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Quality evaluation of mechanically-biologically treated MSW subjected to longer duration of biological treatment

Authors:
Maria Chiara Di Lonardo, Francesco Lombardi, Iason Verginelli, Renato Gavasci

University of Rome "Tor Vergata"
Department of Civil Engineering and Computer Science Engineering
Division of Sanitary Environmental Engineering

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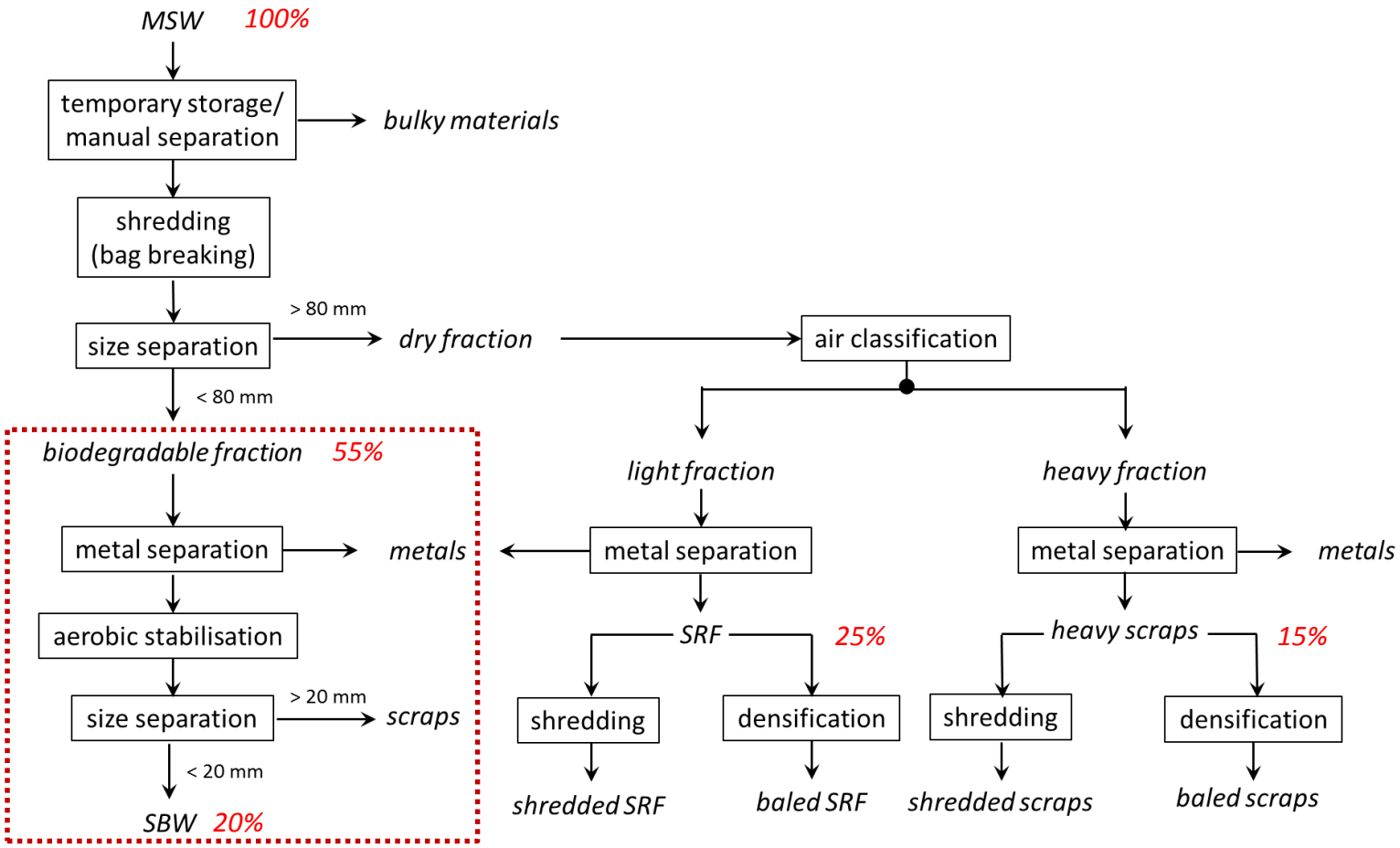
STUDIED MBT PLANT

