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Assessing the environmental performance of construction materials testing using EMS: An Australian study

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ABSTRACT

This paper reports the audit findings of the waste management practices at 30 construction materials testing (CMT) laboratories (constituting 4.6% of total accredited CMT laboratories at the time of the audit) that operate in four Australian jurisdictions and assesses the organisation's Environmental Management System (EMS) for indicators of progress towards sustainable development (SD). In Australia, waste indicators are 'priority indicators' of environmental performance yet the quality and availability of waste data is poor. National construction and demolition waste (CDW) data estimates are not fully disaggregated and the contribution of CMT waste (classified as CDW) to the national total CDW landfill burden is difficult to quantify. The environmental and human impacts of anthropogenic release of hazardous substances contained in CMT waste into the ecosphere can be measured by construing waste indicators from the EMS. An analytical framework for evaluating the EMS is developed to elucidate CMT waste indicators and assess these indicators against the principle of proportionality. Assessing against this principle allows for: objective evaluations of whether the environmental measures prescribed in the EMS are 'proportionate' to the 'desired' (subjective) level of protection chosen by decision-makers; and benchmarking CMT waste indicators against aspirational CDW targets set by each Australian jurisdiction included in the audit.

Construed together, the EMS derived waste indicators and benchmark data provide a composite indicator of environmental performance and progress towards SD.

The key audit findings indicate: CMT laboratories have a 'poor' environmental performance (and overall progress towards SD) when EMS waste data are converted into indicator scores and assessed against the principle of proportionality; CMT waste recycling targets are lower when benchmarked against jurisdictional CDW waste recovery targets; and no significant difference in the average quantity of waste diversion away from landfill was observed for laboratories with ISO14001 EMS certification compared to non-ISO14001 certified laboratories.

1. Introduction

The adoption of EMSs amongst CMT laboratories in Australia is substantive however effectively measuring the demonstrable impact of the EMS in reducing environmental harm remains an issue. There is no readily available benchmark for comparing the effectiveness of ISO14001 certified and non-certified EMSs in the extant literature to adequately quantify the environmental impact of refuse created by CMT laboratories in Australia. Benchmarking is a well-established method for measuring business performance. Environment statistics and benchmarking applied to waste practices and (ecologically) sustainable development (SD) is still an emerging field. The problems arising from waste diversion to landfill in Australia are significant and complex (Australian Government, 2010). Some of the social and environmental effects of landfill waste are obvious such as noise, dust and air pollution while other unpredictable effects such as leachate absorption into soil particles are harder to manage (Australian Government, 2010; Baun and Christensen, 2004). Empirical studies of CDW have shown that concentrations of arsenic and chromium were significantly higher in experimental simulated landfill leachate compared to the control simulated landfill leachate (Jambeck et al., 2008). The presence of chromium in CDW in landfill poses a risk to human health through leachate and other forms of release into the environment; the hexavalent form of chromium (CrVI) is toxic by inhalation and has been classified as a Class A inhalation carcinogen (IARC, 1990). Major anthropogenic sources of atmospheric Cr(VI) include CDW (European Commission, 2002;

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Butera et al., 2014) and the production of cement, lime, plaster and concrete as construction inputs (National Pollutant Inventory, 2016). Environmentally speaking, Cr(VI) compounds are generally considered the most toxic (Shanker et al., 2005; Zayed and Terry, 2003; IARC, 1990). From the point of view of toxicity and carcinogenicity, Cr(VI) compounds are of great significance for workers at landfill and construction and demolition sites who handle CDW and are at a greater risk of occupational exposure (Hayes, 1980; Paustenbach et al., 1992).

Soil (as a construction material) must be excavated in preparation for testing which has the potential to negatively impact the environment by increasing the concentration of airborne particles, yet excavated soil is considered 'inert' and is seldom included in CDW studies because it is not considered a major environmental problem (Kartam et al., 2004; Kofoworola and Gheewala, 2009; Myhre, 2000).

1.1. Rationale and aims of the study

In Australia waste data are often difficult and expensive to collect and the estimates based on uncertain or limited data affect the reliability of the outputs (DSEWPaC, 2014). There is a paucity of research on the environmental risks of CDW (disaggregated into specific waste streams) to landfill. The aims of the study are to: address this research gap by contributing reliable disaggregated CMT waste indicators for assessing environmental impact; and develop a systematic framework for analysing the EMS to construe waste indicators for evaluating progress towards SD (DSEWPaC, 2014; Australian Government, 2010);

The study is part of a broader agenda to: promote sustainable development by the adoption and application of the precautionary principle within the important building and construction sector (BCS); develop a future data set of human health risk indicators for CDW; and encourage further research on the social and environmental impacts by the sector and its affiliated operations in Australia.

