 5.1)
- AQUIFERS RECHARGED BY DIRECT INJECTION (Quality 5.2)
- IRRIGATION OF FOREST OR NON ACCESIBLE GREEN AREAS (5.3)





aqualia

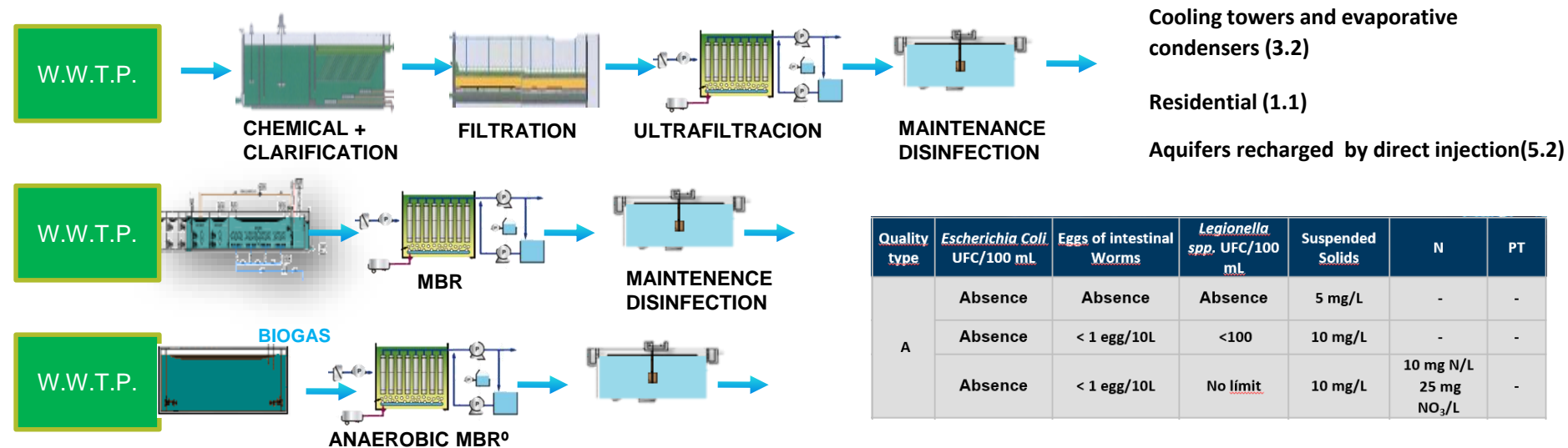
* Classification of uses of treated water according to Spanish regulation, R D 1620/2007

** 2014 Data from PWC study about Water management in Spain



USE	Quality type	<i>Escherichia Coli</i> UFC/100 mL	Eggs of intestinal Worms	<i>Legionella spp.</i> UFC/100 mL	Suspended Solids	 N	 PT
Cooling towers and evaporative condensers (3.2)	A	Absence	Absence	Absence	5 mg/L	-	-
Residential (1.1)		Absence	< 1 egg/10L	<100	10 mg/L	-	-
Aquifers recharged by direct injection(5.2)		Absence	< 1 egg/10L	No limit	10 mg/L	10 mg N/L 25mg NO ₃ /L	-
- Municipal services (1.2) - Agricult. irrigation with restrictions (2.1) - Golf courses Irrigation (4.1)	B	<100 – 200	< 1 egg/10L	<100	20 mg/L	-	-
- Agricultural Irrigation of products for fresh consumption. - Animal pasture irrigation. - Aquaculture (2.2) - Process water in food industry (3.1)	C	<1.000	< 1 egg/10L	No limit	35 mg/L	-	-
- Aquifers recharged by direct injection (5.1)		<1.000	No limit	No limit	35 mg/L	10 mg N/L 25 mg NO ₃ /L	-
- Woody crops, nurseries and industrial crops irrigation (2.3) - Water lakes without public access (4.2)	D	<10.000	< 1 egg/10L	<100	35 mg/L	-	-
						-	2 mg/L
- Forests and green areas not accessible to the public irrigation (5.3)	E	No limit	No limit	No limit	35 mg/L	-	-
- Environmental: wetlands maintenance, minimum flows(5.4)	F	To be determined in each case.					

A QUALITY: TREATMENT PROCESS



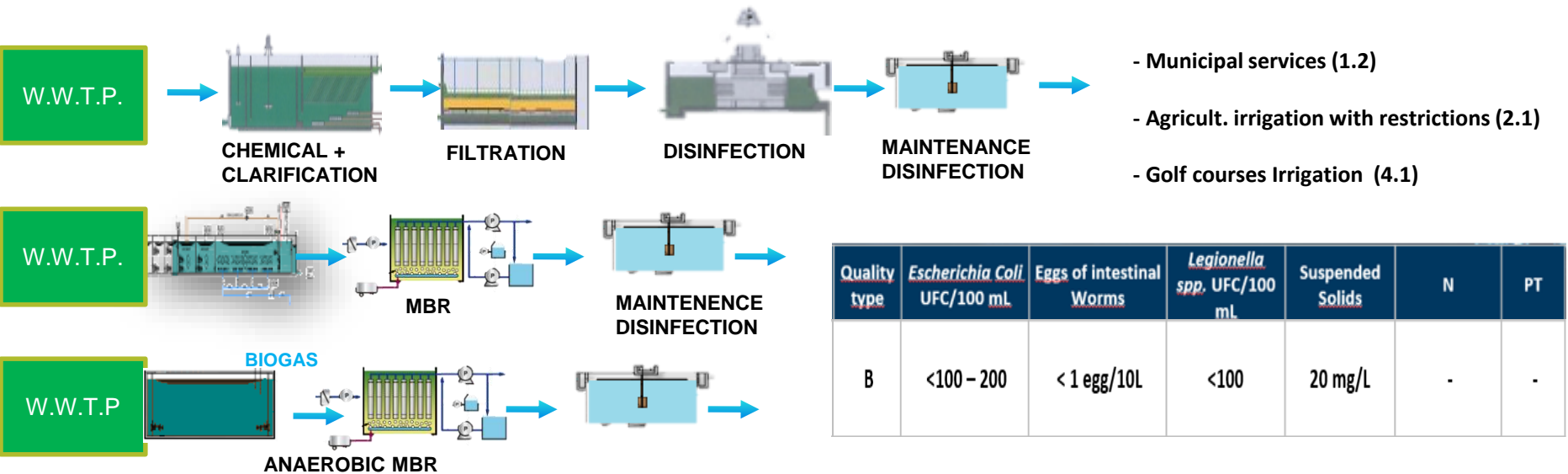
Due to the limits of *Escherichia coli*, a physical barrier for its retention is necessary => Ultrafiltration membranes.

