CONFERENCIA FINAL BlueWWater
6 nov 2026, CETMAR, Vigo

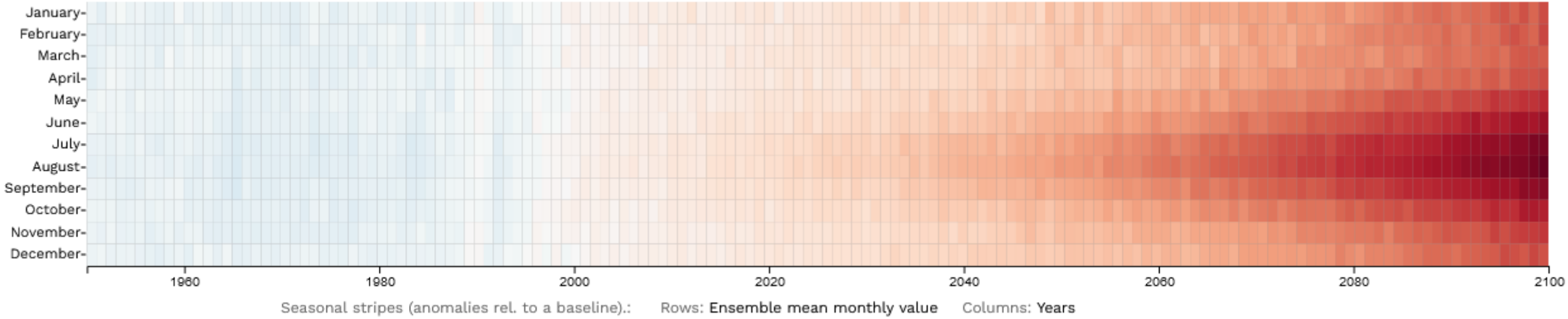
Efluentes urbanos como fonte alternativa e sustentável de água para a agricultura: o contributo do projeto BlueWWater

Bruno Sousa, Cristiano Soares & Fernanda Fidalgo

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CLIMATE CHANGE

Projected **temperature increase** for the **Mediterranean region** (IPCC 2021)



"There's one issue that will **define the contours of this century** more dramatically than any other, and that is the **urgent and growing threat of a changing climate**."

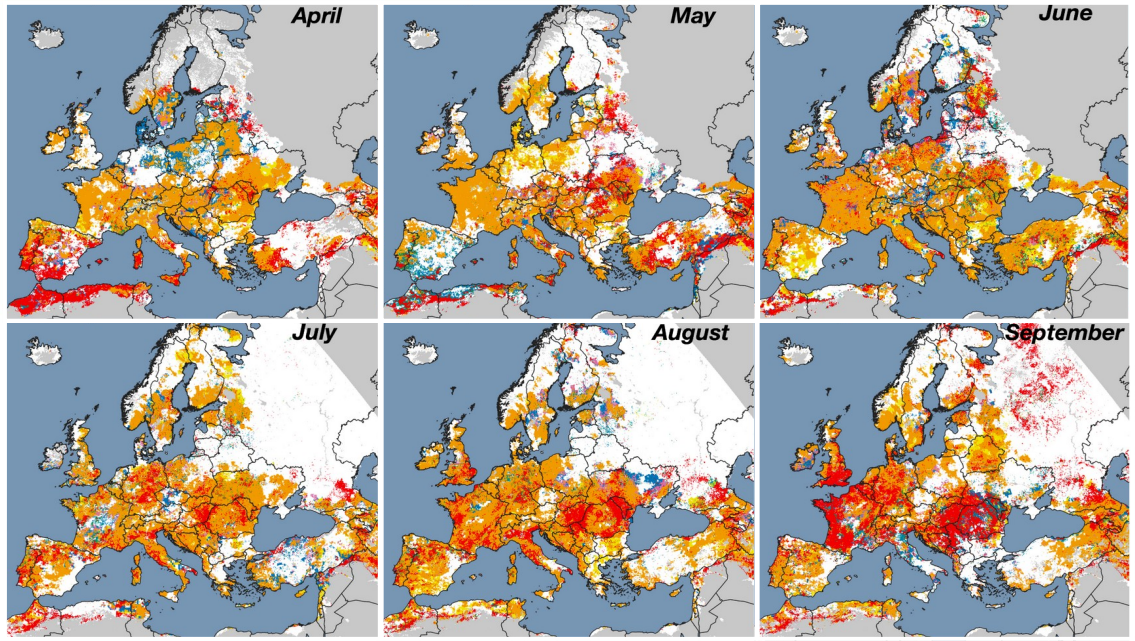
@Barack Obama – United Nations Climate Change Summit (2014)

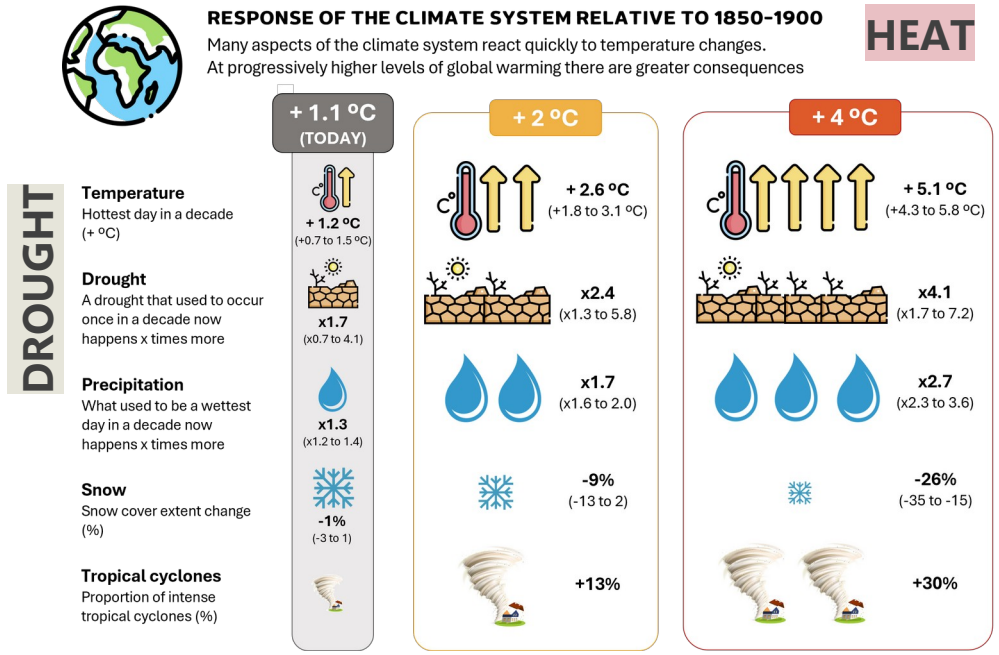
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CLIMATE CHANGE

As population **increases**, food production must **DOUBLE** by **2050** to ensure human needs...

