CHAPTER 3

SOLID WASTE DISPOSAL

Contents

Tables

Boxes

3. SOLID WASTE DISPOSAL

3.1 INTRODUCTION

No refinement

3.2 METHODOLOGICAL ISSUES

3.2.1 Choice of method

3.2.1.1 FIRST ORDER DECAY (FOD)

This refinement attempts to guide the inventory complier on estimation of methane emissions from active aeration landfill to the extent of current knowledge and data available. Feature of management of SWDS by active aeration as well as other managements is given in Box.3.0a.

The 2006 IPCC Guidelines present the basic concept of FOD as "…..The basis for the calculation is the amount of Decomposable Degradable Organic Carbon (DDOCm) as defined in Equation 3.2. DDOCm is the part of the organic carbon that will degrade under the anaerobic conditions in SWDS. It is used in the equations and spreadsheet models as DDOCm. The index *m* is used for mass. DDOCm equals the product of the waste amount (W), the fraction of degradable organic carbon in the waste (DOC), the fraction of the degradable organic carbon that decomposes under anaerobic conditions (DOCf), and the part of the waste that will decompose under aerobic conditions (prior to the conditions becoming anaerobic) in the SWDS, which is interpreted with the methane correction factor (MCF)…..". The parameter that is related to aerobic condition is expressed in terms of MCF. The guidance on the use of MCF in different conditions and management condition is updated in Table 3.1 in chapter 3 of the 2006 IPCC Guidelines. Currently many countries use active aeration or aerobic stabilization of managed landfills at large scale as abatement measure (e.g. Germany and some European countries). Decomposition of the organic matter is promoted about 3-4 times (Ishigaki 2003, Ritzkowski 2012). Fast aerobic decomposition reduces DOC available for anaerobic decomposition.

The IPCC FOD method is adopted as a relatively simple model for estimating CH_4 emissions from SWDS, that express overall decomposition process of a series of chain reactions of anaerobic decay of DOC. Theoretically, it is not possible to express aerobic decomposition of DOC by this model. However, the addition of reactions for aerobic decay of DOC to this model makes it complex. Therefore, the MCF is introduced to express the part of waste that is decomposed under aerobic conditions. This idea had also expanded for continuous aerobic management in semi-aerobically managed landfills in the 2006 IPCC Guidelines although it defines MCF as a part of waste degraded aerobically prior to the conditions becoming anaerobic. From this context, CH_4 emission from active aeration of managed landfill is also estimated by IPCC FOD method by introducing specific values of MCF.

BOX 3.0A

CALCULATION OF MCF FOR NEW CATEGORY OF AEROBIC MANAGEMENT OF SWDS (MANAGED POORLY–SEMI-AEROBIC, MANAGED WELL–ACTIVE-AERATION, MANAGED POORLY–ACTIVE-AERATION)

In addition to air injection to SWDS under active aeration, certain design of piping, air volume, pressure, control of temperature and moisture are required (Ritzkowski and Stegmann 2012). High-pressure aeration hardly promotes the aerobic decay of DOC due to reduction of moisture. Since very limited number of experience have been obtained so far, difference of conditions of management and climate gives variability of reductions. Well-designed operation of aerobic management of SWDS in a laboratory has shown to reduce of 70% of emissions of CH4 (Ishigaki et al., 2003). However, the field operation has revealed less effectiveness for emission reduction due to the escape substantial penetration of oxygen to the waste body. Even if the designed aeration is enough for organics in SWDS, the unused oxygen can escape out from the SWDS by shortcut via void in waste and/or soils. In order to avoid this situation and to save the energy and cost for excess aeration, a low-pressure aeration has been implemented for SWDS. These projects have shown the reduction of CH_4 emission about 10% (Raga 2014) to 60% (Hrad and Huber-Humer 2013), which corresponds to MCF of 0.4 to 0.9. Cases of lower conversion to aerobic conditions are ascribed to the inhibition of air penetration to saturated zone and the reduction of moisture by high pressure aeration. It is obvious that the climate and landfill management conditions influence the aerobic atmosphere in SWDS. Water level and drainage condition must be carefully managed especially in tropical climate. Aeration for fresh waste in SWDS is less effective than aged waste, especially in the tropical climate or moist waste to be disposed. Best result of aerobic coversion as 0.4 was given to a default MCF for a category of managed well-active aeration. Default MCF of 0.7 for a category of managed well-active aeration.average was derived from average of available literature shown above (0.5-0.9).

