MELISSA
MICRO-ECOLOGICAL LIFE SUPPORT SYSTEM ALTERNATIVE

2022 MELISSA CONFERENCE
8-9-10 NOVEMBER 2022

CREATING A CIRCULAR FUTURE

INTEGRATION OF HUMAN URINE DERIVATIVES IN SOILLESS SYSTEMS FERTILIZATION TO GROW SALAD CROPS

Christophe El-Nakhel, **Danny Geelen, Jolien De Paepe, Peter Clauwaert, Youssef Rouphael & Stefania De Pascale**

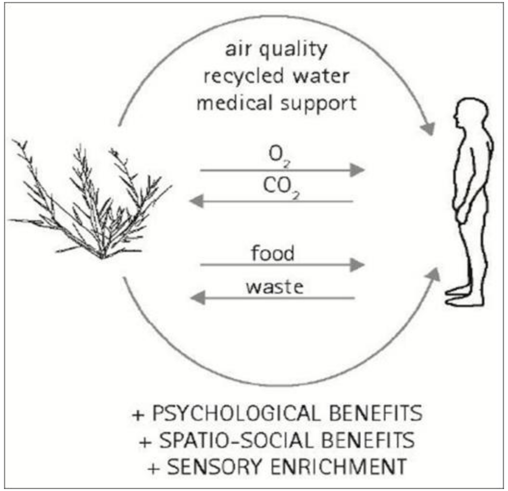
UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

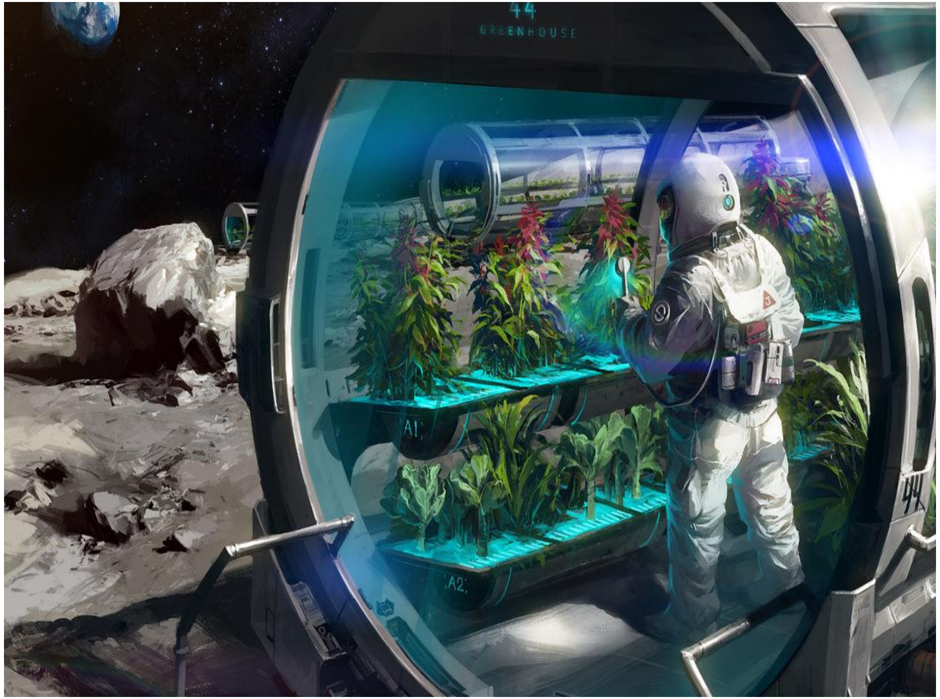
DIPARTIMENTO DI AGRARIA

Regenerative life support systems.

For long term missions:

- Food
- Water
- Oxygen





Circular pathway for food production.