If N removal is required, it should be done in the WWTP => Alternative MBR processes

The alternative AnMBR does not remove nutrients. It would be necessary to study if it is viable in case of residential use.

If salt removal is required, an alternative with reverse osmosis may be necessary

B QUALITY: TREATMENT PROCESS



- Municipal services (1.2)
- Agricult. irrigation with restrictions (2.1)
- Golf courses Irrigation (4.1)

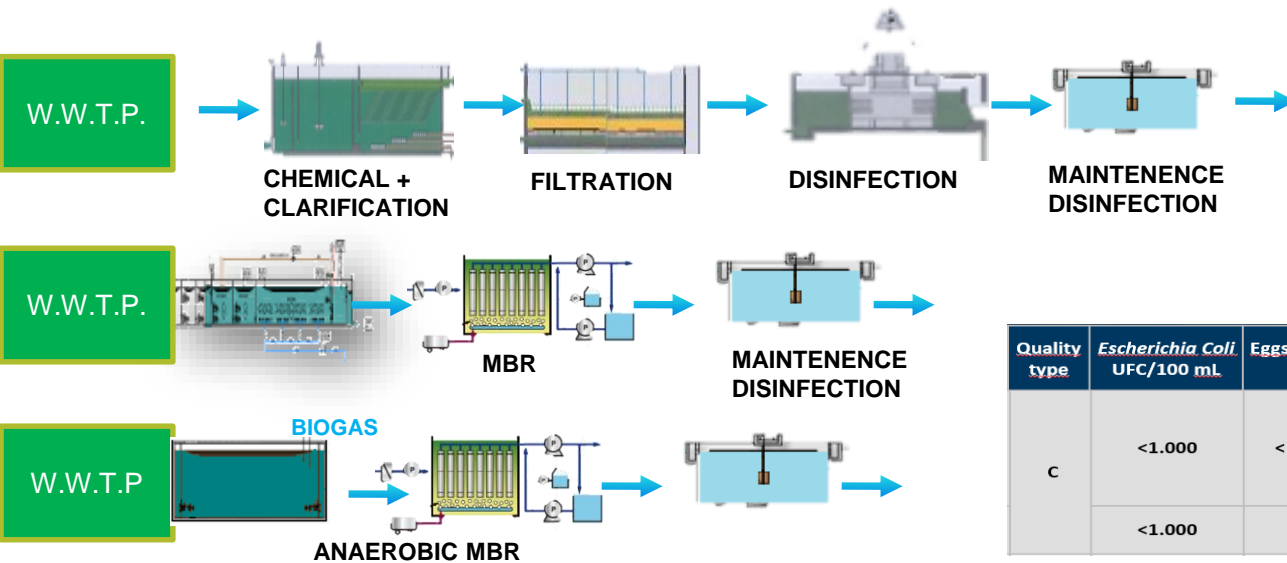
The physical barrier is no longer needed but a filtration system that ensures the intestinal worms eggs removal is required.

Although N removal is not necessary, the alternative with MBR can be interesting.

The alternative AnMBR is very interesting in the case of agricultural irrigation.

If salt removal is required, an alternative with reverse osmosis may be necessary

C QUALITY: TREATMENT PROCESS



- Agricultural Irrigation of products for fresh consumption.
- Animal pasture irrigation.
- Aquaculture (2.2)
- Process water in food industry (3.1)
- Aquifers recharged by direct injection (5.1)

Quality type	<i>Escherichia Coli</i> UFC/100 mL	Eggs of intestinal Worms	<i>Legionella spp.</i> UFC/100 mL	Suspended Solids	N	PT
C	<1.000	< 1 egg/10L	No limit	35 mg/L	-	-
	<1.000	No limit	No limit	35 mg/L	10 mg N/L 25 mg NO ₃ /L	-

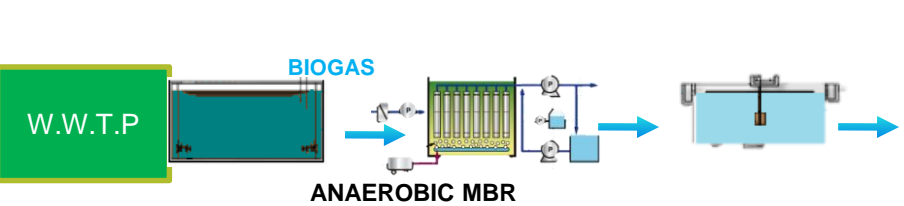
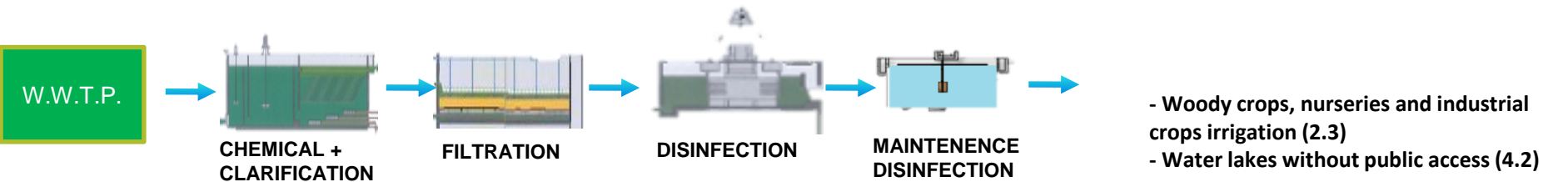
The physical barrier is no longer needed but the system must guarantee the correct disinfection

The alternative with only MBR will be interesting in some cases

The AnMBR alternative is very interesting in the case of reuse for agricultural irrigation.

