Two days training on the operation and management of WWTPs

9-10 September, Murcia

Non-conventional technologies

Presented by: Dr. Isabel Martin

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Background of wastewater treatment and reuse

The access to drinking water, proper sanitation, treatment of urban wastewater and a safe water reuse provide the backbone of development in a country.

There is an important imbalance between developed and developing countries/areas.

Problem is more or less solved in large and medium cities-areas with adequate social, economic and technological development.

Population most affected is concentrated on rural and scattered areas, and on marginal zones of large cities in underprivileged countries.

Background of wastewater treatment and reuse

Wastewater management according to economic development

Characteristics	Low-income countries	Lower-middle-income countries	Upper-middle-income countries	High-income countries
Access to basic sanitation services	▪Low coverage, especially for urban poor. ▪Mainly non-sewered options.			▪Good coverage. ▪Mainly sewerage.
Wastewater treatment	▪Few or no WWTPs. ▪Severe operational deficiences. ▪Affordability issues dominate.			▪Generally high treatment levels. ▪Non-OECD: increasing investments over 20 years. ▪OECD: major investments over 50-60 years.
Water pollution issues	▪Health problems from inadequate sanitation and raw sewage "in the streets".			▪Primarily concerned with amenity values and toxic substances.

(Adapted from *A. Bahri, 2011)*

Background of wastewater treatment and reuse

Wastewater management according to economic development

Characteristics	Low-income countries	Lower-middle-income countries	Upper-middle-income countries	High-income countries
Practices- reuse	▪Widespread direct and indirect use of untreated sewage.			▪Direct use of reclaimed effluent common and well-regulated.
Policy framework	▪Non-existent or unenforced. ▪Informal (unplanned) use predominates.			▪Use policies defined and enforced.
Health issues	▪High burden of helmints and diarrheas. ▪Difficult to ascribe cause due to high background levels.			▪Pathogens under control. ▪Industrial discharges under control. ▪Anthropogenic compound concern.

(Adapated from *A. Bahri, 2011)*

Concept of small community

There is no definition for the specific number of people below which a population can be considered as “small community”.

The size of the population can be established in terms of the number of inhabitants and/or pollution load (population equivalent, p.e), which is the criterion usually applied to differentiate small, medium-sized and large communities.

❖EU: < 2,000 p.e, in accordance with the limits set up by Directive 91/271/EEC on Urban Wastewater Treatment, under which wastewater must be given adequate treatment, whether it flows into coastal waters or inland waters and estuaries. This has been the criterion applied by most EU Member States to develop their own legislation and sanitation plans and to establish limits on water discharges.

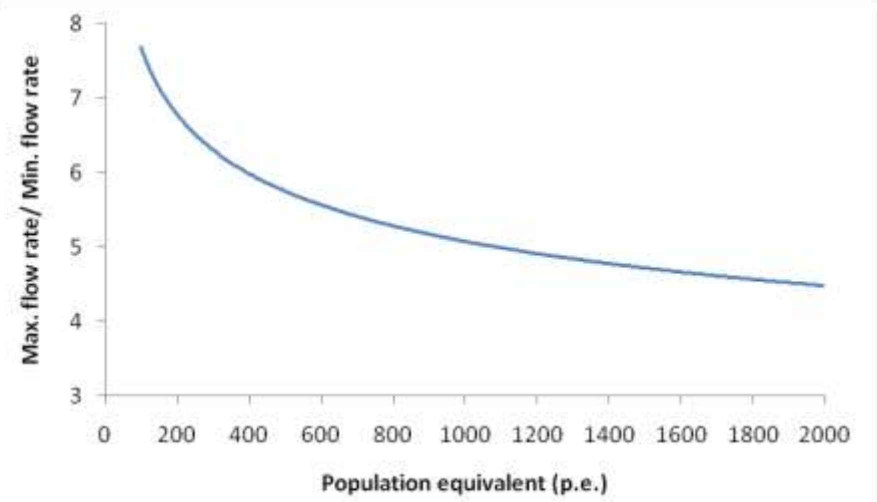
Some EU countries have adopted limits discharges from small communities, less stringent than those for large populations: Poland, UK, Austria, Finland, Denmark, France.

❖IWA: <4,000 p.e, and distinguishes between very small (1 to 10 households), medium-sized (50-500 PE) and larger communities (500-4,000 PE).

Wastewater treatment.
Problematic associated to small communities

- High communities dispersion→ complexity in infrastructure management
- Characteristics of wastewater :

High oscilations in flow rate during the day, to be taken into account in the dimensioning and design.



Wastewater quality:

Small communities usually generate a "small", but highly polluted volume of wastewater, related with low shortage on water supply.

Parameter	Regular range
Suspended solids (mg/l)	300 – 500
BOD_5 (mg/l)	400 – 600
COD(mg/l)	800 – 1.200
Nitrogen(mg N/l)	50 – 100
Phosphorus (mg P/l)	10 – 20
Grease(mg/l)	50 – 100
Total coliforms(CFU/100 ml)	10^7-10^8

Wastewater treatment.
Applied technologies in small communities

Two types of technologies:

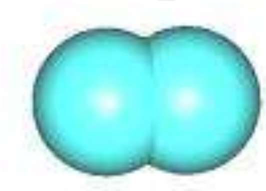
Intensive/conventional

Extensive/non-conventional

Wastewater treatment.
Applied technologies in small communities

Oxigen support:

O_2



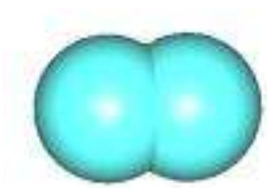
Energy consumption

INTENSIVE TECHNOLOGIES

High energy consumption

Low implementation surface

O2



EXTENSIVE TECHNOLOGIES

Low/cero energy consumption

High implementation surface

Wastewater treatment.
Applied technologies in small communities

❖ Commonly, in small settlements have been implemented technologies with high treatment costs. **PROBLEM:** settlements can not afford these costs (inoperative facilities or with severe operative problems)








WWT technologies most suitable for small communities: Non-conventional technologies

Most existing WWT technologies are applied to small settlements, although some are more appropriate than others, in small communities should prevail those meet with the following requirements : (EPA, 1977):

- •Processes requiring minimum operator time.
- •Equipment requiring minimum maintenance.
- •Efficient functioning with a wide range of flow rates and loads (in small communities there are significant variations).
- •Minimum power consumption.
- •Facilities where possible equipment or process failures cause minimum loss of effluent quality.
- •Maximum integration into the environment.

In rural or small communities, design, construction, maintenance and operation of treatment facilities, should be approached with the same rigor as in larger agglomerations.

WWT technologies most suitable for small communities: Non-conventional technologies

Classification by the level of treatment achieved:

➢**PRIMARY TREATMENT:** removes SS and floating matter

➢**SECONDARY TREATMENT:** involves the biological treatment of wastewater and aims mainly to remove dissolved organic matter

➢**TERTIARY TREATMENT OR ADVANCED TREATMENT:** removes the contaminants remaining after the previous stages

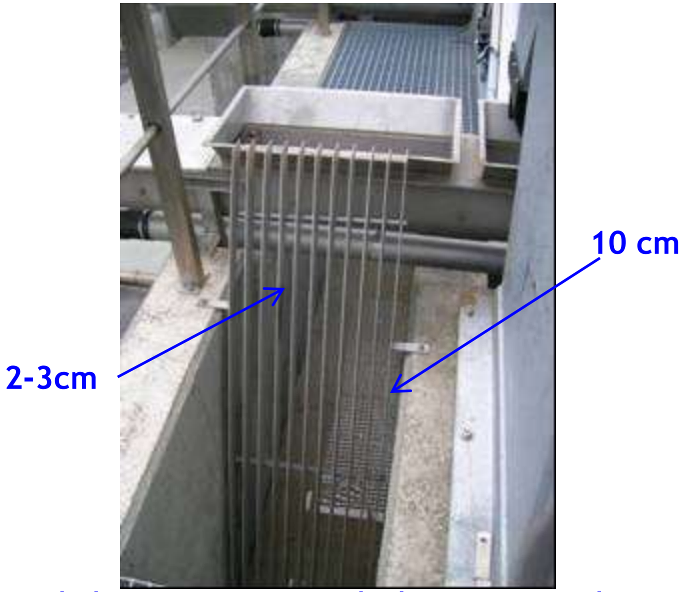
The first step, which is the same for all WWTP, requires the installation of a **PRE-TREATMENT** system where large solids and waste in the wastewater are removed.

