WATER MANAGEMENT AFTER A NATURAL DISASTER

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ABSTRACT

The purpose of this bachelor's thesis was to gain an understanding into management methods that increases the availability of safe and secure water in the event of, or after the occurrence of a natural disaster. The thesis was prepared as a teaching reference for the nursing department of HAMK University of Applied Sciences.

Information in this thesis were mainly gathered from academic articles and books in water emergency, disasters, disaster management and management in general with the aim of producing a material that focuses on water management after a natural disaster. At the beginning of the thesis, an overview of disaster trends around the world was discussed to show how big an issue disaster occurrence is around the world. Various impacts on water resources by different disaster types was also examined. By understanding these impacts, the reader would be able to appreciate how these disasters affect water resources. The need for disaster response planning and what should be included in a disaster response plan such a water assessment, estimation of damage to water sources, water quality in emergencies and disaster water quality assessment, were discussed. Considerations on water sources after a disaster and different water treatment and distribution systems which are feasible in a disaster situation were also discussed. Disaster management, management of water in disaster and the roles and responsibilities of response actors, including public health personnel, in emergency response planning and the execution were discussed in the thesis.

As a conclusion; the necessity of a well-planned response and the effective implementation of the plan was highlighted as the panacea for water management after a natural disaster.

Keywords Disaster, water, management, emergency response, disease prevention.

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Terms and Definitions

Emergency

An emergency occurs when an event occurs suddenly and mostly unexpectedly, such that it requires immediate or fast action in order to avoid harmful results or to prevent further harmful results. It is a state in which normal procedures are suspended and extra-ordinary measures are taken to avert a disaster.

Vulnerability

Vulnerability as it relates to disasters explains the characteristics of a person or a group which predisposes them to the dangers of a naturally hazard as well as their situation that influences their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard.

Resilience

Resilience simply put is the ability to return to the original form after being changed or affected. Resilience after a natural disaster is the ability of individuals, communities, organizations, and states to adapt to and recover from hazards, shocks, or stresses without compromising long-term prospects for development.

Rehabilitation

Rehabilitation is the restoration of something that was damaged to its original form. Rehabilitation after a natural disaster is the restoration to basic normal functions.

Reconstruction

Reconstruction is the process of building or creating something which has been destroyed. During the reconstruction stage after a natural disaster, preventive measures are put in place to mitigate or attenuate the effect of future occurrence of the natural disaster. After the reconstruction stage, there is a full resumption of socio-economic activities.

Response (emergency)

Emergency response is an umbrella term used to describe actions targeted towards mitigating the effect of an emergency or preventing further damage resulting from an emergency. Emergency response can be initiated on ground and remotely but there will mostly be a physical presence of help before the response is complete.

Responders (emergency)

During emergency response, responders are mostly the first help to the scene, also known as first responders. These can include the police, fire, community responders, and emergency health personnel. They mostly act fast to bring emergency under control. They may likely expose themselves to the initial harm resulting from the emergency.

1 INTRODUCTION

Environmental and Public Health are very important aspects of human health. Health problems are not just viewed, in recent times, as merely a somatic problem but a combination of other factors such as ones related the environment. The direct environment has been linked as a contributing factor to some major health problems such as cancer, diseases -both infectious and non-infectious- poisonings, and other illnesses.

Natural disasters are one of the leading causes of environmental disruption, causing physical, emotional and health damages both directly and indirectly. As a direct effect, natural disasters causes disruption of populations, direct injuries resulting from the disaster occurrence, and other direct damages to humans and property resulting from the disasters. Natural disasters can, however, cause scarcity of water as both direct and indirect effect which carries with it (water scarcity) problems of disease spread due to poor hygiene, lack of food availability, economic losses due to diseases and death resulting from these diseases.

Given the high impact of disasters on the environment, and human health and wellbeing, mitigatory steps and, when necessary, remediation plans are of high importance in preventing and reducing the impacts of natural disasters respectively. Planning for potential adverse effects of disasters even before they occur is an important step towards mitigating adverse consequences for people and the environment. These steps laid down in the disaster mitigation plans offer a great way to increase the resilience of people around areas prone to disasters and other areas, too. These disaster response plans can also be put in place after a disaster has occurred if they were not put in place before a disaster occurrence.

The implementation of plans contained in a disaster response plan requires expertise, labor, and resources. Different groups are always involved in disaster response including local responders, government agencies, international agencies, Non-Governmental Organizations, and many others depending on the place and groups who are either obligated to participate, or voluntarily become members of the response team.

Disaster situations especially one in which water scarcity is a possible outcome must have an open eye for the public health problems. Disease outbreak and spread are not out of the question. In fact, public health problems resulting from poor hygiene due to lack of water, and water contamination and recontamination might become one of the major causes of life loss post-disaster, if adequate measures are not put in place to combat the incidence of disease spread. Public health personnel, therefore, have an important role to play in natural hazards involving water scarcity.

2 HAZARDS AND NATURAL DISASTERS

Natural disasters are occurring in an overwhelming number around the world and carrying with them various forms of human impacts as well as economic, social, and psychological disturbances which affect the quality of life of people living in or around the impact areas. Natural disasters are always following from the impact of natural hazards. Though natural disasters are considered as occurring from natural sources, human action can go a long way in changing the course of impact and the effect of natural hazards that, if unchecked, could become overwhelming and resulting eventually in a disaster.

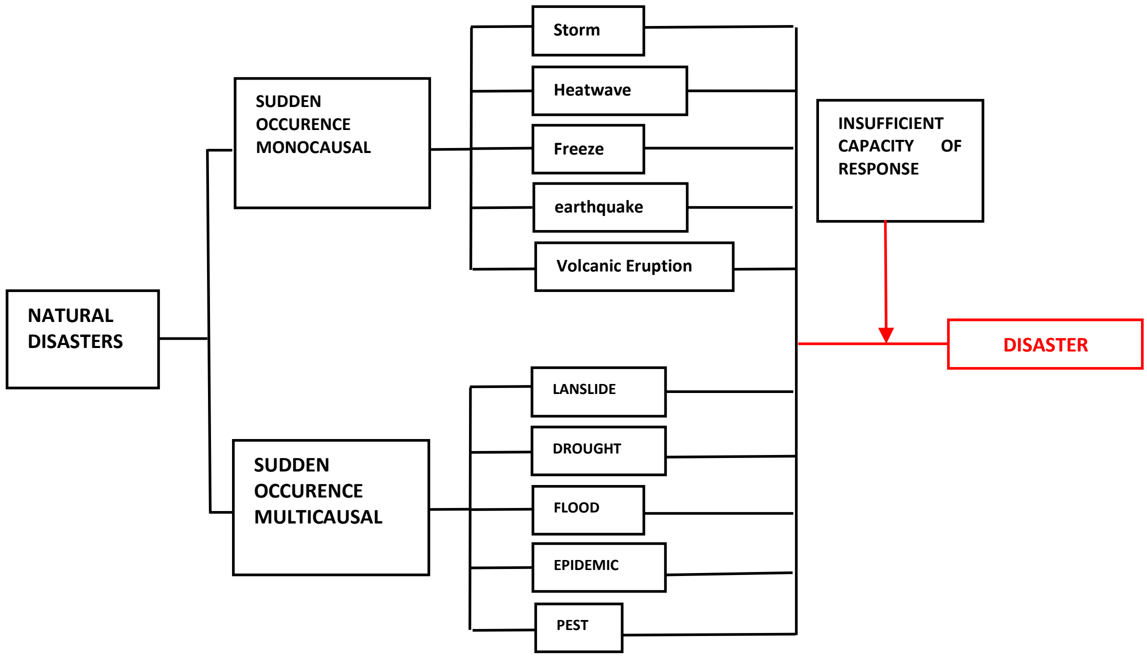


Figure 1, Classification of Natural disaster by causal factors
(WHO/WHA Training Package Pan African Emergency Training Center, 2002)

The inherent ability of an area or community to remain undamaged from the impact of hazards without the hazard causing suffering or without the resulting effect exceeding the capacity of the affected community to adjust to the effects of the hazard is the most important factor in the meaning of a natural disaster. Natural disasters can be monocausal, meaning that the events leading up to the disaster are usually from one source, or multiclausal, meaning that different events will eventually lead to the disaster (Figure 1).

Natural disaster according to the Center for Research on the epidemiology of disasters is “a situation or event [which] overwhelms local capacity, necessitating a request to a national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering”. According to the world Health organization, “it is the people who matter most, and without the people we have no disaster.” (WHO, 2002).

Hazards on the other hand are natural or human-made events that threaten or adversely affect human life, property, or activities to the extent of causing a disaster. A hazard could result from human actions such as war or from natural causes such as volcano or hurricane. Hazards could occur spontaneously from a single cause or as a chain of events which lasts a longer period from various causes. Natural disasters are those types of disasters occurring from natural hazards and is the scope of this work.

Planning for natural disasters or planning disaster management after the occurrence of a disaster can go a long way in either mitigating the impact of the disaster or preventing further damage from it.

A well-thought and well-organized emergency strategy will be able to quickly adjust and adapt to unforeseen situations and complications. Disasters are difficult to plan and anticipate because they are innately different from common emergency events. While it is true that both can lead to large amounts of casualties and property damage, the difference between a disaster and a common emergency event is more than one of magnitude alone. (G. M. Burnham et al., 2007)

There is no single measure of a disaster that can capture the full scope of a disaster. A common measure is the number of people killed or affected. The individual will consider the impact on his or her family and livelihood. Disaster managers will assess the speed and success of the disaster response. Economists will measure physical loss to houses and buildings and loss of production. Politicians will assess political damage from a poor response by state agencies. Health workers will consider the resource

The classification of hazard as shown in Figure 1 depends on their origin. Natural disasters are those related to natural events, that is “physical phenomena arising in nature” (Pan American Health Organization, 2002). There are sometimes a series of events of human influenced phenomena which can result in a “natural disaster”. An example is the effect of deforestation on erosion which can subsequently lead to a landslide. Natural disasters can also be classified as having a sudden onset as the case of volcanic eruption or as having a gradual onset for example in flooding.

Others may focus on the nature of the hazard, the social consequences, and the impact on specific elements of the infrastructure. To think seriously about a disaster means we must consider all affected and their losses both in the immediate and the longer term.

2.1 Global disasters and water scarcity trends

Natural disasters around the world are such that occur at various times in varying magnitudes. The magnitude and impact of natural disasters is better appreciated when viewed globally since there are different disasters happening at different times in different locations around the world. Some of the "popular" disasters around the world in recent times include Ebola epidemic in West Africa in 2014, earthquake in Haiti in 2010, Tsunami in Sumatra in 2004, hurricane Katrina in the US in 2005, Earthquake in Pakistan in 2005, Sichuan earthquake in China in 2008, flood in Malawi in 2015, acute water shortage in Myanmar in 2016 among others.

According to the CRED, in 2015 there were 346 reported disasters of which 98.6 million people were affected resulting in 22,773 human deaths and there was US$66.5 billion economic damage. (CRED, 2015). The highest economic damage occurred in 2005 and 2011 (Figure 2) with the greatest cost of economic damage occurring mostly in Asia in both years. (CRED, 2015).

Between 1994 and 2013, natural disasters affected an average of 218 million people every year, per the EM-DAT database. Over this period, EM-DAT recorded 6,873 disasters, which claimed a total of 1.35 million lives, an average of almost 68,000 deaths per year. For an occurrence or incidence to be recorded as a natural disaster in EM-DAT, an event must meet at least one of the following criteria:

1. Ten or more people reported killed
2. 100 or more people reported affected
3. Declaration of a state of emergency or
4. Call for international assistance. (CRED, 2015)

Included in the effects of disaster occurrence is the economic impact resulting from these disaster occurrences. Figure 2 shows the total economic damage caused by reported natural disasters between years 2000 and 2018 according to EM-DAT. The total economic damage is scaled to the total of billion US dollars. Looking at the trend there was a sharp rise of economic loss in the Americas between 2003 and 2005, the highest economic loss within that period peaked in 2005 to a tune of 214 billion dollars.

The Americans and Asia also saw a fairly constant rise in economic damage due to disasters between 2006 and 2008, the peak within this period was up to a tune of 134 and 72 billion dollars in Asia and the Americas respectively in 2008. The highest economic damage between the period of 2000 and 2018 was reported in Asia in 2011 to a tune of 297 billion US dollars. Economic damage in Africa peaked in 2003 to a tune of 7 billion us dollars. Economic losses in Europe peaked in 2002 to a tune of 32 billion US dollars.

According to WHO and UNICEF, 844 million people don't have clean water (WHO/UNICEF, 2017) 2 billion people do not have a decent toilet (WHO/UNICEF, 2017). Every minute, a newborn dies from infection caused by lack of safe water and unclean environment (WHO, 2015).

