Increasing CO_2 reductions related to source separation of Municipal Biowaste in The Netherlands

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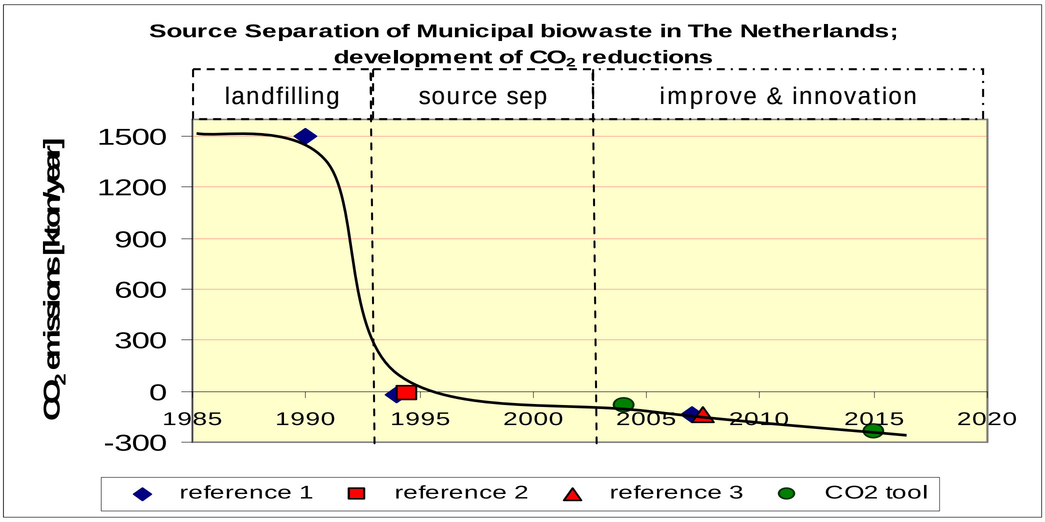
EXECUTIVE SUMMARY

In **1990** (Kyoto base year) Municipal Biowaste was not separated at source in The Netherlands. A lot of waste was land filled and existing Waste Incinerators had to comply with severe emission standards (dioxins). Especially land filling of the Biowaste Component of Municipal waste contributes to emissions of the greenhouse gas methane. 1,5 million tons of land filled municipal waste generated ±1.000 kg $CO_{2\text{-}eq}$/ton, 1.500 kton $CO_{2\text{-}eq}$/year.[1]

In **1994** source separation of Municipal Biowaste was implemented by law (completed in 1995) resulting in 1.5 million tons of Biowaste to be composted each year and diverted from the landfill. As a result, the mentioned emissions of 1.500 kton $CO_{2\text{-}eq}$ were avoided. Farmers using compost save on the use of artificial fertilizer in agriculture and contribute to soil carbon sequestration. This results in net savings (negative flux of -11,3 kg $CO_{2\text{-}eq}$/ton Biowaste, -17 kton $CO_{2\text{-}eq}$/year based on 1.500 kton Biowaste/year)[1,2]

In **2007** composting processes were strongly improved, energy consumption was lowered, resulting in high quality compost. More compost was sold replacing peat in potting soils and gardening. A quick scan at four composting plants demonstrated lower process emissions. These results were confirmed by TAUW[3] in 2007. The negative flux for greenhouse gases improved to -90 kg $CO_{2\text{-}eq}$/ton Biowaste, -135 kton $CO_{2\text{-}eq}$/year based on 1.500 kton Biowaste/year[1,3]

In **2015** we expect this development to continue. Composters increase their environmental performance, selling more high quality compost for peat replacement, produce upgraded biomass, ready to use for biomass power plants. The share of anaerobic digestion is increasing. Importance of compost suppressing plant diseases is growing. Results of public RFP (province Utrecht, 2007) granted on price and CO_2 performance indicate results in savings on greenhouse gases up to160 kton $CO_{2\text{-}eq}$/ton of Biowaste to be realized in 2009. So this is achievable as mean value in 2015 for the Dutch amount of 1.500 kton Biowaste, resulting in -240 kton $CO_{2\text{-}eq}$/year.



LIST OF REFERENCES BY THE GRAPH

[1] CE (2006) –report published in Dutch language- Waste treatment and CO_2 Quick scan of greenhouse gas emissions of the waste sector in The Netherlands, covering land filling, incineration and composting

[2] European Commision (2001) Waste management options and climate change

[3] Tauw (2007) -published in Dutch language- Report on representative values for CH_4 and N_2O emission levels in Dutch municipal biowaste composting and digestion.

