



Environmental Services for Health Protection in Disasters and Emergencies



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National Institute of Disaster Management
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FOREWORD

Disasters are the most prominent catastrophes which severely hinder the growth and pace of development of a country. Climate-related disasters in the South Asian region are becoming more frequent, destructive, and costlier in terms of both economic and social impacts. Interestingly, the rate of mortality associated with such disasters has been considerably reduced in the current era, even though the number of people reportedly affected has been increased enormously. Although, India has been rapidly urbanizing, its state of health, well-being, and infrastructure capacity are in a period of transformation.



This paper focuses on understanding the main environmental services essential for risk management in event of such disasters and emergencies. Vector-borne diseases such as Malaria, diarrhea, dengue and malnutrition are major public health problems post disasters. Disasters often hamper the basic services like water supply, sanitation etc. which can have major health impacts on affected population and also cause other worries in disaster scenarios. With the projected increase in disasters in coming years it is important to lay focus on enhancing the capacity of these services to reduce the impact on livelihoods, human lives as well as infrastructure in the country.

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PREFACE

India faces high exposure to climate-related disasters, and is one of the most vulnerable countries in the world to extreme weather events in the world. The global economic losses due to natural disasters have increased over time, and are likely to increase in the foreseeable future, especially in the developing countries like India. This is due to the influence of three factors: bio-physical drivers, exposure and vulnerability. Vulnerability of populations is often increased when adequate attention is not given towards bettering the subset facilities and activities required to ensure good health and well being post disaster events.



Disasters often causes emergency situations, clear reduction in the abilities of people to sustain their normal living conditions, which result in damage to health, life and livelihoods. The environmental health problems arising from emergencies and disasters are connected to their effects on the physical, biological and social environment that pose a threat to human health, well-being and survival: shelter, water, sanitation, disease vectors, pollution, etc.

There is a need to prioritize the essential aspects of environmental health management in disasters. These included the provision of emergency water and sanitation services; the burial or cremation of the dead; vector and pest control; food hygiene; and the assessment of the danger of epidemics following emergencies and disasters, etc. This paper highlights these aspects and provides strategize for enhancing their resilience.

(Prof. Anil K Gupta)

Environmental Services for Health Protection in Disasters and Emergencies

ABSTRACT

Emergencies and disasters can occur anywhere in the world, affecting human health, people's lives and the infrastructure built to support them. Disaster management requires a continuous chain of activities that includes hazard prevention, preparedness, emergency response, relief and recovery, including activities to reconstruct infrastructure and rehabilitate shattered lives and livelihoods. Within each phase of the disaster-management cycle, short-range goals can simultaneously contribute to long-range ones. During “normal” times, development activities should aim to reduce the vulnerability of people and infrastructure to future emergencies and disasters. The concept of integration is central to current thinking and practices of disaster management. Disasters cause serious environmental health problems and burden on general waste collection processes. Environmental health problems arising from emergencies and disasters are connected to their effects on the physical, biological and social environment that pose a threat to human health, well-being and survival: shelter, water, sanitation, disease vectors, pollution, etc. Waste management has also emerged as a critical issue in responding to a disaster. Strategies, issues and challenges to cope up with the disaster generated waste are varying with the type of disaster, magnitude, location, country etc. Further, poor implementation of prevailing rules and regulations; poor standards of local expertise and capacities, inadequate funds, lack of communication and coordination are the key issues to be addressed.

Keywords: Disasters, Environmental health, Disaster waste, DRR, Public Health

I. Introduction

The natural environment is blessing to the mankind with the countless benefits, be it food water, medicine and many more. Despite the countless benefits we receive from nature, we often forget the importance of preserving it. The natural environment has been threatened by several manmade phenomena like deforestation, mining activities, industrialisation etc. These activities induce climate change, which in turn has resulted in numerous tragic disasters such as floods, landslides and earthquakes. Such events often take place on a massive scale, consequently claiming the lives of hundreds of millions of people and leaving a country in severe economic distress (EM DAT, 2019). On higher priority people should understand the evident cycle of disasters is going to continue if the natural environment is subject to continuous threat. It is very important to understand the vulnerability of our planet for various disasters, as a result of many years of exploitation and human negligence.

The World Health Organization (WHO) describes disaster as an occurrence of an event that cause damage to human lives, cattles, destruction to health services and economy of any region. Disasters are usually sudden and extreme and are exacerbated by human activity. For example, flooding in Uttrakhand was amplified and worsened due to rampant construction at riverside in absence of effective building regulations and hydropower policy in the state in 2013 (Dash et al., 2019). Extreme events create stress in human life and properties because the forces involved are greater than those with which the systems and structures normally cope because most of the houses are capable to withstand some wind, but beyond a certain wind speed all will fail.

