Biological and Chemical Weapon Use, Disposal, and Impact

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1. Introduction

"Biological weapons (BWs) deliver toxins and microorganisms, such as viruses and bacteria, so as to deliberately inflict disease among people, animals, and agriculture. Biological attacks can result in the destruction of crops, temporarily discomforting a small community, killing large numbers of people, or other outcomes." (Federation of American Scientists, 2013). These weapons, either naturally occurring in the environment or artificially created, impact more than just the people or targets they are intended to hit. They cause risks to the health of communities and to the air and water we breathe. Often times when conflicts are happening and there is a necessity for biological weapons to be provided and used, the disposal portion of the operation is commonly neglected which in turn creates more problems than those that existed beforehand.

2. Production of biological weapons

When a country or nation is faced with the decision to produce or use biological weapons, multiple steps must be assessed. First, a biological agent must be chosen and acquired. In addition to choosing toxins as the particular agent, there also has to be a consideration as to where and how the toxin will be retrieved. Secondly, there must be alterations done to the agent to allow it to grow and multiply to the wanted quantity. Next, the agent is ready to be prepared for delivery.

Choosing an agent requires weighing the pros and cons of the results from the attack and the characteristics of the agent. According to the Federation of American Scientists (FAS) website in their segment about the production of biological weapons, characteristics such as how much of an agent can cause disease, which is also known as its pathogenicity, the amount of time between exposure tof the agent and individuals getting ill (incubation period), how debilitating the disease is on the population affected (virulence), its lethality, and how readily the disease spreads to others (transmissibility) are all considered. If a pathogen is chosen to be the agent, there are two ways they can be obtained. Pathogens can be naturally occurring in the environment as well as derived through a microbiology laboratory or bank. When taken from the environment from places such as soil, water, or infected animals, there has to be enough of the microorganism taken for samples to allow for proper testing of all of these characteristics (FAS, 2013). Toxins can be produced by adding their DNA coding to bacteria. With the technology in today’s world, it has been made possible to synthesize certain viruses based on its genome, or an organism's genetic instructions, and using basic materials such as DNA. Dr. Eckard Wimmer first demonstrated this by re-creating the poliovirus in 2001, which was followed by Dr. Craig Venter's synthesis of the bacteriophage phiX174 in 2003 and the 2005 re-creation of the 1918 flu virus by Dr. Jeffrey Taubenberger and Dr. Terrence Tumpey (FAS, 2013).

When choosing to grow microorganisms, certain conditions must be met. Cells are required to be living for the replication of viruses and some bacteria. Fungi, most bacteria, and other microorganisms can be grown in Petri dishes. Growing large amounts of an agent is possible, but it can also be limited by factors such as equipment, space, and safety concerns that come from coming into contact with dangerous germs and chemicals. Each situation is different in that large amounts may not be necessary if the target population is small. Microorganisms have the ability to be modified to receive different results from those produced in its original state. For example, agents modified for increased pathogenicity and a shorter incubation period could result in a more severe, fast-acting disease. Another example could be microorganisms that normally do not harm potential targets modify into deadly diseases. On the contrary, other changes could make treatments, vaccines, or the body's immune system useless. Delivering an agent requires preparing it to remain effective when outside of its standard growing conditions. Environmental stresses such as temperature, ultraviolet radiation, and drying can lower the agent's activity. Other agents need further processing to minimize the amount of damage done to it and it also allows it to retain its normal activity when actually dispersed to the target area. Procedures such as direct freeze drying (lyophilization), deep freezing, powdering, and milling. Once stabilized, the pathogens are ready to be dispersed into the environment.

3. Scientific and Historical Application

The Centers for Disease Control and Prevention, also known as the CDC, has done research and kept a record on some of the biological and chemical weapons that have been used in the United States. According to their Chemical Weapon Elimination Initiative information page, the United States produced their own chemical weapons from the start of World War I up until 1968. The US began this production as a means to counteract the use of chemical weapons by Axis Powers and other enemy countries during the time period. These weapons were not actually dispersed into the environment, but rather relocated in stockpiles across the United States. These chemicals, now collected as the US national stockpile of lethal chemical warfare agents, have six main chemicals that comprise two different categories: Nerve Agents and Blister Agents. Nerve agents, as the name states, impact the nervous system. The Organization for the Prohibition of

Chemical Weapons (OPCW) states that all nerve agents belong chemically to the group of organo-phosphorus compounds. Dr. Gerhard Schrader, a German chemist, was reportedly the first scientist to begin experimentation with highly toxic phosphorus compounds to create a pesticide. Examples of nerve agents are GA, also known as Tabun or ethyl N,N-dimethyl phosphoroamidocyanidate, GB, also known as Sarin or isopropyl methylphosphonofluoridate, and VX, also known as O-ethyl-S-(2-diisopropylaminoethyl)-methyl phosphonothiolate.