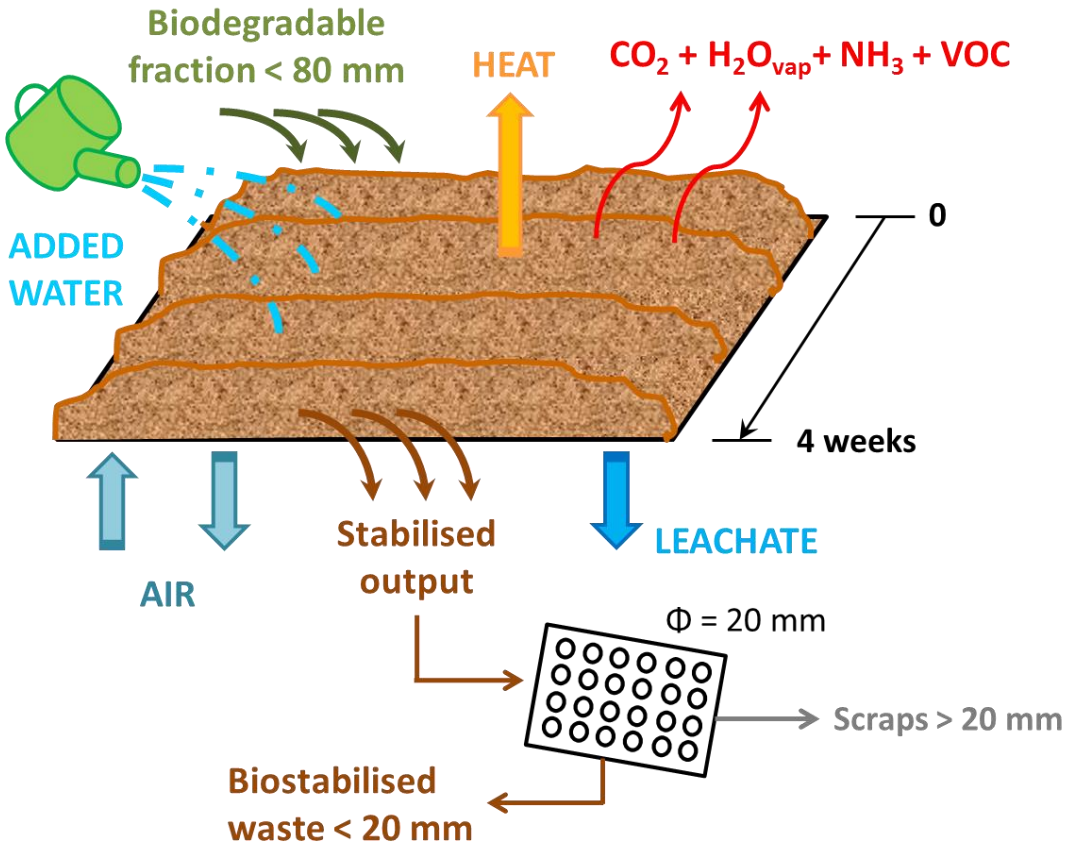
In this study waste materials were sampled in 1 of the **4 MBT plants** operating in Rome.



After Di Lonardo et al. 2012

The focus was on the **biodegradable fraction** that is around **55% of MSW** feeding the plant.

- The **undersized biodegradable fraction,** separated through the preliminary sieving process, is then stabilized under forced aerated conditions for **4 weeks**



Different **augers** moved by a crane allow to **turn over the material** in order to keep proper free air space for **aeration** (avoiding the formation of anaerobic conditions) and **move the material along the basin**.

During the turning, **water is added** to the material by nozzles fixed on the crane, in order to keep the water content favourable for the microbial activity.

The **stabilised output then is sieved in a trommel screen** with a mesh opening of 20 mm (refining unit) in order to separate an oversized fraction mainly composed of plastics and inert materials from the undersized fraction consisting of the final biostabilised waste (BSW)

- The **biostabilised waste** is not subjected to a further maturation phase but it is directly **landfilled**

AIM OF THE WORK

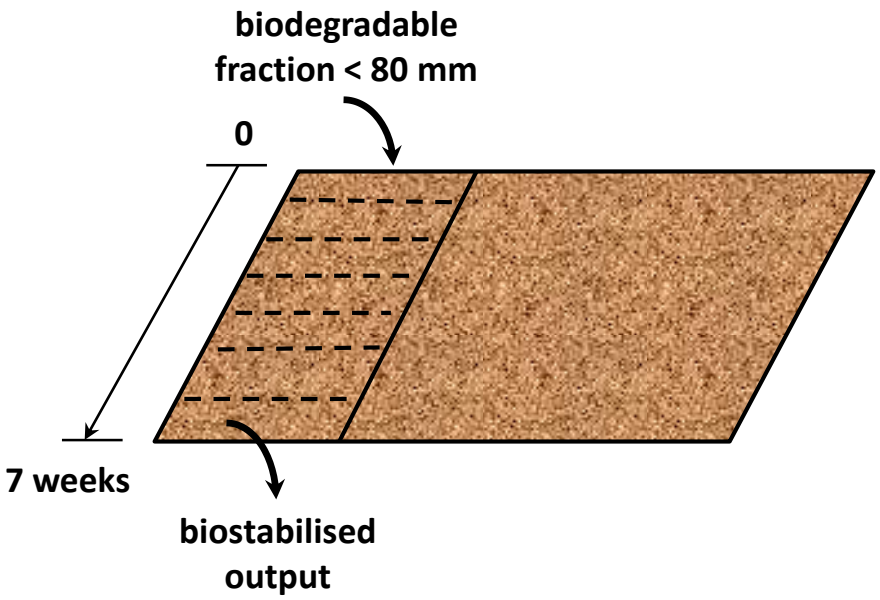
- In a previous study (Di Lonardo et al., 2012) we have found that **SBWs,** as currently treated in this MBT plant, **don't have a suitable quality for waste recovery**

How the **biological treatment duration** influence the characteristics and quality of bio-stabilized wastes (BSW)?