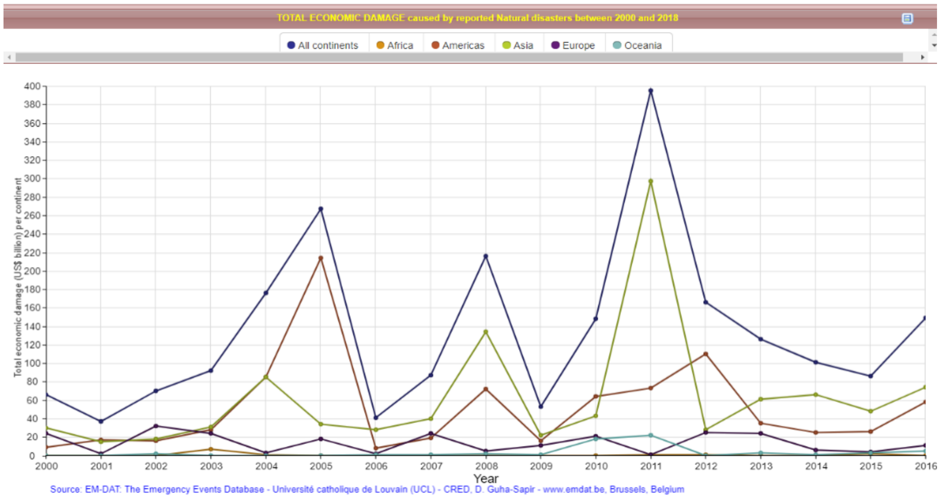


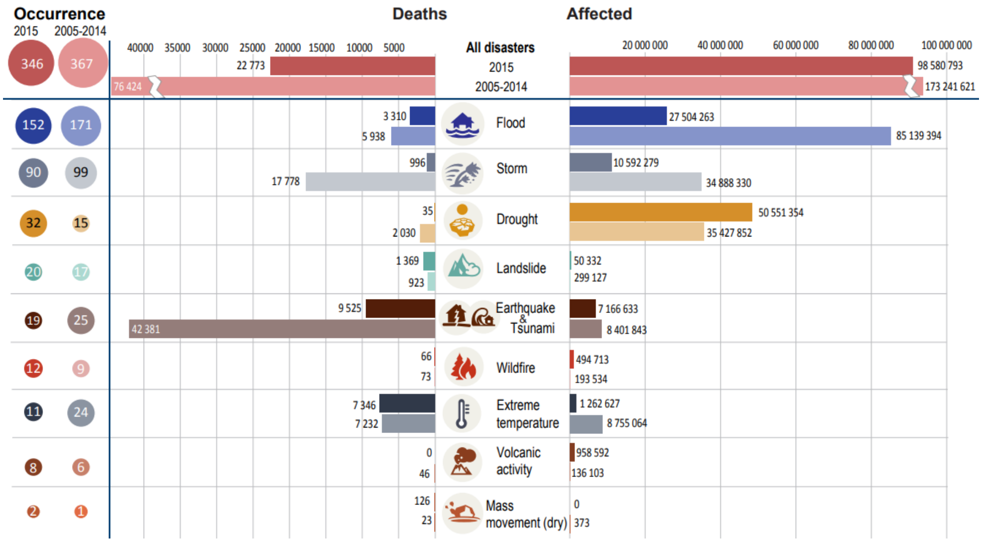
Figure 2, Total Economic Damage by reported Naural disasters bewteen 2000 and 2016

It is important at this point to note that the economic losses scaled to US dollars does not necessarily equate to the number of disaster and does not serve as a direct comparison for the amount of disasters. Factors such as currency values and the corresponding economic value of property destroyed makes for a wide difference in the amount of economic damage in US billion dollars reported.

According to Center of Research on Epidemiology of disasters, 2015 saw a record amount of disaster occurrence and human impact by disaster. Between 2005 and 2014 there were a total of 367 disasters however, there were a total of 347 reported disasters in just 2015 as indicated in the Figure 3. Earthquake and Tsunami up to 9525 deaths, and extreme temperature up to 7346 deaths resulted in the highest number of deaths by disasters in 2015. This number showed how much 2015 saw a great impact from natural disaster since the amount of death of a ten-year period (2005 – 2014) by earthquake and Tsunami was 42381, meaning that 2015 is far above the average of 4238 deaths, better even demonstrated by the amount of deaths by extreme temperature which culminated to a total of 7346 deaths outnumber the total number of deaths of the ten-year period (2005 – 2014) of 7232 deaths.

Following the global trend in natural disaster, every continent recorded a natural disaster between 1994 and 2013. The greatest impact, taking the frequency and the total number of people killed and affected into account, was in Asia.

A summary of water scarcity trend around the world shows that 663 million people -1 in 10- lack access to safe water. About 2.4 billion people-1 in 3-lack access to a toilet. Twice the population of the United States lives without access to safe water. One third of the global population lives without access to a toilet. More people have mobile phone than a toilet. (wateraid.com, n.d.).



Picture 3, Human impact of disaster types (2015 versus average 2005 – 2014)
2015 disasters in numbers, Centre for Research on the Epidemiology of Disasters (CRED)

3 NATURAL DISASTER IMPACTS ON WATER SUPPLY

Natural disasters have a disruptive impact on various water resources network and facilities and thus hinder or delay water supply after their occurrence. This disruption results in changes to the planning and execution of water supply.

The planning and execution of emergency water supply involves all the steps to resolve the challenges posed by the destructive impact of natural disasters to provide water to the affected population to a satisfactory quality and quantity level in the short term without causing any health challenges, while continuously working to return the water distribution to the optimal level. The disruptive impacts of natural disasters, depending on type of the disaster causing the impact, are either partial or complete damage of surface structures, water tanks, partially buried tanks, elevated tanks, rock-fill dams, in earth dams, concrete dams, underground or buried works, pumping equipment and electrical installations, water intakes, diversion structures and distribution system. These damage lead to the contamination of both surface water sources and ground water sources. (PAHO, 1998; 17 - 44)

3.1 Earthquake

An earthquake is the sudden, rapid shaking or rolling of the Earth. Earthquakes happen when rocks break or slip along fault lines in the Earth’s crust, releasing energy that causes the ground to move. Earthquakes have consequences ranging from near-total devastation of infrastructure in places heavily populated, to less destruction in less populated areas. (UNICEF, 2015; 81).

3.1.1 Impacts on Water supply facilities and property

Earthquakes cause damage to surface water supply structures. The level of damage will depend on the seismic resistant design and materials used in the construction of these works. (PAHO, 1998; 19)

Earthquakes can damage water tanks. The extent of the damage depends on the type of water tank. Additional damage to elevated water tank results because there is an added risk that elevated tanks will resonate with the vibration of the earthquake. (PAHO, 1998;22)

Partially buried tanks (including those for regulation or storage for cities and towns) generally constructed of stonework, concrete, reinforced concrete, or other materials, can suffer damage such as:

Cracks in the walls, floor, covering, or in areas where these elements meet, such as in the entrance or exit of pipes, which may require simple repairs or require total reconstruction. Partial cave-in of the cover, interior columns or part of the walls or floor, requiring either minimal repairs or total reconstruction. Total collapse of the structure. (PAHO, 1998; 21-29)

Effects of an earthquake on elevated tanks include light damage, such as shear of the diagonal supports, which can be repaired or replaced quickly, Damage in the supporting structure and/or in the storage tank can vary from minor to very serious, and the collapse of the structure. (PAHO, 1998; 21-29).

Effects of an earthquake on concrete tanks include Loss of exterior stucco. This is easily repaired although scaffolding may be required, damage to pipes entering or leaving the tank or to superimposed elements such as access ladders, and cracks in the supporting structure or storage tank

Earthquakes also causes damage to Rock-fill dams such as small, medium or large cracks or leaks, collapse of reservoir embankments, and total collapse of the dam. (PAHO, 1998; 21-29).

Damage caused by earthquake to in earth dams include small leaks. This should be immediately repaired to avoid the increase of erosion. Accumulation of soil because of landslides, this may need dredging. Earthquakes can also cause collapse of the dam. (PAHO, 1998; 21-29).

Earthquake causes the following damage to concrete dams. Cracks or small leaks that should be repaired immediately, cracks that would require the reservoir to be emptied for repair (implying loss of stored water), Accumulation of soil due to slides, and collapse of the dam. (PAHO, 1998; 21-29).

Earthquake causes damage to pipes and conduits of drinking water, sewage, and storm water; chambers, valves, and domestic installations; underground water intakes such as wells, drains, and galleries. These damages can lead to the the risk of Contamination of ground water sources Contamination of Drinking Water Sources by infiltration through broken joints (PAHO, 1998; 21-29).

3.2 **Hurricanes**

Tropical cyclone is a low-pressure system that generally forms in the tropics. Cyclone is accompanied by thunderstorms and, in the Northern Hemisphere, a counterclockwise circulation of winds near the earth's surface. Hurricane is a type of tropical cyclone defined as an intense tropical weather system of strong thunderstorms with a well-defined surface circulation and maximum sustained winds of 74 mph (64 kt) or higher. (Hurricnes.com, 2018).

A Strong wind can destroy tanks and cause spills of stored water and depending on the nature of the tank could amount to thousands of cubic meters of water. Damage to connecting pipes and in adjoining installations could also result from hurricanes. While the main structure may survive, access stairs, protective railing, or in- and outflow pipes could be damaged. Tanks are prone to damage by hurricanes such as tanks for public drinking water supply for towns and cities, which probably store the largest quantities of water, intermediate-sized tanks for industry, markets, schools, etc., and small tanks for domestic use. (PAHO, 1998; 31-32).

3.3 **Floods**

Flood is a state of high water level along a river channel or on the coast that leads to inundation of land, which is not usually submerged. Floods may happen gradually and may take hours or even happen suddenly without any warning due to breach in the embankment, spill over, heavy rains etc. (Disha Experts, 2017; 100)

The greatest effects of floods on water supply system is resulting indirectly in water borne illnesses from poor sanitation and hygiene. Some of the water borne illnesses connected to poor sanitation and hygiene after flooding include typhoid, cholera, dysentery, infectious hepatitis, gastroenteritis among others.

The contamination of drinking water by floods can occur due to one or a combination of the contamination of surface sources of drinking water due to animal cadavers near intakes, excessive increase in the turbidity of water, or pollution from other types of contaminants. Also due to flood levels that surpass the height of well-head walls, or waters that flow directly over wells and other intakes. And due to the rise of water levels in sewer outfalls can cause waste water to flow back and flood the interiors of homes, lower levels of buildings, and public throughways. In homes this occurs through toilets and washbasins; in streets, it occurs through manholes, and rainwater sinks. This means that if fuels mix with flood waters, it becomes even more difficult to boil water for sterilization. (PAHO, 1998; 33-35).

Floods cause physical damage such damage to pipelines and appurtenances. These affect different types of chambers and valves and may include damage to partially buried tanks. These tanks are usually located in high terrain and flood damage is rare. Damage to pumping equipment and electrical installations, and damage to intakes, dams, and other surface constructions. (PAHO, 1998; 33-35).

3.4 **Landslide**

Landslide is defined as the movement of a mass of rock, debris, or earth down the slope, when the shear stress exceeds the shear strength of the material. (Westen, n.d.).

The effects of a landslide on water system include diversion structures such as rock barrages, diversions, and intakes located in mountainous regions can be buried or washed out from the impact of flows, avalanches, and landslides. Landslides can cause earthen or rock fill dams constructed for water supply to fail because of slides on their embankments or overtopping of the dam because of slides into the reservoir. There is a risk of slide on surface intakes in mountainous areas which results to water contamination because of increased turbidity. Such damage can cover huge areas in the case of slides caused by earthquakes or extreme rainfall. Landslides cause washout and destruction of sections of pipe, canals, valves, and pumping installations located over or in the path of slides, flows, and avalanches, and damage to treatment plants over or in the path of a slide, flow, or avalanche. (PAHO, 1998;39 -41)

3.5 **Volcanic Eruption**

Volcanic eruptions happen when lava and gas are discharged from a volcanic vent. The most common consequences of this are population movements as large numbers of people are often forced to flee the moving lava flow. Volcanic eruptions often cause temporary food shortages and volcanic ash landslides called Lahar. (International Federation of Red Cross and Red Crescent Societies, 2012).

The final or aftermath damages cause by a volcanic eruption can far outweigh the initial damage by the actual incidence of the eruption. These consequences include Seismic effects generated by the volcanic eruption, flooding and or snow, earth, or mud slides resulting from heating of the earth and localized ground shaking, the eruption of ashes, dust, gases, rocks, and lava.

3.6 **Damages Caused by Volcanic Eruptions**

Volcanic eruptions cause the contamination of Drinking Water in different ways. Some of the contamination of drinking water by volcanic eruption are due to deposit of ash, the effect of gases or toxic substances, or animal cadavers near intakes or in open water canals.

Contamination of ground water is relatively unlikely, unless the ash-falls are very extensive and/or contain high levels of contaminants, or if they enter well openings (particularly those without protective coverings), thereby polluting stored water.

Filters or water treatment plants can be contaminated by ash-fall in settling tanks, flocculation tanks, or filters. Volcanoes can also cause the contamination of open tanks or reservoirs. (PAHO, 1998; 42)

Volcanic eruption cause damage to Pipelines, Partially Buried Tanks, and Other Installations. When there is an abundant lava flows with enough erosion capacity, there is damage to Drinking or waste water pipes. Pipes, chambers, and valves can be unearthed, displaced, or crushed; Semi-buried tanks or reservoirs can be partially or totally destroyed. Damage in Surface Works and Buildings. (PAHO, 1998; 40- 41).

3.7 Drougts

Drought is a deficiency in precipitation over an extended period, usually a season or more, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people. It is a normal, recurrent feature of climate that occurs in virtually all climate zones, from very wet to very dry. Drought is a temporary aberration from normal climatic conditions, thus it can vary significantly from one region to another. Drought is different than aridity, which is a permanent feature of climate in regions where low precipitation is the norm, as in a desert. (NOAA, 2008)

General Effects of Droughts, unlike other natural disasters, do not occur suddenly, but are slow-onset disasters resulting from insufficient rain or snow over a period of months, and, sometimes, years. Its effects are principally seen in the decrease or extinction of sources of drinking water. Surface water such as rivers and ponds will usually suffer the effects of drought before ground water. (PAHO, 1998; 43).

Depending on the characteristics of surface water sources and the type of drought, impacts could include a decrease in the normal volume of drinking water, which, depending on its severity, could result in moderate to severe rationing or the total extinction of some sources.

Decrease in the self-cleansing capacity of rivers or ponds because of reduced flow; Increased concentration of pesticides, insecticides, or industrial wastes; Decreases in free oxygen resulting in contamination from fish kill-off; Contamination caused by dead animals near intakes for drinking water. (PAHO 1998: 44).

4 DISASTER MANAGEMENT

Disaster management is a collective term encompassing all aspects of planning for and responding to emergencies and disasters, including both pre- and post-event activities. It refers to the management of both the risk and the consequences of an event. (Indiana University, 2016)

4.1 The aim and phases of disaster management

The aims of disaster management are to create proactive plans to mitigate various potential risks that could arise from a disaster. Disaster management also minimizes loss via more effective preparedness and response. This helps in creating more effective and durable recovery.

