Briefing Note
on
Quantification of Greenhouse Gases from Composting

October 2007

Basic Theory

The evolution, or degradation, of biodegradable carbon from organic matter under aerobic and/or anaerobic conditions yields various greenhouse gases (GHG). Under aerobic conditions (composting), CO$_2$, or carbon dioxide, is the primary GHG byproduct:

\[ \text{Organic Matter} + O_2 \rightarrow \text{Microbial Metabolism} \rightarrow \text{Stabilized Organic Residue (Compost)} + CO_2 + H_2O + \text{Heat} \]

There is also evidence, which is not yet definitive, to suggest that under various composting conditions, such as windrowing, nitrous oxides (NO$_x$) may also be produced, but by and by, CO$_2$ is generally accepted as the main GHG emitted from composting.

In contrast to the above, carbon evolution under anaerobic conditions is a slower, multi-step process that yields both CO$_2$ and methane (CH$_4$) as the primary GHG byproducts.

Each GHG has been assigned a Global Warming Potential (GWP) value, or rating, by the Intergovernmental Panel on Climate Change (IPCC), an international body set up in 1988 by 2 UN organizations (the World Meteorological Organization and the United Nations Environmental Program) to assess climate change risks caused by human activity. The GWP of a GHG is an estimate of how much it contributes to global warming relative to CO$_2$ (CO$_2$ equivalent or CO$_2$-e). Taking the GWP of CO$_2$ as 1 over a 100 year time frame, the calculated GWPs, on a weight comparison basis, of CH$_4$ and nitrous oxide are 21 and 296$^1$.

Quantification of Offsets

Emission of GHGs from an activity, or project, can be calculated versus a baseline case, or what otherwise would have been done if the project or activity had not been carried out. An offset is generated if there are less emissions, in terms of CO$_2$-e, under the project condition than the baseline condition, i.e.:

$^1$ The calculation, which is an integrated summation over time from an instantaneous release at $t = 0$, is not precise because it depends on estimated values for how the concentration of a GHG decays over time in the atmosphere. Nevertheless, in 2001, the IPCC adjusted the calculated 100 year GWP of CH$_4$ from 21 to 23.
Emission Reduction = Emissions\textsubscript{Baseline} – Emissions\textsubscript{Project}

For a composting project or activity, the above equation becomes:

Emission Reduction = Emissions\textsubscript{Baseline} – Emissions\textsubscript{Composting}

The baseline case for most organic materials that are composted would be to send those materials to landfill\textsuperscript{2}. Other than those sites specifically designed and constructed to operate in a bioreactor mode, most landfills can be considered to be largely anaerobic digesters with no mixing\textsuperscript{3}. The quantification of GHG emissions from landfills has been well studied, with the generally accepted models being based on the Scholl Canyon model, which uses a first order kinetic decay equation integrated over time to produce a generation curve. USEPA’s published LandGEM program is one of the better known versions of the Scholl Canyon model. The kinetic constants in LandGEM require calibration for site specific conditions related to climatic factors (temperature and precipitation), quality of capping, pH, waste composition, etc. The nature and capture efficiency of any landfill gas collection systems present at the site and the reuse of that gas would also significantly affect the baseline condition.

On the composting side, modelling can also be used to quantify process CO\textsubscript{2} emissions. Alternatively, with various assumptions, a quick ballpark estimate of CO\textsubscript{2} production can be made stoichiometrically\textsuperscript{4}.

Use of Protocols

A protocol can be thought of as a standard procedure, or generic recipe, for ensuring that all the relevant measurement, monitoring and GHG quantification elements (the sources, sinks and residues) associated with the composting and baseline conditions are considered in a complete and systematic life cycle analysis. By comparing them, many of the elements can then be justifiably excluded in the final quantification exercise. On the upstream side, for example, the emissions from collection and transportation of feedstocks may be excluded, as they will likely be functionally equivalent in both the composting and baseline scenarios. Similarly, for a composting operation that continues year after year,

\textsuperscript{2} This would likely apply for municipalities composting solid waste. The baseline for biosolids that would otherwise be land applied, or hog fuel that would be burned, or a host of other feedstocks would be different.

\textsuperscript{3} Under the mix of aerobic, anoxic and anaerobic conditions prevalent in a landfill, the main gases emitted are CO\textsubscript{2} and CH\textsubscript{4} in roughly equal proportions, with additional trace amounts of other gases and organic compounds, such as nitrogen, oxygen, H\textsubscript{2}S, BTEX, vinyl chloride and siloxanes, also being present.

\textsuperscript{4} Assume, for example, that the organic fraction of MSW is 60\%, that 1/3 of it will convert to CO\textsubscript{2} during composting, and that the typical composition of it is a molecule of make up C\textsubscript{6}H\textsubscript{10}O\textsubscript{5}. Stoichiometrically, 6 molecules of CO\textsubscript{2} will be produced for every molecule oxidized.
the typically minimal emissions associated with infrastructure development, construction and final decommissioning can also be justifiably excluded.

