DEMOWARE

# Reduction of clogging in agricultural irrigation networks

IRTA Torre Marimon
Carmen Biel
Robert Savé

CTM
Montse Calderer
Gemma Serra

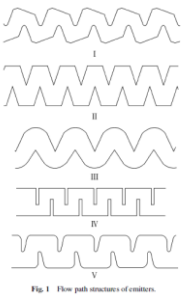
Water Reuse Conference
June 13-14, 2016

## Introduction

Emitter clogging is one of the bottlenecks to restrain the application and popularization of reclaimed water with drip irrigation technology. It is tightly related to the formation of biofilms attached on drip irrigation pipes and emitters.

Biofilm formation in the emitter depends on design, water flow velocity, water pressure, suspended solids, o.m.

Yan et al. 2009



## Objectives

One objective is testing the standard maintenance cleaning of irrigation system with nitric acid against a novel system based on the injection of $CO_2$ in the water.

Second objective is to compare two drippers with different hydraulic properties because its design and internal path.



## Tested treatments

- Reclaimed water from WWTP Caldes de Montbui (Barcelona)
- Reclaimed water + Nitric Acid
- Reclaimed water + $CO_2$ injection
- Well water = water from underground extracted from the same plot

IRRIGATION DRIPPERS

Compensated dripper model PCJ Junior

Integral dripper model Uniram RC

Netafim Israel (Image from: www.Netafim.com web)

## Reclaimed water from WWTP Caldes de Montbui

- Contracting body: Consorci per a la Defensa del Besós
- Working load: 6000 $m^3.day^{-1}$
- Population: 25.000 inhabitants
- Treatments: Remove fats, remove sand, homogeneisation
- Primary treatment: Decanting
- Secondary treatment: Activated sludge
- Drying: Filter



## Reclaimed water from WWTP Caldes de Montbui

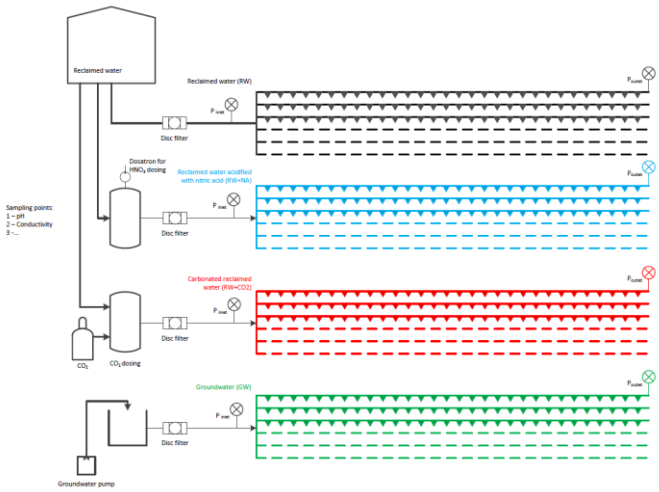


## Irrigation water quality characteristics

| Water quality parameters | Underground water | Reclaimed Water | Normal values for irrigation |
|---|---|---|---|
| **Electric Conductivity 25ºC (dS.m$^{-1}$)** | 2.04 | 1.487 | 0-3 |
| **pH** | 7.1 | 8.50 | 6.5-8.5 |
| **Bicarbonate (mg.l$^{-1}$)** | 247.13 | 319.13 | 0-600 |
| **Carbonates (mg.l$^{-1}$)** | 0 | 28.80 | 0-3 |
| **Nitrate (mg.l$^{-1}$)** | 285.51 | 6.51 | 50 |
| **Phosphorus (µg.l$^{-1}$)** | 6.23 | 2963.50 | |
| **Potassium (mg.l$^{-1}$)** | 3.32 | 16.42 | 20 |
| **Calcium (mg.l$^{-1}$)** | 176.15 | 78.46 | 0-400 |
| **Magnesium (mg.l$^{-1}$)** | 46.90 | 25.70 | 0-60 |
| **Sodium (mg.l$^{-1}$)** | 35.31 | 178.48 | 0-900 |
| **Sulfate (mg.l$^{-1}$)** | 91.50 | 65.08 | 0-1000 |
| **Chloride (mg.l$^{-1}$)** | 76.04 | 194.62 | 0-1100 |
| | | | |
| **Boron (mg.l$^{-1}$)** | 0.08 | 0.25 | 0-3 |
| **Copper (mg.l$^{-1}$)** | 0 | 0 | 0-0.2 |
| **Iron (mg.l$^{-1}$)** | 0 | 0 | 0-5 |
| **Fluoride (mg.l$^{-1}$)** | 0 | 0.035 | 0-1 |
| **Manganese (mg.l$^{-1}$)** | 0 | 0 | 0-0.2 |
| **Zinc (mg.l$^{-1}$)** | 0.03 | 0.02 | 0-2 |