The WHO recorded 1200 outbreaks in 168 countries during the period 2012-2017, taking into account new or reappearing infectious diseases (WHO, 2019). Emergencies and disasters are major threats to health care systems. From 2001 to 2018, over 5000 water-related disasters (WRDs) occurred globally, accounting for 73.9% of all-natural disasters. In total, WRDs (i.e., floods, storms, landslides, and droughts) caused over 300,000 fatalities and approximately 1.7 trillion USD in economic damages worldwide. Floods and droughts had significant economic repercussions in recent history. In the 20th century, an estimated 365 billion USD was lost worldwide due to approximately 2100 floods and 430 droughts. The 21st century thus far has experienced a higher frequency of WRDs and their associated consequences: from 2001 to 2018, about 600 billion USD was lost globally due to over 2900 flood or 290 drought events. These events have also had disastrous health impacts on 2.8 billion people. For instance, nearly 300,000 people suffered from flood-related physical injuries during 2001-2018 (EM DAT, 2019).

Disasters often causes emergency situations, clear reduction in the abilities of people to sustain their normal living conditions, which result in damage to health, life and livelihoods. Evacuation from the disaster site to avoid loss from a disaster can cause

disruption of normal life. Sudden and large-scale movements of people within and between countries often produce emergency conditions. Dramatic loss of livelihoods and increased spending needs due to drought or flooding may place people in a very vulnerable situation. During an emergency, primary effects of the disaster is followed by secondary effects. For instance, the primary effect of a mudslide might be that many people are injured and need urgent medical attention. A secondary effect might be that blocked sewers and broken water mains lead to an outbreak of water and sanitation related disease some weeks later. Human needs for non-material things, such as security and cultural identity can also be affected, and the psychological and social impacts of a disaster may be felt many years after the event.

Disasters causes serious damages to the natural environment by creating large amount of waste (Hayes et al., 2021; Marchesini et.al., 2021) which underpins human survival, yet we largely fail to account for the loss of services from the damaged environmental when it comes to accounting for disaster related costs. Disasters can generate large quantities of solid and liquid waste such as construction and demolition debris, hazardous chemicals, and unconsolidated sediment that threaten public health, hinder reconstruction and impact the environment (Zhang et al., 2019). Disaster waste can be generated by the actual disaster and later during the response and recovery phases. Public health risks can arise from: direct contact with waste accumulated in the streets, hazardous wastes such as asbestos, pesticides, oils and solvents, and indirectly from vectors such as flies and rodents, and from post disaster collapse of unstable structures. Environmental impacts, which are closely associated with human impacts, can include waterways, agricultural areas and communities contaminated by chemicals and heavy metals. Physical obstruction of waterways can also occur. The waste can disturbed existing solid waste management facilities and impact on other emergency response and recovery activities. If poorly managed, the waste can have significant environmental and public health impacts and can affect the overall recovery process (Alabi et al., 2019).

Therefore disposal of hazardous chemicals must be handled with care and proper planning, unconsolidated material can cover large areas and cause direct and indirect impacts by disrupting transport services, water supply, waste water, and electricity services (Wilson et al., 2014) and health issues such as respiratory, skin, and eye irritations. Therefore, disaster waste management by safe handling and removal is a critical aspect of response and recovery activities (Zhang et al., 2019). In most of the cases, disaster waste puts more burdens on communities already struggling to cope with catastrophe. Sometimes, it also presents opportunities as it may contain valuable material such as concrete, steel, and timber as well as organics for composting. This value can be realized as either a source of income or as a reconstruction material, and reduce burdens on natural resources. Effective approaches can reduce disaster waste risks to human life and health and produces opportunities from the waste to support

recovery and development outcomes. Unfortunately, current management practices are not good enough to manage waste properly as it involves either no action, in which the waste is left to accumulate and decompose, or improper action, in which the waste is removed and dumped in an uncontrolled manner. In the latter case, improper dumping may create long-term environmental problems that affect the community or occur on economically significant land and require the waste to be moved again, creating additional costs.

Rapid removal and treatment of waste generated during any emergency is essential for the rapid recovery and reconstruction of the affected area. However, the environmental burden of disaster waste management efforts should not be overlooked even in disaster situations. Disaster waste management should be systematized as an integrated system wherein disaster waste management processes flow from generation to treatment. Life cycle thinking effectively makes sense of each stage of disaster waste management. Disaster waste prevention also might effectively reduce the environmental burden.

2. Essential Services after Disasters for Effective Disaster Management

2.1 Shelter Management

The survival of affected people after disasters is one of the key concerns for any region or country. Availability of evacuation shelters and food, water and medicines are the necessary services, require after disaster. Local governments generally designate community centres, school and gyms as shelters during emergencies (AIDR, 2017; LRG, 2018; Bendito et al., 2019) These temporarily designated shelters have insufficient capacity to accommodate evacuees. Therefore, people often evacuate to undesignated shelters (Yabe et al., 2016; Nishigami et al., 2017) and these undesignated shelters often do not receive a sufficient amount of relief goods, compared to the designated shelters (Araki et al., 2017). In undesignated shelters, people are expected to provide the relief goods essential for survival by themselves.

In disaster situations it is essential that the victims are categorised on priority. Therefore; a place must be considered for keeping victims and doing triage (Koukopoulos et al., 2021). Well-equipped ambulances should also be used to move the victims because improper transfer can cause more injuries. Sufficient capacity for airlifting should be provided. It should be noted that the victims should be conveyed to the healthcare centres based on the type of the injury not transferring all of them to the nearest centre. Lack of systematic monitoring for the victims' transfer is a major problems faced during emergencies.

