Waste-Water-Energy nexus: a feasible, sustainable approach in climate-change affected Mediterranean regions

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Waste and Wastewater: Issues or Resources?
The issue of posing easy questions....
...is that then you expect simply answers,...
...but often you do not get the right one (or at least the complete truth)

Before ...Never
The mean quality of the information from media and the “miracles” it promises

This is **PAOLA**. She weighted 140 kg. She went to the doctor, started the diet and the gym and she lost 6 kg in 6 months.

The girl next to her is her cousin **MARTA**.
Context of disinformation, which should no longer be underestimated because if it is fed and continuously repeated

Waste does not exist

COVID does not exist

but which spherical are you talking about?……

NO Masks No social distancing
....as much as folkloristic it may seem to us, it can create doubts to people (even against science)
Because when a “likely” but fake news is repeated and repeated and repeated
For many persons it may go over the evidence.
And if the many are MANY the consequences can be disastrous
Spatial distribution of municipal waste generated in Europe

Scarlat et al. 2019 Status and Opportunities for Energy Recovery from Municipal Solid Waste in Europe
Suitability map for waste-to-energy plant location

Scarlat et al. 2019 Status and Opportunities for Energy Recovery from Municipal Solid Waste in Europe
Mediterranean Drought conditions areas
Issue: the diffusion of uncompromising approach

End of an error?
TRUE: Nature doesn’t know the term “waste”
Issue: the world today is not more so simple and natural and it cannot be so simply represented.
Refusal of any Waste treatment Plants (but WtE is first in line)
Issue: Non Recyclable waste
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Issue: how many cycles – some scientific and public concern

Health fears over recycled food packaging

Home is where the toxins are - the hidden poisons we live with

Some houses can be susceptible to a buildup of formaldehyde created by cleaning products. Which other everyday items can leave a harmful chemical trail?
Issue: innovation in new composite materials versus potential recycling rate
Issue: ‘Social behaviour’
Door to door collection
(consierge+internal space)
Door to door
(consierge+internal space)
social behaviour
(waste migration and dispersion)

Catania nord trasformata in discarica a cielo aperto: “A contribuire i pendolari dei rifiuti”

di Lucia Murabito

A denunciarlo è il consigliere comunale di Art.4 Giuseppe Catalano: San Giovanni Galermo e tutta la zona nord della città sono invase da mini discariche abusive e rifiuti abbandonati ad ogni angolo
Issue: scraps from plastic waste selection

up to 50%
Scraps from composting up to 20%
Issues: we still have the unsorted waste (‘social behaviour’)
Circular economy is a fundamental part of the solution in waste management but.....

SUSTAINABLE Circular ECONOMY
Really sustainable
Once we made the perfect door to door separate waste collection....
How far from the goal are we yet?

- 230 cm
- 90 cm
Two simple calculations: %
Separate collection VS Recycling

SC 75-80% (when???)

60-65% recycling

20-25% (unsorted)

32-38%

12-13% (Scraps)
Two simple calculations: %
Separate collection VS Recycling

SC 65-70% (soon???)

50-60% recycling

30-35% (unsorted)

40-48%

10-13% (Scraps)
How to manage Residual waste (unsorted + scraps)???
The first fork..

Unsorted waste 35%
Separate collection 65%
Waste 100%
Scraps 13%

RESIDUAL 47,9%
To selection 52% new materials

????????
Residual waste to landfill (less than 10% al 2035)

- Waste 100%
  - Unsorted waste 35%
  - Separate collection 65%
  - Scraps 13%
- To selection 52% new materials
- Landfill 47.9%
- Leachate
Management Alternatives

- **Unsorted waste (35%)**
  - Separate collection (65%)
  - Scraps (13%)
  - To selection
  - 52% new materials
- **Landfill (47.9%)**
  - <10% Leachate

- **Separate collection (65%)**
  - Scraps (13%)
  - To selection
  - 52% new materials

- **Waste (100%)**
  - WtE (47.9%)
  - Recycling (14%)
  - Landfill (3%)
NO WtE
NO Landfill ….is there any other way?

Residual waste from 65% separate collection 48Kg over 100 kg can go to…..
The third way... abroad

Economic losses... and RESILIENCE losses
Context and open issues: climate change and drought

Italy drought: 11 regions poised for state of emergency

Eleven of Italy’s 20 regions are set to ask for a state of emergency to be declared in order to help tackle the ongoing drought.
One of the most beautiful coastal area of Sicily
One of the most untreated wastewater discharge in the previous coastal area
Context and open issues: High impacts from discharges and zero wastewater reuse
Context and open issues: sludge management
In summary, we have... so many issues
HOW to change the waste/wastewater management paradigm in South Europe regions?
The “Symbiosis Approach” is evaluated on the Metropolitan Area of Catania plus the provinces of Enna, Siracusa and Ragusa.

