

**Part IV**  
**Commemoration Ceremony**

# A Century of Chemical Warfare: Building a World Free of Chemical Weapons

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**Abstract** The first major use of chemical weapons in warfare was on April 22, 1915, when Germany attacked Allied forces along the Ypres Salient in Belgium in World War I. Since that historic attack a century ago, dozens of countries have researched, developed, tested, and deployed still more deadly chemical weapons. These inhumane and indiscriminate weapons of mass destruction were again used in 1924 by Spain against Morocco, by Italy against Libya and Ethiopia in the 1920s and 1930s, and by Japan against China in World War II (Robinson 1971). More recently they were deployed by Iraq against Iran and Iraq's Kurdish population in the 1980s, and from 2012 to the present in the Syrian civil war. The 1993 Chemical Weapons Convention (CWC) in 2016 includes 192 countries, 98% of the world's population, with only four countries—Egypt, Israel, North Korea, and South Sudan—still missing. And of the 72,525 metric tons of chemical agents declared to date in eight possessor states, over 66,000 metric tons—92%—have been safely destroyed in the last 25 years. This is a historic achievement in global disarmament and peace-building and needs to continue until we rid the world of all chemical weapons, prevent their re-emergence, and promote peaceful uses of chemistry.

## 1 Introduction

Chemicals have been used as weapons for centuries, primarily in poison arrows and darts and in targeted assassination attempts. But just a century ago, on April 22, 1915, a chemical, in this case chlorine, was used on a massive scale in major warfare. The advance of the German 4th Army against Ypres, Belgium, in November 1914 had been stalemated for months by British, French, Belgian, Canadian, Algerian, Senegalese, and other Allied forces which were dug into trenches along the Ypres Salient in World War I. At 5 o'clock in the afternoon of April 22, when the wind had finally turned to blow from the northeast, German

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troops opened valves on 5,700 canisters of pressurized liquid chlorine and let the green-yellowish toxic industrial chemical mix with air, turn gaseous, and waft across the Allied trenches.

The Allied forces, primarily Canadian, British and French, had two bad choices—either remain in their trenches and choke on the chlorine gas, or jump above the heavier-than-air toxic cloud and be machine-gunned by the German troops. This impossible choice caused thousands to be killed that day as the Germans advanced on the town of Ypres from the northeast.

Over the next several years of major warfare, over 190,000 tons of chemical agents, much more deadly than chlorine, were produced and used by Germany, France, Britain, the United States, and others in WWI. As a result, some 90,000 troops were killed and another million or more injured with chemical weapons in the war.<sup>1</sup> A famous photo of Allied troops, walking one behind the other with their arms on the shoulders of the soldier in front of them and their eyes bandaged, illustrates the horrible injuries of the widespread use of mustard agent in WWI, and the international outcry thereafter against the cruel and inhumane use of chemicals in warfare.

On April 22, 2015, a very moving nightly memorial ceremony took place at the Menin Gate Memorial to the Missing in Ypres, Belgium, dedicated to those British soldiers who took part and died in the Ypres Salient and who remain missing—still over 54,000 names engraved on the gate. This historic ceremony has been ongoing since 1928 except for the years during World War II when Ypres was occupied by Germany, and recently surpassed its 30,000th evening ceremony.

## 2 The Geneva Protocol

On June 17, 1925, just a few years after the end of World War I, the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, otherwise known as the Geneva Protocol, was opened for signature. This historic international treaty stated:

Whereas the use in war of asphyxiating, poisonous or other gases, and of all analogous liquids, materials or devices, has been justly condemned by the general opinion of the civilized world; and Whereas the prohibition of such use has been declared in Treaties to which the majority of Powers of the world are Parties; and To the end that this prohibition shall be universally accepted as a part of International Law, binding alike the conscience and the practice of nations.<sup>2</sup>

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<sup>1</sup>For a fuller account of estimated casualties in World War I, see [https://en.wikipedia.org/wiki/Chemical\\_weapons\\_in\\_World\\_War\\_I](https://en.wikipedia.org/wiki/Chemical_weapons_in_World_War_I). We will never know exact numbers of deaths and injuries from chemical agents in WWI, but Michael Duffy in *Weapons of War—Poison Gas*, estimates 90,198 deaths and 1,140,655 injuries from use of chemicals, see <http://www.firstworldwar.com/weaponry/gas.htm>.

