

Compost and digestate: sustainability, benefits, impacts for the environment and for plant production

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2008

Airflow pressure drop evaluation in forced aeration composting

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objective: Estimate the airflow pressure drop in forced aerated windrow composting

A blower specification means to determine a flow rate and a pressure to overcome.

An adequate blower selection is essential to a successful composting and to minimize costs.

Adapted from Manufacturer's blower METEC, 2007

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to the objective:

Estimate the airflow pressure drop through a substrate using the Ergun's semi-empirical flow model.

Evaluate the Ergun's model by comparing the theoretical and the experimental values of a swine digestate bio-solid substrate in a windrow pilot scale composting facility.

Measure the swine bio-solid vertical airflow resistance.

Fit the experimental data to empirical airflow models.

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The experiments were performed with digestate bio-solid from a swine farm as substrate.

The pilot scale facility consists of a blower which is connected to a set of ducts distributing the air underneath the windrow base.




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Pressure measuring with an U manometer.



Flow rate measuring with an anemometer.



Turning windrow operation.




Bulk density measuring test.

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Tests performed in laboratory:

- substrate screening
- moisture
- organic matter content

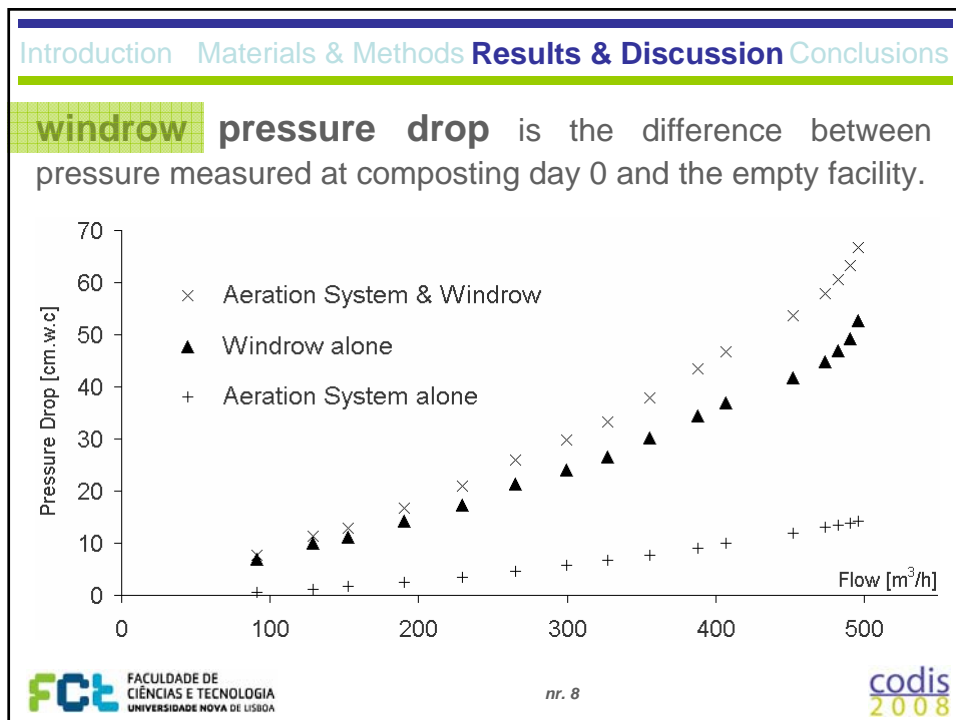
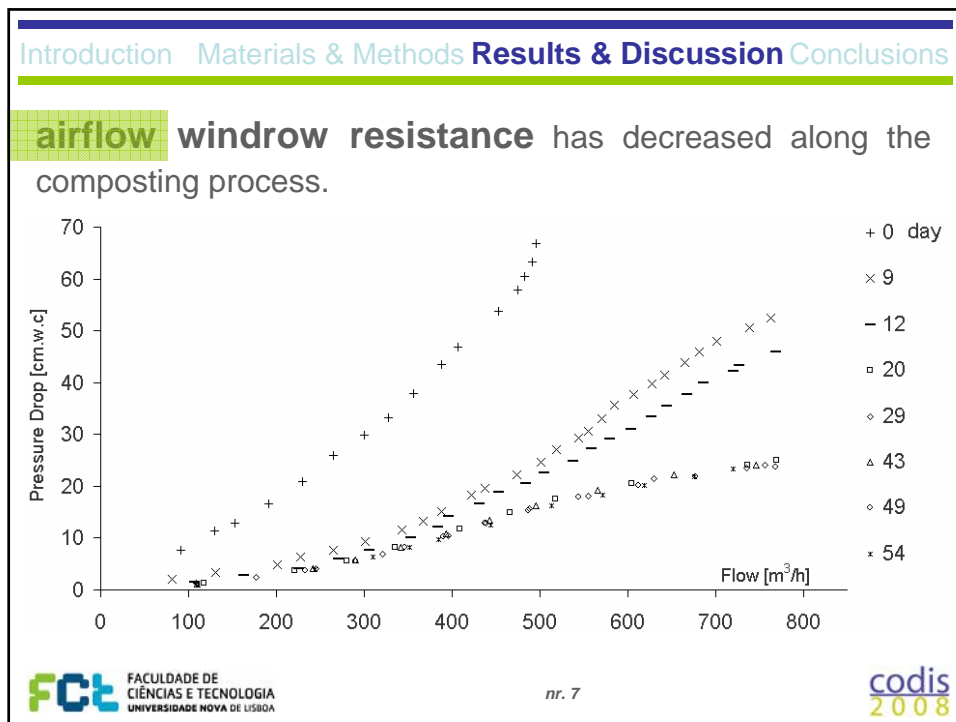
Composting was monitored with temperature and oxygen probes. A geosynthetic textile covered the windrow to prevent rain to get in but allowing exhaustion of gases.