Semi-aerobically managed SWDS is also one type of aerobic management. The nature of semi-aerobically managed SWDS is natural ventilation driven by difference of temperature between inside and outside of SWDS, which is supported by the connection of network of drainage pipes and certain number of gas exhausting (ventilation) pipes. Since the exits of leachate drainage pipes also serve as an entrance for air penetration, it must be always open to the atmosphere. At least the water level in the landfills should be kept low in order to avoid the situation of sunk of drainage pipe. Otherwise, ventilation does not occur (Laboratory of Solid Waste Disposal Engineering, 2016). In the tropical climate zone or other high-precipitation region, it is quite hard to manage the water level in SWDS (Tsubaki et al., 2009). In the case of drainage sunk, the amount of air penetration is reduced by about 40% of the best result of semi-aerobically management (Ishimori et al., 2017). Default MCF of 0.7 for a category of poorly managed semi-aerobic landfill is derived from 40% reduction of aerobic decay of DOC from well-managed semi-aerobic landfill (0.5 + (1 - 0.5) x 40%)

In addition to the refinement of methane emission from active aerobic landfill, there are some studies on methodology of N_2O emission from active aerobic landfill that is well accepted in CDM methodology AM0083. This methodology is not mentioned in the 2006 IPCC Guidelines. Information of N_2O emission estimated is elaborated in Box 3.0 B .

BOX 3.0B
NITROUS OXIDE EMISSION FROM SWDS

Significant generation of N_2O from SWDS was already indicated by IPCC Forth Assessment Report (2007) though 2006 IPCC Guidelines do not mention on it. Approved CDM methodology, AM0083 (UNFCCC CDM Executive Board 2009), is on handling of venting and low-pressure aeration for landfilled waste in closed SWDS. The AM0083 gives methodology to estimate N_2O emission from the aeration project as optional information according to aerobic treatment of waste. Aerobic pathway of N_2O generation in SWDS is well known (Borjesson and Svensson 1997; He et al., 2011; Harborth et al. 2013), and the emission factor given in AM0083 refered to waste composting which is regarded as analogue process. Not only active aeration of managed landfills, but cover soils and woking faces in all SWDS are potential emission sources of N_2O. Emission of N_2O has not been reported in semi-aerobically managed landfills while not so many information is available. If the specific project on active aeration of SWDS in each country is adopted for emission estimation, and if it also reported N_2O emission as well in accordance with AM0083, that is also taken into consideration for inventory report.

Anaerobic generation of N_2O is also common and have been observed in SWDS (Rinne et al., 2005; Matthew et al., 2005; Ishigaki et al., 2016). Anaerobic pathway of N_2O generation is combined with denitrification process and is correlated to anaerobic decay of DOC. There are two uncertainties on the degree of conversion of nitrogen to N_2O and the degree of carbon consumption on nitrogen conversion for the emission estimation. Apparent correlation of N_2O and CH_4 emissions was obtained about 20% by equivalent to CO_2 in anaerobically managed landfills (Ishigaki et al., 2016), wheareas it requires to validate for country specific condition in order to estimate the reliable emission.

3.2.2 Choice of activity data

No refinement

3.2.3 Choice of emission factors and parameters

DEGRADABLE ORGANIC CARBON (DOC)

FRACTION OF DEGRADABLE ORGANIC CARBON WHICH DECOMPOSES (DOC_f)

This refinement elaborates default values of DOC_f for different waste components based on waste components analysed in literature review. The uncertainty values are also updated.

Fraction of degradable organic carbon which decomposes (DOC_f) in SWDS was reported to vary depending on type of organic waste materials being degraded. Highly decomposable waste components were food wastes and grass. Moderately decomposable wastes were papers, coated paper, old newsprint, old corrugated containers and office paper. Less decomposable wastes were wood components including tree branches and leaves (Eleazer et al., 1997). Recent literatures have reported different biodegradability of waste components in laboratory experiments and field-scale observations. Structural organization of the organic matter in the waste materials was found as predominant factor affecting their biodegradability and their biodegradability were found to be related to the lignin-like residual fraction presented in the waste materials (Bayard et al., 2017). The biodegradation yields of the waste components under anaerobic condition were found largely varied from one component to other ranging from few percentages for wood to high percentages (60-80%) for food wastes and office paper. Meanwhile, biogenic carbon conversion of paper products were varied largely (21% to 96%) depending on paper products. In general, papers made from mechanical pulps are less degradable than those made from chemical pulps where essentially all lignin was chemically removed whereas the diaper exhibited limited biodegradability (Wang et al., 2015). According to Wang et al. (2016), carbon conversion to methane were different for softwoods (0-9.5%) and hardwoods (17-28%). The carbon loss for wood samples recovered from landfills were found to be low and climate did not influence much on decay of wood in landfills but wood types were more susceptible to biodegradation (Ximenes et al., 2015).

