Closing the nutrient cycle in urban areas: The use of municipal solid waste compost for peri-urban and urban agriculture

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1

Introduction - Research questions - Methods - Results - Conclusions

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Urban agriculture (UA)

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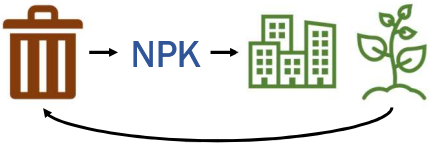
UA +  = More benefits for the city

(EEA, 2015; Rufí-Salís et al., 2020)



Benefits of (1) OMSW compost as alternative fertilizer and (2) integrating nutrient flows of waste and food systems in cities

(Martínez-Blanco et al., 2009; Tonini et al., 2013; Trimmer and Guest, 2018)

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Few have upscale OMSW compost to supply NPK at UA scale and assess it through a circular lens...

2/15

2

1. What is the of potential of OMSW compost to supply NPK demanded by UA?

2. And what are the environmental benefits and trade-offs of replacing mineral fertilizer with OMSW compost while minimizing waste?

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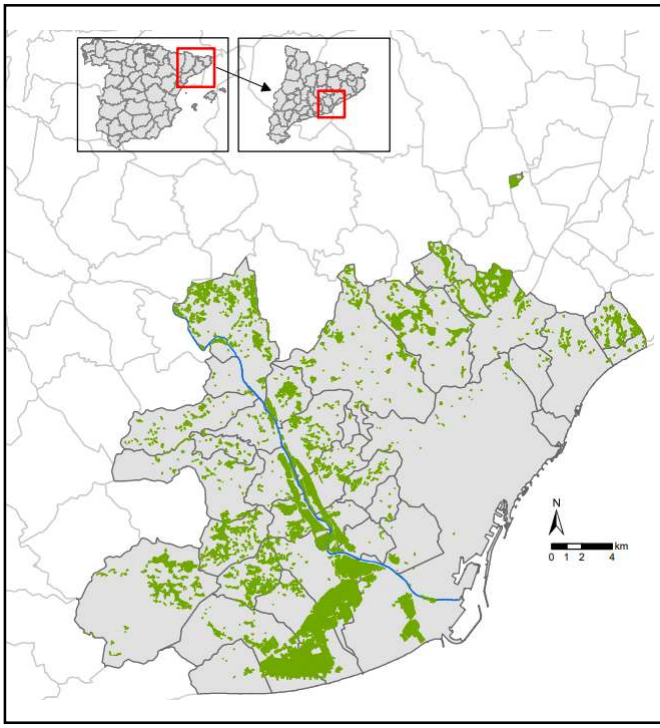


