Hybrid percolation system for treatment of agrifood SMEs wastewaters

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An understanding of the nature of wastewater is fundamental for the design of appropriate wastewater treatment plants and the selection of effective treatment technologies.

Wastewater characteristics from agrifood industry

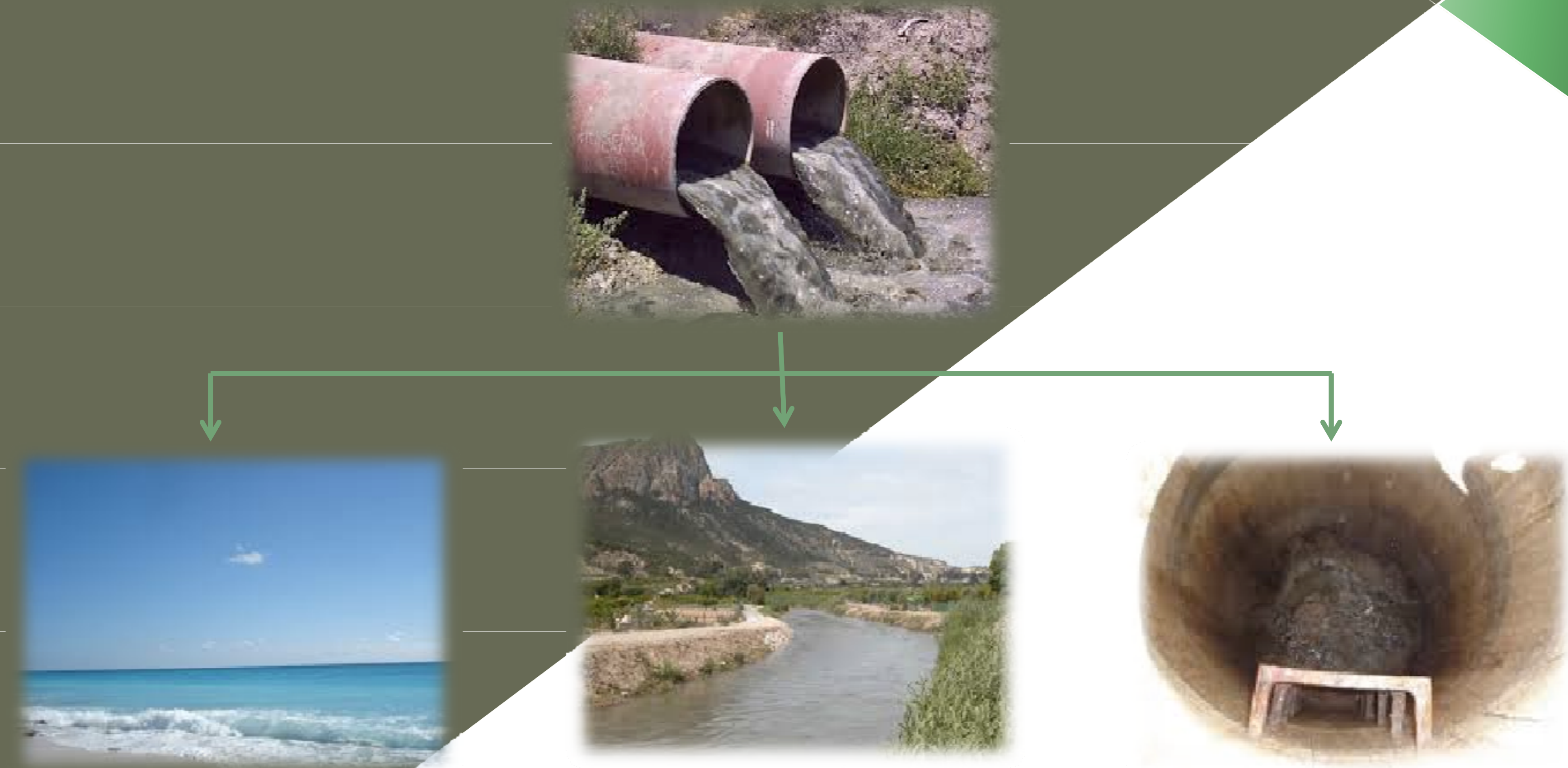
- High volume
- High organic load (biodegradable)
- High total suspended solids concentration
- Sometimes extreme pHs
- Sometimes high conductivity (brines)
- Absence of toxic compounds

The characteristics of the wastewater generated differ quite significantly depending on the raw material processed, both in volume and pollutant load.