Performance (%)

Stage	SS	BOD_5	*E. coli*
Pre-treatment	5-15	5-10	10-25
Primary treatment	40-70	25-40	25-70
Secondary treatment	80-90	80-95	90-98
Tertiary treatment	90-95	95-98	98-99

PRE-TREATMENT: SCREENING + GRIT CHAMBER + GREASE CHAMBER

SCREENING. Remove the small and medium-sized solids from the wastewater by trapping them in grids and/or screens placed in a channel.



Coarse solid screen (manual cleaning) and fine solid screens


Authomatic cleaning system (scraper)

Pre-treatment

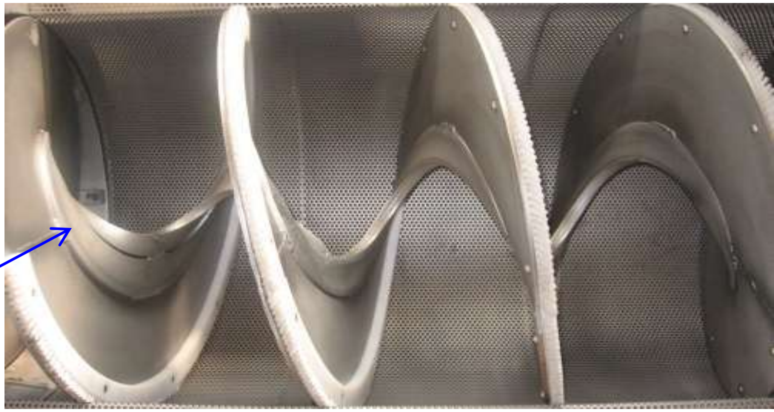
SCREENING

Self-cleaning static sieve

Rotary sieve

Sliding sieve

Archimedes screw



Screw sieve

Pre-treatment

GRIT CHAMBER. remove most of the denser matter contained in wastewater, which has a diameter larger than 0.2 mm in order to prevent its sedimentation in the channels, pipes and treatment units and to protect the pumps from abrasion. Both non-organic matter (sand, gravel) and non-decaying organic matter (coffee beans, bones, egg shells, etc.) are removed.

fixed flow rate: 0.3 m/s

Two-channels static **grit chamber**

GREASE CHAMBER. remove the grease and other floating materials lighter than water.

Static grease chamber with a superficial system for grease removal

COMBINED GRIT AND GREASE CHAMBER

Mobile bridge

Aerated grit-grease chamber

PRIMARY TREATMENT: SEPTIC TANK, IMHOFF TANK, PRIMARY SETTLING TANK

SEPTIC TANK. Reduce both floating and settling suspended solids. Generally, they are buried.

Prefabricated plastic units

Prefabricated concrete unit

SEPTIC TANK

ADVENTAGES	DISADVENTAGES
•Low operation and maintenance costs. •Quick, easy installation in the case of prefabricated units. •Attenuation of peaks of contaminants loads. •Simplification of sludge management. •No visual impact since the tanks are buried. •No noise impact.	•They only can achieve primary treatment levels; therefore their effluent must usually undergo supplementary treatment before being discharged into the environment or reused. •Septic effluent •Unpleasant odours

Primary treatment

IMHOFF TANK . Reduce both floating and settling suspended solids. Generally, they are buried.

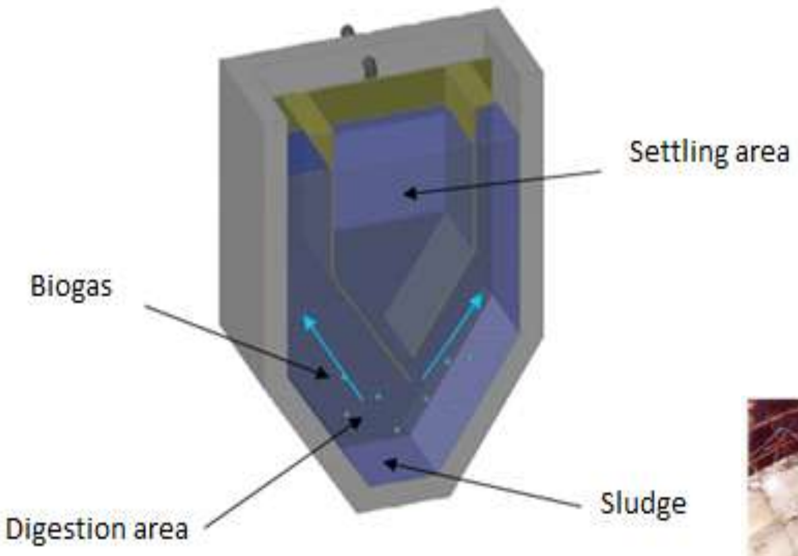


Diagram of an Imhoff tank

Imhoff tank (500 e.p)

Concrete

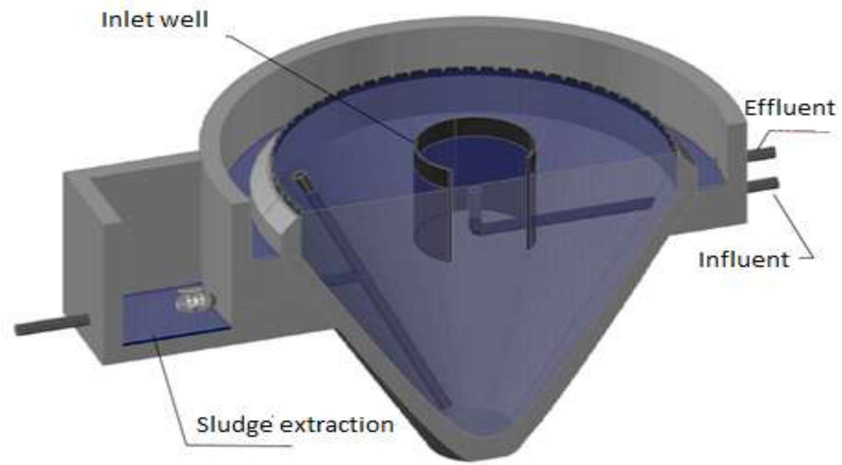
Metal sheet

IMHOFF TANK

ADVENTAGES	DISADVENTAGES
•Low septicity of the treated effluent. •Low operation and maintenance costs. •Quick, easy installation in the case of prefabricated units. •Simplification of sludge management. •No visual impact when the tanks are buried. •No or very low noise impact.	•They can only achieve primary treatment levels; therefore their effluent usually needs supplementary treatment. •Not stable in hydraulic overloads conditions. •Unpleasant odours. •Risk of contamination of underground water when the construction is deficient.

Primary treatment

SETTLING TANK. Remove an important amount of the suspended solids from the wastewater through the action of gravity. Therefore, this step will remove only settleable solids and floating matter while the colloidal and dissolved solids will remain unchanged.



Section of a cylindrical-conical static primary settler

PRIMARY SETTLING TANK

ADVENTAGES	DISADVENTAGES
•Less oxygen demand and, consequently, less energy consumption in the subsequent treatment units, since part of the organic load has been eliminated. •Greater thickening of the sludge or silt accumulated in this unit which requires post treatment. •Possibility of removing the sand and floating matter not removed in the pre-treatment process. •In some plants, the primary settling units are used as storm tanks, eliminating a large part of the organic solids.	•Greater operational complexity of the plant. •They only can achieve primary treatment levels. Effluent, therefore, usually needs supplementary treatment. •Not stable in hydraulic overloads conditions. •Possible unpleasant odours due to incorrect sludge management. •Generation of non-stabilised sludge which has to be frequently removed from the system.

