2011

Rethinking the Development of Weapons and Their Impact

Petros J. Katsioloudis
Old Dominion University, pkatsiol@odu.edu

Mildred V. Jones
Old Dominion University, mjones@odu.edu

Original Publication Citation

Katsioloudis, P. J., & Jones, M. V. (2011). Rethinking the development of weapons and their impact. *Technology and Engineering Teacher*, *71*(3), 12-17.

Rethinking the Development of Weapons and Their Impact

By Petros J. Katsioloudis and Mildred V. Jones

Conventional weaponry may be effectively harmful to our enemies, but pollution from these weapons is severely impacting the environment as well.

As you read about the history of humans, you see very early on that humans are naturally "tool users." More specifically, humans used tools as a means of subsistence and survival. Even today humans use tools to extend their capabilities beyond imagination. Axes and knife-like tools made from stone and flint could be used to pound or hammer or cut. The earliest humans were hunter-gatherers and for survival had to capture or kill "an evening meal." Spears, bows, and arrows became tools for hunting to kill larger prey for food and subsistence. However primitive, these early weapons would soon be used against other humans to defend territorial domains, to defend against other warring groups, or for protection against large predator animals.

The "inconvenient truth" we must face as a society is that weapons are necessary as we defend our country from foreign as well as domestic enemies. Whether it is a catastrophic event such as 9/11, a shooting on a college campus, or our commitments to help our allies overseas during wartime, our military and police need weapons to defend against these adversaries. However, we can also note that weapons are used for recreation as well—in hunting and shooting competitions for example. Given the enormous number of weapons used for protection or recreation, can we expect that conventional weapons are harmful to the environment? Absolutely, in many ways, and have been since the Greeks used sulfur mixtures to produce suffocating fumes in the Trojan War (431 BC) (Harigel, 2001).

Conventional weaponry may be effectively harmful to our enemies, but pollution from these weapons is severely impacting the environment as well. Some of these weapons include chemical, biological, depleted uranium, landmines, nuclear, jet fighters, and even the conventional lead bullets fired from rifles and handguns. "It is estimated that the Pentagon generates five times more toxins than the five major U.S. chemical companies combined" (Hay-Edie, 2002). The U.S. military is the "largest single source" of environmental pollution in the United States. It is estimated that the cost to clean up military-related sites costs approximately $500 billion dollars (Hay-Edie, 2002).

Chemical Weapons

Although the disposal of chemical weapons in the ocean ended in 1970, there is still concern about the potential hazards they may have on human health and safety as well as ocean life (Bearden, 2007). Following World Wars I and II the most effective and efficient way to dispose of chemical weapons was to dump them in the ocean. Between 1945 and 1970, our oceans became the dumping grounds for chemi-

cal weapons—some of which were known to be leaking and/or damaged and posing immediate risk to those handling the weapons. The U.S. contributed 93,995 tons, France 9,250 tons, Britain 122,508 tons, and Russia 70,500 tons to the ocean floor. The United States has also dumped approximately 100,000 tons (the equivalent to 39 railroad cars) in the Gulf of Mexico and off the coast of New Jersey, California, Florida, South Carolina, India, Italy, Norway, Denmark, Japan, and Australia (Harigel, 2001). Specific locations of dumping are not known, making it difficult to ascertain exactly who is at risk. While some of these weapons are water soluble, others are not and can remain active for many years. Others are denser than seawater and may remain on the floor of the ocean, where they pose a greater threat. In addition, colder temperatures prevent the degradation of the chemicals (Bearden, 2007). Ocean currents can carry contamination far beyond the original site where chemicals were dumped. In the Baltic Sea, fishermen have reported catching "encrusted sulphur mustard" in fishing nets while trawling, posing threats to sea life as well as humans (Bearden, 2007). As these weapons continue to deteriorate, they threaten our seas and the ocean life, extending threats to humans and the environment around them.