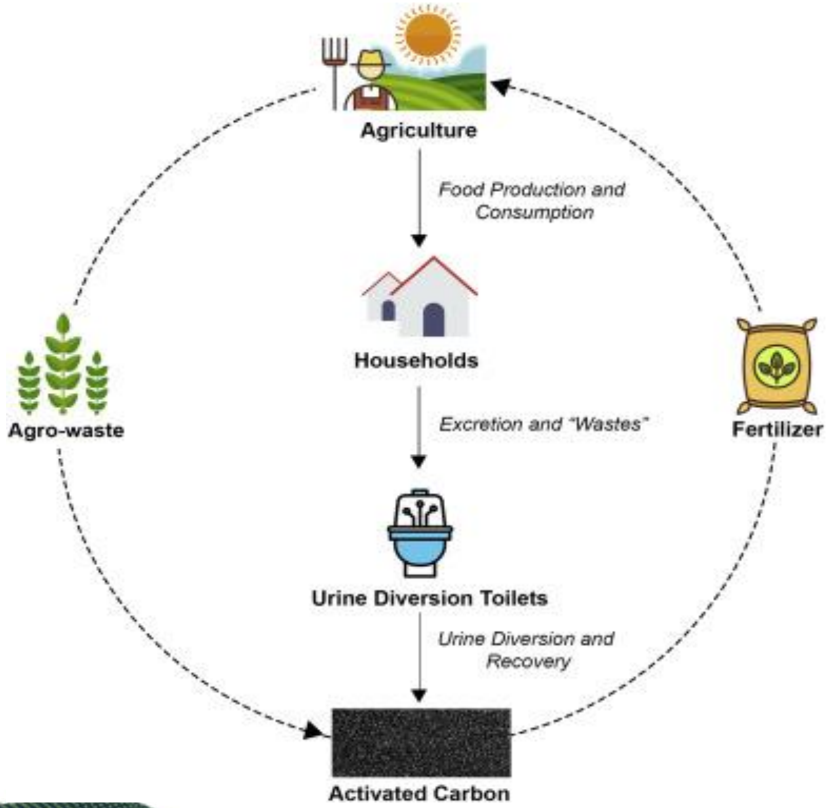
Reinforcing and optimizing sustainable food production is an urgent contemporary issue.

The depletion of natural mineral resources is addressed by recycling mined potassium and phosphorus and produced nitrogen.

A closed-loop approach of fertilizer usage requires the necessity of managing organic waste, rich in minerals.

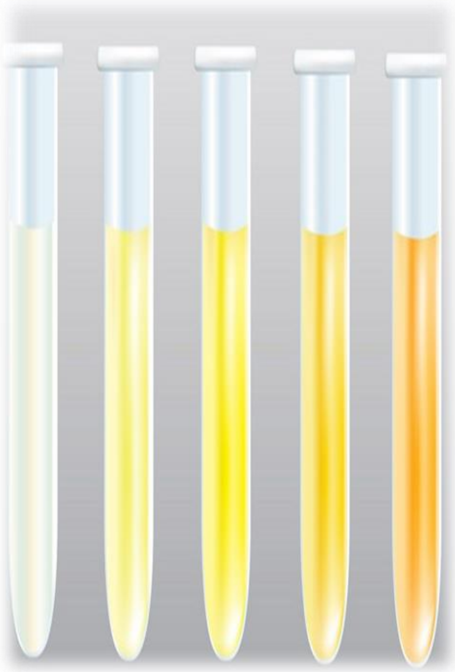
- Closed-loop fertility cycle asserts the realization of adequate natural resource management, amelioration of human welfare, and sustainable food security.

- A circular nutrient management approach, incorporate exhaustive recycling of nutrients encompassed in human excreta into agriculture.



Human urine:

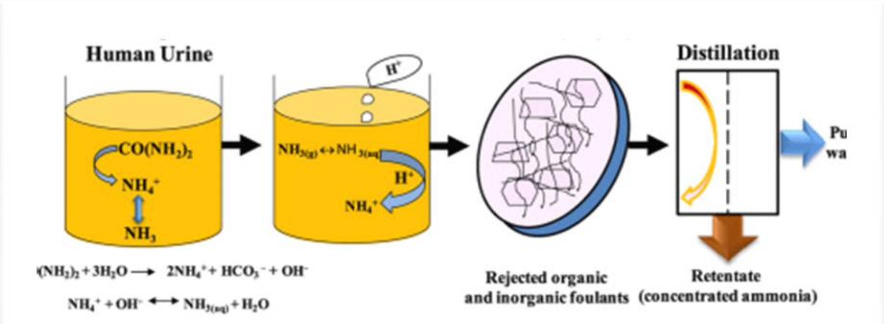
- Economically sustainable
- Rich in nutrients
- Easy to collect
- Environmentally friendly
- In situ available resource
- Safe for growing plants