The knowledge of disaster recovery cycle is important to ensure that proper steps are taken where required to plan for and reduce the impact of disasters, react during, and immediately following a disaster, and take steps to recover after a disaster has occurred and properly manage disasters. All disaster response begins at the local level and as such, communities must be prepared for whatever happens, no matter how big or small.

Health care systems play an integral role in a community's disaster response; therefore, these systems must also be prepared to meet the tremendous challenges that are brought forth by disasters and public health emergencies. Successful disaster response requires a community and its health care system to:

- Define and anticipate disaster risks and hazards;
- Prepare the material resources and skilled personnel to respond to these risks and hazards;
- Develop comprehensive plans to deploy these resources to assist the community and its recovery;
- Learn from disasters and translate the lessons learned into invaluable future preparedness. (J. Herrmann 2007)

Since each disaster is unique and will require certain different approaches, the disaster recovery stages might differ slightly in the sense that the stages may follow a different sequence than described. The stages of recovery do not always follow a neatly defined course or timeline. Yet there are several phases that unfold as communities begin to rebuild their lives after disasters. Because relief and recovery may take a long time, it is important to create a strategic plan of response to identify and help the most vulnerable and severely affected people.

The process of disaster management is commonly visualized as a two-phase cycle, with post-disaster recovery informing (providing guide for) pre-disaster risk reduction, and vice versa. The significance of this concept is its ability to promote the wholistic approach to disaster management as well as to demonstrate the relationship between disasters and development.

There are slightly varying terms used by policy makers, practitioners, trainers, educators, and researchers to describe the phases of a disaster recovery. There are four core phases of disaster recover. Sometimes it is listed as five with the inclusion of evaluation phase which is, per se, not a core disaster recovery phase or could be merged with the mitigation phase as evaluation and mitigation phase. These phases are often described as part of a continuous process.

While there are different understandings of Disaster Management, it is generally viewed as a cycle with the following four key phases:

- Planning and Preparedness Phase
- Mitigation Phase
- Response Phase
- Recovery Phase

Each phase however should be adapted to suit the need of the disaster situation in question and therefore could include sub phases and slightly different descriptions and components. (The Johns Hopkins and Red Cross Red Crescent, 2008)

Picture 4: Phases of a disaster

4.2 Mitigation Phase

The focus of the mitigation phase is minimizing the effects of disaster. Examples: building codes and zoning; vulnerability analyses; public education and other steps that foresees and prevents disaster occurrence. This stage includes any activities that prevent an emergency, reduce the chance of an emergency happening, or reduce the damaging effects of unavoidable emergencies. During this phase, steps are taken to prepare a community for disaster, especially high-risk locations (e.g. hospitals in areas that typically flood) and populations. (The Johns Hopkins and Red Cross Red Crescent, 2008)

There is supporting research which suggests that individuals, communities, and hospitals are more resilient following disaster when they have anticipated and prepared for disaster outcomes. (J. Herrmann, 2007). This stage usually takes place before the event of a disaster, it could however take place after disaster occurrence in a situation where it was not put in place or not adequate before the disaster occurrence.

4.2.1 Planning and Preparedness Phase

Preparedness in connection with disaster, according to the Federal emergency management agency (FEMA), is defined as “the range of deliberate, critical tasks and activities necessary to build, sustain, and improve the operational capability to prevent, protect against, respond to, and recover from domestic incidents.” “Preparedness is a continuous process involving efforts at all levels of government and between government and private sector and non-governmental organizations to identify threats, determine vulnerabilities, and identify required resources” (FEMA, 2006).

During this phase, preparations are made to handle an emergency. Activities characteristic of this phase include but not limited to plans to save lives and to help response and rescue operations, evacuation plans and stocking food and water are both examples of preparedness. Preparedness activities take place before an emergency occurs.

4.2.2 Response phase

The response phase involves immediate and ongoing activities, tasks, programs, and systems to manage the effects of an incident that threatens life, property, operations, or the environment. It is the response to emergencies using all systems, plans, and resources necessary to preserve adequately the health, safety, and welfare of persons or property affected by the emergency.

The onset of response is when an emergency event is imminent or immediately after an event occurs. “Response encompasses the activities that address the short-term, direct effects of an incident. Response also includes the execution of EOPs and of incident mitigation activities designed to limit the loss of life, personal injury, property damage, and unfavorable outcomes.” (FEMA, 2006)

4.2.3 Recovery Phase

The recovery phase follows from the response phase and could be considered a long-term response phase. The focus of the recovery phase is on activities and programs designed to return conditions to a level that is acceptable to the affected population. Various activities in this phase involve the development, coordination, and execution of service- and site-restoration plans; the reconstitution of government operations and services; individual, private-sector, non-governmental, and public-assistance programs to provide housing and to promote restoration; long-term care and treatment of affected persons; additional measures for social, political, environmental, and economic restoration; evaluation of the incident to identify lessons learned; post incident reporting; and development of initiatives to mitigate the effects of future incidents. (Brown & Ghilarducci , 2014)

The focus of this thesis is mostly on the response phase. However, there will be discussions of elements from other phases since the response phase does not and cannot exist in isolation of other phases. Some level of planning and preparedness must be made even after the disaster has occurred, and sometimes when a disaster has not been anticipated, the whole planning and preparation is done after the occurrence of the disaster.

The response phase and the recovery phase, as mentioned earlier, vary mainly in their duration and complexity of activities, with recovery stages seeing more of longer lasting activities and more complex rehabilitation and rebuilding activities targeted at restructuring the affected community.

4.3 ASSESSMENT OF WATER IN DISASTER

After disaster occurrence, the best way to determine if response is needed and what amount of response is needed is by carrying out a disaster assessment. Assessment is a vital component of the planning and implementation of the response. Damage assessment, in short, involves the identification and qualitative and quantitative examination of the effects of the event on the affected systems. (Pan American Health Organization, 2016). The necessary information needed is provided from the assessment. Standard methodologies are needed to carry out an accurate assessment.

The purpose of the assessment is to assist the authorities in the affected unit and the disaster management team in the identification and prioritization of needs for relief assistance and to facilitate a timely, appropriate response.

One of the cross-cutting themes that emerged from the expert interviews was that too often emergency responders do not adequately consider the local context before designing and launching safe water interventions. Failure to do so often leads to poor intervention performance and/or wasted resources. (S. I Ali and K. Kadir, 2016)

Generally, an assessment covers the impact of disaster on health, housing and infrastructure, water and sanitation, power sector, economic sectors, agriculture, manufacturing, commerce, tourism, and the environment. Considering the scope of this work, our focus here is the assessment of disaster impact on water and sanitation.

Considering that it is very essential for day to day functioning of a community, the water, sanitation along with the health sector are one of the first that must be rehabilitated after a natural disaster. Special attention must be paid to water quality, excrement removal (sanitation) and garbage handling, as one of the first stages following the emergency (United Nations, 2014).

4.3.1 Estimating damage to water systems

Due to the uniqueness of every water system, it is important to understand the characteristics of a water system before starting to estimate the impact of the disaster on the system. The following sections explain the steps to be taken in estimating the impact of a disaster on the water and sanitation sector.

During the assessment of water and sanitation after a disaster, the sectors under assessment include water supply, sanitary sewage disposal and solid waste collection and disposal. These assessments require special procedures.

Component	Damage			Sector		Effect of the Balance of payments
	Total	Direct	Indirect	Public	private	
Total Water supply systems Urban systems Infrastructure Rehabilitation expenses Diminished utility revenue Higher production costs Rural systems Infrastructure Rehabilitation expenses						
Waste water disposal systems Infrastructure Rehabilitation expenses Diminished utility income Higher production costs Rural systems Infrastructure Rehabilitations expenses Wells and latrines Solid waste systems Rehabilitation expenses Diminished utility revenue						

Table 1, Sample Table of Damage and Losses to Water Subsystems
United Nations, 2014

Before the assessment, the assessment team should have the detail of the affected system to enable them to understand and accurately evaluate the damage to the system. These details are utilized in the field to compare and figure out the losses and damage impacted by the disaster. “After the assessment is concluded, it should be possible for the water and sanitation specialist to prepare a table showing the most accurate and summarized information on damage and losses to the subsystems" See Table 1 (United Nations, 2014)

The typical steps to be followed during an assessment of damage and losses are the following:

- Define a pre-disaster baseline
- Develop a post-disaster situation
- Estimate damage and losses on a sector-by-sector fashion
- Estimate overall amount of disaster effects
- Estimate macro-economic impact
- Estimate impact on personal/household employment and income (Global Facility for disaster reduction and recovery (GFDRR , 2013; 5), (Alfred Opere, 2005; 12)

The water and sanitation specialist should strive to obtain all available information on the subjects listed below as a basis for the assessment. (United Nations, 2014). The information needed for in this regard as outlined by the united nations include the following:

4.4 **Drinking water system**

This is meant to establish the extent of damage done to drinking water system by comparing the pre-disaster situation with the post disaster situation in order to ascertain the differences in the systems. The differences, if there are, tell the changes and the extent of damage done to the drinking water system by the disaster.

4.4.1 The pre-disaster situation

The pre-disaster situations considered for are the organization the water sector institutions providing services (divided into public and private institutions), regulatory and policy setting entities with jurisdiction over the affected territory. Determining the pre-disaster coverage levels of water service including the urban and rural systems. Disaggregation of the population served by mass-distribution and private systems (piped water systems, wells, multifamily and single-family systems)

Another pre-disaster situation evaluated is the System layout plans. The system layout plan tells about the population served before the disaster (house connections, consumption levels, other aspects), rate schedules, existing subsidies and bill collection levels, production, and invoicing of subsystems (or firms) before the disaster, and the technical coefficient of producing companies and service providers (UN, 2014)

4.4.2 The post-disaster situation

Identify the urban and rural systems affected by the disaster, their administration and functioning. Determine the nature of damage to the affected systems, techniques and materials used in constructing system components, and physical accessibility of components of the affected systems. Determine whether the disaster has affected water treatment facilities, which would mean additional requirements for chemical products, reagents, or equipment (increase in inputs or intermediate consumption of the utility firms). Costs of materials, construction, equipment, chemical products, reagents, and other inputs needed to rehabilitate the systems. (UN, 2014)

Determine the remaining capacity and level of production and billing after the disaster, indicating any increase in the price of water supplied. Estimate the time needed for rehabilitating the affected systems. Obtain information on the organization and activities of water and sanitation utilities for providing interim service while systems are being restored. Those measures may include temporary use of desalination plants, tanker trucks or delivery of bottled water. Determine the measures for rehabilitating the systems. (UN, 2014)

4.5 **Damage to drinking water flood control structures**

Structures built with the drinking water system to prevent it from damage during flooding is one of the structures tested for damage post disaster.

Using the information on pre- and post-disaster situation, water supply specialist should estimate the damage to the system. “Generally speaking, damage will involve the destruction or disruption of infrastructure and equipment for urban and rural services (disaggregated by components) and the destruction of stocks (chemical products, stored water, spare parts and other assets).” (UN, 2014)

The estimation of damage is done by compiling a list of the damage to the system such as the drinking water system. The damage is grouped into into components or subsystems for each city or each system affected (United Nations, 2014). For example, in the case of an urban drinking water system, the information can be organized as follows:

- Catchment: intake A, intake B ....
- Pumping stations: station 1, station 2....
- Treatment plants: plant 1, plant 2......
- Main conduits to the storage tanks
- Storage tanks: tank A, tank B....
- Distribution network
- Other (specify in each case) (UN, 2014: 144)

The recommendation for the procedure of estimating the damage is to compile a summary description of the main characteristic and the type of damage and the approximate quantity of structures or materials of the damaged component affected using the appropriate units of measurement.

For each damaged component, indicate:

- The type of structure or material
- The unit price (UP) of full replacement by component
- The unit cost of repair (R%) , as a percentage of the unit price of replacement (UN, 2014; 144)

4.6 **Water quality in Emergencies and disasters**

Water quality after natural disaster is a major public health concern, one that requires immediate response. The success or averting or mitigating the spread of waterborne diseases is dependent on the effective management of water to enhance the quality of drinking water as well as water for other uses. "The greatest waterborne risk to health in most emergencies is the transmission of fecal pathogens, due to inadequate sanitation, hygiene and protection of water sources. Some disasters, including those caused by or involving damage to chemical and nuclear industrial installations or spillage in transport or volcanic activity, may create acute problems from chemical or radiological water pollution." (WHO, 2008; 61)

The effect on water quality after natural disaster depend on the type of disaster causing disruption to the water quality. Earthquake, landslides, hurricanes and other have different effects on water quality. The situation of people affected by a disaster also determine their exposure to water contamination. "When people are displaced by conflict and natural disaster, they may move to an area where unprotected water sources are contaminated. When population density is high, and sanitation is inadequate, unprotected water sources in and around the temporary settlement are highly likely to become contaminated." (WHO, 2008).

Other factors also contributing to the spread of disease after a disaster is the prevalence of diseases cases and carriers in the affected population. Since a natural disaster may come with it a reduction in food production, there are possibilities of diseases resulting from malnutrition which can increase the risk of water-borne diseases.

Where there are existing water treatment facilities before the disaster, there could be a reduction of water quality due to destruction or breaks in the water treatment and distribution system. This can cause untreated or partially treated water to be distributed, and contamination of drinking-water in the distribution system due to broken sewers and water transmission pipes.

Floods may contaminate wells, boreholes, and surface water sources with fecal matter washed from the ground surface or from overflowing latrines and sewers. During droughts, people may be forced to use unprotected water supplies when normal supplies dry up; as more people and animals use fewer water sources, the risk of contamination is increased.

4.7 Water Quality Assessment

Water supply in emergency follows from source identification to assessment, then purification, storage, and supply. The assessment and purification stages involve other sub stages which are dependent on a couple of factors such as the type of water source to be used; the nature of contamination characteristic of that source as well as the treatment technology suitable for the source.