1.2. The building and construction sector and waste

The BCS contributes significantly to Australia's gross domestic product (GDP). The affiliated businesses that provide important services to the BCS include waste collection, landfill, demolition and construction materials testing; these 'affiliates', clustered together, contribute significantly to Australia's GDP in themselves (Australian Bureau of Statistics, 2012a). The contribution of the BCS to Australia's GDP is accompanied by a negative impact by the sector and its affiliates on the environment. The most recent national waste data show Australia generated 43.8 million tonnes of solid waste in 2006–07. CDW streams generated by the BCS accounted for 38% of the total waste; commercial and industrial waste (CI) accounted for 33% and municipal solid waste (MSW) accounted for 29% of the total (Australian Government, 2010).

1.3. Waste indicators and benchmarking CDW data in Australia

A standardised set of waste indicators and accompanying measures of progress towards SD have not been developed for application to CDW in Australia (Australian Government, 2010). Waste indicators are an important measure of a country's environmental performance and progress towards SD (United Nations Statistics Division, 2014; YCELP, 2014). Waste data do not contribute to countries' global ranking in the Environmental Performance Index (EPI) due to the difficulty in measuring the ecological impact of waste in national accounts (YCELP, 2014). Consequently 'imperfect proxy indicators' often make provision for measuring the environmental and societal impacts of waste (Cherchye and Kuosmanen, 2004). Proxy indicators such as 'progress *towards* recycling targets' (EPA, 2012) used for comparing the benchmark strategies across national jurisdictions are derived from different waste targets and different baseline years as a 'measure of performance' (DSEWPaC, 2014). The subjective nature of proxy indicators limits their application in complex environmental decision-making for properly ('genuinely') accounting for the environment. It has been argued by some authors that genuine progress indicators (GPI) are preferable for use in national accounting as they at least attempt to account for the environmental impact of waste outputs (including generation of CDW and waste to landfill) resulting from sustained growth. (Australian Bureau of Statistics, 2012b; Lawn, 2003, 2006; Dasgupta and Heal, 1974; Daly and Cobb, 1989; El Serafy, 1989; Daly, 1979, 1996).

2. Methodology

2.1. Elucidating CMT waste indicators, CMT waste volume to weight conversion and disposal routes

At the time of the audit there were 647 laboratories accredited by the National Association of Testing Authorities (NATA) to test construction materials in accordance with the relevant standards in Australia (NATA, 2015). The 30 laboratories audited constituted a sample size of 4.6%. The audit data was collected over one year (2013–2014). The audits specifically entailed direct observation of the waste practices at each laboratory during which quantitative (waste volumes) and qualitative (waste composition) CMT data were recorded to characterise CMT waste and construe attendant waste and environmental performance indicators. The volumes of waste received by each laboratory and tested, waste streams generated and waste disposal routes were recorded for a period of 5 h per laboratory representing a total of approximately 150 h of auditing.

The type of EMS adopted by each CMT laboratory (ISO14001 certified, non-ISO14001 certified or no EMS) was recorded and each EMS was reviewed; waste data including waste reduction targets from a baseline year and progress towards achieving waste targets were recorded where indicated in the EMS.

The specific method of data collection comprised of: counting the number of 25 kg sample bags containing soil and scheduled for testing and disposal on the same day; and estimating the volumes of tested material held in waste receptacles that had already been tested that day. Volume to weight conversion factors were applied for estimating the weight of partially filled bags; conversion factors of 1.4 and 1.6 (Victorian Government, 2004) were applied to partially filled bags of hazardous and clean soil respectively. The estimated weights of partially filled bags were summed and rounded to the nearest bag where the weight was less than 25 kg. Other solid wastes including rubble, concrete, asphalt and aggregate were received in receptacles ranging in size from 1 m^3 and above in volume making their weights readily calculable by applying conversion factors of 1.4, 2.4, 0.8 and 1.52 respectively (Victorian Government, 2004). Estimations of volumes of disposed waste (tested refuse) were based on the size of the waste receptacles. A colour coding system was used at many of the laboratories surveyed to determine the waste disposal route of tested refuse. 'Clean fill' (non-hazardous) refuse was held in receptacles of one colour to aid identification and contaminated refuse was held in a receptacle of another colour.

In cases where the composition of the refuse was comingled, such as CDW rubble, the appropriate conversion factor was applied for each component.