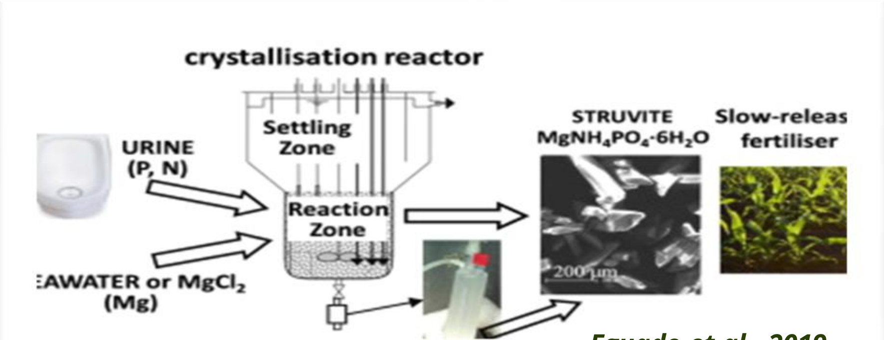
Urine recovery.

Technologies for urine recovery:

- Membrane distillation
- Electrochemical concentration
- Stabilization + distillation
- Ammonia stripping
- Struvite precipitation

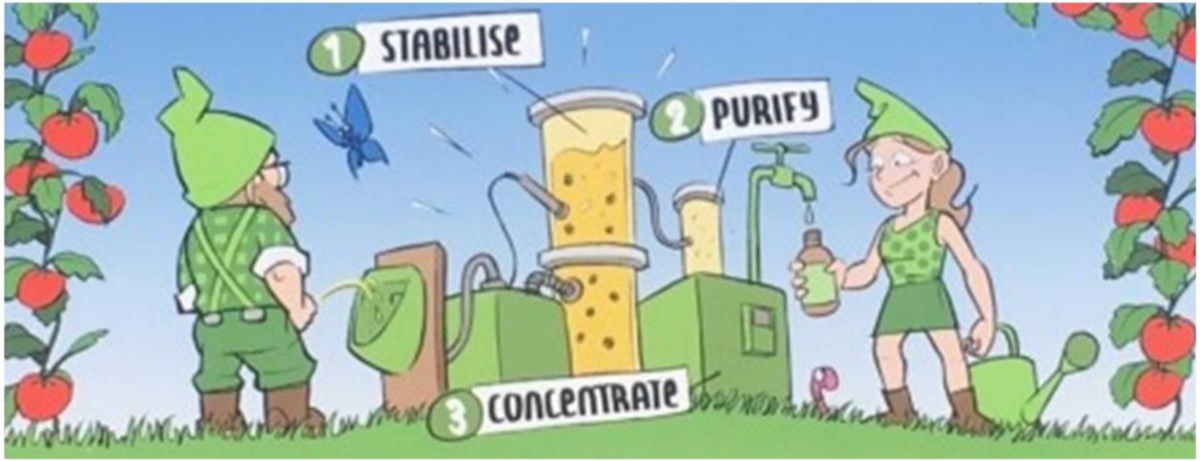


Tun et al., 2016



Eguado et al., 2019

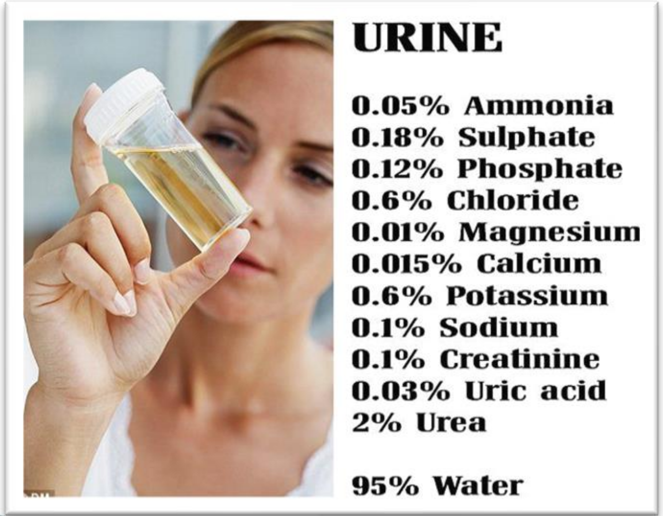
The technology required for source-separation and transforming human urine into fertilizer exists. However, the application of urine-derived fertilizer is currently limited to small-scale pilot initiatives.