AIM OF THIS WORK

In order to assess if a longer duration of the biological process can improve the quality of bio-stabilized waste we have increased the biological treatment duration from 4 weeks - normal operating conditions of the MBT facility - to **7 weeks**

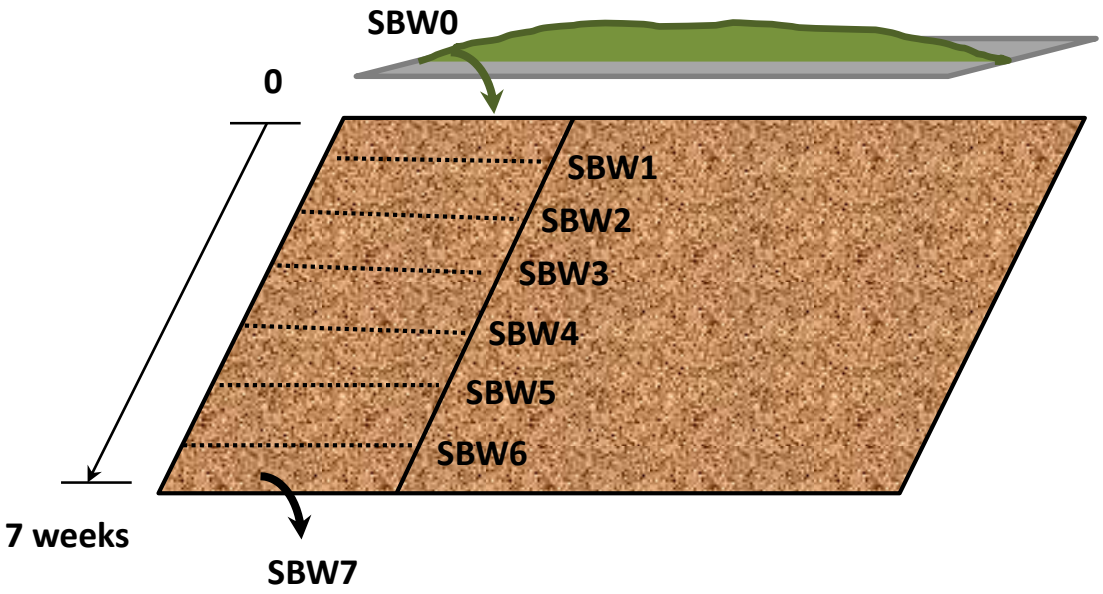
- One part of the biostabilisation basin was isolated and set up in order to:
  - keep and treat the material for 7 weeks by turning the material once per day (instead of 2-3 times per day)
  - allow the process monitoring and the material sampling
  - not hinder the normal operating conditions of the plant



SAMPLING PROCEDURE

- Prior to the beginning of the biological process, the input material - untreated biowaste, **SBW0** - was sampled from the conveyor belt carrying the biodegradable fraction to the stabilisation basin

- Afterwards, during the aerobic biodegradation process, 7 samples of the biostabilised waste - **SBW1 → 7** - were progressively collected week by week



- After mixing and quartering, a final quantity of roughly 20 kg for each sample was sent to the laboratory for the biological and physical-chemical analysis.

- A secondary quartering in lab was carried out in order to split:
  - 15 kg for the biological analysis, which needed as-received material
  - 5 kg which was air dried prior to perform all physical-chemical tests

BIOLOGICAL-PHYSICAL-CHEMICAL CHARACTERISATION (1/2)

For each collected sample a biological and physical-chemical characterization was performed. Namely, the following parameters were determined:

- **Biological stability degree** → determination of **dynamic respiration index - DRI**, i.e. the absolute maximum value of oxygen consumption due to microbial activity (Adani et., 2004; UNI/TS 11184, 2006):
  1. measure of moisture content and absorbing water capacity
  2. water addition at 75% of maximum absorbed water to as-received sample → optimum moisture content for biodegradation
  3. ≈ 10-15 kg in 30 l **adiabatic respirometric reactor** (Costech International Respirometer 3024) at aerobic optimised conditions for 5 days