Non-conventional secondary treatments

Imitating natural processes

Non-conventional secondary treatments: classification

- **SOIL APPLICATION**

  - **Superficial application**
    - Low-load (Green Filter)
    - Rapid infiltration
    - Superficial irrigation

  - **Subsuperficial application**
    - **Filtering ditches, filtering beds, filtering pits**
    - **Intermittent sand filters**

- **PEAT FILTERS(based on filtration of wastewater through natural carbon)**

- **CONSTRUCTED WETLANDS (CW)**
  - Subsuperficial CW (vertical and horizontal)
  - Superficial CW

- **LAGOONING SYSTEM**
  - **Anaerobic pond**
  - **Facultative pond**
  - **Maturation pond**

- **FIXED BIOFILM POROCESSES**
  - **Trickling filter**
  - **Rotating biological contactor**

Green filter

Area of land surface on which a tree plantation has been established, with the inlet normally being introduced through trenches or by flooding. The inlet to green filter should be a secondary treated wastewater .

The treated effluent percolates through the soil to be incorporated into the aquifers. The quality of percolation is controlled by lysimeters and/or piezometers.

Green filter

ADVENTAGES	DISADVENTAGES
•Operational simplicity, limited to periodic rotation of the plot, quarterly harrowing of the soil in order top re-aerate it and break the crusts that may have formed. •Nil or very low energy consumption. •Low operation and maintenance costs. •The operation cots of water treatment can be defrayed in part by selling the wood produced. •No sludge production. •Perfect environmental integration. •Absence of odours.	•It requires a very large surface area (25 m^2/p.e), with the result that installation costs is directly related to land costs. •The terrain can not be very steep, there must be no shallow aquifers and the soil must have a certain level of permeability. •Not suitable for high rainfall areas, due to the risk of permanent flooding.

Intermittent sand filters

Shallow beds (0.6-1.1 m deep), equipped with a surface distribution system for the sewage and a drainage piping to collect the treated effluent at the bottom of the filter.

After the pre-treatment and primary treatment processes (usually septic or Imhoff tanks), the wastewater flows vertically through the filtrating substrate, where a bacterial film develops, which is kept unsaturated and in aerobic conditions, since the filters are fed intermittently and because the drainage system is ventilated.

Basic mechanisms of wastewater treatment:
- Filtration
- Adsortion
- Biological oxidation

Intermittent sand filters

ADVENTAGES	DISADVENTAGES
•Operational simplicity. •Very low or zero energy consumption if the wastewater can flow by gravity, low consumption if it is necessary to use a pump, and somewhat higher in filters with recirculation. •Low operation and maintenance costs. •Rapid implementation of the system.	•Their installation requires a larger surface area (2-3 m^2/e.p.) than for intensive technologies. This drawback is minimized though in filters with recirculation. •If the locally available material is not appropriate for the filtration, the installation costs may increase substantially. •Little flexibility since there are few control elements that can be regulated during the operation, which is why it is essential that the intermittent sand filters be properly designed, dimensioned and constructed.

Peat filters

Sewage filtration through beds using peat as filtering medium. A series of physical-chemical and microbiological properties which make it especially suitable for urban liquid waste purification.

Consist of beds with a series of filtrating layers composed, from the top down, of peat, gravel and fine gravel. The water purification occurs mainly in the peat layer, while the rest of the strata basically retain the upper layers.

Once the effluent has flowed down through the peat, it is collected at the bottom of the filter by channels or drainage pipes.

Peat filters

ADVENTAGES	DISADVENTAGES
•Low operation and maintenance costs. •Operational simplicity. •The system can work without any energy input if the wastewater reaches the purification plant by gravity and the intermittent feeding of the filter is made through U-bend devices. •From the moment of entry into service of the filters, high water purification rates are obtained, which makes them very suitable for the treatment of sewage in communities where wastewater production is highly seasonal.	•High cost of the peat compared to inert substrates used in intermittent sand filters, infiltration-percolation systems, and subsurface flow constructed wetlands. •The effluent may, sometimes, have a light yellow colour, which comes from constituents in the peat itself. •Little flexibility since there are few control elements that can be regulated during the operation, which is why it is essential that the peat filters be properly designed, dimensioned and constructed. •If no peat with the appropriate characteristics is available locally, installation costs may increase substantially.

Constructed wetlands (CW)

Reproduce the processes of contaminant elimination which occur in natural wetlands.

Wastewater treatment occurs by circulating the wastewater through the artificial wetlands and combining physical, chemical and biological processes.

CW technology operates as a complex ecosystem made of the following elements (Vymazal, 2008; Kadlec *et al*., 2009):

❖ Water, which flows through the filtrating substrate and/or vegetation.
❖ Substrate, which is the support of the plants and has to retain the microbial population (in the form of a biofilm).
❖Emerging aquatic plants (macrophytes), which supply surface area for the formation of bacterial films, facilitate the filtration and adsorption of the wastewater constituents, help to oxygenate the substrate and remove the nutrients, etc…

Constructed wetlands (CW)

Uses

Urban-Industrial wastewater treatment

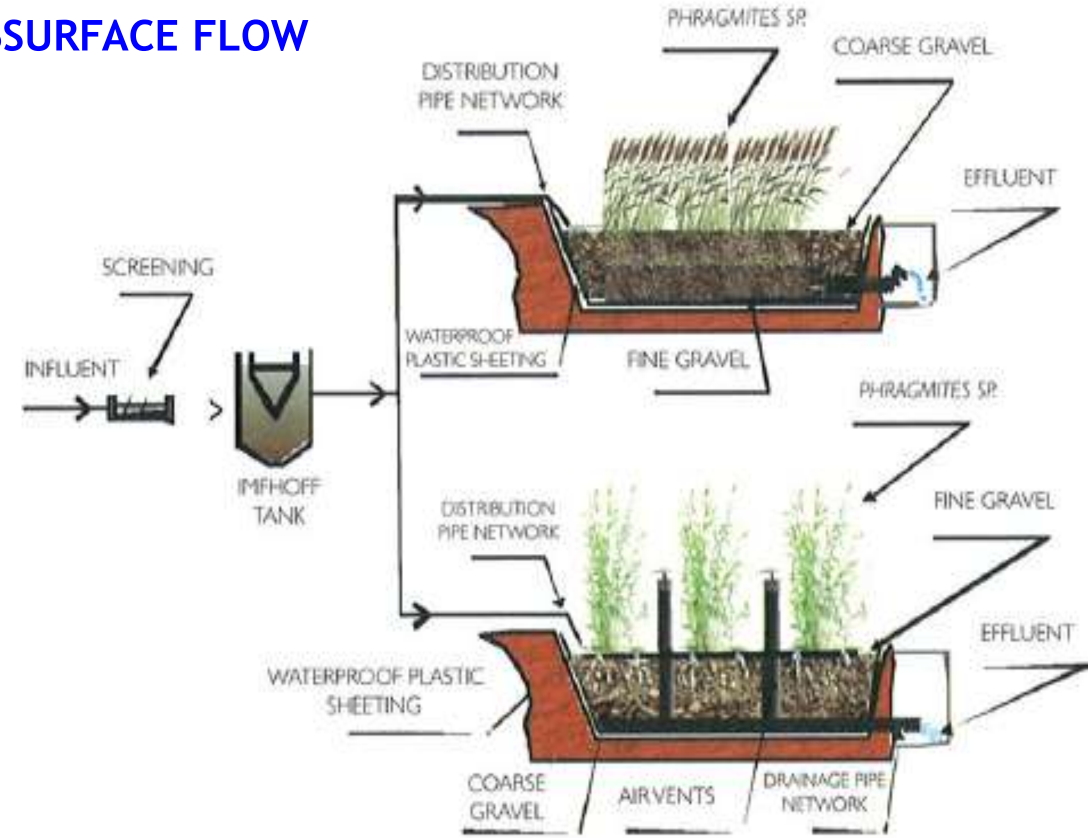
Restauration and recreation of water ecosystems