A common characteristic in this type of industry, mainly in small companies, is that throughout the year production stops occur and therefore the generation of wastewater also stops. This is due to the different campaigns, prices of raw materials, season of the year.

Wastewater treatment involves the application of a sequence of basic operations. The number of operations depends on:

- The desired level of treatment
- The characteristics of the wastewater to be treated
- The cost of facilities



Decree 16/1999

Annex III

Parameter	Value
pH (interval)	5.5 – 9.5
Conductivity	5000 µS/cm
Total suspended solids	500 mg/L
Greases and oils	100 mg/L
BOD_5	650 mg/L
COD	1100 mg/L
TKN	50 mg/L

Quality groups Segura River Bassin

(RD 1664/1998; RD 594/2014)

PARAMETER	LIMIT VALUE ACCORDING TO QUALITY GROUP		
	FIRST	SECOND	THIRD
pH	6.5 - 7.5	6.0 – 8.5	5.5 – 9.0
Dissolved O_2(mg/L)	>5	>3	>1
Conductivity (µS/cm)	<500	<750	<1000
Total suspended solids (mg/L)	<30	<70	<120
COD (mg O_2/L)	<80	<120	<300
BOD_5 (mg O_2/L)	<15	<30	<60
Ammonium (mg NH_4^+/L)	<0.5	<1	<1
Total P(mg P_2O_5/L)	<5	<10	<20
Nitrates (mg NO_3^-/L)	<100	<200	<300

PRETREATMENT

Objective

Removal of large solids, grit and grease

Basic operations

- Screening
- Sieving
- Degritting
- Degreasing

Physical processes

PRIMARY TREATMENT

Objective

Removal of setteable and floatable materials

Basic operations

- Primary sedimentation
- Flotation
- Coagulation-flocculacion

Physical and chemical processes

SECONDARY TREATMENT

Objective

Removal of dissolved and colloidal organic matter

Basic processes

- Bacterial degradation
- Secondary sedimentation

Biological processes

TERTIARY TREATMENT

Objective

Removal of suspended, colloidal, and dissolved constituents remaining after conventional secondary treatments

Basic processes

- Filtration
- Coagulation-flocculacion
- N and P removal
- Disinfection

Physical, chemical and biological processes

Biological treatments

Biological processes used for wastewater treatment may be classified under four major headings:

- Aerobic
- Anaerobic
- Anoxic
- Combined processes

These processes are further subdivided, depending on whether the treatment takes place in a suspended-growth system an attached-growth system or a combination of both. The most commonly used biological processes are activated sludge process, trickling filters and rotating biological contactors.

APLICATIONS

- Removal of carbonous organic matter
- Nitrification
- Denitrification
- Phosphorus removal
- Sludge stabilization

Aerobic processes	
Suspended growth	Activated sludge: • Conventional (plug-flow) • Complete-mix • Graduated aeration • Step feed • Extended aeration • Oxidation ditch • High-rate aeration • Pure oxygen • Membrane Bioreactor (MBR) • Sequential Batch Reactor (SBR)
Attached growth	• Trickling filters • Rotating biological contactors
Combined processes	• Activated biofilters

Anaerobic processes	
Suspended growth	• Complete-mix • Anaerobic contact • Anaerobic Sequential Batch Reactor (ASBR) • Upflow anaerobic sluge blanket (UASB) • Anaerobic Membrane Bioreactor (MBR)
Attached growth	• Anaerobic Filter (AF) • Expanded-bed • Fluidized-bed • Downflow Stationary Fixed Film (DSFF)

Biological processes comparison	
Aerobic process	**Anaerobic process**
• Higher performance depuration • Well known process • Needs oxygen supply • Can not treat high organic loads • Great unstabilized sludge production • Allows simultaneous nitrification	• Small production of sludge • Low operating costs • Energetically usable byproducts • Can treat high organic and hydraulic loads • Needs little nutrients • Slow and delicate startup • Post-treatment necessary