Box 1. Use of public venues as shelters in COVID-19 health disaster

Since the COVID-19 outbreak, Wuhan adopted three methods of admitting patients for treatment: designated hospitals, newly built temporary hospitals and Fangcang shelter hospitals. It has been proven that converting large-scale public venues such as stadiums and exhibition centres into Fangcang shelter hospitals, which serve as hospitals for isolation, treatment and disease monitoring of patients with mild symptoms, were the most effective way to control virus transmission and reduce mortality (Sood et al., 2020).

The Fangcang shelter hospitals in China were large-scale, temporary hospitals, rapidly built by converting existing public venues, such as stadiums and exhibition centres, into health-care facilities. Fangcang shelter hospitals had three characteristics including rapid construction, massive scale and low cost of building and running that made them particularly well suited to address public health emergencies.

The Fangcang shelter hospitals played five major functions for combating COVID 19. These were - isolation, triage, basic medical care, frequent monitoring and rapid referral and essential living and social engagement (Chen et al., 2020). Early descriptive evidence suggests that the Fangcang shelter hospitals were a major reason for the successful COVID-19 control in China. The number of confirmed cases in Wuhan steadily declined from Feb 18, 2020, 12 days after the first Fangcang shelter hospitals started admitting patients.

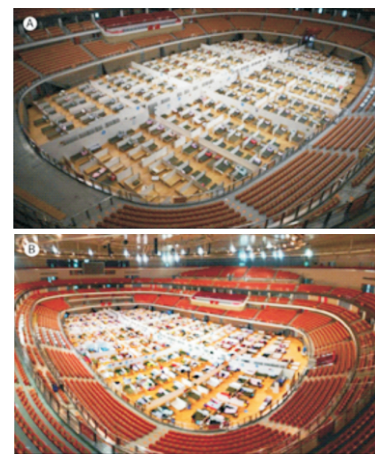


Figure 1: Illustration of Rapid Built Shelter Hospital

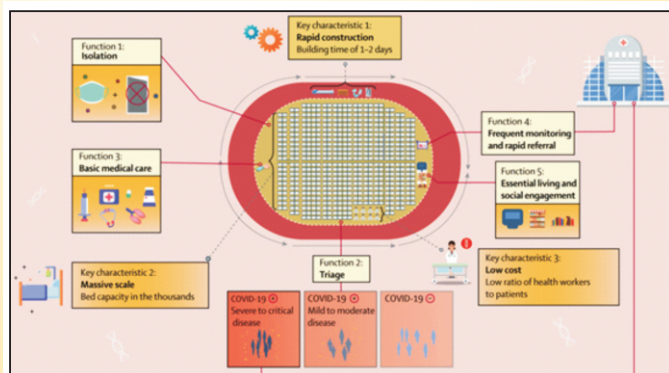


Figure 2: Key characteristics and essential functions of shelter hospitals

2.2 Medical facilities

Health care management in disasters is one of the main parts of disaster management. Health in disasters is affected by performance of various sectors, and has an interactive impact on various aspects of disaster management. Currently, coronavirus disease 2019 (COVID-19) is at the centre of a recent emergency situation that requires increased attention from health care professionals, including pharmacists.

The staff of emergency medical services plays an important role in providing emergency services immediately after disasters, and then delivering these services in the field hospitals as well as improving health level of the public. The staff of emergency medical services should train other people in terms of preparation for emergencies and disasters. The level of preparedness of emergency medical services personnel can minimizing the damage caused by disasters. Disaster can easily disrupt the food and drinking water supply at any time, which is very important to maintain in emergency situations.

2.3 Telemedicine system

When a disaster hit a remote area it is tough to provide medical and other essential services as in remote areas roads are closed due to disaster. In this type of emergencies telemedicine system play an important role and it involves telecommunications for doctors to see their patients in a virtual manner, through live video or still images captured and saved for their reference on a computer. Medical centers should be equipped with the latest technologies for a faster response to the disaster. Technology will increase the efficiency of governments in improving public healthcare services.

2.4 Mental health and psychological support

Lack of employment; homelessness, environmental destruction, loss of family, death of kins and disorganisation due to disaster make people psychologically weak. Therefore, post disaster psychological support should be made available based on the needs (Makwana, 2019). However, psychosocial support is mentioned in the Sendai Framework for disaster risk reduction and identified among functions in the WHO health emergencies and disaster risk management framework (HEDRMF, 2019) implementation of proactive mental health and psychological support have been limited globally. To provide psychological support, a team consisting of psychologists, psychiatrists, social workers, and specialists of neuroscience should be present in the affected area. All rescuers should also be familiar with the techniques of psychological and emotional support for various affected groups including women, children, and the elderly people because the various groups express different emotional reactions to the disaster. If psychological support programs are limited to the time of a disaster, the states such as fear, anxiety, isolationism, and other mental illnesses may persist long after the disaster. One of the proposed solutions is planning for continued psychological

supports until the victims return to a psychological balance by establishing psychological support centres. Mental health in disasters is a matter of concern (Huremovic, 2019; WHO, 2018).