**Historical Background**

As a nation, Canada was one of the first to sign the Kyoto Protocol in April 1998. Formal government ratification came in late 2002. With Russia signing and ratifying Kyoto in 2003, the Accord gained sufficient world wide support for the provisions of the Protocol to come into effect in Feb 2005. The gist of the Kyoto Protocol calls for signature nations to reduce their total GHG emissions by 6% below 1990 levels by the end of the commitment period of 2012. In April 2005, the federal government announced some details of its Kyoto implementation plan. Included in that was a plan to develop GHG quantification protocols for some 30 industrial activities, including composting.\(^5\) In late 2005, the Alberta government filed a formal objection to the federal government’s implementation plan, indicating that it would proceed with putting its own legislation in place for regulating GHG emissions within the province.

Against that background, the City of Edmonton retained a consultant in 2005 to develop a site specific protocol and quantify the GHGs associated with the Edmonton Composting Facility (ECF). This work was completed in early spring of 2006. Just prior to that however, the federal Conservatives won the January 2006 national election, unseating the incumbent Liberals, and formed a minority government. Based on what they had campaigned on, Canada’s new government quickly moved to cut funding for a number of climate change programs and initiatives that had been set in motion by the previous regime. This included the work intended to develop GHG quantification protocols.\(^6\)

On a more technical note, the ISO 14064 standard was formally published in April 2006 and the quantification work completed by Edmonton was therefore revised to conform to the accounting principles of the new standard\(^7\). The various parts of ISO 14064 provide guidance for quantification, monitoring, accounting and reporting of GHG emissions and removals within the following framework:

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\(^5\) See, for example, the presentation made by Dennis Jackson of Environment Canada at the Composting Council of Canada’s annual conference at Lake Louise, Alberta in 2005.

\(^6\) To date, Canada’s new government has continued to back away from any commitments to attempt to meet the Kyoto GHG reduction targets, preferring instead to support other international alternatives, such as the Asia-Pacific Partnership on Clean Development and Climate wherein the focus is more on voluntary emission reduction targets and developing and sharing new climate change mitigation technologies.

• GHG assertions of offsets being cast into the form of a *Project Statement* or *Project Report* by the project proponent or project owner;

• *Validation* of the proponent’s GHG assertion by an independent third party. Validation occurs before a project starts and is essentially a critical review of the assertion to ensure that the protocol followed is relevant and logical and that the projected amounts quantified are a true and fair assessment of the GHG emissions and offsets for the project; and

• Independent third party *Verification* of the GHG assertion during and after a project to ensure data completeness, accuracy and integrity and that the calculations for emissions and removals are correct.

Validation is a one time exercise and in some offset systems, is an optional step, whereas verification is an ongoing, periodic quality assurance activity that continues as long as the project continues or as long as the proponent makes GHG assertions for his project or activity.

**Alberta Legislation**

In 2006-7, the Province of Alberta moved forward with its intent to separately regulate GHG emissions. Legislation was introduced and the Climate Change and Emissions Management Act and the Specified Gas Emitters Regulation (SGER) came into effect on 1 July 2007. These pieces of legislation pertain to emitters of over 100,000 tonnes/year of CO₂-e (roughly 110 facilities in Alberta). Under the legislation, facilities in that category will be required to reduce their emissions intensity (over a six year period) by 12% starting in 2008.⁸ Other compliance options for facilities that operationally will be unable to meet that 12% target will be to:

• Pay $15/tonne CO₂-e for their excess emissions into a provincial Climate Change and Emissions Management Fund; or

• Purchase emission performance credits from other Alberta facilities exceeding their regulated intensity reduction targets; or

• Purchase offset credits from Alberta based projects generating the same.

SGER enables a market-driven approach to reducing GHGs through emissions trading. The setting of a $15/tonne CO₂-e price for the Climate Change and

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⁸ Emissions intensity refers to the emission of GHGs per unit of production. The use of intensity based reduction targets attempts to allow for continued economic growth in the jurisdiction where the emissions are occurring. The argument against using them has always been that the total GHG emissions from a facility can still legally stay the same or even increase if the facility can efficiently increase its production by more than the required intensity reduction. To use a simple Alberta based numerical example, if a facility emits 1000 tonnes CO₂-e, produces 1000 widgets and is required to reduce its emissions intensity by 12%, a production increase of 136 more widgets (23/year over 6 years) would allow it to continue to emit 1000 tonnes CO₂-e.
Emissions Management Fund also serves to provide a value guide point for offset emissions trading in Alberta.³

**Alberta Offset System**

In support of a market-based approach, Alberta hired a consultant to develop a series of protocols for activities, projects and industries likely to generate GHG offsets. Each protocol underwent stakeholder and public consultation and both the approved and draft protocols have since been posted on an Alberta based website.¹⁰ For composting, the consultant used the City of Edmonton's Project Statement and GHG Emission Statement for the ECF as technical seed documents to develop the protocol.