Average biogenic carbon content stored in the landfills was reported to be 64.6% and 35-95% of the biogenic carbon present in the waste components was recalcitrant and can be expected to go into long term storage. (De la Cruz et al., 2013).

Therefore, it is *good practice* to use DOC_f values specific to waste types when waste composition data are available. Table 3.0 shows the recommended default DOC_f values for waste components with different degree of biodegradability. When information on composition of deposited wastes in SWDS is not available, default DOC_f value for bulk wastes can be used. The recommended default DOC_f value of bulk wastes of 0.5 in the 2006 IPCC Guidelines is still valid based on information derived from updated literatures.

TABLE 3.0
FRACTION OF DEGRADABLE ORGANIC CARBON WHICH DECOMPOSES (DOC_F) FOR DIFFERENT WASTE TYPES

Type of Waste	Recommended Default DOC_f Values	Remark
Less decomposable wastes e.g. wood, branches and leaves	0.2	An average value of 0.226 was derived from DOC_f values for woods, branches and leaves reported in 5 references[1-5] (n = 14).
Moderately decomposable wastes e.g. paper, textile, diaper	0.5	An average value of 0.523 was derived from DOC_f values for paper products, textile and diaper reported in 4 references[1,4,5,6] (n = 22).
Highly decomposable wastes, e.g. food wastes, grasses	0.7	An average value of 0.706 was derived from DOC_f values for food wastes and grasses reported in 3 references[1,4,5] (n = 5)
Bulk waste	0.5	Reported value of 0.46[4] and 0.34[7]

[1] Eleazer et al. (1997); [2]Wang et al (2016); [3] Ximines et al. (2015); [4]Bayard et al. (2017); [5]Jeong (2016); [6]Wang et al (2015); [7] De la Cruz et al. (2013)

BOX 3.0C
EFFECT OF DOC LEACHING FROM SWDS

The amount of DOC leached from the SWDS was not considered in the estimation of DOC_f in the 2006 IPCC Guidelines. Recent literature reported that the operation of anaerobic landfills under wet conditions yielded higher organic carbon release in gas and leachate forms while reducing landfill gas production potential due to carbon washout by leachate (Jiang et al., 2007). Rainfall influenced total amount of methane generated from food waste because carbon washout increase with rainfall (Karanjekar et al., 2015). Drainage of leachate with a high organic loading in high food waste content MSW led to a loss of landfill gas of more than 10% (Zhan et al., 2017). Therefore, it is good practice to estimate available DOC for degradation by subtracting DOC lost with the leachate from total DOC in SWDS if the DOC mass in leachate could be determined. The default DOC_f values could be applied to the DOC stored in SWDS.

METHANE CORRECTION FACTOR (MCF)

This refinement elaborates on the MCF default value of active aeration landfills under Tier 1 estimation.

The MCF for shallow and deep unmanaged SWDS considers the degree of reduction of anaerobic microbial activity due to air penetration. But in case of aerobically managed landfills, both semi-aerobic and active aeration, the reduction of anaerobically available DOC due to aerobically degradation cannot be ignored. Further, the drying of waste in a part of active aeration results in reduction of the activity of microbes (both aerobic and anaerobic). Behavior of CH_4 emission from aerobically managed landfills including active aeration and semi-aerobically managed landfills are known to experience high fluctuation (Sutthasil et al., 2014) due to difficulty of management to keep aerobic conditions. DOC degraded under aerobic conditions depends on the way of management of SWDS. Therefore the effects of management that affects DOC decay in aerobically managed landfills is considered in new categories of MCF. Method for estimation is given in Box 3.0A

TABLE 3.1 (UPDATED)
SWDS CLASSIFICATION AND METHANE CORRECTION FACTORS (MCF)

Type of Site	Methane Correction Factor (MCF) Default Values
Managed – anaerobic [1]	1.0
Managed well – semi-aerobic [2]	0.5
Managed poorly – semi-aerobic [3]	0.7
Managed well – active-aeration [4]	0.4
Managed poorly – active-aeration [5]	0.7
Unmanaged [6] – deep (>5 m waste) and /or high water table	0.8
Unmanaged [7] – shallow (<5 m waste)	0.4
Uncategorised SWDS [8]	0.6

[1] **Anaerobic managed solid waste disposal sites**: These must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) levelling of the waste.