If salt removal is required, an alternative with reverse osmosis may be necessary

D QUALITY: TREATMENT PROCESS



Quality type	<i>Escherichia Coli</i> UFC/100 mL	Eggs of intestinal Worms	<i>Legionella</i> spp. UFC/100 mL	Suspended Solids	N	PT
D	<10.000	< 1 egg/10L	<100	35 mg/L	-	-
					-	2 mg/L

The physical barrier is no longer needed but a filtration system that ensures the intestinal worms eggs removal is required .

MBR alternative is not interesting

AnMBR is interesting for a new WWTP and irrigation.

If salt removal is required, an alternative with reverse osmosis may be necessary

E QUALITY: TREATMENT PROCESS

W.W.T.P.

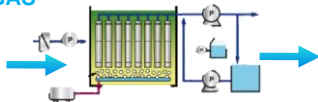


FILTRATION

- Irrigation of forest and green areas not accessible to the public (5.3)

W.W.T.P.

BIOGAS



ANAEROBIC MBR

Quality type	<i>Escherichia Coli</i> UFC/100 mL	Eggs of intestinal Worms	<i>Legionella</i> spp. UFC/100 mL	Suspended Solids	N	PT
E	No limit	No limit	No limit	35 mg/L	-	-

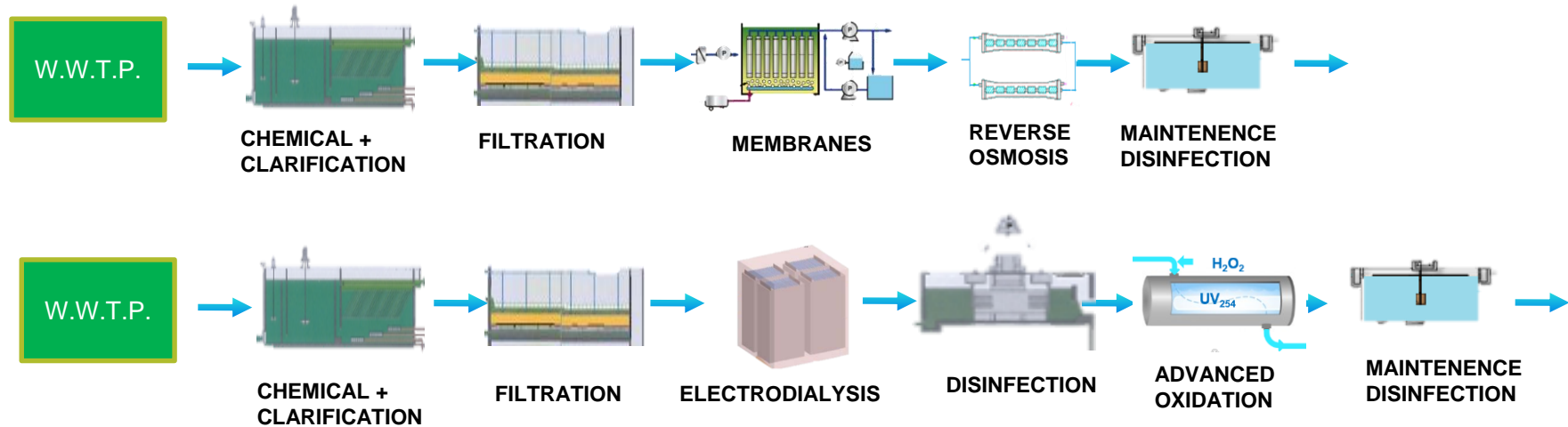
Depending on the WWTP outlet, no more treatment is required.

A filtration without disinfection is a good alternative to reduce solids

For new WWTP AnMBR is a good alternative.

If salt removal is required, an alternative with reverse osmosis or EDR may be necessary

QUALITY: TREATMENT PROCESS



USE & QUALITY SELECTION CONCLUSIONS

If absence of coliforms is required, the ideal process must include a barrier of ultrafiltration / reverse osmosis.

For intestinal worms eggs a filtration system of de 5 - 10 microns is required.

For effective disinfection, a filtration stage is recommended.

If N removal is required, it should be achieved in the WWTP. In this case the MBR process is a good alternative.

AnMBR process will become a very good alternative for irrigation in the future.

New regulations will imply the use of advanced oxidation for persistent organic pollutants removal.

Under the Patronage of the Minister of Environment Water & Agriculture
Eng. Abdulrahman bin Abdulmohsen Al Fadhili

منتدى المياه السعودي
saudi water forum SWF



"Sustainable Water.. for Sustainable Development"

وزارة البيئة والمياه والزراعة
Ministry of Environment Water & Agriculture
المملكة العربية السعودية Kingdom of Saudi Arabia