While project proponents will still have the option of quantifying their GHG offsets using custom or imported protocols, the use of an Alberta approved protocol is one way to manage some of the scientific uncertainty surrounding the exercise. In some instances, a project proponent may feel that industry specific emission factors and statistics, as recorded in the Canadian GHG National Inventory, are not suitable to his own site-specific situation and attempt to apply his own factors.

On the policy side, Alberta has also imposed the following criteria to determine whether GHG offsets from particular projects would be eligible for emissions trading. Some of these follow from international practices and standards that have developed elsewhere surrounding emissions trading, others are more arbitrary:

- Result from actions taken on or after 1 January 2002 or occur on or after 1 January 2002;¹¹
- Be real, demonstrable and quantifiable- this implies the proponent taking specific actions, with good record keeping and monitoring, and using scientifically acceptable quantification protocols;
- Not otherwise be required by law – offsets resulting from composting projects based on legislated landfill bans of organics would likely not qualify under this criterion;
- Have clearly established ownership – as established by contract or legal agreement;
- Counted only once¹²;

³ The value of offset credits traded will likely be less than the $15/tonne price because of greater scientific uncertainty in calculating offsets and the higher business risk involved in purchasing offsets versus simply paying into the fund.
¹⁰ Climate Change Central’s www.climatechangesolutions.ca
¹¹ This date ties back to the release of the first Alberta climate change plan in 2002. While the 1 January 2002 start date appears to be cast in stone in Alberta, administratively, there may still be opportunities to work around this limitation.
¹² A registry is one mechanism that can be used to mitigate against double counting of offsets. Alberta has recently announced that the public offset registry to support the provincial system will be managed by
Be verified by a qualified third party – as per ISO 14064 3:2006; and
Have occurred in Alberta\textsuperscript{13}.

Emissions Trading

Emissions trading seeks to leverage the efficiencies of capitalism to produce reductions in GHG emissions at the lowest total cost. Advocates often point to the success of such a model during the 1980s and 1990s at reducing acid rain in the U.S. resulting from industrial SO\textsubscript{2} emissions.

As with any market-based system, there are buyers and sellers, with the buyers essentially paying for others to undertake GHG emission reduction activities and projects to the extent required by their legislated targets. Economically, this may make sense where one facility may only have limited opportunities to reduce their own emissions and easier and more cost effective reduction choices (“lower hanging fruit”) are available elsewhere. The argument is made that as long as someone, somewhere, carries out the emission reductions required of the buyer, there is a net climate change benefit.

GHG emissions trading in Canada is still in its infancy, with only three exchanges in operation.\textsuperscript{14} Other than buyers and sellers, there are also brokers and aggregators that have roles to play in the trading process. Brokers seek to bring together offset buyers and sellers and may act for either. Like real estate agents, they are usually paid on a commission basis. The need for aggregators comes about because buyers are usually interested in purchasing larger amounts of credits (100+ kilo-tonnes) and sellers, by themselves, cannot generate all the necessary offsets required. Aggregation, the bundling up by an agent of similar offsets generated by different sellers for sale through a single transaction, allows smaller sellers to take part in emissions trading. It also spreads the cost of the transaction amongst the various sellers whose offsets are bundled up by the aggregator. An aggregator may also be large enough to carry the financial security typically required by the buyer in support of the offsets being sold. Finally, validators and verifiers, as per ISO 14063 3:2006, provide the independent quality assurance services required by both regulators and the market place.

\begin{footnotes}
\item \textsuperscript{13} The author’s discussions with Alberta Environment officials indicate that while harmonization opportunities may arise with the development of a federal offset system, for now the fire wall provisions remains in place around the province.
\item \textsuperscript{14} The Chicago Climate Exchange, the Montreal Climate Exchange and the Canadian Climate Exchange, with the latter being an off shoot of the Winnipeg Commodities Exchange.
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Current Situation – National Level

The Composting Council of Canada has received a proposal from Baseline Emissions Management Inc., an aggregator/broker based out of Calgary, to develop a national quantification protocol for composting. Acting as a consultant, Baseline Management developed the Alberta composting protocol approved earlier this year.

There are some advantages to having a national quantification protocol developed for composting and for the Composting Council to be at the forefront of that effort. These include:

- Being “first past the post” with a protocol if - some may say when here - the federal government eventually adopts a market-driven approach as part of its overall climate change mitigation strategy. An industry developed protocol that is seen to have industry acceptance thus would likely have a better chance of being officially recognized;
- Use of a standard protocol is one means of mitigating some of the scientific uncertainties associated with GHG quantification and could potentially increase the quality, and hence the financial value, of the offsets generated; and
- Use of a standard protocol would make it easier to aggregate composting offsets for trading and also widen the participation base amongst Council members, particularly with the smaller operations. For municipal projects, there may also be additional social and political capital to be gained over and above the additional revenues accruing from any sale of offsets.

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