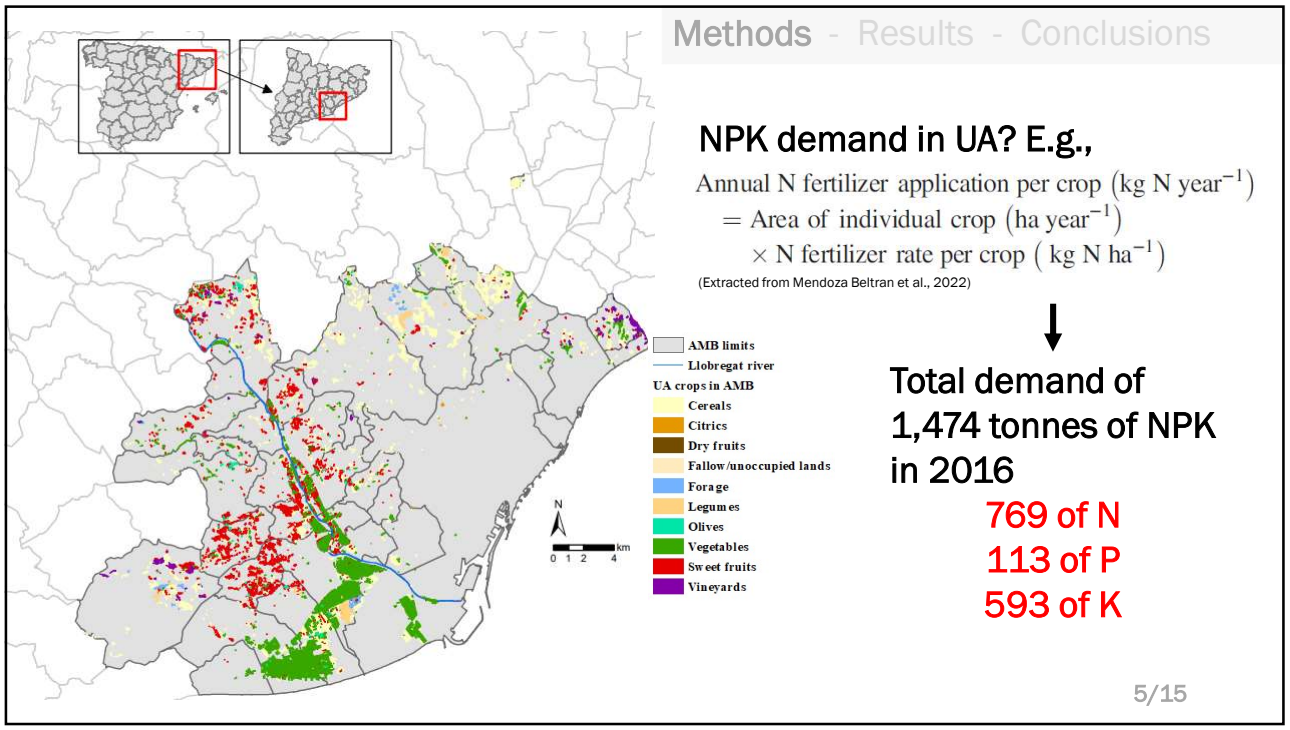
Case study:
Metropolitan Area of Barcelona (AMB)

3.2 million inhabitants
(5,093 inhabitants/km^2)

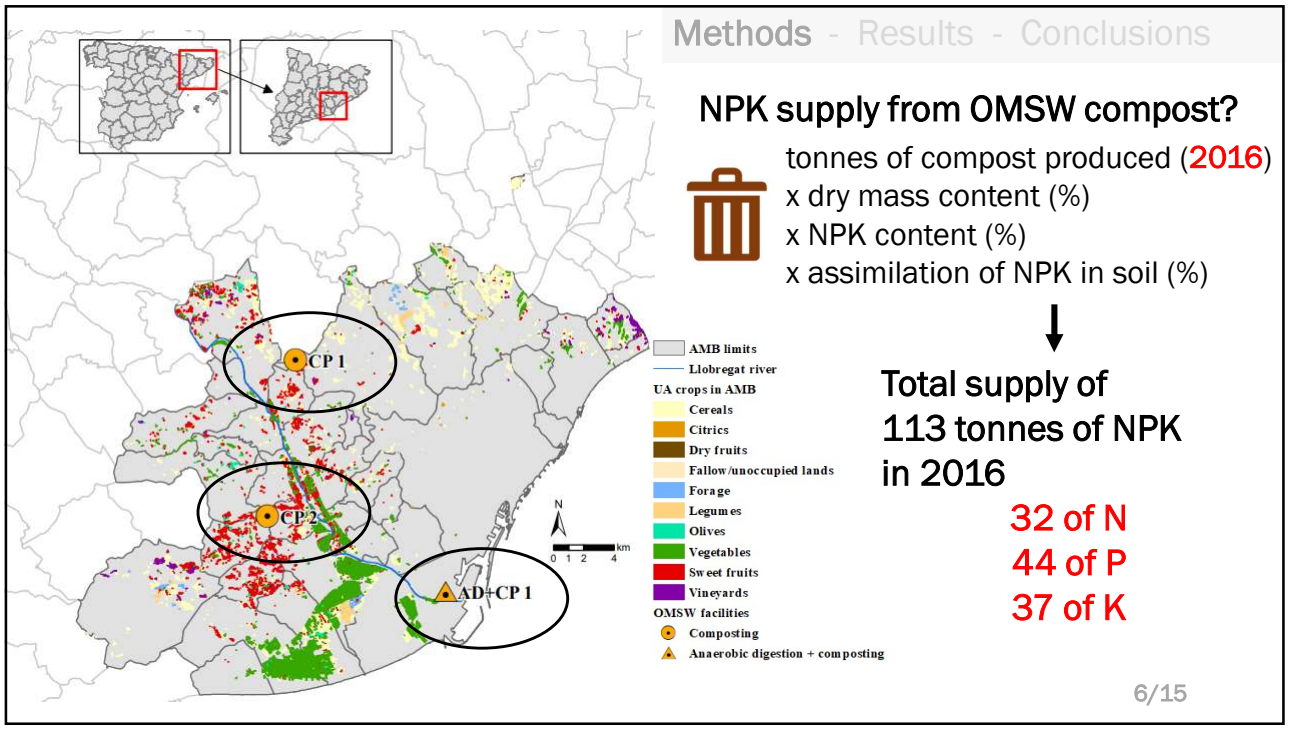
→ 5,568 ha of UA (2016)

