CONSIDERATION OF EMISSION RATIOS IN INTEGRATED SUSTAINABLE MUNICIPAL SOLID WASTE MANAGEMENT PLANNING

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SUMMARY

The treatment and disposal of Municipal Solid Waste (MSW) may cause environmental pollution

Expose humanity to harmful substances and bacteria that affects human health and the ecosystem

Accurate quantification and detailed documentation of emissions data from Municipal Solid Waste Management (MSWM) will enables a city or region to demonstrate transparency and enhance the credibility of its corporate environmental and climate change strategy

Establishing a comprehensive corporate emissions inventory is an important first step in developing an environmental and climate change strategy

This is justified if adequate resource utilization and environmental implications are considered in planning the collection, transportation and treatment/disposal of MSW, hence developing a city wide, regional or national Integrated Sustainable MSWM system.

SUMMARY

This IS a methodological approach for emissions inventory with case study in conducting a baseline emissions inventory using Life Cycle Assessment Model (LCAM)

It presents best practices in establishing the organizational and operational boundaries of a MSWM scenario emissions inventory in a sustainable city, region or national environment

In this study, site-depended data for the landfills together with regional waste composition are used with associated collection, transportation and treatment/disposal data, to determine the emission levels associated with the landfills.

The environmental profile of the three MSW landfills were evaluated and compared in relation to their total waste intake over twenty years period (19720157.6 tonnes, 3533333.528 tonnes and 43538.452 tonnes for Hampton Downs, Tirohia and Taupo landfills respectively).

Using the impact categories as classified in EASEWASTE, the emission ratios per tonne of waste are compared to assess the contributions of the landfills to the emissions associated with MSWM in the region.

The paper provides guidance on improving and maintaining emissions inventory in the MSWM sector to guide stake holders in reducing the impact of MSW in an Integrated Sustainable manner.

The need for zoning MSW collection/transportation system using available disposal/treatment sites as focal points is therefore advocated.

A modified generalized emissions inventory model for the MSW sector is suggested.

KEY WORDS

- Process generated emissions
- Emissions inventory
- Emissions inventory model
- Municipal solid waste management
- Integrated sustainable municipal solid waste management

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INTRODUCTION

The health and environmental effects of MSWM have since been demonstrated

- **Obnoxious aspects of bad air quality**
- **Adverse impact on economic value of properties near landfills**
- **Potential health hazards**
- **Fires and explosion hazards**
- **Vegetation damage**
- **Ground water pollution**
- **Surface water pollution**
- **Socioeconomic impacts**
- **Air pollution and global warming**

- Public opposition (NIMBY)
- Stringent environmental laws targeting MSWM
- Improved MSWM around the world
- MSWM has continually become part city planning management
- Targets have been set as a way of monitoring performance indicators

Introduction

Results of analysis of results from the landfills revealed that the emission ratios (emissions associated with one tonne of waste) from the landfills differ significantly as a result of variations in the scenario created by significant difference in MSW transfer/transportation set up.

This is a demonstration of the need to incorporate comprehensive emissions inventory as a step towards monitoring and showing the progress that are made in MSWM.

Emission Inventory

According to US EPA (2011), an emissions inventory is a database that lists, by source, the amount of air pollutants discharged into the atmosphere of a community during a given time period and the development of a complete emission inventory is an important step in an air quality management process

Emissions and releases to the environment are the starting point of every environmental pollution problem. Information on emissions therefore is an absolute requirement in understanding environmental problems and in monitoring progress towards solving them.

Emission Inventory

- Emission inventory includes:
  - Emission from various pollution sources in a geographic area:
  - It contains all regulated pollutants.
- It is used for the following:
  - To determine sources of pollution
  - Establish emission trend over time
  - Target regulatory actions
  - Estimate air quality through dispersion modelling

Emission Inventory

Emission inventories are developed for variety of purposes which can be categorised into two broad groups:

- Policy use, to track progress towards emission reduction targets and develop strategies and policies. The annual reporting of national total emissions of greenhouse gases and air pollutants in response to obligations under international conventions and protocols like UNFCC for GHG and regular emission reporting by individual industrial facilities in response to legal obligations are examples of this type of application.
- Scientific uses like inventories of natural and anthropogenic emissions are used by scientists as inputs to air quality models. Example of this is the Pollutant Release and Transfer Registers for air quality models.

This research falls under the first group as the purpose is the quantification of emissions from MSWM to help in monitoring progress being made in that sector as a step towards improving on the processes.