Also, affecting the treatment technology or method to be used is the level of water need and supply. This means that there may be some differences or variations in the treatment techniques and technologies employed in different scenarios such as bulk water treatment for displaced population, village level water treatment or family (household) level water treatment.

Contamination type	Contamination agents
Physical	Particles and suspended solids: sediment or organic material suspended in the water of lakes, rivers and streams from soil erosion.
Biological	Fecal waste, Algae, Bacteria, Viruses, Protozoan, and Parasites
Chemical	Nitrogen, bleach, salts, pesticides, metals, toxins produced by bacteria, and human or animal drugs and Soil type

Table 2, Common water contaminants
Oxfam Humanitarian Department. Oxfam Guidelines for Water Treatment in Emergencies
United States Environmental Protection Agency

During emergency water assessment, the main specifications which are usually considered especially for time sensitive, short term supply are suspended solids, level of fecal contamination (microbiology), pH, and conductivity (measure of salinity). While the urgency of water need may warrant that the quality level of water treatment does not necessarily limit water supply, the goal is to continuously improve water quality along the line till the best possible quality is reached. These common types of contamination encountered in emergency water treatment are given in Table 2 above.

An important initial step in the treatment of water in emergency is the identifying the type of contamination that requires treatment. Since different modes of contamination means different treatment technologies employed, identifying the contamination type answers to what type of treatment technology is needed.

Water quality is most likely to be affected after an emergency. According to the WHO, “the greatest water-borne risk to health in most emergencies is the transmission of fecal pathogens, due to inadequate sanitation, hygiene, and protection of water sources” When water is not properly taken care of these water risks could culminate water-borne infectious diseases such as cholera, dysentery, typhoid, and infectious hepatitis (WHO, 2010)

As mentioned earlier, even though water quality might be low, the initial target of emergency water supply is to strike a balance between water quality and the provision of enough water for vital health protection. Water quality is then continuously improved throughout the response period till the optimal possible level of quality is reached.

Since many chemicals which can contaminate water become a health concern when they are consumed over an extended period, the advised strategy is to focus more on disinfection treatment which can kill pathogens as to to enhance the speedy supply of water to the affected population and at the same time reducing the risk of outbreaks which could happen due to water borne or water-washed diseases (WHO, 2008).

On the other hand, when water supply even during an emergency is meant for an extended use, chemical and radiological contaminants which may have chronic health implications would be given greater attention. The Addition of a treatment process to remove these chemical and radiological contaminants is one option at this stage or where possible, the usage of different water sources lacking in the radiological or chemical contaminant “of interest”. (OXFAM, 2001)

4.8 **Testing for Contaminants**

The following methods and guidelines follow from the World Health Organization’s guidelines on water testing during an emergency.

4.8.1 Bacteriological Testing

Before moving forward to test for bacterial contaminants in water, some important points are worth noting. The most important indicator tested for during bacteriological testing according to the WHO is “fecal indicator” organism. This is in the form of excreta of warm-blooded animals, health and unhealthy. During the testing, the target is to identify the degree to which this “fecal indicator” organism has contaminated a water body.

One “fecal indicator” bacteria that is a litmus test for the presence of contamination is the bacteria from the thermotolerant (fecal) coliform group according to the WHO. Thermotolerant coliforms are the type of coliforms that produce acid and gas from lactose at 44.5± 0.2°C within 24±2h, also known as fecal coliforms due to their role as fecal indicators (Ashbolt N. J., Willie O.K. Grabow and Mario Snozzi, 2001)

When they are found in water there is a strong indication of fecal contamination. Escherichia coli is mostly the typical species of Thermotolerant Coliforms derived from feces. However, it is sometimes necessary to test for bacterial from the total coliform group. This is used mostly after water treatment to determine how effective the treatment was in killing or removing bacteria from the water.

Filtration by means of a membrane technology, incubation or culturing are the steps involved in bacteriological testing. This method is fast and mostly cost effective which makes it suitable for emergency situations where time is always a factor. Other fecal indicator of bacteria includes fecal Streptococci or intestinal Enterococci. (WHO, 2008).

The membrane technology is used to filter a known volume of water leaving bacteria on its surface. The membrane, together with the bacteria is incubated in a favorable medium, using a battery-controlled incubator for 18 hours. During this 18-hour period, the thermotolerant coliform bacteria will reproduce and the count of bacteria present can be determined using a tactical calculation and the number of tubes which have given a positive reaction. (WHO, 2008).

A positive reaction means either a color change and/or gas production. This test is also suitable for emergency situations because its accommodates turbid samples of water even with sewage, sewage sludge, or mud and soil particles. (WHO, 2008)

Since it is difficult to reach conventional bacteriological standards while responding to disasters, especially in the immediate post-disaster period, it is recommended to classify water safety and use based on the WHO guidelines of zero E. coli per 100 ml of water (WHO, 2008).

A range of safety could be created based on WHO recommendations as:
zero E. coli/100 ml: guideline compliant;

- 1–10 E. coli/100 ml: tolerable;
- 10–100 E. coli/100 ml: requires treatment;
- greater than 100 E. coli/100 ml: unsuitable for consumption without proper treatment. (WHO, 2008)

There is a need still to test for other forms of biological contamination since the fecal indicator bacteria alone cannot guarantee a good biological quality of water. There are possibilities that some pathogens, including viruses and protozoa are present since they may be more resistant to treatment which would ordinarily remove the indicator bacteria, for example treatment with chlorine. If a bacteriological test or analysis finds out the possibility of a fecal contamination, it is always regarded as a high risk so that other biological contaminants need to be tested for.

Generally, microbial safety of water is measured with parameters such as E. Coli test using the thermotolerant coliform indicator, residual chlorine, pH, and turbidity.

4.8.2 Residual chorine test

Residual chlorine test, as mentioned earlier, is one of the tests done to ascertain the microbial safety of water. Testing for chlorine in the field is done with a color comparator. It is used for water in the range of 0.2 – 1milligram per liter (mg/l). It is not the most reliable indication of chlorine concentration but can test for the presence of chlorine. It has some limitations, for example, it should not be used in the presence of any oxidizing agents including Bromine, iodine, permanganate, hydrogen peroxide, and ozone which can interfere with the result. Sample color and turbidity may also interfere. (WHO, 2010). It is used in emergency testing due to affordability.

4.8.3 pH test

The essence of pH testing in water before disinfection is to ascertain the type and time of treatment needed. More alkaline water, for example, needs longer contact time or higher chlorine level towards the end of the contact time to enhance disinfection. (WHO, 2010)

Water pH testing can be done in three different methods of pH measurement; pH indicator paper, liquid colorimetric indicator, and electronic meters. The pH indicator paper is simple and inexpensive but not very accurate since its reading is subjective and could be prone to errors. However, it is suitable for emergency due to cost and easiness of use. The Liquid colorimetric indicators change color in accordance with the pH of the water with which they are mixed. The color that develops can then be compared with a printed card, with colored glass standards, or with a set of prepared liquid standards. (WHO, 2010)

Colorimetric methods are reasonably simple and accurate to about 0.2 pH units. Their main disadvantage is that standards for comparison or a comparator instrument must be transported to the sampling station. Moreover, physical, or chemical characteristics of the water may interfere with the color developed by the indicator and lead to an incorrect measurement. The third method, electrometric pH measurement, is accurate and free from interferences. Pocket-sized, battery-powered, portable meters that give readings with an accuracy of ± 0.05 pH units are suitable for field use. Larger, more sophisticated models of portable meter can attain an accuracy of ± 0.01 pH units. (WHO, 2010)

Care must be taken when handling such equipment. The electrodes used for measurement generally need replacing periodically (e.g. yearly). Old or poor-quality electrodes often show a slow drift in the readings. (WHO, 2010)

4.8.4 Turbidity

Turbidity is the amount of cloudiness in the water. This can vary from a river full of mud and silt where it would be impossible to see through the water (high turbidity), to a spring water which appears to be completely clear (low turbidity). It is measured to determine what type and level of treatment is needed. It can be carried out with a simple turbidity tube that allows a direct reading in turbidity units (NTUs). Turbidity adversely affects the efficiency of disinfection and could increase the cost of water treatment.

The advantages of the turbidity tube especially with respect to emergency water treatment are its simple design, inexpensive use and that it is not easily damaged. The disadvantages however are that it cannot measure very lower turbidites (usual minimum is 5TU) and it is less precise.

Under normal circumstances not requiring a high cost sensitivity, a turbidity meter could be used, which has a higher efficiency level than the turbidity tube but is expensive.

4.8.5 Sanitary surveys and catchment mapping

Another, and mostly more valuable, way of assessing the likelihood of water source contamination is a sanitary survey. According to The US Environmental Protection Agency, "Sanitary survey means an onsite review of the water source, facilities, equipment, operation and maintenance of a public water system for the purpose of evaluating the adequacy of such source, facilities, equipment, operation and maintenance for producing and distributing safe drinking water."(EPA, n.d).

A sanitary survey is more reliable than the bacteriological testing alone because with a sanitary survey it is possible to see what needs to be done to protect water source. Since sanitary survey is done one period at a time, it gives a current, more reliable state of water source and water facilities.

In combination with bacteriological, physical, and chemical testing it enhances the efficiency of assessing water contamination and may provide a basis for monitoring water supplies in the post disaster period. (WHO, 2008)

The catchment method of water treatment utilizes a catchment system which demarcates water sources based on surrounding characteristics. These characteristics could be based on proximity of fecal contamination (human or animal), color and smell, the presence of dead fish or animals, presence of foreign matter such as ash or debris and the presence of chemical or radiation hazard or a water discharge point upstream. Visual assessment is made on sources of, and potential routes for pollution. A sanitary survey and catchment mapping standards are followed to ensure that the outcome is reliable.

4.8.6 Chemical and radiological contaminants

While choosing emergency water supply source it is important to avoid water bodies considered to have high risk of chemical and radiological contamination, even as a temporary measure.

5 EMERGENCY RESPONSE PLAN

Emergency Response Plans (ERPs) for community drinking water are plans of actions that a community water system (CWS) would take in response to major events. These events include, among others, major disasters, or emergencies such as storms, earthquakes, tornadoes, hurricanes, flood, explosion, and fires regardless of cause and catastrophic events which have significant effects leaving damages, disruption severely affecting the population, environment, infrastructure, teleonomy, and government functions.

An up-to-date emergency response plan would help a community drinking water system achieve its primary goal of protecting public health especially in crisis situations. In adapting emergency response plan, care should be taken that the guide used fits the number of the people served by the plan. This number reflects the population of the people living in the community. According to the Environmental Protection Act in the US, there are guidelines for Systems serving populations between 3,301 and 99,999 and Systems serving populations of 100,000 and greater. (EPA, 2011, EPA, 2002)

Before setting out to develop an emergency response plan for drinking water emergencies, a vulnerability assessment should be carried out first. Undertaking a proper and carefully planned assessment helps in understanding the situation in order to identify the problem(s), the source of the problem(s), and the consequence(s). At the stage of the assessment, identifying an intervention is not necessary as the aim at this point is to find out whether, or not, an intervention is needed.

During the planning stage of emergency response, it is important to identify and coordinate with first responders as well as other ERP partners or groups who will assist in the event of water disaster. Some of these groups include healthcare department, laboratories, law enforcement departments, fire departments, local environmental agencies, hospitals, community groups, broadcast and print media and nearby utilities. Included as well could be state and Federal agencies. It is important to coordinate with these groups during the planning stage to get the best advice for developing the response plan as well as to notify each group of their role during the emergency. This helps everyone involved to respond better to the emergency increasing emergency response success.

Following the guideline outlined by the United States Environmental protection Agency (USEPA), there are elements common to an ERP that should be utilized during water emergencies. These eight core elements are the foundation for responding to water event

1. System Specific Information;

2. CWS Roles and Responsibilities;
3. Communication Procedures: Who, What, and When;
4. Personnel Safety;
5. Identification of Alternate Water Sources;
6. Replacement Equipment and Chemical Supplies;
7. Property Protection; and
8. Water Sampling and Monitoring. (EPA, 2011)

5.1 System Specific Information

Certain information is crucial for responding to water emergencies. The smooth execution of emergency response depends on this technical information being readily available for first responders, personnel, repair contractors/vendors, the media and others who play a role in water emergency response. Such technical information as source water locations, distribution maps, location of critical documents, detailed plan drawings, site plans, and operations manuals should be already identified and easily reachable in the event of water emergency response activities. It is important to note that the location and review of these information should have already been done during the Vulnerability assessment stage. The emergency response plan only needs to clarify [its] availability. (EPA, 2002; 4)

5.2 Basic Information in Emergency Response Plan

The following information should be included in the emergency response plan, as outlined by US EPA.

- Public Water System (PWS) ID, Owner, Administrative Contact Person, Alternate Administrative Contact Person;
- Population Served and Service Connections;
- Distribution Map;
- Pressure Boundary Map;
- Overall Process Flow Diagrams;
- Site Plans and Facility “As-Built” Engineering Drawings
- Pumping and Storage Facilities
- Reservoirs and Retention Facilities
- Water Treatment Facilities
- Booster Pump Stations
- Pressure-Regulating Valve (PRV) Sites
- Distribution System Process and Instrumentation Diagrams (P&ID)
- Equipment and Operations Specifications
- Emergency Power and Light Generation
- Maintenance Supplies
- Operating Procedures and System Descriptions including back-up systems and interconnections with other systems;

- Supervisory Control and Data Acquisition (SCADA) System/Process Control Systems Operations;
- Communications System Operation;
- Site Staffing Rosters and Employees' Duties and Responsibilities; and
- Chemical Handling and/or Storage Facilities and Release Impact Analyses (i.e., chemical releases into air or water). (EPA, 2011)

All the above information, however, do not need to be available before you can successfully operate a response intervention. A complex Community Water System would nonetheless have a higher level of technical documentation plan for an emergency response plan.