68,800 tonnes of fresh produce a year

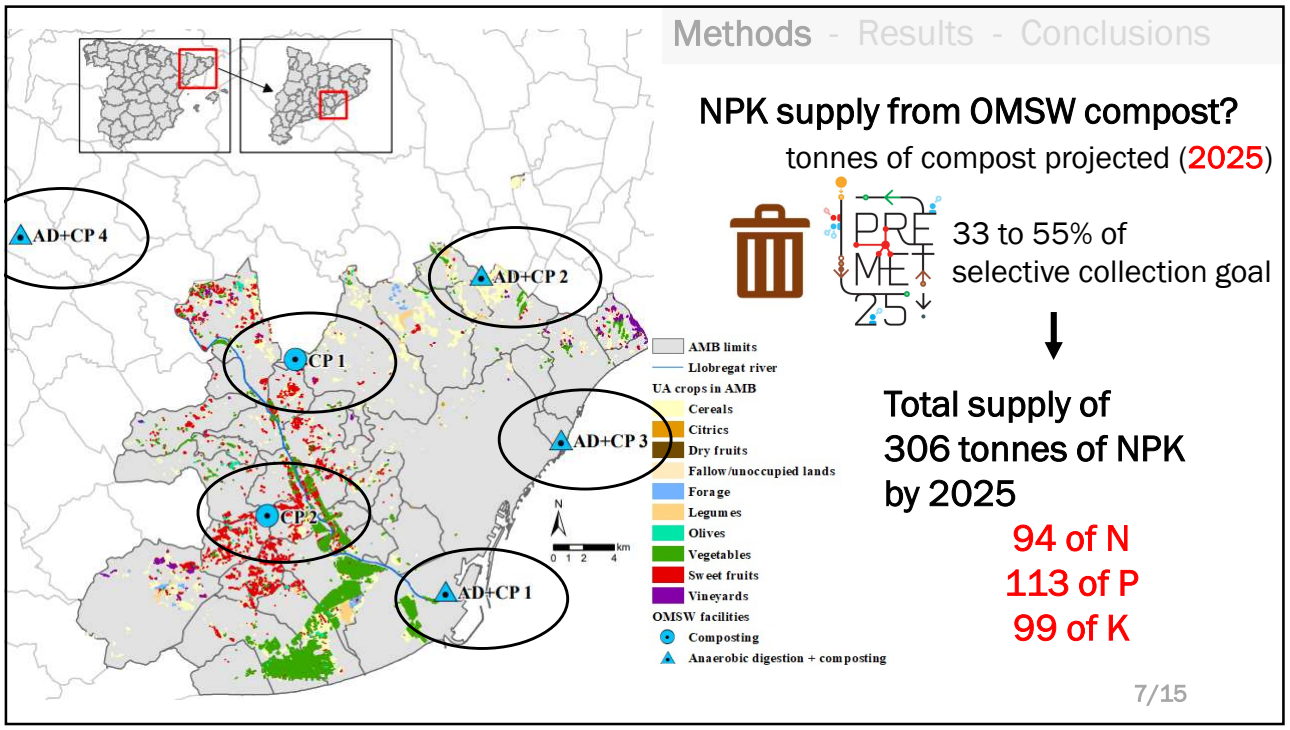
4


Methods - Results - Conclusions
NPK demand in UA? E.g.,
Annual N fertilizer application per crop (kg N year^{-1})
= Area of individual crop (ha year^{-1})
× N fertilizer rate per crop (kg N ha^{-1})
(Extracted from Mendoza Beltran et al., 2022)
Total demand of 1,474 tonnes of NPK in 2016
769 of N
113 of P
593 of K
AMB limits
Llobregat river
UA crops in AMB
Cereals
Citrics
Dry fruits
Fallow/unoccupied lands
Forage
Legumes
Olives
Vegetables
Sweet fruits
Vineyards
N
km
0 1 2 4
5/15