2.5 Human resources management

To minimize the damage and the suffering the disasters, it is important to maximally mobilize all human resources to cope with difficult situations (Samsuddin et al., 2018). When a disaster hit any region, various groups including medical and nursing students, public and organizational forces came to the region with charitable purposes to provide assistance. The presence of these groups in the effected region made a chaos in the region as this presence was without coordination and without considering the actual needs of the region. Sometimes, specialties were required to deal with the problems as the ordinary people or a first-grade medical student could not manage those problems. Therefore a training programme was needed to provide the proper assistance relief.

2.6 Nutrition Management

In the early days of the disaster, canned foods are often given to the victims but in the following days prepared, foods such as beans, rice etc. should be provided (Ainehvand et al., 2019) with the help of nutrition expert. Experts can help in determining the specific diets in times of a disaster, and using health professionals to monitor closely the sites of food and drinking water in terms of preparation, distribution, and storage during the disaster are so crucial.

2.7 Inter-organizational coordination

One of the causes of chaos in the disaster affected region can be mismanagement of healthcare rescuers as they are undetectable from ordinary people. Many caregiver physicians and nurses in the affected area did not have an identification card or special clothing to be identified from other people. To maintain public health and provide healthcare services, in addition to care providing organizations, other organizations are also responsible. It seems that providing security by the police force, supplying healthy drinking water by water and wastewater organization, collecting bodies by municipality, opening the roads for easy transportation of the victims by the Department of Road and Transportation, etc. Lack of coordination among these bodies will cause delay in responding (Opdyke et al., 2017; Jung et al., 2019)

3. Environmental interventions for preventing Disaster related diseases

Various infectious diseases spread during disasters for e.g. the most common health problem in a flood is the transmission of diseases via water and during an earthquake, infections are usually transmitted due to the collapse. Therefore, construction of prefabricated toilets and wastewater disposal control are important parts of the environmental health. Filled wastewater wells constructed for toilets and being flowed in the camps, the accumulation of garbage in the city and not collecting them are some environmental pollution factors.

3.1 Water supply

Water-supply problems arise in all phases of the disaster-management cycle. As with all other elements of emergency management, water supplies can be designed and maintained in ways that help to reduce the health impacts of disasters. It is useful to distinguish between large-scale, formal water-supply systems (e.g. urban water-supply systems) and small-scale, scattered supplies. The distinction is not so much between urban and rural areas, as one based on the level of technology and the institutional arrangements for management, maintenance, and protection. Whether the affected systems are rural or urban, sanitation surveys may be necessary to identify the main health hazards (World Health Organization, 2018).

Water sources are exposed to a variety of hazards that may damage or contaminate them, but they can be protected against disasters to some extent. This section is concerned mainly with ways in which improvements to existing water supplies can make them more resistant to damage.

Box 2. Water Supply Issues post Floods

Generally, domestic water supply is treated and clean before distributed for human consumption. The hygienic of water supply during flood events is difficult to achieve if there is no systematic management to ensure the clean water is distributed continuously especially in flood evacuation centers. This possibly due to the water need for domestic uses such as washing, bathing, drinking, cooking in flood evacuation centers by the effected victims. Flood disaster not only deteriorate the economy of the flood victims, but it also pose a negative impact on water resources. Some negative effects of the floods are damaging agricultural production, livestock, infrastructure facilities as roads, bridges, irrigation systems, flood control structures and loss of life as well as water supply. (Paterson et al., 2018; Safapour, 2020) There are five main impact of floods on water supply system namely

- (i) destruction of the whole or part of the river water intake,
- (ii) damage to the water pumping station,
- (iii) blocked components due to sediment deposition,
- (iv) loss of water intake area due to changes in the flow of rivers and streams, and
- (v) pollute or reduce the availability of groundwater

Flood Event	Issues of Water Supply	Source
Bangkok, Thailand, 2011	• Waterborne diseases outbreaks • Disruption of water treatment facilities • Contamination of water supply	Molla et al., 2016
Bhuapur, Bangladesh, 2007	• Drinking water sources are often contaminated • Damage to water supply infrastructure • Loss of safe water accessibility • Scarcity of portable water	Hossain et al., 2014
Darbhanga District, Bihar, India, 2016	• Contaminated the local water supply • Waterborne diseases outbreak	Kumar et al., 2016
Isoko South, Nigeria, 2012	• Waterborne diseases outbreak	Ubachukwu et al., 2017
Johor, 2006/2007	• Contaminated water bodies with high conductivity and suspended solids • Outbreak of Leptospirosis disease	See et al., 2012 Hashim et al., 2010

Flood Event	Issues of Water Supply	Source
Kelantan, Malaysia 2014	Contaminated water sources - high sediment content in water	Shaharudin et al., 2017
Kota Bharu, Kelantan, Malaysia 2010/2011	Waterborne diseases outbreak	Ali Khan et al., 2014
Malaysia, 2004-2012	- Contaminated water bodies - Damage the water and sanitation networks - Contaminated safe drinking water - Waterborne disease - Leptospirosis outbreak	Ali Khan et al., 2014

3.2 Food safety

Food may become difficult to obtain in an emergency or following a disaster. Crops may be destroyed in the fields, animals may be drowned, food supply lines may become disrupted, and people may be forced to flee to areas where they have no access to food. Moreover, the safety of whatever food there is may be affected, resulting in a greater risk of epidemics of food borne disease.

