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Disaster waste management in Italy: Analysis of recent case studies

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ABSTRACT

The geomorphology of the Italian territory causes the incidence of many disasters like earthquakes and floods, with the consequent production of large volumes of waste. The management of such huge flows, produced in a very short time, may have a high impact on the whole emergency response. Moreover, historical data related to disaster waste management are often not easily accessible; on the other hand, the availability of data concerning previous events could support the emergency managers, that have to take a decision in a very short time. In this context, the present paper analyses four relevant recent case studies in Italy, dealing with disaster waste management after geologic and hydrologic natural events. Significant differences have been observed in the quantity and types of generated wastes, and, also, in the management approach. Such differences are mainly associated with the kind of disaster (i.e. earthquake vs. flood), to the geographical location (i.e. internal vs. coastal area), to the urbanisation level (i.e. industrial vs. urban). The study allowed the identification of both strengths and weaknesses of the applied waste management strategies, that represent "lessons to learn" for future scenarios. Even though it deals with Italian case studies, this manuscript may have a high impact also at international level, making available for the first-time emergency waste management data, that are considered an indispensable support for decision makers.

1. Introduction

In 2015, Italian population, about 60 million people, produced approximately 30 million tonnes of municipal solid waste (MSW), corresponding to an average value of 1.3 kg/capita for day. In peacetime, waste management includes collection, transport, recovery, recycling and disposal. In emergency scenario after a natural disaster (e.g. earthquake, flood, storm, any other extreme natural event), the authorities must deal with abnormal quantities of debris and waste. In such circumstances, it is impossible to apply the ordinary waste management methods. Emergency management is entrusted to the National Civil Protection Department. This assignment is necessary to apply a specific protocol for an appropriate disaster waste management (DWM) response. Even though many events have occurred in the Italian territory, the Authorities have not yet developed a specific protocol to manage waste and debris in the post-disaster scenario. The lack of standards, let to an empirical management, in order to treat the largest waste quantity in the shortest period to restore initial (pre-disaster) conditions. At a worldwide level, the most relevant standard guidelines were produced by the Federal Emergency Management Agency in the US (FEMA, 2007), the Ministry of Environment in Japan (Ministry of the Environment Japan, 2011) and the United Nations (UNEP/OCHA-MSB, 2011). An additional example is that of Malaysian authorities, that defined guidelines for DWM after the many hydro-geological disasters, caused by heavy rainfall during the monsoon season (Zawawi et al., 2015). These documents report detailed information relevant to several kinds of emergency scenarios, focusing on specific areas. However, even if some strategies could be applied also in the Italian territory, the geomorphological, legal and socio-cultural differences of countries, make very difficult the drafting of a standard protocol, appropriate for all countries in the world. The definition of a guideline for the DWM should be a priority for every country in order to plan the best choices in peace time and to be prompt in the response during the emergency. In this regard, a depth study of the historical case studies represents the starting point for the identification of

Abbreviations: FEMA, Federal Emergency Management Agency; DWM, Disaster Waste Management; MSW, Municipal Solid Waste; C&D, Construction and Demolition; WEEE, Waste Electrical & Electronic Equipment; GEJE, Great East Japan Earthquake; WTE, Waste to Energy; TDSRS, Temporary Debris Storage and Reduction Site; EWC, European Waste Catalogue.

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strength and weaknesses of a specific area, and to acquire "lessons to learn", for future decisions.

As concerns the Italian territory, the scientific material relating to natural disasters (Table 1) usually focuses on either the socio-cultural aspects (e.g. human reactions) or the technical aspects (e.g. magnitude, geophysical analysis); more rarely it considers the issue of DWM. On the other hand, the waste management after a natural disaster is a very hot topic, that in the recent years has created some difficulties within the emergency management. In this context, the present paper is addressed at analysing data dealing with the waste management under emergency, for four relevant case studies in Italy. The first aim of the manuscript is to make available data that in some cases are not public, in order to improve the scientific literature, that mainly deals with Asian events. Indeed, numerous scientific studies concern the DWM after the Great East Japan Earthquake 2011 (Brown and Milke, 2016; ENDOH, 2016; Ide, 2016; Ministry of the Environment Japan, 2014, 2011; Sasao, 2016; Shibata et al., 2012; Tasaki et al., 2012; The World Bank, 2014), the Wenchuan earthquake 2008 in China (Hu and Sheu, 2013; Xiao et al., 2012), the Malaysian floods (Agamuthu et al., 2015; Yusof et al., 2016; Zawawi et al., 2016, 2015), the four typhoons Nari 2001, Toraji 2001, Mindulle 2004 and Aere 2004 analysed by (Chen et al., 2007), the Marmara earthquake 1999 in Turkey (Baycan, 2004; Herdem, 2011). Furthermore, also Hurricane Katrina 2005, has been extensively studied in terms of DWM (Brown, 2011; Brown and Milke, 2016; May et al., 2006) and the Canterbury and Christchurch earthquakes 2010/2011 in New Zealand (Brown and Milke, 2016; Potter et al., 2015). As concerns the Italian case studies presented in this manuscript, the problem about DWM of L'Aquila earthquake 2009 has been discussed in the literature (Brown et al., 2010; Brown and Milke, 2016), however with no details on the specific data; also, DWM within the Emilia earthquake 2012 was studied targeting a LCA study (Daria et al., 2013), but, also in this case, the data dealing with waste production after the disaster have been poorly addressed. As concerns the DWM after the two Italian floods presented in this work (i.e. Senigallia 2014 and Genova 2014), they have not been addressed in the literature. Such four case studies were selected to understand how the competent authorities have handled the debris generated by natural events, such as earthquakes and floods. With this aim, it was necessary to process all the documents and reports that have been issued for the different emergencies. The survey also involved the regulatory and legislative aspect: indeed, all ordinances and legal provisions issued for disasters have been considered. The data reported here, even if dealing only with the Italian territory, are considered important also for an international audience, as potential support for decision makers under emergency conditions.