MUNICIPAL SOLID WASTE MANAGEMENT (MSWM)

- MSWM is the collection, transportation, processing or disposal, managing and monitoring of waste materials.
- It depends on local and waste characteristics which vary with cultural, climatic, socioeconomic variables and institutional capacity.
- The impact of waste management on the environment and human health depends on the management processes and procedures. On this base, the waste management hierarchy (Figure 1) evolved.
- The hierarchy gives priority to management strategy that is friendlier to the environment starting with reducing or preventing its generation through to reuse, recycling, recovery and finally residual management or disposal

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MSWM

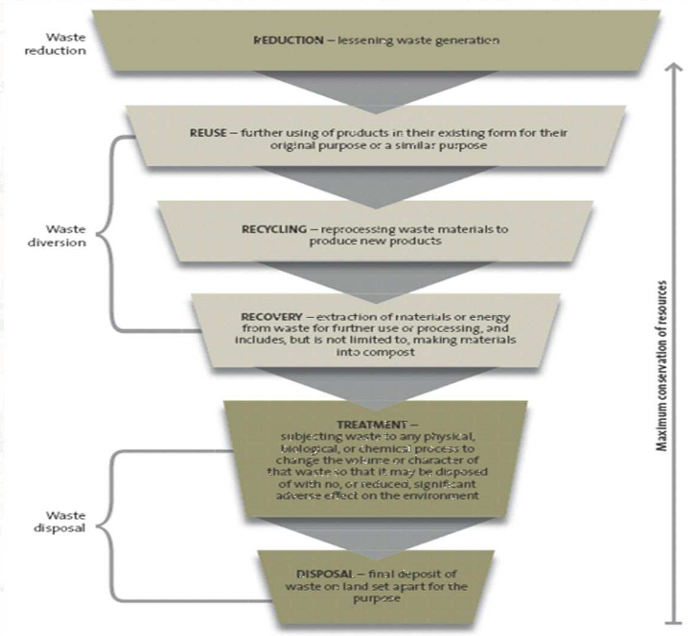

Figure 1

Waste management hierarchy (Source: Vergara and Tchobanoglous, 2012)

Emission from MSWM

- ✓ According to World Bank (2012), about 1.3 billion tonnes of MSW is generated annually by urba settlers globally and this is expected to increase to 2.2 billion tonnes by 2025.
- ✓ Van de Klundert & Anschütz (2001) and UNEP (2009) agrees that waste management cannot be effectively managed without due consideration for issues such as the city's overall GHG emissio labour market, land use planning, and myriad related concerns.
- ✓ The estimated global annual emissions from solid waste disposal sites (SWDS) are in the range o 20 - 40 million tonnes of CH_4, of which the most comes from industrialized countries
- ✓ This contribution is estimated to be approximately 5-20 percent of the global anthropogenic CH_4 which is equal to about 1 to 4 percent of the total anthropogenic greenhouse gas (GHG) emission
- ✓ The emissions around the world including that from developing countries and countries with economies-in-transition will increase in the near future due to increased urban population, increased specific (pro capita) MSW generation due to improved economy and improved SW management practices.
- ✓ The emissions include both GHG and non-GHG, microbes, particles and odorous substances, her the need for comprehensive Emission Inventory covering all aspect of waste management components – collection, transportation, treatment and disposal.
- ✓ This will help to improve on best management practices.

WHAT IS INTEGRATED SUSTAINABLE MSWM (ISMSWM)?

- ISMSWM offers an unconventional way of thinking and looking at waste management
- One designed to avoid and counterbalance the typical technology/financial-centred approach
- It provides insights into the less obvious, but equally urgent planning aspects, including the environmental, socio-cultural, institutional, political and legal aspects
- ISMSWM puts all stakeholders into focus, in a matrix with the more traditionally recognised elements of the waste management system, such as prevention, reuse, recycling, collection and disposal.
- According to van de Klundert & Anschütz (2001), “other problems are caused or made more serious by factors that are not technical or financial, but relate to managerial (in)capacities, the institutional framework, the environment, or the social or cultural context
- Therefore, changes results from changing social, institutional, legal or political conditions.

WHAT IS INTEGRATED SUSTAINABLE MSWM (ISMSWM)?

