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1S1b Models and tools for estimating circularity of alternative food and agricultural systems

Assessing circularity of biomass utilisation, valuing functionality in the application: Circularity Analysis Tool

Broeze J 1), Elbersen W 1), Voogt J 1), Soethoudt H 1)

1) Wageningen University & Research, The Netherlands

Ineffective use of bio-resources largely impair food security and availability of biomass for biobased applications. Indirectly, the inefficiencies lead to excessive environmental impact including loss of biodiversity, greenhouse gas (GHG) emissions, loss of soil organic matter and water use. Reducing such inefficiencies is considered effective measure both fulfilling food demand and reducing associated environmental impacts: higher benefits are obtained with less production.

Commonly, utilizing a biomass residue for feed or returning it to the soil is considered circular solution. However, this basic approach overlooks the fact that components (like proteins, sugars, starch, fats and different fibre components) in the biomass have different functional value in the ‘application’. Components that are not or poorly utilized in the application are considered lost. Therefore, we promote to assess the circularity of a biomass application through valuing the functional value and efficiency of the individual components in the application. For instance a using a protein-rich stream with high feeding value in animal feed is considered more circular than application for bioenergy. And using a wood product in which the structural functionality is retained is more circular than converting it to energy (this also reflects that after use as construction material it can be re-used).

Next to quantifying the circular value per component, we also propose to distinguish between the values of the components. For instance agricultural production of proteins requires more land and inputs (nitrogen fertilizer) than sugar or fibres per unit product. Likewise, oil/fat may be higher appreciated than carbohydrates, also because of the higher energy content.

According to above approach the circularity of a certain application j of a biomass stream is expressed as:

$$\mathrm{Circularity}_j = \frac{\sum_{\mathrm{components}\ i} \mathrm{Appreciation}_i \times \mathrm{Content}_i \times \mathrm{Efficiency}_{(i,j)} \times \mathrm{Functionality}_{(i,j)}}{\mathrm{reference\ value}}$$

where the reference value is the sum-product in the application food or biomaterial.

We have implemented above equation, including compositions of a large set of biomass streams and conversion efficiencies for various applications varying from food, feed for diverse livestock categories, biobased applications and waste management options in the Circularity Analysis Tool (CAT). This tool is used for assessing the degree of circularity for different application options of a residue stream. In the near future we will also use it for monitoring national progress on circularity of biomass utilisation.

Keywords: quantifying circularity, functional use, quantitative tool