...but can agriculture cope under the **present climatic instability?**





Copernicus Climate Change Service
European State of the Climate | 2022

PROGRAMME OF THE EUROPEAN UNION

Copernicus Europe's eyes on Earth

IMPLEMENTED BY ECMWF

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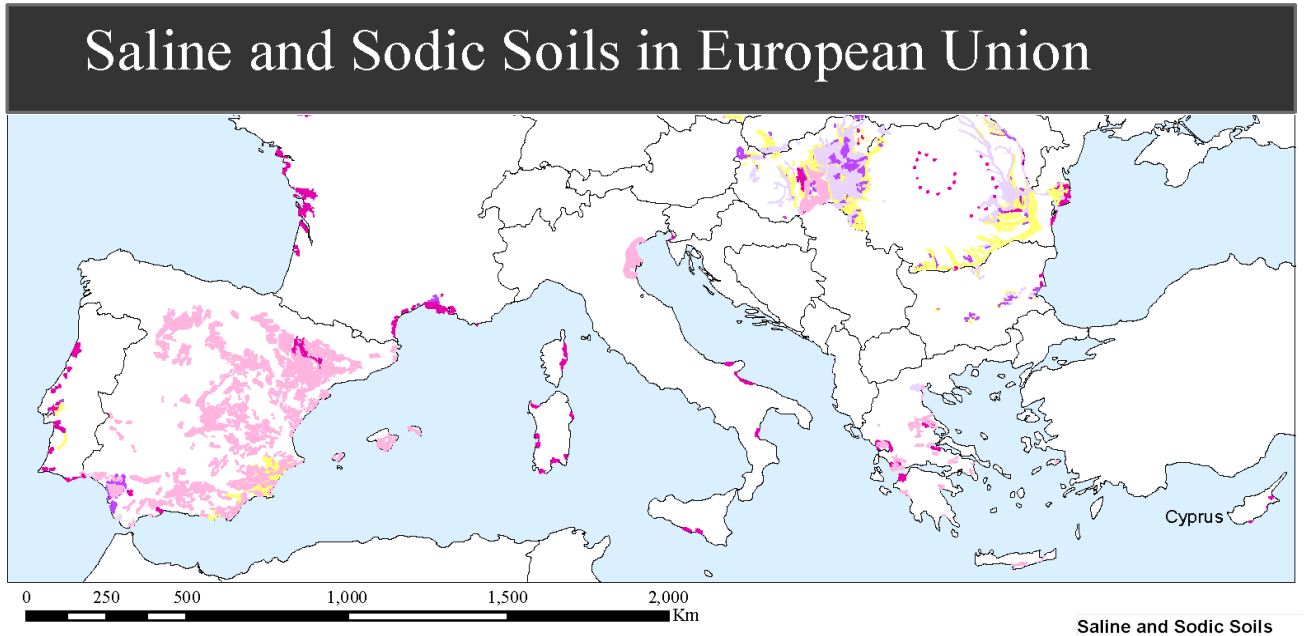
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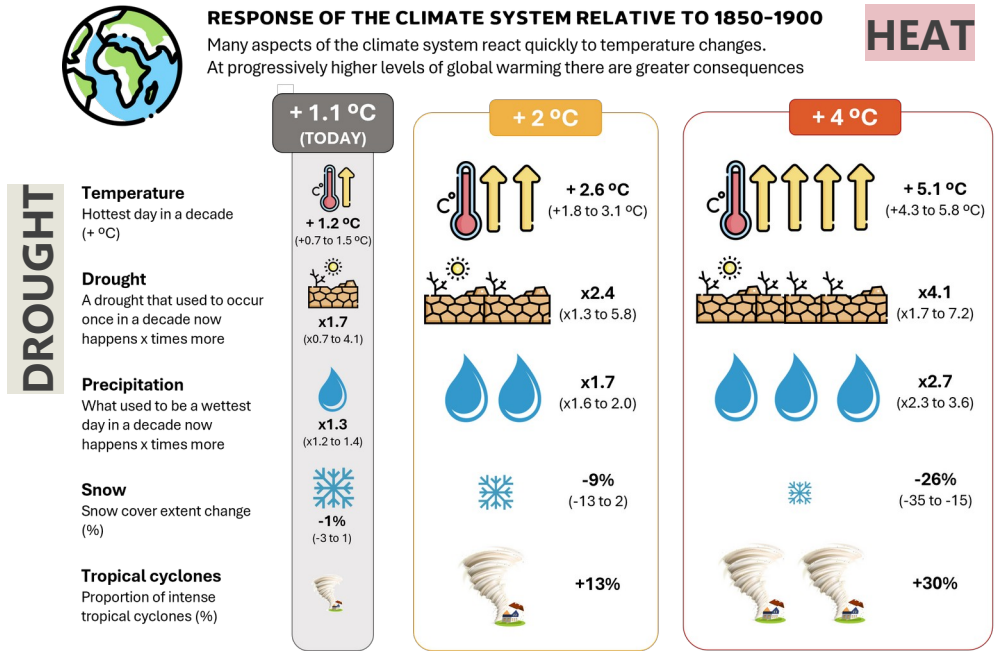
CLIMATE CHANGE

As population **increases**, food production must **DOUBLE** by **2050** to ensure human needs...

...but can agriculture cope under the **present climatic instability?**



"The Mediterranean is the **most susceptible region in Europe** to soil degradation and desertification"
(Ferreira et al., 2022)



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WASTEWATER MANAGEMENT

"**70-90% of the water in the world is reportedly utilized for agriculture**, with ~ **70%** being sourced from **freshwater sources,** including rivers and groundwater"