## Experimental design and pipes distribution



## Experimental design

- Dripper's nominal water flow rate is 2 $L.h^{-1}$ at working pressure: 1.4 and 1.8 $kg.m^{-2}$
- Type of operation:

  Irrigation during 10 minutes x 2 times a day at 9:00 and 16:00 hours.
- Since april 2016 we change irrigation schedule: 5 minuts at 9, 12, 15 an 18 hours in order to increase the water movement and increase the oxygen and nutrients supply.

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## Experimental design

- Irrigation control room and tanks for $CO_2$ injection and acid application to water

Automatic control panel for irrigation schedule and $CO_2$ injection

Tanks for reclaimed water and one with $CO_2$ injection (right tank).

## Nitric acid injection to the irrigation pipes

Pressure control

Dosatron

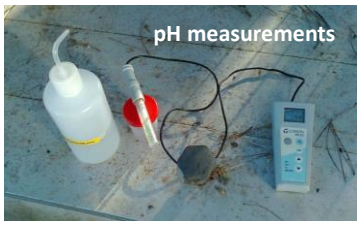
(for accurately dose a liquid into water)

Nitric acid solution

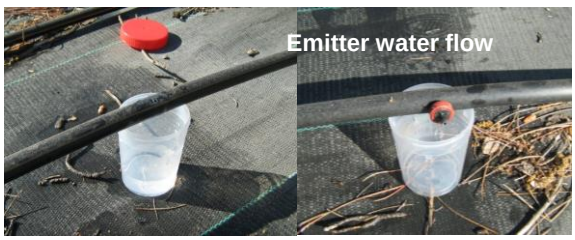
Nitric acid diluted on the water through a venturi system (Dosatron International SAS, France),



## Measurement at irrigation pipes

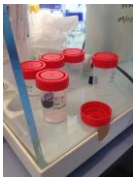


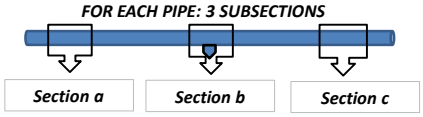


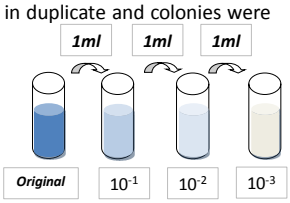
## Biofilm sampling

1. Sample collection: pipe sections will be monthly collected and transported to the laboratory in insulated cold boxes and sterile bottles.



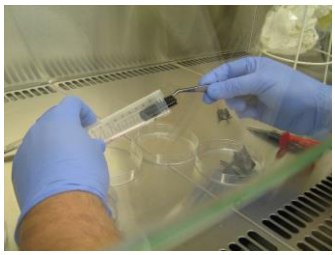


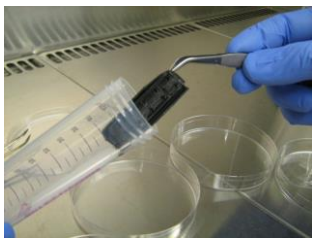

2. Swabbing: Each pipe will be cut into three portions and biofilm will be collected by swabbing the surface.
3. Bacteria extraction: Vortexing vigorously the swab to release the bacteria into the sterile solution (Ringer ¼ ).
4. Heterotrophic plate count (HPC) method: The number of heterotrophic bacteria in each sample will be counted on R2A Agar. Each sample was tested in duplicate and colonies were counted after incubation at 22ºC for 7 days.
5. Results: concentration per unit area of the pipe surface.






