Eszter Sas [1]
Nicholas J. B. Brereton [1]
Adrien Frémont [1]
Mathieu Sarrazin [2]
Julien Lamontagne [1]
Ahmed Jerbi [1]
Simon Barnabé [3]
Michel Labrecque [1,4]
Frédéric E. Pitre [1,4]

PHYTOCHEMICAL ADAPTIONS OF FAST-GROWING WILLOW TO FIELD-SCALE MUNICIPAL WASTEWATER IRRIGATION

[1] University of Montreal, Institut de Recherche en Biologie Végétale (IRBV), Canada – [2] Collège de Maisonneuve, Centre d'Étude des Procédés Chimiques du Québec (CÉPROCQ), Canada – [3] Université du Québec à Trois-Rivières (UQTR), Canada – [4] Montreal Botanical Garden, Canada

Corresponding author: Eszter.Sas@umontreal.ca

INTRODUCTION

BACKGROUND

- Municipal wastewater treatment is a severe environmental and economical burden. In Canada alone, 5.9 trillion litres of wastewater are produced per year.
- Fast growing willow plantations are tolerant to contamination and can filter high volumes of water.
- Willow trees produce over 2000 secondary metabolites for functions such as protection against a/biotic stresses, many of which persist in high abundance in stem biomass.
- Biorefinery can harness plant bioresources to produce sustainable energy and green phytochemicals.

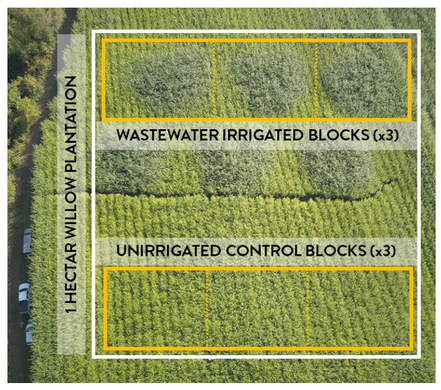
RESEARCH QUESTION

Is it possible to integrate wastewater treatment with biorefinery using a willow plantation?

OBJECTIVE

This study aims to unravel the impact of primary wastewater effluent irrigation on the secondary metabolite composition of willow trees in a controlled field plantation and identify the persistent phytochemicals important for sustainable biorefinery.

METHODS



Field-scaled Treatment

- One-hectare *Salix miyabeana* 'SX67' plantation in Southern Quebec (Canada)
- Two growing conditions:
  Unirrigated control blocks (n=3)
  Wastewater irrigated blocks (n=3)
- Irrigation rate around 29 million L ha^{-1} yr^{-1}

Biomass Harvesting

- 3 entire trees sampled per block (18 trees in total)
- 3-year growing cycle (mature trees harvested)

Biomass Processing

- Whole stem air-drying
- Controlled particle size reduction (180-850 µm)

Pressurised Liquid Extraction

- Dionex Accelerated Solvent Extractor (ASE)
- Methanol-Water (75-25% v/v)

Untargeted Metabolite Analysis

- Liquid chromatography (LC)
- Mass spectroscopy (MS/MS) using a QTOF with ESI(-) mode

Differential Abundance Analysis

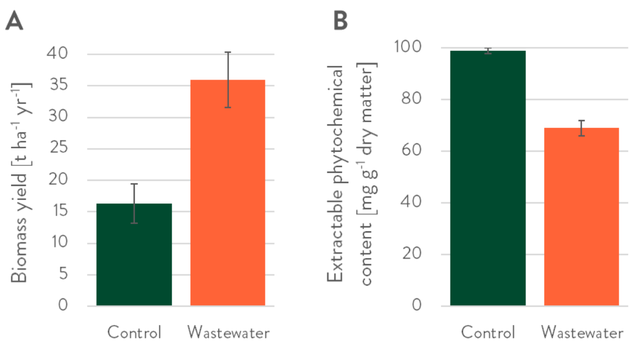
- Alignment of metabolite features across replicate samples (MZmine2)
- Statistical comparison between treatment using Mann-Whitney U-test with FDR correction

Metabolite Feature Identification

- Sequential annotation pipeline using Salicaceae and public metabolite libraries
- MS and MS/MS fragmentation resolved