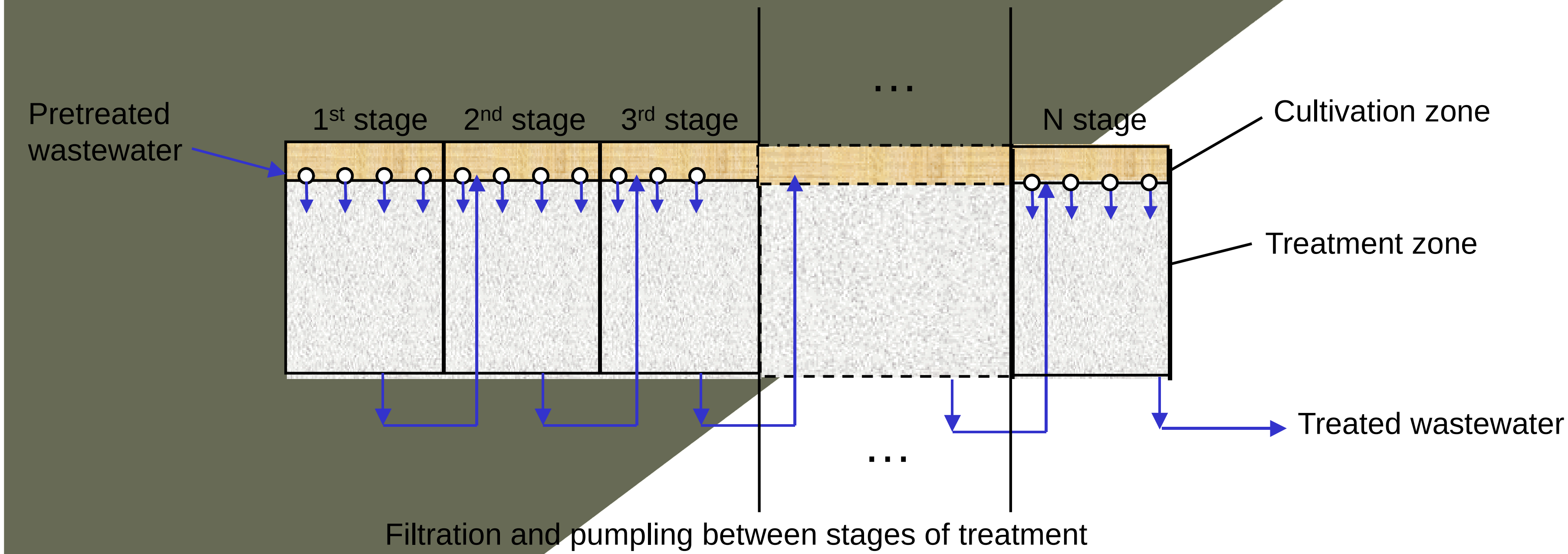
THICKENING	ESTABILIZATION	CONDITIONING	DEWATERING
Objective To increase the solid content of the sludge	**Objective** To reduce biodegradable fraction of sludge	**Objective** To enhance sludge dewatering characteristics	**Objective** To reduce the moisture content of the sludge
Basic operations - Gravity settling - Flotetion thickening - Centrifugation - Rotary drums	**Basic processes** - Biological stabilization - Chemical stabilization - Thermal stabilization	**Basic processes** - Thermal conditioning - Chemical conditionig - Elutriation	**Basic processes** - Mechanical dewatering - Thermal dewatering - Drying beds
Physical processes	**Physical, chemical and biological processes**	**Physical and chemical processes**	**Physical processes**

Conventional treatment (disadvantages)