Stabilization -dehydration of sludge

Landscape integration

Constructed wetlands (CW)

SUBSURFACE FLOW

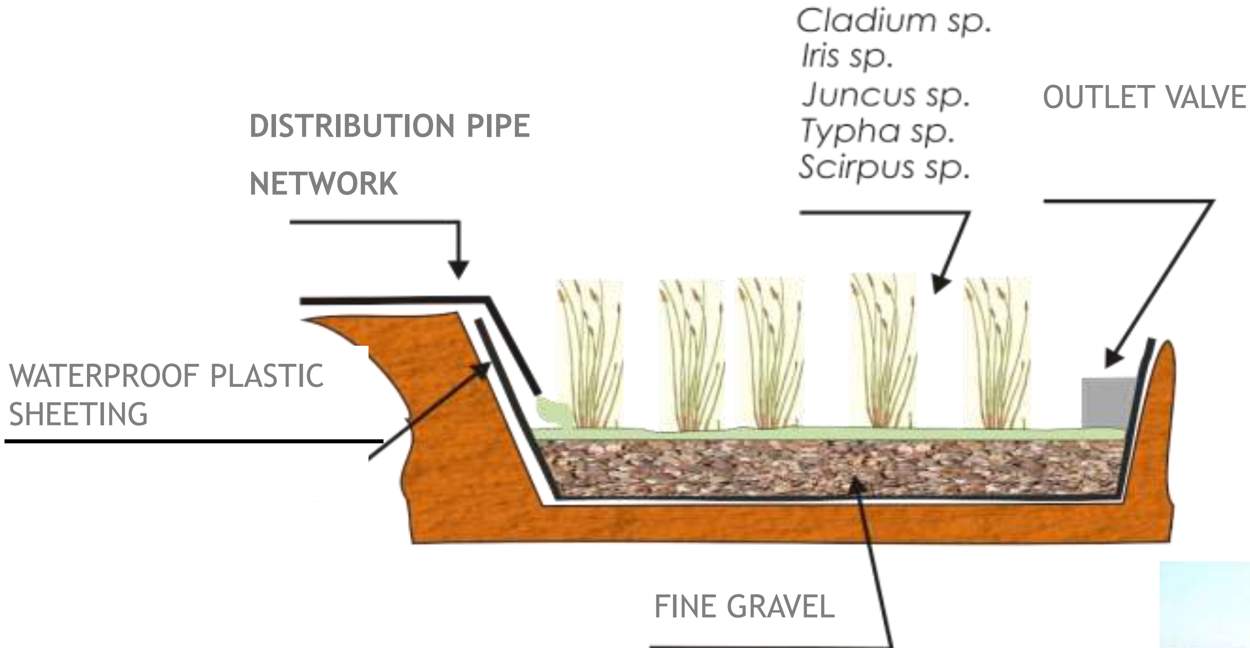


HORIZONTAL

VERTICAL

Constructed wetlands (CW)

SURFACE FLOW



Constructed wetlands (CW)

CWs combination

Constructed wetlands (CW)

ADVENTAGES	DISADVENTAGES
•Operational simplicity. •Nil or very low energy consumption. •Low operation and maintenance costs. •Possible use of the plants produced (ornamentation, animal fodder, basketwork). •Surface flow wetlands, in particular, allow for the creation and restoration of wetlands, which encourage wildlife, for environmental education and as recreational areas. •Very little generation of odours since the water of the subsurface flow wetlands is not exposed to the atmosphere, and because the surface flow wetlands usually work with water that has already been treated. •Perfect integration in the natural environment, in particular the surface flow wetlands.	•Their installation requires a large surface area (2-3 m^2/e.p). •Subsurface flow wetlands, especially horizontal wetlands, may suffer clogging problems in the substrate if the correct substrate is not selected, or if the pre-treatment and primary treatment systems do not work properly or if the facility receives anomalous waste with a high suspended solid or grease content and these are not removed during the previous processes. •Few control elements can be regulated during the operation, which is why it is essential that the constructed wetlands be properly designed, dimensioned and constructed. •If the locally available material is not appropriate for the filtration, the installation costs may increase substantially. •Water loss due to evapo-transpiration, which raises the salinity of the purified effluent. •Possible appearance of mosquitoes in the surface flow wetlands and pests that could damage the plants

Constructed wetlands (CW)

Clooging beds

❖Cooper *et al.* (2006) reported that 111 of 225 reedbeds inspected were flooded at the inlet end (medium age ~ 10 years)

❖Clooging is most severe within the first 1/4 to 1/3 of beds (Bavor *et al.*, 1989; Fisher, 1990; Tanner and Sukias, 1995; Tanner *et al.*, 1988; Young *et a*l., 2000, George *et al.*, 2000)

Lagooning system

It is made up of several lagoons connected in series. Their depth is gradually reduced and they alternately present conditions of absence or presence of oxygen. They reproduce the water self-purification process that is found in natural water courses

Lagooning system

Basic types of ponds:

-<u>Anaerobic.</u> Deep (3-5 m). It presents a double objective: the **reduction of suspended matter** (settleable and floating), as a primary treatment, and the **stabilisation of the sludge** accumulated at the bottom. Anaerobic lagoons are also used as primary treatment in other biological water purification technologies (Trickling Filters, Rotating Biological Contactors).

-<u>Facultative.</u> Deep (1.5-2 m). The main objective of the facultative phase is the **biodegradation**, essentially aerobic, of the **organic matter** contained in wastewater to be treated, thanks to the oxygen produced by the photosynthetic activity of the microalgae and, to a lesser extent, to surface aeration caused by the wind.

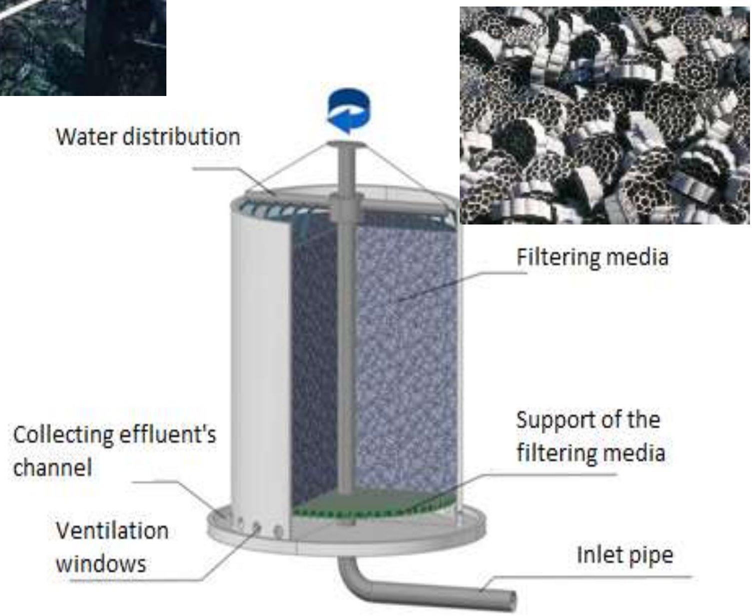
-<u>Maturation</u>. Deep (0.8-1 m). It has got a low organic load, and offer appropriate conditions to receive in-depth solar radiation. Due to its **strong disinfecting power**, this type of lagoon is used after other water purification treatments.

