

LUNCH & LEARN WEBINAR SERIES

Irrigation Water Treatment 101

November 14th, 2019



WEBINAR LOGISTICS

- Everyone is muted.
- Questions will be addressed during the Q&A session at the end of the presentation.
- This presentation is being recorded.
- The recording/slides will be available to WG members only.
- Adjourn (60 minutes).
- There will be 3 important survey questions at the conclusion of this webinar. Your responses will be appreciated.

Presenter



Ana Allende

Expert Researcher on Fresh Produce Safety

CSIC - Centro de Edafología y Biología Aplicada del Segura (CEBAS)

Quick Poll

Please take a minute to answer the following two questions

14th November 2019

 **CSIC**

Quality, Safety and Bioactivity
of plant foods

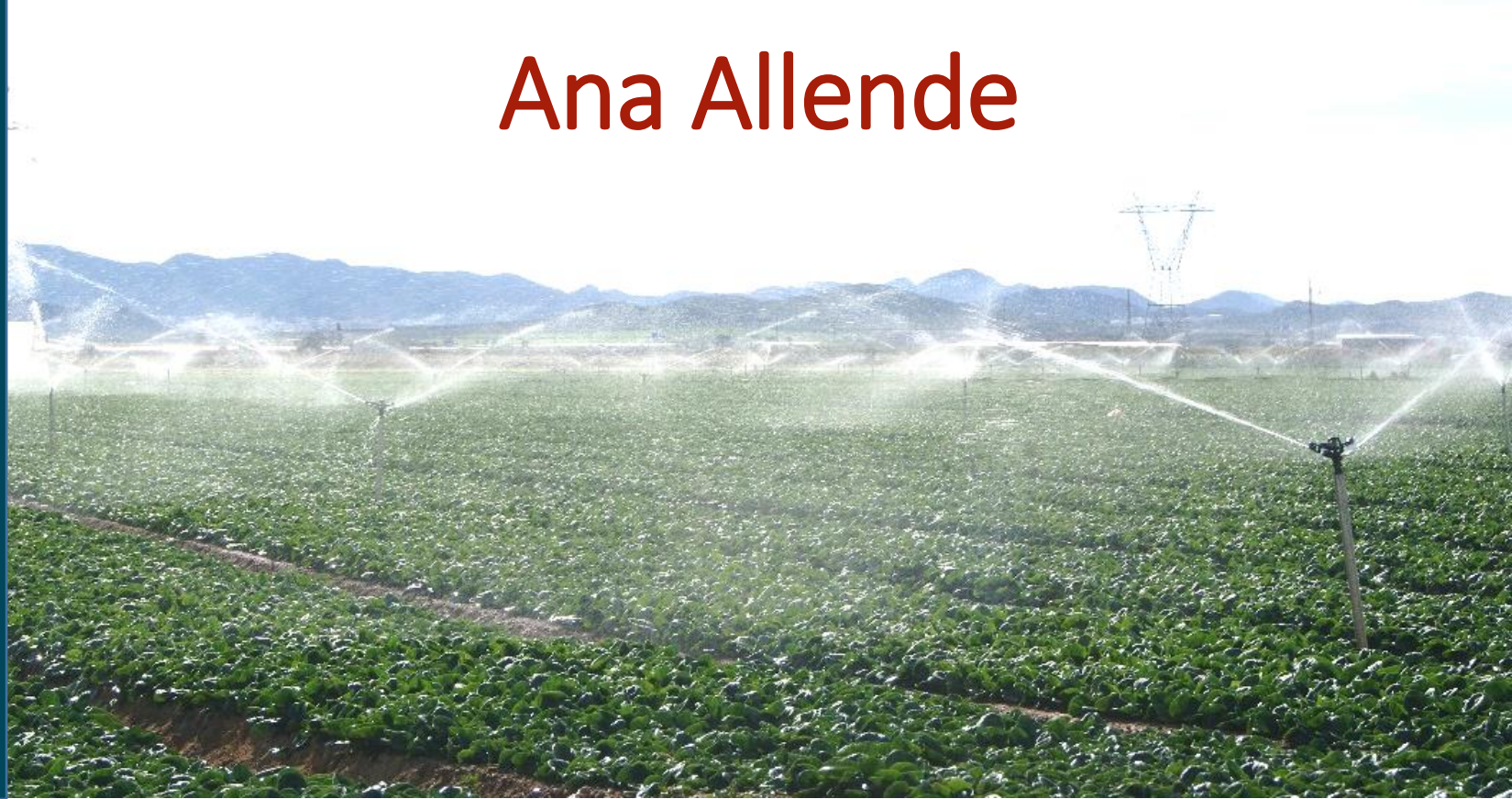


aallende@cebas.csic.es



Webinar on Irrigation Water Treatment

Ana Allende





Why Water Treatment?



Risks Linked to Irrigation Water in Leafy Green Production



WHO



- Primary production is probably the main concern in terms of introduction of microbial hazards
- Postharvest practices provide many opportunities for amplification of microbial hazards

Review papers have summarized the likely source of contamination of fresh produce

(Uyttendaele et al., 2015; Allende and Monaghan, 2015)

Int. J. Environ. Res. Public Health **2015**, *12*, 7457-7477; doi:10.3390/ijerph120707457

OPEN ACCESS

International Journal of
Environmental Research and
Public Health

ISSN 1660-4601

www.mdpi.com/journal/ijerph

Article

Irrigation Water Quality for Leafy Crops: A Perspective of Risks and Potential Solutions

Ana Allende ¹ and James Monaghan ^{2,*}

Comprehensive
REVIEWS
in Food Science and Food Safety

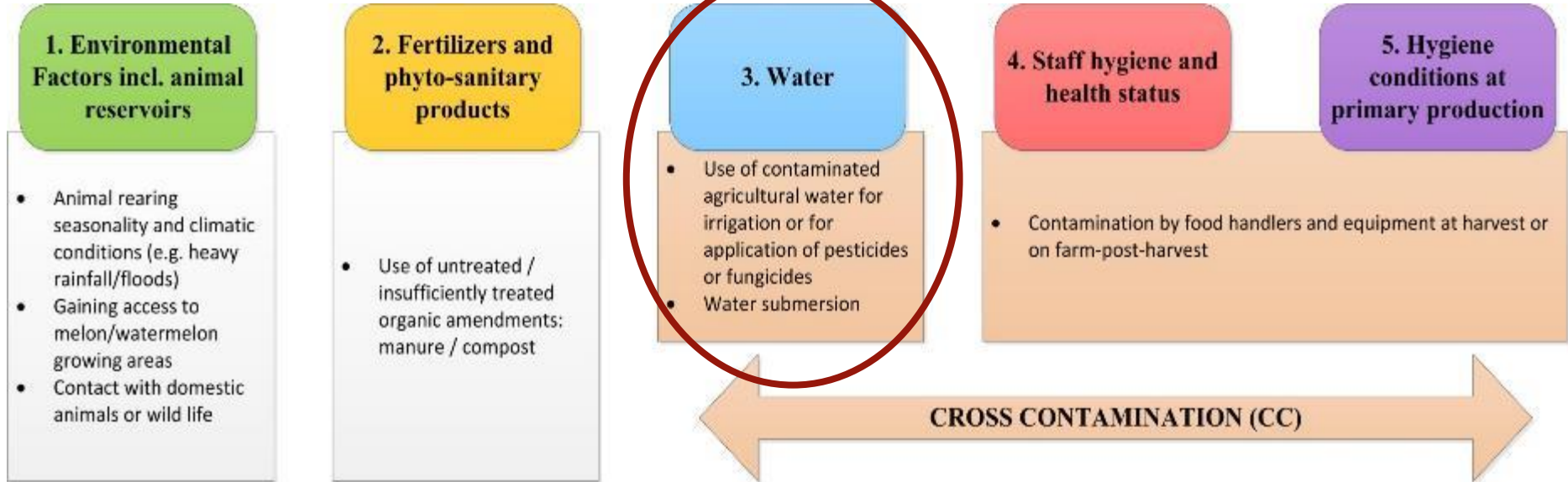
Microbial Hazards in Irrigation Water: Standards, Norms, and Testing to Manage Use of Water in Fresh Produce Primary Production

Mieke Uyttendaele, Lee-Ann Jaykus, Philip Amoah, Alessandro Chiodini, David Cunliffe, Liesbeth Jacxsens, Kevin Holvoet, Lise Korsten, Mathew Lau, Peter McClure, Gertjan Medema, Imca Sampers, and Pratima Rao Jasti

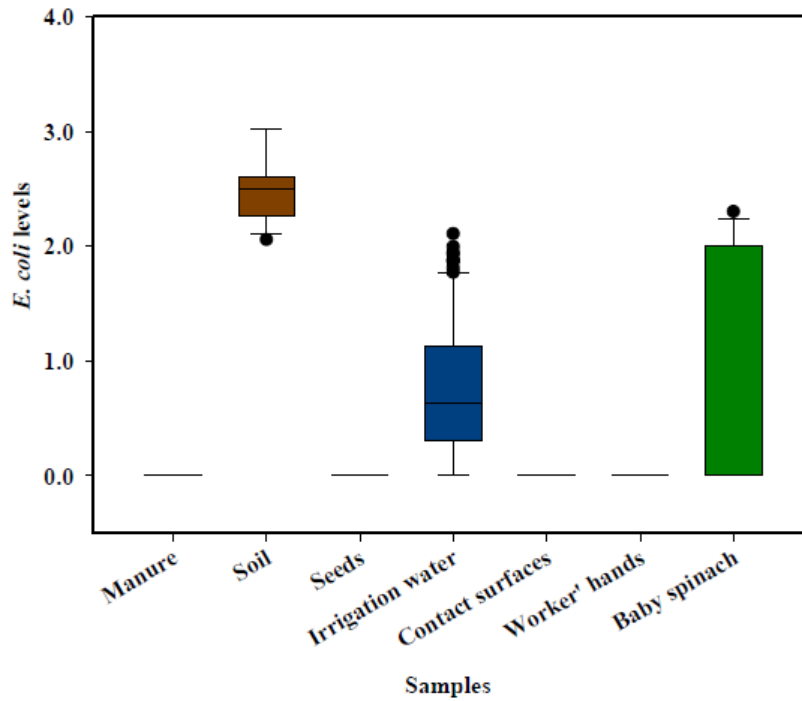
Guidance document on addressing microbiological risks in fresh fruits and vegetables at primary production through good hygiene



Why Water Treatment?

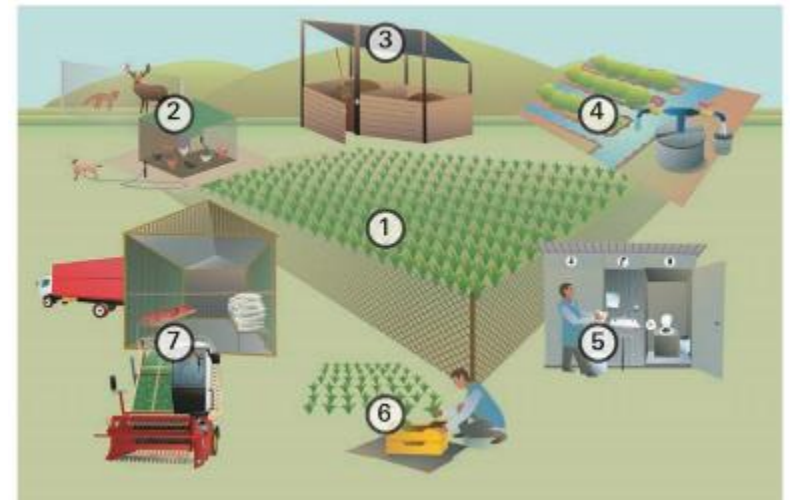


Risks Linked to Irrigation Water in Leafy Green Production



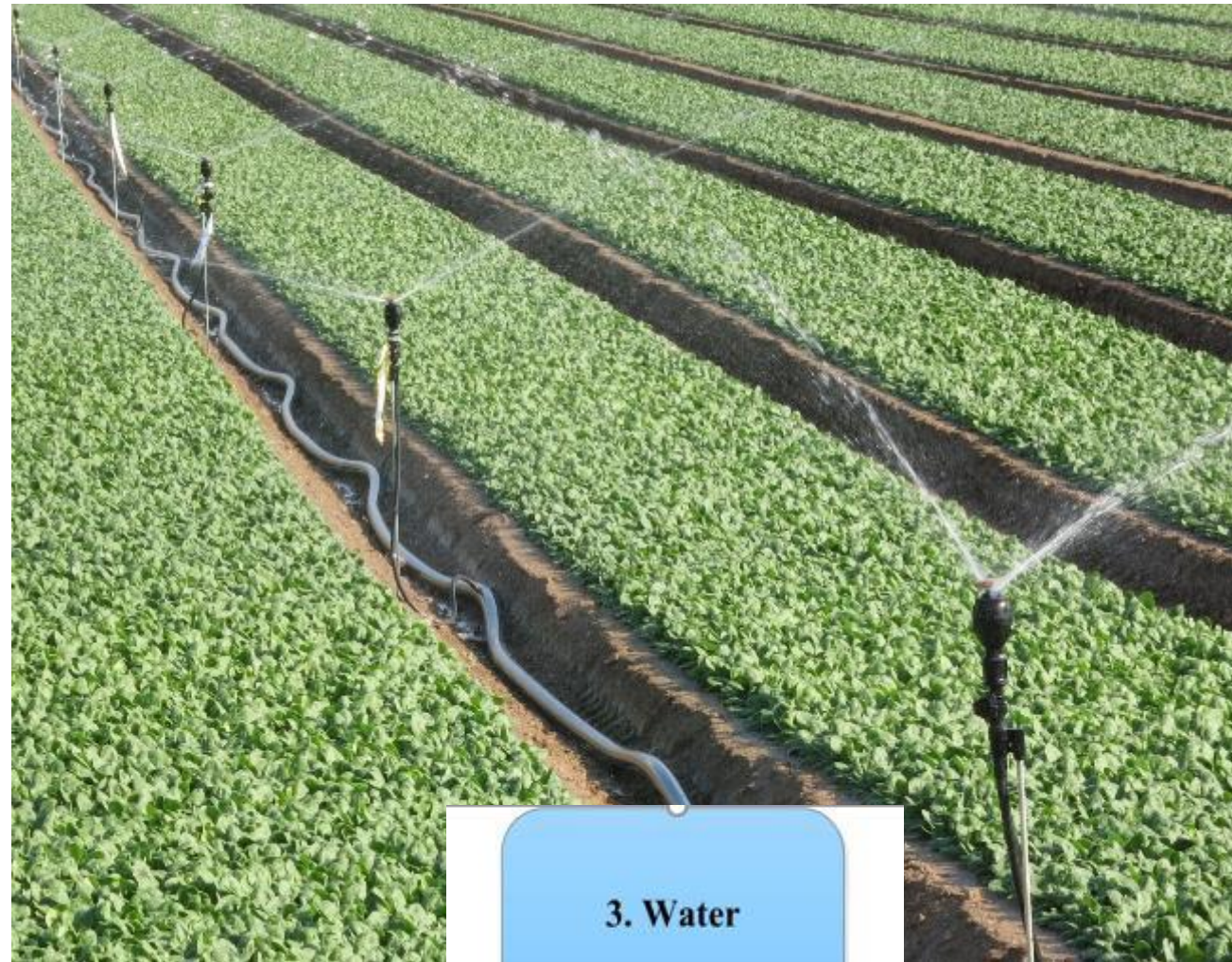
Type of sample	Amount	Positives <i>Salmonella</i> - STEC
Produce	1379	23 (1.7%)
Water	950	54 (5.7%)
Soil	1186	16 (1.3%)
Fertilizers	54	2 (3.7%)
Contact surface	72	0 (0%)
Seeds	18	0 (0%)

Why Water Treatment?