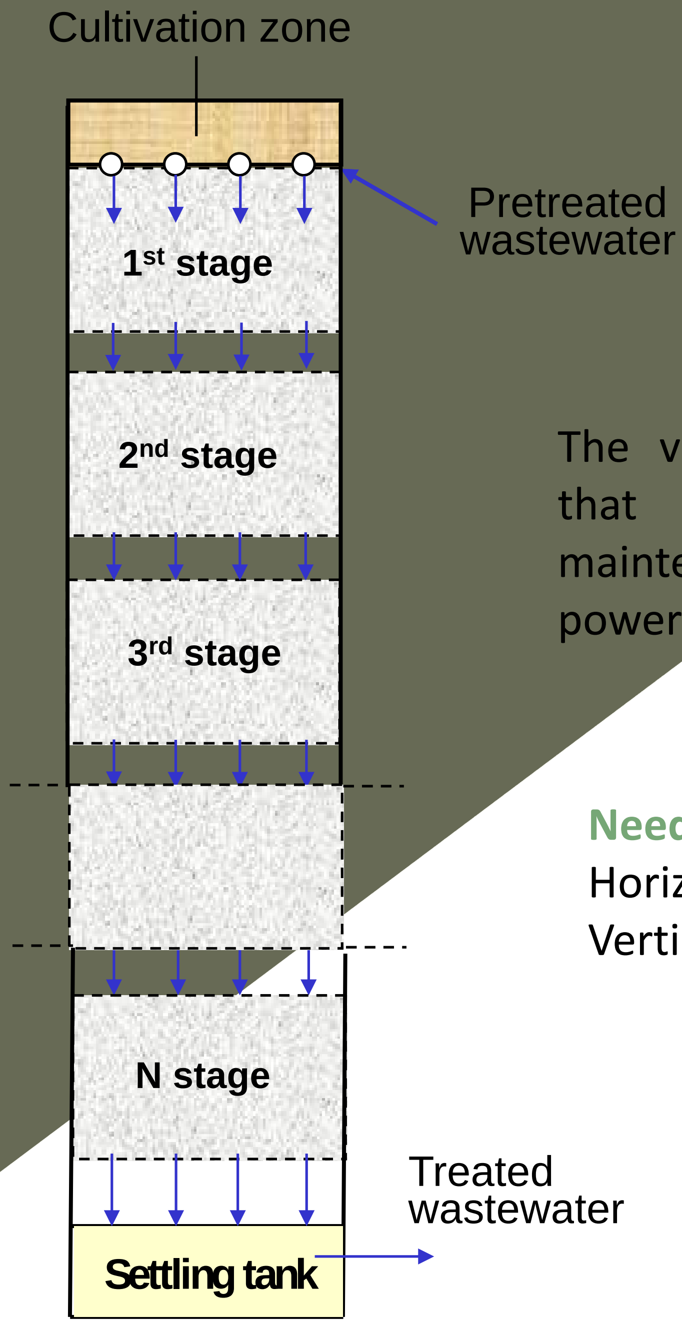
- High cost of construction and maintenance
- Operational difficulties due to fluctuations in wastewater flow rate and pollution loads
- High energy consumption
- Slow start up after a stopping

Non-conventional technologies

- Minimum or null energy cost
- Simple operational and maintenance procedures
- High efficiency
- High level of inertia when faced with large fluctuations in the flow and the effluent load to be treated
- Less sludge production



Hybrid percolation system
(horizontal distribution)



The vertical distribution has the advantage that presents lower construction and maintenance cost as well as lower surface and power requirements.

Needs of surface:

Horizontal distribution: 0.1 m^2/p.e. (each stage)

Vertical distribution: 0.1 m^2/p.e.

Hybrid percolation system

(vertical distribution)

BENEFITS OF THE TECHNOLOGY

- ✓ Fast construction increasing the returns on the investment
- ✓ No chemical additives are required for its optimal performance
- ✓ Less surface area required for installation than non conventional wastewater treatment
- ✓ Good quality of the treated effluent and high resistance to hydraulic and load shock
- ✓ Low energy consumption
- ✓ High versatility
- ✓ The system can be adapted to suit the requirements of any type of client, blending in perfectly with the surrounding area, either industrial or residential
- ✓ Possibility of non-stop use, even though it allows stoppage without producing a significant decrease in its performance when the process is restarted
- ✓ Reduced maintenance
- ✓ Lack of bad odours
- ✓ Minimum level of generation of sludge.

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(horizontal distribution)

Maximum treatment capacity: 500 m^3/d

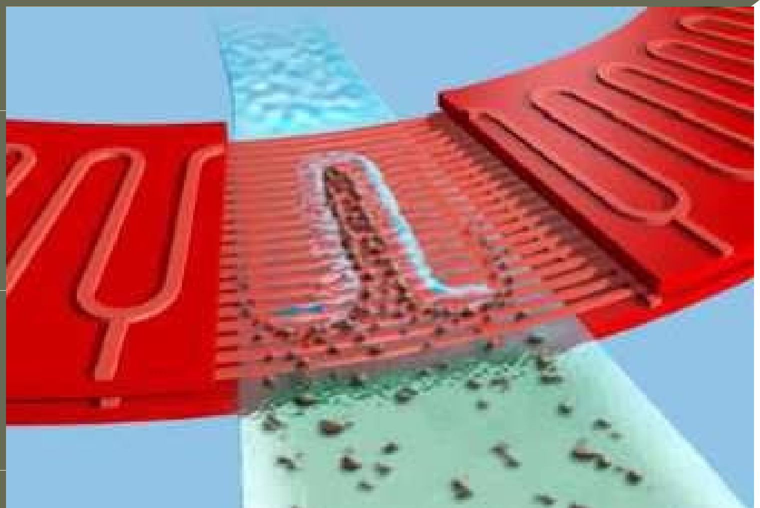
Average flow: 36 m^3/h

Monday to friday (10 h/d) ≈ 360 m^3/d

Weekends ≈ 200 m^3/d

125 μm

75 μm



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(horizontal distribution)