5.3 Roles and Responsibilities of Community Water System (CWS)

The planning of emergency response for water after a natural disaster requires an Emergency Response lead (ER Lead). The role of this emergency response lead will be as the main point of contact and as a decision maker during the emergency response after the disaster. The responsibilities of the ER lead include evaluating incoming information, managing resources and staff, and deciding on appropriate response actions. He should work closely with the first responders during the emergency response activities. (EPA, 2002).

An alternate Emergency Response lead (ER) should be appointed to fill in, in case of absence of the main ER lead. Nevertheless, the main and alternate ER lead should be reachable at every hour of the day and every day of the week. Note, however, that there could be a different title, name, or designation for the ER lead. The roles and responsibilities of an ER lead in water emergency coordination does not change even with a change in name. (EPA, 2002).

The role of the ER lead is explained in the meaning of Incident Command System (ICS). The Incident command system applies the incident command model to the command, control, and coordination of an emergency response. The incident command system necessitates a structure for coordinating first responders and improving a command structure for specifying roles and responsibilities in stabilizing water emergency and protecting life, property, and the environment. (EPA, 2002)

At the CWS level, the ER lead is the main contact person and the decision-maker, they are also known as the Incident commander in the Incident Command System. In the event of major disaster of higher significance, the local, State, or Federal officials can take over the Incident command system in which case they would have an incident commander who in turn is the ER lead. (EPA, 2002)

5.4 Communication Procedures

Communication is an important aspect of general emergency planning and response. Knowing who, what and when at every point during and emergency can prove indispensable for the success of emergency coordination and response. During water emergency planning and response, a clear communication structure should be identified for CWS staff and personnel, external non-CWS agencies, and the public through the media. (EPA, 2002; 6)

During the planning of response to water emergency, a comprehensive list of names of the necessary agencies together with their communication contacts; phone numbers, emails, or other communication channels should be maintained and promptly updated for effective communication and coordination.

Whatever means of communication possible -traditional and non-traditional means- a failsafe and efficient communication is indispensable to exchange information of coordination of actives with water emergency players and to provide timely, accurate and complete information to the media and the public. (EPA, 2002; 6)

5.5 Personnel Safety

Safety is an important issue during water emergency. A crucial aspect of emergency response for water after a disaster is anchored upon keeping both emergency responders and the residents of the community in question safe. There may be a risk of harm, injury, or even death to the emergency personnel and these should be taken into consideration while making emergency response plan.

Taking personnel safety into account during water emergency response planning requires taking certain factors of safety into account. Factors such as evacuation planning, training and information, assembly areas and accountability, and shelter.

Plans should be made for evacuation routes and exits making sure that they are clearly marked, not obstructed, lighted, and would not expose personnel to additional harm. The staff and responders in a water emergency should be trained and equipped with the necessary information.

At the end of each round, there is need to identify every personnel. It is important to designate a specific place for gathering at specific times for taking head counts using identified specific procedures.

Shelter is an important element of safety in emergency. Taking shelter during some major events (shelter in place) can prove to be the best means of protection in that case. Shelters can be within the Community water system or away from it at another location provided a provision is made for it.

Staff in CWS and other internal and external responders to emergency water management should be trained in evacuation, shelter and other safety procedures. (EPA, 2002)

5.6 Emergency Equipment

Emergency response equipment need to be available at all time during emergency response. The procedure for use and maintenance of that equipment need to be clearly stipulated in a written form. This can also form a part of the training and information section in emergency preparation.

Occasions requiring first aid treatment during emergency response should be anticipated. As such, provisions of first aid treatment for staff and others onsite at the CWS should be made. Water emergency response planning should include safety precautions for victims and more detailed information for medical professionals. It is recommended that individuals or groups responsible for first aid, as well as other medical interventions be identified during the emergency response planning.

As outlined by the USEPA, "You should focus on standard Occupational Safety and Health Administration (OSHA), Spill Prevention Control and Countermeasures (SPCC), Risk Management Program (RMP), and State procedures to define your own personnel safety procedures. Your staff should understand when to evacuate, when and how to use PPE, and how to rapidly locate additional safety information, such as chemical-specific Material Safety Data Sheets (MSDS). You could also consult with other utilities and water organizations." (EPA, 2002; 8)

5.7 Identifying Alternate Water Sources

Before moving forward with planning for alternate water sources, it is important to have clear information about factors directly involved with water situation at the moment, such as the extent of water supply outages, the current water supply system as well as the distribution channels and the water system demand requirements. Water outages can be short-term, ranging from hours to days, or long-term which can span from weeks to months. During the response planning, identifying alternate water sources fitting each situation (long term or short-term outages) is crucial to a successful response execution. (EPA, 2002)

6 EMERGENCY DRINKING WATER SUPPLY

Factors relating to the feasibility of water supply are examined before emergency water supply commences in order to find out the situations of water supply in the affected area and what needs to be done to provide useable water to the affected population.

6.1 Emergency water supply situations

During water emergency as it is almost always the case after a natural disaster, varying situations have a huge impact on the type and strategies of water supply system needed, from the water source, retrieval, transportation (if needed), treatment and supply. According to the World Health Organization "situations demanding an emergency water-supply response Short-term water-supply needs and emergency measures may differ in the following types of situations:

- short-term emergencies affecting rural or unserved peri-urban communities;
- short-term emergencies in urban situations where a central water service is available;
- short-term emergencies involving population displacement and temporary shelters;
- long-term displacement emergencies that result in semi-permanent emergency settlements.

The process of assessment provides valuable data for identifying the situations, needs, damages and resources which are needed in order to appropriately and effectively respond to each situation with the right amount of tool and force needed. This means that close monitoring is essential over the course of emergency supply in order to observe changes and apply the relevant responses needed.

Another interest of emergency water supply is hygiene promotion of the affected population. Hygiene promotion reduces risk, increases resilience, and mitigates the impact of disaster on health according to the WHO. This means that water supply design and implementation should take into consideration the hygiene needs of different population categories; women, children, the sick and elderly. Appropriate consultations should be made during the phase of design to ensure a proper design with hygiene considerations.

The success of emergency response depends on the planning and preparation level long before the emergency event takes place. However, certain factors cannot be known unless the disaster strikes and water distribution, availability or integrity has been affected. One cannot tell the extent of damage, or interruption, vulnerability levels of water before an event. Estimations, however, could be made, and preparations put in place to help quick response in the event of an emergency.

Water Safety Plans embody a comprehensive risk assessment and management approach that examines all possible points of recontamination from catchment to consumer (WHO, 2005).

Before a water emergency and the corresponding response, an emergency drinking water plan can be developed in four steps. These plans can also take place after a disaster has occurred as to respond appropriately to the situations of water disturbance.

i. An assessment of the vulnerability and the potential level of outage taking the events, likelihood of events and the consequences of those events into account.

Potential vulnerability to water supply utilities and water integrity are assessed before the event of a disaster. If an already prepared document or procedure is not available, the extent of the vulnerability can be assessed after the occurrence of a disaster. The likelihood and potential impacts on basic infrastructure and on water distribution operation is assessed before the disaster and like the former situation, the resulting impacts on basic infrastructure and on water distribution operation is assessed after the even had occurred. Information on water outage is very important in responding to water emergency. Knowing for how long water supply is interrupted and consequently identifying alternative water sources during the interruption period is very important. The scope and level of the outage will vary. This will depend on the extent to the disaster event and to what extent the water system has been affected.

ii. A target level of water quantity and quality to be reached post-event should be determined. Where possible, the recommendation is to start with 3 gallons per person per day at a quality acceptable for human consumption. Timing recommendation after the onset an event is within the first 3 days, 10 days, and 21 days.

iii. Alternative drinking water should be identified, analyzed and a detailed implementation plan should be developed.

iv. Plan implementation, pre- and post-event (WHO, 2008)

6.2 CONSIDERATIONS BEFORE IMPLEMENTING EMERGENCY DRINKING WATER PLANS

Before implementing emergency, drinking water plans certain practicalities need to be figured out to ensure a smooth implementation. The basic components of water supply which include procurement, implementation and operation are very important to examine and understand. Other factors which are directly affecting the extent of intervention needed include water use per capita, time scale of outages, the population affected, and the water quality targets.

6.2.1 Basic components of Water supply

Water supply to a community or customers in emergency situations follow four important steps. These steps involve the retrieving water from the source, then the treatment of water, the storage, and the distribution. At each stage of these steps of water supply, considerations are made about factors affecting the feasibility of each stage. These factors are generally grouped into procurement, implementation, and operation. (WHO, 2002)

6.2.2 Procurement

At each stage of the water supply planning and implementation, steps, and coordination of getting the required equipment or services needed for a stage is an important factor, especially during an emergency. The necessary procedures should be taken to overcome legal and regulatory constraints at each stage of the procurement. Financial factors and terms of procurement should be addressed before procurement as well as coordination between agencies involved in the procurement activity. Depending on the level of water impact and disruption after a natural disaster, the need for source procurement can range from easy to difficult with respect to the legal and regulatory constraints, financial factors, and coordination procedures between and within agencies. (EPA, 2011; 27)

6.2.3 Implementation

Another consideration relating to a successful execution of the four steps of water supply during emergency is the actual implementation of plans. During the implementation period at each stage, certain issues such as transportation and equipment, issues relating the site and the acquirement of the necessary permits required for the work as well as coordination between and within all the agencies involved. (EPA, 2011)

6.2.4 Operation

Operational planning is considered with respect to the water source, the treatment and, the storage and supply. Issues relating to staffing are important at this stage of planning and execution. During staffing planning, considerations are made regarding hiring, positioning and management of employees. Every stage, water source, treatment and the storage and supply require different kinds of staffing planning and constituents. The same goes for other factors of operation such as maintenance, agency coordination and demobilization after the hazard restoration. (EPA,2011)

Before planning a successful emergency intervention, estimations are made about factors directly affecting the extent of the intervention needed and the corresponding data collected.
The key estimation for planning requires assumption regarding water use per capita, time-scale of outages, the population affected and the water quality targets. (WHO, 2008)

6.2.5 Water Use per Capita

Water use per capita means the amount of water an average person uses per day. Depending on a place, estimates do vary between places. Under normal situations, estimates are made between 80 and 100 gallons of water per person, per day. However, the recommended estimate during emergency situations are between 0,5 gallons to 5 gallons per person per day. This amount depends on whether water for all purposes are included in the estimation or water for only one purpose (e.g. drinking, bathing, food preparation, hygiene, etc.) This value also depends on the area, the extent of the hazard impact and the availability of water resources. (WHO, 2008)

6.2.6 Time scale of outages

Due to the importance of water in all daily activities, from consumption to hygiene as well as other production activities such as agriculture and industrial use, water outage can prove catastrophic if it lasts a long time before either restoration or relieve to support the affected population before a lasting solution is reached. It is therefore of high importance to evaluate the time scale of outage already during emergency preparation phase. Having information on the time scale of outages can make clear the type of response needed and the time needed to start the response. According to the WHO, water supply needs for short term or long term depends on some factors. "Short-term water-supply needs, and emergency measures may differ in the following types of situations: — short-term emergencies affecting rural or unserved peri-urban communities;

6.2.7 Population affected

An important consideration before commencing emergency water supply is the number of people affected by the outage. The main public health target is to provide to provide basic water supply to the affected population. The most effective way to ensure an efficient emergency water supply measure is through a process of assessment, monitoring and review. The number of people affected by a hazard and their extent imminent emergency water supply needs could be identified by a careful assessment. This method ensures that the response remains relevant to the needs and resources of the communities affected by the disaster. (WHO, 2008).

6.2.8 Water Quality Targets

In emergency situations, availability of water sources is very limited. Providing a sufficient quantity of water for personal and domestic hygiene as well as for drinking and cooking is important. "Guidelines and national drinking-water quality standards should therefore be flexible, taking into consideration the risks and benefits to health in the short and long term, and should not excessively restrict water availability for hygiene, as this would often result in an increased overall risk of disease transmission." (WHO) According to a guideline provided by the world health organization, some factors should be considered while thinking of drinking water for a population affected.

The following are the guidelines by the WHO:

- The quantity of water available and the reliability of supply – Because it is usually easy to improve water quality than increase its source, finding enough quantity of water is of the overriding concerns of water during emergency. It is also harder to move affected people close to a place where there is higher water supply. (WHO, 2008; 105)

- The equitability of access to water – Ensuring that access to water is equitable for all people to meet their need is an important aspect of managing water in disaster. Rationing water at some point might be a good idea to ensure equitability. (WHO, 2008; 105)

- The quality of the raw water – Where there is an option to choose, "It is preferable to choose a source of water that can be supplied with little or no treatment, provided it is available in sufficient quantity. " (WHO, 2008; 105)

- Sources of contamination and the possibility of protecting the water source – Protecting water sources from contamination should be a top priority of water management in emergencies. (WHO, 2008; 105)

- The treatment processes required for rapidly providing a sufficient quantity of potable water – "As surface water sources are commonly used to provide water to large populations in emergencies, clarification of the raw water – for example, by flocculation and sedimentation and/or by filtration – is commonly required before disinfection. "(WHO, 2008; 105) .

- The availability of bottled or packaged water – Although bottled water or packaged water is good for emergency situations, getting them to people who need them could be quite challenging. Using local, small treatment plans can be a solution to this. There are possibilities of recontamination during storage, distribution and use and this should be prevented from happening. (WHO, 2008; 105)

- The treatment processes appropriate for post-emergency situations – It is important that treatment options chosen are sustainable by considering cheaper options and this is done early in the emergency response. (WHO, 2008; 105)

- The need to disinfect drinking-water supplies – Poor hygiene is usually a possibility during emergencies. This often leads to disease outbreak and spread especially in populations with low immunity. Disinfection of water is therefore very important in this case. (WHO, 2008; 105)

- Acceptability – "It is important to ensure that drinking-water provided in emergencies is acceptable to the consumers, or they may resort to water from unprotected or untreated supplies. "(WHO, 2008; 105)

- The need for vessels to collect and store water – Vessels that are hygienic and appropriate to local needs and habits are needed for the collection and storage of water to be used for washing, cooking and bathing.