Why Water Treatment?



3. Water

- Use of contaminated agricultural water for irrigation or for application of pesticides or fungicides
- Water submersion



Frequently Asked Questions



Why
Water Treatment?

- **Water Sources** (e.g. wells, canals, reservoirs...)
- **The recommended microbiological threshold values**
- **Suitability for agricultural purposes** (e.g. intended use...),
- **Frequency of monitoring**
- **Corrective actions**



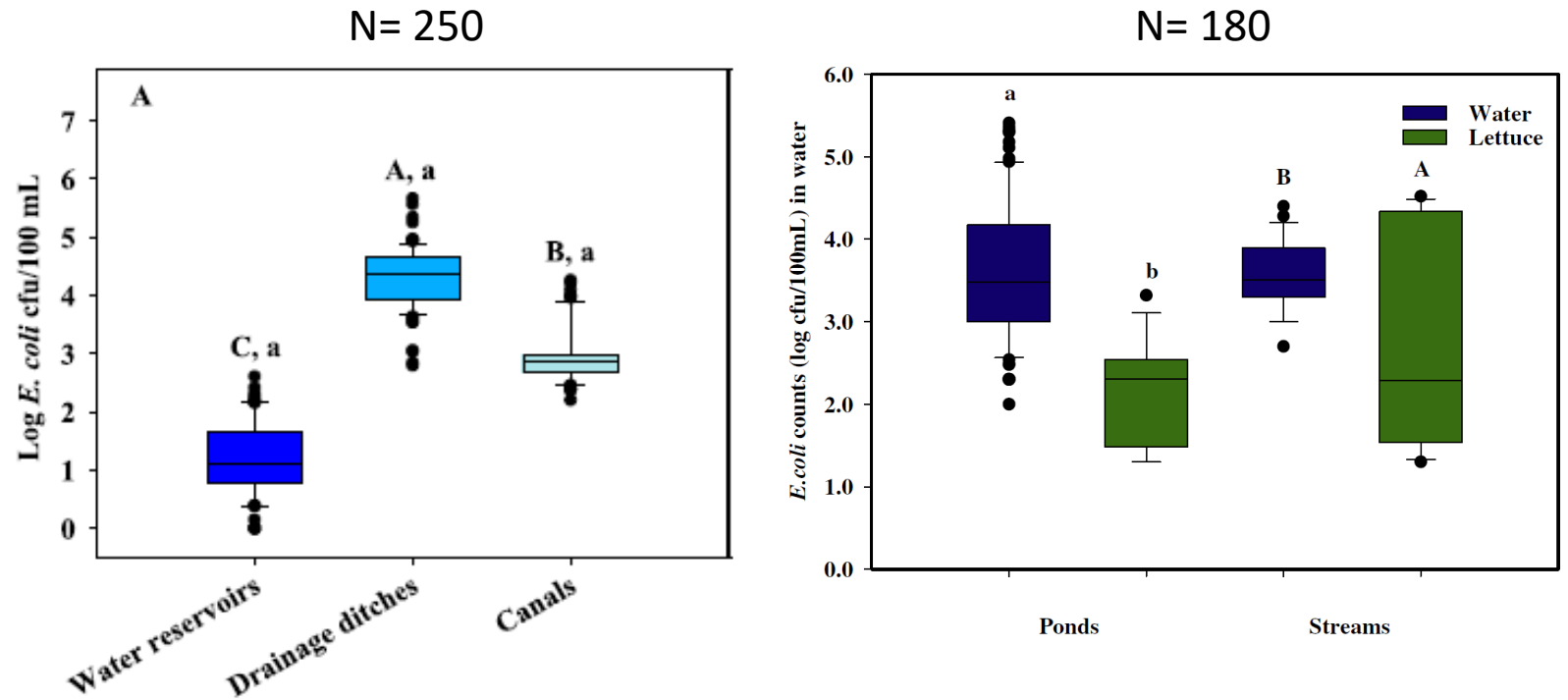
Risks Linked to Irrigation Water in Leafy Green Production



Why
Water Treatment?



Water Sources

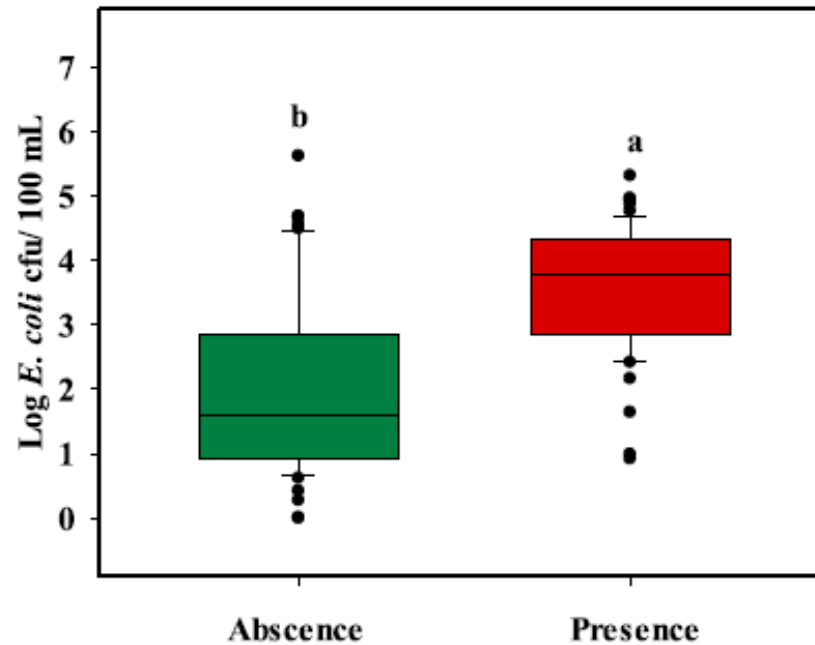


P. Truchado et al. / Water Research 128 (2018) 226-233
Tombini Decol et al., / Food Microbiology 65 (2017) 105-113



Risks Linked to Irrigation Water in Leafy Green Production

The recommended microbiological threshold values



The *E. coli* level of **2.35 log cfu/100 mL** was identified as a cut-off.

- For the samples with levels of *E. coli* under 2.35 log cfu/100 mL there was a 90% probability that the samples were not contaminated with pathogenic microorganism.
- Almost three quarters of samples contaminated with *E. coli* at levels above 2.24 cfu/100 mL were also contaminated with pathogenic microorganisms.

A classification tree analysis was used to determine the cut-off level of *E. coli* with the smallest misclassification error.

Why
Water Treatment?



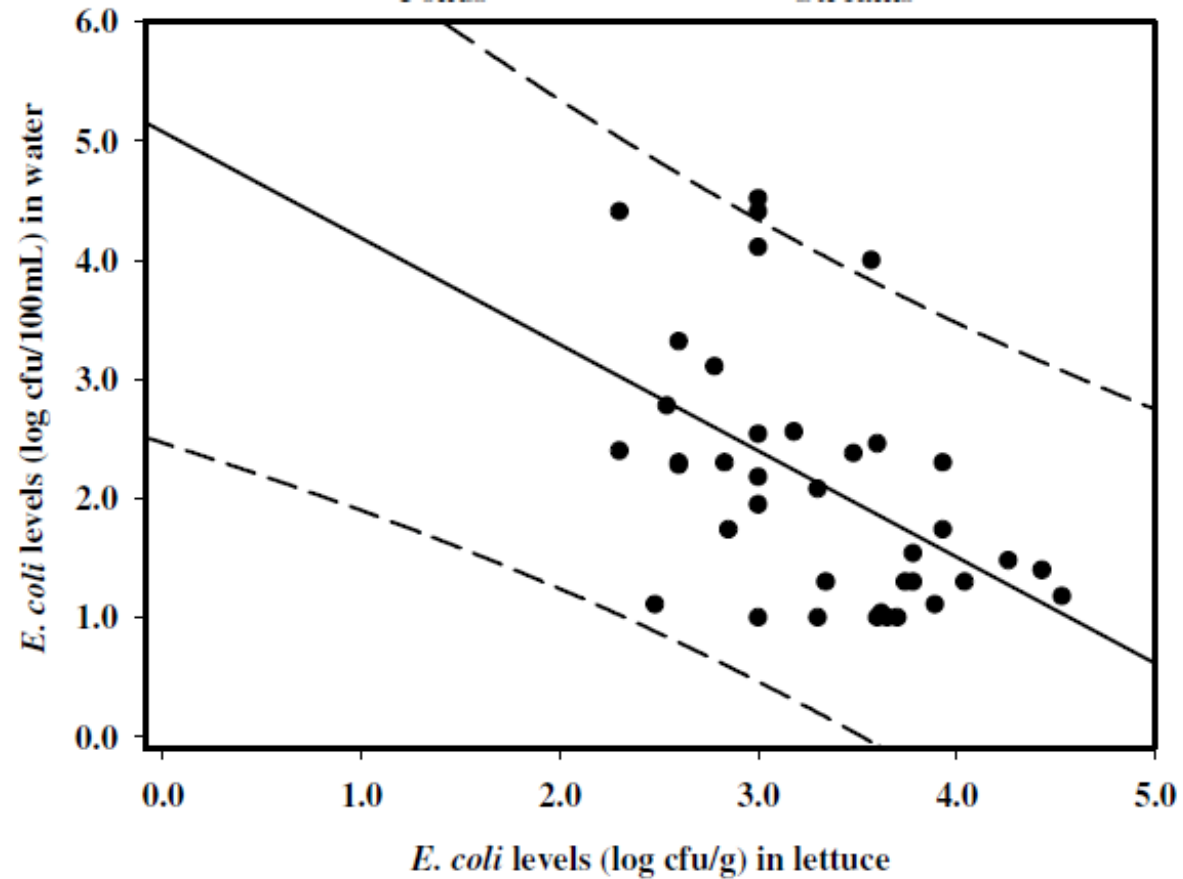


Why
Water Treatment?