Four stages of treatment
Surface: 205 m^2/stage (14.85 m x 13.8 m)
Gravel bed depth: 1 m
100 drip lines with 93 drippers each one

Drip lines

Top view of the biological treatment

Side of the biological treatment and channel for collecting the treated water

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(horizontal distribution)

Physical-chemical characterization of raw wastewater and effluent

Parameter	Raw wastewater	Effluent	91/271/EEC Directive
pH	7.20-8.67 (8.12)	6.7-7.4 (7.1)	
Conductivity (mS/cm)	1.84-3.81(2.57)	2.1-3.5 (2.8)	
DO (mg O_2/L)	0.23-5.42 (2.28)	2.3-8.6 (5.9)	
TSS (mg/L)	126-617 (312)	2.4-39 (16)	35
COD (mg O_2/L)	272-938 (630)	12-41.6 (28.3)	125
BOD_5 (mg O_2/L)	130-540 (341)	1-10 (5.3)	25
TKN (mg N/L)	30.9-120 (78)	0-28 (5.7)	
NH_4^+-N (mg N/L)	28.2-98.0 (68)	0-27.8 (5.0)	
TP (mg P/L)	3.2-25.3 (10.9)	2.6-7.5 (4.8)	
PO_4^{3-} (mg P/L)	1.8-12.8 (5.4)	2.6-6.2 (4.5)	
Nitrates (mg N/L)	0-1.6 (0.08)	5.7-67.6 (35.5)	
Nitrites (mg N/L)	0-3.4 (0.34)	0-0.5 (0.03)	

Average removal efficiencies: COD 83%, BOD_5 88%, TSS 88%, TKN 93%, TP 34%.

BP OMEGA GAS STATION
(horizontal distribution)

Average flow: 40 m^3/d

130 μm

BP OMEGA GAS STATION

(horizontal distribution)

Four stages of treatment
Surface: 21 m^2/stage
Gravel bed depth: 1 m
Sand: 30 cm
15 drip lines with 16 drippers each one/stage

91/271/EEC Directive
Decree 16/1999

Removal efficiencies:
- COD > 88 %
- BOD_5 > 98.9 %
- TSS > 80 %

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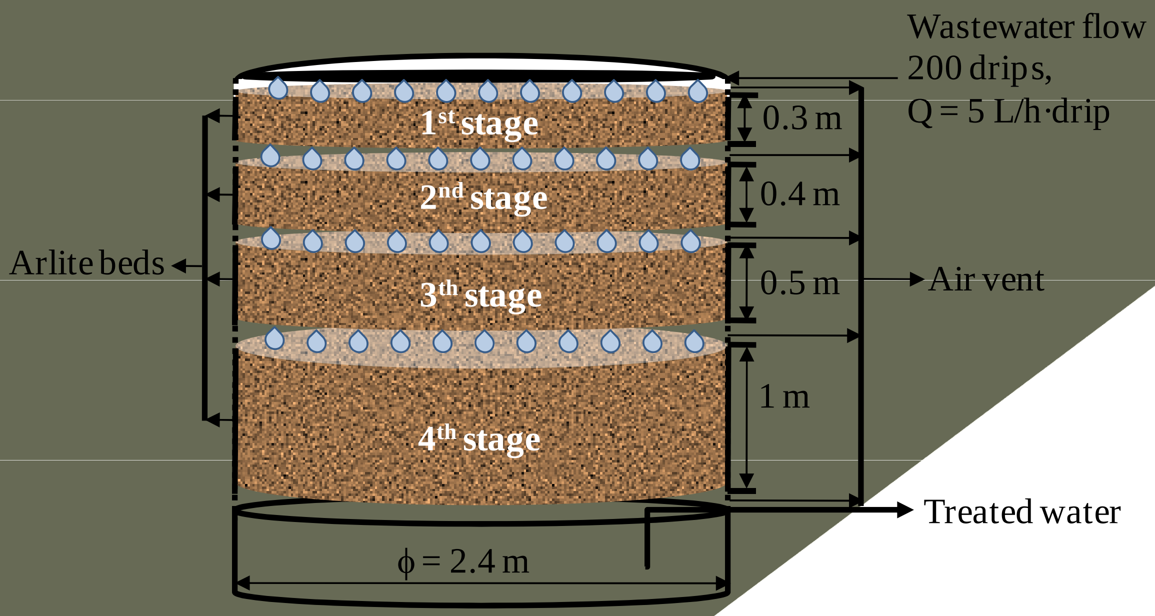
(vertical distribution)