## Alternative method to obtain biofilm



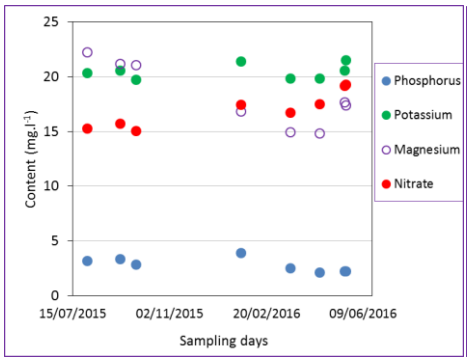


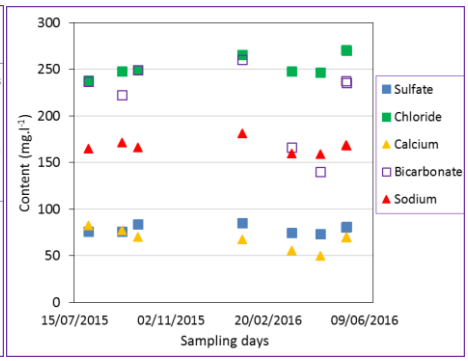
**Microbial biomass.**

For bacterial abundance, drippers with biofilm were incubated with 0.025 mmol/L tetrasodium pyrophosphate solution, shaken for 1 h and subsequently sonicated (180 s, 40 W output, Branson) to detach and disaggregate cells (Velji & Albright, 1986).

To determine total aerobic heterotrophic microbial populations, miniaturized most probably number was carried out in microtiter plates (8 replicates per dilution) from ten-fold dilutions conducted from biomass resuspensions on tetrasodium pyrophosphate solution. R2 broth was utilized as rich liquid growth medium