Wastewater Treatment

Reduces water abstraction – relieving demand for freshwater resources

Reduces water pollution – lower discharge of effluent into water bodies

Higher content of organic carbon/matter than groundwater

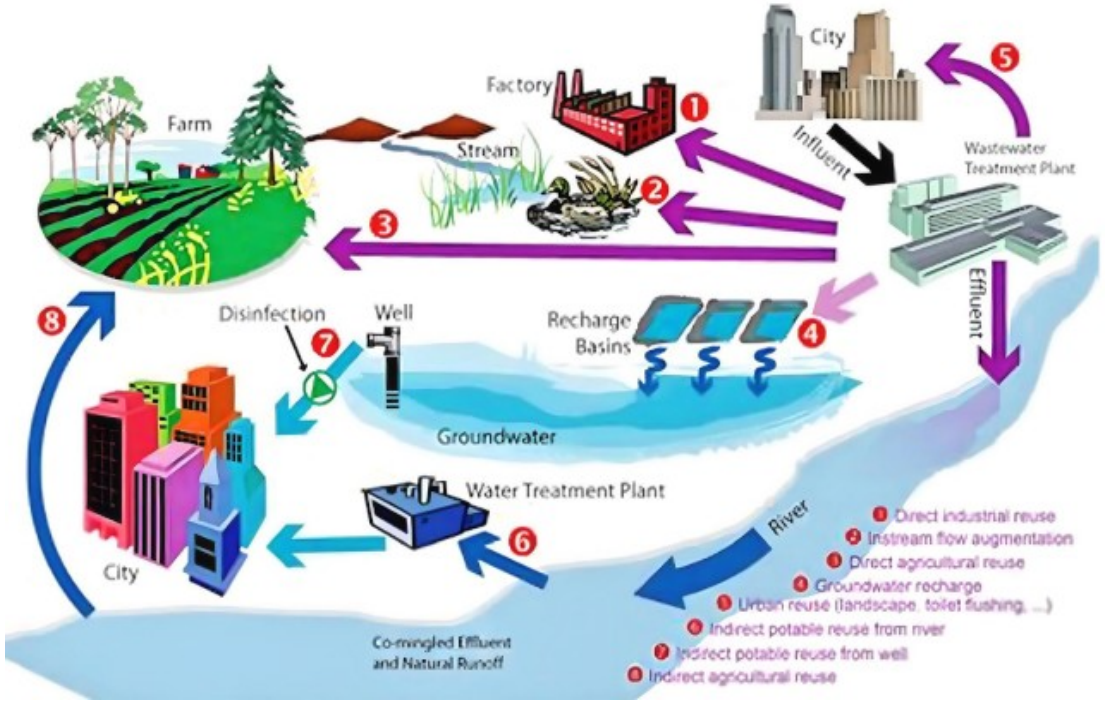
Higher nutrient content

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WASTEWATER MANAGEMENT

The use of wastewater for irrigation dates back several decades.

In the early 20th century, cities in Europe were using wastewater for irrigation (sewage farms).

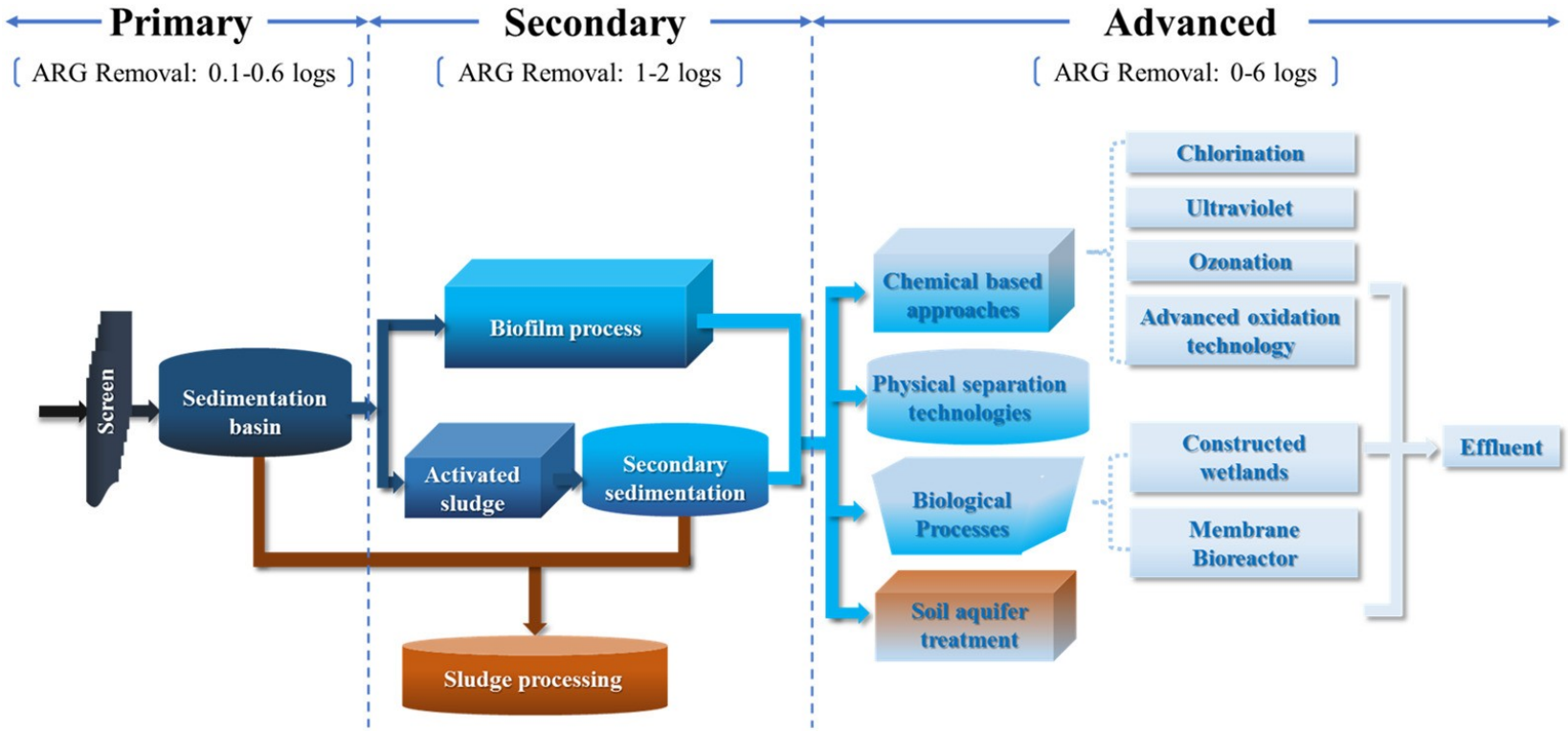


This promoted agriculture but later became an environmental and health issue.

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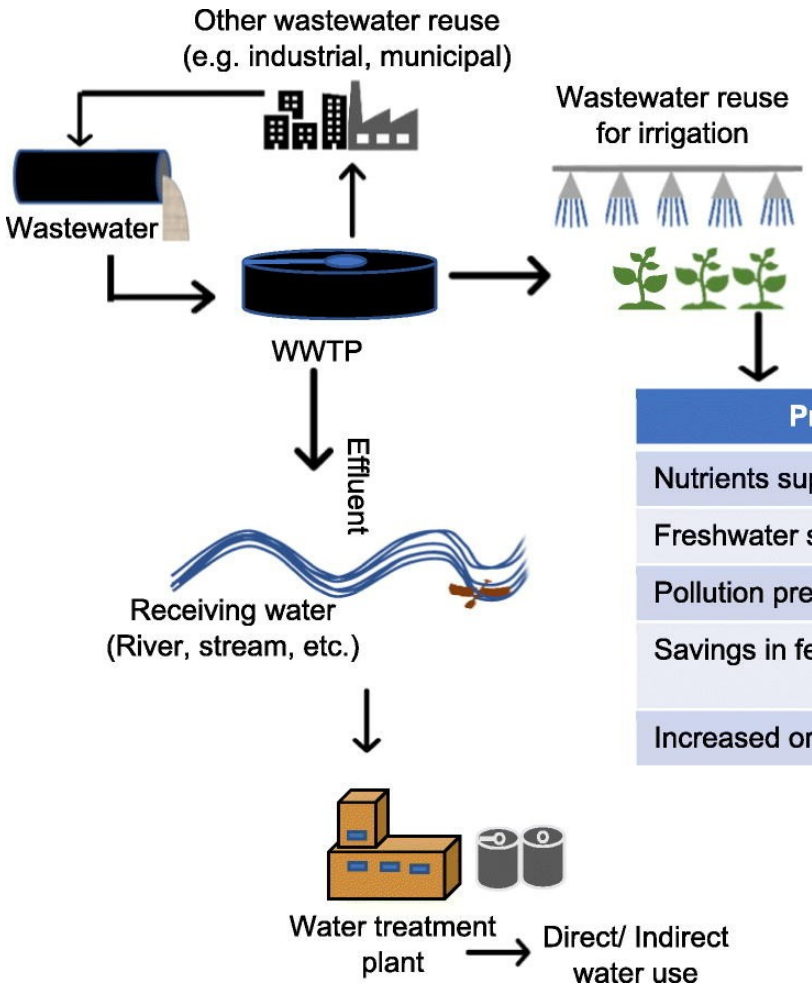
WASTEWATER MANAGEMENT