Aim of the study

Thus far, the exploration of nitrogen- and phosphate-rich human urine to grow lettuce in soilless systems, has received little attention.

In this work, the performance of urine derivatives was compared with commercial fertilizer, in a short growing cycle of lettuce.



Experimental design.

Treatments were arranged in a randomized complete block design with three replicates.

8 Urine Derivatives + CTRL

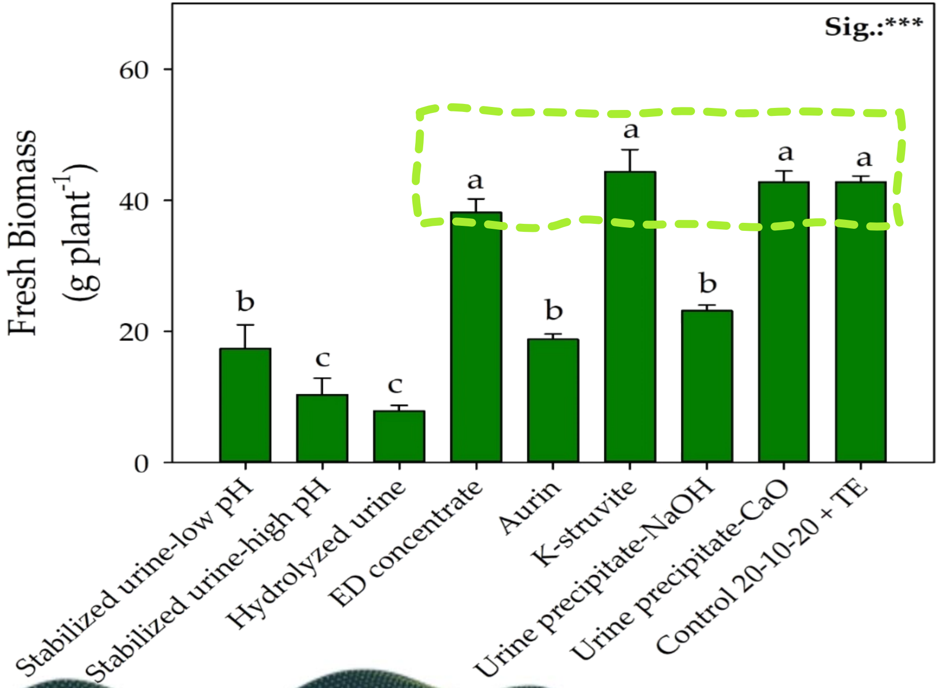
- Stabilized urine-low pH
- Stabilized urine-high pH
- Hydrolyzed urine
- ED concentrate
- Aurin
- K-struvite
- Urine precipitate-NaOH
- Urine precipitate-CaO
- Control 20-10-20 + TE