<sup>2</sup>See the United Nations Office of Disarmament Affairs Treaties Database, accessed at <http://www.un.org/disarmament/treaties/t/1925.html>.

36 countries, including a number of chemical weapons states and victims of WWI chemicals—Austria-Hungary, Belgium, Canada, France, Germany, Italy, Russia, the United Kingdom, and the United States—signed the protocol that day, but many of the early signatories took decades to ratify and join the chemical ban. The Geneva Protocol banned the use of both chemical and biological weapons, but unfortunately did not limit research, development, testing, evaluation, and stockpiling of these weapons. It entered into force on February 8, 1928, but only 25 countries, including France, Germany, the Soviet Union, and the UK, had ratified the treaty by 1930; other chemical weapons powers such as the United States did not ratify it until many decades later—1975 in the case of the US. And of 137 States Parties today, 46 or one-third have ratified or acceded with reservations. The US and other reservations stated that the country reserved the right to retaliate in kind if attacked by chemical and/or biological weapons. US President Franklin Roosevelt stated specifically in 1943 that the “use of such [gas] weapons has been outlawed by the general opinion of civilized mankind.”<sup>3</sup>

### 3 Chemical Weapons Convention

Fortunately the broad condemnation of chemical weapons after World War I appeared to impact the non-use of them for over half a century thereafter. Although many countries researched, developed, and produced thousands of tons of chemical agents and launch systems before, during, and after World War II, few countries deployed them in any major WWI-type attacks. Britain used adamsite against Russian troops in 1919 and possibly against Iraq in the 1920s; Bolsheviks used gas in the peasant Tambov Rebellion of 1920 in Russia; Spain used chemicals against Moroccan RiF tribesmen in the 1920s; and Italy used mustard agent against Libya in 1930 and in Ethiopia in 1936. Japan had shipped thousands of chemical weapons with their troops to China in WWII, but left them behind after minimal use when they retreated back to Japan. Both Italy and Germany produced large chemical weapon stockpiles in WWII, along with Russia, the United States, and Britain, but never used them in Europe except for a 1939 reported accidental attack by Germany on Warsaw with mustard agent. And Egypt used chemical weapons, although ineffectively, in Yemen in 1963.<sup>4</sup>

In 1968 Sweden was successful in placing both biological and chemical weapons on the agenda of the Eighteen Nation Disarmament Conference (ENDC) convening in Geneva, Switzerland and co-chaired by the Soviet Union and the United States. A year later the United Kingdom introduced a draft convention banning biological weapons which eventually resulted in the Biological and Toxin

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<sup>3</sup>See <https://www.state.gov/t/isn/4784.htm> for the Roosevelt quote and a brief history of the Geneva Protocol. Also <http://disarmament.un.org/treaties/t/1925>.

<sup>4</sup>See [https://en.wikipedia.org/wiki/Chemical\\_weapons\\_in\\_World\\_War\\_I](https://en.wikipedia.org/wiki/Chemical_weapons_in_World_War_I).

Weapons Convention of 1972.<sup>5</sup> Article IX of the BTWC (or more commonly, BWC) was a step towards a ban on chemical weapons by stating:

Each State Party to this Convention affirms the recognized objective of effective prohibition of Chemical Weapons and, to this end, undertakes to continue negotiations in good faith with a view to reaching early agreement on effective measures for the prohibition of their development, production and stockpiling and for their Destruction, and on appropriate measures concerning equipment and means of delivery specifically designed for the production or use of chemical agents for weapons purposes.<sup>6</sup>

The BWC entered into force in 1975, effectively banning all development, production, stockpiling, and use of biological weapons although it did not include any verification or inspection mechanisms. This was the first time such an international treaty banned a whole class of weapons of mass destruction and it thereby opened the door to follow-on negotiations on a similar chemical weapons ban. In 2016 the BWC has 175 States Parties and eight signatories, but 13 countries still remain outside its regime.<sup>7</sup>