Lagooning system

ADVENTAGES	DISADVENTAGES
•Simplicity of construction since the main work is earth moving. •No energy consumption when the wastewater reaches the WWTP by gravity. •Absence of breakdowns when no electromechanical equipment is used during coarse screening. •Simple, easy maintenance, since only the waste from pre-treatment has to be removed and the surface of the lagoons kept free of floating solids to prevent the proliferation of mosquitoes. Furthermore, the appearance and smell of the different lagoons are sufficient to evaluate their operational status. •Little production of sludge, which is highly mineralised due to the long retention time in the anaerobic lagoons (5-10 years), which enormously facilitates its handling and disposal. •Great inertia, due to large volumes, and, therefore, long retention times. •Strong pathogen inactivation that can reach 3-4 logarithmic units. •Good environmental integration.	•A large area of land is needed for their installation. •They may be not advisable in cold areas or areas with little sunlight. •Generation of unpleasant odours in anaerobic lagoons, although these odours can be minimised and limited to the immediate area of the lagoon, if the aforementioned recommendations are followed. •Possible proliferation of mosquitoes. •Water loss by evaporation entailing an increase of salinity in the treated effluent. •Frequently, high concentrations of suspended solids in the outlet, as a consequence of the proliferation of microalgae. •Risk of aquifer contamination by infiltration if the system is not completely impermeable.

Trickling filter

Also known as percolating filters, are the most traditional method of biofilm process used for the biological treatment of wastewater.



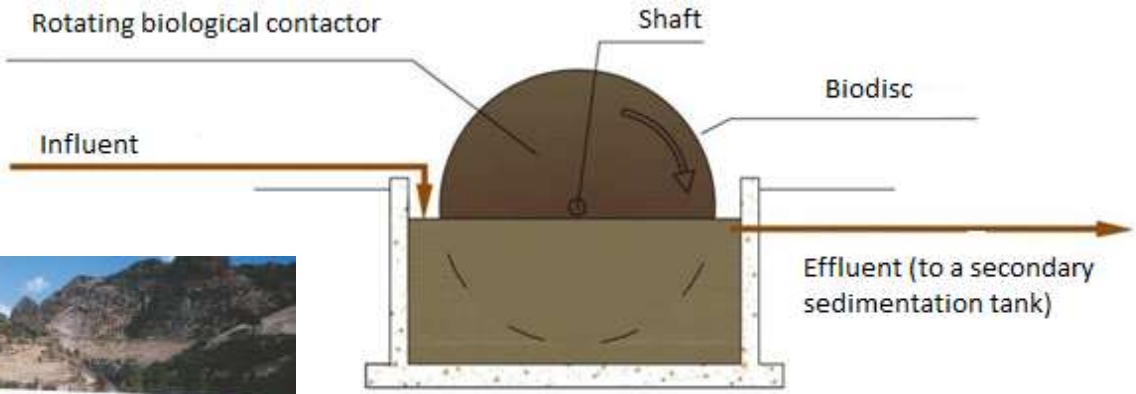
Aerobic process, where the wastewater, after receiving prior treatment (pre-treatment and primary treatment), percolates by gravity through a filling material (stones, plastic material) , which constitutes the medium on which microorganisms develop and grow, forming a biofilm of variable thickness. The filling material is fixed, inside the reactor, and provides a high specific surface area.

Trickling filter

ADVENTAGES	DISADVENTAGES
•Low surface area requirements. •Good tolerance of occasional hydraulic overloads. •Good response to toxic events. •Relatively simple operation since no sludge recirculation system, control of dissolved oxygen level, measurement of solid concentration in the reactor, etc., are required. •Low energy consumption and low operation costs. •Low generation of noise. •Robustness of the equipment.	•More electrical and mechanical equipment is required compared with natural (extensive) systems, and these consume electricity and require more complex and costly maintenance. •Generation of non-stabilised sludge. •Less flexibility than extended aeration processes, so poorer adaption to variations from design conditions. •Poor landscape integration.

Rotating Biological Contactor (RBC)

Systems where microorganisms adhere to a medium which is half-submerged (approximately 40% of its surface area) and rotates in the wastewater.



Rotating Biological Contactor(RBC)

ADVENTAGES	DISADVENTAGES
•Low space requirements. •Low energy consumption and low operation costs (compared with extended aeration systems). •Relatively simple operation since no sludge recirculation system, control of dissolved oxygen level, measurement of solid concentration in the reactor, etc., are required. •Good response to toxic events as the biomass enters into contact alternately with both the wastewater and the atmosphere. •Easy, gradual construction. Since it is a modular system, it can be gradually enlarged depending on the needs for water purification. •Low generation of noise, since the equipment is low-powered. •As RBCs are usually located in covered sites, the wastewater is maintained at a higher temperature. Performance is, therefore, less affected during cold periods.	•High installation costs due to the cost of equipment, mainly the contactors themselves. •Generation of non-stabilised sludge, which therefore requires subsequent mineralisation. •Less flexibility than activated sludge processes, so poorer response to variations from design conditions. •Relatively complex mechanical installation and some dependence on the manufacturer since these are patented systems. •Compared with extensive systems, the electrical and mechanical equipment requires maintenance and consumes electricity.

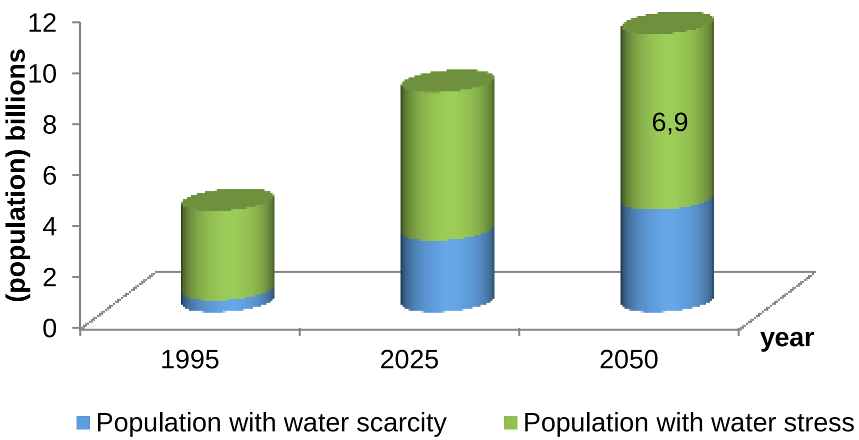
Wastewater treatment performance

	Removal (%)					Removal (log)
Secondary treatments	**SS**	**BOD_5**	**COD**	**N**	**P**	**Faecal coliforms**
91/271/EC (normal areas)	90	70	75	-	-	-
Green filter	85-95	85-95	80-90	50-90	40-90	1-2
Intermittent sand filter	90	90-95	80-90	40-50	15-30	2-3
Peat filter	85-95	90-95	80-90	15-20	70-80	1-2
Horizontal CW	90-95	85-90	80-90	20-30	20-30	1-2
Vertical CW	90-95	90-95	80-90	60-70	20-30	1-2
Lagooning system	40-80	75-85	70-80	40-80	30-60	3-4
Anaerobic pond	50-60	40-50	40-50	5-10	0-5	0.2-0.5
Facultative pond	0-70	60-80	55-75	30-60	0-30	2.2
Maturation pond	35-40	25-40	20-35	15-50	30-45	3-4
Trickling filter	85-95	85-95	80-90	30-35	10-35	0.5-0.6
RBC	85-95	85-95	80-90	20-35	10-35	0.5-0.6
Extended aeration	85-95	85-95	80-90	30-40	20-30	0.6

(Martín,I. *et al.*, 2007, 2010; Salas, *et al.*, 2007; Ortega *et al.*, 2010)