## Chemical composition of reclaimed water



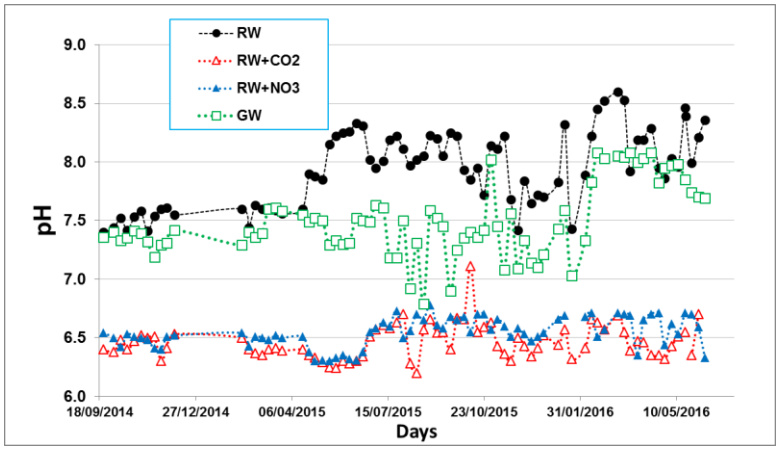






## Water quality parameters comparision between maintenance treatments

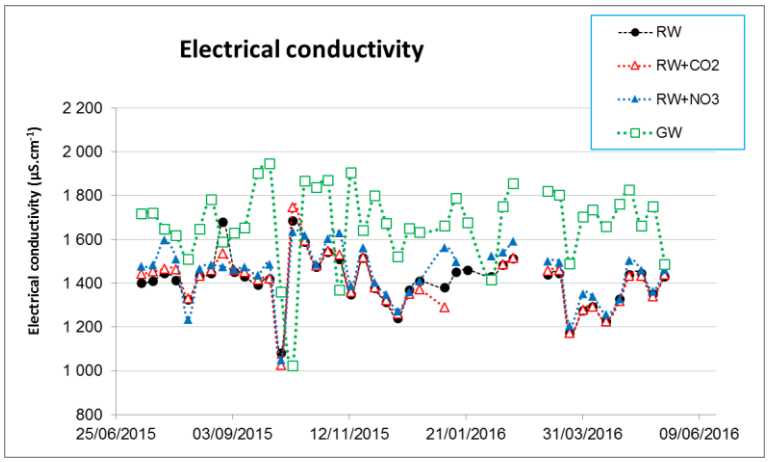
| Water quality parameters | RW | RW+$CO_2$ | RW+$NO_3$ | GW |
|---|---|---|---|---|
| Electrical Conductivity 25ºC (dS.m$^{-1}$) | 1.6 | 1.9 | 1.8 | 2.0 |
| pH | 8.2 | 6.8 | 6.8 | 7.1 |
| Bicarbonate (mg.l-1) | 222.7 | 281.3 | 203.8 | 209.3 |
| Carbonates (mg.l-1) | 28.2 | 3.0 | 3.0 | 3.0 |
| Nitrate (mg.l-1) | 15.7 | 14.6 | 95.6 | 445.3 |
| Phosphorus (mg.l-1) | 3.3 | 3.5 | 3.4 | 0.07 |
| Potassium (mg.l-1) | 20.6 | 20.0 | 19.8 | 6.7 |
| Calcium (mg.l-1) | 77.5 | 79.5 | 78.3 | 215.3 |
| Magnesium (mg.l-1) | 21.2 | 20.8 | 20.5 | 55.0 |
| Sodium (mg.l-1) | 171.5 | 167.2 | 167.0 | 30.8 |
| Sulfate (mg.l-1) | 76.3 | 63.5 | 59.3 | 79.9 |
| Chloride (mg.l-1) | 247.9 | 242.4 | 244.0 | 118.3 |