The issue of chemical weapons remained part of ongoing discussions at the United Nations in Geneva and a number of countries tabled various drafts throughout the next decade. Both the United States and the Soviet Union recognized the need to limit, perhaps even to eliminate, their large and dangerous stockpiles of chemical weapons and initiated a bilateral working group thereon. In 1978 the Geneva group of 40 countries established an ad hoc working group on a chemical weapons treaty, and an increased focus thereon was launched with a US draft convention in 1984 (Kenyon and Feakes 2007, especially Chap. 1). The use of chemical weapons by Iraq against Iran in the 1980s, the first major use of chemical agents in warfare since WWI, also increased pressure on diplomats to negotiate a treaty; it is estimated that 20,000 Iranians died, and another 80,000 were injured, from Iraqi chemical attacks throughout the 1980's Iran-Iraq War (Kenyon and Feakes 2007, 9–10).<sup>8</sup>

The Geneva Conference on Disarmament (CD), newly renamed in 1980, began ongoing negotiations on a chemical weapons ban, and intensified bilateral discussions between the US and the Soviet Union, now with a new and forward-looking president, Mikhail Gorbachev, led to a bilateral agreement to reduce US and Soviet CW stockpiles to 20% of their then-current inventories and to reduce them down to 5,000 metric tons each by 2002. This agreement, called the “Wyoming

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<sup>5</sup>For the text of the BWC, see [http://www.unog.ch/80256EE600585943/\(httpPages\)/04FBBDD6315AC720C1257180004B1B2F?OpenDocument](http://www.unog.ch/80256EE600585943/(httpPages)/04FBBDD6315AC720C1257180004B1B2F?OpenDocument).

<sup>6</sup><https://www.state.gov/t/isn/4718.htm> English.pdf.

<sup>7</sup>[http://www.unog.ch/80256EE600585943/\(httpPages\)/7BE6CBBEA0477B52C12571860035FD5C?OpenDocument](http://www.unog.ch/80256EE600585943/(httpPages)/7BE6CBBEA0477B52C12571860035FD5C?OpenDocument).

<sup>8</sup>See [https://en.wikipedia.org/wiki/Chemical\\_weapons\\_in\\_World\\_War\\_I](https://en.wikipedia.org/wiki/Chemical_weapons_in_World_War_I).

Agreement,” was signed in 1990 but never entered into force. It however allowed both the US and the Soviet Union to move forward unilaterally and reciprocally with the destruction of their existing large CW stockpiles.<sup>9</sup>

Another chemical weapons attack, again by Iraq under Saddam Hussein’s leadership, took place in 1988 against Kurdish citizens in northern Iraq, including the town of Halabja, killing several thousand Iraqi citizens and shocking the world. This also propelled the negotiations forward in Geneva on a multilateral treaty banning these inhumane and indiscriminate weapons.<sup>10</sup>

In 1990 the US began unilaterally operating its prototype incinerator for the destruction of chemical weapons on Johnston Atoll in the middle of the Pacific Ocean. The US had secretly moved forward-deployed chemical stockpiles from both Germany and Okinawa to this remote atoll over a decade earlier and had accumulated 1,842 metric tons of mustard agent there.

After a series of diplomatic breakthroughs including agreement on intrusive on-site inspections, sharing of peaceful chemistry training and technology, and national declarations, agreement on an international convention was reached in Geneva on September 2, 1992. The draft text was transmitted to the United Nations and opened for signature in Paris on January 13, 1993.<sup>11</sup> Two-thirds of the world—over 130 countries—signed the Chemical Weapons Convention (CWC) in its first two days, but it didn’t enter into force until April 29, 1997, 180 days after 65 countries had ratified it. After a long political battle in Washington, D.C., the US ratified the CWC on April 25, 1997, just in time to become a full-fledged member before formal entry into force. Russia also faced a difficult political fight over ratification and finally ratified the treaty on November 5, 1997.