Food safety problems vary in nature, severity and extent, and depend on the situation during the emergency or disaster. For example, during floods and hurricanes, food may become contaminated by surface water that has itself been contaminated by sewage and waste waters. Flood waters often pick up large quantities of wastes and pathogenic bacteria from farms, sewer systems, latrines and septic tanks. The crowding of survivors after disasters may aggravate the situation, particularly if sanitary conditions are poor.

Any breakdown in vital services, such as water supply or electricity, also severely affects food safety. In the absence of electricity, cold storage may be more difficult, if not impossible, and foods may be subject to bacterial growth. This may happen at all stages of the food chain, from production to consumption. Lack of safe drinking-water and sanitation hampers the hygienic preparation of food and increases the risk of food contamination.

Populations of pests and stray animals, such as dogs and cats, may also increase in the aftermath of disasters. Flies and other rapidly-breeding insects may increase dramatically in numbers. People may be tempted to eat drowned animals after floods, which carries a risk. Food is especially susceptible to contamination when it is stored and prepared out of doors or in damaged homes where windows and possibly even walls are no longer intact.

Disaster-affected people eating food from centralized kitchens that are not properly equipped or run are extremely vulnerable to outbreaks of foodborne disease. The combination of environmental contamination and improper handling of food increases the risk of epidemics of diseases such as cholera and shigellosis (Conforti et al., 2018).

3.3 Control of communicable diseases and prevention of epidemics

The five most common causes of death in emergencies and disasters are diarrhoea, acute respiratory infection, measles, malnutrition and, in endemic zones, malaria. All except malnutrition are communicable diseases directly related to environmental health conditions, and even malnutrition is greatly exacerbated by communicable disease.

Disaster-affected people are particularly vulnerable to communicable diseases when the disaster and its immediate consequences reduce resistance to disease because of malnutrition, stress, fatigue, etc. and when post-disaster living conditions are unsanitary.

The control of communicable diseases depends on a healthy environment (clean water, adequate sanitation, vector control, shelter), immunization, and health workers trained in early diagnosis and treatment. Thanks to effective environmental health measures, epidemics following disasters are no longer common. Exceptions are the epidemics occurring in chronic emergencies triggered by drought and civil strife, such as those that occurred in Africa in the 1980s and 1990s, and the epidemics of communicable diseases that have swept refugee camps in Africa and other parts of the world. Functioning disease surveillance systems and intact environmental health services are crucial in protecting public health and in responding to these outbreaks when they occur in times of disaster.

The conditions leading to an epidemic are caused mostly by secondary effects and not by the primary hazard, except in the case of flooding, which can cause an increase in waterborne and vector-borne diseases. Other hazards may leave standing water or pollute, or interrupt drinking-water supplies. High winds, coastal storms, mud slides and even earthquakes can all result in standing water, especially where a “cascade” of physical effects occurs. For instance, in the Andes it is not uncommon for a volcanic eruption to melt ice and snow, creating floods, mud flows and rock falls.

Box 3. Epidemic cholera in refugee camps (Monje et al., 2020)

Cholera can spread very quickly in overcrowded living areas. If an epidemic breaks out:

Control

- An emergency treatment facility should be established.
- Apart from patients, people visiting the facility should be limited to those giving care.
- Stored drinking-water should be purified with at least 0.2mg per litre of free residual chlorine.
- Sodium hypochlorite or calcium hypochlorite should be added to water at the following chlorine concentrations:
 - ❖ 0.05% (0.5 g per litre) for washing;
 - ❖ 0.2% (2 g per litre) for cleaning walls and floors;
 - ❖ 1% (10 g per litre) for disinfecting contaminated bedding and clothes, and for cleaning latrines.

Public-health measures

- Treat wells in the affected area; cover them if possible. Appoint someone to treat each collected bucket of water with sodium hypochlorite or calcium hypochlorite. Ideally this should be done at every well when the water is collected.
- Health workers should regularly visit households to detect cases.
- Gatherings of people should be restricted.
- Carry out precautionary measures to reduce contamination of food sold in markets.
- Test samples of water for the presence of *Escherichia coli*. This indicates faecal pollution and the possible presence of bacteria that cause diarrhoea.
- Send stool samples for laboratory testing, if possible, to confirm the presence of cholera.
- Good record keeping (number of cases and deaths) at clinics and treatment centres will help in assessing whether the epidemic is getting worse, or whether public-health measures are having a positive effect.
- Use patient records to plot outbreaks on a map of the camp.
- Disinfect homes of patients if resources are available.

3.4 Handling the Dead

Early identification of corpses helps to preserve the mental health of the bereaved. Anxiety and uncertainty are replaced by grief, and the process of acceptance of death begins. Prompt identification and disposal ensure that families and friends are not exposed to the offensive by-products of bodily decay.