Most of the negative environmental impacts were associated with secondary treated wastewater. This is so because, secondary effluent has higher nutrients, salts and other contaminants than tertiary effluent.

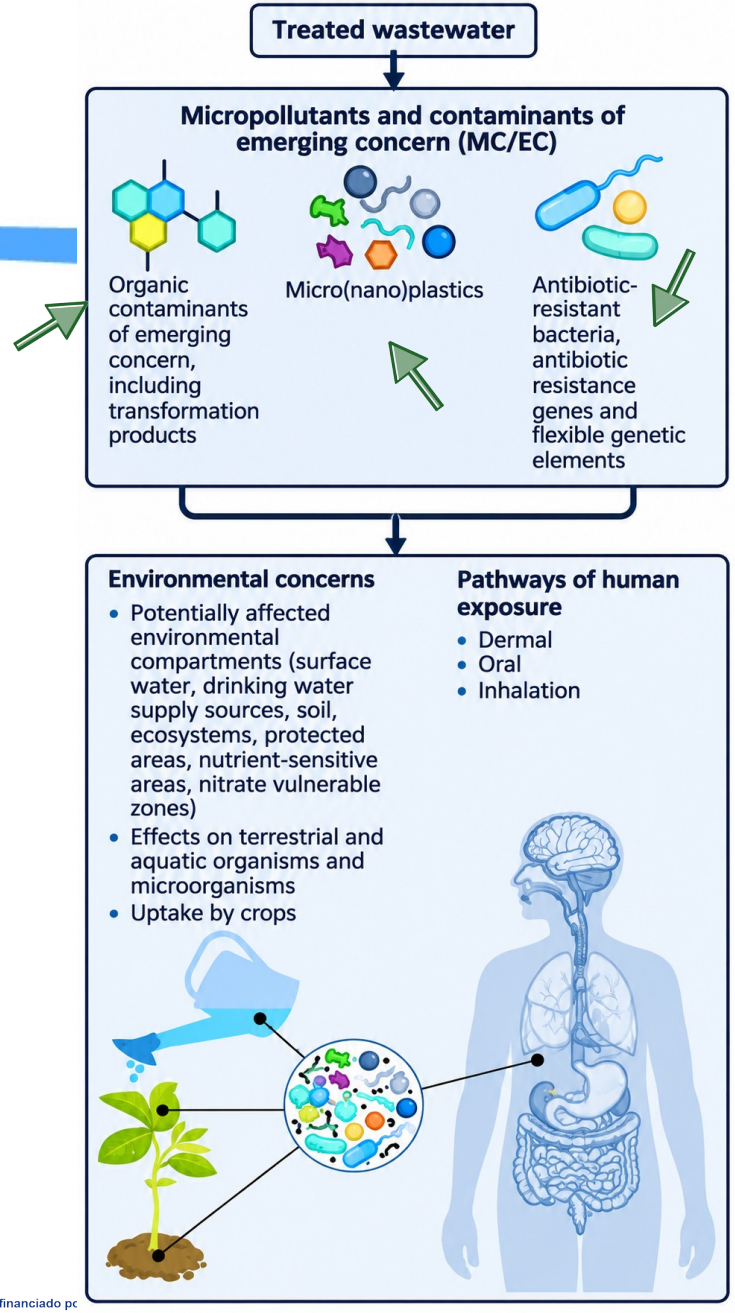


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WASTEWATER MANAGEMENT



Pros	Cons
Nutrients supply	Soil salinization
Freshwater savings	Groundwater pollution
Pollution prevention	Public health risk
Savings in fertilizer cost	Increased sodium adsorption ratio (soil)
Increased organic carbon	



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Where should we look at?

PUBLIC HEALTH

ECONOMICS

PLANTS

- Vegetative growth
- Physiological status
- Bio accumulation patterns
- Yield

MICROBIOME

- Microbial activity
- Diversity indexes
- Population dynamics

SOIL

- Nutrient content
- Contaminant and salinization levels
- Soil functions assessment