Risks Linked to Irrigation Water in Leafy Green Production

Suitability for Agricultural Purposes



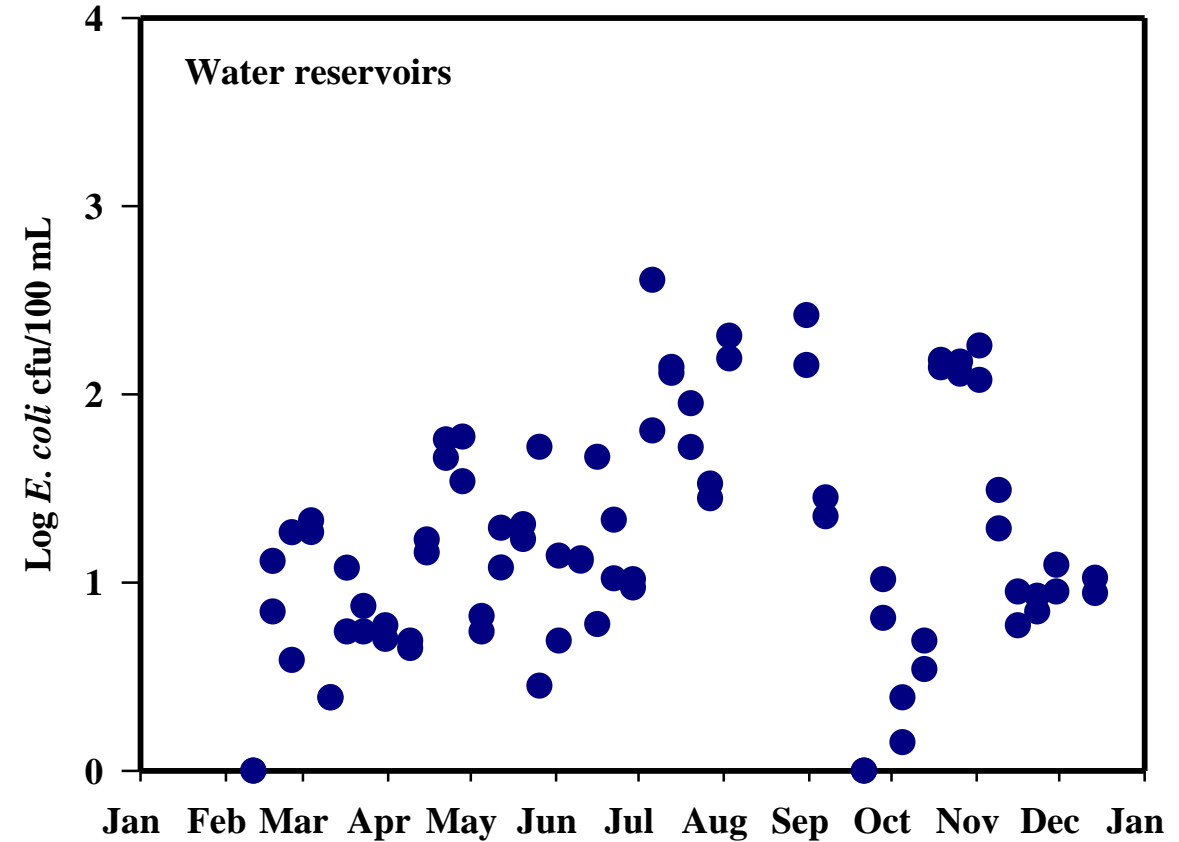
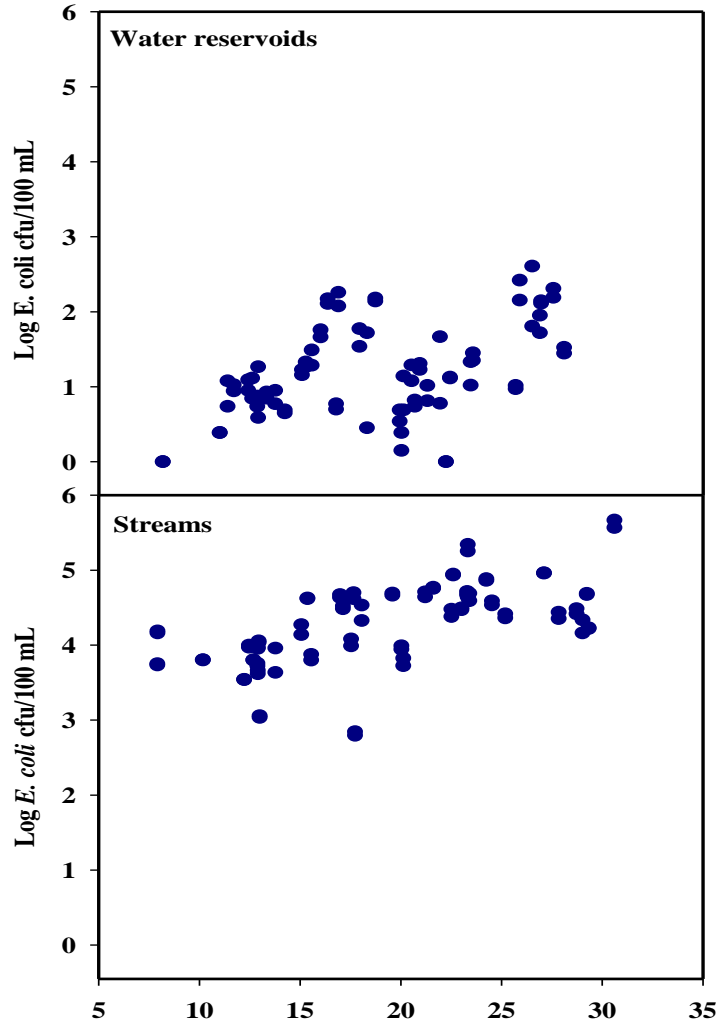
Tombini Decol et al., / Food Microbiology 65 (2017) 105-113

Risks Linked to Irrigation Water in Leafy Green Production

Frequency of Sampling



Why
Water Treatment?



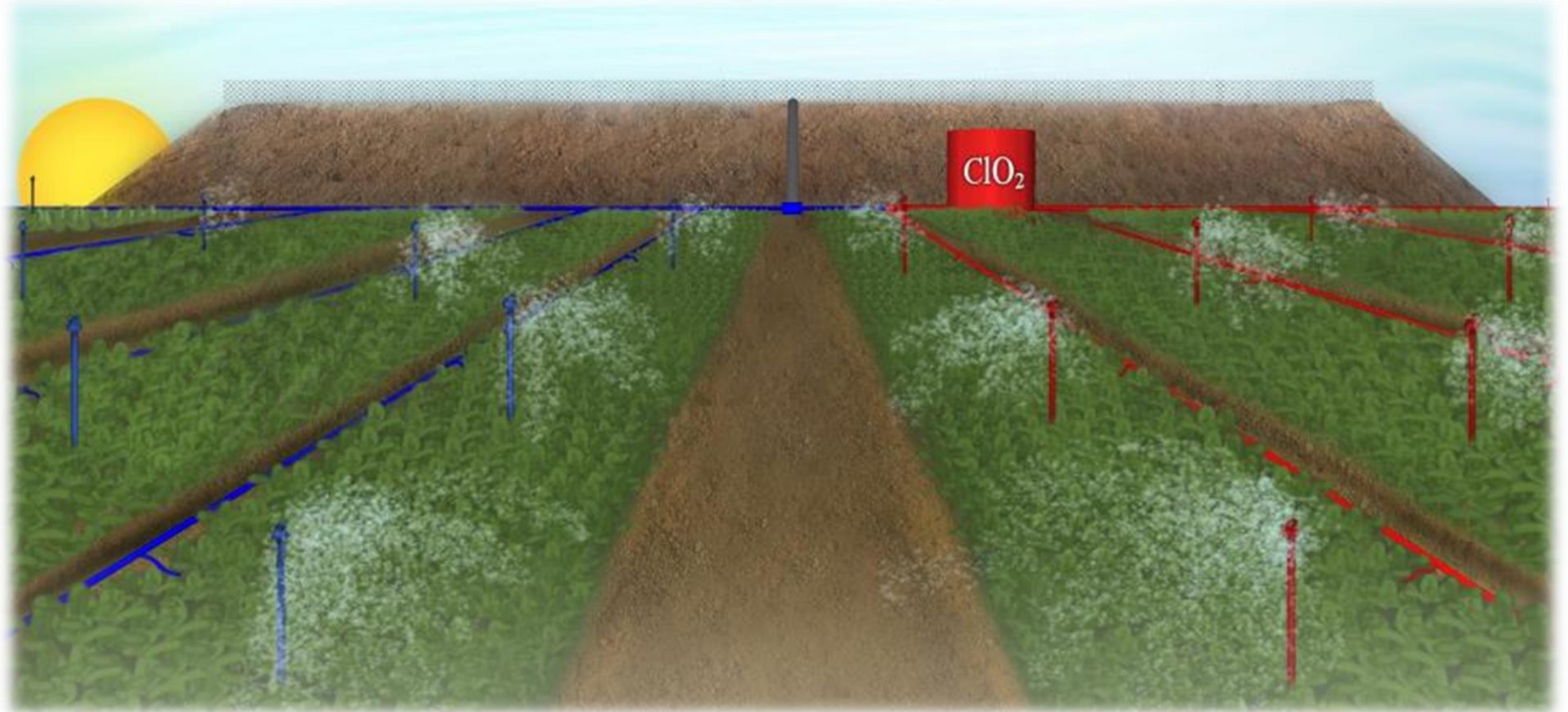


Risks Linked to Irrigation Water in Leafy Green Production

Corrective Actions



Why
Water Treatment?





Why Water Treatment?



ARIZONA LGMA

August 29, 2019

COMMODITY SPECIFIC FOOD SAFETY GUIDELINES FOR THE PRODUCTION AND HARVEST OF LETTUCE AND LEAFY GREENS



COMMODITY SPECIFIC FOOD SAFETY GUIDELINES FOR THE PRODUCTION AND HARVEST OF LETTUCE AND LEAFY GREENS

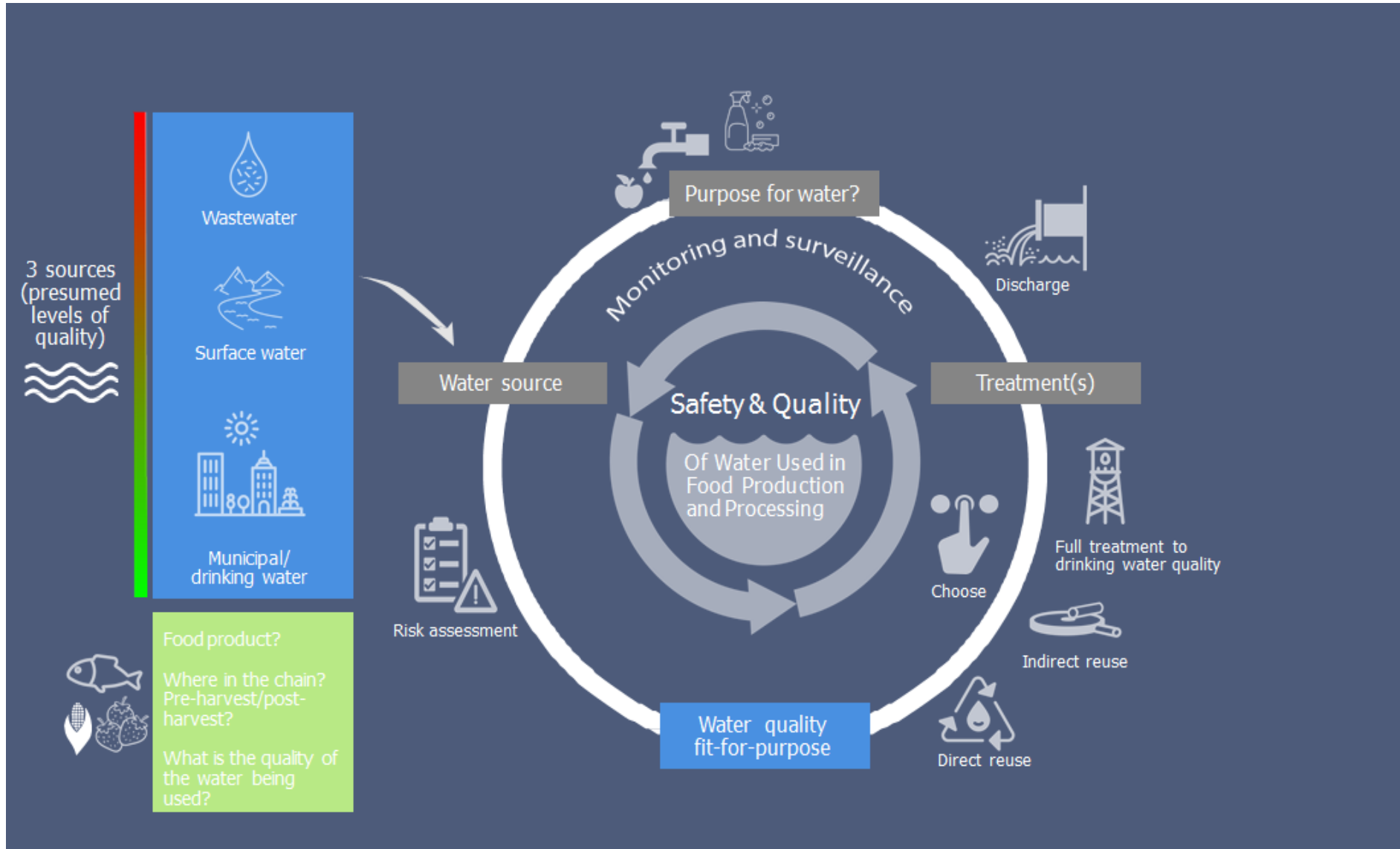


OCTOBER 24, 2019
This document supersedes all previously published versions of the Commodity Specific Food Safety Guidelines for the Production and Harvest of Leafy Greens including those dated March 23, 2007, April 18, 2007, June 5, 2007, October 16, 2007, June 13, 2008, July 10, 2009, January 29, 2010, August 4, 2010, July 22, 2011, January 20, 2012, August 31, 2012, August 2, 2013, January 29, 2016, August 10, 2017, September 28, 2018, April 19, 2019

Document managed by Western Growers - learn more at www.leafygreenguidance.com



Why Water Treatment?





Why Water Treatment?



Good Practices

Assessment of the Water Source

Assessment of the Water System

Assessment of Where it is Applied

Assessment of How it is Applied

Are Corrective Actions Needed?

General Agricultural Water Management



NEVER use water from any water source that has not been microbially characterized.

Why
Water Treatment?



It can be assume that is not suitable
and then water treatment is needed



Why
Water Treatment?

Classification of Water Sources

...Where it can be used

...When it can be used

...How it can be used





Why Water Treatment?



Official Journal of the European Union

C 163



English edition

Information and Notices

Volume 60
23 May 2017

Contents

IV Notices

NOTICES FROM EUROPEAN UNION INSTITUTIONS, BODIES, OFFICES AND AGENCIES

2017/C 163/01

Commission notice on guidance document on addressing microbiological risks in fresh fruits and vegetables at primary production through good hygiene

1

“A risk assessment should be carried out considering the source and the intended use of agricultural water (e.g. irrigation system, FFV characteristics, intended use of FFV...), defining the suitability for agricultural purposes, the recommended microbiological threshold values and the frequency of monitoring “.



Why Water Treatment?



Intended use of the water	Source of water ⁽¹⁾						Indicator of faecal contamination: <i>E. coli</i> ⁽²⁾
	Untreated surface water/open water channels ⁽³⁾	Untreated ground water collected from wells ⁽⁴⁾	Untreated Rain water	Treated ⁽⁵⁾ sewage/surface/waste water/water reuse	Disinfected water ⁽⁶⁾	Municipal water	
PRE-HARVEST and HARVEST							
Irrigation of FFVs likely to be eaten <u>uncooked</u> (i.e. ready-to-eat FFV) (irrigation water <u>comes into direct contact with the edible portion</u> of the FFV) Dilution or application of pesticide, fertiliser or agrochemicals and cleaning equipment for ready-to-eat FFV and direct contact.	x	x	▲	●	●	√	100 CFU/100 ml
Irrigation of FFVs likely to be eaten <u>uncooked</u> (i.e. ready-to-eat FFV) (irrigation water <u>does not come into direct contact</u> with the edible portion of the FFV) Dilution or application of pesticide, fertiliser or agrochemicals and cleaning equipment for ready-to-eat FFV and no direct contact	x	x	▲	●	●	√	1 000 CFU/100 ml (?)
Irrigation of FFVs likely to be eaten <u>cooked</u> (irrigation water <u>comes into direct contact with the edible portion</u> of the FFV). Dilution or application of pesticide, fertiliser or agrochemicals and cleaning equipment used in this FFV direct contact).	▲	▲	●	●	●	√	1 000 CFU/100 ml
Irrigation of FFVs likely to be eaten <u>cooked</u> (irrigation water <u>does not come into direct contact with the edible portion</u> of the FFV). Dilution or application of pesticide, fertiliser or agrochemicals and cleaning equipment used in this FFV (no direct contact)	●	●	√	√	√	√	10 000 CFU/100 ml
POST-HARVEST							
Post-harvest cooling and post-harvest transport for non-ready-to-eat FFVs. Water used for first washing of products in case of ready-to-eat products. Cleaning equipment and surfaces where the products are handled.	x	x	▲	●	●	√	100 CFU/100 ml



Why Water Treatment?