رؤية
2030
المملكة العربية السعودية
KINGDOM OF SAUDI ARABIA

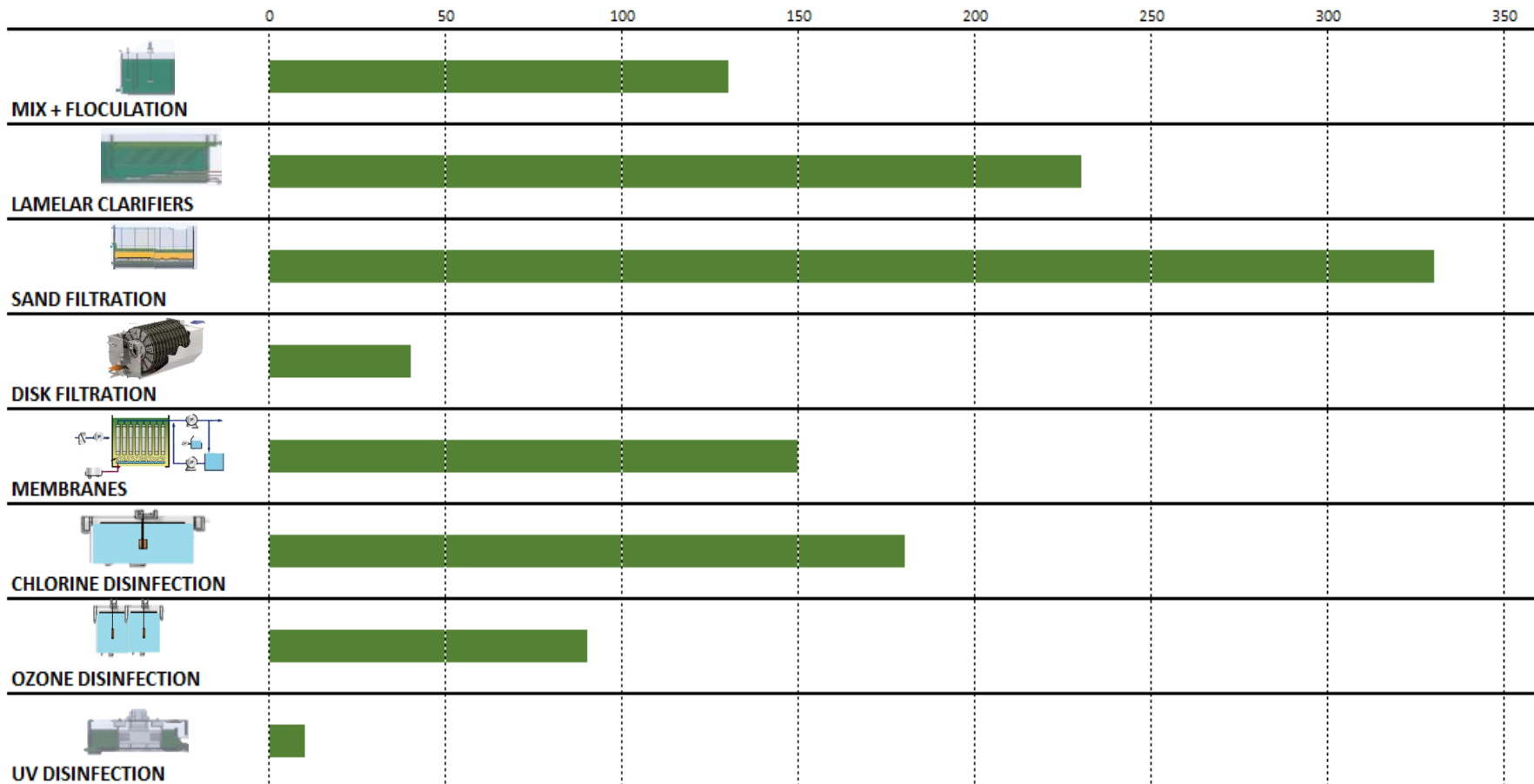
swforum.sa



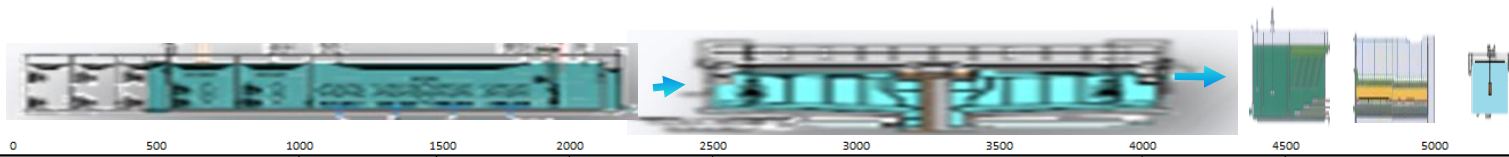
/SaudiWaterForum

3 .- SELECTION BASED ON THE REQUIRED AREA

AREA REQUIRED FOR DIFFERENT PROCESS m² / 1000 m³/h



AREA REQUIRED FOR CONVENTIONAL / MBR PROCESS



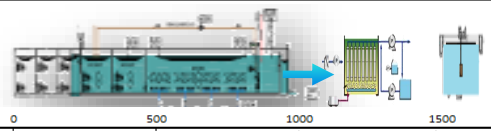
BIOLOGICO TREATMENT

SECONDARY CLARIFIERS

MIX FLOCULATION CLARIF.

SAND FILTRATION

CHLORINE DISINFECTION



BIOLOGICO TREATMENT

MEMBRANES

DISINFECTION (IF REQUIRED)

Under the Patronage of the Minister of Environment Water & Agriculture
Eng. Abdulrahman bin Abdulmohsen Al Fadhili

منتدى المياه السعودي
saudi water forum SWF



"Sustainable Water.. for Sustainable Development"

وزارة البيئة والمياه والزراعة
Ministry of Environment Water & Agriculture
Kingdom of Saudi Arabia المملكة العربية السعودية