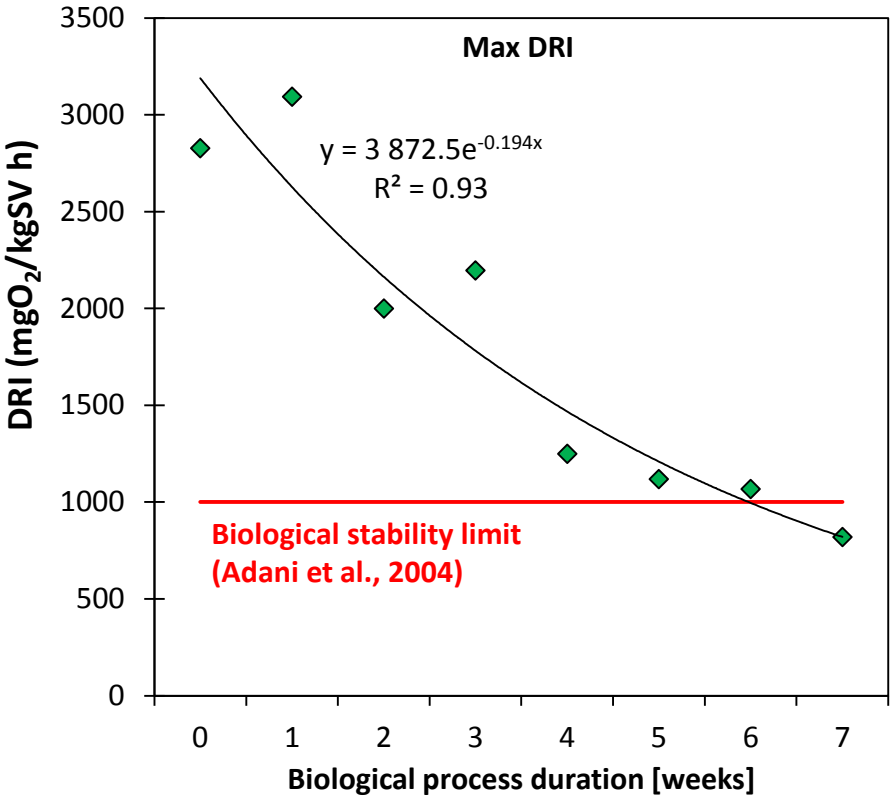
- **Organic matter content** → determination (in triplicates) of
  1. **volatile solids – VS** – **loss on ignition** at 550 °C for 8 h on ≈ 5 g air-dried sample (grinded at 0.5 mm), pre-dried at 105 °C for 4 h (UNI/TS 11184, 2006)
  2. **total organic carbon – TOC** – by means of **Shimadzu** SSM-5000A **analyser** on ≈ 0.2 g air-dried sample < 200 µm (UNI EN 13137, 2002)

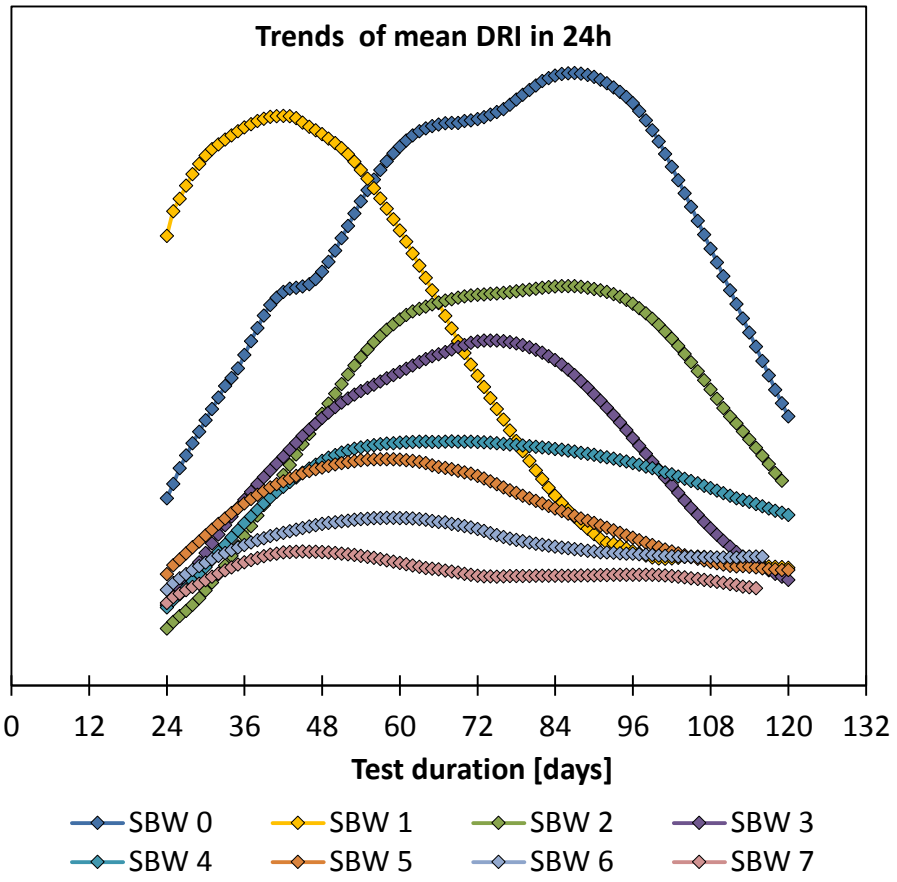
BIOLOGICAL-PHYSICAL-CHEMICAL CHARACTERISATION (2/2)

- **Heavy metals - HM - total content → acid digestion** (EN 15410 – 15411, 2011):
  1. 0.1 g air-dried sample < 0.5 mm + 3 ml HNO_3 + 1 ml of HCl
  2. mixture in closed vessels at 150°C for ≈ 15 h
  3. obtained solution dilute to volume in 25 ml flask, filtered at 0.45 µm and analysed by ICP-AES

- **Contaminant release in water phase → leaching test** (CEN 12457-2, 2002) at **L/S = 10**:
  1. 8 g air-dried sample < 4 mm + 80 ml deionised H_2O
  2. mixture stirred for 24 h
  3. decanting for 15 min → determination of **pH**,
  4. Centrifugation, vacuum filtration at 0.7µm, syringe filtration at 0.45 µm → chlorides - **Cl^-** (Mohr's method: ISO 9297, 1989) - and dissolved organic carbon – **DOC** (Shimadzu TOC-V CPH/CPN analyser)
  5. Filtered eluate subjected to acid digestion to oxidise DOC (APAT Guidelines 29, 2003):
     a. 10 ml eluate + 1 ml aqua regia
     b. mixture in closed vessels at 150°C for ≈ 24 h
     c. obtained solution dilute to volume in 25 ml flask and analysed by ICP-AES → **HM concentrations**