Until 2016 192 countries have joined the Chemical Weapons Convention, with both Myanmar/Burma and Angola having joined in 2015. This leaves just four countries—Egypt, Israel, North Korea, and South Sudan—outside the Convention, although Israel signed the CWC in 1993. Other regions including both Taiwan and Palestine are not members.<sup>12</sup> This makes the CWC the most universal arms control and disarmament treaty so far, and the largest multinational organization outside of the United Nations.<sup>13</sup>

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<sup>9</sup>See <http://www.acq.osd.mil/tc/treaties/bda/text.htm>.

<sup>10</sup>For more history, see: [https://en.wikipedia.org/wiki/Chemical\\_warfare](https://en.wikipedia.org/wiki/Chemical_warfare); [https://en.wikipedia.org/wiki/Chemical\\_weapons\\_in\\_the\\_Rif\\_War](https://en.wikipedia.org/wiki/Chemical_weapons_in_the_Rif_War).

<sup>11</sup>For a full text of the Convention, see <https://www.opcw.org/chemical-weapons-convention/preamble/>.

<sup>12</sup>For a full list of members and dates of signature, ratification, accession, and national entry into force, see OPCW, Note by the Technical Secretariat: Status of Participation in the Chemical Weapons Convention as at 17 October 2015, S/1315/2015, October 19, 2015, at [https://www.opcw.org/fileadmin/OPCW/S\\_series/2015/en/s-1315-2015\\_e\\_.pdf](https://www.opcw.org/fileadmin/OPCW/S_series/2015/en/s-1315-2015_e_.pdf).

<sup>13</sup>See [www.opcw.org](http://www.opcw.org) for more detail on verified chemical weapons destruction.

## 4 Chemical Weapons Destruction

Article IV of the Chemical Weapons Convention requires all States Parties which have declared chemical weapons stockpiles to begin destroying them “not later than two years after this Convention enters into force for it [the State Party],” and to “finish not later than 10 years after entry into force of this Convention.” This means that each country possessing chemical weapons should complete its destruction program by April 29, 2007, a decade after the CWC’s 1997 entry into force. There is also a provision for a maximum five-year extension of this deadline until 2012.

Eight countries have declared existing chemical weapons stockpiles to date, with both Russia and the US accounting for about 95% of the total declared tonnage. Table 1 shows rounded estimates of declared stockpiles, although the figures do not add to the estimated total. While most figures are within a few tons of variance, both the Indian and South Korea figures remain rough estimates due to the lack of accurate and transparent numbers from these two possessor states.

*Russia:* The largest declared stockpile is in Russia which declared seven stockpile sites in five oblasts (states) and one republic when it joined the CWC in December 1997. Table 2 shows the declared tonnage—almost 40,000 metric tons of both blister and nerve agents. The two most worrisome sites in the 1990s were the easternmost stockpile, Shchuch’ye, and one of two sites in the Udmurt Republic, Kizner; both of these sites housed weaponized nerve agents in millions of artillery shells which would fit in a briefcase or gym bag, thereby increasing the risk of theft or diversion. They also housed much larger missile warheads with multiple mini-munitions filled with nerve agents. The major concern was that these shells could very easily disappear from either site, and the Shchuch’ye stockpile was located very close to the new Kazakhstan border in Central Asia. The other five declared Russian CW stockpiles all contained blister and nerve agents in bulk storage—large barrels, containers, and railway cars which would be very difficult to steal but were still vulnerable to terrorist attack.

In July 1994 the US and Russian governments organized a high-level, on-site inspection of the Shchuch’ye chemical weapons stockpile, part of the bilateral effort to promote transparency and confidence-building measures between the two major CW possessor states. The US delegation included Dr. Harold Smith, a senior advisor to the US Secretary of Defense, and two US representatives, Glen Browder from Alabama (who had a CW stockpile, Anniston, in his congressional district) and John Spratt from South Carolina, both on the House Armed Services Committee.<sup>14</sup> It also included General Robert Orton, Program Manager of Chemical Demilitarization (PMCD) for the US Army. The delegation was hosted by Russian Army General S.V. Petrov, head of the Russian chemical corps.