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airflow empirical models most used in flow trough porous media were **fit** with a good correlation value.

Model	A	B	R ²
$\Delta P = A \cdot Q^B$ Shedd's model	0,0120	1,340	0,9951
$\Delta P = A \cdot Q + B \cdot Q^2$ Forchheimer's model	0,0551	0,000089	0,9967

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ergun's semi-empirical model relate **A** and **B** with measurable physical characteristics of the flow and the porous media.

$$\Delta P = 150 \cdot \mu \cdot \frac{(1-\epsilon)^2}{d^2 \cdot \epsilon^3} \cdot \frac{1}{s} \cdot Q + 1,75 \cdot \rho \cdot \frac{(1-\epsilon)}{d \cdot \epsilon^3} \cdot \frac{1}{s^2} \cdot Q^2$$

- air dynamic viscosity (μ) and density (ρ)
- substrate particle size diameter (d)
- **substrate free air space (ϵ)**
- **substrate section, transverse to the flow (s)**

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substrate free air space (ε) estimate according to the work of Van Ginkel *et. al.* (1999).

$$\epsilon = 1 - \rho_{bulk} \left(\frac{1 - DM}{\rho_w} + \frac{DM \cdot OM}{\rho_{om}} + \frac{DM \cdot (1 - OM)}{\rho_{ash}} \right)$$

- total wet bulk density (ρ_{bulk}), substrate measuring
- dry matter content (DM) , substrate measuring
- organic matter content (OM) , substrate measuring
- water density (ρ_w), 1000 kg/m³
- organic matter density (ρ_{om}) , 1600 kg/m³
- ash density (ρ_{ash}) , 2500 kg/m³

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swine bio-solid physical characteristics measured (day 0).

667,63 kg/m³
(σ = 54,95)

21,61 %
(σ = 0,36)

88,82 %
(σ = 0,36)

Moisture
78,39 %
(σ = 0,001)