رؤية
VISION
2030
المملكة العربية السعودية
KINGDOM OF SAUDI ARABIA

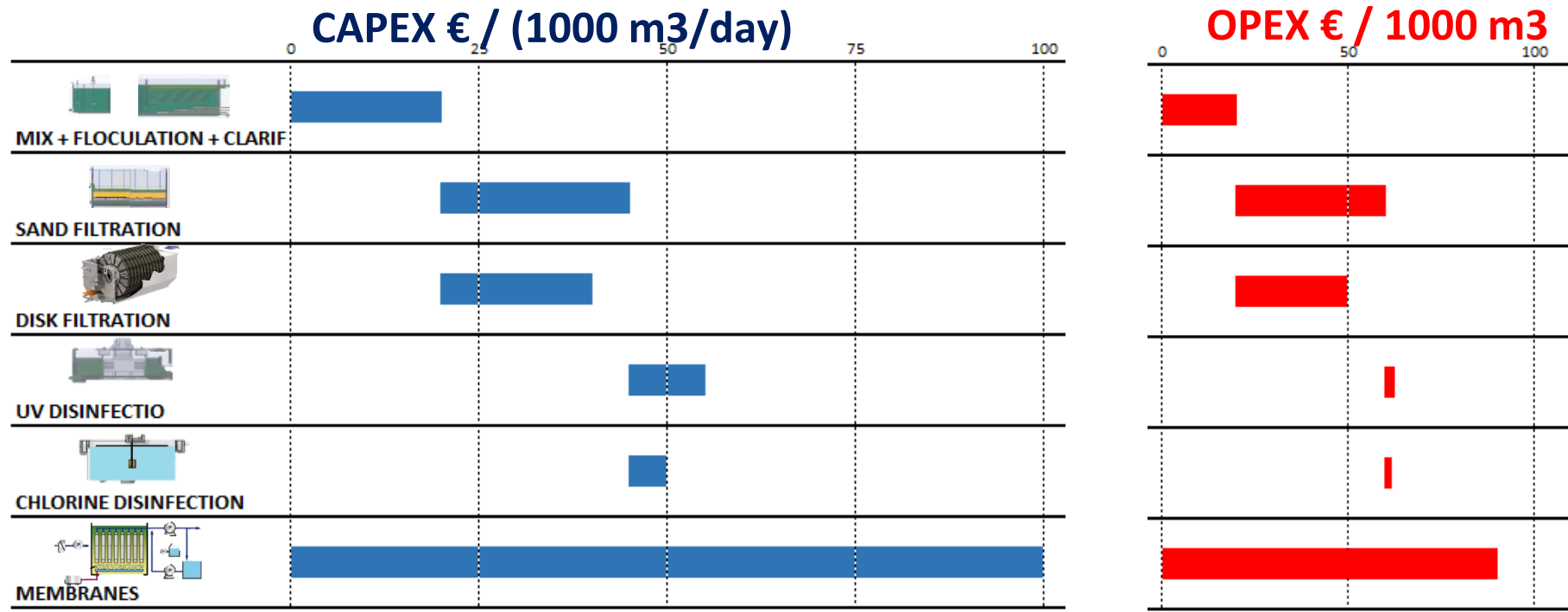
swforum.sa



/SaudiWaterForum

4 .- SELECTION BASED ON CAPEX & OPEX

SELECTION BASED ON OPEX & CAPEX

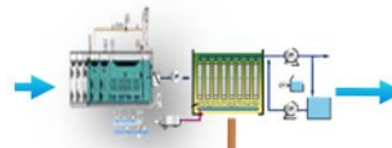


The figures included are estimations, they depend on the plant size, energy costs, labor costs,...
They are valid for the comparison between process.

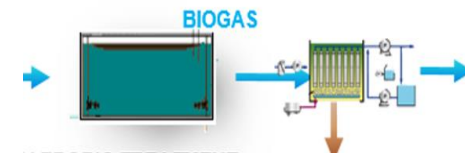
SELECTION BASED ON OPEX & CAPEX



CONVENTIONAL WWTP TERTIARY TREATMENT



MBR



ANAEROBIC MBR

CONSTRUCTION COSTS

10 % HIGHER

SIMILAR TO CONVENTIONAL

OPERATION COSTS

10 % HIGHER

**30 % LOWER THAN
CONVENTIONAL**

Under the Patronage of the Minister of Environment Water & Agriculture
Eng. Abdulrahman bin Abdulmohsen Al Fadhili

منتدى المياه السعودي
saudi water forum SWF



"Sustainable Water.. for Sustainable Development"

وزارة البيئة والمياه والزراعة
Ministry of Environment Water & Agriculture
Kingdom of Saudi Arabia المملكة العربية السعودية



رؤية
VISION
2030
المملكة العربية السعودية
KINGDOM OF SAUDI ARABIA

swforum.sa

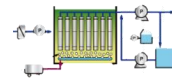
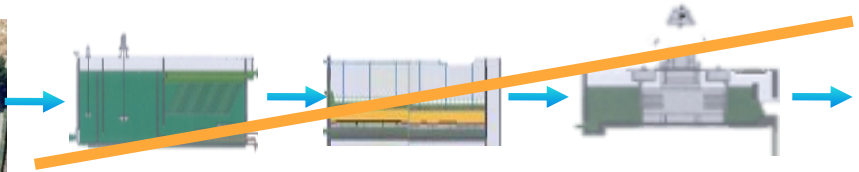


/SaudiWaterForum

5 .- TECHNOLOGY SELECTION EXAMPLES

WATER TREATMENT IN AVILA WWTP

- There was an existing WWTP with 30,000 m³/day capacity which removes S.S. and BOD₅ up to 35 and 25 mg/l
- The treated water is sent to a dam from where different towns in the area take the drinking water (indirect reuse)
- High quality requirements, in S.S. and total coliforms
- N and P Removal (10 mg/l and 1 mg/l)



MBR PROCESS



WATER TREATMENT IN AVILA WWTP



A conventional regeneration treatment would allow the S.S. and biological contamination removal.

N removal meant triple the volume of biological treatment. It would not fit in the existing area.

The solution with MBR allows to include the treatment in the existing area.

A new pre-treatment, and primary lamellar treatment is included.