The identification of dead bodies can be difficult when there are many of them: 1000 unidentified bodies require over 2000 square metres of space to display adequately, and a person walking between the rows of bodies may have to walk some 800 metres. When bodies decay rapidly, handling and identification become very unpleasant, so that it is sometimes preferable to bury the bodies quickly, and to carry out identification later, after disinterment, using forensic anthropological techniques. Rapid burial is not recommended, however, if facilities for conserving bodies, e.g. ice, electricity and embalming fluids, are readily available.

The identification of bodies by people other than family or friends can be a very lengthy process. If the disaster has taken place in an area where people usually carry some form of identification (i.e. credit cards, identity cards, driving licences), a professional team can process 100 bodies per hour. In parts of the world where such items are not carried, the process can obviously take much longer, and rapid burial should therefore be considered.

Although burial is a quick and economical method of body disposal, alternatives can be used if they are more acceptable culturally, and if resources (including time) are available. Such alternatives include cremation, embalming, and certain types of ritual display of the dead. It may be useful to take tissue samples from the deceased for identification purposes. The samples can later be compared with samples from surviving relatives.

4. Waste Management after Disasters

As mentioned earlier, the increasing incidence and severity of disasters such as hurricanes, floods and landslides are leaving more people vulnerable each year, mainly the poor ones. Climate change is increasing the frequency and intensity of these climate-related hazards, leading to a higher number of deaths and injuries as well as increased property and economic losses. Disasters not only damage environment and loss of human life but also add-on large amount of waste.

The waste produced by disaster comes in all shapes, scales, and degrees of danger. For example in 2016 Kumamoto earthquakes of Japan about 2.89 million tons of debris was generated as shown in Figure 3. (Sakai et al., 2019) But this is very much less than the waste spawned by Hurricanes Katrina and Rita along the Gulf Coast where more than 100 million cubic yards of waste was generated. For Sandy, the NYC Department of Parks and Department of Sanitation opened up Jacob Riis Park as a temporary “short dump,” a short-term staging location for moving waste to immediately before deciding how to handle the waste in the long term.



Figure 3. Debris from building collapse after Kumamoto earthquakes in Japan
(Source *The Economist* April 23 2016)

The ongoing coronavirus disease 2019 (COVID-19) pandemic that began in December 2019 is continue to create panic among people around the world (Gorbalenya et al., 2020) (Sood et al., 2020). The Huanan seafood market in Wuhan, China, was primarily believed to be the origin of this virus (Chan et al., 2020). It was primarily spread in Wuhan, China in December 2019 and resulting in current pandemics (Dzigbede et al., 2020). On 11 March 2020, the World Health Organization (WHO) has announced a global health emergency and declared an infectious disease (WHO, 2020).

When the pandemic first hit, nationwide lockdown was implemented to stop the spread of the deadly virus, which in turn reduced environmental impact of air pollution. With flights grounded and people having nowhere to drive, carbon dioxide emissions plummeted and many cities around the world had clean air (Goel et al., 2020). In India, a complete nationwide lockdown was implemented for a total of 68 days through four phases, from 25 March to 31 May 2020 (Barwal et al., 2020). Jain and Sharma (2020) compared the concentrations of criteria air pollutants for five metro cities (Delhi, Mumbai, Chennai, Kolkata, and Bangalore) of India before the lockdown (10-20 March 2020) and during the lockdown (25 March-6 April). According to their findings there was a declines of $PM_{2.5}$ concentration of 14% in Chennai to 41% in Delhi for the lockdown period. In addition other studies have estimated 50% reductions in $PM_{2.5}$ and PM_{10} concentrations in cities such as Delhi, along with reductions of approximately 53% in NO_2 concentrations and approximately 30% in CO concentrations during lockdown (Mahato et al., 2020).

However, there was an environmental dark side to pandemic, everyone stayed at home and created an enormous amount of plastic waste by online package delivery, food delivery, single use plastic bags, and masks, gloves and other forms of personal protective equipment (PPE). Not only did we create more plastic trash during the pandemic, but we may have created long lasting habits that will litter our lands and oceans with plastic.

A range of personal protective equipment (PPE) made from plastics have played crucial roles in protecting doctors, nurses and other healthcare providers during the COVID-19 pandemic. However, there is a growing concern over the unprecedented increase in single-use plastics (SUPs) including sharp and general wastes, such as syringes, and scalpels, gloves, surgical masks, surgical and isolation gowns, face shields, shoe covers, sanitizer containers, and waterproof aprons (Figure 4). The management of wastes arising from SUPs is a troubling upshot of the COVID-19 pandemic which has wrecked the global healthcare systems and disrupted the economies of nations (Benson et al., 2021; Vanapalli et al., 2021; Herron et al., 2020; Silva et al., 2020). Essential municipal