In addition to the disposal of chemical weapons, the use of chemical weapons during wartime has long-lasting effects as well. While harmful chemicals were used to gas humans to death in Nazi concentration camps, one of the more recent well-known uses of chemical weapons is Agent Orange. It is estimated that the U.S. military used 19 million gallons of Agent Orange in the Vietnam War between 1962 and 1971. This herbicide killed trees and other vegetation, allowing for troops to better see the enemy. However, it also had an overwhelming effect on human and wildlife populations. We are still dealing with the lingering effects of this chemical nearly 50 years later. Agent Orange contaminated the Vietnamese soil and water, passing into the food supplies, and specifically contaminating fish that the Vietnamese eat as a basic staple. However, the contamination of the human population is very clear as well. We see serious health effects in the Vietnamese people as well as our own military families that were affected by this harmful chemical. These health issues include, but are not limited to, cancer and serious birth defects (N.A., N.D.).

Another use of "chemicals" to harm human populations and the environment occurred on September 11, 2001. When terrorists used commercial airliners to attack the World Trade Center, the explosion released chemical agents in "90,000 liters of jet fuel [that] burned at temperatures around 1,000 degrees C" (Enzler, 2006). This fuel explosion released toxins into the air. Clouds of gaseous particles continued to form and expand over much of Manhattan and Brooklyn, exposing everyone in their path to dangerous chemicals for weeks. Some of the effects have been seen in rescue workers suffering from respiratory diseases; however, it may be years before we see the full effects of this act of terrorism on the human population and environment that was exposed.

Biological Weapons

Biological weapons are categorized into three basic types: spore-forming bacteria; vegetative bacteria (nonspore-forming); and viruses (Stuart, 2005). Studies have indicated that survival of these agents increases in air, water, textiles, and in soil (Stuart, 2005). Biological weapons may be more harm-

Figure 1. Chemical weapons are the most insidious of weapons, as their presence is not obvious. They are hidden from view, and they may be in the form of gases, liquids, and powders that lie in wait for unsuspecting military or civilian personnel. Their effects may be immediate in paralyzing a human or animal or cause a lingering death and lead to extensive environmental damage. Shown here is a photograph of a sailor wearing a protective chemical weapons suit. *(Credit: Library of Congress [www.loc.gov/pictures/item/98506956/].)*

ful than chemical weapons simply due to the fact that their effects on the environment cannot be reversed. They spread disease and infections that cannot be detected immediately and lie in the environment around us for years, continuing to infect humans and the environment. In addition, it is very difficult to predict the impact of these weapons since viability depends on physiological factors in both the agent and the host at the time of contamination. Hence, sampling will result in more actual, accurate data instead of predicting what the hazards may be to the environment (Stuart, 2005). In addition to wartime weapon development, these agents have been developed to control illegal crops (i.e. poppy fields in Afghanistan and the coca plant in Columbia). However, biological weapons also spread disease and destroy the environment around them; they are just as much a threat to humans as they are to ecosystems and wildlife. Biological weapons applied on a large scale can wipe out entire populations quickly and without forewarning. Sometimes the effects are not known for months or perhaps even years. This, in particular, makes predicting their impact very difficult.

Depleted Uranium

Used during the Gulf War (approximately 600,000 lbs.), depleted uranium (DU) has a half-life of 4.5 billion years, making this a long-term problem. In Afghanistan, there is evidence that DU ammunition has been used, causing contamination to the environment and "long-term health hazards" (Hay-Edie, 2002). It is the by-product of the extraction process after natural uranium and extract-enriched uranium are combined for nuclear fuel and weapons (Pesic, 2005). DU is delivered with conventional weapons (i.e., tank rounds, machine guns, Gatling guns, artillery, and even sniper rifles) and significantly increases the "lethal range" of these conventional weapons (Pesic, 2005). Upon impact, DU converts to radioactive dust, which is easily ingested. The World Health Organization has suggested that children are the most vulnerable to DU due to the fact that "typical hand-to-mouth activity in inquisitive play could lead to high DU ingestion from contaminated soil" (N.A., N.D.). Biological effects of ingestion are both radiological and chemical and may include kidney failure and cancers related to the immune system, blood, and/or bone (Pesic, 2005).

Landmines

A passionate cause of the late Princess Diana of Great Britain was to highlight the fact that landmines pollute the world. Sixty (60) to 110 million landmines cover the ground around the world, including hundreds of thousands littering the fields and mountains of Afghanistan (Hay-Edie, 2002). Annually, landmines are responsible for over 26,000 deaths across the globe, not including wild and domesticated animals. They account for other issues related to deforestation, soil erosion, and water pollution as well. These mines account for not only physical and emotional injury in humans and animals, but also leave farmlands rendered useless, creating severe shortages of food and thus causing malnutrition in some areas of the world.