2. The Italian case studies

As shown in Figs. 1 and 2, the geomorphology of Italy makes it susceptible to natural disasters, such as geophysical (e.g. earthquakes) and hydrogeological events (e.g. floods, landslides). The history reports many significant episodes of earthquake that hit different geographical areas of the country, with variable effects; for example, only considering the last fifty years, the events in Sicily (January 1968), Friuli-Venezia Giulia (May 1976), Campania (November 1980), Molise (October 2002), Umbria, Lazio and Marche (August 2016). Furthermore, hydrogeological events occurred during different seasons, involving several Italian places like: Vajont (October 1963), Stava Valley (July 1985), Piemonte region (November 1994), Versilia (June 1996), Messina (October 2009). As concerns the relatively high frequency of earthquakes, the reason is in the geographical location of Italy, involved in the collision of the Eurasian and African tectonic plate (Wortel, 2000). On the other hand, the phenomena related to hydrological instability (landslides and floods) are connected both to physical reasons (the geological, morphological and hydrographic of the area) and to the strong urbanisation of the 50 s. Indeed, the increase of population in the city areas caused an inadequate planning of land use, sometimes illegal, with the building of several

Table 1
Scientific literature related to the two most frequent Italian extreme natural events.

Event	Keywords	Article
Geophysical	L'Aquila Earthquake, Italian Government Policy, Disaster Response	(Alexander, 2010)
	Seismic Events, Emergency Management, Civil Protection, Damage, Losses, Economic Impact	(Dolce and Di Bucci, 2015)
	Reconstruction, Construction and Demolition, Waste, Debris, Recycling, Earthquake	(Furcas et al., 2012)
	Vulnerability Curves, Damage Data, Italian Building Stock, Loss Estimation, Analytical Methods	(Colombi et al., 2008)
	Magnitude Determination, Italian Earthquake Catalogue	(Castello et al., 2007)
	Fragility Curves, Italian Earthquake, Damage Data	(Rota et al., 2006)
	Waste Management, Disaster Recovery, L'Aquila Earthquake, Disaster Management	(Brown et al., 2010)
	Debris Management System, L'Aquila Earthquake, Waste, Environmental Protection, Public Safety	(Durastante and Persia, 2013)
	Earthquake Damage, Reconstruction, Public Grant, Repair and Strengthening, Costs, RC And Masonry Buildings	(Di Ludovico et al., 2016)
	Emilia Earthquake, Infilled RC Buildings, Damage States, Non-Structural Damage, Fast Method	(Manfredi et al., 2014)
	Natural Disasters, Earthquake, Psychological Distress, PTSD	(Bland et al., 2005)
	Displacement, Environmental Disaster, L'Aquila, Migration, Migration System, Vulnerability	(Ambrosetti and Petrillo, 2016)
	Expected Loss, Insurance Premium, Resilience, Risk Aversion, Seismic Hazard, Structural Fragility	(Asprone et al., 2013)
	Consumption, Liquidity, Mortgage, Public Transfers and Quasi-Exp.	(Acconcia et al., 2015)
Hydro-geological	Landslide Susceptibility Map, Geographic Information Systems (GIS), Grass, Shell Script, Northern Italian Apennines	(Clerici et al., 2006)
	Landslide, Inventory, Quality Index, Natural Hazards, GIS, Italy	(Trigila et al., 2010)
	Great Landslide Events, Italian Artificial Reservoirs	(Panizzo et al., 2005)
	Landslide Risk Policy, Policy Change, Drivers of Change, Transformation, Advocacy Coalitions, Epistemic Communities	(Scolobig et al., 2014)
	Distribution, Fractals, Landslides, Marche-Umbria Italy, Power Law	(Guzzetti et al., 2002)
	Historical Catalogue, Italy, Landslide Frequency, Mortality Rates	(Guzzetti, 2000)
	Debris Flows, Pyroclastic Soils, Rainfall, Southern Italy	(Fiorillo et al., 2001)
	Flood and Landslide Damage, Risk Index, Italian Regions	(Messeri et al., 2015)
	Extreme Precipitation Events, Flash Flood, L-Moments, Radar Rainfall Estimation, Precipitation Return Time	(Norbiato et al., 2007)
	Hydro-Meteorological Analysis, Flash Flood, Eastern Italian Alps	(Borga et al., 2007)
	Peritraumatic Dissociation, Posttraumatic Symptoms, PTSD	(Craparo et al., 2014)
	Flash Floods, Magra River Basin (Italy), Multicellular Thunderstorm	(Sacchi, 2012)
	Cross-Cultural Analysis, Natural Disaster Response, Northwest Italy Floods, US Midwest Floods	(Marincioni, 2001)

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