[2] **Well managed semi-aerobic managed solid waste disposal sites**: These must have controlled placement of waste and will include all of the following structures for introducing air to waste layer: (i) permeable cover material; (ii) leachate drainage system without sunk; (iii) regulating pondage; and (iv) gas ventilation system without cap, (v) connection of leachate drainage system and gas ventilation system.

[3] **Poorly managed semi-aerobically managed solid waste disposal sites:** When SWDS, that is equipped as well as semi-aerobically managed SWDS, is managed under the following condition, it is changed as poor management; (i) condition of sunk of leachate drainage system; (ii) closing of valve of drainage or atmosphere-unopening of drainage exit; (iii) capping of gas ventilation exit.

[4] **Well managed active aeration of managed solid waste disposal sites**: Active aeration of managed landfills, which includes the technology of in-situ low pressure aeration, air spurging, bioventing, passive ventilation with extraction (suction), These must have controlled placement of waste and will include leachate drainage system to avoid the blockage of air penetration, and (i) cover material; (ii) active aeration or gas extraction system without drying of waste.

[5] **Poorly-managed active aeration of managed solid waste disposal sites:** When SWDS, that is equipped as well as active aeration of managed SWDS, is managed under the following condition, it is judged as poor management; (i) suck of aeration system due to failure of drainage; (ii) lack of available moisture for microorganisms due to high- pressure aeration.

[6] **Unmanaged solid waste disposal sites – deep and/or with high water table**: All SWDS not meeting the criteria of managed SWDS and which have depths of greater than or equal to 5 metres and/or high water table at near ground level. Latter situation corresponds to filling inland water, such as pond, river or wetland, by waste.

[7] **Unmanaged shallow solid waste disposal sites**; All SWDS not meeting the criteria of managed SWDS and which have depths of less than 5 metres.

[8] **Uncategorised solid waste disposal sites**: Only if countries cannot categorise their SWDS into above four categories of managed and unmanaged SWDS, the MCF for this category can be used.

Sources: IPCC (2000); Matsufuji *et al*. (1996)

3.3 USE OF MEASUREMENT IN THE ESTIMATION OF CH_4 EMISSIONS FROM SWDS

No refinement

3.4 CARBON STORED IN SWDS

No refinement

3.5 COMPLETENESS

No refinement

3.6 DEVELOPING A CONSISTENT TIME SERIES

No refinement

3.7 UNCERTAINTY ASSESSMENT

No refinement

3.7.1 Uncertainty attributable to the method

No refinement

3.7.2 Uncertainty attributable to data

Please see Section 3.7.2.2

3.7.2.1 UNCERTAINTIES ASSOCIATED WITH ACTIVITY DATA

No refinement

3.7.2.2 UNCERTAINTIES ASSOCIATED WITH PARAMETERS

Methane correction factor (MCF), Degradable organic carbon (DOC) and Fraction of degradable organic carbon which decomposes (DOC_f)

This section provides updates on uncertainty estimates for DOC_f in Table 3.5 (Updated). The estimates are based on DOC_f derived from information reported in the literatures and expert judgement. Reported biodegradability of waste components were varied in a wide range depending on the composition of materials in bulk wastes as well as environmental factors in which the wastes are undergone biodegradation. It is recognized that laboratory experiments where some of reported DOC_f values are derived from would be quite different from the real condition of SWDS but there was also some good agreement between the reported biodegradable fractions of waste components derived from laboratory experiments and observed data from field investigations. In 2006 IPCC Guidelines, the uncertainty range of proposed default DOC_f value of bulk wastes is ±20% which is in agreement with recent updated information on reported in the variation of DOC percentages found in the SWDS at ±18% (De la Cruz et al., 2013). Moreover, the proposed default DOC_f values for different waste component are derived based on the information reported in the literatures.