The Centers for Disease Control and Prevention recorded that the amount of stockpiled chemical warfare agents in the United States reached nearly 40,000 tons by the year 1968 (CDC, 2014). These chemical warfare agents were stored in bulk containers or as assembled weapons and ammunition at nine sites across the United States. Operation Cut Holes and Sink 'Em (CHASE) was in operation from **1967 to 1970** and during this time, thousands of tons of unwanted chemical warfare agents and ammunition were disposed of by loading them onto old ships that then were intentionally sunk at sea. In **1970**, Congress passed a law that is directed by the Department of Health and Human Services (HHS) and the Office of the Surgeon General (OSG) where they are required to review all of the plans made by the Department of Defense (DoD) to transport, test or dispose of lethal chemical agents, and to recommend actions to protect the public's health and safety during such activities.

The National Center for Environmental Health's (NCEH) Environmental Public Health Readiness Branch has reviewed plans for DoD's chemical weapons demilitarization program. After these reviews, NCEH recommends actions to ensure the protection of public health and safety when chemical warfare agents are destroyed. In **1986** as part of PL 99-145 (50 USC 1521), Congress required that all stockpiles of U.S. chemical warfare agents be destroyed. U.S. stockpiles totaled approximately 30,500 tons, according to the 1997 Organization for the Prohibition of Chemical Weapons (OPCW) inventory. No stockpile chemical warfare items, such as recovered chemical weapons and chemical agent identification sets, were estimated to exist at more than 200 sites in the United States and its territories. The DoD stored chemical warfare agents, either in bulk containers or as assembled munitions, at eight different locations in the continental United States. The rest of the stockpile was transferred to Johnston Atoll, a small remote island in the Pacific Ocean (southwest of the Hawaiian Islands).

Items that are considered to be chemical warfare material that needs to be disposed of include:

- Former chemical weapons production facilities
- Recovered chemical weapons
- Chemical samples
- Binary chemical weapons
- Miscellaneous equipment, such as empty aerial spray tanks.

When items suspected as recovered chemical warfare are found, they undergo a series of nondestructive tests. If they contain chemical warfare agents, they are destroyed and disposed near the area where they are found. This is done by using equipment specifically designed for that purpose. The CDC's role in this process is to review plans and methods to ensure that public health is protected. As an example, portable explosive destruction systems will be used to destroy WWI-era chemical munitions.

On a global aspect, there have been case studies conducted that show the effects of chemical warfare dumping in European seas. Author Della Terre conducted a case study titled "DNA damage, severe organ lesions and high muscle levels of As and Hg in two benthic fish species from a chemical warfare agent dumping site in the Mediterranean Sea" (Terre, 2010) which evaluated the threat imposed on sea life due to chemical weapon dumping in the Adriatic Sea. The abstract from the study reads:

> "An ecotoxicological approach using chemical analysis and biological responses was applied, in two sentinel species: the Blackbelly rosefish, Helicolenus Dactylopterus, and European Conger. Specimen were collected in a stretch of sea, where had been dumped war materials and from a reference site free of ordnance. Residues of yperite, Hg and As were measured in fish fillets. Skin, liver, kidney and spleen were examined for histopathological and macroscopical lesions. Liver detoxifying capacities (EROD and UDPGT) and genotoxicity (comet assay) were also investigated. As and Hg levels were three-four times higher than those from the reference site in both species ($p<0.001$). Both species captured in dumping site showed clear signs of chronic illness according to the health assessment index (HAI). Deep ulcers and nodules were observed on skin and external organs. Histological lesions such as periportal and bile duct fibrosis, pericholangitis, steatosis, granuloma and elevated splenic MMCs were detected in liver and spleen. Significantly higher EROD activities were also found in both species from dumping site ($p<0.01$). Comet assay revealed genotoxicity in gills of C. conger from dumping site, indicating uptake of chemical warfare agents through fish gills. European conger was found to be a more sensitive bioindicator of this type of contamination than the Blackbelly rosefish."