WWTP AND TERTIARY TREATMENT IN ILLESCAS

Estate with villas and apartments of new construction and golf course in Illescas (Toledo)

It requires a WWTP for 5,000 inhabitants

Treated water will be used for irrigation of golf course

Possible solution:

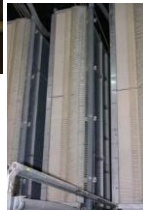
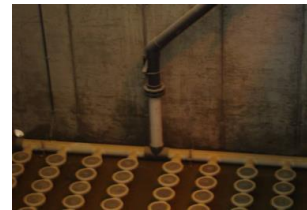
WWTP with conventional regeneration

It would generate odour and noise problems

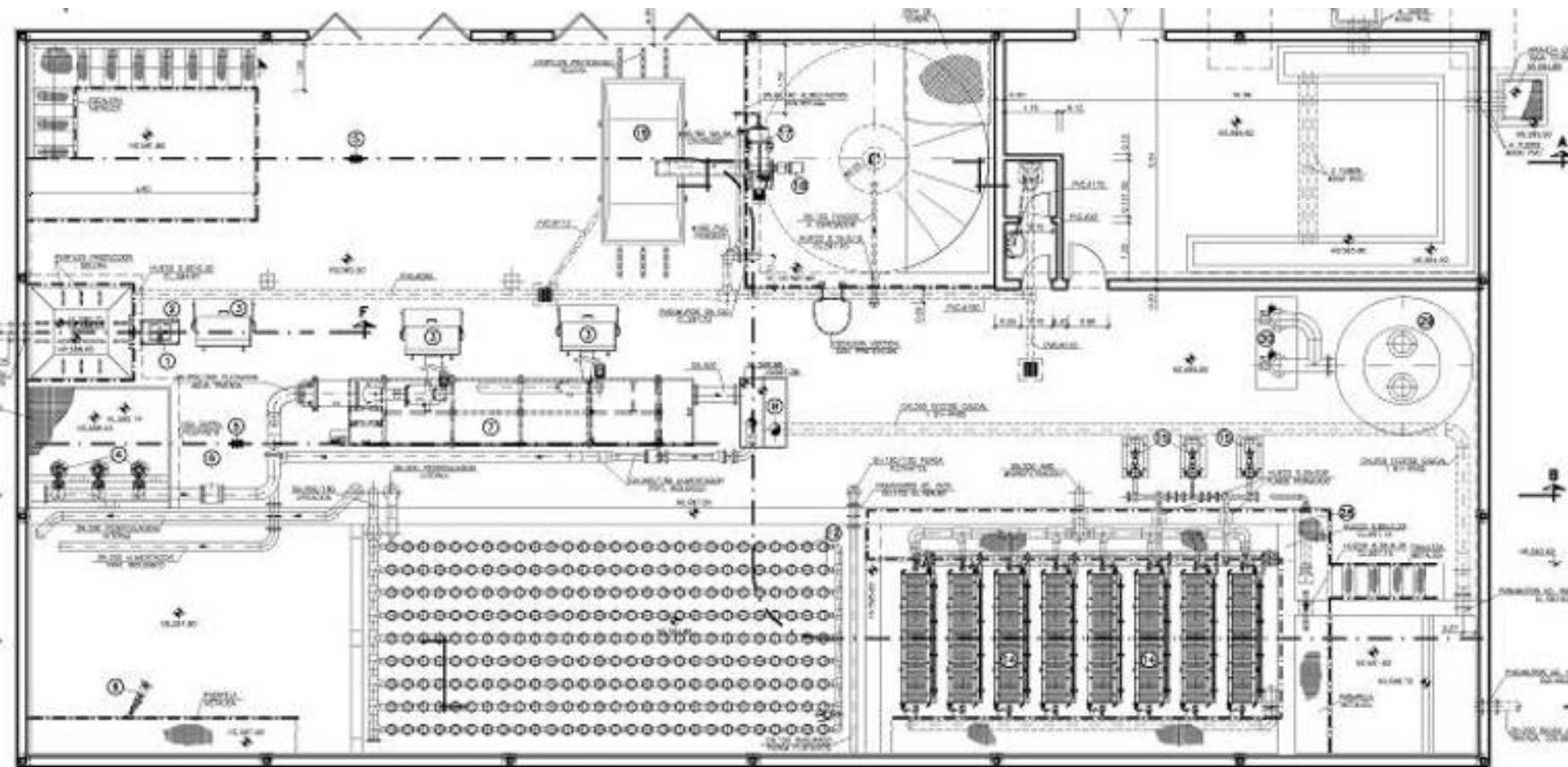
Solution: Compact WWTP with MBR inside a building.