It considers 2 million p.e. in terms of waste production and 545,000 p.e. in terms of the WWTP capacity.
Comparison of three scenarios

**SCENARIO A (current)**
- WASTE (Separate Collection 30%)
  - Recycling and recovery
- WASTEWATER
  - WWTP
  - Sludge
  - Water bodie pollution
- Energy

**SCENARIO B (2030)**
- WASTE (Separate Collection 68%)
  - Selection
  - Recycling and recovery
- WASTEWATER
  - WWTP
  - Sludge
  - Water bodie pollution
  - Air emissions
  - CH₄, CO₂, VOC

**SCENARIO C (2030)**
- WASTE (Separate Collection 68%)
  - Selection
  - Scaps
  - Recycling and recovery
- WASTEWATER
  - WWTP
  - Sludge
  - Water bodie pollution
- Energy

**Air emissions**
- CO₂
- CH₄
- VOC

**Landfill**
Symbiotic exchanges

1. Part of the heat generated by waste-to-energy, suitably commensurate through a well-dimensioned management of steam spills, can be used, also in semi arid climate regions to carry out the AD in the thermophilic phase reducing digestion times and volumes, increasing the biogas production yield with an advantage that also affects the greater efficiency of sludge digestion compared to more traditional mesophilic processes.
Symbiotic exchanges

2. Also the recovery of the energy content of OFMSW is maximized as it is no longer necessary to burn, in the boiler, part of the biogas produced by the same process. The heat is now supplied by the treatment of the residual fraction of MSW in the WtE plant. The biogas produced can be totally converted into biomethane thus maximizing any economic incentives.
Symbiotic exchanges

3. Energy demand for the treatment of OF waste is severely reduced, leaving only the minimum residual maturation phase to the much more expensive energy-consuming composting with an advantage in terms of direct and indirect CO$_2$ emissions (for energy production) while still producing quality compost.
4. Part of the **heat from waste-to-energy** could also be used in the process of **converting biogas into biomethane**, reducing the costs for its use in public transportation and waste collection trucks, increasing the benefits of circularity for the territory and further reducing GHG emissions;
5. Part of the heat from waste-to-energy can be used to pre-drying the dewatered digestates (sludge of even both) with a view to their energy recovery, in a dedicated line of the waste-to-energy plant, which also collects contributions from other smaller nearby plants, to ensure recovery of phosphorus from the ashes and eliminate the problem of final disposal (ZERO DISCHARGE).
6. The electricity produced by the WtE plant can be partially used (a few percentage units) to support the tertiary treatment phase and pumping of the treated wastewater to the agricultural areas in order to make the cost of the treated wastewater competitive, guaranteeing its full reuse avoiding that the concentrated load is discharged into water bodies with the related impacts, especially in islands and coastal areas (ZERO DISCHARGE GOAL). The huge amount of remaining electricity can go to the market.
Symbiotic exchanges

7. A further part of the electricity produced by the WtE plant could be used to support the entire wastewater treatment process in full view of industrial symbiosis (Almost ZERO CO₂ Emissions Goal).

- The oxidation phase in the water line should in any case be conducted as a classic scheme with a high load to minimize energy consumption, taking into account subsequent reuse also through a limitation of denitrification.
Symbiotic exchanges

8. Part of the purified effluent can be used as cooling water for the waste-to-energy plant, saving a precious resource for other uses and increasing the overall circularity of the proposed system.
9. The residual fraction and non-recyclable waste are reduced in volume (about 10%) by reducing the landfill requirement and the consequent impacts.
Symbiotic exchanges

10. Thanks to the recovery of bottom ashes in construction materials, the reduction of waste to be disposed of in landfills could be further limited to only inertized fly ash (approximately 2-4% of the total waste, in full compliance with the European directives (which set the limit of 10% by 2035)). This allows to increase the overall recycling of materials (+5-10%) of the total waste depending on the residual portion) - significantly increasing the circularity of the entire system helping to respect Recycling EU Directives.
Symbiotic exchanges

11. Part of the heat from WtE can be used to support **surrounding industries** (existing or wishing to enter the industrial district) by **exploiting the residual heat at advantageous conditions for their processes** (e.g. agri-food process industry), in addition to any **heating and cooling needs**, in full view of industrial symbiosis with a consequent reduction of their CO_2 emissions.

12. Part of the heat from WtE can also be used to **pre-drying biomasses from the agricultural sector** before their energy recovery in the same waste-to-energy plant, reducing disposal problems;
Symbiotic exchanges

13. A part of the CO₂ produced by the conversion process into biomethane and/or contained in the fumes of the waste-to-energy plant could be recovered (e.g. converted into algal biomass to be used for high added value products).
14. The liquid fraction of the digestate can be recirculated to the WWTP as effluent, greatly reducing management costs (with direct/indirect recovery of nutrients).

15. The composted digestate and the wastewater contribute to increasing the agricultural yield by favoring a closure of the organic cycle.
A rough energy balance

WtE Electricity production (year) 452,6 GWh

WtE Heat production (year) 726,1 GWh

WtE Energy required for the WWTP (year) 9,9 GWh

Energy required for tertiay treatment +pumping (year) 20,2 GWh

Heat requirement for sludge digestion (year) 14,2 GWh

Heat requirement for sludge drying (year) 29 GWh

Heat requirement for OF digestion (year) 19,4 GWh

Heat requirement for digestate drying (year) 112 GWh

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Other Companies (district heating and cooling)
Recycling, Recovery and (wastewater) Reuse are complementary to divert waste and sludge from landfill.
TAKE HOME MESSAGE

Environmental Shamans
People Stakeholders
Scientists

Jacob Anthony Angeli Chansley (born 1988), also known under the name Jake Angeli, and as the QAnon Shaman,
TAKE HOME MESSAGE

Don’t be afraid to open your mouth
And always be a paladine of the correct environmental information to people.
Just a final thought for Southern Europe regions (Sicily is mine)

“Change everything to not change anything”

Giuseppe Tomasi di Lampedusa: author of «The Leopard».

“I don't want to live only for the future; I want to live in the present; And never forget that this present is the future someone promised me.”

Giuseppe Mancini March 2021