WATER

- < Water abstraction
- Assess water pollution



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EXPERIMENTAL DESIGN

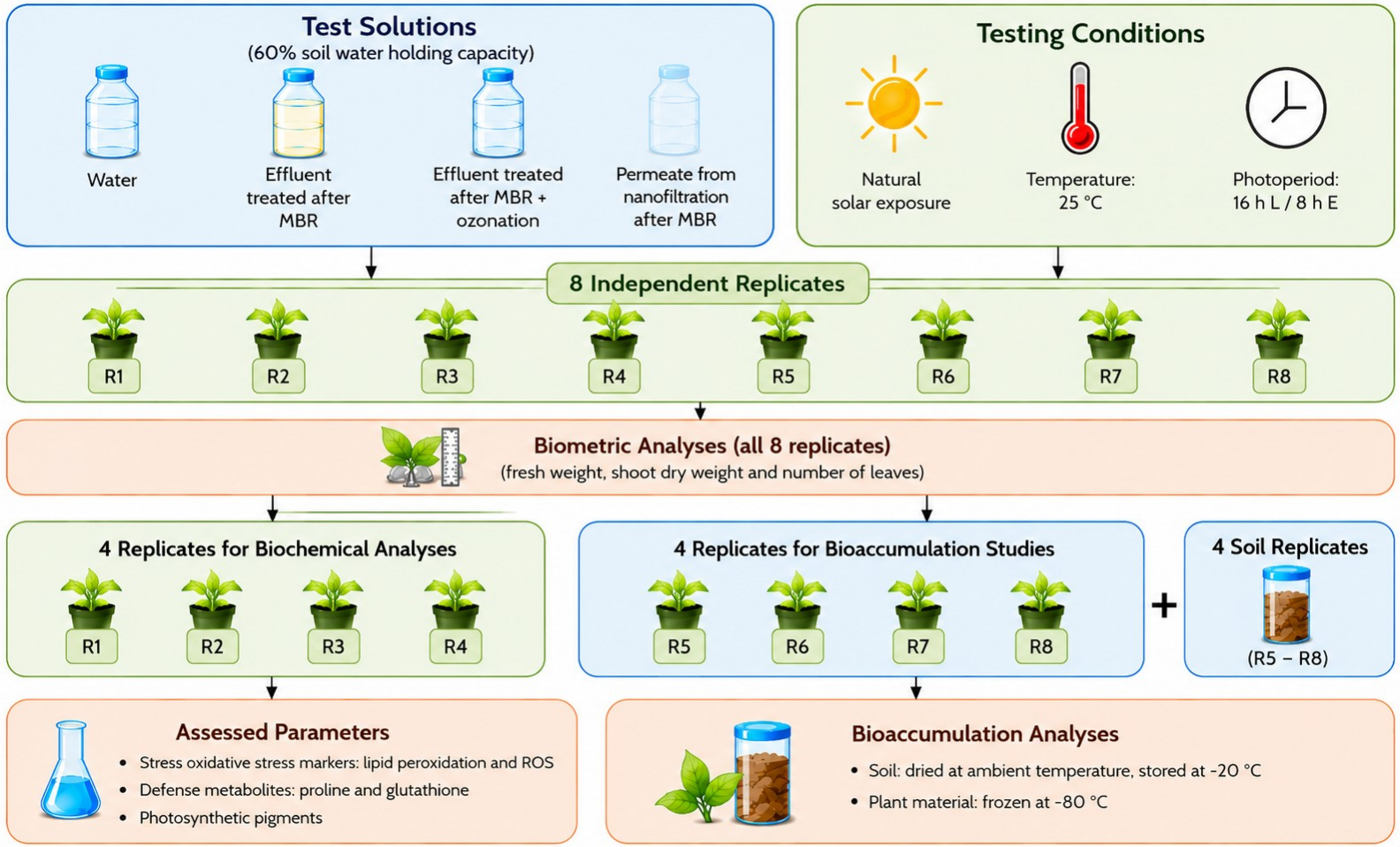


Maize
(*Zea mays* L.)



Lettuce
(*Lactuca sativa* L.)

Treated effluent (approx. 20 L) was stored in aliquots and frozen at −20 °C.



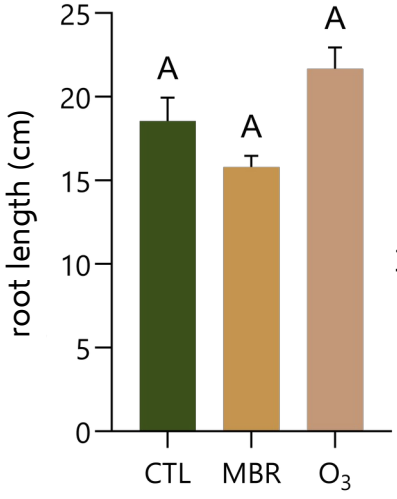
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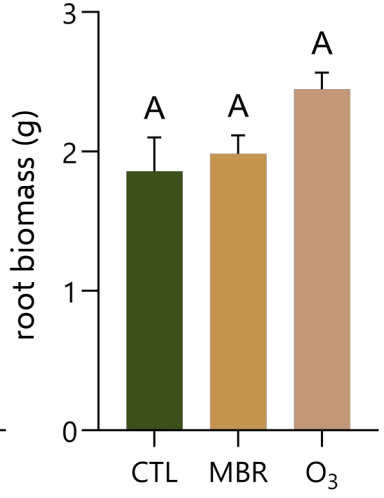
Plant growth attributes