RESULTS – BIOLOGICAL STABILITY DEGREE (1/2)

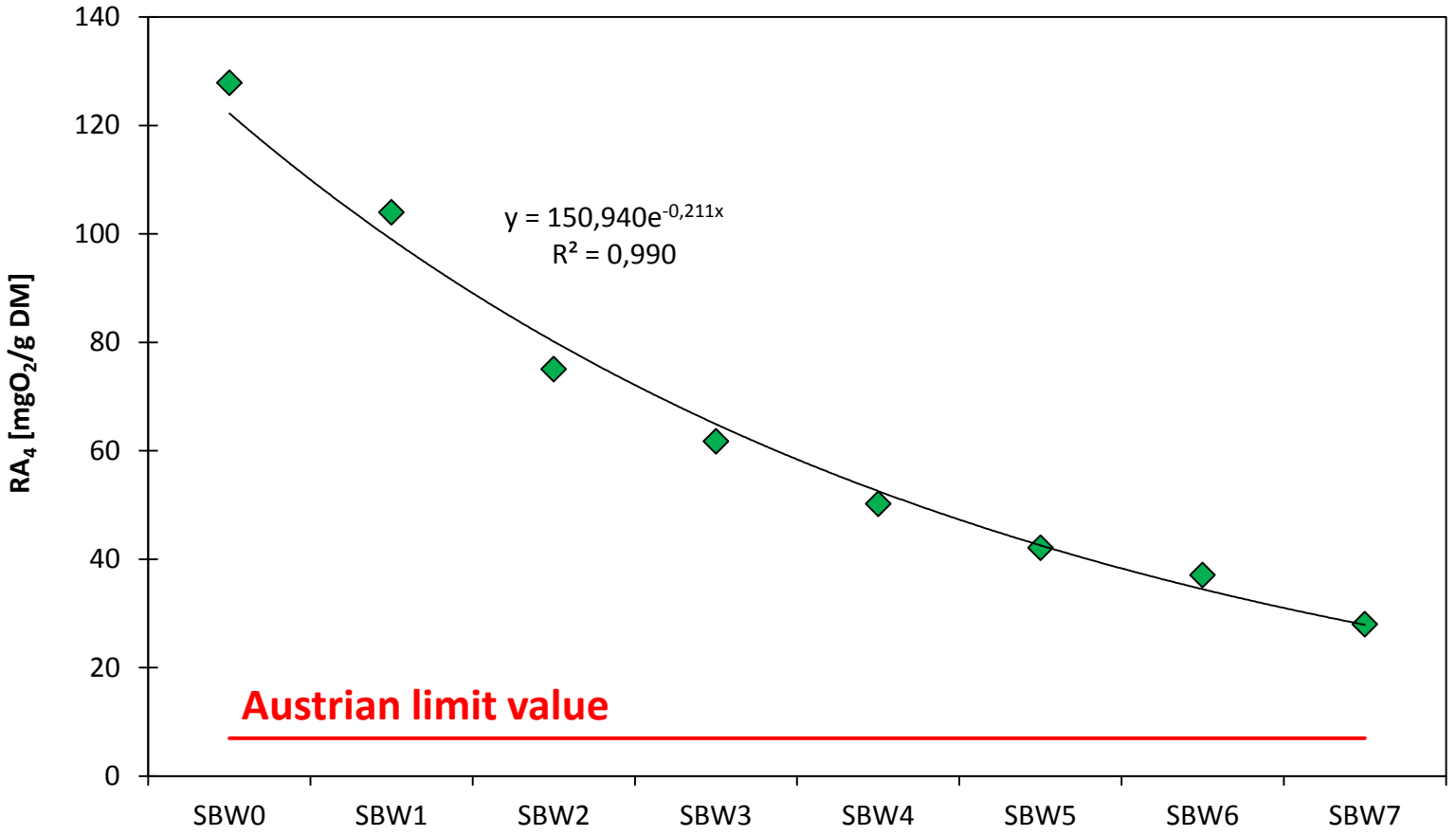




- Progressive reduction of DRI, i.e. **increase of biological stability** during the biostabilisation process with exponential decreasing trend
- After 7 weeks of aerobic biodegradation we observed a DRI reduction of 70 % comparing with non-stabilised waste with a DRI < 1000 mgO_2/kgVS h