The impact of biological weapons does not only affect humans but when they are dispersed into the environment, they negatively affect the lives of animals as well. Often times, animals are used to conduct test trials to determine the effectiveness of the chemical agents wanting to be used on people. JY Yeh in his study titled "Animal bio warfare research: historical perspective and potential future attacks" (Yeh, 2012) discuss the vulnerability of livestock animals when it comes to the use of chemical agents. His abstract reads:

> "A biological attack on livestock or poultry could result in the loss of valuable animals, costs related to the containment of outbreaks and the disposal of carcasses, lost trade and other economic effects involving suppliers, transporters, distributors and restaurants; however, it is not

possible to secure all livestock, and livestock is much less well guarded than human targets. Thus, the vulnerability of the livestock industry to the introduction of biological agents varies for the following reasons: (i) the majority of lethal and contagious biological agents are environmentally resilient, endemic in foreign countries and harmless to humans, making it easier for terrorists to acquire, handle and deploy these pathogens, (ii) with animals concentrated in fewer production facilities and frequently transported between these facilities, a single pathogen introduction could cause widespread infection and (iii) the extent of human travel around the globe makes it difficult to exclude exotic animal diseases as possible biological agents. Historically, many governments have developed and planned to use biological agents for direct attacks on livestock or poultry. In the past, developed nations have actively developed biological weapons to target animals. The potential spectrum of bioterrorism ranges from isolated acts against individuals by individuals to tactical and strategic military attacks and state-sponsored international terrorism intended to cause mass casualties in animals, humans or both. This review provides an overview of the past development and use of biological weapons and describes potential future attacks.

4. Continued Disposal of Chemical Weapons

On the congressional aspect of Chemical Weapon disposal, Glenn Hess of the Chemical and Engineering News, writes in an article about the intentions of the Obama Administration to proceed with disposing of the stockpiles around the U.S. He writes:

> “The Obama Administration’s proposed fiscal 2012 budget calls for spending more than $1.6 billion to continue activities associated with the elimination of the U.S.’s chemical weapons stockpile. The Department of Defense is requesting $1.2 billion for the Army’s efforts to dispose of chemical warfare materials stored at installations in several states. An additional $477 million, which includes $75 million in construction funding and $402 million for R&D, would be used for new facilities at the Blue Grass Army Depot in Richmond, Ky., and the Pueblo Chemical Depot in Colorado.”

Although there are requests being made to continue with the task of eliminating the un-used chemical weapons, there is still concern from certain parties who feel that Congress will only continue to push the issue to the back-burner and allocate the requested money elsewhere. Despite this possible outcome, there are still groups present who have formed to assist with offering suggestions and providing direction to ensure that the treaty regarding the disposal of chemical weapons will be carried out efficiently and effectively. Lois Ember, a writer for the Chemical and Engineering News, provides insight about the 10th anniversary of the Chemical Weapons Working Group (CWWG). As stated on their website, the CWWG is described as:

> “[The Chemical Weapons Working Group is] an international coalition

> of citizens living near chemical weapons storage sites in the United States, the Pacific and Russia who are most affected by the disposal of these munitions. The CWWG mission is to oppose incineration of chemical weapons as an unsafe disposal method and to work with all appropriate decision-making bodies to ensure the safe disposal of these munitions and other chemical warfare and toxic material. As stated herein, the CWWG mission is based on a primary concern for the preservation and protection of the health and safety of all citizens and the environment in which they live."

The CWWG got their start when the Kentucky Environmental Foundation first convened in 1991 because they were also opposed to incineration. At that time, individuals from Richmond, Kentucky, where the meeting was being held, as well as the individuals from the other 8 stockpile locations came to the summit meeting to express their concerns regarding chemical weapon disposal. The Kentucky Environmental Foundation (KEF) decided that their method of disposal for chemical weapons is a "closed loop neutralization and supercritical water oxidation process" (Kentucky Environmental Foundation, 2014) compared to the standard incineration method. The KEF's main focus, in the beginning ,was to focus on the safe disposal of chemical weapons stockpiled at the Blue Grass Army Depot and to stray away from the proposed option of incineration as a means to keep and prevent chemical agents from being released into the environment. From that point on, the CWWG was able to establish their goal for the organization:

> "CWWG members determined at that time to work together toward the common goal of safe disposal of chemical weapons, using-non-incineration technologies. The consensus was reached at this first CWWG conference that transportation of these weapons to another community was **not an option**. From a divided position of "not in my backyard," the gathered citizens moved to an inclusive, responsible and unified positon of "develop safe disposal technologies." All agreed that to win on this issue, citizens from all affected sites would continue to work together, sharing information and developing strategies."