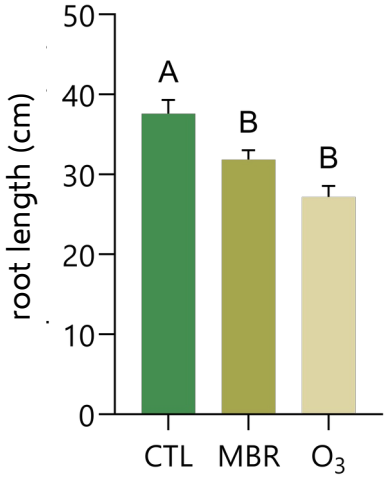


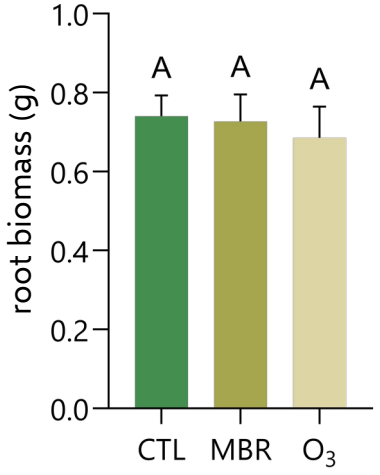


CTL **MBR** **O_3** **CTL** **MBR** **O_3**









At the root level **there were no observable stimulant effects**

No significant diferences were observed for lettuce plants



In maize→ root growth reduction without inhibition of biomass accumulation

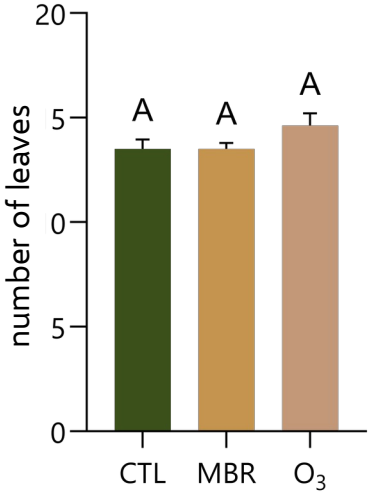


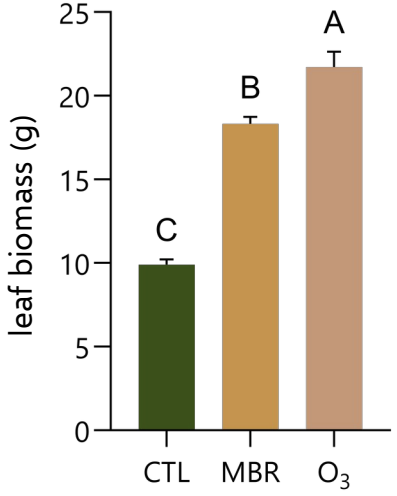
Plant growth attributes

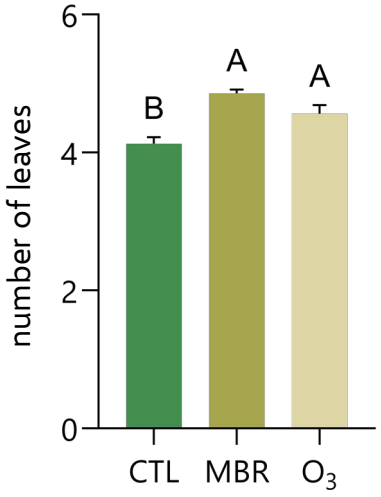


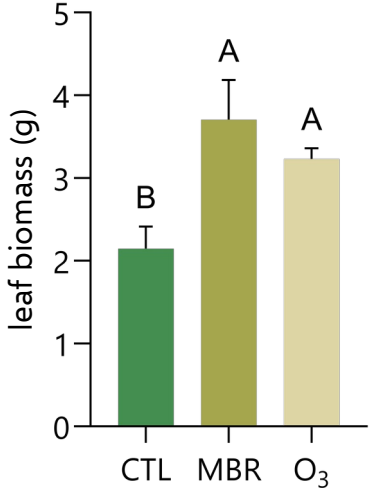


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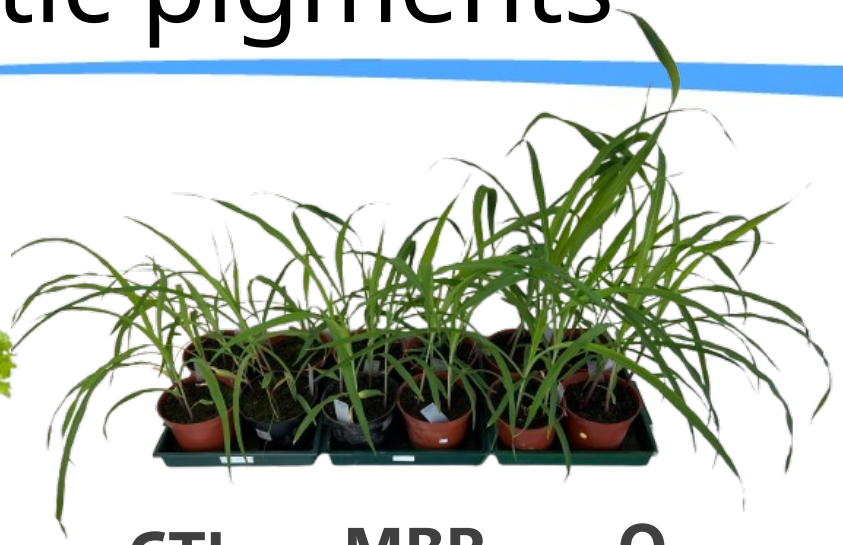
Neither treatment led to phytotoxicity symptons in plant shoots

Treated wastewater resulted **in increased plant growth** for both species

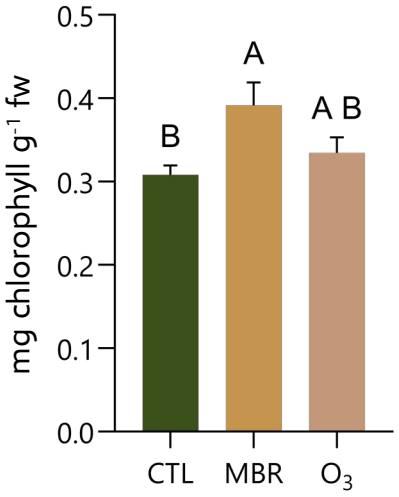
Ozonation led to an **increase in lettuce leaf biomass of around 120%**

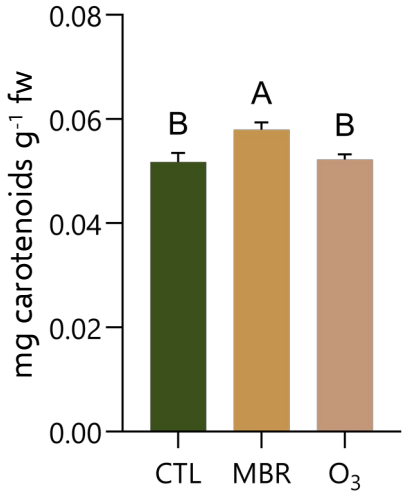
Photosynthetic pigments

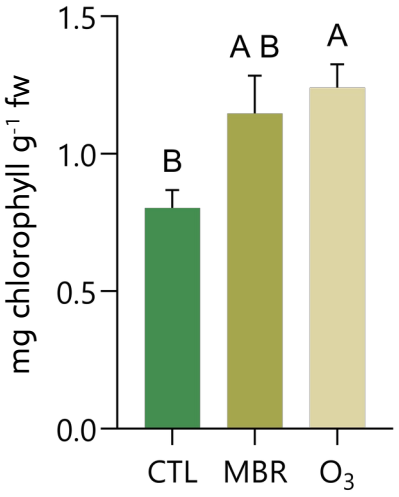


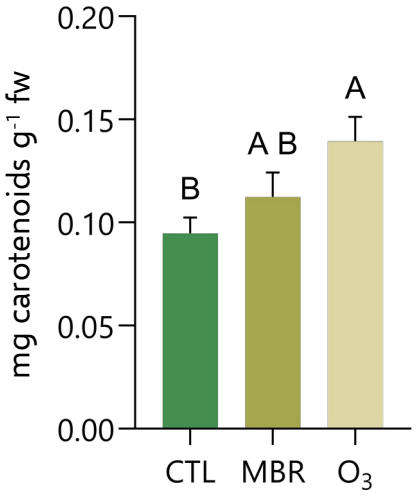


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General stimulation for the accumulation of **photosynthetic pigments**

Bigger and more vigorous plants

The use of treated wastewater can be a promising strategy for sustainable agriculture