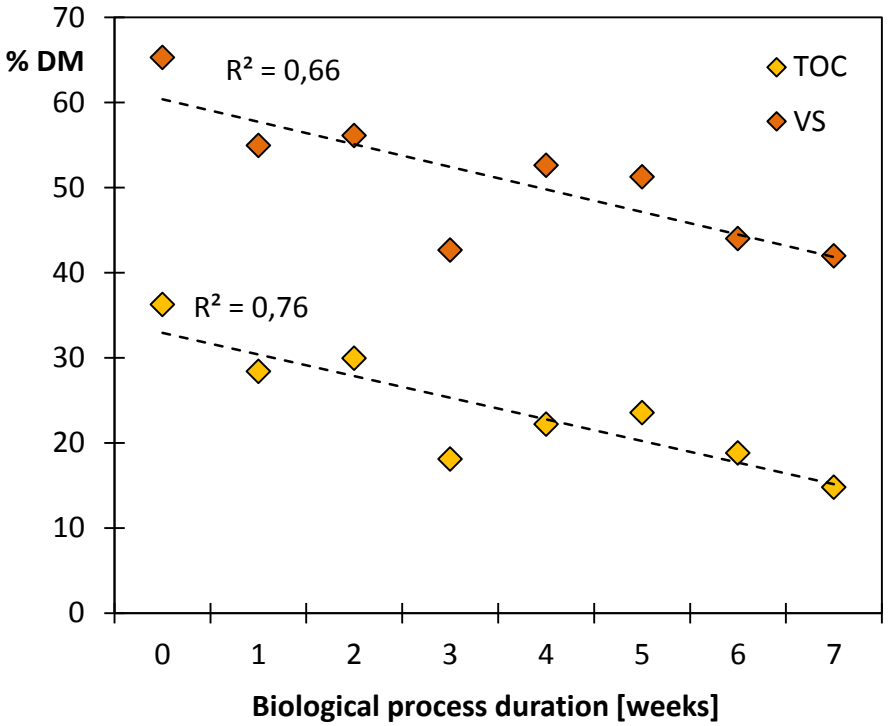
RESULTS – BIOLOGICAL STABILITY DEGREE (2/2)

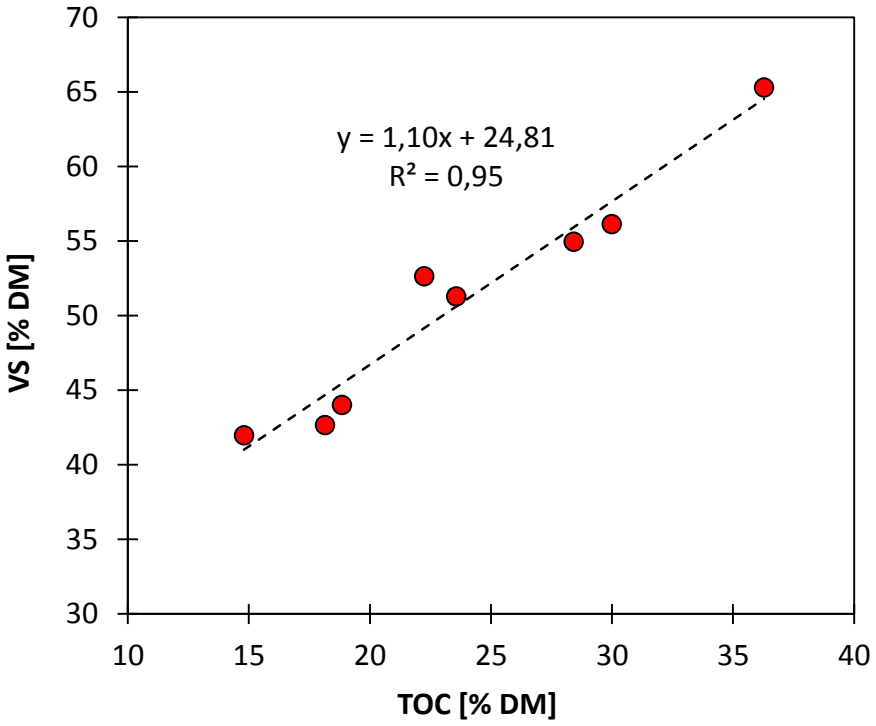
- In other European Countries, such as Austria, waste biological reactivity is analysed measuring the cumulative oxygen uptake after 4 days RA_4 (respiration activity in 4 days)



- RA_4 values were higher than the **maximum limit value** equal to **7 mgO_2/gDM** set by the Austrian Landfill Ordinance → high reactivity even after 7 weeks of biodegradation