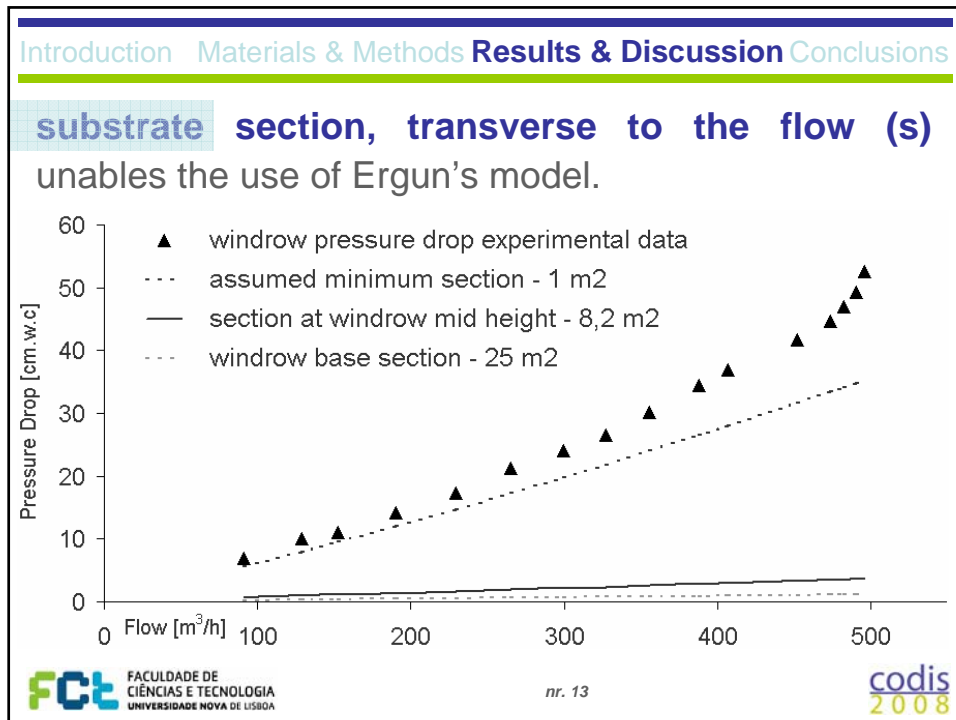
$$\epsilon = 1 - \rho_{bulk} \left(\frac{1 - DM}{\rho_w} + \frac{DM \cdot OM}{\rho_{om}} + \frac{DM \cdot (1 - OM)}{\rho_{ash}} \right) = 30,71 \%$$

$$\Delta P = 150 \cdot \mu \cdot \frac{(1 - \epsilon)^2}{d^2 \cdot \epsilon^3} \cdot \frac{1}{s} \cdot Q + 1,75 \cdot \rho \cdot \frac{(1 - \epsilon)}{d \cdot \epsilon^3} \cdot \frac{1}{s^2} \cdot Q^2$$

?

1,5 mm

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The **windrow** airflow resistance measuring method seems to be effective for a composting pilot scale with forced aeration.

This method may be applied whenever the substrate pressure drop is greater than the aeration system own pressure drop, as the case of the swine bio-solid substrate.

To improve the method it is possible to use more sensitive pressure measure instruments or implement changes to minimize aeration system own pressure losses.

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Shedd and Forchheimer models were successfully fit to the measured curve of windrow pressure resistance against airflow rate.

The results apply to a swine bio-solid substrate with 78% moisture and a windrow heights of 0,84 m.

Future work: perform more measurements on swine bio-solid substrates, different windrow heights and moisture to improve the models fitting curves.

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Ergun's model failed to predict the pressure loss through the substrate in a windrow type composting process.

The amount of uncertainties raised with the attempt to apply the model to an open airflow system, as the windrow case, showed the importance to perform these experiments in pilot scale facilities to collect data closer to the real phenomena.

The graphic features a dark grey background with a fine grid pattern. At the top left, the text 'Compost and digestate: sustainability, benefits, impacts for the environment and for plant production' is written in a small, white, sans-serif font. To the right of this text, the word 'codis' is written in a large, blue, lowercase sans-serif font, with a horizontal line underneath it. Below 'codis', the year '2008' is written in a large, yellow, lowercase sans-serif font. In the center, the words 'thank you' are written in a large, white, lowercase sans-serif font. Below this, a white rectangular box contains the names and email addresses of the organizers: 'Pedro Almeida' and 'Ana Silveira' on the left, and 'virgilio.pedro@gmail.com' and 'ais@fct.unl.pt' on the right. At the bottom left, the logo for FCT (Faculdade de Ciências e Tecnologia) is displayed, consisting of the letters 'FCT' in a stylized, multi-colored font. To the right of the logo, the text 'FACULDADE DE CIÊNCIAS E TECNOLOGIA' and 'UNIVERSIDADE NOVA DE LISBOA' is written in a small, white, sans-serif font.

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thank you

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