The chemical weapons stockpile at Shchuch’ye was massive, housing over 2 million nerve agent artillery shells and almost 1,000 short- and medium-range

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<sup>14</sup>The author was fortunate to participate in this on-site inspection in 1994 while he was a Professional Staff Member of the Armed Services Committee in the US House of Representatives.

**Table 1** Declared chemical weapons stockpiles<sup>a</sup>

Russian Federation	39,965 metric tons
United States	28,577 metric tons
India	1,056 metric tons (est.)
South Korea	605 metric tons (est.)
Libya	26 metric tons
Albania	16 metric tons
Iraq	n.a
Syria	1,308 metric tons
Total	72,525 metric tons (est.)

<sup>a</sup>See [www.opcw.org](http://www.opcw.org) as well as historical documents for national estimates of CW stockpiles. There are several reasons for the variance in figures, including the 1997 CWC entry into force which came seven years after the US had initiated its CW destruction process in 1990. The US had incinerated 1,436 metric tons at Johnston Atoll and Tooele prior to CWC EiF. The South Korean and Indian figures are estimates. The Iraqi numbers are unknown

**Table 2** Declared Russian chemical weapons stockpiles<sup>a</sup>

Gorny, Saratov Oblast	1,142 metric tons
Kambarka, Udmurt Republic	6,349 metric tons
Shchuch'ye, Kurgan Oblast	5,457 metric tons
Kizner, Udmurt Republic	5,745 metric tons
Maradykovsky, Kirov Oblast	6,890 metric tons
Leonidovka, Penza Oblast	6,885 metric tons
Pochep, Bryansk Oblast	7,498 metric tons
TOTAL	39,965 metric tons <sup>b</sup>

<sup>a</sup>These figures are taken from a 2004 presentation of Viktor Ivanovich Kholstov, the Deputy Chief of the Federal Agency for Industry at the time, at a Green Cross annual national dialogue in Moscow, Russia

<sup>b</sup>The total may not add up due to rounding

missile warheads in old, decrepit, above-ground warehouses of corrugated metal and wood, with large barn-like doors locked with bicycle padlocks. The shells were stored in wine rack-type shelving as far as the eye could see, while the warheads were on railroad dollies, all very battlefield-ready. While this bilateral US-Russian inspection was a major historic step forward in destroying both US and Russian CW stockpiles, the visit documented the lack of any comprehensive inventory of chemical weapons, and also illustrated the disturbing lack of high security at the site. It was clear that the Shchuch'ye stockpile was highly vulnerable to theft, diversion, and proliferation, right in the middle of a region prone to growing terrorism and Islamic jihadism.

Dr. Smith, representing the US Department of Defense, offered his Russian counterparts a turnkey incinerator, similar to what had been operating since 1990 on Johnston Atoll in the Pacific Ocean as the first prototype US destruction facility for



chemical weapons. This would be fully funded by the US Cooperative Threat Reduction (CTR) Program which Congress had initiated two years earlier under the bipartisan leadership of Senators Sam Nunn, a Democrat from Georgia, and Richard Lugar, a Republican from Indiana, amongst others (Walker 2016b). Russian General Petrov, along with the Chairman of the Russian Military Committee in the Duma in Moscow, rejected the offer stating that incineration was opposed by the environmental and public health communities in Russia, was too expensive and high-maintenance, and too risky to build. Petrov and his colleagues offered, however, to establish a Joint Evaluation and Research Program (JREP) with US colleagues to study what Russian technologies might be available and/or developed to safely destroy Russia's enormous stockpiles.

Russia eventually chose neutralization, a wet chemistry process in which the weapons and tanks are drained of their liquid chemical agents which are in turn mixed with hot water and a caustic reagent such as sodium hydroxide. This chemical mixing destroys most of the toxicity of the agent but produces 10 times the volume of liquid waste which must in turn be treated in a secondary process. The neutralization process is preferred by many experts because it can contain and manage all emissions, gaseous, solid, and liquid, while incineration pumps large amounts of potentially toxic gaseous emissions out the smokestack. For Shchuch'ye, Russia chose bituminization for its secondary treatment process, mixing the toxic liquid waste with asphalt to solidify it for long-term, retrievable storage in barrels and bunkers. Russia first sought to use this asphalt to pave roads and parking lots, but it was discovered that the liquid waste was slightly carcinogenic, thereby precluding any possible reuse.