Brussels, 28.5.2018
COM(2018) 337 final
2018/0169 (COD)

Proposal for a

REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

on minimum requirements for water reuse



Why Water Treatment?



ANNEXES

to the

Proposal for a Regulation of the European Parliament and of the Council

on minimum requirements for water reuse

Table 2 Reclaimed water quality requirements for agricultural irrigation

Reclaimed water quality class	Indicative technology target	Quality requirements				
		<i>E. coli</i> (cfu/100 ml)	BOD ₅ (mg/l)	TSS (mg/l)	Turbidity (NTU)	Other
A	Secondary treatment, filtration, and disinfection	≤10 or below detection limit	≤10	≤10	≤5	<i>Legionella</i> spp.: <1,000 cfu/l where there is risk of aerosolization in greenhouses Intestinal nematodes (helminth eggs): ≤1 egg/l for irrigation of pastures or forage
B	Secondary treatment, and disinfection	≤100	According to Council Directive 91/271/EEC ¹ (Annex I, Table 1)	According to Directive 91/271/EEC (Annex I, Table 1)	-	
C	Secondary treatment, and disinfection	≤1,000			-	
D	Secondary treatment, and disinfection	≤10,000	-			



Why
Water Treatment?

APPENDIX A: Ag Water System Assessments and Remediation Guidelines

Overhead irrigation Type B water <21 days before harvest.....
must be treated”

- Treat water only with antimicrobial treatments approved by the USEPA for use in agricultural applications in accordance with label specifications, guidelines for use, and consideration of environmental impacts.
- Antimicrobial treatments must be used and managed in a manner that meets all federal, state, and local regulations.





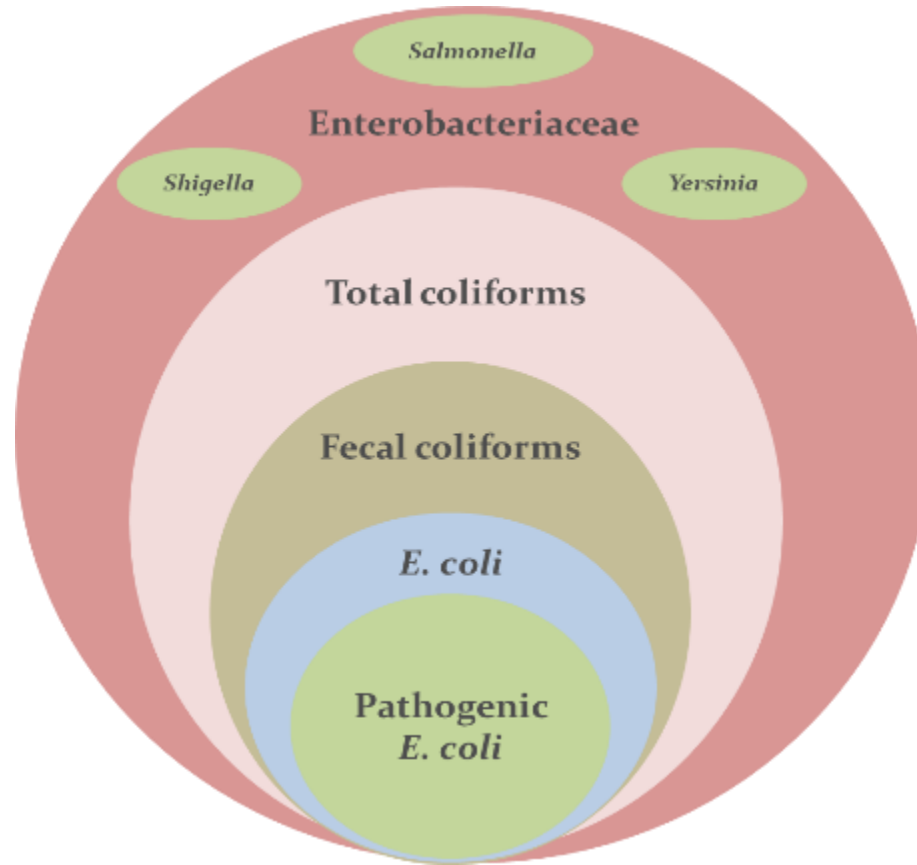
Target Microorganisms



Why Water Treatment?



COLIFORMS	Gram-negative, non-spore-forming, rod-shaped bacteria that ferment lactose to gas. They are frequently used as indicators of process control but exist broadly in nature.
ESCHERICHIA COLI (E. COLI)	<i>Escherichia coli</i> are common bacteria that live in the lower intestines of animals (including humans) and are generally not harmful. <i>E. coli</i> are frequently used as an indicator of fecal contamination but can be found in nature from non-fecal sources.
FECAL COLIFORMS	Coliform bacteria that grow at elevated temperatures and may or may not be of fecal origin. Useful to monitor effectiveness of composting processes. Also called "thermotolerant coliforms."



Total coliforms are often used to validate performance of treatment and the quality of the final water source.



Water must be treated



Application	Agricultural water systems (possible sources)	Treatment methods for use in direct contact with crop	Microbial indicator
<ul style="list-style-type: none"> Overhead applications (including irrigation, pesticide spray, aerial chemigation) applied within (\leq) 21 days of scheduled harvest date 	Treated Type B \rightarrow A agricultural water systems with open components such as reservoirs, ponds, canals, laterals, ditches, etc.	Must be treated and tested to demonstrate treatment efficacy and compliance with microbial standards.	generic <i>E. coli</i> and total coliforms

Remediation by Water Treatment

Agricultural Water Treatment Systems

There are typically three types of water treatment systems that a grower would employ to meet current LGMA metrics for Agricultural Water Type B to Type A. Category I – Liquid Chemical Injection, Category II – Tablet System, or Category III – Physical Treatment with Pesticide Device.

Liquid Chemical Injection

- Liquid hypochlorite
- Peroxyacetic acid
- Chlorine dioxide
- Hydrogen peroxide
- Liquid Calcium hypochlorite

Physical Treatment with Pesticide Device as referenced by EPA

- Ultraviolet light
- Ozone generator
- Physical filtration (membrane or other media)

Tablet Systems

- Calcium hypochlorite

Why
Water Treatment?





Liquid Chemical Injection

Sodium Hypochlorite

Why
Water Treatment?



© Jim Monaghan (Harper Adams University, UK)





Why
Water Treatment?



Liquid Chemical Injection

Sodium Hypochlorite





Why
Water Treatment?



Liquid Chemical Injection

Sodium Hypochlorite





Liquid Chemical Injection

Chlorine Dioxide



Why
Water Treatment?



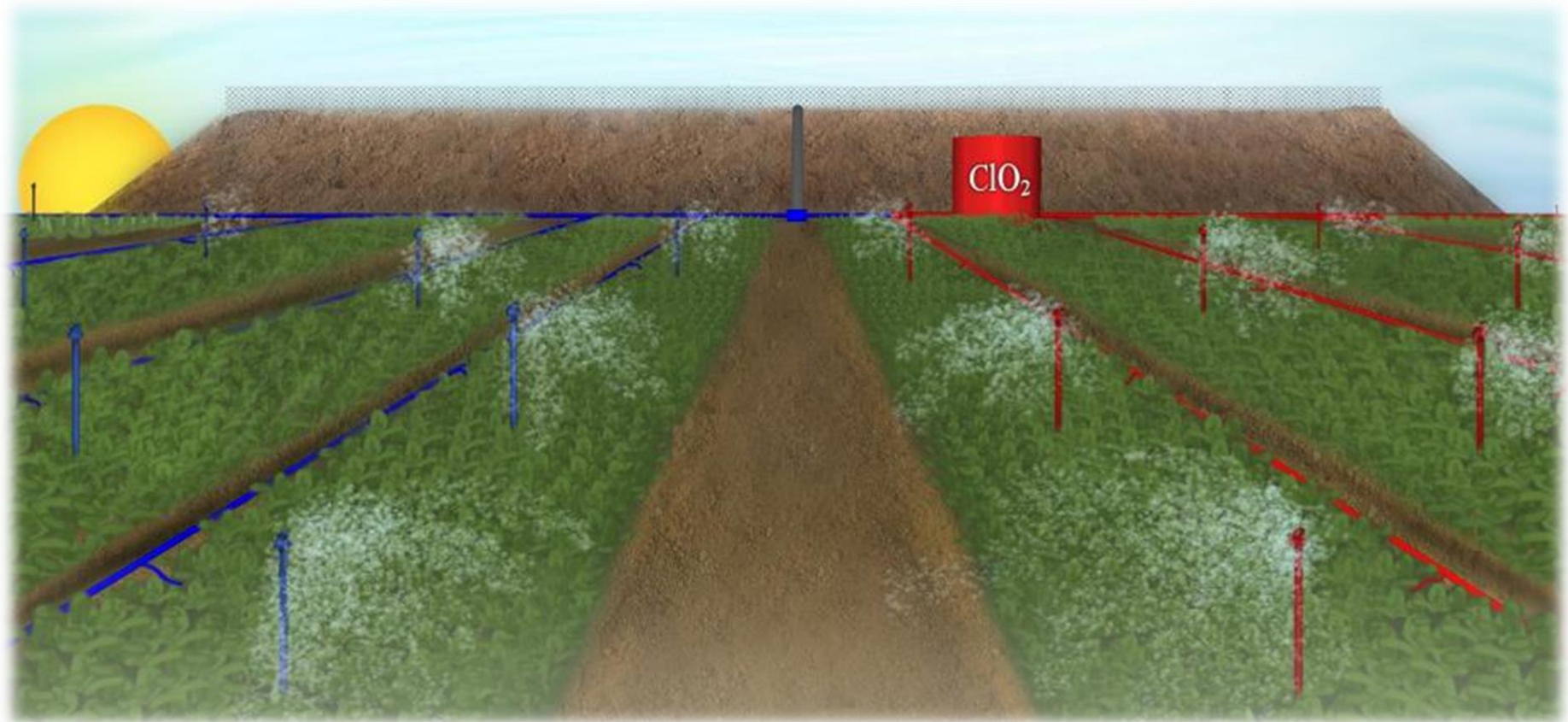


Why
Water Treatment?



Liquid Chemical Injection

Chlorine Dioxide





Why
Water Treatment?



Liquid Chemical Injection

Chlorine Dioxide





Why Water Treatment?



Liquid Chemical Injection

Chlorine Dioxide

Practical Demonstration in Commercial Open Field – Surface water



- **Baby Spinach**
- **Two production sites: 0.5 Ha – 0.8 Ha, 150–200 L ClO₂/growing cycle**
- **Two repetitions: Jan // Mar**
- **Evaluation of *E. coli* and pathogenic microorganisms:**
Natural contamination from the soil and irrigation water
- **Changes in natural microbiota**
- **Presence of disinfection by products: Chlorates**

***Chlorates:** inhibition of thyroid iodine uptake in healthy adults causing problems in young children with low iodine intake*



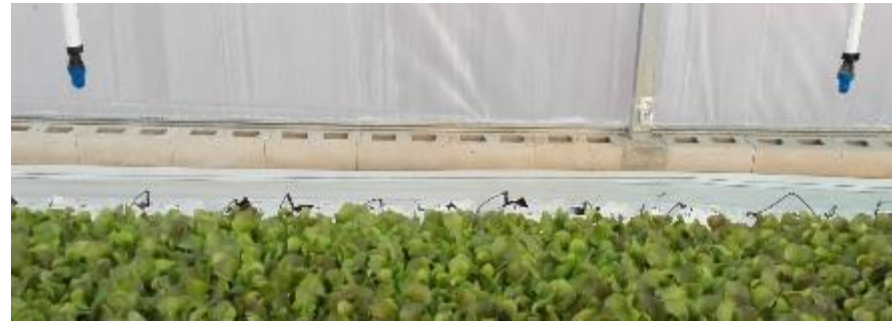
Why
Water Treatment?