CO_2 tool: based on LCA-work for the Dutch Waste Plan and references 1, 2 and 3 and developed for the Dutch Association of Waste Companies (will be explained in oral presentation and paper)

1. introduction

There is a growing interest from municipalities to implement sustainability when purchasing services. This sustainable purchase is promoted by the Dutch minister of Environmental Affairs, Mrs. Jacqueline Cramer. Discussions about sustainability in waste treatment, especially concerning municipal biowaste, have a long history in The Netherlands. This has to do with changes in waste policies over time, as a result of specific problems and priorities in a certain timeframe and the development of the waste market, market requirements and resulting performance of the developing waste treatment industry.

When sustainability becomes a part of Requests for Proposals, things becomes serious and it should be clear how sustainability is defined. In this paper we start with a closer look on sustainable processing of municipal biowaste. From recent publications, we conclude that there is a sufficient level of agreement between the government, NGO's and the waste treatment industry about this. So we start describing sustainability based on the available recent publications.

In the public opinion, greenhouse gases, climate change and CO_2 are the key words. We should place the importance of CO_2 in the right perspective. After that, we describe the improving performance of the waste treatment sector in a historical context, covering the timeframe from 1985 to 2015. So we are also pointing out the way to the future.

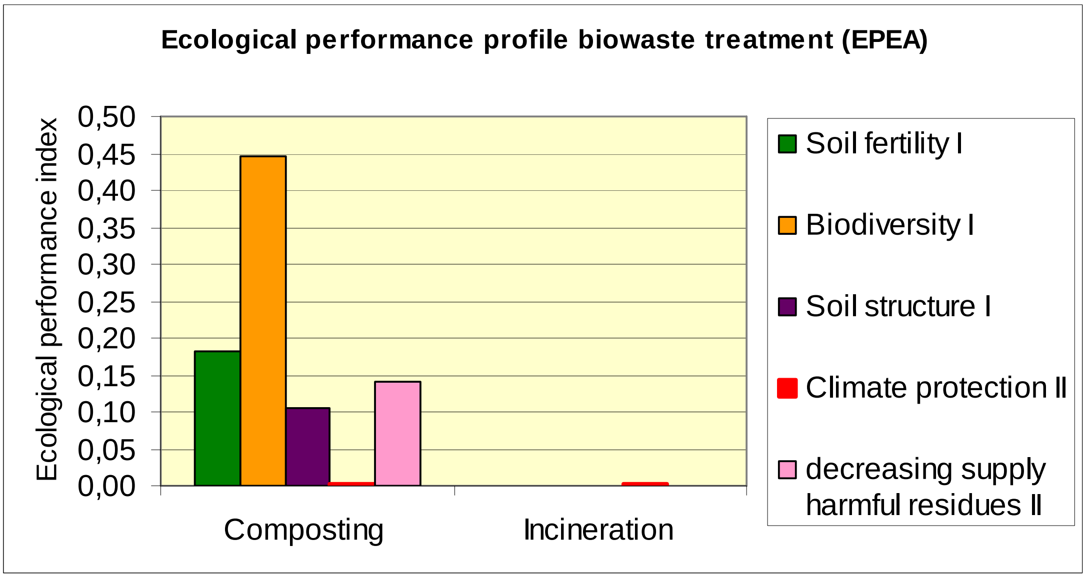
To do so, we use a CO_2 tool that has been based on the extensive Life Cycle Analysis (LCA) studies that have been completed, starting with the environmental impact study connected with the Dutch National Waste Plan (January 2002). This LCA has been discussed and improved by IVAM/Grontmij (November 2004), CE (March 2006), TAUW (November 2007) and put together to the CO_2 tool by IVAM. The tool was developed for the Dutch Association of Waste Companies but also adapted by Elsinga and IVAM for Afvalverwijdering Utrecht (AVU). AVU wanted to implement the tool as a part of the European Public Request for Proposal for 90.000 ton/year municipal biowaste in 2007. Subscribers could win the RFP not only by offering a low price, but also by offering a solution with a high net CO_2 capture, expressed in kg CO_2/ton biowaste.

Using this model, we can describe what could be the potential and technically feasible CO_2 savings/ton Biowaste and how this can be achieved with state of the art technology and making us of existing markets for compost.