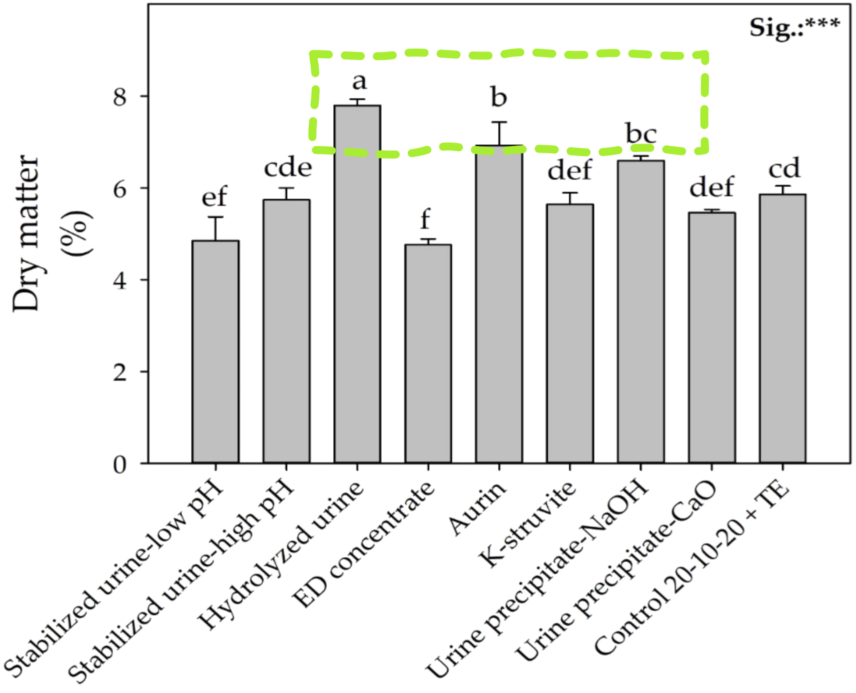
Materials & methods

Preparation of urine derivatives

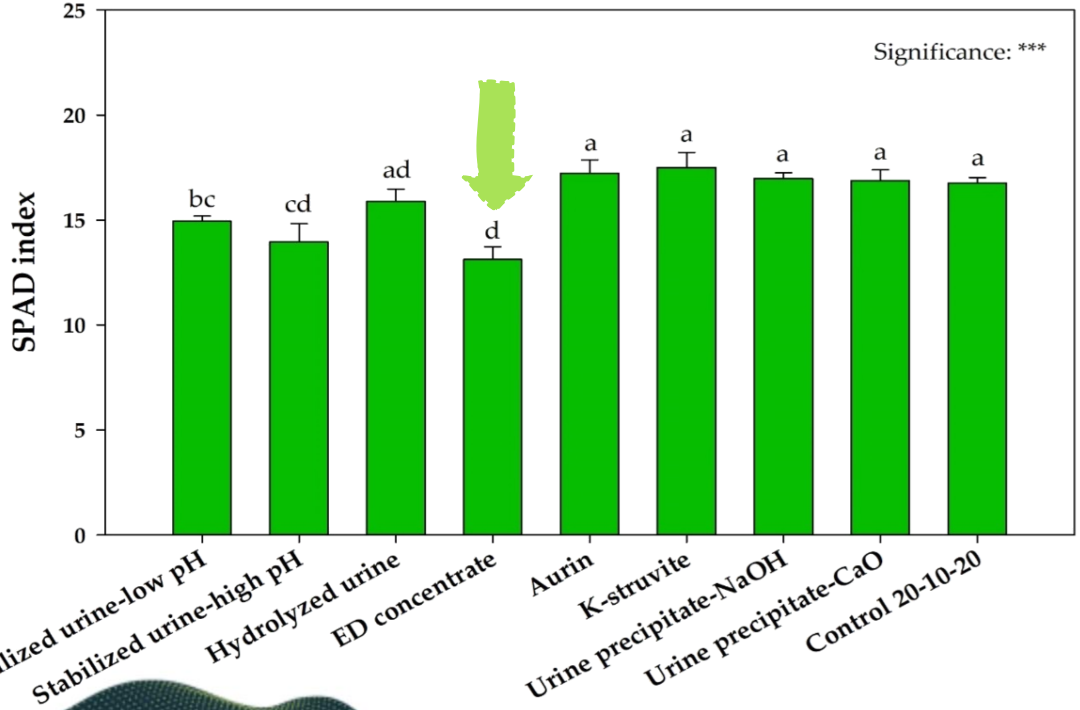
URINE DERIVATIVES	Liquid/solid	PREPARATION
Stabilized urine – low pH	Liquid	Stabilized real human urine at pH 2 after HCl addition
Stabilized urine – high pH	Liquid	Stabilized real human urine at pH>11 after NaOH and CaO addition
Hydrolyzed urine	Liquid	Stored real human urine (after spontaneous urea hydrolysis)
ED concentrate	Liquid	Real human urine treated with precipitation, nitrification & electrodialysis
Aurin	Liquid	Commercial fertilizer made from real human urine, using partial nitrification and distillation
K-struvite	Solid	Precipitate obtained from urine by removing all NH4-N (below 50 mg N/L), adding an equivalent molar amount of Mg2+ and increasing the pH to 10.
Urine precipitate – NaOH	Solid	Precipitate obtained by increasing the pH of fresh urine to 12.5 with NaOH
Urine precipitate – CaO	Solid	Precipitate obtained by increasing the pH of fresh urine to 12.6 with CaO