Liquid Chemical Injection

Chlorine Dioxide

Practical demonstration in Green House –
Reclaimed water



- **Pigmented baby lettuce**
- **Three growing cycles: July // October // November**
- **Evaluation of *E. coli* and pathogenic microorganisms:**
Natural contamination from the soil and irrigation water
- **Presence of disinfection by products: Chlorates**



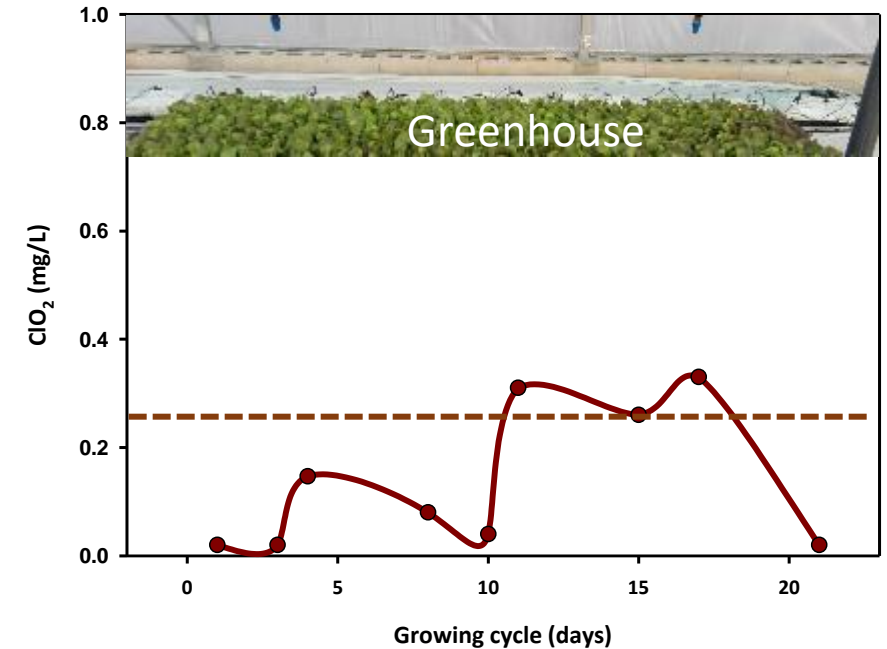
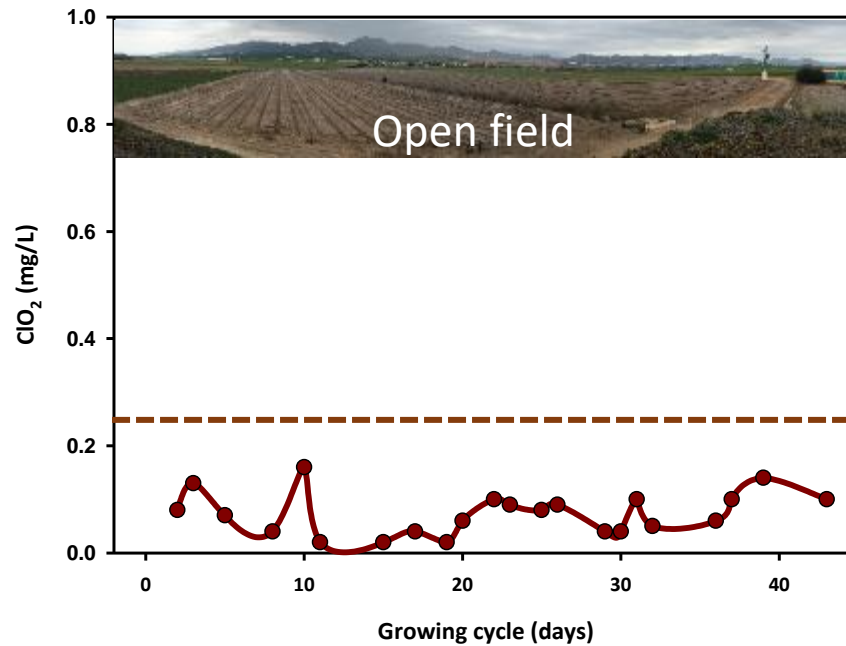
Liquid Chemical Injection

Chlorine Dioxide

Monitorization of the Disinfection Treatment



Why
Water Treatment?



Residual ClO₂ dose in irrigation water below recommended limit of 0.25 ppm

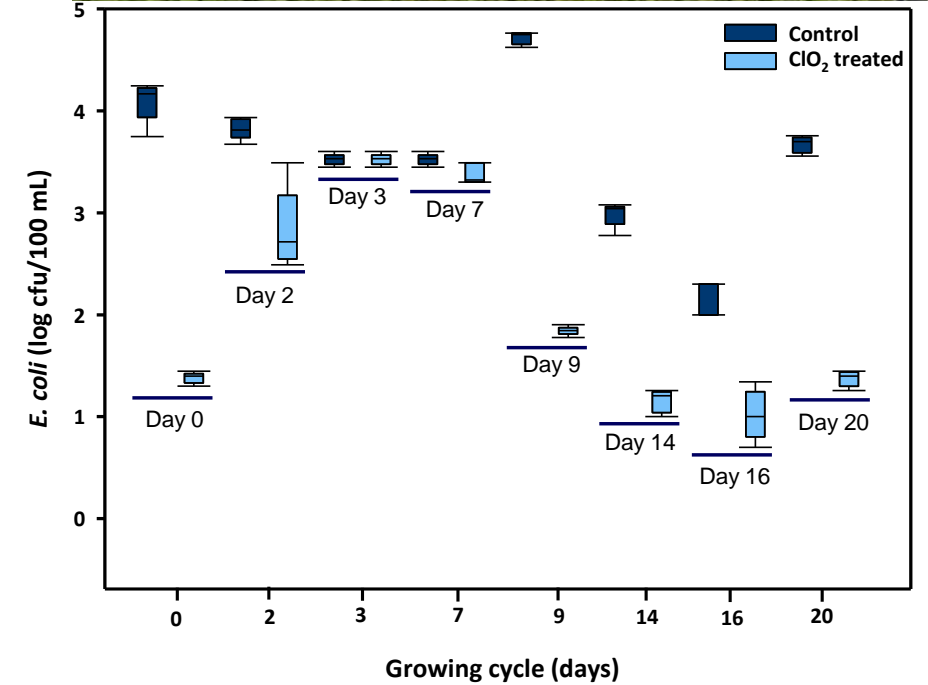
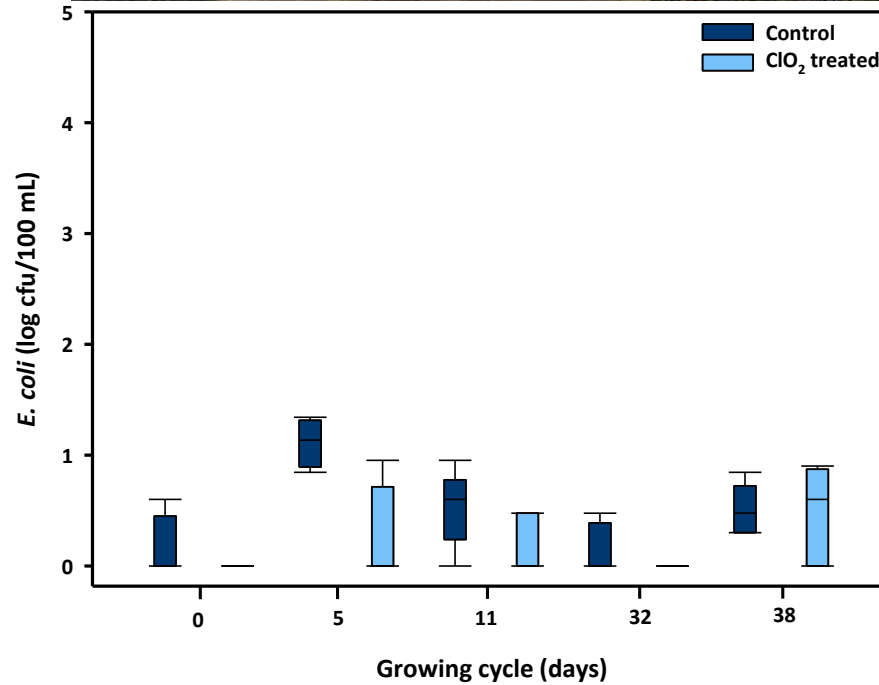
Liquid Chemical Injection

Chlorine Dioxide

Antimicrobial Efficacy of the Disinfection Treatments



Why
Water Treatment?





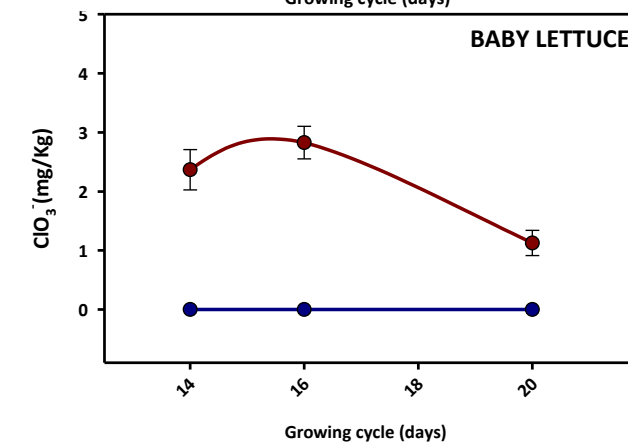
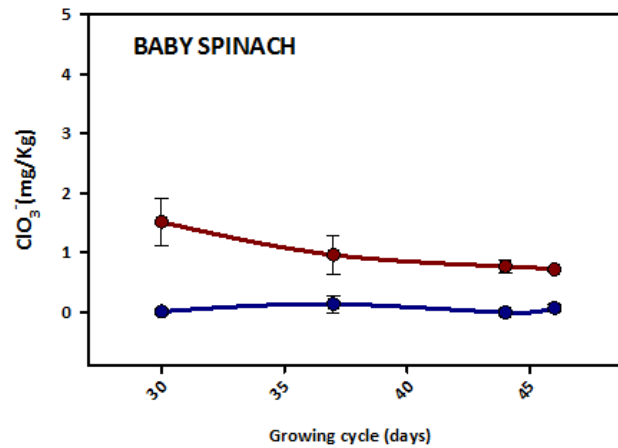
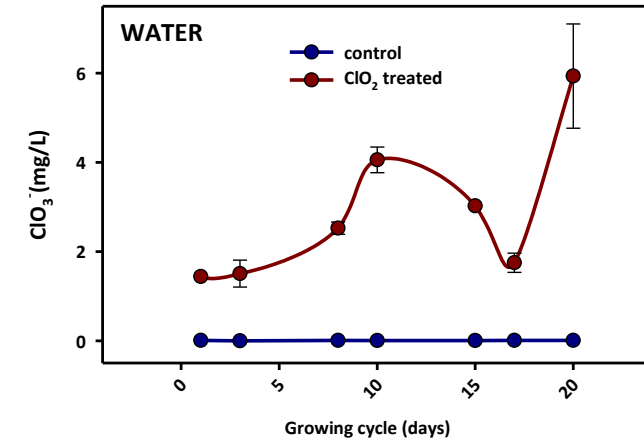
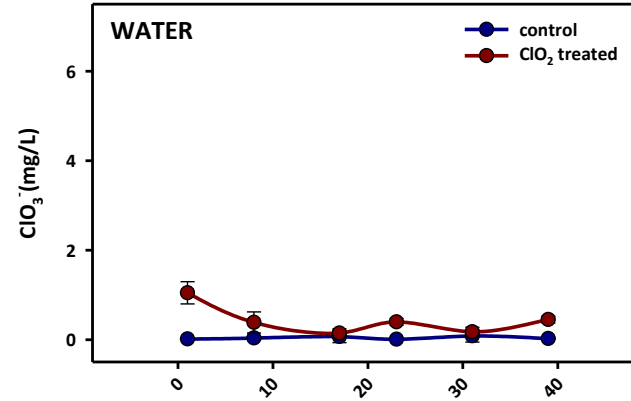
Liquid Chemical Injection

Chlorine Dioxide

Presence of disinfection by-products



Why Water Treatment?





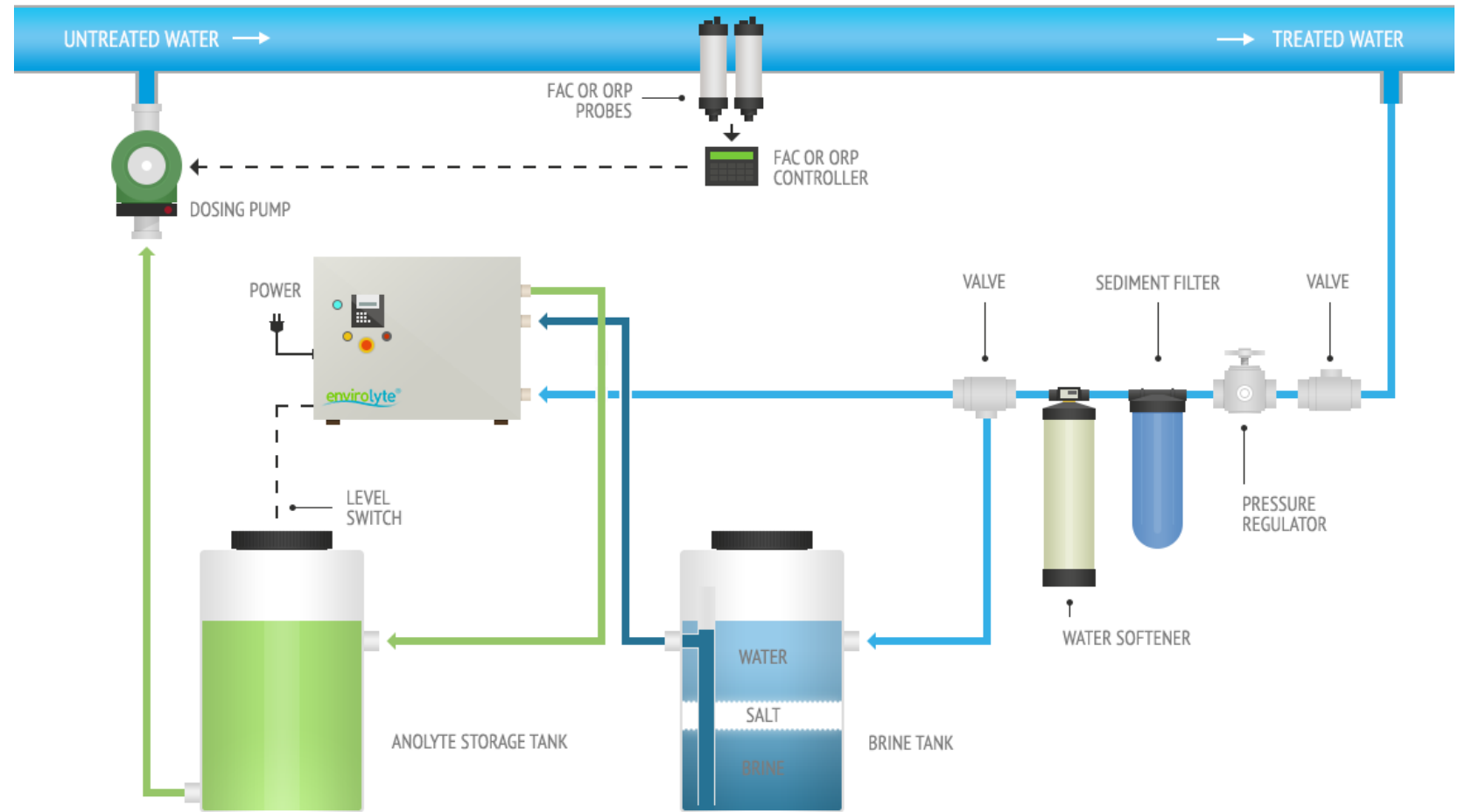
Why
Water Treatment?



Liquid Chemical Injection

Electrolyzed Water

Presence of disinfection by-products





Why
Water Treatment?