- The ISMSWM concept was developed:
- ✓ To promote technically appropriate, economically viable and socially acceptable solutions
- ✓ It promotes the development of a waste management system that best suits the society, economy and environment in a particular location, base on;
  - ✓ equity, effectiveness, efficiency and sustainability.
- ✓ ISMSWM will assist in assessing existing system, designing of a new system and selecting of a new technology.
- ✓ A comprehensive emission inventory will assist in taking good decision in achieving these goals

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METHODOLOGY

Name of landfill	Hampton Downs	Tirohia	Taupo
Average annual intake (tonnes)	986007.88	176666,68	2176922.6
Expected total intake (tonnes)	19720157.6	3533333.53	43538.45
Average distance from source of waste (km)	34	142	18
Gas management plan	Flare (energy recovery in view)	Flare (energy recovery in view)	vent
Landfill design	Modern Engineered	Modern Engineered	Modern Engineered
Waste composition	Regional	Regional	Regional
Landfill design height (metre)	10	10	8
Density (t/m3)	1.8	1.8	1.8

Methodology

- The landfills are chosen because of the similarities in design of Hampton Downs and Tirohia landfills, and the differences in the management scenarios of the three landfill, which affects the ways and level they impacts on the environment and human health (Table 1).
- There is no particular methodological approach for emission inventorying which is suitable for all purposes.
- All depends on the purpose, available data/tools and available fund for the task.
- The IPCC Guidelines give two methods for estimation of CH_4 emissions from solid waste disposal (IPCC, 1996) -The IPCC default method and First Order Decay (FOD) method .
- A lot of computer models have been developed for emissions estimation, depending on the purpose and type of emission.
- To compile an emission inventory, all sources of the pollutants must be identified and quantified.
- Each of the pollutants in the inventory emissions are typically estimated by multiplying the intensity of each relevant activity or activity rate in the geographical area and time span with a pollutant dependent proportionality constant known as emission factor.

Therefore, the general model for emission from waste disposal is: **E = AD X EF [1]**

Where E represents total emission, AD stand for activity data, while EF is emission factor.

Methodology

- EASEWASTE software (Kirkeby et al., 2006a) was adop
and used to create an emission inventory based on available
for each of the landfills
- This implies the application of the integrated life cycle management concept, which presents a unique opportunity t
reconcile the general management of MSW with environme
protection, good resource utilization and human health.
- the inventory took into account, transportation data, collecti
processes data, and the waste treatment plan at the landfills;
hence the comprehensive expected emission inventory was created

Methodology

- The inventory was analysed in relation with the quantity of MSW landfilled in each of the landfills , to get the ratios per tonne of MSW
- Table 2 represents the categorization of the emission into the various impact category and the contributions from the MSWM processes.
- The values are normalized to facilitate comparisons.
- The impact categories include; Global Warming (GW), Human Toxicity via water (HTw), Spoiled Groundwater Resources (SGR), Ecotoxicity via water (ETw), Stratospheric Ozone Depletion (SOD), Human Toxicity via air (HTa), Acidification (AC), Stored ecotoxicity in water (SETw), Human toxicity via air (HTs), Photochemical Ozone Formation, High NOx (PhOzF(HNOx)), Stored Ecotoxicity in soil (SETs), Nutrient Enrichment (NE), Photochemical Ozone Formation, low NOx (PhOzF(LNOx)), and Ecotoxicity in water, chronic (ETwc).

	Waste management processes	Tirohia Landfill [PE]	Hampton Downs Landfill [PE]	Taupo Landfill [PE]
HTw	Collection	7.00E-05	7.00E-05	7.00E-05
	Transportation	6.98E-05	3.70E-05	2.92E-04
	Treatment & Disposal	1.65E-03	2.50E-03	1.65E-03
SGR	Collection	0.00E+00	0.00E+00	0.00E+00
	Transportation	0.00E+00	0.00E+00	0.00E+00
	Treatment & Disposal	1.20E-01	1.50E-01	1.20E-01
ETw	Collection	6.29E-08	6.29E-08	6.29E-08
	Transportation	6.27E-08	3.32E-08	2.62E-07
	Treatment & Disposal	4.49E-05	1.59E-04	4.49E-05
SOD	Collection	0.00E+00	0.00E+00	0.00E+00
	Transportation	0.00E+00	0.00E+00	0.00E+00
	Treatment & Disposal	1.43E-02	9.67E-02	1.43E-02
HTa	Collection	1.62E-03	1.62E-03	1.62E-03
	Transportation	1.62E-03	8.56E-04	6.75E-03
	Treatment & Disposal	2.22E-03	2.18E-03	2.22E-03
AC	Collection	1.17E-03	1.17E-03	1.17E-03
	Transportation	1.17E-03	6.19E-04	4.88E-03
	Treatment & Disposal	4.29E-03	2.33E-03	4.29E-03
SETw	Collection	0.00E+00	0.00E+00	0.00E+00
	Transportation	0.00E+00	0.00E+00	0.00E+00
	Treatment & Disposal	2.57E-02	2.57E-01	2.57E-01
HTs	Collection	1.76E-06	1.76E-06	1.76E-06
	Transportation	1.75E-06	9.28E-07	7.32E-06
	Treatment & Disposal	1.26E-04	5.73E-04	1.26E-04
PhOzF(HNOx)	Collection	9.32E-04	9.31E-04	9.31E-04
	Transportation	9.28E-04	4.92E-04	3.88E-03
	Treatment & Disposal	2.77E-03	1.62E-02	2.77E-03
SETs	Collection	0.00E+00	0.00E+00	0.00E+00
	Transportation	0.00E+00	0.00E+00	0.00E+00
	Treatment & Disposal	2.04E-02	2.04E-02	2.05E-02
NE	Collection	2.44E-03	2.44E-03	2.44E-03
	Transportation	2.43E-03	1.29E-03	1.01E-02
	Treatment & Disposal	9.33E-03	9.19E-03	9.33E-03
PhOzF(LNOx)	Collection	7.63E-04	7.63E-04	7.63E-04
	Transportation	7.61E-04	4.03E-04	3.18E-03
	Treatment & Disposal	2.35E-03	1.36E-02	2.35E-03
ETwc	Collection	9.93E-03	9.93E-03	9.93E-03
	Transportation	9.90E-03	5.24E-03	4.13E-02
	Treatment & Disposal	1.54E-02	1.79E-02	1.54E-02