Biometric results





SPAD (Green Leaf) Index

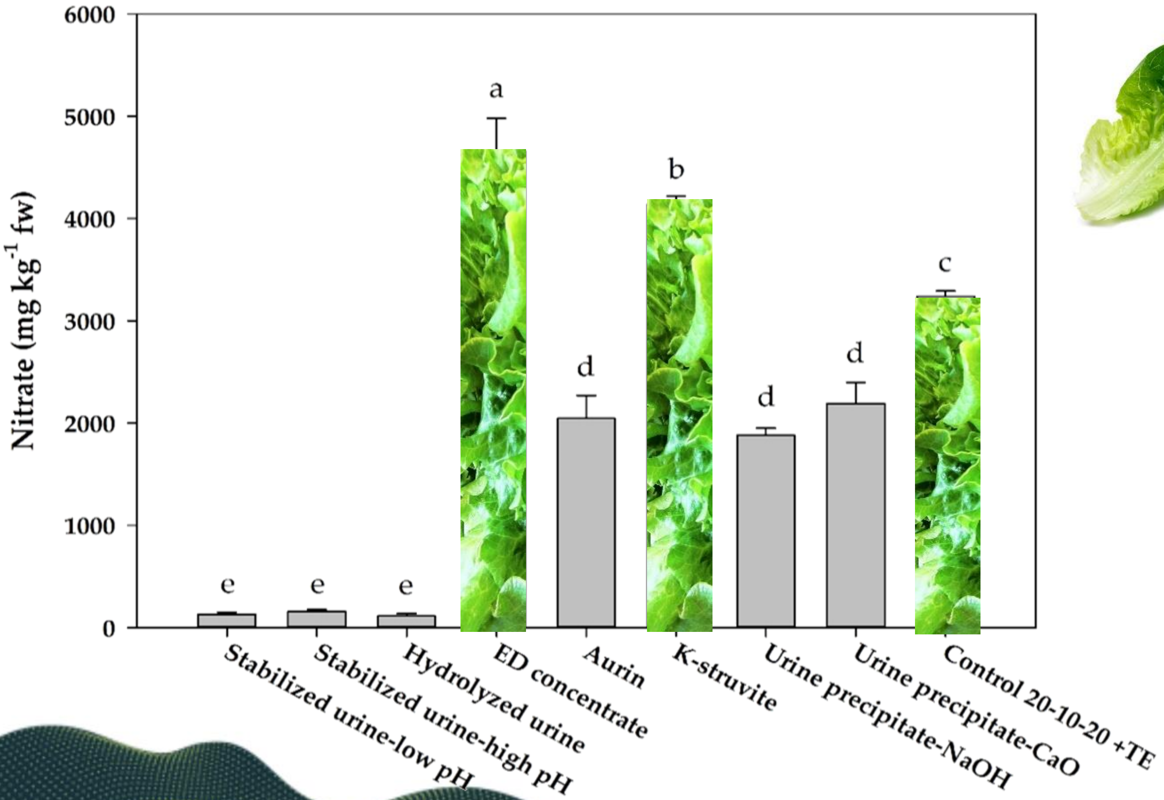


Chlorophyll SPAD

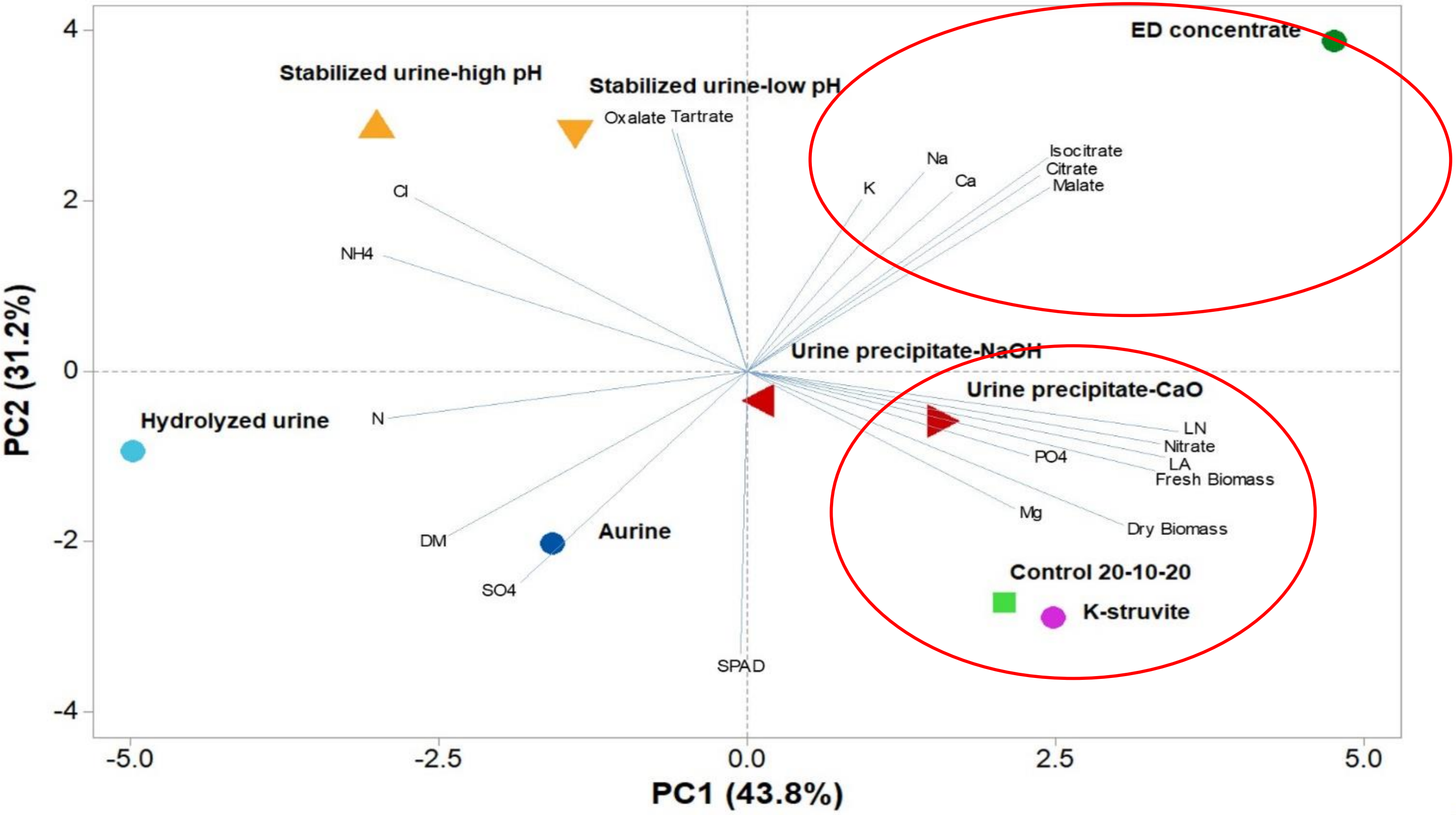
Leaf mineral concentration (g dw kg^{-1})

Treatments	PO_4	K	Ca	Mg	Na	Cl
Stabilized urine-low pH	17.13	75.63	3.65	1.63	15.11	53.32
Stabilized urine-high pH	14.25	67.70	1.88	1.24	11.84	41.16
Hydrolyzed urine	14.76	63.94	1.36	1.02	7.70	44.21
ED concentrate	18.38	78.66	3.64	1.54	32.06	21.22
Aurin	15.62	64.04	1.18	0.93	10.01	28.35
K-struvite	20.48	65.96	1.47	3.52	9.03	7.63
Urine precipitate-NaOH	17.99	51.08	2.03	2.53	25.56	29.22
Urine precipitate-CaO	13.68	62.02	3.99	2.17	13.49	27.59
Control 20-10-20 + TE	20.07	67.11	1.99	2.43	1.08	5.35
Significance	***	***	**	***	***	***

Nitrate leaf concentration (mg fw kg^{-1})



Principal component analysis



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sustainability

MDPI

Article

An Appraisal of Urine Derivatives Integrated in the Nitrogen and Phosphorus Inputs of a Lettuce Soilless Cultivation System

Christophe El-Nakhel [1,2,*], Danny Geelen [2], Jolien De Paepe [3], Peter Clauwaert [3], Stefania De Pascale [1] and Youssef Rouphael [1,*]