The KEF and CWWG have been heavily involved in numerous environmental health and environmental justice campaigns to advocate for the safe disposal of chemical weapons. As recorded by World News by The Guardian, there has been controversy regarding the continued disposal of chemical weapon stockpiles.

> "The United States promised but failed, to destroy these stocks by 2012 at the very latest. The most recent forecast from the US is that the process of "neutralizing" the chemicals in its Colorado weapons dump will be finished by 2018; the date for Kentucky is 2023. That will be 11 years after the US promised to destroy its chemical weapons stockpiles, and eight years after Russia – the other major possessor of declared chemical weapons – says it will have finished destroying its arsenal.

About 2,611 tons of mustard gas remains stockpiled in Pueblo, Colorado. The second stockpile, in the Bluegrass Region of Kentucky, is smaller – 524 tons – but more complicated to decommission because it consists of a broader range of lethal gasses and nerve agents, many of which are contained within weaponry. The US and Russia have struggled to decommission their own stockpiles of weapons, built-up during decades of confrontation during the cold war. The process has taken place under the auspices the Chemical Weapons Convention – the same treaty Syria has now pledged to commit to as well. Enforcement of the convention is overseen by the Organization for the Prohibition of Chemical Weapons (OPCW), which is based in The Hague. The OPCW provided the scientists who conducted recent United Nations weapons inspections in Damascus.

India and South Korea, which have destroyed similar-sized stockpiles, took about three or four years to destroy their weapons, but that process only began after the lengthy process of building the plants that were used to destroy the chemicals. Weapons destruction, a technologically complicated and risky process, is determined by the types of chemical agents, their location and whether or not they have been "weaponized". The US already spends $500m to aid other countries in nuclear, biological and chemical weapons destruction around the world, via one congressionally-authorized program. Russia, Germany, France, the UK or Canada might also be expected to contribute to any weapons destruction process.

5. Conclusion

It is important to realize that although some chemical agents are naturally occurring in the environment, which does not guarantee that they are healthy for those living or inhabiting the area. It is also important that the armed forces, in their efforts to protect our country, take advantage of the assistance given by various programs implemented to assist with the proper disposal of chemical agents. In retrospect, it is a benefit that the majority of the United States' chemical weapons are located in stockpiles not being used, however, the issue regarding their next locations is the big issue. It is vital that consideration is taken into account about what is the safest option for the disposal to take place. I feel that in order for that to happen effectively, there should be more research done on the composition of popular chemical agents and see what the most environmentally-friendly disposal method is. That way, the goal imposed by the Pentagon to have the stockpiles cleared by no later than 2032 can begin to be attained.

Inside one study, researchers decided to use a novel immunization strategy so they could try to generate high-affinity monoclonal and polyclonal antibodies against native ricin, BoNT/A, and BoNT/B. They use antibodies along with antibodies against SEB and abrin to establish a highly sensitive magnetic and fluorescent multiplex bead array with excellent sensitivities between 2 ng/L and 546 ng/L from a minimal sample volume of 50 µL.Finally as their method came to an end they figured out it was a successful one. Also, the end results were that their tool they picked to used was a good tool for large-scale screening of samples for the food supply chain. (Diana Pauly *et al*. 2009)

In another study, mathematical expressions for the mean number of casualties were used to see the resulting from a deliberate release of biological and chemical agents into a food supply chain. Their first examination showed the amount of contaminated food as a function of the network topology. It also showed vessel sizes in the food processing plant. By the end of these researchers studies it was determined that these simple formulas can be used by the U.S. government. It also determined it could be used by the food industry to develop a rough-cut prioritization of the threats from food terrorism. It was also proved that could become the 1st step toward the allocation of appropriate prevention and mitigation resources. (Y. Liu *et al.* 2008)

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