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Disaster Solid Waste Management: A review paper

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ABSTRACT

Disaster waste management is one of the most cynical tasks associated with recovery after any disaster. The waste can overcome existing solid waste management facilities and influence on other emergency response and recovery activities. If poorly managed, the waste can have significant public health and the environment impact and can affect the overall recovery process. This paper presents a system outline of disaster waste management based on existing literature. The literature does not specifically address the effect of organisational structures, existing legislation and funding mechanisms on disaster waste management programmes, nor does it decently cover the social effect of disaster waste management programmes. It is realised that the argument presented in this paper, and the literature gaps identified, will form a basis for future full-scale research on disaster waste management. Successively research will lead to better preparedness and response to disaster waste management problems.

Key words : *Waste Composition, Waste Treatment, Disposal and Environment*

Introduction

Disasters take place in many forms, natural or man-made; some natural disaster are ûood, earthquake, tsunami, pandemic, etc. some manmade disasters may be civil conict, drought, civil war with varying degrees and types of physical and social impacts.

Depending on their nature and severity, disasters can create large volumes of debris and waste. According to Reinhart and McCreanor, (1999) in some cases debris volumes from a single event were the equivalent of 5–15 times of the annual waste generation rates of the affected community. Similar proportion were found by Basnayake *et al*, in 2006 following the 2004 Indian Ocean Tsunami. These volumes often affect existing solid waste management facilities and personnel.

The presence of disaster waste impacts almost every aspect of an emergency response and recovery effort by different agencies and organisations.

It has been reported by Chang, (2010) that research studies are often isolated and event specific. Issues of variability between disasters, time limitations and data access difculties all make it difcult for quantitative, cross-disaster studies.

Johnston *et al*., (2009) JEU, (2010) stated that disaster waste usually handled by two options: technical and management.

Technical aspects include collection, identifying temporary storage sites, transportation of debris, storage, recycling, hazardous waste handling and disposal thereof. This paper give out a system outline of disaster waste management based on existing literature. It is presumed that the discussion presented in this paper, and the literature gaps identied, will form a basis for future comprehensive and cohesive research on disaster waste management.

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This review objects to analyse following some aspect of waste management:

Planning of disaster waste

Preferably plans should be developed in advance a disaster event; however, in many cases plans are only formulated after a disaster has struck. These plans give little guidance on decision-making, option to consider and action to be taken in different disaster situations.

Identifying Waste composition and quantity

The nature of disaster waste will not only be dependent on the type of disaster but it will also be greatly dependent on the nature of the built environment being affected. For example the nature of disaster waste produced from masonry houses will vary greatly from an environment with predominantly wooden houses.

The waste streams produced by disasters are Vegetative debris, Sediment, soil, rock, human and animal corpses.

Household hazardous waste such as oils, pesticides, refrigerants etc. Construction and demolition debris from damaged buildings and infrastructure such as roads, pipe networks and other services. Industrial and toxic chemicals i.e. fuel products

Putrescible wastes such as rotting food. Vehicles and vessels. Recyclables such as plastics, metals, etc. Electronic and white goods.

Waste from disaster-disturbed pre-disaster disposal sites as state Pilapitiya *et al.,* (2006); UNDP, 2006; O'Grady, 2009; Sagapolutele, 2009.

Furthermore other waste have identied that can be indirectly generated post-event, including: emergency relief food packaging, Solis *et al.,* 1995 large amounts of health care wastes Petersen, 2004, rotten food from power outages, Luther, 2008 and excessive unwanted donations, Ekici *et al.*, 2009.

On reported by Kobayashi, 1995; Solis *et al.,* 1995; Reinhart and McCrea nor, 1999; USEPA, 2008 that different types of waste are generated depending on both the type of built environment impacted and the type of disaster.

Recently, FEMA launched an incentive programme, by way of increased cost share of any future disaster debris management responses, to encourage municipalities to prepare debris management plans.

Quantity

The quantity, composition and nature of waste will vary based on the type of disaster and the built environment affected. Table 1 shows reported waste volumes from some large scale disasters in the previous disasters

Chen *et al.,* (2007) taken three parameters such as population density, total rainfall and ûooded area for estimation of debris generated from flood. He found a signicant non-linear correlation with these variables which could be used to predict future Food waste volumes. The main component of disaster waste, in most cases, is construction and demolition waste.