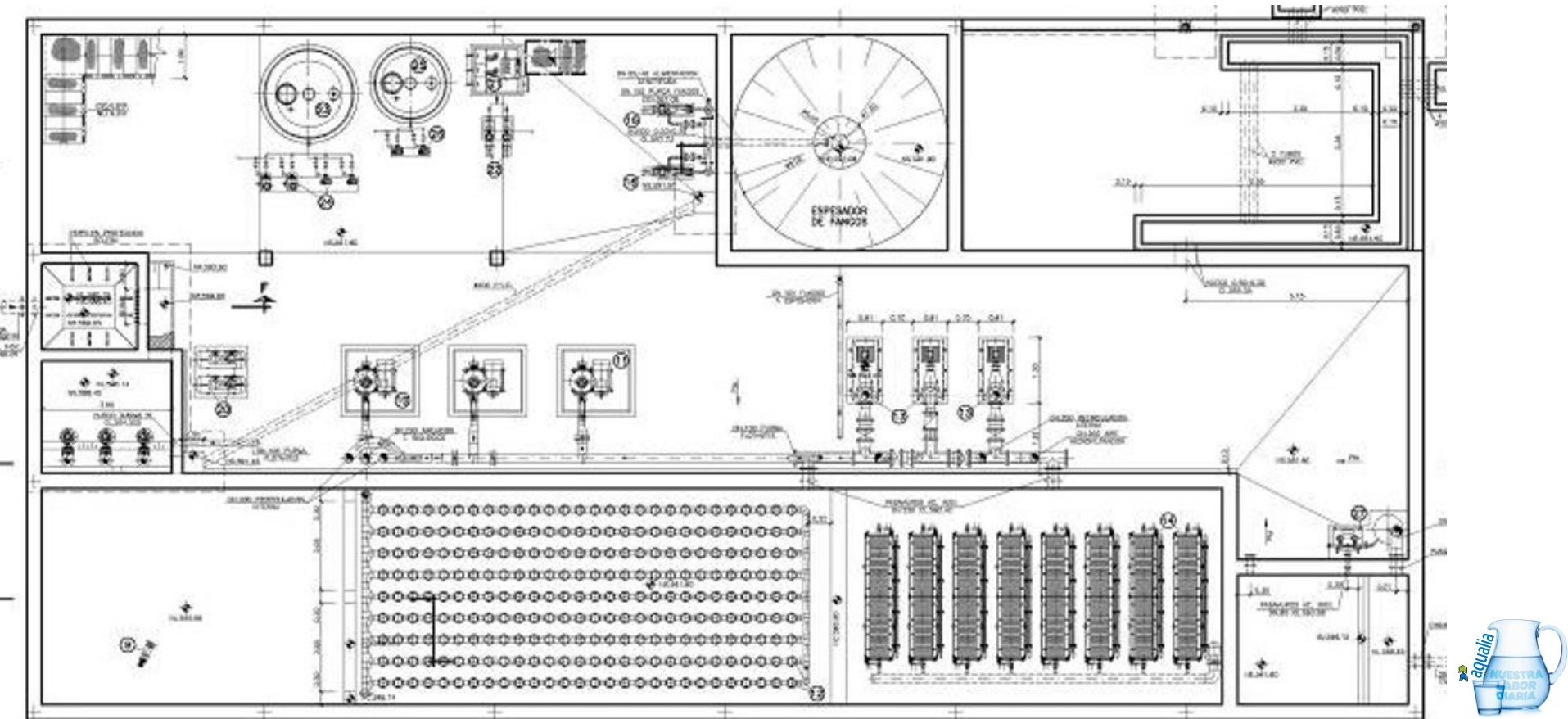
WWTP AND TERTIARY TREATMENT IN ILLESCAS



WWTP AND TERTIARY TREATMENT IN ILLESCAS



WWTP AND TERTIARY TREATMENT IN ILLESCAS



MARKS



Required quality: S.S. < 10 mg/l;

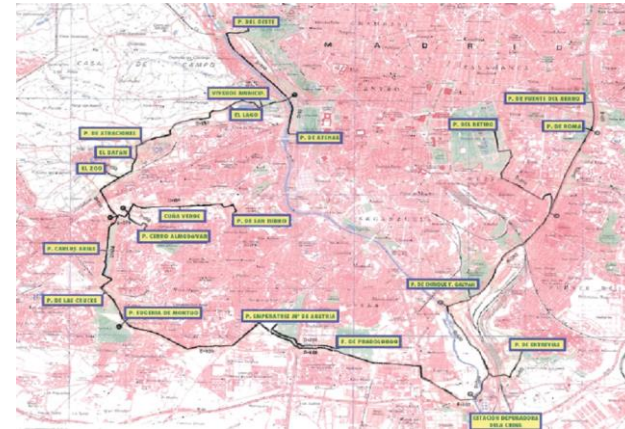
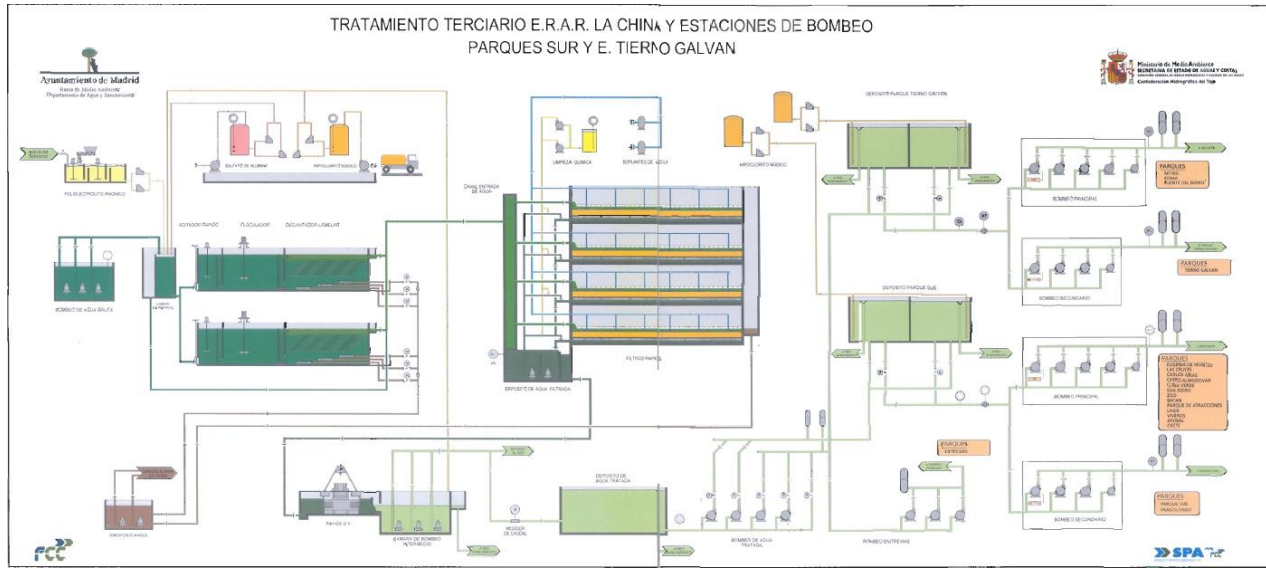
Required quality:

S.S. < 10 mg/l;