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(vertical distribution)

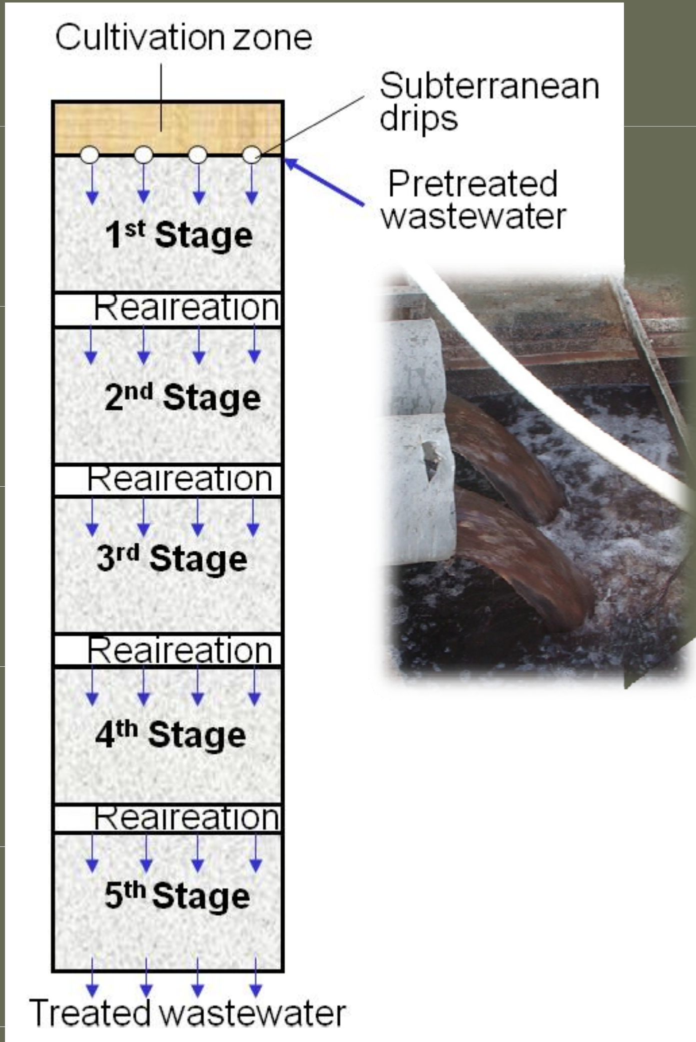
Parameter	Influent	Effluent	91/271/EEC Directive
pH	7.13 - 7.69 (7.52)	6.60 - 7.25 (6.90)	
Conductivity (mS/cm)	1.26 - 3.35 (2.67)	1.90 - 2.97 (2.38)	
DO (mg O_2/L)	0.78 - 5.54 (1.90)	6.29 - 8.16 (7.14)	
TSS (mg/L)	76 - 258 (135)	11.5 – 34.5 (17.2)	35
COD (mg O_2/L)	214 – 710 (419)	22 – 57 (42)	125
BOD_5 (mg O_2/L)	130 - 490 (274)	2 - 9 (6)	25
TKN (mg N/L)	26.4 – 122.8 (88.1)	0.52 -9.84 (5.75)	
NH_4^+-N (mg N/L)	23.1 – 106.7 (77.6)	0.27 – 8.87 (5.08)	
Nitrates (mg N/L)	0 - 2.11 (0.83)	30.03 – 44.28 (35.91)	
TP (mg P/L)	4.2 – 11.1 (7.8)	5.1 – 9.3 (7.0)	
PO_4^{3-} (mg P/L)	2.6 – 6.2 (4.7)	4.6 – 7.0 (5.6)	

Average removal efficiencies: COD 89 %, BOD_5 97.5 %, TSS 85.9 %, TKN 92.9 %

Construction, operation and maintenance costs of the most widely used technologies for wastewater treatment (MARM, 2011) and the presented technology

Technology	Construction costs (€/person)	Operation and maintenance costs (€/person.year)
WSPS	250 - 800	8 - 34
Constructed wetlands	250 - 450	18 - 48
Rotating biological contactors	340 - 490	16 - 24
Trickling filters	200 - 700	17 - 25
Activated sludge	100 - 300	22 - 34
Hybrid percolation system	100 - 250	10 - 20

APPLICATION TO CANNERY WASTES TREATMENT



Pilot WWTP COLUMBIA FRUITS

(Marín Giménez, Moratalla)