Table 2: Compared impact assessment ratio per tonne of waste in each of the waste management processes in the landfills

Substances	Hampton Downs Landfill (PE)	Tirohia Landfill (PE)	Taupo Landfill (PE)
Methane (CH4)	8.01E-03	9.07E-03	8.20E-02
Carbon Dioxide CO2	5.27E-03	8.12E-03	5.01E-03
CFC 12	3.63E-04	3.63E-04	2.02E-03
Carbon Monoxide (CO)	3.72E-05	4.79E-05	3.86E-04
CFC 11	2.64E-05	2.64E-05	1.97E-04
HCFC 22	2.41E-05	2.41E-05	6.83E-05
CFC 113	2.14E-05	2.14E-05	2.15E-05
Nitrous Oxide (N2O)	1.33E-05	1.70E-05	1.34E-05
HCFC 21	1.79E-06	1.79E-06	2.78E-10
Dichloromethane	1.17E-06	1.17E-06	5.07E-06
Hydrocarbons (HC)	6.69E-07	9.34E-07	6.99E-07
Carbon Tetrachloride	1.93E-07	1.93E-07	6.15E-07
1,1,1-Trichloroethane	1.64E-07	1.64E-07	1.90E-07
HFC 134a	6.63E-10	6.63E-10	7.67E-10

Table 3: Compared emission ratio per tonne of waste by contributing gases to global warming

RESULTS AND DISCUSSION

Fig. 2: Emission ratio per tonne of waste

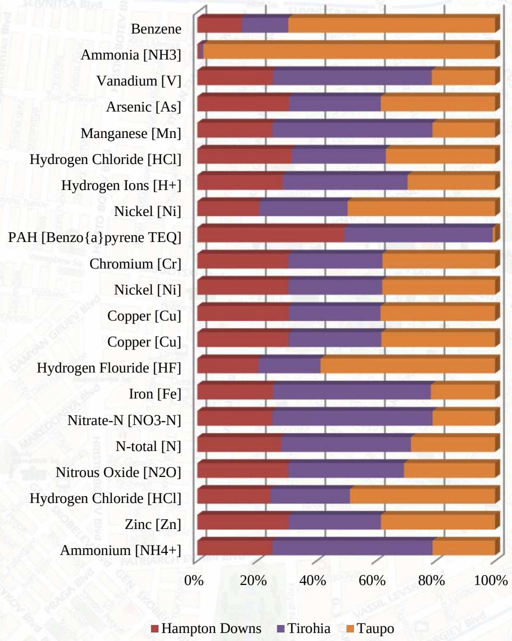
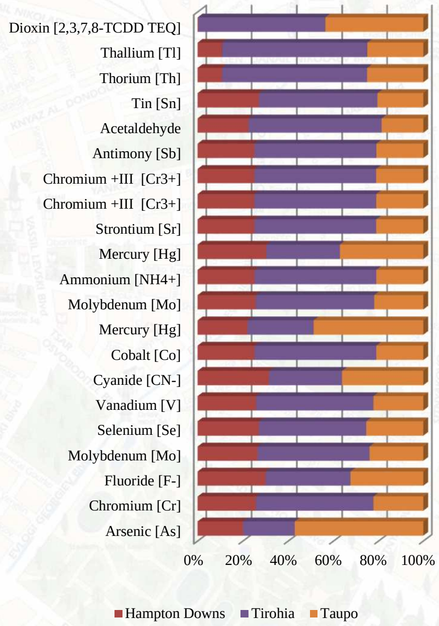