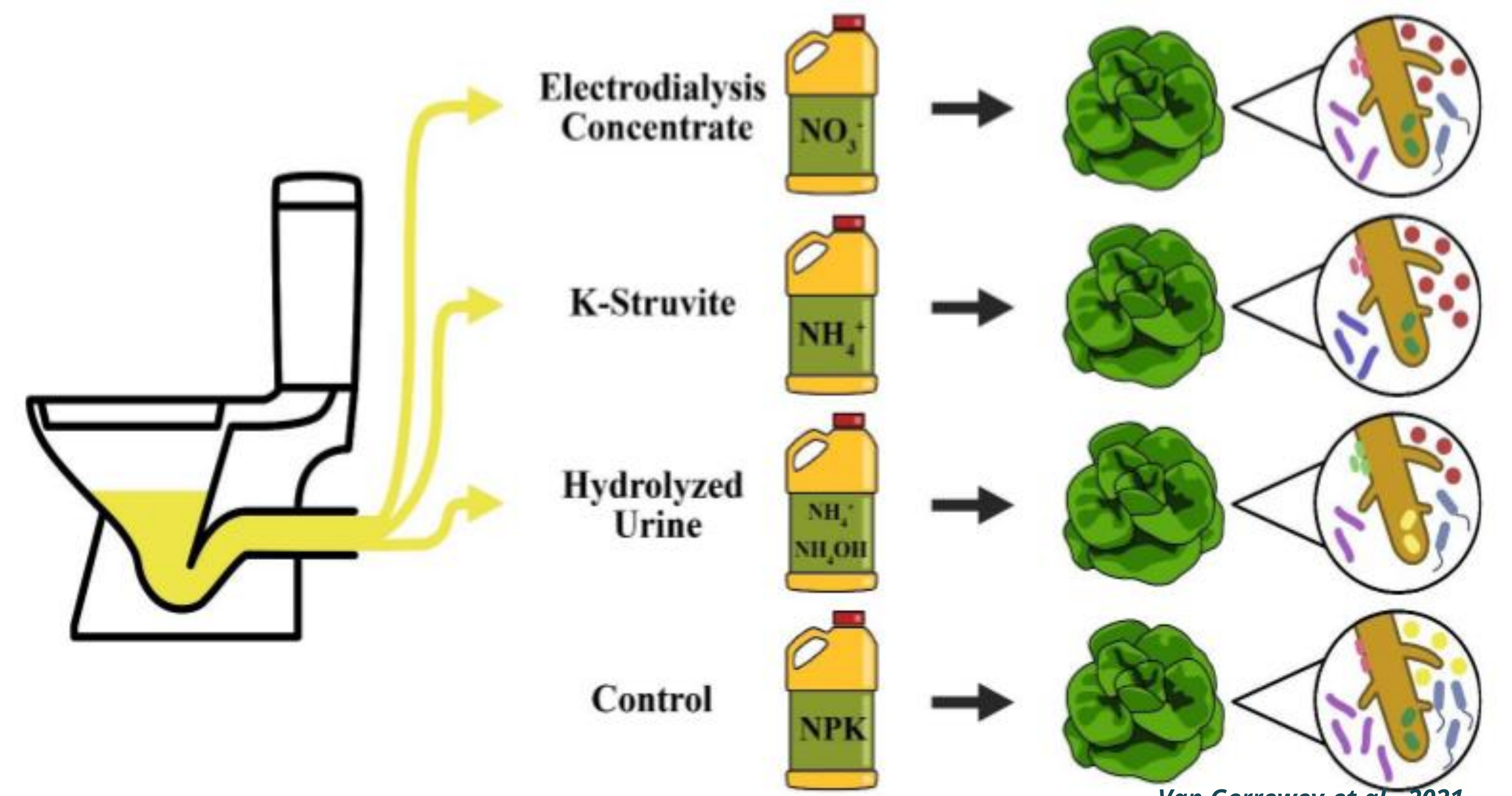
microorganisms

MDPI

Article

Root-Associated Bacterial Community Shifts in Hydroponic Lettuce Cultured with Urine-Derived Fertilizer

Thijs Van Gerrewey [1,3], Christophe El-Nakhel [1,2], Stefania De Pascale [2], Jolien De Paepe [3], Peter Clauwaert [3], Frederiek-Maarten Kerckhof [3], Nico Boon [3] and Danny Geelen [1,*]



Van Gerrewey et al., 2021

Conclusions

- ✓ Using recycled nutrients to grow horticultural crops would contribute reducing the depletion of natural mineral and energy resources.
- ✓ Nitrogen- and phosphate-rich human urine integration with commercial fertilizers prove to have potential future.
- ✓ Several urine derivatives (ED concentrate, K-struvite, and urine precipitate-CaO) performed similarly as mineral fertilizer.
- ✓ Human urine use as in situ resource has potential value for food production.
- ✓ Nonetheless, advanced research is needed to reduce NaCl concentrations in urine derivatives due to their drawbacks in agriculture.

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THANK YOU.

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