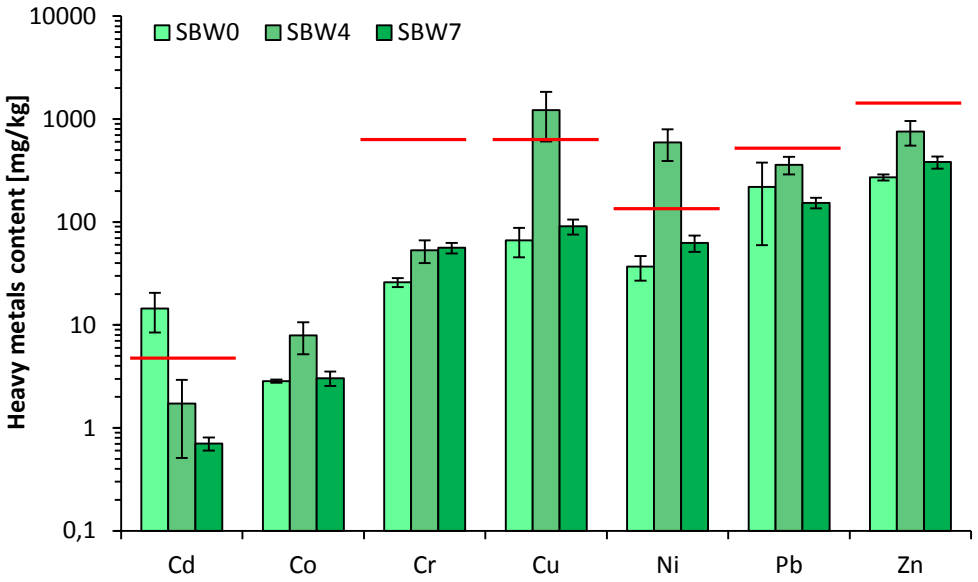
RESULTS – ORGANIC MATTER CONTENT





- Reduction of organic matter content due to biodegradation was observed with a linear decreasing trend (**TOC → 60% reduction** after 7 weeks, **VS → 35 % reduction** after 7 weeks)
- TOC and VS showed to have roughly the same trend during the 7 weeks of biological treatment with high linear correlation - **R^2 = 0.95 →** they are both direct indices of the organic matter content.

RESULTS – HEAVY METALS TOTAL CONTENT

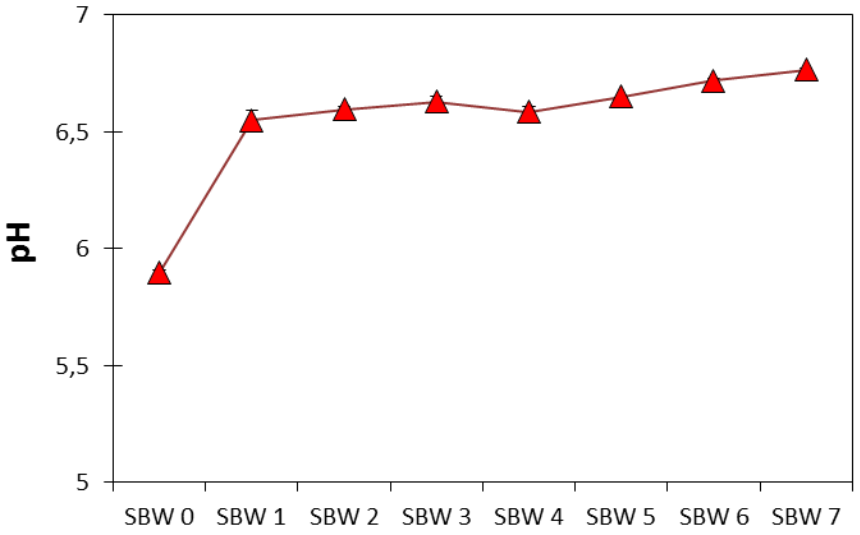


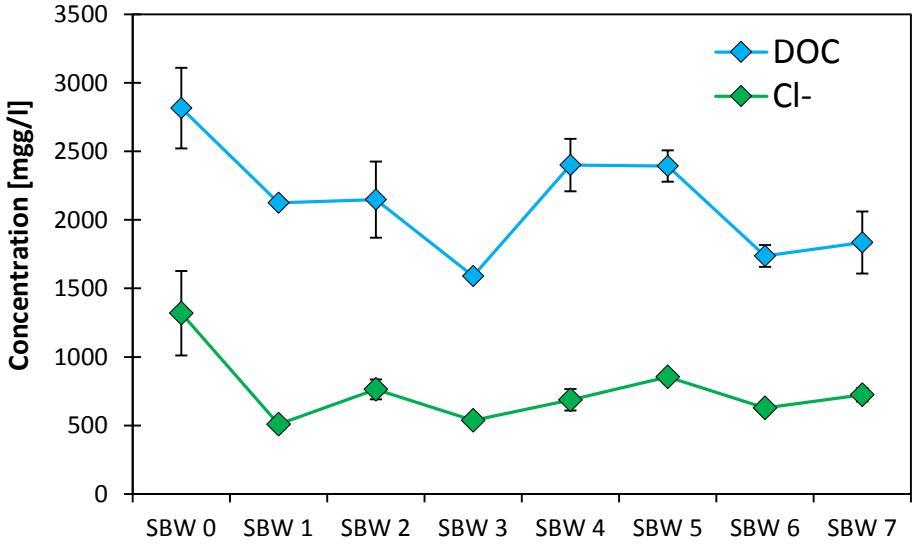
— European regulation for SBW recovery. European Commission (2001) document drafted by the European Commission "Biological treatment of biowaste - 2nd draft"

- The HM total content was significantly different in the 3 collected samples. This can be due to:
  - **heterogeneity of SBW samples** as also highlighted by the significant standard deviations
  - **increase in concentration due to mass loss** occurring during the degradation of organic matter → e.g. HM content in SBW4 > HM content in SBW0, with the exception of Cd
  - **metal loss through percolation** → HM content in SBW7 < HM content in SBW4 indicating that probably metals were transformed in more mobile forms in the last 3 weeks of biostabilisation.
- SBW7 fulfils the requirements fixed by the European commission indicating that after 7 weeks of biological treatment the stabilised biowaste could be potentially utilised in environmental remediation applications

RESULTS – pH, DOC and chlorides

- The pH values did not vary significantly during the biostabilisation process but followed approximately the characteristic trend of an aerobic biodegradation, ranging from 6, at the beginning, to 7, at the end of the process.