## Results : water pH evolution

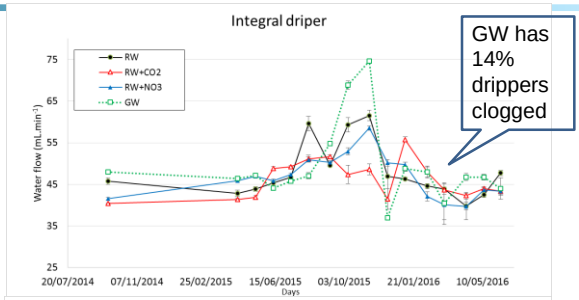


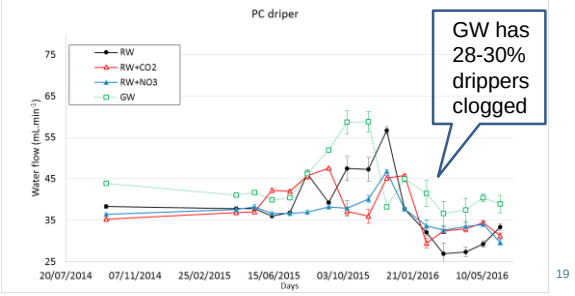



## Results: Electrical conductivity



## Evolution of water flow in integral drippers line and PC dripper



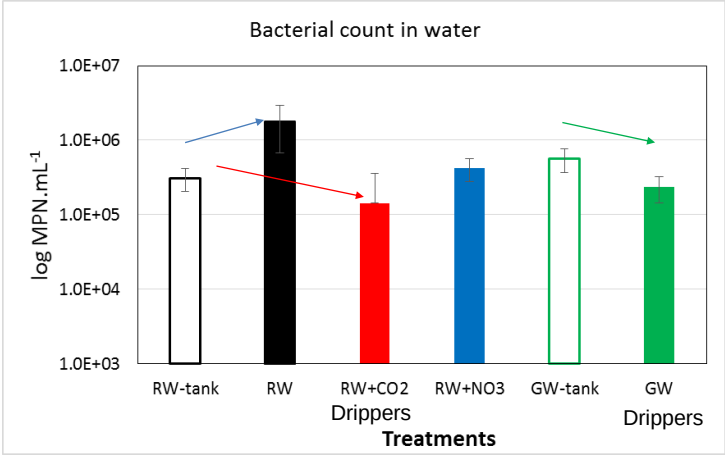






## Quality characteristics

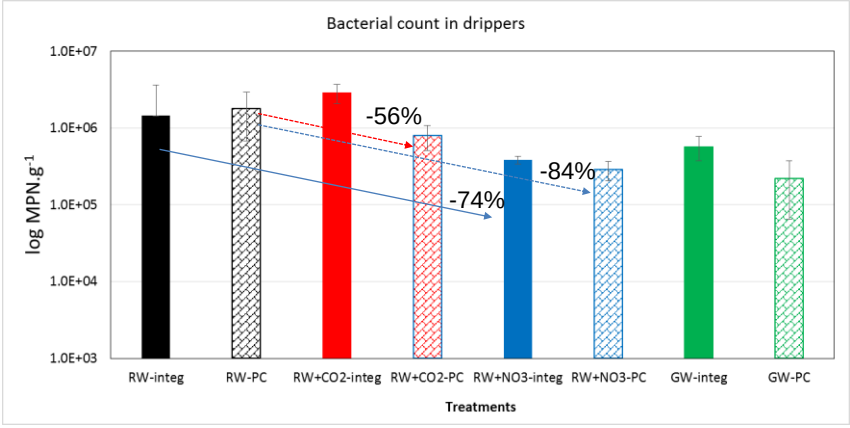
| Quality parameters | units | April 2016 | May 2016 |
|---|---|---|---|
| **Total suspended solids** | (mg.L$^{-1}$) | <1.5 | < 2 |
| **Turbidity** | (NTU) | 9.5± 1.8 | 0.8± 0.1 |
| **TOC** | (mgC.L$^{-1}$) | 4.7 | 6.2 |
| **DBO** | (mgO2.L$^{-1}$) | | 2 |
| **TIC** | (mg.L$^{-1}$) | | 45.6 |
| | | | |
| **Total heterotrophic bacteria** | (CFU.mL$^{-1}$) | 4.60E+04 | 1.14E+06 |
| **Clostridium perfringens** | (CFU.mL$^{-1}$) | 0 | |
| **E.Coli** | (CFU.mL$^{-1}$) | 0 | |
| **Taenia spp.** | (egg.10 L$^{-1}$) | < 1 | |
| **Helmint eggs** | (egg.10 L$^{-1}$) | < 1 | |
| **Coliforms** | (CFU.mL$^{-1}$) | 0 | |
| **Protozoa (Giardia spp. and Cryptosporidium)** | | x | |
| **Somatic coliphages** | | x | |
| **Viruses (enterovirus, adenovirus, norovirus, rotavirus)** | | x | |

## Bacterial count in the water: tank and drippers






## Bacterial count into the drippers



## Conclusions

- Twenty months of treatment, operating in total 137 hours, there has been biofilm grow in the pipes and drippers.
- We have not detected an significant increase of water pressure differences between the in and out of the irrigation pipes in RW.
- In the groundwater drippers there were clogging (30% of drippers). These clogging cause an increase of pressure and water flow in the remaining drippers.
- Reclaimed water kept in the tank during three weeks showed an increment of the pH, then we have to adjust $CO_2$ injection and nitric acid dosification.



## Conclusions

• Mean bacterial count in reclaimed water was 4.2E+3 CFU.mL$^{-1}$ and standard error of 1.4E+5.

• Bacterial count in the RW-$NO_3$ drippers showed differences with respect RW drippers (-74 and -84% in integral and PC drippers).

•We will determine the bacterial community composition in order to see if there are differences due to nitric acid or $CO_2$ treatment.

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# Thank you!!!

Carmen.Biel@irta.cat