2. CO_2 reductions based on biowaste should not harm compost production.

In April 2008 leading papers covered the serious concerns of the world leaders about the supply of food. Great Britain's prime minister Gordon Brown scheduled the problem for the meeting of the G8 in Washington. The FAO reported a sharp rise of food prices. A main problem is that crops are increasingly used for the production of fuel. This creates the dilemma 'fuel for the rich or food for the poor'. Municipal biowaste is partly food waste. Applying source separation of the waste is the precondition to produce a clean compost. This is in line with the

Cradle to Cradle (C2C) approach: Waste is Food. Because of the discussions around energy from biomass, the Dutch NGO's presented a report called 'clear green biomass' (Natuur en Milieu January 2008) in which they formulated criteria for clear green biomass, which should not compete with food production. Municipal Biowaste was considered to be clear green biomass on the condition that CO_2 reductions by means of energy production should not harm compost production. Different departments of the Dutch National Government published together a report expressing the vision of the National government on bio-based economy in the energy transition, 'closing the circle'. In this vision the contribution of compost plays an important role (ministerie van LNVOctober 2007). The importance of food production and a healthy and sustainable soil management is back on the agenda. But this important issue was always the missing link in LCA's. At least, the LCA –approach had problems to quantify 'soil fertility' or 'soil structure'. The German EPEA-institute made a good first effort to close this gap with their study called 'Ökologisches Leistungsprofil von Verfahren zur Behandlung von biogenen Reststoffen',EPEA (2008). We derived the following figure from their publication:



Within this framework we will not go into detail about this publication, but some explanation should be helpful. EPEA developed two sets of indices: indices I that show the performance based on a ton of biowaste and indices II that show the performance as a more or less significant effect on a National level (in their case Germany). In this graph composting and incineration (Mass Burn) are compared. We see that the most important ecological contributions of composting are demonstrated with the indices 'Soil fertility', 'Biodiversity' and 'decreasing supply of harmful residues' to the ecosystem. All these indices are related to the production of compost, which is destroyed by incineration. We see that the performance index on Climate protection (CO_2 reduction) is in both cases relative low.

We look for an approach that could help us out of the dilemma 'CO_2 reduction or food production' and we would like to have both. We suggest that this is possible. In the EPEA study the assumption has been made that anaerobic digestion and biogas production goes hand in hand with some loss of the nutrients P, K and Mg. We came to other conclusions (IVAM 2008). In this LCA-study, comparing anaerobic digestion of Municipal Biowaste with composting, it was assumed that the P, K and Mg could be saved from losses in waste water treatment and the compost production could stay on the same level.

3. CO2 reductions 1985-2015 related to Dutch municipal biowaste

Talking about CO_2 reductions, it is not always clear what are the real savings, and a lot of comparisons have been made. To give a clear picture, we describe the improving performance of the waste treatment sector in a historical context, covering the timeframe from 1985 to 2015. So we are also pointing out the way to the future. But we start in times – not long ago – when nearly all the waste was land filled.

In **1990** (Kyoto base year) Municipal Biowaste was not separated at source in The Netherlands. A lot of waste was land filled and existing Waste Incinerators had to comply with severe emission standards (dioxins). Especially land filling of the Biowaste Component of Municipal waste contributes to emissions of the greenhouse gas methane. 1,5 million tons of land filled municipal waste generated ±1.000 kg $CO_{2\text{-eq}}$/ton, 1.500 kton $CO_{2\text{-eq}}$/year under the land filling conditions applied in that timeframe (CE 2006).

In **1994** source separation of Municipal Biowaste was implemented by law (completed in 1995) resulting in 1.5 million tons of Biowaste to be composted each year and diverted from the landfill. As a result, the mentioned emissions of 1.500 kton $CO_{2\text{-eq}}$ were avoided. Farmers using compost save on the use of artificial fertilizer in agriculture and contribute to soil carbon sequestration. This results in net savings, a negative flux of -11,3 kg $CO_{2\text{-eq}}$/ton Biowaste, -17 kton $CO_{2\text{-eq}}$/year based on 1.500 kton Biowaste/year (CE 2006, European Commission 2001).

In **2007** composting processes were strongly improved, energy consumption was lowered, resulting in high quality compost. More compost was sold replacing peat in potting soils and gardening. A quick scan at four composting plants demonstrated lower process emissions. These results were confirmed by TAUW in 2007. The negative flux for greenhouse gases improved to -90 kg $CO_{2\text{-eq}}$/ton Biowaste, -135 kton $CO_{2\text{-eq}}$/year based on 1.500 kton Biowaste/year (CE 2006, TAUW 2007).