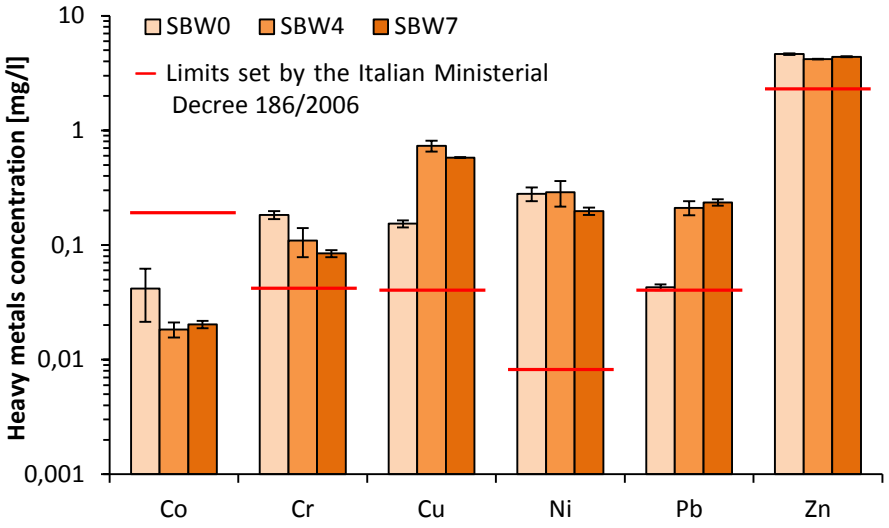




- DOC and chlorides globally reduced after 7 weeks of aerobic biodegradation comparing with untreated waste.
- Nevertheless they did not showed a clear trend presumably due to the heterogeneity of the tested material.

RESULTS – LEACHING OF METALS

Metal concentrations measured in the eluates

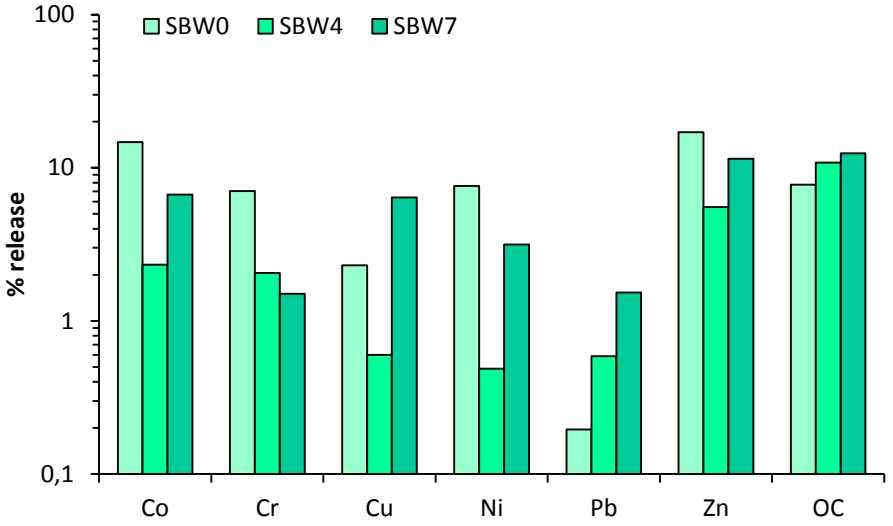


- Metal concentrations in the eluates did not vary significantly during the biostabilisation process.
- Only Co fulfills the limit values set by MD 186/2006, hence, according to the Italian legislation the produced SBW cannot be re-used but must be sent to landfill.

- Some metals, such as Cr , show a decreasing release trend that could be indicative of a progressive tendency of the metal during the biological process to be bound to organic solid matter
- For other metals, such as Pb, the release increased presumably because such metals tend to leach along with the dissolved organic carbon (that progressively increases during the biological treatment)

HM and organic carbon (OC) percentage release

$$\% \text{ release} = 100 \cdot C_{leach}/C_{sol} \text{ [mg/kg]}$$



CONCLUSIONS

In the present work, the influence on biostabilised characteristics of longer duration of the aerobic biological process from 4 weeks - duration in normal operating conditions of the MBT facility of Rome - to 7 weeks was evaluated.

The obtained results showed that:

- **After 4 weeks** of biological treatment, the waste was **still quite reactive** → a **good biological stability degree** was reached **after 7 weeks**, even if a **further maturation treatment** could be also investigated in order to obtain a highly biostabilised material
- **Metals total content** in biostabilised waste after 7 weeks of biological treatment was found to **fulfil the requirements for a potential utilisation** in environmental remediation applications (for non food production)
- **Metal concentrations in the eluates** did not fulfil the limits set by the Italian Ministerial Decree 186/2006 on non-hazardous waste recovery. Therefore from this point of view the biostabilised waste showed to **not have a suitable quality for a possible recovery** and this was in contrast with what was found for the heavy metals total content
- Contaminants release in water phase showed to increase for some metals (Cu and Pb) during the biostabilisation likely due to the significant affinity with the dissolved organic carbon. **Further investigations on leaching of contaminants** (e.g. pH dependence test and percolation test) need to be carried out in order to better understand release controlling mechanisms and to assess long term leaching behaviour, especially in view of a possible use in environmental remediation