Combining Biowaste Treatment Technologies to Extract Value Products

A simple spreadsheet-based model can help predict the resource extraction potential of a given amount of biowaste, using a combination of two or more biowaste treatment technologies. The aim is to motivate waste managers to reconsider the multiple resource values of biowastes. Imanol Zabaleta[1], Hildemar Mendez[2], Christian Zurbrügg[1]

				1st Technology: Anaerobic digestion						2nd Technology: Vermicomposting									
	FEEDSTOCK			RANGES (%)			DIGESTATE			RANGES (%)			DEWATERED DIGESTATE				VERMICOMPOST		
	%	kg	-	Min	Max	Alert	%	kg	-	Min	Max	Alert	%	kg	-	Alert	%	kg	-
Mass (ww)*	-	300	-	-	-	-	-	290.8	-	-	-	-	-	20.1	-	-	-	8.6	-
TS	5.0	15	-	5	29		2.0	5.8	-	19	65		28.7	5.8	-		51.7	4.4	-
VS	78.0	12	-	31	91		85.4	4.9	-	12	78		69.2	4.0	-		60.0	2.7	-
TN	3.1	0	-	1	18		6.8	0.4	-	0.2	3.1		2.9	0.2	-		2.1	0.1	-
TP	0.4	0	-	0.2	1		1.1	0.06	-	0.1	0.3		0.7	0.04	-		0.9	0.0	-
TC	43.0	6	-	3	49		47.5	2.7	-	7	80		38.5	2.2	-		33.3	1.5	-
C:N	-	-	25	3	45		-	-	7	25	57		-	-	30		-	-	16
pH	-	-	7	4	7		-	-	7	6	9		-	-	7		-	-	7
Value products							*Biogas (m^3)***	3.6 – 6									*N° worms:* *kg worms:*		*3075* *1.6*

*: ww: wet weight, **: Assuming a biogas yield of 300–500 L/kg VS

Table 1: Model results from combining anaerobic digestion and vermicomposting.

Introduction

Biowaste, the main waste fraction in low- and middle-income settings, typically is an unused resource. Many biowaste treatments create products of value and generate residual materials that may contain recoverable resources. A simple spreadsheet-based model developed by Hildemar Mendez during her Master's thesis evaluates mass and substance flows when combining different organic waste treatment technologies, i.e. composting, vermicomposting, anaerobic digestion (AD), black soldier fly processing and slow pyrolysis. It can help decide how to extract maximum value from the same biowaste.

Model description

The MS Excel-based spreadsheet model allows for the combination of two different treatment technologies. Parameters describing the feedstock (blue cells in Table 1) i.e. mass (kg), total solids (%), volatile solids (% of TS), total nitrogen, phosphorus and carbon concentrations (% of TS), Carbon-Nitrogen ratio and pH, are the input values.

The spreadsheet first evaluates if the input values for each parameter meet the requirements of the first selected technology (yellow cells in Table 1). If the values of the input parameters are within the accepted range, the spreadsheet highlights it in green. Otherwise, an alert appears in red. Using transfer coefficients and equations developed based on literature and case studies, the model calculates the mass for the different output products of the technology and respective parameter values (orange cells in Table 1). The obtained mass flows are the input for the next technology.

Combining anaerobic digestion and vermicomposting

Table 1 shows the scenario of treating 300 kg of manure by AD to produce biogas and digestate, and then using the digestate for vermicomposting to obtain worms and vermicompost. All feedstock parameters for manure are suitable for AD (no red alerts). The spreadsheet calculates the expected output amounts of biogas (around 3.6–6 m^3) and of digestate with its respective parameters (first orange column in Table 1). The digestate is then evaluated as feedstock for the second technology, vermicomposting, and the spreadsheet alerts the user that certain digestate parameters are outside the suitable range for vermicomposting (marked in red). The user can now consider a treatment step for the digestate, e.g. dewatering or addition of another feedstock. Based on this treatment, the only parameter that remains out of range is total phosphorus (which is in excess), but this would not hinder the treatment process. The model calculates that around 685 worms (0.4 kg) are needed to treat this amount of dewatered digestate and estimates the amounts and parameters of the vermicompost output product.

Conclusion

This tool can quickly assess the potential resources to be obtained by combining different biowaste treatment technologies. Because several assumptions underlie the calculations, the tool outcomes should be considered as rough estimates, not accurate values. Using more case studies with real data to test the model will help refine it. We are confident that such simple models can motivate waste managers to reconsider the multiple resource values of biowastes.

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