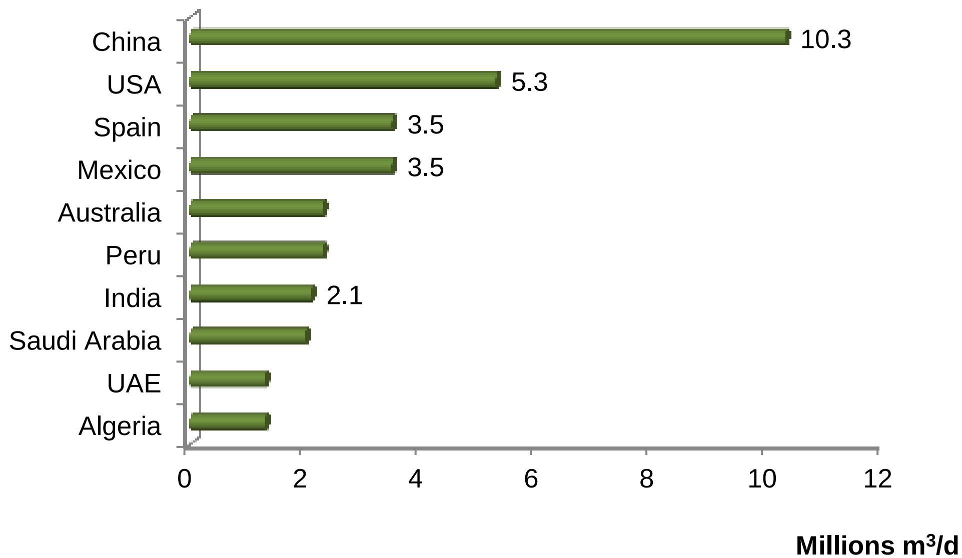
Water reuse: the wastewater as a resource

COUNTRIES WITH WATER SCARCITY AND WATER STRESS (WHO, 2006)



TREATED WASTEWATER REUSE

FUTURE EVOLUTION (2009-2016)



Risks associated to wastewater use

Pathogens

SAFE WATER REUSE

Potential health risk

<,> wastewater treatment and/or water reclamation

Regulations for water reuse

COUNTRY	REGULATION
USA	Title 22 of California Code of regulation water reuse
USEPA	▪Guidelines for water reuse (2004). (1992)
WHO	▪Guidelines for the safe use of wastewater, excreta and greywater, 2006. (1973, 1989)
AUSTRALIA	▪Environment Protection No. 66/1996 ▪Health (Infectious Diseases) Regulations, 1990
CYPRUS	▪Provisional Standars, 1997
FRANCE	▪Decree 94/469 ▪Circular DGS/SDI.D/91/nº 151
ISRAEL	▪Regulation by Ministry of Health
ITALY	▪Decree nº 152, 1999 ▪Decree nº 185, 2003
JORDAN	▪Jordanian Technical Base nº 893/2006
MALTA	▪Guidelines applied to irrigation area supplied with treated sewage effluent ▪Legal Notice LN71/98
EUROPE	▪Urban wastewater Directive (91/271/EC) ▪Europen Water Framework Directive (2000/60/EC) , establishing a framework for the Community action in the field of water policy.
SPAIN	**▪Royal Decree 1620/2007, establishing a legal regimein the field of treated wastewater reuse..**

Spanish Royal Decree for water reuse (1620/2007)

<table>
<tr><th>USE</th><th>QUALITY</th><th>E. Coli (cfu/100ml)</th><th>Intestinal nematodes (egg/10l)</th><th>SS (mg/l)</th><th>Turbidity (UNT)</th></tr>
<tr><td>•Cooling towers and evaporative condensers</td><td rowspan="3">A</td><td>Absence</td><td>1</td><td>5</td><td>1</td></tr>
<tr><td>•Irrigation of private gardens
•Discharge of sanitary fixtures</td><td>Absence</td><td>1</td><td>10</td><td>2</td></tr>
<tr><td>•Direct aquifer recharge</td><td>Absence</td><td>1</td><td>10</td><td>2</td></tr>
<tr><td>•Urban services, fire protection systems, vehicle washing
•Unrestricted irrigation
•Golf courses irrigation</td><td>B</td><td>100-200</td><td>1</td><td>20</td><td>20</td></tr>
<tr><td>•Irrigation of agricultural products for human consumption not in fresh
•Grasslands irrigation for animals producing
•Acuiculture</td><td rowspan="3">C</td><td rowspan="3">1,000</td><td rowspan="2">1</td><td rowspan="3">35</td><td rowspan="3">No limit</td></tr>
<tr><td>•Water and cleaning for food industry</td></tr>
<tr><td>•Aquifer recharge by field percolation</td><td>No limit</td></tr>
</table>

Spanish Royal Decree for water reuse (1620/2007)

<table>
<tr><th>USE</th><th>QUALITY</th><th>E. Coli
(cfu/100ml)</th><th>Intestinal nematodes
(egg/10l)</th><th>SS
(mg/l)</th><th>Turbidity
(NTU)</th></tr>
<tr><td>•Watering woody crops without contact with fruits
• flowers, nurseries and greenhouses without contact with production
•Non-food industrial crops</td><td rowspan="3">D</td><td rowspan="3">1,000</td><td rowspan="3">1</td><td rowspan="2">35</td><td rowspan="2">No limit</td></tr>
<tr><td rowspan="2">•Water processes and cleaning, except food industry

•Other industrial uses</td></tr>
<tr><td>35</td><td>15</td></tr>
<tr><td>•Pools, water bodies and ornamental flow, without public access</td><td>E</td><td>10,000</td><td>No limit</td><td>35</td><td>No limit</td></tr>
<tr><td>•Irrigation of forests and parks, without public access
•Silviculture</td><td>F</td><td>No limit</td><td>No limit</td><td>35</td><td>No limit</td></tr>
</table>

Water reclamation treatments

- Physico-chemical
  - In line
  - Conventional
  - Advanced
- Filtration
  - Sand
  - Disc
  - Membranes
  - Sieve
- Desalination
  - Electrodialysis reversal (ER)
  - Reverse osmosis (RO)
- Disinfection
  - Cloration
  - UV
- Biological treatment
  - Membrane bioreactor (MBR)
  - Non-conventional Technologies

Experimental Center for R&D&I of Carrión de los Céspedes, Seville

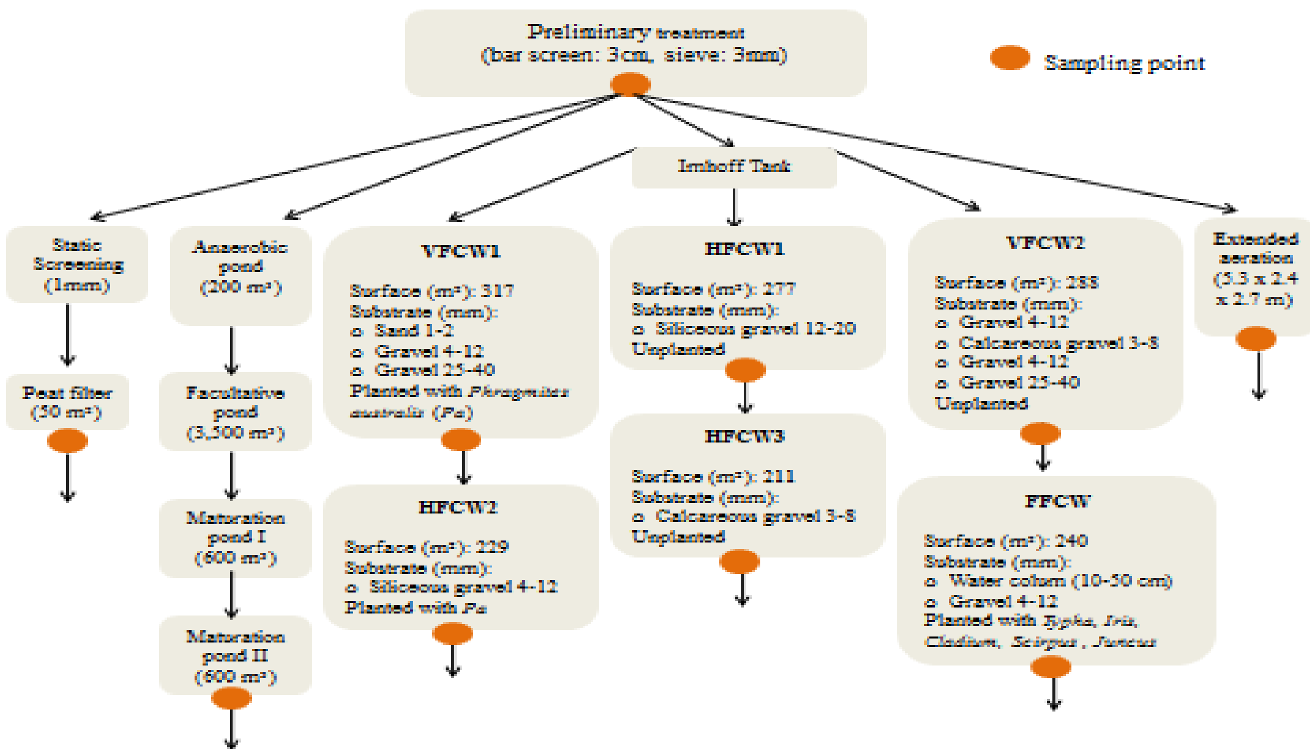
http://www.centa.es

45,000 m² for wastewater treatment and reuse in small communities, using conventional and non-conventional technologies.