Russia's chemical weapons destruction process began in December 2002 at Gorny in the Saratov Oblast, where Germany had helped Russia build a prototype neutralization facility for the lewisite stockpile. The facility was built in larger scale at Kambarka in the Udmurt Republic for lewisite neutralization as well, also with the support of Germany. In 2016 Russia has been successful at eliminating six of its seven chemical weapons stockpiles, neutralizing 92%—about 37,000 metric tons—of its declared stockpile, with its remaining 3,000 metric tons still in process of neutralization at Kizner, the site in the Udmurt Republic similar to the Shchuch'ye stockpile.

The Organization for the Prohibition of Chemical Weapons (OPCW) in The Hague, the multilateral group which oversees implementation of the Chemical Weapons Convention, approved a five-year extension for Russia's CW destruction program until 2012, but Russia missed this final legally binding deadline, along with the US and Libya, and has now projected that it will complete its program in September 2020.<sup>15</sup>

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<sup>15</sup>See OPCW 2016c, paragraph 1.15. See also the decision of the OPCW Conference of States Parties in December 2011: Decision: Final Extended Deadline of 29 April 2012, C-16/DEC.11, December 1, 2011, [https://www.opcw.org/fileadmin/OPCW/CSP/C-16/en/c16dec11\\_e\\_.pdf](https://www.opcw.org/fileadmin/OPCW/CSP/C-16/en/c16dec11_e_.pdf).

**Table 3** Declared US chemical weapons stockpiles<sup>a</sup>

Johnston Atoll, Pacific Ocean	1,842 metric tons
Tooele, Utah	12,353 metric tons
Edgewood, Maryland	1,471 metric tons
Anniston, Alabama	2,045 metric tons
Umatilla, Oregon	3,374 metric tons
Pine Bluff, Arkansas	3,494 metric tons
Newport, Indiana	1,152 metric tons
Blue Grass, Kentucky	475 metric tons
Pueblo, Colorado	2,369 metric tons
Total	28,577 metric tons <sup>b</sup>

<sup>a</sup>These figures are taken from US Chemical Materials Agency (CMA) reports, formerly the Program Manager for Chemical Demilitarization (PMCD), and now the Program Executive Office, Assembled Chemical Weapons Alternatives (PEACWA) in Aberdeen, Maryland; see <http://www.peocwa.army.mil/>

<sup>b</sup>The total may not add up due to rounding of tonnage

*United States:* The second largest chemical weapons possessor country is the US, which declared 28,577 metric tons (31,501 US tons) at nine sites in the early 1990s. The US National Defense Authorization Act for 1986 directed the Secretary of Defense to carry out the safe destruction of the US chemical weapons stockpile.<sup>16</sup> The early destruction plan for the US was to build three centralized incinerator facilities on Johnston Atoll; Tooele, Utah; and in the south (likely Anniston, Alabama or Pine Bluff, Arkansas), to which the nine stockpiles would be shipped by train and truck and burned. The US Congress, upon hearing of this plan, banned transportation of these old and leaking chemical weapons and storage tanks, necessitating the US Army to build destruction facilities at all nine sites (Table 3).<sup>17</sup>

The next challenge for the US CW destruction program was to address public concerns over incineration. The US Army was very reluctant to introduce alternative technologies for destruction due to the potential for additional costs, schedule delays, and technical complexities. Very early in the program, however, it became clear that there would be strong and vocal opposition to incineration; a national grassroots group, the Chemical Weapons Working Group, was formed in Kentucky in 1991, and state public health and environmental regulators also began to raise concerns.<sup>18</sup>

In order to help overcome this dilemma, which was mounting between the US Army and state officials and incinerator opponents, the Assembled Chemical Weapons Assessment (ACWA) Program was created by Congress in the 1997

<sup>16</sup>National Defense Authorization Act (NDAA) for Fiscal Year 1986. Public Law 99–145.