- Epidemiological considerations – It is important to consider every transmission route for waterborne and sanitation related diseases in disasters and this includes person-to-person contact, aerosol, and food intake. This also provides perspective in the method for water treatment. (WHO, 2008; 105)

7 SIGNIFICANT AREAS OF EMPHASIS FOR EMERGENCY DRINKING WATER PLAN

In building blocks for emergency water plan there are several categories. In order to make a good plan, it is essential that the degree of the outage is measured as well as the damages caused to the water providing infrastructures. Once these areas of damages are identified, repair of the damaged areas will be made to avoid the wastage of feature supplied water. This is an important step during planning.

7.1 System Lay-off and Repair Capabilities as Ways of Minimizing Water Outage

Water scarcity can be compensated without seeking alternative source(s) depending on the extent of the outage.

- Lost water services can be minimized by laying-off some pipe connections and through tactical placing of valves to separate pipes that are damaged. For instance, Cleveland and New York City use this redundancy method for emergency water supply plan whereas Seattle uses the pipe connection and separation method to disconnect damaged pipes thereby increasing the service availability.

- In order to separate the damaged pipe areas and to avoid sources of pressure loss, it is necessary that there is availability of usable valves. Information regarding the valve requirements of the system will be ascertained through field enquiries.

- While the water treatment plants are being repaired, already treated water storage may be used to maintain service at the period.

- Equipment such as generators, fuels, pipes can be helpful in delivering water services through already existing systems in cases of light outage and water pipe damages. It was recorded that insufficient fuel for an emergency generator and inability to recharge cell phones and radios hindered the emergency response in the repercussion of Hurricane Katrina.

In reinforcing an emergency drinking water plan after a natural disaster, there are many building blocks/factors that are essential, i.e. source, treatment, storage, and distribution. Each of these factors are discussed below in details. (WHO, 2008).

7.2 Sources

The basics for sustainability, treatment and total recovery of water outage is dependent on the available alternative sources.

The conversation about drinking water sources (and other sources) with the people convened is carried out by the primary health-care worker or other development personnel before an emergency arises (WH0, 2002). In a situation where there is no existing plan for alternative water sources before a disaster, temporary solutions are made for a short term including water trucking and light-weight, mobile equipment. They are more appropriate than solutions which require gradual improvement. It is recommended to review the situation of the people needing this type of supply to estimate the number of people needing this supply, their health status, and the length of time they would need emergency water supply (WHO, 2002).

The available source could be treated which includes water from pipes, trucks, and bottles or untreated which includes surface and groundwater. The major alternative sources include:

- Local alternative source
- Water utilities in the neighborhood
- Massive water transport
- Bottled water
- Other sources (Diaries, soft drink bottling plants, breweries, large swimming pools WHO, 2002).

7.3 Water Treatment

As a way of achieving water quality targets, humanitarian workers have traditionally relied on bulk chlorination to inactivate pathogens present in clear water (both for groundwater and surface waters). In the case of high turbidity source waters (often surface waters), an additional pre-treatment step to reduce turbidity of assisted sedimentation (commonly using Aluminum Sulphate - alum) is indicated. According to Ali S.I. and Kadir K. (2016), Reiff (2002) notes that Alum flocculation and chlorination are widely used in the humanitarian sector because materials are widely available, they are simple to use and relatively low cost, and importantly, because chlorination provides residual protection against recontamination Ali S.I. and Kadir K. (2016). While this approach to water treatment has been dominant, particularly in large displacement camps, the increasing sophistication of water sanitation and hygiene (WASH) response has also resulted in the diversification of approaches to water treatment in emergencies.

Choosing the right water treatment method in emergency situations can simplify and facilitate water delivery. Care should be taken, therefore, that a simple and cost-effective water treatment option is chosen. Where possible, sources with higher safety quality should be used to minimize the treatment demands. When treatment is found to be necessary, deciding which treatment system is the most suitable depends not only on the raw water quality but also on the availability of construction materials and chemicals. It is important to note that many of the water treatment methods used would need disinfection before water is safe for drinking.

"The processes required to render raw water potable depend on its physicochemical and biological quality. Surface water that is highly turbid and heavily contaminated usually needs some form of pretreatment to prepare it for disinfection or, in some cases, slow sand filtration." (WHO)

The spread of waterborne pathogens is of concern during population displacements (due to war, famine, or natural disaster), major floods, and fecal-oral disease outbreaks (Watson, Gayer, and Connolly, 2007; Lemonick, 2011; Cann et al., 2013).

7.4 **Removal or reduction of suspended solids**

The quantity of suspended solids in water besides constituting, in itself a, contamination to the water determines the quantity of pathogens in water and how easy it is to kill off the pathogens in water during disinfection. Water nephelometric turbidity units (NTU) is the measure of how suspended materials in water is carried. These suspended materials are mud, rust, algae, dust, and other solid matter on water. Surface water is prone to suspended solids and unlike groundwater sources require the removal of these suspended solids to prepare water for use.

7.4.1 Treatment of suspended solids at intake

The essence of treatment of suspended solids at intake is to take, care at the level of planning and implementation of water intake, that debris and other dirt do not get into the uptake system thereby constituting additional water treatment problems.

According to OXFAM guideline, creating an intake channel which does not face the main flow of a river can be effective in reducing the number of suspended solids carried to any suction pipe inlet screen. The design should be made such that the position of the intake is situation at a slower flowing area of the water source since faster flowing areas carry more dirt.

OXFAM guideline also encourages a twin line of pipes which can allow that maintenance be carried out without a disruption in the water uptake. Filtering at suction level either by using fabrics on the suction pipe and customized pipes with holes and drums or gabions made of coarse gravel will protect water intake from excessive suspended solids. A gabion is a wire mesh cage or basket usually filled with stones. Gabions are useful in construction works, for example to protect earth embankments, to line channels, to manage or divert, river or stream flow and to protect river banks or coastlines. One of the advantages is its permeability, allowing water to run through and act as filters for finer soil particles, thus giving protection to less stable materials. The position of the intake pipe can improve the quality of drawn up water. The positioning can be at about 0.5m below water surface which can prevent algae growth. However, the position should be above the water bed to prevent sediments rising from the bottom of the water.

7.5 Treatment options

It is common after a disaster to have a certain number of people displaced from their homes. The choice of water treatment approaches differs to some extent depending on whether mass displacement has occurred or not.

Water treatment in all situations target to provide potable water, that is, free of pathogens and chemically adjusted for consumption and safety. In most cases of emergency, the noticeably most important water contaminants are pathogens (microbial contamination). Chemical contaminants, nonetheless, could be dangerous but they are not, always, immediately life threatening in emergency conditions. However, it is suspected that future water pollutions in certain locations can pose more threats of water chemical contamination, as in the case of Bangladesh and East India where there is excessive ground water poisoning.

Water supply during emergency may fall below the WHO recommendations in the beginning. As the supply progresses, the target is to improve water quality as well as quantity to acceptable limits as soon as possible. In emergency, surface water presents the most easily reachable water source. However, surface water sources, unlike ground water sources are more susceptible to contamination with particles and pathogens. Water purification in these situations is characterized by a removal of suspended particles and water disinfection.

While choosing a water source after a disaster, it is recommended to consider both the water quality and the water quantity (EPA, 2012). It may not be entirely wise to focus on one factor while ignoring or giving adequate attention to the other. In an ideal situation (non-emergency situation) water supply quality can be strict and still have available resources to produce adequate quantity. This is not the case in an emergency. Care should be taken that enough water is provided to sustain individuals and community activities until the normal water functions are restored. At the same time, a balance between the quantity and quality should be struck in such a way that the water provided is safe for health and other hygienic activities and sufficient to sustain necessary activities.

There is a possibility to separate water supply in terms of quality. Under this consideration, water use could be divided in such a way that higher quality water is assigned for food preparation and consumption while the “poorer” quality water is assigned for other activities (e.g. washing). This, however, could pose a management challenge since different facilities and mechanisms of treatment might be needed to maintain this process. Considering from ease-of-management point of view, a large dirty water supply might be easier to handle even though it requires a labor-intensive treatment process. This is so considering that the treatment and supply of water from one source (centralized) as opposed to from different sources (decentralized). Decentralized water treatment and supply can pose a management challenge even though water from smaller sources might be cleaner. Water supply from one source reduces the amount of transportation needed for water supply and the transportation for treatment supplies and increases coordination between groups and communities.

Post-disaster water treatment could be organized under three categories: point-of-use treatment, semi centralized, and centralized or satellite (distributed) treatment.

The semi centralized, and the centralized systems are similar with few differences. The most important difference in the amount of people intended to be served by the systems.

Table 3: Organization of water treatment

Water treatment options	**Description**	Scale
Point of use	Individual homes	Small scale 10s - 100s
Semi-centralized	A level serving few multiple homes	Medium scale: 1000s – 10,000s
Centralized	A single point serving a town-size settlement (urban, village, large camps)	Large scale: 100,000s– 1,000,000s of liters per day

7.5.1 Point of use

Point of use or point of entry water treatment is mostly done at household, businesses, or school levels. This means that water is treated at the same place where it is intended to be used and for a small number of people. Household water treatment (HHWT) solutions are the steps taken to bring water treatment technologies closer to home use. Physical methods for HHWT include boiling, solar disinfection, UV irradiation, plain sedimentation, filtration, and aeration. Chemical methods include coagulation-flocculation, chemical precipitation, adsorption, ion exchange, chlorination, ozonation, chlorine dioxide, iodination, acid/base treatment, and silver/copper contact. (Ali and Kadir, 2016)

According to Ali S.I. and Kadir K. (2016), Sobsey 2002) points out that there are also options of HHWT that combine physical and chemical processes such as combined flocculant-disinfectant products and systems integrating coagulation-flocculation, filtration, and disinfection Ali S.I. and Kadir K. (2016). Some of the more common types of HHWT include combined flocculant-disinfectants (e.g. PuR, WaterMaker), chlorination (e.g. Aquatabs, CDC Safe Water System), rapid and slow sand filters (e.g. ceramic filters, biosand filters), solar disinfection (e.g. SODIS), and ultraviolet disinfection (Ali and Kadir, 2016).

Since household members carry out these treatments, training is required for a correct deployment of the treatment processes. HHWT has been shown to have certain level of lower effectiveness as compared to laboratory results using similar principles, due to an incomplete compliance with the recommended treatment methods. (Enger et al., 2013)

The methods of point-of-use water treatment are suitable for water taken from any source but, in general, will only remove physical and microbiological pollution. Pollution by chemicals such as after a spillage of industrial waste will not normally be removed by these processes and specialist advice should be taken. (Kayaga & Reed, 2011)

Generally, household water treatment undergoes stages from straining, storage/settlement, filtration, and disinfection as shown in figure below

7.6 **Straining**

Straining is a very simple method of filtration. In this process, water is poured through a piece of cloth, which removes some of the suspended silt and solids and destroys some pathogens (WHO, 2011) After straining, water may not be perfectly safe for drinking, but it can be a drinking water improvement step for people with no other treatment options. It is very important to use a clean cloth, as a dirty cloth may introduce additional pollutants into the water.

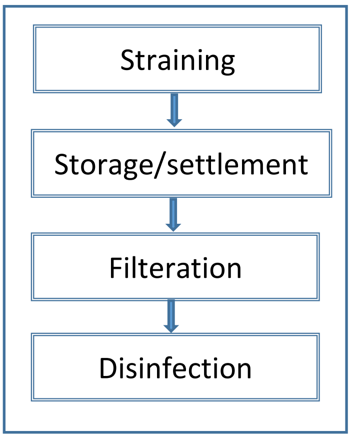


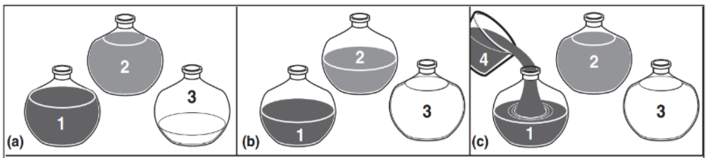
Figure 5 Household water treatment method

Some monofilament filter cloths are specifically made for this purpose and may be used in areas where guinea-worm disease is prevalent. Such cloths remove organisms known as copepods, which act as intermediate hosts for the guinea-worm larvae. The cloth must always be used with the same surface uppermost. The cloth may be cleaned using soap and clean water (WHO, 2011)

7.7 Aeration

Water treatment by aeration brings water and air in close contact to remove dissolved gases (such as carbon dioxide) and oxidizes dissolved metals such as iron, hydrogen sulfide, and volatile organic chemicals (VOCs). During aeration, constituents are removed or modified before they can interfere with the treatment processes. With increased oxygen content, volatile substances such as hydrogen sulphide and methane which affect taste and odor are removed. Carbon dioxide content of water is reduced and dissolved minerals such as iron and manganese are oxidized so that they form precipitates, which can be removed by sedimentation and filtration.

At the household level, water and air are brought in close contact in a number of ways: rapidly shake a container part-full of water, for about five minutes and then allow to stand for a further 30 minutes to allow any suspended particles to settle to the bottom. On a larger scale, aeration may be achieved by allowing water to trickle through one or more well ventilated, perforated trays containing small stones. (Kayaga & Reed, 2011)



Always draw water for drinking from Pot 3. This water has been stored for at least two days, and the quality has improved. Periodically this pot will be washed out and may be sterilized by scalding with boiling water. Each day when new water is brought to the house:

(a) Slowly pour water stored in Pot 2 into Pot 3, wash out Pot 2.
(b) Slowly pour water stored in Pot 1 into Pot 2, wash out Pot 1.
(c) Pour water collected from the source (Bucket 4) into Pot 1. Strain it through a cloth.

Using a flexible pipe to siphon water from one pot to another disturbs the sediment less than pouring.