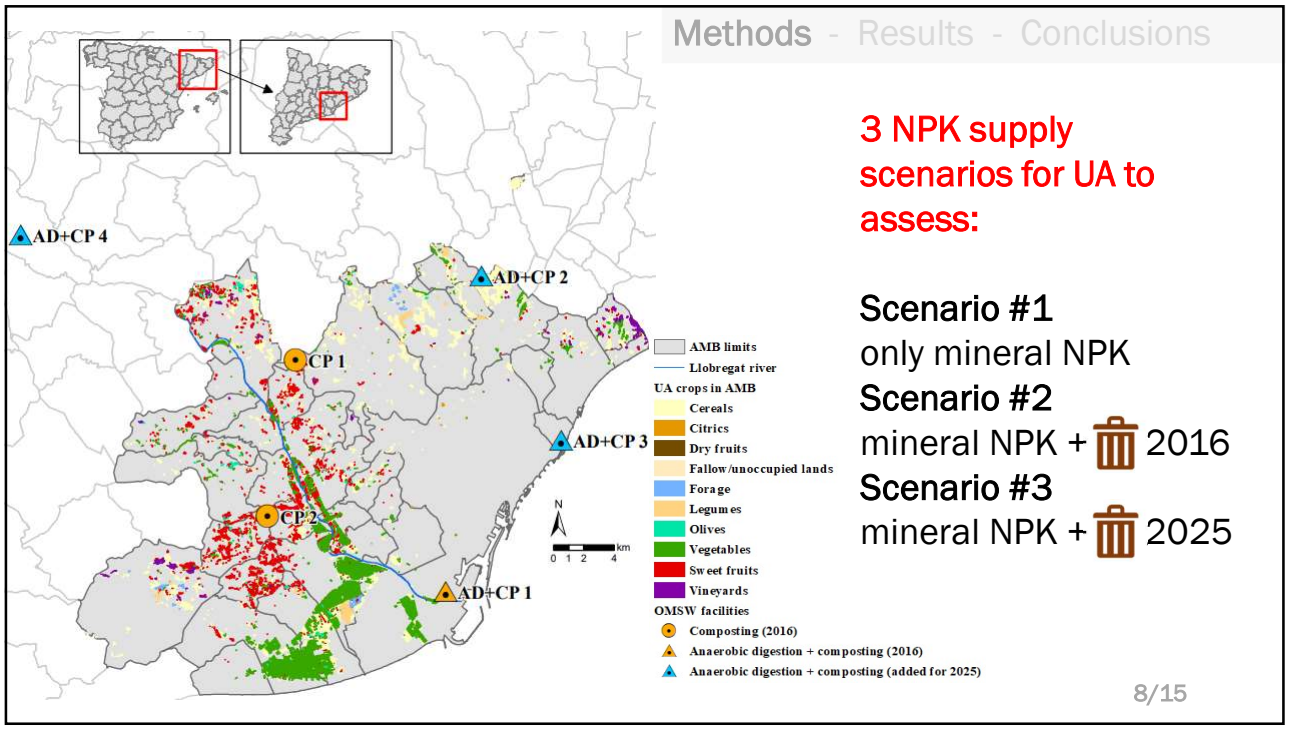
5


Methods - Results - Conclusions
NPK supply from OMSW compost?
tonnes of compost produced (2016)
x dry mass content (%)
x NPK content (%)
x assimilation of NPK in soil (%)
Total supply of 113 tonnes of NPK in 2016
32 of N
44 of P
37 of K
CP 1
CP 2
AD+CP 1
AMB limits
Llobregat river
UA crops in AMB
Cereals
Citrics
Dry fruits
Fallow/unoccupied lands
Forage
Legumes
Olives
Vegetables
Sweet fruits
Vineyards
OMSW facilities
Composting
Anaerobic digestion + composting
N
km
0 1 2 4
6/15