In **2015** we expect this development to continue. Composters increase their environmental performance, selling more high quality compost for peat replacement, produce upgraded biomass, ready to use for biomass power plants. The share of Anaerobic digestion is increasing. Importance of compost suppressing plant diseases is growing. Results of public RFP (province Utrecht, 2007) granted on price ánd CO_2 performance indicate results

in savings on greenhouse gases up to160 kton $CO_{2\text{-eq}}$/ton of Biowaste to be realized in 2009. So this is achievable as mean value in 2015 for the Dutch amount of 1.500 kton Biowaste, resulting in -240 kton $CO_{2\text{-eq}}$/year.
The graph, demonstrating this development from 1985 to 2015 is in the executive summary. Expected technological developments and market developments for compost are converted into CO_2 reductions, making use of all the LCA-work that has been done and mentioned above.

4. CO2 tool to compare options for municipal biowaste, used in RFP's

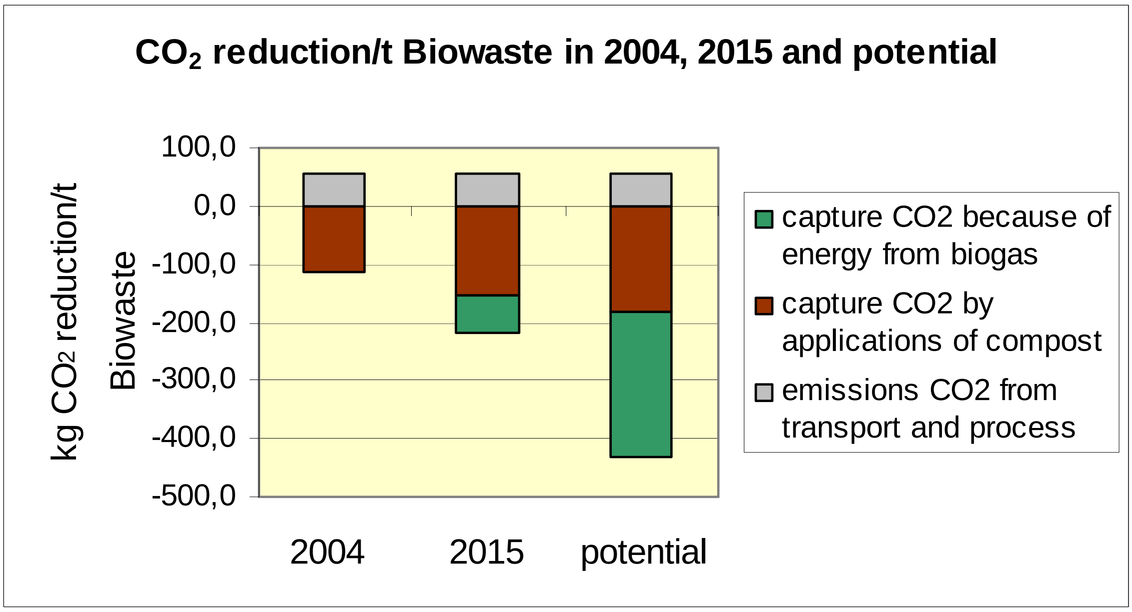
The presented CO_2 tool has been based on the extensive LCA studies that have been completed, starting with the environmental impact study connected with the Dutch National Waste Plan (January 2002). This LCA has been discussed and improved by IVAM/Grontmij (November 2004), CE (March 2006), TAUW (November 2007) and put together to the CO_2 tool by IVAM and has been adapted for RFP purposes by Elsinga (2008). The tool was developed for the Dutch Association of Waste Companies but also for Afvalverwijdering Utrecht (AVU). AVU wanted to implement the tool as a part of the European Public Request for Proposal for 90.000 ton municipal biowaste in 2007. Subscribers could win the RFP not only by offering a low price, but also by offering a solution with a high net CO_2 capture, expressed in kg CO_2/ton biowaste.
Using this model, we can describe what could be the potential and technically feasible CO_2 savings/ton Biowaste and how this can be achieved with state of the art technology and making us of existing markets for compost.