Figure 6 Three-pot treatment
WHO, 2011. Regional Office for South-East Asia. Emergency treatment of drinking water at point-of-use

7.8 Storage and Settlement

Storage and pre-settlement/settlement is a system used to remove bacteria from water by storing it. "When water is stored in the dark for a day in safe conditions, more than 50% of most bacteria die." (WHO, 2011). The storage causes suspended solids and some pathogens to settle to the bottom of the container. The container used for storage and settlement should have a lid to avoid recontamination but should have a neck wide enough to facilitate periodic cleaning. For example, a bucket with a lid could be used for this purpose. Water should be drawn from the top of the container where it will be cleanest and contain fewer pathogens. Storage and settlement for at least 48 hours also eliminates organisms called the cercariae (snail larvae) which act as an intermediate host in the life cycle of Bilharziasis (Schistosomoasis), a water-based disease prevalent in some countries. Longer periods of storage will leader to better water quality. A household can maximize the benefit of storage and settlement by using the three-pot system illustrated avove in Figure 6 (WHO, 2011).

7.9 **Filtration**

Filtration is the process of separating suspended solid matter from a liquid, by causing the latter to pass through the pores of some substance, called a filter. The liquid which has passed through the filter is called the filtrate. The filter may be paper, cloth, cotton-wool, asbestos, slag- or glass-wool, unglazed earthenware, sand, or other porous material. Sand is mostly used in household water treatment, where polluted water is passed through sand as the porous medium. The process uses the principle of natural cleansing of the soil.

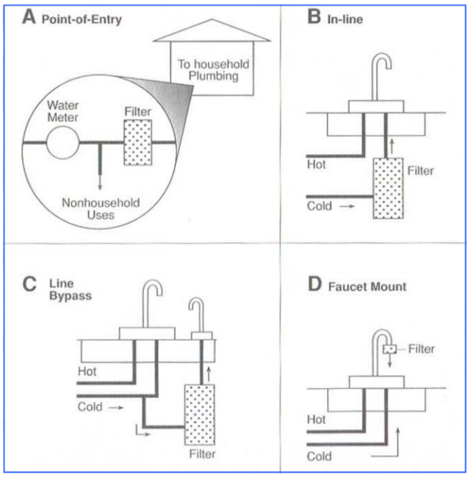
7.10 **Simple up-flow sand filter**

In the simple up-flow sand filter method, the sand used is coarser than for slow sand filtration and the rate of flow is faster (conventionally the velocity of flow is between 4 and 8m/hr). Rapid sand filtration is used for removing suspended solids from water and is particularly effective after coagulation and flocculation. (Skinner & Shaw, n.d.).

The simple filters are placed either into a clay, metal or plastic containers, filled with layers of sand and gravel and pipework arranged to force the water to flow either upwards or downwards through the filter. A filter such as this could be built from a 200-liter drum. It has a filter bed made up of coarse sand (about 0.3 m depth) of grain size between 3 and 4 mm in diameter and supported by gravel covered by a perforated metal tray. The effective filtration rate of such a filter could be as high as 230 liters per hour. Such filters must be dismantled regularly to clean the sand and gravel and remove any settled silt. The frequency of cleaning is dependent on the level of turbidity of the raw water. Furthermore, such filters are not effective at removing the pathogens. Therefore, the water must be disinfected or stored for 48 hours to make it safe. (WHO, 2013)

7.11 **Activated Charcoal (Carbon) filters**

Activated carbon is charcoal that has been cleansed by a slow heating process in the absence of oxygen and “activated” using temperatures up to 800 degrees Celsius. This process greatly increases the internal porosity, and one gram of “new” activated carbon can have a surface area of 500 to 1,000 m2 (Agri-facts, 2011).



Picture 7: Activated carbon filtering devices are designed for point-of-entry or point-of-use treatment. Lemley, Wagenet & Kneen, 1995.

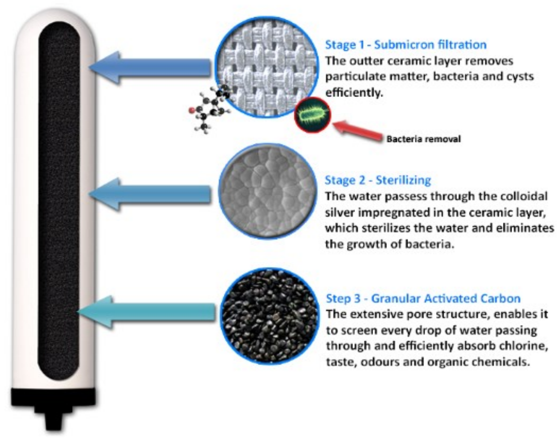
Granular charcoal can be used during filtration. It can be quite effective at removing some tastes, odors, and color. However, there is evidence that sometimes charcoal, particularly if not regularly replaced, can become the breeding ground for some harmful bacteria. (Skinner & Shaw, n.d.).

Ordinary charcoal available locally could be used, but activated carbon is more effective, though rather expensive.

7.12 **Ceramic filters**

According to Ali & Kadir (2016), Sobsey explains ceramic filtration as the use of porous ceramic (fired clay) to filter microbes or other contaminants from drinking water. Pore size can be made small enough to remove virtually all bacteria and protozoa by size exclusion, down to 0.2µm, in the range referred to as microfiltration. Small-scale ceramic filtration has a long history, having been used in various forms since antiquity. (Ali & Kadir, 2016).

Water may be purified by allowing it to pass through a ceramic filter



Picture 6 Three-stage ceramic filter process. (Eko Planet)

element. These are sometimes called candles. In this process, suspended particles are mechanically filtered from the water. The filtered water must be boiled or otherwise disinfected. Some filters are impregnated with silver which acts as a disinfectant and kills bacteria, removing the need for boiling the water after filtration. Ceramic filters can be manufactured locally but are also mass-produced. (WHO, 2013)

They can be costly but have a long storage life and so can be purchased and stored in preparation for future emergencies. The impurities held back by the candle surface need to be brushed off under running water, at regular intervals. To reduce frequent clogging, the inlet water should have a low turbidity. Figure 8 shows a three-stage ceramic filter process.

7.13 **Disinfection**

Healthy, consumable water should be free from harmful organisms. The reduction of harmful biological agents in water occurs during storage, sedimentation, and filtration but this is not enough to ensure a complete removal of harmful microbial agents in water.

Further disinfection steps are taken to remove harmful biological agents in water and it is recommended to be the final treatment stage, as many of the disinfection processes will be hampered by suspended solids and organic matter in the water. There are various methods of achieving disinfection at a household level.

7.13.1 Disinfection by boiling

Boiling is a simple method of water disinfection. Heating water to a high temperature, 100°C, kills most of the pathogenic organisms, particularly viruses and bacteria causing waterborne diseases.

The water should be brought to a rolling boiling for at least five minutes but preferably up to a period of twenty minutes. Apart from the high-energy costs involved in boiling, the other disadvantage is the change in taste of water due to the release of air from the water. The taste can be improved by vigorously stirring the water or shaking the water in a sealed container after it has cooled. A better water quality can be obtained by storing the boiled water, as described in the section on 'Storage and Settlement'. (WHO, 2013)

7.13.2 Disinfection using chlorine

Chlorine inactivates a microorganism by damaging its cell membrane. Once the cell membrane is weakened, the chlorine can enter the cell and disrupt cell respiration and DNA activity (two processes that are necessary for cell survival).

The characteristics of chlorine that makes it suitable for small-scale, household use for disinfection of drinking water are its ease of use as well as the ability to measure its effectiveness, its availability and relatively low cost. When used correctly, chlorine will kill all viruses and bacteria, but some species of protozoa and helminths are resistant.

There are several different sources of chlorine for home use; in liquid, powder, and tablet form. Chlorine is commonly available to households as liquid bleach (sodium hypochlorite), usually with a chlorine concentration of 1%. Liquid bleach is sold in bottles or sachets, available on a commercial basis. (WHO, 2010)

Chlorine is used carefully since a greater amount of chlorine than needed can distort the taste of water. However, chlorine must be used up to the amount that is enough to destroy all the germs in the water. The chemicals should also have a sufficient contact time with the pathogens (at least 30 minutes for chlorine). Deciding on the right quantity can be difficult, as substances in the water will react with the disinfectant at different rates. (WHO, 2008).

The strength of chlorine may decrease depending on the storage. The WHO recommends that a qualified professional dispenses chlorine in emergency. During the dispensation, guidance on the use and storage of chlorine should be provided by the dispensing professional. Necessary equipment for the correct use and storage of chlorine should also be provided at the same time.

Another widely utilized and simple household water treatment product deployed in emergencies is a chlorine tablet (e.g Aquatabs). Despite its apparent simplicity, incorrect and/or inconsistent use remains common, leading to doubts around its actual public health value. (Ali & Kadir, 2016).

Incorrect type of chlorine tablets is dangerous both for people and the environment. Chlorine tablets can come in the form of calcium Hypochlorite and chlorinated Isocyanurates. In the United States, Calcium Hypchlorite products are the only products labeled and approved for wastewater disinfection. This is because calcium hypochlorite is very reactive. It kills 99% of bacteria in wastewater within the first ten minutes of contact. The interesting part of the product is that the chlorine residue present after disinfection dissipates rapidly and this causes it to be harmless to the receiving environment. This is the major area where it differs from chlorinated Isocyanurate. (Kendall County, n.d.)

Isocyanurates (swimming pool tablets) are formulate for swimming pool disinfection and are dangerous when used for wastewater treatment. They dissolve more slowly compared to the calcium hypochlorite and leave an after-residue which does not dissipate. This method may work for swimming pools where recirculation of water makes the slow dissipation a sought-for effect, but it is not an effect needed in wastewater treatment. This is dangerous for the receiving environment. Another danger associated with this tablet is that it accumulates moisture which over time begins to decompose and release an explosive gas called nitrogen trichloride. When the concentration of nitrogen trichloride builds within the wastewater system it can be ignited when in contact with open flame or organic contaminates (Kendall County, n.d.).

7.13.3 Solar disinfection (SODIS)

Solar disinfection uses solar energy to destroy pathogenic microorganisms causing water borne diseases thereby improving biological quality of drinking water. Pathogenic microorganisms are vulnerable to two effects of the sunlight: radiation in the spectrum of UV-A light (wavelength 320-400nm) and heat (increased water temperature).

Solar disinfection is achieved by using transparent plastic containers which allows the UV rays of the sun to reach the water. The transparent container is filled with water and exposed to sunlight, mostly on top of the roof for maximum exposure, for about five hours (or two consecutive days under 100% cloudy sky). Disinfection occurs by a combination of radiation and thermal treatment (WHO, 2010).

7.14 **Semi-Centralized**

The Semi-centralized and centralized systems of water treatment options differ in two different ways: one by the number of households served by the system which can range from several dozens to several tens of thousands, and second by the outline/size of the system relative to the centralized system.

The semi-centralized system of water treatment tends to bring the responsibility of water treatment towards the beneficiary population since part of the treatment responsibilities are carried out by the receiving population. This could sometimes pose a challenge where there are few designated, trained and appropriately incentivized operators. Effective supervision is necessary at the semi-centralized level to enhance successful operation

7.14.1 Bucket Chlorination

This treatment method is widely used during emergency. As the name implies, the chlorination of water is done at the point of collection, usually by a trained professional. Chlorination is done directly to the collection vessel (bucket for example) collection water from a general source (eg. Hand pump or natural surface water source).

Though this approach is widely practiced in emergencies there needs to be a great deal of research to build the evidence base around it. Along similar lines, there are also simple manually-operated chlorine dis-pensers that people collecting water can use to release a pre-fixed dose into their containers as they fill them. (Ali & Kadir, 2016)

The appropriate amount chlorine dosage is determined empirically on a daily basis. (Branz A., Levine M., Lehmann L., Bastable A., Ali S. I., Kadir K., Yates T., Bloom D., & Lantagn D., 2017). There is currently no conclusive research on the effectiveness of bucket chlorination in emergency. However, certain researches point to its effectiveness. Recent research during a cholera outbreak in Cameroon documented that 83 per cent of households had FCR <0.2 mg/L 24 hours after bucket chlorination (Murphy et al., undated). According to Branz A. et. al. (2017), Roberts et al, 2001 stated that when researchers added a dose of 2.5 mg/L chlorine to buckets of water in a refugee camp in Malawi, E. coli was reduced by 99 per cent for four hours. However, by six hours, E. coli increased to >250 CFU/100 mL Branz A. et. al. (2017).

7.14.2 Package Water Treatment Units (WTUs)

Another possible water treatment alternative in emergency is the supply of package water using potable water treatment units. This, however, is not the first alternative for emergency water supply. These systems require longer to transport and set-up time and are therefore more appropriate after the acute phase of an emergency has passed the Improvement of these systems is desirable, as their limitations have prevented a wider use in emergencies. (Ali & Kadir, 2016).

7.15 **Centralized water treatment**

Centralized water treatment is a system of community water treatment where the population is supplied with drinking water from large, unified water treatment plants. The treated water is piped to all the communities in the geographical area served by the treatment plant, thus requiring an extensive pipe network, to reach even the most remote communities.

In emergency, centralized water treatment mostly operates in such a way that water tankers are widely used to deliver safe water to affected populations especially in the acute phase of emergencies. There are challenges in this system, for example, the best treatment method especially how to appropriately dose chlorine to ensure water safety at the point of consumption.

The centralized system utilizes large-scale treatment options which include low pressure membrane filtration (i.e., microfiltration and ultrafiltration) and high-pressure membranes (e.g., reverse osmosis). It is however difficult to maintain these systems in emergency situations since they are cost intensive and more expertise.

Storage, packaging, and distribution of water are other important factors to consider after deciding what treatment solution (Centralized or decentralized system) is suitable for a particular emergency situation. The practicalities of distributing water to the affected population may pose significant challenges. (US EPA, 2011)

7.16 Roles and responsibilities in emergency water treatment

A Successful management of water disaster requires appropriate and adequate definition of roles and responsibilities in emergency response. These roles require different level of expertise, with some requiring equipment operator expertise. The amount and type of staff needed during an emergency water supply is, however, a continuous process and brief trainings can be provided to available personnel which could come from neighborhood emergency response team volunteers, aid from outside agencies such as Red Cross and other emergency response team volunteers within and without the communities.