5 drip lines
4 drippers each line
4 L/h each dripper
Total flow: 80 L/h

5 stages of treatment
Surface: 1 m^2 aprox
Depth of each stage: 50 cm
Cultivation zone: 20 cm

Ring filter: 100 μm

Filtering material: arlite (expanded clay pellets)

Effluent from peach and pear processing

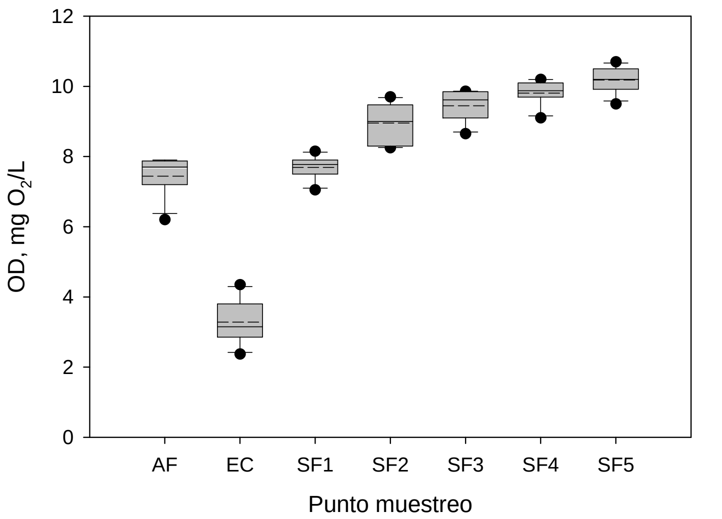
Parameter	Raw wastewater
pH	6.81- 8.65
Conductivity (μS/cm)	1402 - 2160
COD (mg O_2/L)	4475 – 5235
BOD_5 (mg O_2/L)	2900 - 3450
TSS (mg/L)	350 – 630

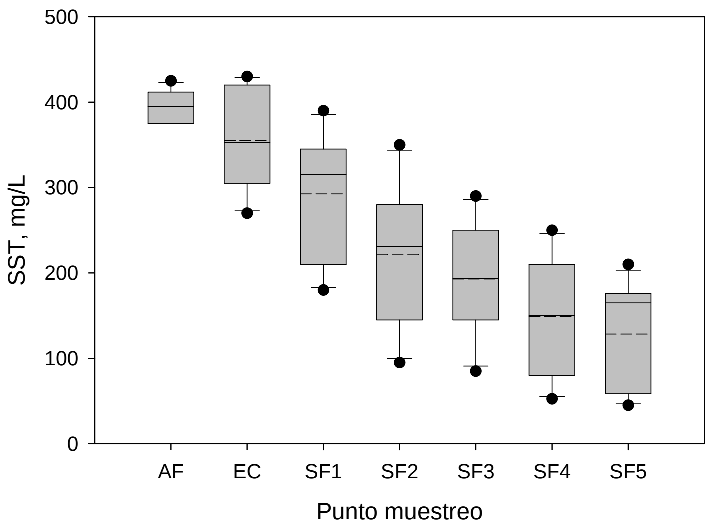
Pretreatment

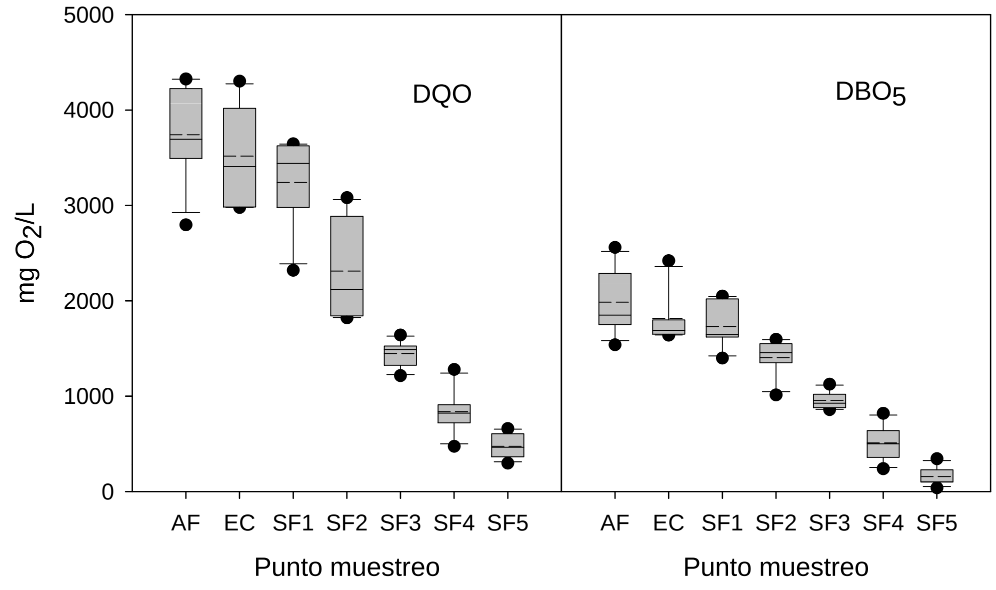
- Grid to remove large solids
- Rotary sieve 0.8 mm mesh size
- Flotation with flocculant addition
- Equalization tank
- pH adjust with phosphoric acid.