Liquid Chemical Injection

Electrolyzed Water



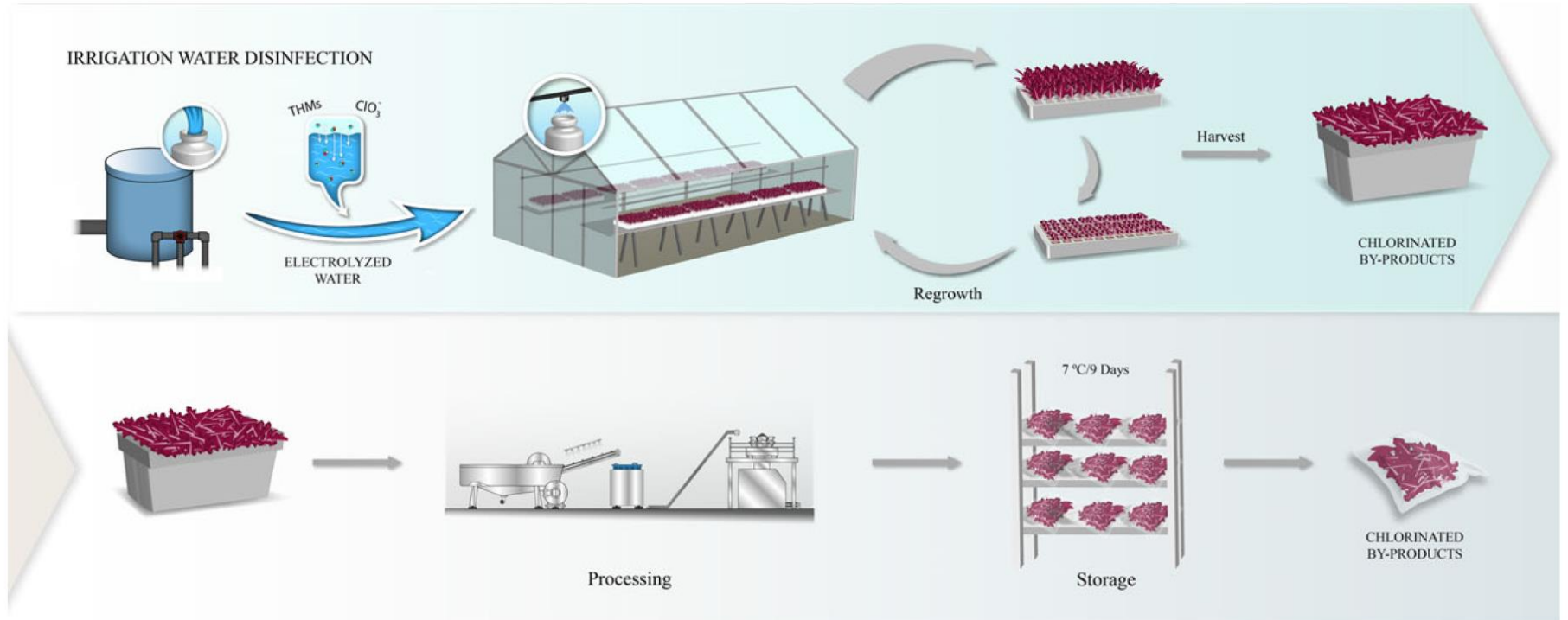


Liquid Chemical Injection

Electrolyzed Water



Why
Water Treatment?



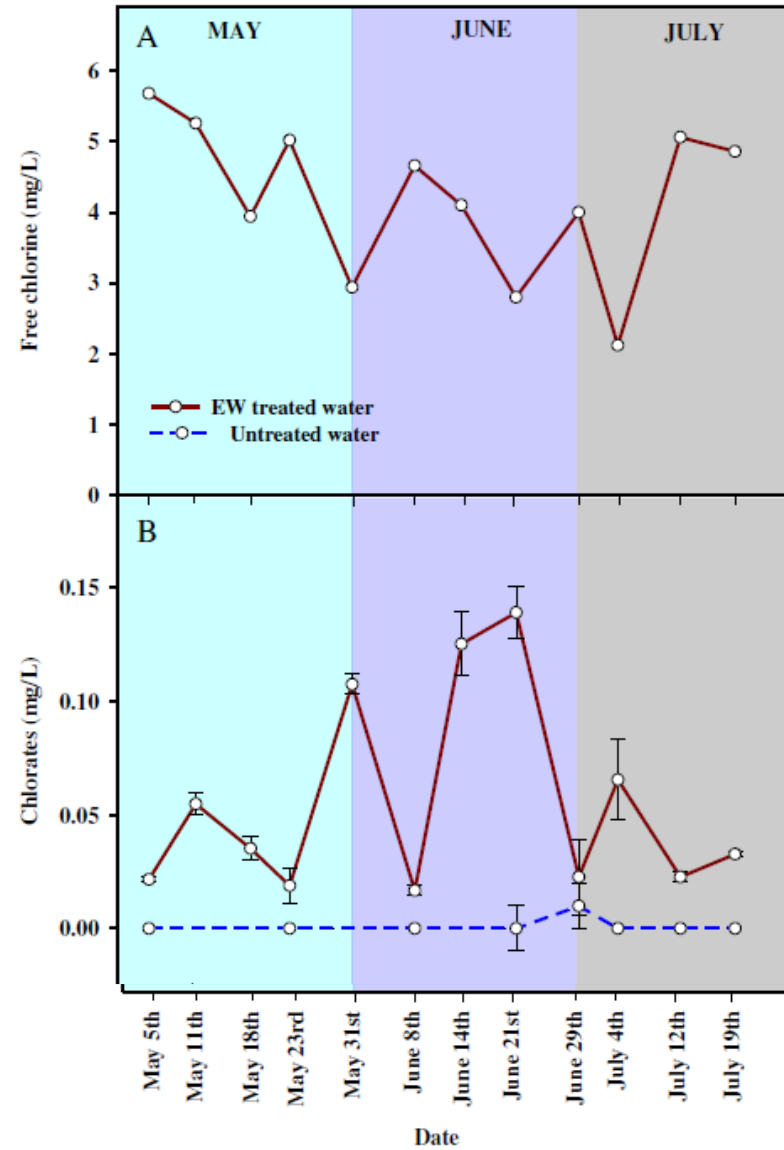


Why Water Treatment?



Liquid Chemical Injection

Electrolyzed Water





Tablet Systems

Calcium hypochlorite



Why
Water Treatment?



<http://www.accu-tab.com/>



Physical Treatments

UV-C



Why
Water Treatment?



(C) 2006-1991 Daniel Friedman



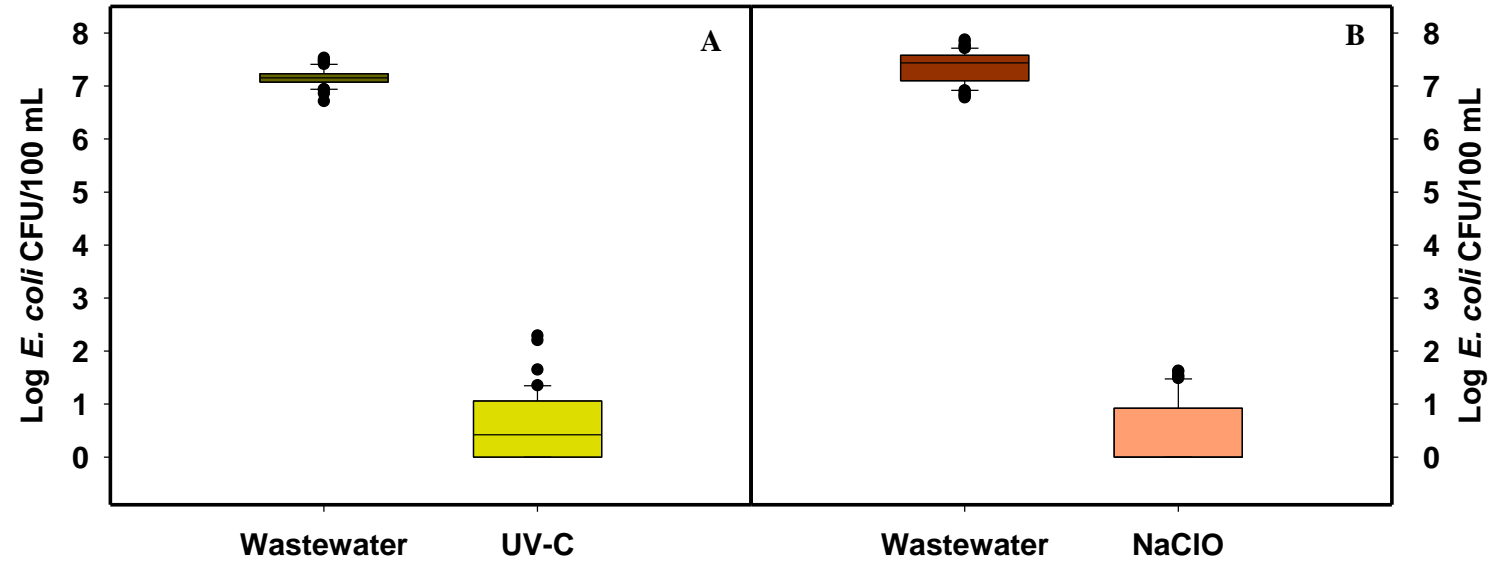


Physical Treatments

UV-C



Why
Water Treatment?



UV-C



Chlorine



Why
Water Treatment?



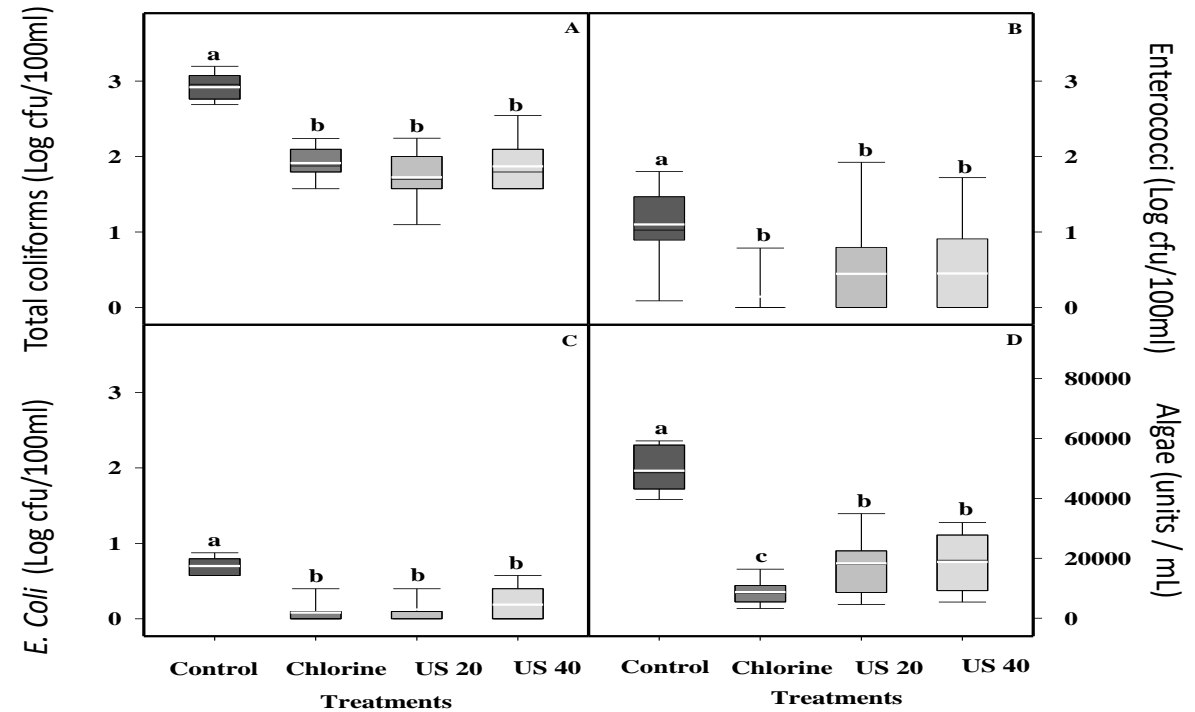
Physical Treatments

Ultrasound

US 20



US 40



Water Treatments



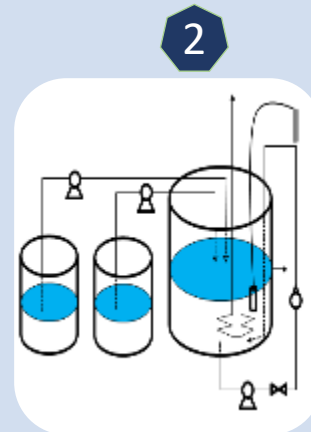
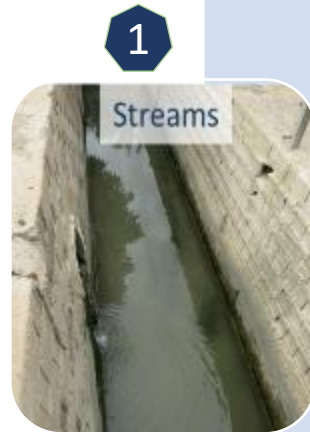
Monitorization of critical parameters

Validation of treatments

Selection of sensors for monitoring

Verification the performance of the system

Elaboration of SOPs



Why Water Treatment?

- Monitoring of operational parameters are part of the agricultural water treatment system to control the process and to apply corrective actions if monitoring indicated non-compliance
- **Verification** asks whether the system is being implemented according to the SOP. It is the process of confirming the truth, accuracy, or validity of your agricultural water treatment system.
- **Validation** is conducted to demonstrate that a process, when operated within established limits, produces a product of consistent and specified quality with a high degree of assurance.





Why Water Treatment?



Assessment of a Water Treatment

Initial Assessment Testing

- After activating and stabilizing your treatment system (i.e., all lines are pressurized and the performance-established feed-rate is verified), sample and test the treated water source for total coliform and generic *E. coli* in three (3)-100 mL samples. To maintain its Type A status, water samples must have: no detectable generic *E. coli* in at least two (2) of the three (3) samples with a maximum level no greater than (\leq) 10 MPN in the remaining sample, and
- data monitoring and total coliform at a level no greater than (\leq) 99 MPN in 100 mL

Sampling Frequency:

This is a **one-time seasonal sampling event** conducted for each irrigation system during one irrigation event occurring before the 21-day-to-scheduled-harvest-period begins.

Collect the three (3)-100 mL samples no closer than 20 minutes apart. (Also conduct this assessment after any material modifications to Type A overhead irrigation systems.)



Why Water Treatment?