6

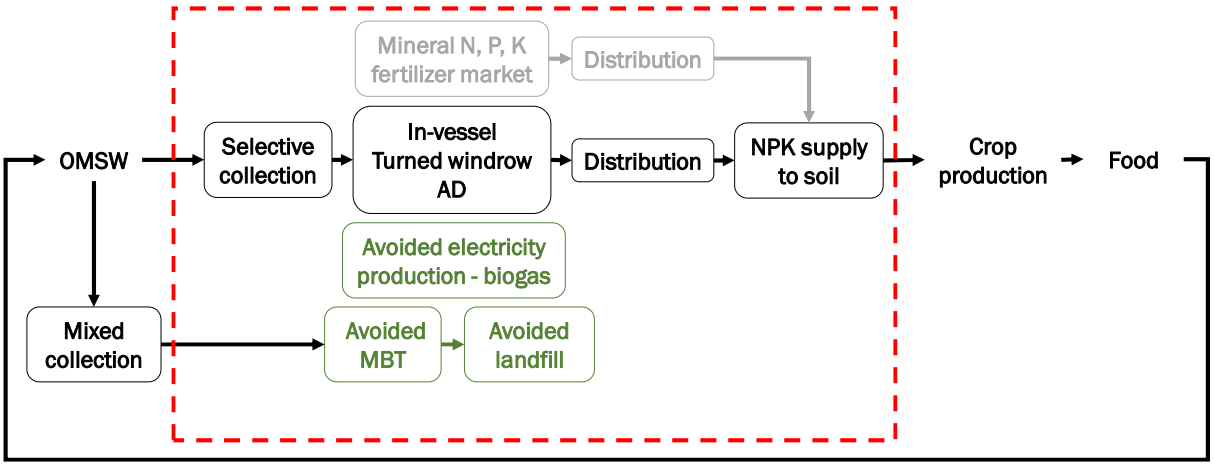

Methods - Results - Conclusions
NPK supply from OMSW compost?
tonnes of compost projected (2025)
33 to 55% of selective collection goal
Total supply of 306 tonnes of NPK by 2025
94 of N
113 of P
99 of K
AD+CP 4
AD+CP 2
CP 1
AD+CP 3
CP 2
AD+CP 1
AMB limits
Llobregat river
UA crops in AMB
Cereals
Citrics
Dry fruits
Fallow/unoccupied lands
Forage
Legumes
Olives
Vegetables
Sweet fruits
Vineyards
OMSW facilities
Composting
Anaerobic digestion + composting
7/15

7


Methods - Results - Conclusions
3 NPK supply scenarios for UA to assess:
Scenario #1
only mineral NPK
Scenario #2
mineral NPK + 2016
Scenario #3
mineral NPK + 2025
AD+CP 4
AD+CP 2
CP 1
AD+CP 3
CP 2
AD+CP 1
AMB limits
Llobregat river
UA crops in AMB
Cereals
Citrics
Dry fruits
Fallow/unoccupied lands
Forage
Legumes
Olives
Vegetables
Sweet fruits
Vineyards
OMSW facilities
Composting (2016)
Anaerobic digestion + composting (2016)
Anaerobic digestion + composting (added for 2025)
8/15

8

LCA, ISO 14040; FU: Supply total NPK demand of UA; SimaPro; ReCiPe method (H)

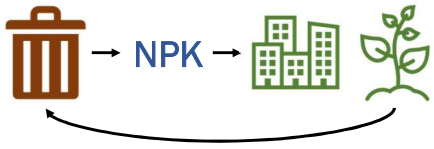


OMSW collection: container, route distance
Composting: water, electricity, direct emissions, refuse
Distribution: distance
Compost NPK to soil: direct emissions

Mineral N, P, K: ES market, distance
Mineral N, P, K to soil: direct emissions (**local N_2O - URBAG**)
Savings: biogas recovery, avoided OMSW treatment