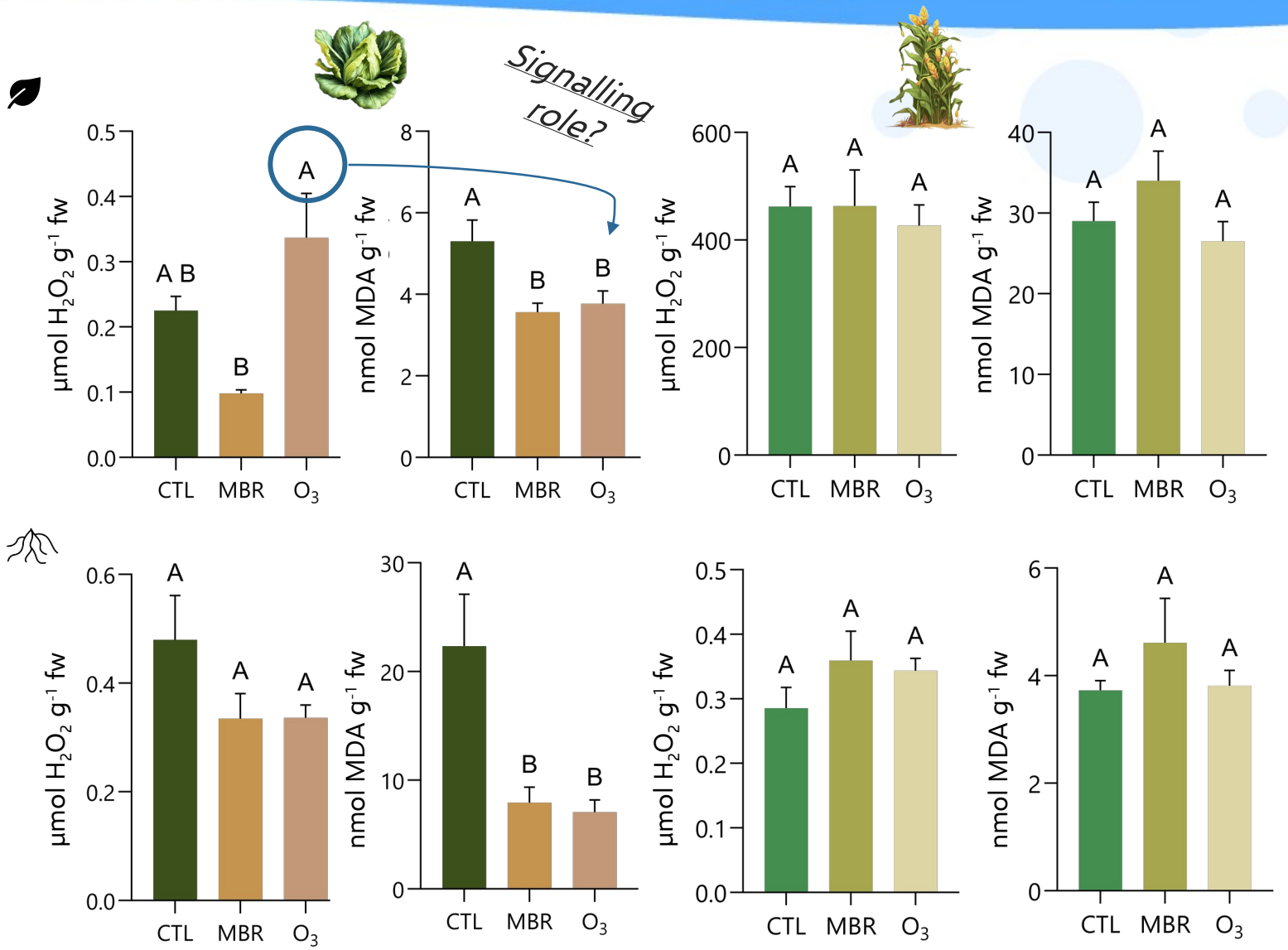
Are there any redox disturbances?

Oxidative stress markers

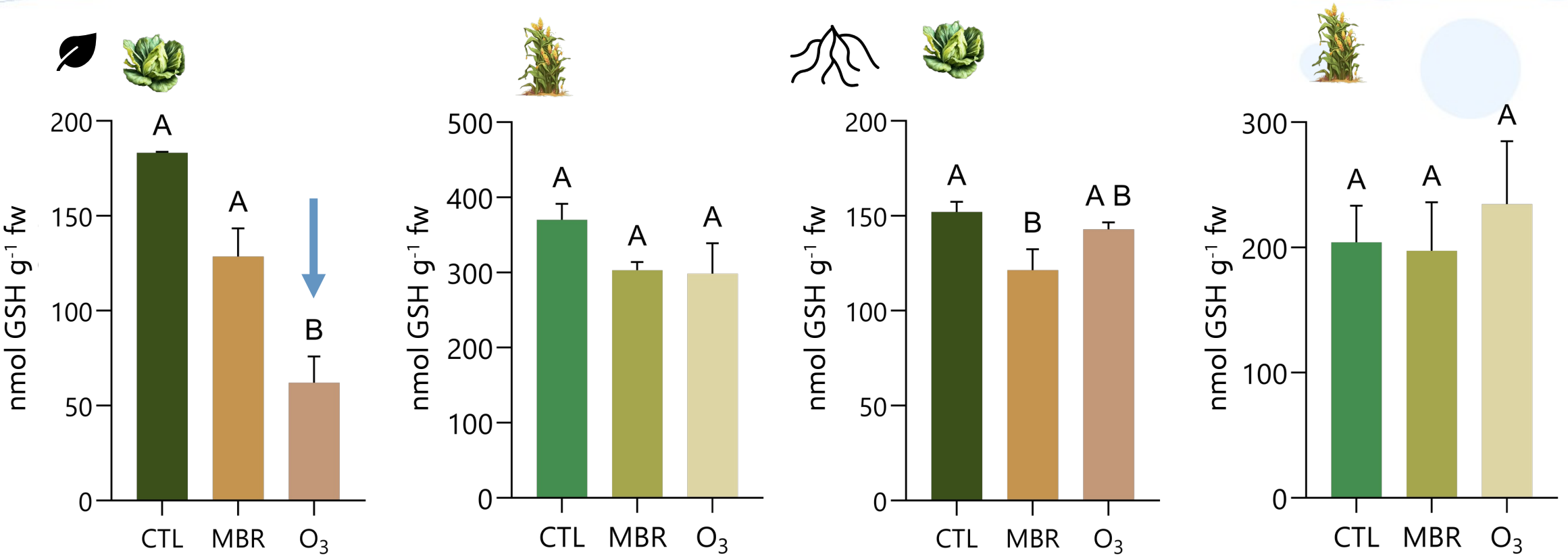
No treatment led to noticeable **symptoms** of **oxidative stress** on plant tissues

Equal or lower levels of H_2O_2 and lipid peroxidation among treatments

Absence of stress or efficient activation of defense pathways?