A relatively new development that has appeared in the wars in Iraq and Afghanistan are IEDs or "improvised explo-

Figure 2. As military planners, scientists, and engineers as well as terrorists develop new weapons, researchers are looking for ways to counter those weapons with new technologies. Shown here is a Foster-Miller Talon Mk.II searching an area while a Micro Air Vehicle (MAV) provides a 360-degree view as the two work together to search for a simulated improvised explosive device (Credit: Naval Air Warfare Center Weapons Division). [See www.navair.navy.mil/nawcwd/nawcwd/media_galleries/photos/photos_technology.htm]

sive devices." The IED is a repurposing of existing weapon technologies and is used in much the same manner as land mines. Unlike land mines that lie dormant until some unsuspecting soldier or civilian steps on them, IEDs can be triggered by remote wireless control, push buttons, or trip wires. They result in devastatingly serious injury or death. To counter such weapon threats, new technologies are being developed to discover and disarm such weapons. Figure 2 shows a micro air vehicle searching for a simulated IED.

Nuclear Weapons

The danger of nuclear weapons is astounding. A global nuclear war has the potential to kill more than three billion people—half of the world's population. The additional radiation that would remain in the air, soil, and water would affect the surviving population. Nuclear weapons would wipe out land and water supplies, rendering the world without the ability to grow food and resulting in starvation in much of the population. Life would literally cease to exist on earth.

Nearly seventy years ago, in the midst of World War II, a decision was made to explore and develop a nuclear weapon that would eventually become the world's most powerful and devastating weapon. It was feared that Adolf Hitler's Germany would develop a similar weapon first. Subsequently would begin what is now known as the "nuclear age." The Manhattan Project brought together engineers, scientists, and technicians from around the United States to develop an atomic weapon of such scale that it would bring to a close a global war. It is important to note that nuclear science was in its infancy at this time, and little was known about the health effects of radiation and nuclear materials on humans. The construction of the world's first atomic bomb began at the Los Alamos Laboratory in New Mexico under the direction of Dr. J. Robert Oppenheimer (ACHRE, 2011).

Jet Fighters

Jet fuel used to power jet fighters is as toxic to the environment as any other weapon. Jet fuel pollutes the air, soil, and water around us. Many times, the military has been known to "dump" fuel from jets in bodies of water as well as over unpopulated land areas. A typical jet fighter burns 105 liters (or 27.74 U.S. gallons) of jet fuel per minute (1,664.40 gallons per hour), while a C-17 cargo jet burns 11,350 liters per hour (or 2,998.35 U.S. gallons) (Biello, 2011). To put this in perspective, one typical U.S. car burns .8 gallons per hour if running idle. Given this tremendous amount of fuel that is burned by military jets, we can imagine the impact emissions and dumping of fuel has on our environment. However, the military has announced that it is reducing its carbon footprint in several ways. First, Navy Secretary Ray Mabus announced in 2009 that the Navy would be building the "Green Hornet," a biofuel-powered F/A-18 jet fighter ready for flight in three years. This initiative is expected to save approximately 127,000 barrels of fuel per year and provide for a much cleaner-burning fuel source to help the war on pollution (Tirella, 2009). In addition, the military is also expected to convert its entire fleet of 50,000 vehicles to electric and hybrids by the year 2015 (Tirella, 2009).