TABLE 3.5 (UPDATED)
ESTIMATES OF UNCERTAINTIES ASSOCIATED WITH THE DEFAULT ACTIVITY DATA AND PARAMETERS IN THE FOD METHOD FOR CH_4 EMISSIONS FROM SWDS

Activity data and emission factors	Uncertainty Range
Total Municipal Solid Waste (MSW_T)	**Country-specific:** 30% is a typical value for countries which collect waste generation data on regular basis. ±10% for countries with high quality data (e.g., weighing at all SWDS and other treatment facilities). For countries with poor quality data: more than a factor of two.
Fraction of MSW_T sent to SWDS (MSW_F)	±10% for countries with high quality data (e.g., weighing at all SWDS). ±30% for countries collecting data on disposal at SWDS. For countries with poor quality data: more than a factor of two.
Total uncertainty of Waste composition	±10% for countries with high quality data (e.g., regular sampling at representative SWDS). ±30% for countries with country-specific data based on studies including periodic sampling. For countries with poor quality data: more than a factor of two.
Degradable Organic Carbon (DOC)[1]	**For IPCC default values** : ±20% **For country-specific values**: Based on representative sampling and analyses: ±10%
Fraction of Degradable Organic Carbon Decomposed (DOC_f) = 0.2	**For IPCC default value (0.5)**: ± 20% **For IPCC default value for each waste type** ±140% [1]

[1] The uncertainty range given applies to the DOC content in bulk waste. The ranges for DOC for different waste components in MSW given in Table 2.4 can be used to estimate the uncertainties for these components.

= 0.5 = 0.7	±75% [2] ±40% [3] **For country-specific value** ± 10% for countries based on the experimental data over longer time periods.
Methane Correction Factor (MCF) = 1.0 = 0.8 = 0.5 = 0.4 = 0.6	**For IPCC default value:** –10%, +0% ±20% ±20% ±30% –50%, +60%
Fraction of CH_4 in generated Landfill Gas (F) = 0.5	**For IPCC default value**: ±5%
Methane Recovery (R)	The uncertainty range will depend on how the amounts of CH_4 recovered and flared or utilised are estimated: ± 10% if metering is in place. ± 50% if metering is not in place.
Oxidation Factor (OX)	Include OX in the uncertainty analysis if a value other than zero has been used for OX itself. In this case the justification for a non-zero value should include consideration of uncertainties.
half-life ($t_{1/2}$)	Ranges for the IPCC default values are provided in Table 3.4. Country-specific values should include consideration of uncertainties.
Source: Expert judgement by Lead Authors of the Chapter. [1] Derived from reported values in 6 references (Eleazer et al., 1997; Wang et al., 2016; Ximenes et al., 2015; Bayard et al., 2017; Jeong, 2016; Ximenes et al., 2008) [2] Derived reported values in 4 references (Eleazer et al., 1997; Bayard et al., 2017; Wang et al., 2015; Jeong 2016) [3] Derived reported values in 4 references (Eleazer et al., 1997; Bayard et al., 2017; Jeong 2016; De la Cruz et al., 2013)	

3.8 QA/QC, Reporting and Documentation

No refinement

References

Bayard, R., Benbelkacem, H., Gourdon, R. and Buffière, P. (2017) Characterization of selected municipal solid waste components to estimate their biodegradability. *Journal of Environmental Management* (article in press).

Börjesson, G., and Bo H. Svensson (1997) Nitrous oxide emissions from landfill cover soils in Sweden, Tellus B: Chemical and Physical Meteorology, 49:4, 357-363

De la Cruz, F. B., Chanton, J.P. and Barlaz, M.A. (2013) Measurement of carbon storage in landfills from the biogenic carbon content of excavated waste samples. *Waste Management* **33**: 2001-2005.

Eleazer, W. E., Odel III, W.S., Wang, Y.S. and Barlaz, M.A. (1997) Biodegradability of municipal solid waste components in laboratory-scale landfills. *Environmental Science and Technology* **31**: 911-917.

Harborth, P., Fuss., R, Münnich., K, Flessa, H.,Fricke., K.(2013) Spatial variability of nitrous oxide and methane emissions from an MBT landfill in operation: strong N_2O hotspots at the working face. Waste Manag. 33(10):2099-107

He, P., Yang, N., Gu, H., Zhang, H., Shao, L. (2011) N_2O and NH_3 emissions from a bioreactor landfill operated under limited aerobic degradation conditions. *Journal of Environmental Sciences* , 23(6) 1011–1019

Hrad, M., Gamperling, O., and Huber-Humer, M (2013) Comparison between lab- and full-scale applications of in situ aeration of an old landfill and assessment of long-term emission development after completion. *Waste Management* **33**: 2061-2073.