CO2-tool to compare processing options	**unit**	**Value (2015)**	**factor**	**kg CO_2**
Return distance Biowaste-supply (truck)	km	75	0,13	9,75
Return distance Biowaste-supply (rail)	km	0	0,038	0,00
Return distance Biowaste-supply (ship)	km	0	0,034	0,00
Total use electricity	kWh/t Biowaste	32	0,73	23,36
methane emission (biowaste-processing)	kg/t Biowaste	0,170	21,0	3,57
N2O emission (biowaste-processing)	kg/t Biowaste	0,069	296	20,42
biogas (55% CH4) delivered to the grid	Nm3/t Biowaste	50	-1,27	-63,50
Electricity delivered to the grid	kWh/t Biowaste	0	-0,73	0,00
Heat delivered to third parties	MJ/t Biowaste	0	-0,075	0,00
biogas (55% CH4) replacing diesel oil	Nm3/t Biowaste	0	-1,42	0,00
redisue incinerated mass burn	% of input	2,2	-4,2	-9,24
residue to land fill	% of input	0,0	2,6	0,00
Upgraded biomass to biomass plant	% of input	0	-5,2	0,00
Compost production/t Biowaste	kg/t Biowaste	400		
agriculture (50% replacement art. fertilizer)	% of input	54	-0,635	-34,29
greenhouses (100% replacement peat & art fert)	% of input	7	-2,98	-20,86
Potting soil (100% replacement peat & art fert)	% of input	28	-2,75	-77,00
Gardening (100% replacement peat & art fert)	% of input	2	-2,55	-5,10
other (100% replacement art. fertilizer)	% of input	9	-0,80	-7,20
Total net CO2 capture in kg/ton Biowaste				**-160,1**

The grey part of the table describes the emissions of CO_2 from transportation and processing
The green part of the table describes capture of CO_2 because of energy from biogas
The brown part of the table describes capture of CO_2 because of applications of compost

For the use of the model, some knowhow of the biowaste production is needed. For instance, when a bigger part (up to 8% of input) of the biowaste is not composted, but diverted as wood peaces in an early stage of the composting process, this will lower the compost production. We expect each additional % above 3 or 4% will lead to a drop in compost production with ½ %. As we stated before, CO_2 reductions should not harm compost production. But applying the explained correction of ½ % loss of compost for each % of biomass, we find that the model shows that compost applications in the higher market segments (potting soil, gardening) are more effective for CO_2 reductions. An other point is the decreasing energy value of the upgraded biomass in case of high production levels (> 8%).
Bearing this in mind, we can use the model to give a picture of the CO_2 savings that can be expected in 2015 (see the table) . We expect in 2015 an increase of compost sales in the higher market segments (potting soil, gardening) replacing more peat and leading to higher CO_2 reductions than we have today. In 2004, anaerobic digestion played an almost neglect able role in The Netherlands (only BIOCEL < 2% of the municipal biowaste). We expect an increase in anaerobic digestion. In the table we show as a mean value 50 Nm^3 /ton biowaste as a mean value for the Dutch situation. The Dutch Association of Waste Companies (2008) reported to the government that, with sufficient supporting measures, in 2015 900 kton of the 1.500 kton municipal biowaste

could be digested with additional composting. Of course (different from the example in the table) biogas will be used combining heat and power and for transportation goals. We expect a lower share to be delivered to the grid. For estimating the potential we calculated with 200 kWh_{el} and 500 MJ/ton biowaste from combined heat and power produced from biogas and 10% compost to agriculture, 15% greenhouses, 63% potting soil, 3% gardening and 9% other.



CO_2 reduction/t Biowaste in 2004, 2015 and potential	2004	2015	potential
emissions CO_2 from transport and process	57,1	57,1	57,1
capture CO2 by applications of compost	-113,9	-153,7	-183,5
capture CO2 because of energy from biogas	0,0	-63,5	-248,4
total	-56,8	-160,1	-374,8

5. Conclusions

We conclude that source separation of municipal biowaste, composting and digestion contribute to sustainable food production and to CO_2 reduction. Because the important contribution of compost, efforts to increase CO_2 reduction should not harm compost production. In The Netherlands, the biggest gain on CO_2 was achieved when the government implemented the legal obligation for municipalities for source separation and composting municipal biowaste. This led to 'saving the biowaste from the land fill'. The waste industry went through a process of improve and innovations, achieving a negative flux for greenhouse gases of -90 kg $CO_{2\text{-eq}}$/ton Biowaste in 2007. In 2015 -160 kg $CO_{2\text{-eq}}$/ton Biowaste is achievable and there is a realistic and technically achievable potential of -375 kg $CO_{2\text{-eq}}$/ton of municipal Biowaste, without harming compost production. Following this biowaste strategy we can have both: fuel for the rich and food for the poor.

LIST OF REFERENCES

CE (2006) –report published in Dutch language- Waste treatment and CO_2 Quick scan of greenhouse gas emissions of the waste sector in The Netherlands, covering land filling, incineration and composting

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