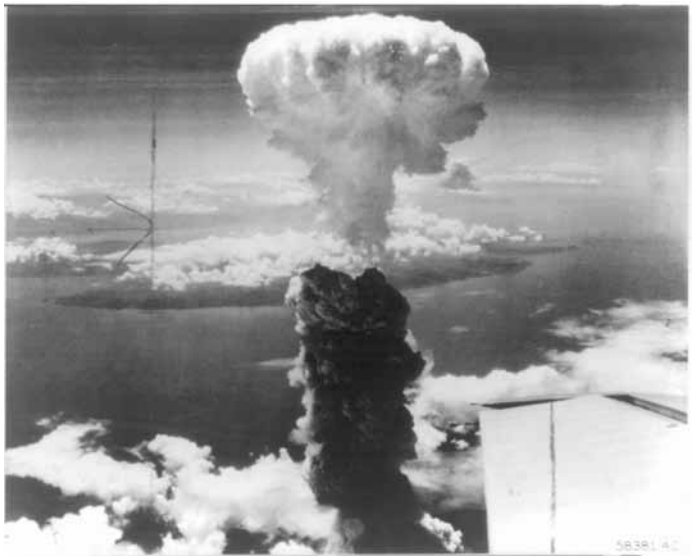

Figure 3. Shown is an aerial photo of the second bombing of Nagasaki, Japan in August, 1945. The unusual but characteristic plume of a nuclear explosion creates devastatingly high winds and temperatures at ground-zero level. The resulting destruction is immediate, and the effects of radiation linger (Library of Congress). [See www.loc.gov/pictures/item/98506956/]

Lead Bullets

Lead has been determined to be one of the most deadly toxins on earth. In the 20th century it is estimated that 20 million tons of lead bullets have been fired in the United States (Virginia Tech, 2004). Researchers at Virginia Tech say that there are approximately 9,000 military and nonmilitary shooting ranges in the United States. "Some 60,000 metric tons of lead are expended by shooting, so there are lead bullets everywhere" (Virginia Tech, 2004). Studying a shooting range in Blacksburg, VA, researchers found that lead is ab-

sorbed in the "top few inches of the soil and does not migrate beyond that" (Virginia Tech, 2004). In addition, significant amounts were found in trees, which means that when trees are cut down, they will contain lead contaminate.

A study published by the Environmental Working Group in 2001 suggests that people who regularly visit the shooting range as well as their families are susceptible to lead exposure. Lead settles into clothing, footwear, and other items of clothing typically worn to the range. "Take-home exposure" is said to be one of the leading causes of secondary lead poisoning (Diaz, 2001). However, direct poisoning can be found in those who cast their own bullets, as "melting lead produces a fume which can remain in the air for several hours" (Diaz, 2001). An example of secondary exposure can be found in a day-care center in Clearwater, FL. This day-care center was forced to close because a shooting range located next door was emitting lead-contaminated air into the playground of the day-care center. Children received blood tests to determine contamination and extent of contamination (Diaz, 2001). Even construction workers in charge of demolition of a shooting range tested positive for lead contamination, as did their children.

Both studies above collected data from a contained area, a shooting range. What about the areas where hunting and wars take place? In these areas, we see less control and perhaps more widespread contamination from lead bullets fired from manual and automatic weapons.

So, what are we doing to be more environmentally conscious while maintaining weapons to protect against our enemies and continuing to allow for recreational use as well?

BAE Systems, a British arms manufacturer, is designing reduced-lead bullets and grenades with reduced smoke, as well as lower-toxin rockets in hopes of lowering carbon emissions (Ungoed-Thomas, 2006). Dr. Debbie Allen, Director of Corporate Social Responsibility says, "Weapons are going to be used, and when they are, we try to make them as safe for the user as possible, to limit the collateral damage, and to impact as little as possible on the environment" (Ungoed-Thomas, 2006).

Design Initiative for Students

As students enter the class they will see an image of a baby born with birth defects such as missing limbs—a shocking photograph with a caption below similar to this one: "The results of the war ten years ago." These kinds of images are very graphic but at the same time very effective in highlighting the impact of weaponry and other toxic materials.

After a few minutes, ask the students if they know who is responsible for the situation of the baby and how we can have such tragic images ten years after active war. Assign groups of three, where students will be responsible to investigate, conduct research, and come up with solutions to the issue. Once solutions are being identified, they should be presented to the rest of the class, and a plan of work should be developed to solve the problem. Provide ideas, such as a day trip to a recycling facility, where students can see alternative materials that can replace toxic or nonbiodegradable materials. Introduce the students to several organizations and provide information about recycling, environmental issues, and balancing environmental concerns and social concerns with technological advancement.

Activities such as the one described above are easy to correlate with ITEEA's technological literacy standards. See Table 1 for correlations with ITEEA's *STL* standards.