Pretreatment removal efficiencies

- COD, 15% - 30%
- BOD_5, 15% - 35%
- TSS, 10% - 30%
- No significative changes in conductivity
- pH decrease due to the addition of phosphoric acid


OD, mg O_2/L
12
10
8
6
4
2
0
AF
EC
SF1
SF2
SF3
SF4
SF5
Punto muestreo


SST, mg/L
500
400
300
200
100
0
AF
EC
SF1
SF2
SF3
SF4
SF5
Punto muestreo


mg O_2/L
5000
4000
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SF4
SF5
Punto muestreo
AF
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SF1
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SF3
SF4
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Punto muestreo

Characteristics of influent and effluent and removal efficiencies

Parameter	Influent	Effluent	Removal, %	Decree 16/1999
pH	4.76 – 7.80	7.71 – 8.97		5.5 – 9.5
Conductivity (μS/cm)	1002 – 1579	1069 - 1800		5000
COD (mg O_2/L)	2978 - 4302	298 - 660	77.8 – 92.6	1100
BOD_5 (mg O_2/L)	1639 – 2420	40 – 343	79.1 – 94.4	650
TSS (mg/L)	270 – 430	45 – 210	45.9 – 87.5	500
TKN (mg N/L)	18.7 – 33.0	7.0 – 15.3	31.4 – 62.6	50
TP (mg/L)	71.7 – 97.9	25.4 – 34.6	61.6 – 64.7	

Contrato para actividades de apoyo tecnológico y/o asesoría entre la Universidad de Murcia y el Centro Tecnológico Nacional de la Conserva y Alimentación titulado "*Desarrollo de una alternativa de depuración biológica aplicable a las PYMES del sector de conservas vegetales" 2008.*

Pilot WWTP HALCON FOODS
(Campos del Río, Murcia)

5 drip lines
4 drippers each line
4 L/h each dripper
Total flow: 80 L/h

6 stages of treatment
Surface: 1 m^2 aprox
Depth of each stage: 50 cm
Cultivation zone: 20 cm

Ring filter: 100 μm

Filtering material: arlite (expanded clay pellets)

Effluent from artichoke processing

Pretreatment

- Rotary sieve 0.5 mm mesh size

Characteristics of influent and effluent and removal efficiencies

Parameter	Influent	Effluent	Removal, %	Decree 16/1999
pH	3.87 – 4.95	4.92 – 7.48		5.5 – 9.5
Conductivity (μS/cm)	1119 – 3500	1053 - 3740		5000
COD (mg O_2/L)	3185 - 8100	1450 - 2352	53.3 – 80.2	1100
BOD_5 (mg O_2/L)	2100 – 4300	680 – 1823	44.0 – 83.7	650
TSS (mg/L)	478 – 765	140 – 344	45.8 – 79.1	500
TKN (mg N/L)	92.0 – 126.0	24.0 – 41.0	67.5 – 79.1	50
TP (mg/L)	16.6 – 29.1	6.7 – 20.3	30.2 – 75.4	

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LIFE PROJECT

Project title:
Hybrid percolation system for treatment of agrifood SMEs wastewater

Project acronym:
HybridWwater

The project will be implemented in the following Member State (s):
Spain – Murcia

Expected start date: 01/09/2015

Expected end date: 31/12/2017

LIST OF BENEFICIARIES

Name of the coordinating beneficiary: National Technological Centre for the Food and Canning Industry Research business association – CTC
Name of the associated beneficiary: University of Murcia – UMU
Name of the associated beneficiary: COATO
Name of the associated beneficiary: Manuel García Campoy

Many thanks for your attention

Mercedes Lloréns Pascual del Riquelme
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