Waste management phases

Typically management of disaster waste and disaster management in general is described in the literature in three phases.

Emergency response; debris management to facilitate preservation of life, provision of emergency services, removing immediate public health and

Table 1. Reported waste quantities from previous disasters.

Year	Event	Waste quantities	Data source
2010	Haiti earthquake	Estimated 23–60 million tonnes	Booth (2010)
2009	L'Aquila earthquake, Italy	Estimated 1.5–3 million tonnes	Di.Coma.C. (accessed 2010)
2008	Sichuan earthquake, China	20 million tonnes	Taylor (2008)
2005	Hurricane Katrina, US	76 million cubic metros	Luther (2008)
2004	Hurricanes Frances and Jeanne, Florida, US	3 million cubic metres	Solid Waste Authority (2004)
2004	Indian Ocean Tsunami	10 million cubic metres (Indonesia alone)	Bjerregaard (2009)
2004	Hurricane Charley, US	2 million cubic metres	MSW (2006)
1999	Marmara earthquake, Turkey	13 million tonnes	Baycan (2004)
1995	Great Hanshin-Awaji earthquake, Kobe, Japan		15 million tonnes

Hirayama et al. (2009)

safety hazards such as unstable buildings, etc.

Recovery; debris management as part of restoring lifeline restoration and building demolition.

Rebuild; debris management of wastes generated from and used in re-construction.

The phases are not distinct and the duration of each phase varies signicantly between disasters. Typically, in terms of waste management, the emergency phase involves the removal of immediate threats to public health and safety, Reinhart and McCreanor, 1999 and generally lasts between a few days and two weeks Haas et al., (1977). During this phase there is little scope for recycling and diversion.

The recovery phase is where the majority of the disaster generated waste will be managed. In past disasters this phase has lasted up to 5 years, New Orleans, Hurricane Katrina- Luther, (2008).

Waste treatment options

• ***Temporary staging sites***

As reported by many authors; FEMA, (2007); Jackson, 2008; USEPA, (2008); Johnston *et al.*, 2009; Temporary staging areas for recycling and waste processing are identiûed as an important element as they provide extra time to appropriately sort, recycle and dispose of the waste. However, the expense of double handling of wastes and of acquiring land can be a limiting factor in their use

Most of the disaster waste management guidelines reviewed; (FEMA, 2007; WRCDEMG, 2008) provide guidance on temporary staging site selection

Many elements of disaster waste can be recycled. Materials can be used for in a number of post disaster applications including soil for landll cover, aggregate for concrete, and plant material for compost, Channell *et al.*, 2009). The benefits of recycling disaster debris is shown in many ways.

The benefits include:

Decrement of landll space used.
Decrement of the quantity of raw material used in re-build.
Income from recycled debris.
Decrement in transportation for raw materials and debris.
Job creation in particular for developing countries.

Waste to energy

A potential disaster waste treatment option It is proposed by Yepsen, 2008. He noted that there are limiting factors in using waste to energy as a treatment option in the US. These include high shipping costs, limited markets in the US, certication requirements for international movement of the biomass and FEMA emergency funding regulations which are geared toward lowest cost debris management contracts with no incentives for benecial use.

Land reclamation and engineering ll

Various disaster responses have used land reclamation as a waste management option. Following the Marmara earthquake some municipalities used the debris as levelling for new housing developments and as land protection

Disposal

Luther, (2008) told that standards at existing disposal sites have also been reduced after some disasters to increase available disposal sites for example the expansion of waste disposal criteria at unlined construction and demolition landlls after Hurricane Katrina.

Petersen, (2006); USEPA, (2008) in many large scale disasters, waste volumes exceed permanent disposal site capacities. Temporary or sub-standard debris and waste disposal sites can be employed, as noted in the Baycan, (2004), Pilapitiya et al.in 2006 stated that disposal of hazardous substances has been identied as problematic for example Indian Ocean Tsunami and Hurricane Katrina disasters. Hazardous waste is disposed of in some cases without segregation as part of the overall waste matrix. Aside from the study by Dubey *et al.*, (2007) on arsenic quantities in the waste post. In the case for land reclamation, there are no post-disaster analyses on the actual environmental effects of disaster disposal sites.