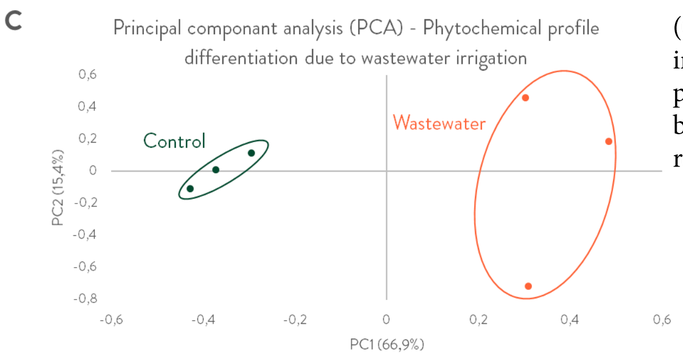
RESULTS

RESPONSE TO WASTEWATER IRRIGATION



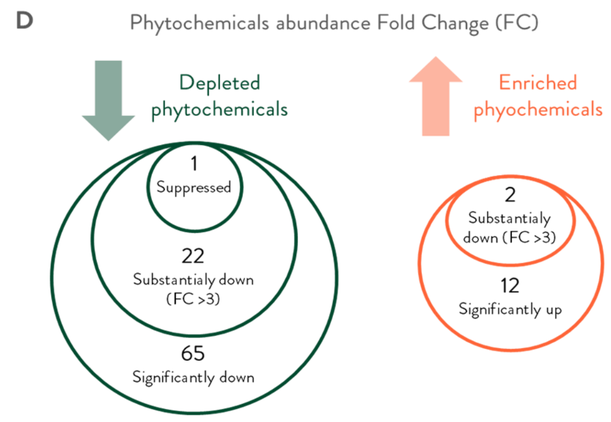
(A) Biomass yield increased by 200% in wastewater irrigated blocks.

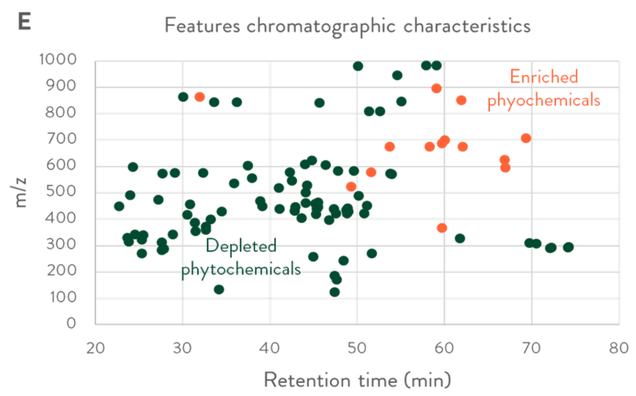
(B) Wastewater irrigation decreased the total extractives concentration.



(C) Wastewater irrigation elicits a phytochemical switch based on compounds relative abundance.

These results suggests a modification of resource investment to different metabolic pathways. Higher production of biomass structural components is associated with lower extractable phytochemical synthesis.





UNTARGETTED METABOLITE ANALYSIS

- 284 putative features were detected within the willow metabolite profile.
- 102 metabolites were significantly differentially abundant between of control and wastewater irrigated trees.

SIGNIFICANT DIFFERENTIAL ABUNDANCE

88 compounds were significantly depleted in wastewater irrigated trees:

- These included flavonoids, terpenoids and fatty acid derivatives.
- Reductions are likely driven by high N fertilization level in wastewater

14 compounds were significantly enriched in wastewater irrigated trees:

- Including important hormones associate to growth, lignans and novel yet-to-be-characterized compounds
- All had relatively high molecular mass and less hydrophilic properties

These results indicate that extractable phytochemicals vary not only in concentration but also in type, with a major increase in specific macromolecules driven by wastewater irrigation.

CONCLUSION

OUTCOMES

- Wastewater irrigation drives a substantial increase in biomass production of willow, leading to a net 50% increase of extractable phytochemical yields.
- Untargeted high resolution metabolite assessment revealed specific wastewater induced phytochemicals with exciting potentially novel functions.
- These field-scale findings reveal a willow phytofiltration as a promising green solution to wastewater treatment combined with production of both renewable bioenergy and sustainable phytochemcials.

FUTURE WORK

- An advanced annotation strategy is being developed for uncharacterised phytochemicals using fragmentation networking.
- Exploration of diverse functions of compounds is underway, including: antimicrobial, antioxidant, chelation and flocculation activities.
- Multidisciplinary research is underway to identify hurdles preventing integration of environmental wastewater treatment with green biorefinery.

ACKNOWLEDGEMENT

NSERC CRSNG
Natural Resources Canada Ressources naturelles Canada
Canada
Canadian Wood Fibre Centre
Developing sustainable forest solutions
Natural Resources Canada Ressources naturelles Canada
Canada

This work was supported by the Natural Sciences and Engineering Research Council of Canada (NSERC) – Strategic Partnership Grant, Canadian Wood Fibre Centre (CWFC) | Natural Resource Canada's (NRCan) – Forest Innovation Program, and Environment and Climate Change Canada's (ECCC) - Environmental Damage Fund.

1st Internation Electronic Conference on Plant Science
01-15 December 2020 | Online
IECPS 2020