Monitorization of a Water Treatment

Monitoring of Agricultural Water Treatment Systems

You must monitor any treatment of agricultural water with **each irrigation event** for the process parameters determined in the initial irrigation water treatment assessment and established by SOP at a frequency adequate to ensure that the treated water is consistently safe and of adequate sanitary quality for its intended use and/or consistently meets the relevant microbial quality as required in the *Leafy Greens Guidelines*' table describing the "Routine Verification of Microbial Water Quality". The following section outlines both non-microbiological and microbiological monitoring activities that support successful implementation of agricultural irrigation water treatment.

Liquid chemical injection

- Verification setting for chemical injection systems
- Verification pumps are on and operating at recommended flow rate
- Verifying Concentration of residual disinfectant
- pH



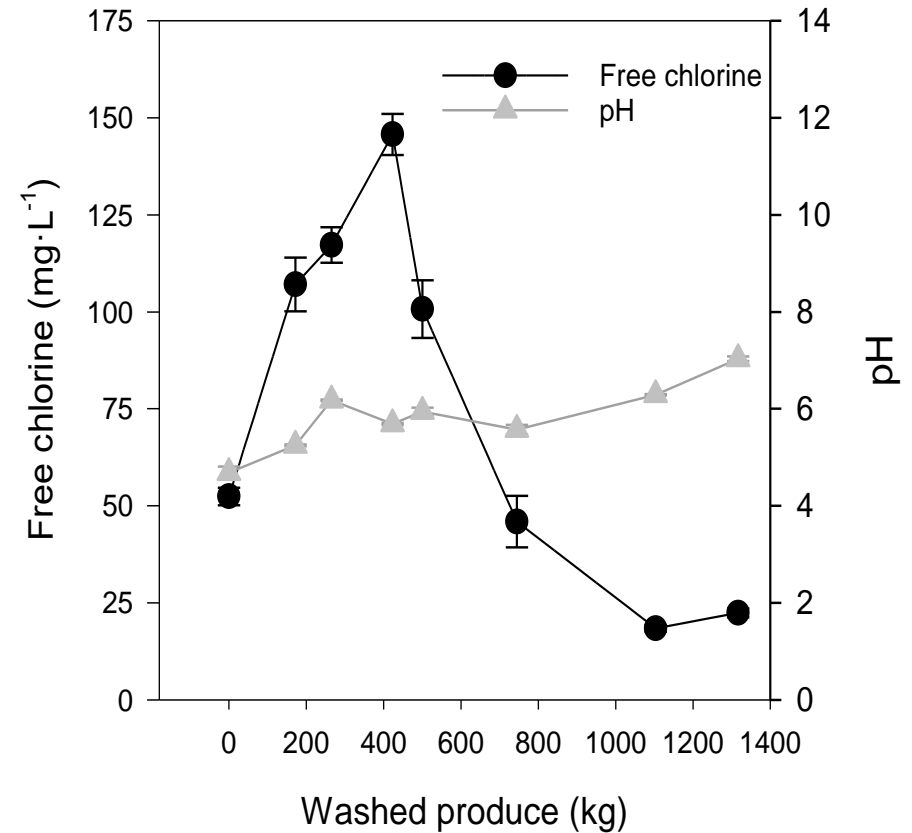
Water Treatment Management Performance

Case Study: Sodium hypochlorite

Several parameters affect the efficacy of the treatment

Why Water Treatment?

- Free chlorine concentration
- Turbidity
- Organic matter
- Total suspended solids
- pH
- Flow rates



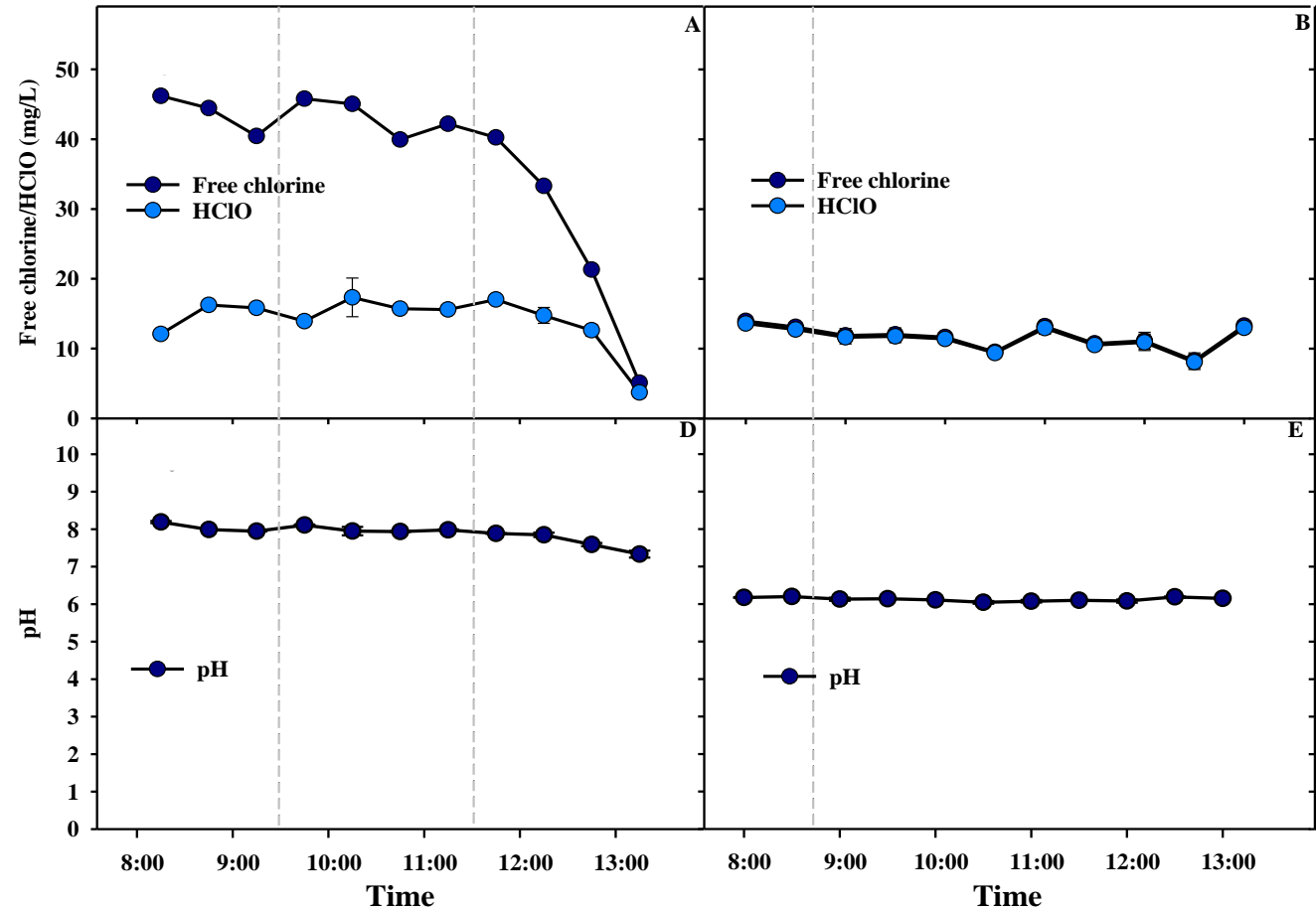


Water Treatment Management Performance

Case Study: Sodium hypochlorite

Several parameter affect the efficacy of the treatment

Why Water Treatment?





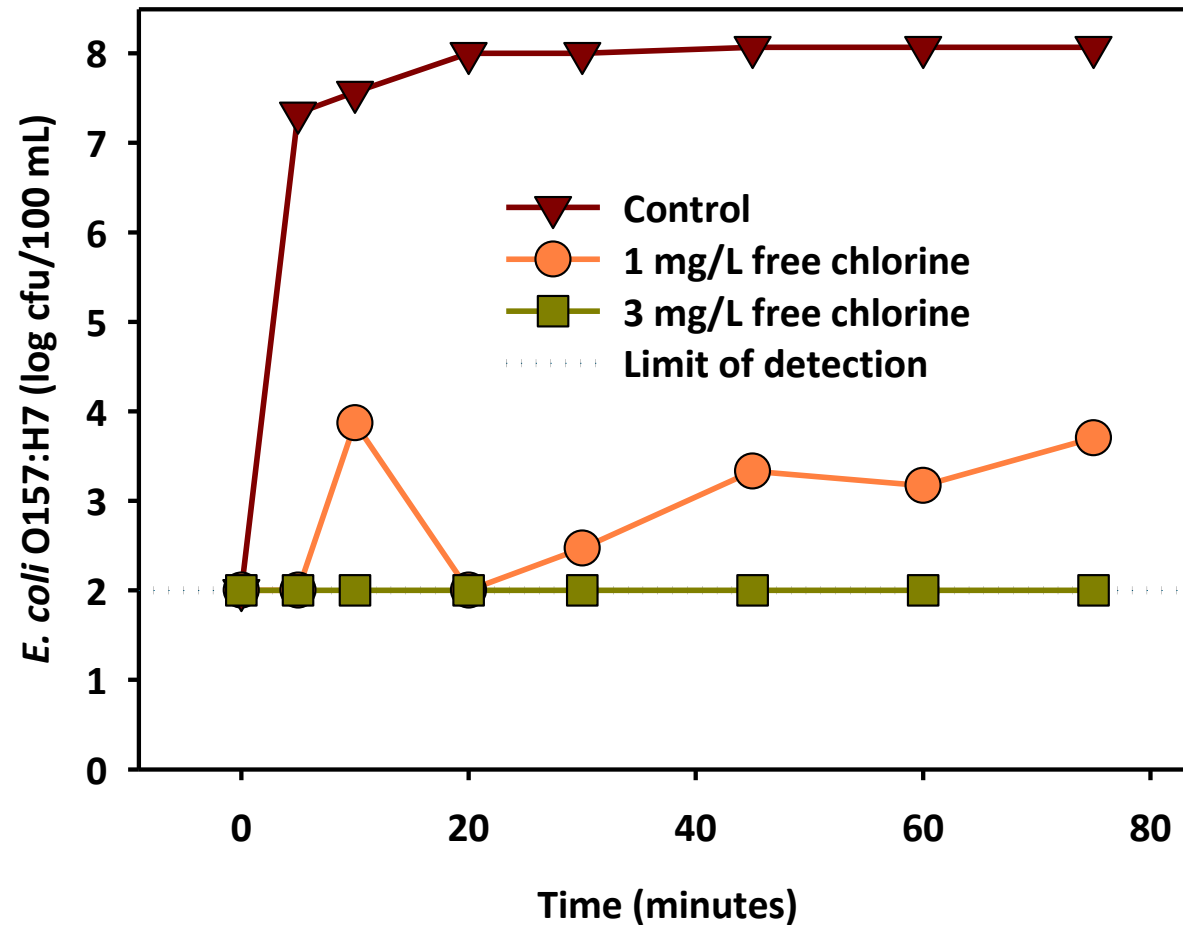
Why
Water Treatment?



Water Treatment Management Performance

Case Study: **Sodium hypochlorite**

Validation: Establishment of critical and operational limits





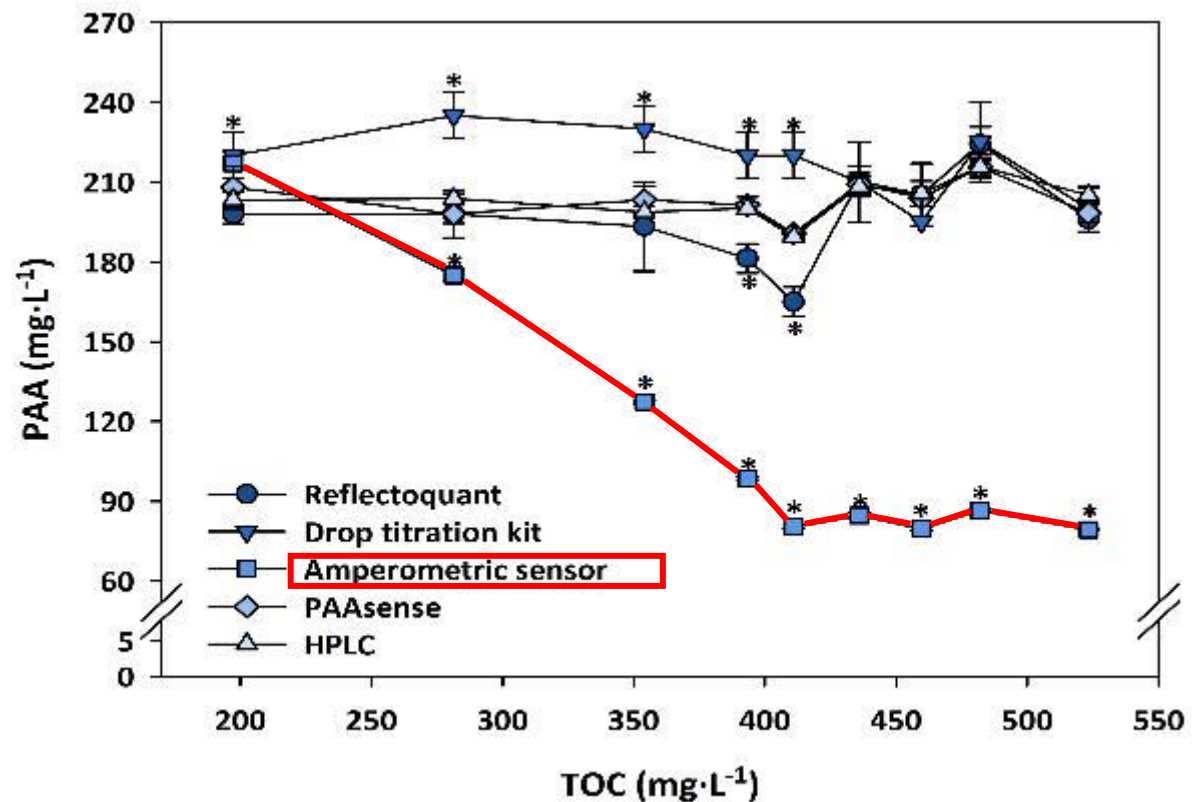
Why
Water Treatment?



Water Treatment Management Performance

Case Study: **Sodium hypochlorite**

Verification: Confirmation that the system and the SOPs are performing correctly.