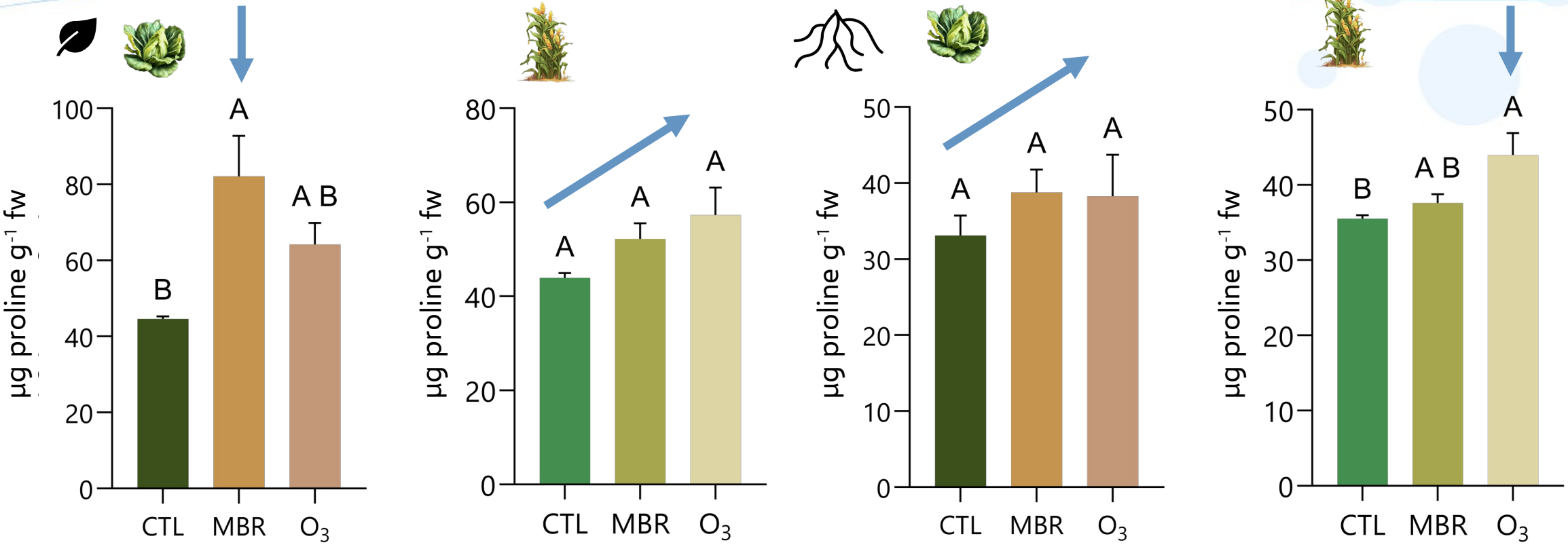
Antioxidant defence metabolites



Glutathione (GSH) levels generally remained constant across treatments.

The **decrease in GSH levels** in lettuce leaves may indicate its **oxidation due to its antioxidant role**, which could be associated with the **higher H_2O_2 levels** observed under this condition.

Antioxidant defence metabolites



There is a general trend towards **increased proline levels** when irrigating with treated wastewater.

> ***Antioxidant and membrane stabilizer –*** *associated with decreased ROS levels and lipid peroxidation*
> ***Compatible solute –*** *potential activation of* ***osmotic adjustment mechanisms***
> **Molecular signal** – activation of gene expression and defense pathways, energy production, and protection of the photosynthetic apparatus

MAIN CONCLUSIONS



Irrigation with treated wastewater appeared to be beneficial for plants

- Growth stimulation and accumulation of photosynthetic pigments
- Absence of oxidative stress symptoms



Need for food and environmental safety analises

- Quantification of emerging compounds on irrigated soil
- Evaluation of their accumulation on plant tissues
- Validation under field conditions and assessment of impacts on soil microbiome

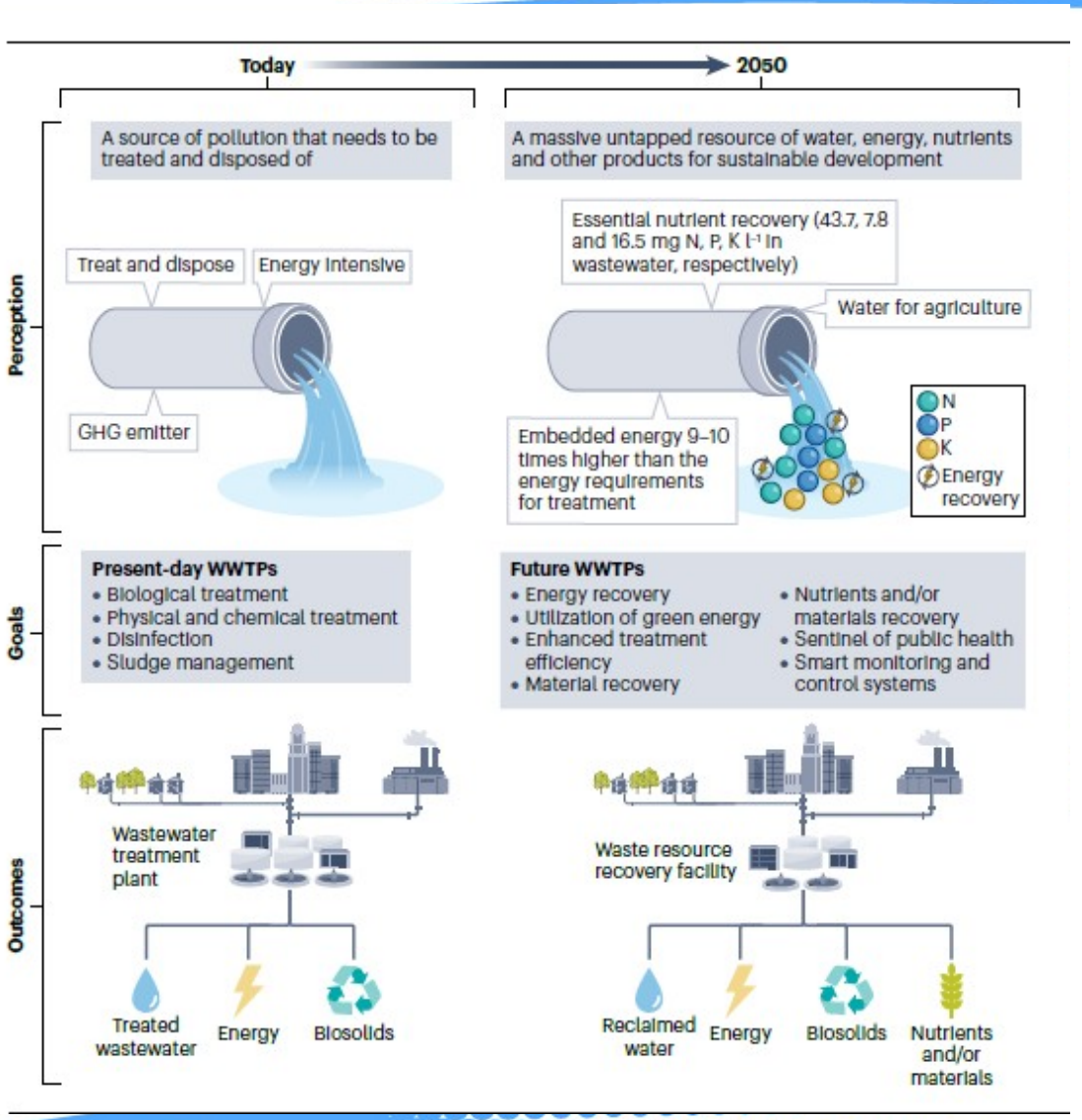


Mechanistic evaluation of the effects of treated wastewater

- Direct effect of treated wastewater vs modulation of soil biological and chemical properties?

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TAKE-home messages



The priority of wastewater irrigation should be water recovery and not nutrient supply

Public perception around the safety of wastewater use for irrigation needs to change

Implementation of increasingly efficient advanced treatments is key

Large scale pilot testing and field validation

The high cost of transporting treated wastewater can be an issue

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Thank You

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