Ishigaki,T., W. S., Akane Nakanishi, Masafumi Tateda, Michihiko Ike, Masanori Fujita. (2003) Application of Bioventing to Waste Landfill for Improving Waste Settlement and Leachate Quality - A Lab Scale Model Study. *Journal of Solid Waste Technology and Management* **29**(4): 230-238.

Ishigaki, T., M. Nakagawa, M. Nagamori, M. Yamada (2016) Anaerobic generation and emission of nitrous oxide in waste landfills. Environ Earth Sci 75:750

Ishimori H., K. Endo, T. Ishigaki, and M. Yamada (2017)Coupled Fluid Flow and Thermal and Reactive Transport Modeling for Evaluating Waste Stabilization in Semi-aerobic Landfill . *The Journal of Solid Waste Technology and Management* (article in press)

Jiang, J., Yang, G., Deng, Z., Huang, Y., Huang, Z., Feng X., Zhou, S. and Zhang, C. (2007) Pilot-scale experiment on anaerobic bioreactor landfills in China. *Waste Management* **27**: 893-901.

Jeong S. (2016) Verification of Methodologies and Estimation of IPCC Model Parameters for Solid Waste Landfills, Ph.D. Dissertation, Seoul National University, 141 pp.

Karanjekar, R. V., Bhatt, A., Altouqui S., Jangikhatoonabad, N., Durai, V., Sattler, M., Hossain, M.D.S. and Chen V. (2015) Estimating methane emissions from landfills based on rainfall, ambient temperature, and waste composition: The CLEEN model. *Waste Management* **46**: 389-398.

Laboratory of Solid Waste Disposal Engineering (2016), Study on semi-aerobic landfill site measuring gas flow rate and temperature, Hokkaido University, Japan

Matthew, C., McBain Jon S., Warland Raymond A. and McBride Claudia Wagner-Riddle (2005) Micrometeorological measurements of N_2O and CH_4 emissions from a municipal solid waste landfill. *Waste Manage Res* **23**: 409-419

Raga, R., and Cossu, R. (2014) Landfill aeration in the framework of a reclamation project in Northern Italy. *Waste Management* **34**: 683-691.

Rinne, J., Pihlatie, M., Lohila, A., Thum, T., Aurela, M., Tuovinen, J.P., Laurila, T., and Vesala, T. (2005) Nitrous Oxide Emissions from a Municipal Landfil . *Environ Sci Technol.* **15; 39**(20):7790-3.

Ritzkowski, M., and Stegmann, R., (2012) Landfill aeration worldwide: Concepts, indications and findings. *Waste Management* **32**: 1411-1419.

Sutthasil, N., Chiemchaisri, C., Chiemchaisri, W., Wangyao, K., Towprayoon, S., Endo, K., Yamada, M. (2014) Comparison of Solid Waste Stabilization and Methane Emission from Anaerobic and Semi-Aerobic Landfills Operated in Tropical Condition. *Environmental Engineering Research* , 19(3): 261-268.

Tsubaki, M., Ueno, S., and Tsuji, Y. (2009) The CDM Metrodology for Reduction of Greenhouse Gas Emission from Landfull Sites by Semi-aerobic Landfill System. In: *Sardinia 2009, Twelfth International Waste Management and Landfill Symposium*, Italy.

UNFCCC Executive Board.(2009) Approved baseline and monitoring methodology AM0083 “Avoidance of landfill gas emissions by in-situ aeration of landfill” AM0083 / Version 01.0.1

Wang, X., De la Cruz, F.B., Ximenes, F. and Barlaz, M.A. . (2015) Decomposition and carbon storage of selected paper products in laboratory-scale landfills. *Science of the Total Environment* **532**: 70-79.

Wang, X. a. B., M.A. (2016) Decomposition and carbon storage of hardwood and softwood branches in laboratory-scale landfills. *Science of the Total Environment* **557-558**: 355-362.

Ximenes, F., Björdal, C., Cowie, A. and Barlaz, M.A. (2015) The decay of wood in landfills in contrasting climates in Australia. *Waste Management* **41**: 101-110.

Ximenes, F. A., Gardner, W.D. and Barlaz, M.A. (2008) The decomposition of wood products in landfills in Sydney, Australia. *Waste Management* **28**: 2344-2354.

Zhan, L. T., Xu, H., Chen, Y.M., Lan, J.W., Lin W.A., Xu, X.B. and He P.J. (2017) Biochemical, hydrological and mechanical behaviors of high food waste content MSW landfill: Liquid-gas interactions observed from a large-scale experiment. *Waste Management* (article in press).