Non-conventional treatment technologies for water reuse

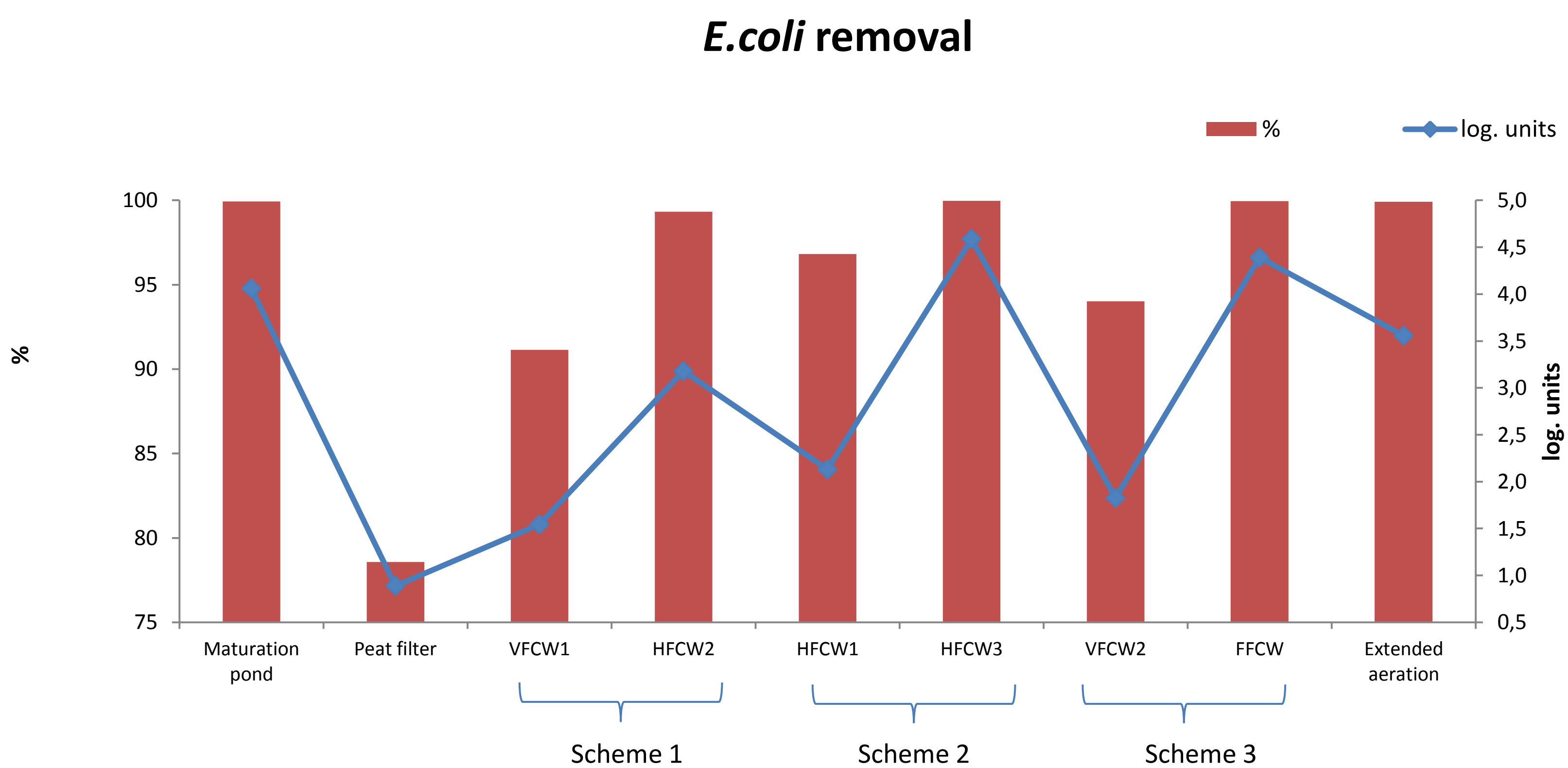
TECHNOLOGIES FOR WASTEWATER TREATMENT AND REUSE

Description, flow diagram and sampling points in wastewater treatment technologies studied in the Experimental Center of Carrión de los Céspedes, Seville, Spain. Martín *et al*., 2012



Non-conventional treatment technologies for water reuse

***E. coli* removal (log and %) in outlet of wastewater treatment technologies**. (Martín, I., 2010)



Non-conventional treatment technologies for water reuse

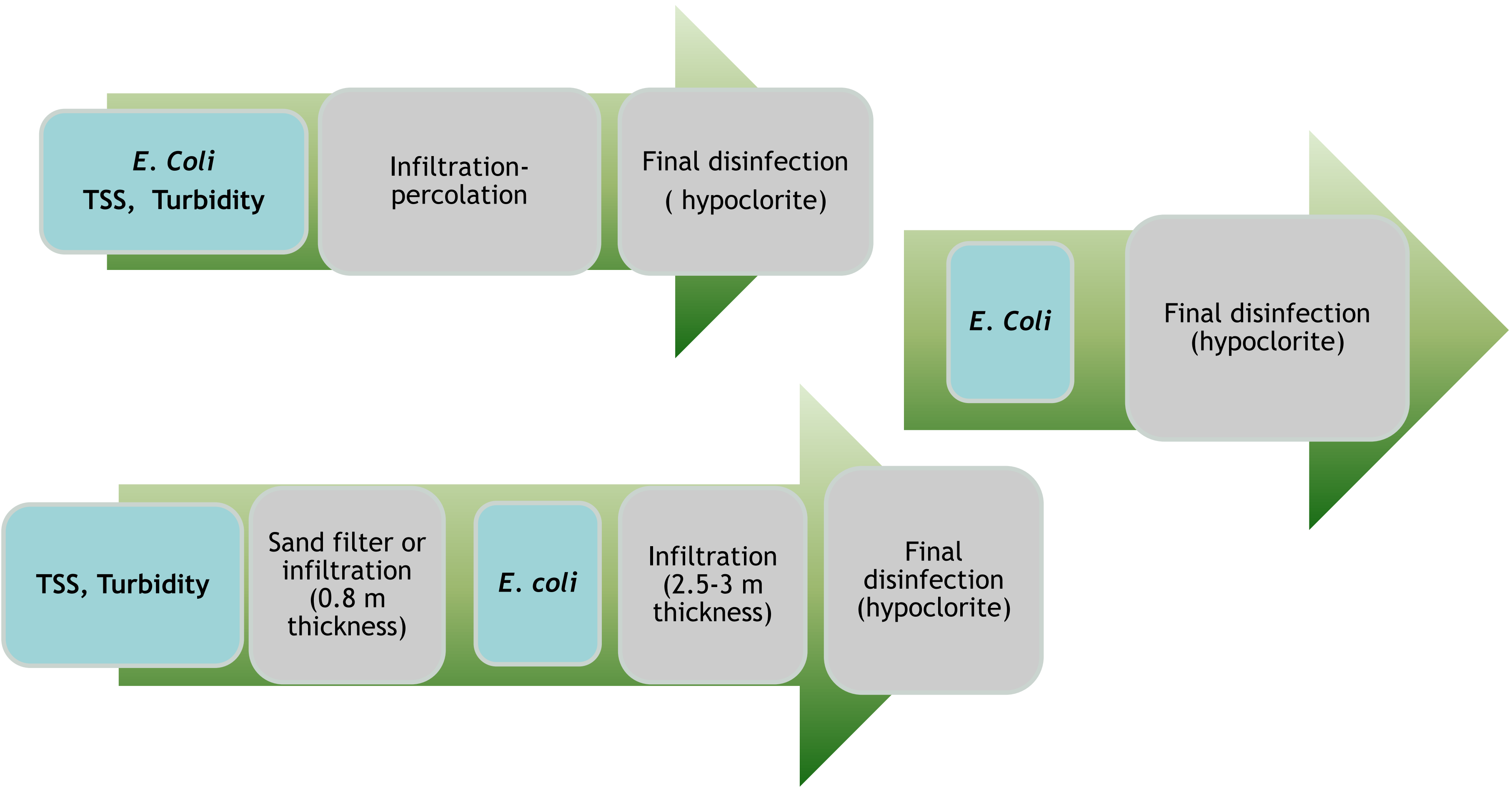
Intended uses for wastewater treatment technologies studied (Royal Decree 1620/2006).
(Martín *et al*., 2012)