Summary

Even though war is a tragedy on its own, sometimes it can be the only solution to prevent the worst. It is vital that we promote the manufacturing of biodegradable weapons that don't pollute the environment and also strengthen the laws that prohibit the use of toxic and other chemical weapons; otherwise, the direct output of this concept—the existence of humanity in the years to come—will be questionable.

References

Bearden, D. (2007). *U.S. disposal of chemical weapons in the ocean: Background and issues for Congress.* Retrieved from www.fas.org/sgp/crs/natsec/RL33432.pdf

Biello, D. (2011). U.S. military links alternative energy research to lives—and dollars—saved. *ScientificAmerican, 27.*

Diaz, T. (2001). *Lead pollution at outdoor firing ranges: Poisonous pastime.* EWG Research. Retrieved from www.ewg.org/files/poison.pdf

Enzler, S. M. (2006). *Environmental effects of warfare: The impact of war on the environment and human health.* Retrieved from www.lenntech.com/environmental-effects-war.htm

Harigel, G. G. (2001). *Chemical and biological weapons: Use in warfare, impact on society and environment.* Nuclear

Correlation with *Standards for Technological Literacy*

The Nature of Technology	Technology and Society	Design
Standard 1: Students will develop an understanding of the characteristics and scope of technology.	**Standard 5:** Students will develop an understanding of the effects of technology on the environment.	**Standard 8:** Students will develop an understanding of the attributes of design.
Standard 2: Students will develop an understanding of the core concepts of technology.	**Standard 6:** Students will develop an understanding of the role of society in the development and use of technology.	**Standard 9:** Students will develop an understanding of engineering design.
Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	**Standard 7:** Students will develop an understanding of the influence of technology on history.	**Standard 10:** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.
Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.		

Table 1. Note: Adapted from *Standards for Technological Literacy: Content for the Study of Technology*. ITEA/ITEEA (2000/2002/2007). Reston, VA: Author.

Age Peace Foundation. Retrieved from www.waging-peace.org/articles/2001/11/00_harigel_cbw.htm

Hay-Edie, D. (2002). *The military's impact on the environment: A neglected aspect of the sustainable development debate.* In G. International Peace Bureau (Ed.). Geneva: International Peace Bureau.

Giles, J. (2004). Green explosives: Collateral damage. *Nature*, (427), 580-581.

Information.org. (N.D.). *The impact of war and weapons on humans and the environment.* Retrieved from www.information.org/cgi-bin/gPage.pl?menu=menua.txt&main=weapons_effects.txt&s=Weapons

Pesic, I. (2005, 2005). *Depleted uranium: Ethics of the silver bullet.* Retrieved from http://cseserv.engr.scu.edu/StudentWebPages/IPesic/ResearchPaper.htm

Stuart, A. L. (2005). Degradation of biological weapons agents in the environment: Implications for terrorism response. *Environmental Science & Technology, 39*(No. 8), 2736-2743.

Tirella, J. (2009). *Eco-friendly fire: Militaries try saving the planet while killing the enemy.* Retrieved from www.fastcompany.com/blog/joseph-v-tirella/joseph-tirella/army-green-militaries-try-saving-planet-while-killing-enemy

Ungoed-Thomas, J. (2006). BAE promoting environmentally-friendly munitions. *The Sunday Times*, September 17, 2006. Retrieved from www.spacewar.com/reports/BAE_Promoting_Environmentally_Friendly_Munitions_999.html

U.S. Department of Energy, The Office of Health, Safety, and Security. (n.d.). *ACHRE report, The Manhattan Project: A new and secret world of human experimentation.* Retrieved from www.hss.energy.gov/healthsafety/ohre/roadmap/achre/intro_3.html

Virginia Tech. (2004). Do lead bullets continue to be a hazard after they land? *ScienceDaily*, November 3, 2004. Retrieved from www.sciencedaily.com/releases/2004/11/041104005801.htm

Petros J. Katsioloudis, Ph.D., *is an assistant professor and Ambassador to Cyprus for the International Technology and Engineering Educators Association. He is a member of the Department of STEM Education and Professional Studies at Old Dominion University in Norfolk, VA. He can be reached via email at pkatsiol@odu.edu.*

Mildred V. Jones *is a senior undergraduate in the Department of STEM Education and Professional Studies at Old Dominion University. She can be reached at mjones@odu.edu.*