Faecal coliforms < 10 NMP/100 ml

Irrigation area 295 Ha. Production 25,500 m³/day

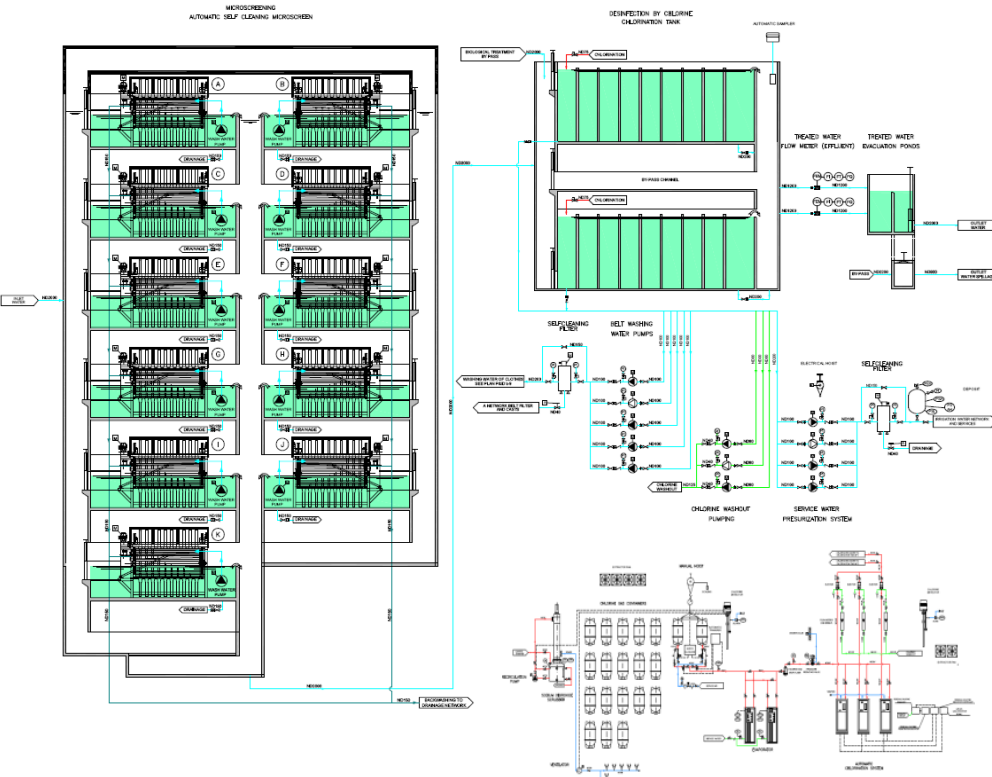
There is enough space, no requirements for nutrient removal. Selection of a conventional solution



WATER TREATMENT IN MADRID FOR IRRIGATION OF PARKS



NEW CAIRO WWTP



Flow: 250,000 m³/day

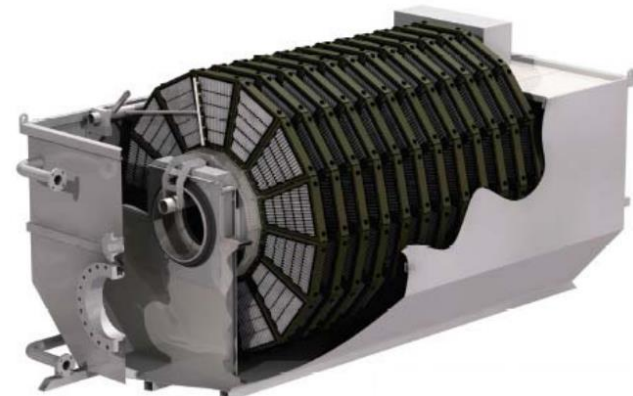
Required quality:

S.S. < 10 mg/l;

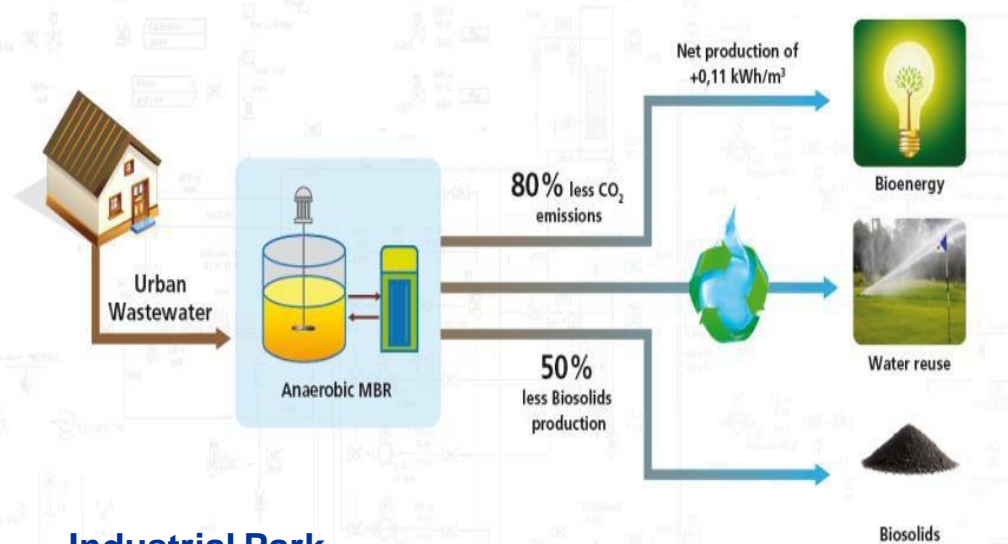
Faecal coliforms < 200 NMP/100 ml

Eggs of intestinal Worms < 1 / l

A conventional solution with disk filters and chlorine disinfection is selected



ANAEROBIC MBR EXPERIENCES



**Industrial Park
Nigrán (Vigo)**

BW – 3 m³/d



**WWTP SANTA ROSA
(BITEM) 18 m³/d**



RESEARCH REQUIREMENTS

- ❑ **Optimization of the filtration process:**
minimize fouling (fouling)
- ❑ **wastewater from low load to low temperature**
low growth rate
- ❑ **methane dissolved in the effluent**
- ❑ **reduction of sulphate to sulphide**
Corrosion of equipment and pipelines...
Quality and quantity of biogas

ALCAZAR DE SAN JUAN

40 M³/DIGESTER 123 M² FILTRATION AREA



Under the Patronage of the Minister of Environment Water & Agriculture
Eng. Abdulrahman bin Abdulmohsen Al Fadhili

منتدى المياه السعودي
saudi water forum SWF



"Sustainable Water.. for Sustainable Development"

وزارة البيئة والمياه والزراعة
Ministry of Environment Water & Agriculture
Kingdom of Saudi Arabia المملكة العربية السعودية



رؤية
VISION
2030
المملكة العربية السعودية
KINGDOM OF SAUDI ARABIA

swforum.sa



/SaudiWaterForum

THANKS FOR YOUR ATENTION