TREATMENT	USE			
	Agricultural (1)	**Industrial (2)**	**Recreational (3)**	**Environmental (4)**
Maturation pond				
Peat filter				
Vertical flow CW1				X
Horizontal Flow CW1				X
Horizontal Flow CW2				X
Combination VFCW 1+ HFCW2	X	X	X	X
Combination HFCW1 + HFCW3	X	X	X	X
Combination VFCW2 + FFCW	X	X	X	X
Extended aeration			X	X

(1): woody crop irrigation without contact with the fruits, flower crop irrigation, nurseries and greenhouses, without contact with the production and non-food industrial crops.
(2): water for cleaning and process, except food industry
(3): ponds, water bodies and ornamental flow, without access to public
(4): irrigation of forests and green areas without access to public, forestry

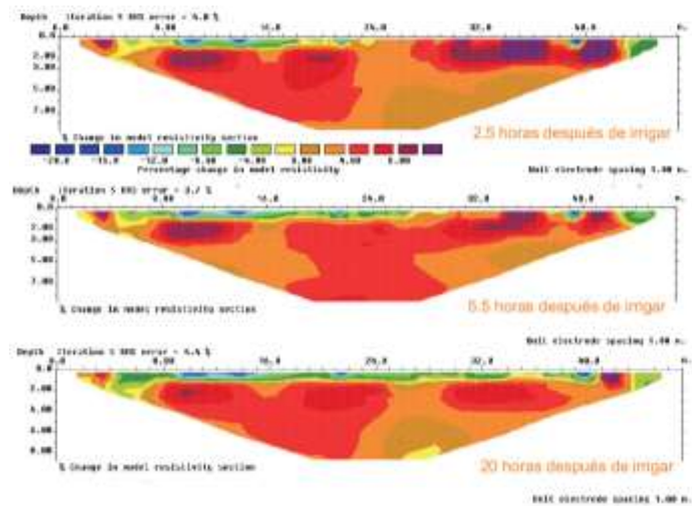
Non-conventional treatment technologies for water reuse

IMPROVEMENT ON TECHNOLOGIES FOR WATER REUSE



CENTA´s researches on wastewater treatment and reuse

Treated wastewater reuse for environmental uses: aquifer recharge through permeable reactive barriers and silviculture for energy production



CENTA´s researches on wastewater treatment and reuse

Treated wastewater reuse for environmental uses: aquifer recharge through permeable reactive barriers and silviculture for energy production

CENTA´s researches on wastewater treatment and reuse

Water reuse: beyong Royal Decree 1620/2007

CENTA´s researches on wastewater treatment and reuse

Water reuse: beyong Royal Decree 1620/2007

CENTA´s researches on wastewater treatment and reuse

Water reuse: beyong Royal Decree 1620/2007

Palygorskite

Activated carbon

Zeolite

CENTA´s researches on wastewater treatment and reuse

The use of intermittent sand filters for water reclamation

Filter substrate thickness: 0.6 m

Filter substrate thickness: 1.5 m

CENTA´s researches on wastewater treatment and reuse

SARASWATI: Supporting consolidation, replication and up-scaling of sustainable wastewater treatment and reuse technologies for india. (VII FP)

WP6: Tools for replication

WP7: Dissemination

CENTA´s researches on wastewater treatment and reuse

Research on Development on Wastewater Treatment and Reuse (Mali and Tunisia)

CENTA´s researches on wastewater treatment and reuse

CROSS-BORDER CAMPUS FOR SUSTAINABLE MANAGEMENT OF WATER RESOURCES

CENTA´s researches on wastewater treatment and reuse

Environmental management system for sustainable sanitation (basic sanitation and wastewater treatment). Environmental, economic and technical perspective. The West Bank (Palestine) .

CENTA´s researches on wastewater treatment and reuse

Design and implementation of an integrated system for wastewater treatment and reuse in the environment of Wadi Al Aroub
Hebron (Palestine) .



CENTA´s researches on wastewater treatment and reuse

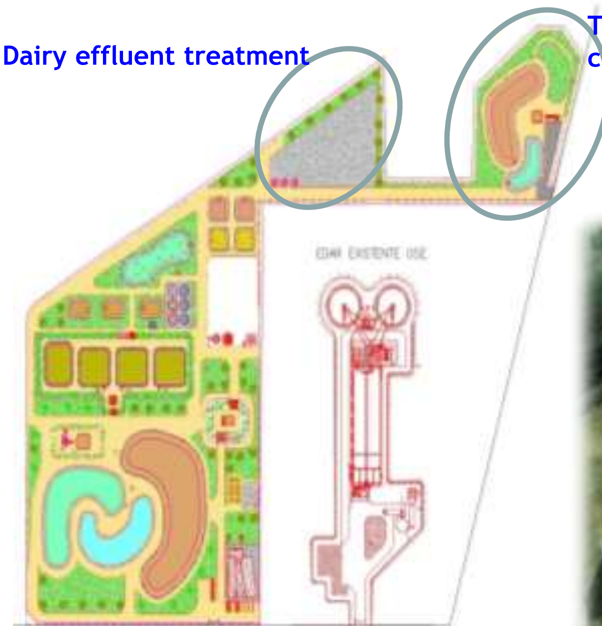
Application of suitable sanitation technology for sustainable human development in small communities in El Salvador.

CENTA´s researches on wastewater treatment and reuse

AMERICAN PROGRAM ON WATER
Thematic area 1.3.:Water supply and Sanitation.

- Course on Non-conventional technologies for wastewater treatment .
- Testing and Training Center in non-conventional wastewater treatment in Canelones

Experimental Center for sanitation and wastewater treatment at small scale.
Platform for meeting and knowledge exchange for water management stakeholders



FINAL CONCLUSIONS

The limited financial and physical resources for wastewater treatment, the socio-economic situation and the context of urbanization affect principally to small communities, rural zones and more disadvantages or developing areas and create the conditions for unplanned and uncontrolled wastewater reuse.

It is therefore in those types of agglomerations where it should be done a bigger effort to correct deficiencies in sanitation, wastewater treatment and reuse, without forgetting that must be found options which reconcile the requirement to treated wastewater with simple operating techniques and operating and maintenance costs that may be really defensible.

مع خالص شكري وامتناني

Thank you for your attention

Merci pour votre attention

For additional information please contact:

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Website: www.swim-sm.eu