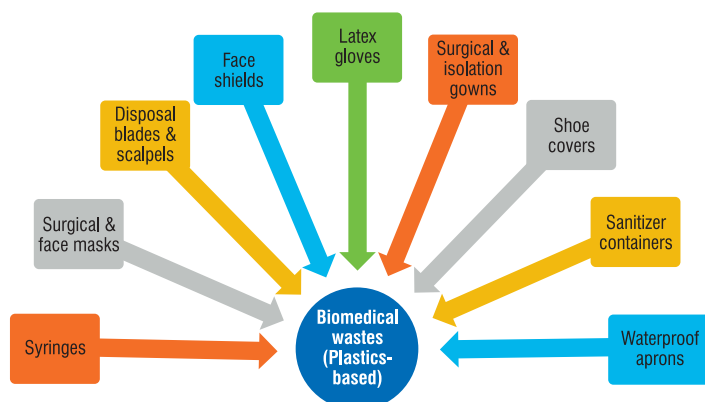


Figure 4. Types of plastic based biomedical wastes originated during COVID-19 pandemic

services such as waste collection and treatment have been threatened while there is an unprecedented rise in the amount of medical and domestic wastes generated (Table 1). Data suggest that COVID-19 virus is highly contagious and could remain viable on plastic surfaces for several days (Chin et al., 2020; Doremalen et al., 2020; Nghiem et al., 2020).

In general, activities like unplanned disposal of biomedical wastes have been regarded as potential sources of toxic, infectious and radioactive pollutants (WHO, 2018). Healthcare wastes include cytotoxic, chemical, pathological, sharp, radioactive and general wastes.

Table 1. Estimated daily COVID-19 facemasks and global plastic waste generation by country prior to management

Rank	Country	Population	Urban Population (%)	Facemask acceptance rate by population (%)	Estimated daily facemask discarded	Total estimated plastic waste (tonnes)
1	China	1,43,93,23,776	61	80	70,23,90,002	10,79,49,283.20
2	India	1,38,00,04,385	35	80	38,64,01,228	10,35,00,328.90
3	United States	33,10,02,651	83	80	21,97,85,760	2,48,25,198.80
4	Brazil	21,25,59,417	88	75	14,02,89,215	1,59,41,956.30
5	Indonesia	27,35,23,615	56	80	12,25,38,579	2,05,14,271.10
6	Japan	12,64,76,461	92	80	9,30,86,675	94,85,734.58
7	Russia	14,59,34,462	74	80	8,63,93,201	1,09,45,084.70
8	Mexico	12,89,32,753	84	75	8,12,27,634	96,69,956.48
9	Nigeria	20,61,39,589	52	70	7,50,34,810	1,54,60,469.20
10	Pakistan	22,08,92,340	35	80	6,18,49,855	1,65,66,925.50
11	Bangladesh	16,46,89,383	39	80	5,13,83,087	1,23,51,703.70
12	Turkey	8,43,39,067	76	80	5,12,78,153	63,25,430.03
13	Iran	8,39,92,949	76	80	5,10,67,713	62,99,471.18
14	Germany	8,37,83,942	76	80	5,09,40,637	62,83,795.65
15	United Kingdom	6,78,86,011	83	80	4,50,76,311	50,91,450.83
16	France	6,52,73,511	82	80	4,28,19,423	48,95,513.33
17	Philippines	10,95,81,078	47	80	4,12,02,485	82,18,580.85
18	South Korea	5,12,69,185	82	80	3,36,32,585	38,45,188.88
19	Italy	6,04,61,826	69	80	3,33,74,928	45,34,636.95
20	Argentina	4,51,95,774	93	75	3,15,24,052	33,89,683.05
21	Egypt	10,23,34,404	43	70	3,08,02,655	76,75,080.30
22	Colombia	5,08,82,891	80	75	3,05,29,735	38,16,216.83

Rank	Country	Population	Urban Population (%)	Facemask acceptance rate by population (%)	Estimated daily facemask discarded	Total estimated plastic waste (tonnes)
23	Spain	4,67,54,778	80	80	2,99,23,058	35,06,608.35
24	Vietnam	9,73,38,579	38	80	2,95,90,928	73,00,393.43
25	DR Congo	8,95,61,403	46	70	2,88,38,772	67,17,105.23
26	Thailand	6,97,99,978	51	80	2,84,78,391	52,34,998.35
27	South Africa	5,93,08,690	67	70	2,78,15,775	44,48,151.75
28	Canada	3,77,42,154	81	80	2,44,56,916	28,30,661.55
29	Ukraine	4,37,33,762	69	80	2,41,41,037	32,80,032.15
30	Iraq	4,02,22,493	73	80	2,34,89,935	30,16,686.98
31	Saudi Arabia	3,48,13,871	84	80	2,33,94,921	26,11,040.33
32	Algeria	4,38,51,044	73	70	2,24,07,883	32,88,828.30
33	Malaysia	3,23,65,999	78	80	2,01,96,383	24,27,449.93
34	Peru	3,29,71,854	79	75	1,95,35,824	2472889.05
35	Poland	3,78,46,611	60	80	1,81,66,373	28,38,495.83

Source: Data retrieved from <https://www.worldometers.info/population/> on June 02, 2020.