9

1. What is the of potential of OMSW compost to supply NPK demanded by UA?



8% of the total NPK demanded by UA, considering OMSW compost produced in 2016

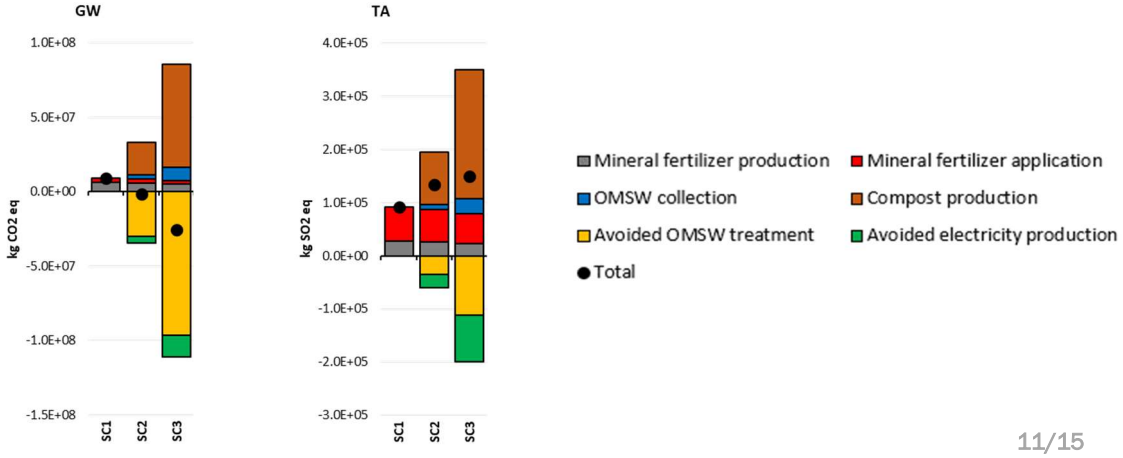
4% of N, 38% of P, and 6% of K

and 21% if compost production increase based on AMB's MSW program goals for 2025

12% of N, 99% of P, and 17% of K

10

2. What are the environmental benefits and trade-offs of replacing mineral fertilizer with OMSW compost while minimizing waste?



11

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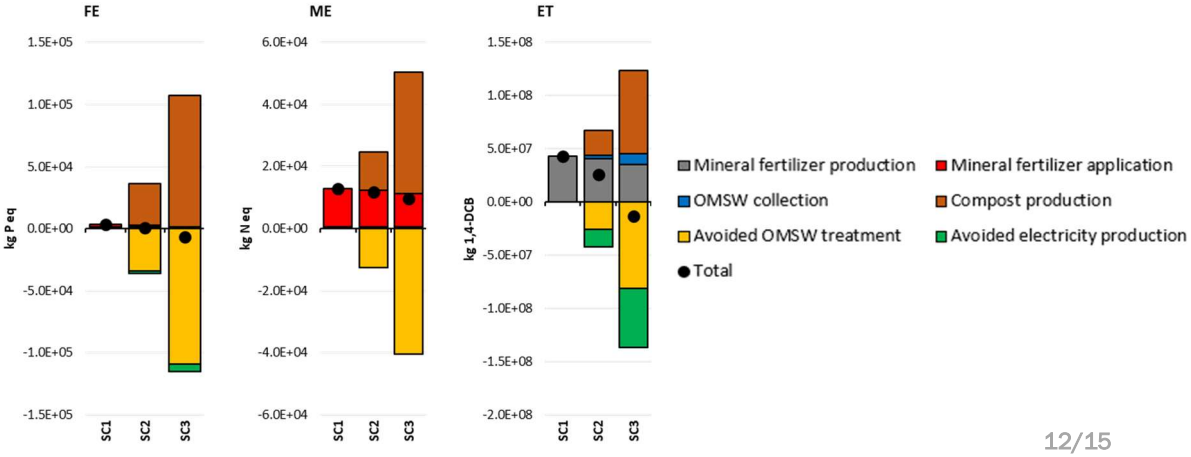

12

PROS:

1. OMSW compost have (some) potential to supply N, P, and K demanded at UA scale
2. Composting of OMSW provides benefits in GW, FE and ET
3. Useful to inform about benefits of nutrient circularity considering entire life cycle in the city
4. No, we don't need more compost. We need to take advantage of the direct and indirect benefits of closing the loop between 2 systems (MSW + UA)

13

CONS:

1. OMSW compost is not the best alternative to replace mineral N fertilizer
2. Composting in open facilities and refuse is still impactful. Aside from prevention, gaseous treatment and selective collection is critical
3. Practice is not easy. Barriers exist preventing nutrient circularity in UA, disconnection between systems

14

Thank you!

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15