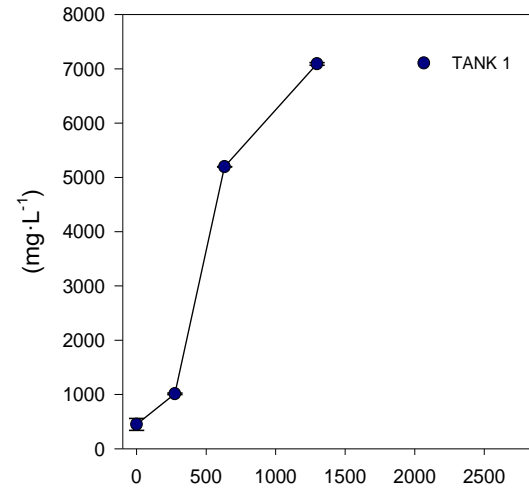


Why
Water Treatment?



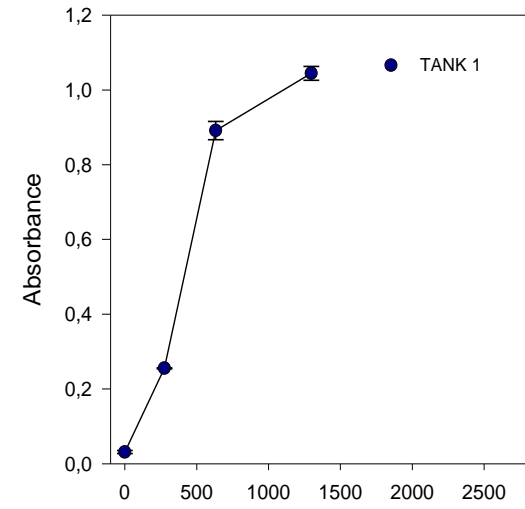
Monitorization of a Water Treatment

COD



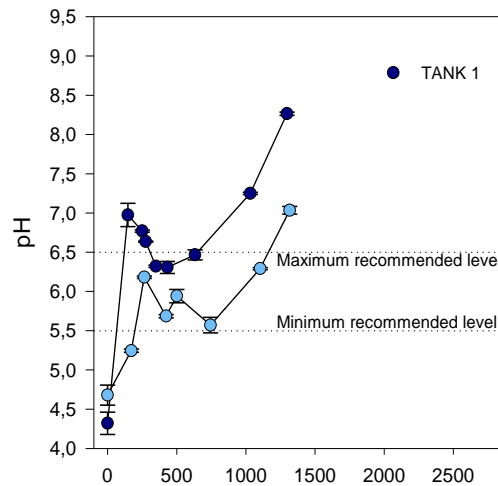
Treatment time

UV254



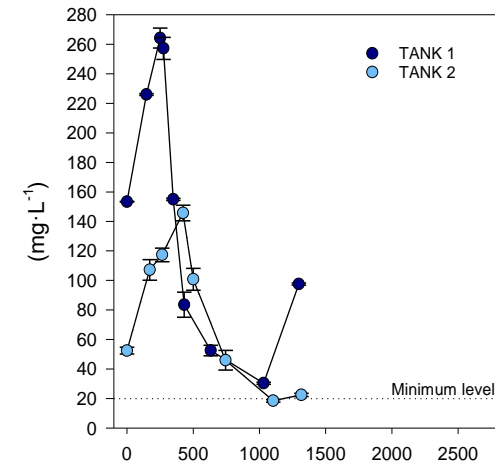
Treatment time

pH



Treatment time

FC



Treatment time



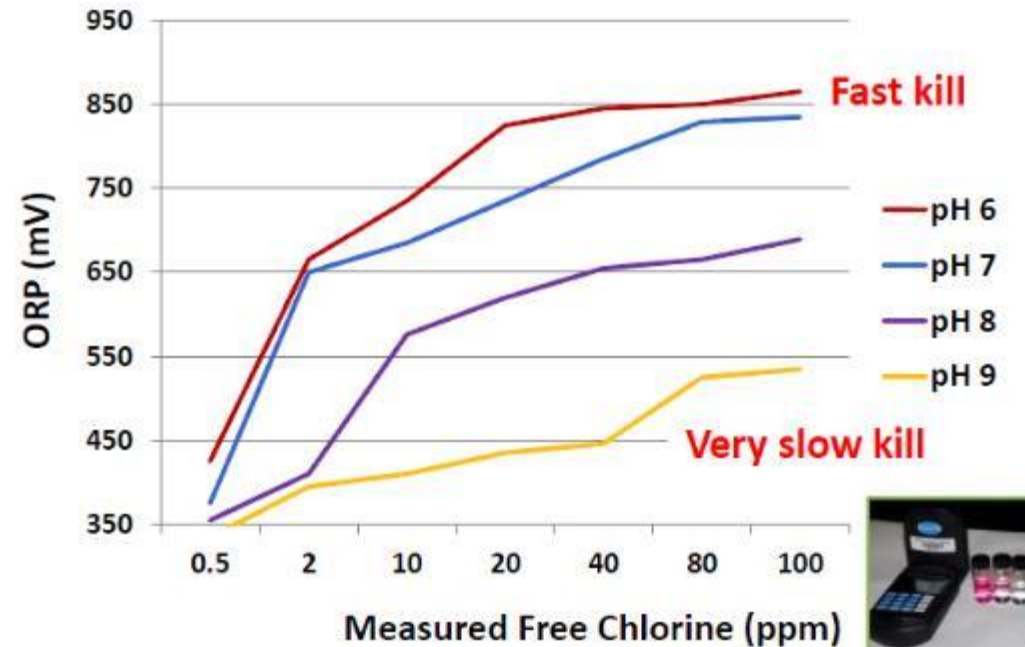
Monitorization of a Water Treatment

ORP: Oxidation Reduction Potential

Why
Water Treatment?



Relationship between ORP and ppm in Low Turbidity Water



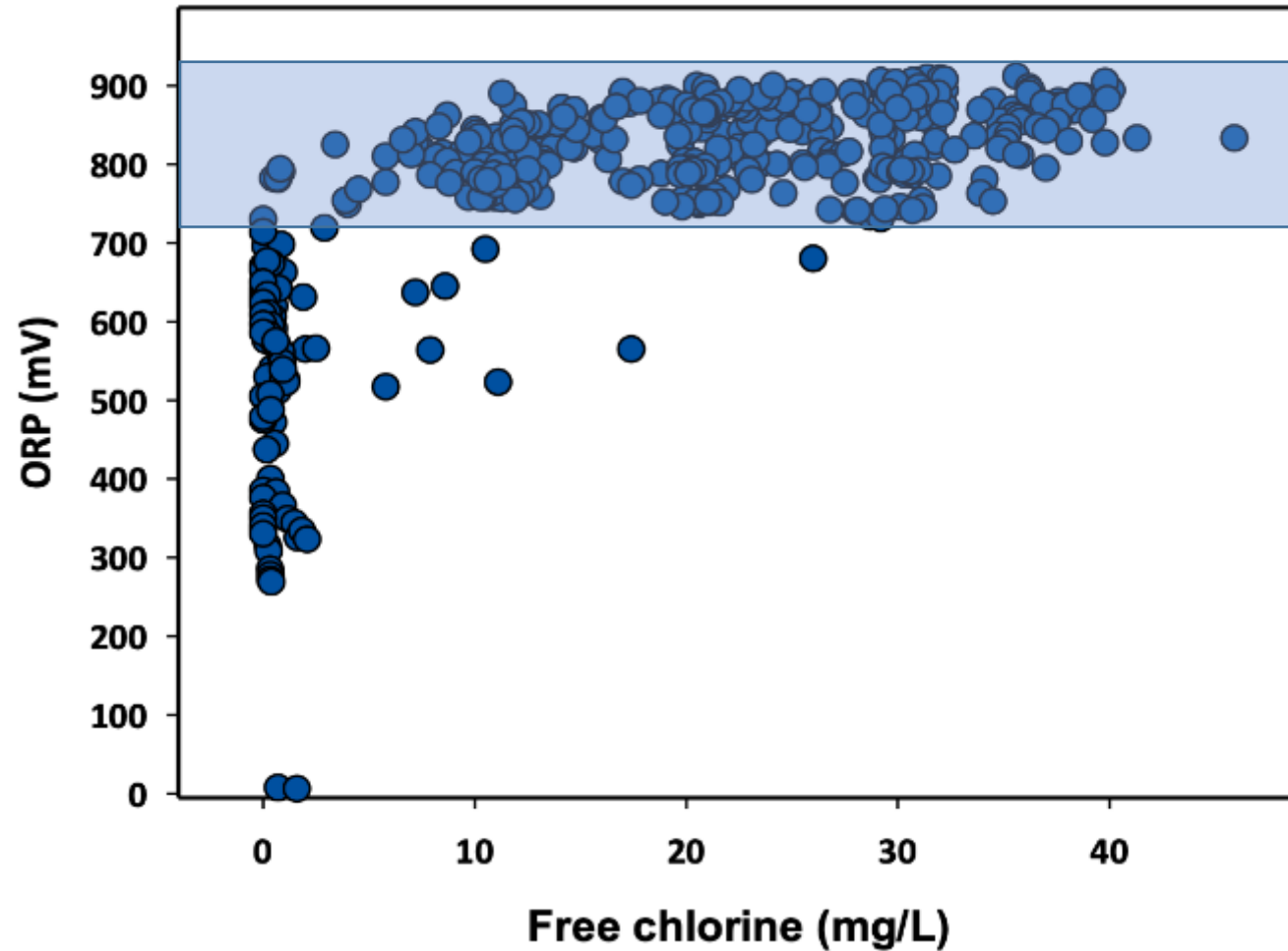


Why
Water Treatment?



Monitorization of a Water Treatment

ORP: Oxidation Reduction Potential
Oxidation reduction potential (ORP)



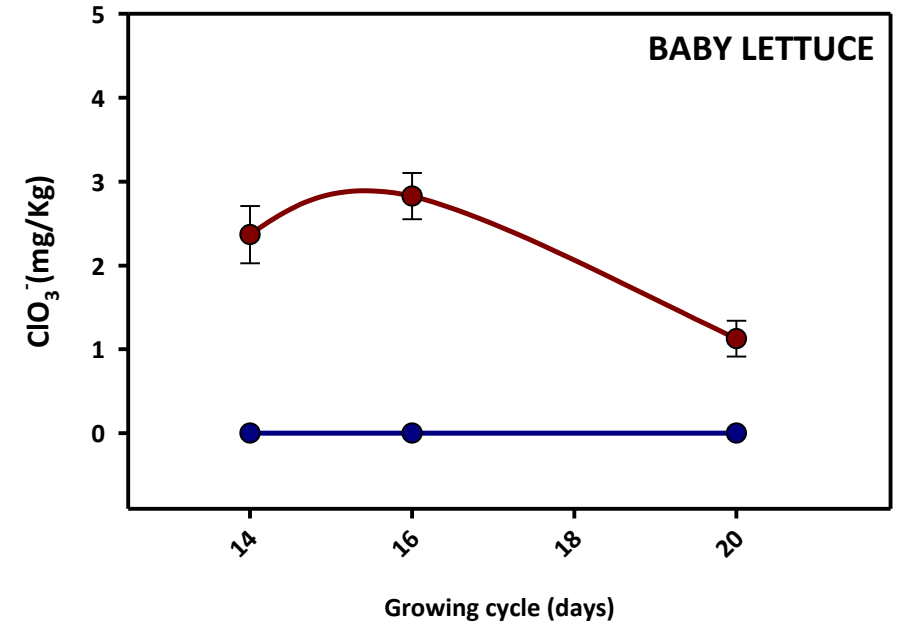
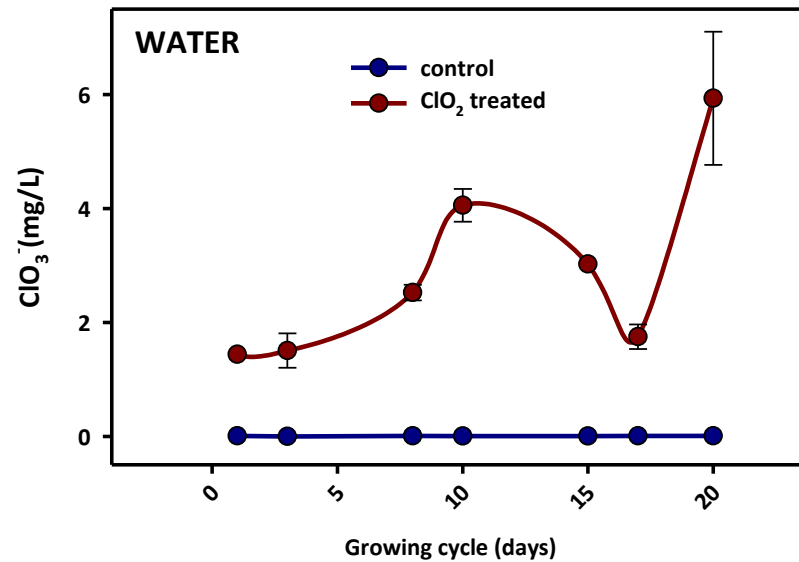


Why Water Treatment?



Monitorization of a Water Treatment

***NOTE:** It is important to note that the USEPA and the National Organic Program (NOP) have established regulations and standards for maximum disinfectant/chemical residuals allowed. "Maximum residual disinfectant level" is a term defined by the USEPA in the Code of Federal Regulations, Title 40 §§ 141.2, 141.65 as the highest level of a disinfectant allowed in drinking water. This level is currently established by the USEPA at 4 mg/L for chlorine (as Cl₂) and 0.8 mg/L for chlorine dioxide and should be followed by industry.





Why Water Treatment?



Conclusions

Good Practices

Assessment of the Water Source

Assessment of the Water System

Assessment of Where it is Applied

Assessment of How it is Applied

Are Corrective Actions Needed?

14th November 2019

 **CSIC**

Quality, Safety and Bioactivity
of plant foods



aallende@cebas.csic.es



Webinar on Irrigation Water Treatment

Ana Allende



Q&A Session

Questions or Comments?

Contact WG's Science & Tech at:

wgscitech@wga.com

or

Sonia Salas
AVP Food Safety, Science & Technology
Email: ssalas@wga.com
Phone: (949) 885-2251