4.1. Management of disaster waste

Effective planning for disaster waste management is very important and essential disaster preparedness strategy (Crowley et al., 2017; 2018). A key aspect is to estimate the anticipated quantities and composition of waste likely to be generated from future disasters, to identify required resources and management approaches. Some studies have used modelling methods to identifying the compositions and quantities of disaster waste by modelling disaster waste generation for earthquakes and flooding (Torres et al., 2017; Tabata et al., 2018).

Covid-19 generated plastics during this pandemic need to be addressed and that can be achieved by proper disposal and strict adherence to approved hazardous medical waste management procedures for single use medical gloves, surgical masks, surgical suits, face shields, and aprons. The development of a tangible conservation strategy for proper sterilization and disinfection of surgical gowns and masks should be carried out while taking into consideration the reduction of risks such guidelines could pose to healthcare workers and the COVID-19 patients. As recommended by the US FDA, healthcare providers could replace single-use PPE with reusable surgical gowns (US FDA, 2020b). Surgical gowns are usually act as a barrier to microbial and fluid transmission during medical procedures (Spark, 2020). In addition, extended use of PPE for multiple patients may be prioritized by healthcare providers. This would ultimately lead to a drastic reduction in the amount of plastic waste generated.

Waste management is a discipline associated with control of generation of waste, storage, collection, transfer and transport, processing, reuse and recovery and disposal of solid waste in accordance with best principles of public health, economics, engineering, conservation of nature, aesthetics and environmental, while considering the general public attitude. Some control suggestions are given below to minimise the burden of disaster generated waste-

5. Conclusion

Recurring natural and technological disasters are environmental health hazards that will continue to affect public health adversely. In response, disaster prevention activities must begin at the local level by communities and agencies implementing indicated disaster management policies, such as proper land-use planning, zoning, and siting. Natural disasters can cause serious damage to health facilities and water supply and sewage systems, having a direct impact on the health of the population dependent on these services. Environmental health has an important role to play in all stages of disaster management ranging from prevention through to recovery. The International Strategy for Disaster Reduction (ISDR) defines post-disaster recovery as: “decisions and actions taken after a disaster with a view to restoring or improving the pre-disaster living conditions of the stricken community, while encouraging and facilitating necessary adjustments to reduce disaster risk.” The Bureau for Crisis Prevention and Recovery (BCPR) of UNDP states that “Managing recovery will require building national capacities, restoring coping mechanisms, empowering communities and determining root causes and vulnerabilities which make societies disaster-prone.”

Post-disaster recovery is part of a continuum that begins with actions that happen before the occurrence of an event, to immediate emergency attention and recovery; from humanitarian aid for the victims in order to save lives, to the restoration of a functioning society. In the initial moments, the response institutions focus their efforts on counting the victims and costs of the disaster (assessing losses and damages), the rescue efforts, caring for the wounded and satisfying basic needs like water, shelter and health of affected persons. Progressively, the situation shifts toward facilitating people's access and mobility, ensuring the livability of those buildings that are still standing, removing debris, restoring livelihoods and ensuring national governance and sovereignty.

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About CECR and HER-CAP Project

Centre of Excellence on Climate Resilience (CECR)

National Institute of Disaster Management (NIDM) has a dedicated division for Environment, Climate and Disaster Risk Management (ECDRM) which has been designated as a Centre of Excellence on Climate Resilience (CECR) under the National Action Plan for Climate Change and Human Health (NAPCCHH). CECR is implementing six research projects namely Climate Adaptive Planning for Resilience and Sustainable Development in Multi-hazard Environment (CAP-RES) with support of DST-Govt of India, National Agriculture Disaster Management Plan (NADMP) funded by the Ministry of Agriculture & Farmers Welfare, Health Resilience and Capacity Building (HER-CAP) with World Health Organization India, Crisis Management Plan for Dealing with Contamination of Water Bodies (CMP-WB) funded by CPCB, Disaster Management Plan for Ministry of Environment, Forest and Climate Change (NEFC-DMP) with the support from MoEFCC and the Disaster Management Plan for Dept. of Chemicals and Petrochemicals (NCP-DMP) supported by DCPC-MoC&F. It also collaborates with a number of international and national organizations working in the areas of climate change adaptation, resilience and disaster risk reduction.

HER-CAP Project

NIDM in collaboration with WHO India has implemented the project “Health Adaptation and Resilience: Advancing Strategic Knowledge and Capacities” (HER-CAP). Under this project, the following documents have been drafted.'

- National Health Adaptation Plan for disasters related illnesses' for Ministry of Health and Family Welfare.
- Training Manual on 'Health Adaptation and Resilience to Climate Risks'.
- A compendium of case studies on 'Climate Change related Disasters and Health Resilience'.
- Four Policy briefs on Regional Issues and Opportunities for Health System Resilience to Climatic Disasters. (For North, East & North-East, West and South Region of India).

- Along with this, four thematic papers on key areas are as follows:
 - Temperature related disasters: Heat and Cold Wave - Implications for Health Adaptation and Resilience.
 - Water related disasters: Floods and Drought - Implications for Health Adaptation and Resilience.
 - Air Pollution and Health: Special Focus on Air Quality Emergencies.
 - Disaster Waste Management and Health Risk Reduction.

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