Fig. 3: Emission ratio per tonne of waste



RESULTS AND DISCUSSION

Fig. 4: Emission ratio per tonne of waste

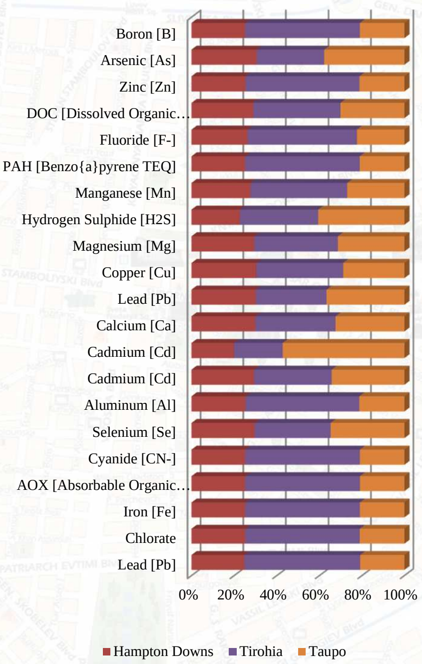
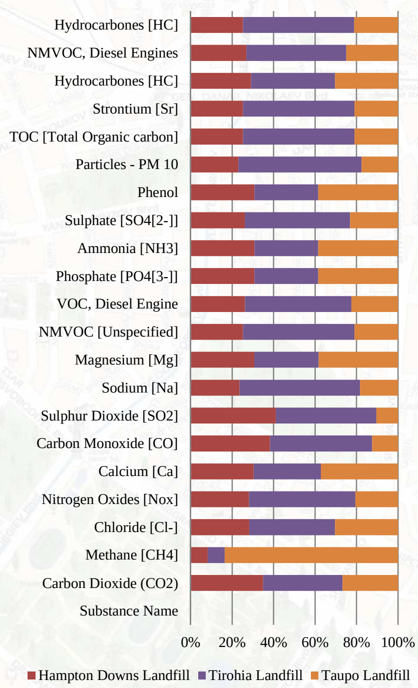


Fig. 5: Emission ratio per tonne of waste



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RECOMMENDATION

- Equation (1) represents the general principle for compilation of emission inventory
- Adopting a recommendation to include emissions from MSWM in planning will therefore require an expanded model:

Emission (Total) = [AD * EF] + [E (Tr) * EF] + [E (En) * EF] + --- [2]

Where E(Tr) = Emission fron Transportation

E(En) = Emissions from the use of Energy

Activity Data and Uncertainties

- Because of the complexities in the activities that are associated in E (Tr) and E (En), it may be difficult to collect activity data that may relate distinctively to each of the activities, for istance;
- Estimation of emissions from road transport requires data for a range of parameters including:
  - Fuel consumed, quality of each fuel type;
  - Emission controls fitted to vehicle in the fleet;
  - Operating characteristics (e.g. average vehicle speeds or types of roads;
  - Maintenance;
  - Fleet age distribution
  - Distance driven, and
  - Climate.

Activity Data and Uncertainties

- Therefore, results will still be uncertain from:
  - Emission factors whose values are laboratory-based hence may not represent real road driven conditions.
  - The activity rates are, like any statistical data, uncertain. In addition as they are not collected specifically for use in emission inventories they may not be exactly the data required by the estimation methodology.
  - The methodology used to estimate emissions may not accurately reflect the true emission processes.

CONCLUSION

- Private haulers and solid waste collection agencies are constantly challenged by the need to reduce emissions to the atmosphere, reduce cost, and at the same time increase collection efficiency and equipment optimization.
- Having the knowledge of their emission contribution will be a good impetus towards achieving these goals, as they will not plan to reduce their pollution if they are not aware of them and the sources.

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CONCLUSION

- To make good use of emission inventory in taking vital decision in MSWM, some other information will be needed. These include:
  - Mapping all waste management activities in the city, region or nation.
  - Knowledge of the physical infrastructure of the areas covered like roads and traffic conditions, lay-out of neighbourhoods.
- Putting the three factors together will help in producing seamless MSWM plan that will stand the taste of time, saving the environment, health and resources

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