Security is an important aspect of emergency water management. In the face of a water scarcity threat, crowd unrest could be a major source of setback. The security personnel in these types of emergency is needed to protect water supplies and controlling crowds at the distribution site (EPA, 2009).

Table 4 Roles and responsibilities of Different organizations

Organisations	Roles and responsibilities
Drinking water and primary agencies	• Regulation of use of contaminated water • Public notification • Environmental concerns for discharge of water • Quality of alternative supplies • Consultation on remediation and recovery plans
Environmental and public health laboratories	• Provide analytical support during consequence management • response and remediation
State government	• establishing formal agreements with state partners or coordinating funding resources. • Should be informed and engaged once contamination has been confirmed to assist in coordination of resources and communication.
State emergency responders	• Provide support if a contamination incident is confirmed. • engaged in consequence management planning to ensure efficient transition in the event that a contamination incident escalates.
State emergency management	• Provide support if a contamination incident is confirmed. • engaged in consequence management planning to ensure efficient transition in the event that a contamination incident escalates.
State law enforcement	• Provide support if a contamination incident is confirmed. • engaged in consequence management planning to ensure efficient transition in the event that a contamination incident escalates.
State department of Health	• Can track data used to determine if there is a public health incident • Can alert health care providers of potential contamination incidents and appropriate treatment methods.
State environmental representative	• Located in public health department and engineering department • Provides guidance on engineering devices which could be use in cleanup as well as monitoring well/devices which can be used to determine the extent of contamination.
National Guard units	• provides assistance in cordoning off quarantined or contaminated areas and may be key to alternate water supply acquisition and distribution.

U.S. EPA (2008).

7.17 Different roles of disaster Personnel

Volunteers and responders, both local and international, all work towards supporting a disaster-struck community and, therefore, are the available lifeline to those communities especially during the initial hours or even days after a disaster has occurred. The roles of personnel working in the immediate aftermath of a disaster can range from rescue and recovery roles, leading a command post, research, and networking (identifying and prioritizing needs and solutions), coordinating tasks and communications, managing, or supporting food, water, shelter, and medical camps, and coordinating movement of resources and supplies. (SSIO, 2015)

After the initial critical phase of disaster response, disaster personnel and volunteers are needed in helping local facilities rebuild their lives, infrastructures, and communities. This can mean the continuation of medical camps, reconstruction of homes and critical-use facilities (e.g. schools and hospitals), education initiatives and skill training. (SSIO, 2015)

7.18 The Role of Public Health Professionals During Water scarcity

Environmental health problems such as water scarcity and the sanitation problems which carries with it disease and infection spread require the expertise of healthcare professionals. In the center of healthcare professionals are public health nurses. Public health nurses are closer to the community and therefore should have a better understanding of the community from a health point of view. According to the association of public health nurses, “Public health nursing is defined as the practice of promoting and protecting the health of populations using knowledge from nursing, social, and public health sciences” (American Public Health Association, Public Health Nursing Section, 2007).

Poor sanitation is a major source of public health problem in developing countries. According to American Public Health Association, Public Health Nursing Section (2007), Black R. et. al. (2010) pointed out that the diseases resulting from poor sanitation cause child fatality globally more than fatalities from AIDS, malaria and measles put together, and diarrhea is the single biggest killer of children in. This highlights the level of public health challenges presented by water scarcity and poor sanitation as a result. The role of public health actors in promoting safe sanitation becomes unavoidable.

In the event of a natural disaster where safe water availability and sanitation have been affected the occurrence of communicable disease is imminent. Disease surveillance is “the ongoing systematic collection, analysis, interpretation and dissemination of specific health data for use in public health” (Teutsch and Churchill, 2000). Through disease surveillance, public health workers can develop strategies for preventing and controlling disease and works to put the strategies in action (Minnesota department of Health, 2014).

According to the Center for Disease Control and Prevention, public health surveillance can be used to facilitate the following:

- Estimate the magnitude of a problem (disease or event).
- Determine the geographic distribution of an illness or symptoms.
- Portray the natural history of a disease.
- Detect epidemics and define a problem.
- Generate hypotheses and stimulate research.
- Evaluate control measures.
- Monitor changes in infectious agents.
- Detect changes in health practices.
- Facilitate planning. (Center for Disease Control and Prevention, 2004)

By using surveillance, “public health departments identify trends and unusual disease patterns, set priorities for using scarce resources, and develop and evaluate programs for commonly occurring and universally occurring diseases or events” (Marcia & Heanette, 2018).

According to Center for Disease control, Health Alert Network (HAN) is their “primary method of sharing cleared information about urgent public health incidents with public information officers; federal, state, territorial, tribal, and local public health practitioners; clinicians; and public health laboratories.” (CDC, 2018). The HAN also “collaborates with federal, state, territorial, tribal, and city/county partners to develop protocols and stakeholder relationships that will ensure a robust interoperable platform for the rapid distribution of public health information.” (CDC, 2017).

Information sharing, and quick response coordination is crucial in achieving results in emergency situations especially ones involving water scarcity, sanitation, and disease control. By using health Alert network(s) public health officials can get information across to appropriate authorities, communities, organizations, etc. as to execute a successful disaster response.

Public education is a major aspect of public health workers’ roles within any community they operate. The role of public health workers in training the community through teachings and exercises are integrated in the emergency response plan and carried out before and during an emergency occurrence. “Statewide, regional, and local exercises are conducted regularly and systematically so all aspects of emergency planning can be tested and refined.” (Minnesota Department of Health, 2014).

Public health workers should be involved in all aspects of planning such as assigning and using available resources to achieve water scarcity objectives. They should ensure that during the incident management system public health officials are well involved. They should also be involved in documenting water scarcity response actives. (Department of Health and Human services, CDC, American Workers Association, EPA & National Oceanic & Administration Association, 2010).

7.19 Ecological Sanitation and Handwashing

The target of a proper sanitation is to reduce recontamination and prevent disease spread and death resulting directly and indirectly from diseases. (Esrey S. A, Gough J., Rapaport D., Sawyer R., Simpson-Hébert M., Vargas J., & Winblad U, 1998). Proper sanitation in emergency will not necessarily meet the standard target of sanitation under normal circumstances but will prevent disease sread.

According to Esrey et. al. (1998), There are two current sanitation practices promoted today are the “flush and discharge” method and the “drop and store” method. During an emergency, the “drop and store” method becomes the most sensible method of fecal handling since the situation is highly water sensitive.

To promote ecological sanitation the principles of ecological sanitation should be applied, and those principles are the sanitation method chosen should prevent disease. The system must be designed to isolate faecal pathogens and destroy them. Faecal pathogens are the most disease-causing element during a sanitation problem. (Esrey et. al., 1998)

Access to toilets in emergencies is a major challenge in an emergency because of scarcity of water to maintain hygiene. A system of the management the collection of faecal deposits and urine should ensure that the Environment is protected by preventing pollution (Esrey et. al., 1998). The the system put in place should be accessible to all and should be easy to operate. (Esrey et. al., 1998). These systems must also be simple enough to ensure that they can be managed with the available resources (Esrey et. al., 1998).

Handwashing is a crucial aspect of transmitting fecal-oral diseases in an emergency. According to WASH (2016), handwashing is often regarded as secondary in emergency, but it is one of the most important aspects of disease prevention in emergency. Handwashing with soap is an easy, effective and affordable method to protect and prevent disease transmission. (WASH, 2016).

8 GUIDELINE TO DISASTER RESPONDERS

In this section we try to go through certain points that are important for disaster responders while preparing for or while in disaster response. This section is divided into xx parts; what to expect,

8.1 What to Expect

The type and nature of disaster will determine the type of assistance needed during a disaster. There will likely be a progressive medical need during a disaster. The medical needs are even more if the disaster occurs in a place with already vulnerable population. (Sathya Sai International Organization, 2015).

Factors determining the nature of medical cases and the needs required include the type and size of the disaster, available resources and medical infrastructure of the area, and the length of time after the disaster event. (SSIO, 2015). This is not an exhaustive list of the factors.

Disaster responders should anticipate some levels of psychological impacts of disasters and should be able to recognize certain behaviors as the outcome of disaster impacts. This means that after a disaster survivor might show signs of acute stress and anxiety such as being disoriented, confused, frantic and agitated, panicky, extremely withdrawn, apathetic or “shutdown”, extremely irritable or angry, and exceedingly worried (SSIO, 2015).

The psychological impact of a disaster is not exclusively for the people living in the disaster area. Disaster responders such as Healthcare Professionals can also suffer some type of trauma which can be directly related to the disaster or indirect trauma from work and the environment. Takin care of people can take physical and emotional toll on disaster responders which can lead to trauma for the disaster relief personnel. Therefore, it is important to assess the mental health of disaster volunteers and personnel periodically. (SSIO, 2015)

8.2 General supplies needed for disaster response mission

Responders and volunteers going abroad or to other cities for response work would need supplies for items they would need during the response period which would probably not be found or, at least, will be difficult to access within the disaster area and framework of the disaster response. Every disaster is unique. This means that an understanding of the type, nature, and the extent of the disaster which the responder is preparing for is very crucial to selecting the supplies that will be needed during the response period.

General supplies needed by responders according to Sathya Sai International Organization include food and water purifier sufficient for the length of your stay, Sleeping bag, pillow, Soap and an alcohol-based hand cleaner (containing at least 60% alcohol), Personal hygiene items (toilet paper, towel, baby wipes, deodorant, sanitary napkins), Insect protection: insect repellent (with DEET) and a bed net.

Depending on the country and region of disaster response, there might be need for Vaccination and/or medication. Responders going on these missions should check the requirements of specific countries and missions and should consult with public health professionals who have expertise in international diseases and vaccinations. During disaster response, provision should be made to appropriately evacuate volunteers who develop allergic reactions to some of the vaccines or medications such as malaria Malarial prophylaxis and emergency malaria treatment. (SSIO, 2015).

Other important Medications needed during emergency response include anti-diarrheal medications (e.g. Loperamide and antibiotic, personal prescriptions (including extras), HIV post-exposure prophylaxis, any preferred over-the counter medications, and copies of all prescriptions (SSIO, 2015).

More items needed during emergency response mission include

- An extra set of prescription eyeglasses and/or contacts.
- Water purification tablets (iodine or chlorine), bleach, or a water purifier.
- Sunscreen, hat, lightweight clothing, rain gear
- Flashlights, headlamps, batteries, matches or lighter
- Mobile phone with text messaging capabilities
- Mess kit (knife, fork, spoon, plate, cup, cooking utensils)
- Self-sealing plastic bags (e.g. Ziploc), electric tape, pocket notepad and pens
- Persons with pre-existing health conditions should consider wearing an alert-bracelet and make sure this information is on a contact card in their wallet or travel documents. A contact card should include the following information:
- Name and contact information of family member or close contact.
- Name and contact information of personal health-care provider.
- Pre-existing health conditions and treatment.
- Important documents should be kept on your person at all times in a discreet waterproof travel pouch or a sealed zip-lock type bag:
- ID cards (hospital ID, driver’s license, health insurance, copy of medical license)
- Passport & four passport-size photographs; airline ticket/booking
- Credit card / cash (SSIO, 2015)

8.3 **Specific supplies**

As mentioned earlier, disasters are unique, and each disaster requires different supplies. Depending on the nature, type and areas affected by disaster the following list according the Sathya Sai International Organization applies uniquely to some response mission. The response volunteer should check which item applies to their mission.

Specific supplies	
– Ample water and on-the-go food or energy bars for the mission – Electrolyte packets – Back Pack – Hard Hat – Safety Goggles or Safety Glasses – Flashlight with batteries – Reflective vest – Work Gloves – Whistle – Pen, Pencil, Marker, and Note Book – Multi-Function Tool and Knife – Sun Screen – Triage Tags – Water Purification Tablets	– Waterless Hand Cleanser – Wrench or Pliers – 12 or 14-inch Pry Bar – Colored Markers or Marking Crayons – Duct Tape – Dust Masks – Emergency Blanket – Hammer – Hard Hat Light – Hand Towels – Insect Repellant – Knee Pads – Light-sticks – Masking Tape – Medical Gloves Latex or Nitrile – Medical Supply Kit (Band Aids, 4x4's, Triangle bandage. Etc.)

Sathya Sai International Organization, 2015.

9 CONCLUSION

Disasters and emergencies resulting in water scarcity can have adverse consequences on the people living in the disaster-struck areas. However, there are ways to considerably reduce the effects of these disasters and people do not have to suffer tremendously during and after the disasters.

The key to averting the dangers of water scarcity resulting in poor water quality and diseases, starts with understanding the areas prone to disasters, drawing up a plan for disaster mitigation and response before any disaster event and implementing them when a disaster occurs. Prevention is mostly very effective in increasing community resilience to disasters and reducing the impacts of a natural hazards which if unchecked can overwhelm the community, resulting eventually to natural disasters.

When disasters do occur, coordination between response teams, and an effective and timely response can go a long way in reducing human impacts, economic losses, and health endangerment. Environmental experts, government personnel, public health personnel, and non-governmental organizations are some of the important actors in disaster response. These actors play a huge role in disaster prevention and response. Capacity in terms of expertise is very important in delivering an effective implementation of disaster response plan.

Assessment of the disaster's impact on water system is one of the important initial steps in verifying the amount of damage done to water system and what needs to be done to build up water capacity. Water quality assessment is also very important in determining the type of water treatment needed and the quality of available water sources.

Due to resource scarcity in emergencies, water purification is managed in such a way that water is good enough for everyday activities and higher amount of resources invested into the treatment of drinking water. This requires a continuous balancing of the system and the resources to ensure that the available resources are made use of appropriately.

The role of the public health personnel is very pronounced in ensuring health safety of the community where disaster has occurred. Their role in community coordination during response, disease prevention through hygiene promotion and overall coordination of health-related aspects of disaster response are pivotal to the success of response after disaster.

Access to toilets and hygiene promotion are a very core aspect of disease prevention in an emergency with high water sensitivity and the public health, and other healthcare professionals play a major role in ensuring hygiene. Access to toilets however can be ensured with the corroboration of environmental experts.

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