Environment

According to UNEP, (2005) b disasters and the environment are inextricably linked. Disasters cause direct physical damage to the environment and inappropriate environmental management and land use can increase the environment's vulnerability to the effects of disaster events. For example, experts believe that the impact of the Indian Ocean Tsunami would have been reduced by proper preservation and management of mangroves and coral reefs as they would have acted as a buffer against the waves

The standard 'peace-time' waste management hierarchy of source reduction, recycling and waste combustion/landlling (USEPA, 1995) a is not always considered possible, particularly when speed of management is a primary objective of the recovery Consequently the focus of a lot of literature on disaster waste management is on the minimising the environmental impact of disaster waste through management options such as recycling, sound disposal and appropriate handling and treatment of hazardous materials.

Economics

An approach to assess the direct costs of various waste management options such as recycling, waste to energy, landll disposal etc. and indirect costs of those options such as slower debris removal, long term environmental degradation, etc. would greatly upgrade disaster waste managers' abilities to respond properly to disasters in the future.

Social Consideration

There is little understanding of the effect of disaster waste management on community recovery and/or the effect of a post-disaster communities' practices on waste management programmes.

First, qualitative and quantitative analysis of the likely public health threats and understanding of waste management options by disaster waste managers will add to the literature. The assessment should consider the public health hazards from the waste matrix, waste management options and from handling the waste. Second, it would be benecial for disaster waste managers to better understand the psychosocial implications of the speed of debris removal process. For example the desire the recover personal belongings Brown *et al.,* 2010a and the emotional attachment owners often have with their properties (Denhart, 2009).

Third, comprehensive guidance on the most effective ways to include communities in post-disaster waste management decision making is missing from the current literature. Waste managers need to recognise that communities can be changed by a disaster

Their expectations, risk tolerance and needs will likely have changed signicantly and so the social relations with the community must also change.

Understanding these factors will enable better planning of disaster waste systems.

Organisation

The organisation structures for any disaster waste management should be the disaster specific and at the same should also suit to the local governance structures. It is matter of further study that how the different organisational structures affect the effectiveness of the waste management programmes and what would be best option to develop a best model to deal with the particular disaster waste management strategy to be the most effective in overall disaster recovery operations.

It is observed that there is no integrated study on the type of organisational models used for disaster waste management programmes. The new approach in this area is required considering the private participation, public participations in integration with local governance structures.

- ***Legal frameworks***

The literature available shows many of examples where legislative frameworks of different countries had become a hurdle in disaster waste management. It is reported by Kobayashi, (1995) that the greater progress in recycling and advanced waste treatment methods have reduced society's ability to cope up with disasters. It is also observed that complex treatment and disposal processes with strict environmental standards are not designed for large acute influx of materials generated by disasters.

- ***Funding***

Funding is context specic like organisational and legal structures. Although, there is value in the analysis of past case studies to identify the success or failure of various funding mechanisms, in particular, the determination of the factors inuencing this result. Again, the authors believe the suitability of funding mechanism may be disaster-specific as much as it is context-specific.

Conclusion

Waste presence in a community also poses a potential public health risk. Organic wastes and standing pools of water caused by debris blocking paths, can become vector breeding grounds. Vector-borne diseases are a common form of communicable disease experienced post-disaster, particularly when there are large numbers of people displaced. However as reported by Watson *et al.,* (2007) the risk of outbreak is relatively low.

Good planning and coordination for response to disaster events is essential to minimise disruption.

There are still signiûcant gaps in our understanding of disaster waste management. In particular, existing literature focuses heavily on technical management aspects of disaster waste management and neglects the institutional organisational, legal and nancial frameworks. Our understanding of the effects of disaster waste management systems, in particular economic and social affects, is also restricted.

It is envisaged that this literature review will form a framework for future comprehensive and cohesive research on disaster waste management. Consecutively, research will generate better preparedness and response to disaster waste management problems.

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