<sup>17</sup>National Defense Authorization Act (NDAA) for Fiscal Year 1995. Public Law 103–337.

<sup>18</sup>For the Chemical Weapons Working Group, see <http://www.kyenvironmentalfoundation.org/cwvg-history-and-accomplishments.html>.

appropriations process to establish “a pilot program to identify and demonstrate at least two alternatives to incineration for the destruction of assembled chemical weapons”.<sup>19</sup> The ACWA Program also established a national dialogue of stakeholders, including federal and state regulators, grassroots activists, state governors’ representatives, the US Army, and interested engineering firms to discuss options such as neutralization for safe and timely destruction of chemical agents, explosives, and rocket propellant. It also established Citizens’ Advisory Commissions (CACs) and public outreach offices at all chemical weapons stockpile sites in order to build trust, confidence, and transparency in the process.

By the early 2000s, the US had completed the destruction of the CW stockpile on Johnston Atoll, and had begun operating several other incinerators. In 2016 the US has safely destroyed 90%—about 25,700 metric tons—of its declared stockpile and closed seven of its nine destruction facilities. The US built and operated five incinerators and two neutralization facilities, and has projected to complete operations by 2020 at Pueblo, Colorado and by 2023 at Blue Grass, Kentucky. The Pueblo, Colorado facility to neutralize 2,369 metric tons of mustard agent started initial operations in September 2016, and the last facility at Blue Grass, Kentucky should open in the next two years. Similar to the Russian program noted earlier, the US missed its last OPCW deadline in 2012 and continues to brief the OPCW on progress towards the 2023 completion date for stockpile destruction.<sup>20</sup>

*Albania:* When Albania joined the Chemical Weapons Convention in 1994 it joined as a non-possessor state and therefore did not declare any chemical weapons. In the early 2000s, it discovered suspicious barrels in a small garage in the mountains outside of Tirana and called in OPCW experts to determine if the barrels contained chemical agents or not. It turned out to be about sixteen metric tons of mustard agent, apparently imported from China under the former government, and a program was established under the G-8 Global Partnership to help Albania secure the site, design a destruction plan, and safely destroy the agent (OPCW Conference of States Parties 2004).

In late 2006 and early 2007 the German engineering firm Eisenmann built a small incinerator which was moved to the remote site in the Albanian mountains and began to burn the barrels. Unfortunately, the volatility of the mustard agent was underestimated and the first barrel burned a hole in the bottom of the furnace and also burned out the afterburner. These repairs took six weeks or more and caused Albania to be the first CWC possessor state to miss a legally binding deadline—April 29, 2007—for completing its CW destruction. Ironically, Albania could have asked the OPCW for an extension to this deadline, but had not, assuming the destruction process would go smoothly. By July 2007, Albania’s sixteen tons of

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<sup>19</sup>OCAA–Omnibus Consolidated Appropriations Act. 1997. Public Law 104–208; Strom Thurmond National Defense Authorization Act (NDAA) for Fiscal Year 1999. Public Law 105–261.

<sup>20</sup>See the US press release of September 7, 2016, <http://www.peocwa.army.mil/2016/09/07/first-chemical-weapons-processed-today-in-pueblo-chemical-agent-destruction-pilot-plant/>.

declared chemical weapons had been safely incinerated, but the remaining toxic waste still is sitting on the site.

*South Korea:* The Republic of Korea declared a stockpile of about 605 metric tons of binary chemical weapons when it joined the CWC in 1997, and it apparently safely destroyed this stockpile by 2008 (OPCW 2005).<sup>21</sup> But very little is known publicly about this stockpile or destruction process due to the high degree of secrecy demanded by South Korea concerning its arsenal. There is speculation about why South Korea is so secretive about this, including theories that it is sensitive due to the existing large CW stockpile in North Korea; it may not want its citizens to know where, when, and how it destroyed the stockpile due to environmental and public health concerns; or perhaps it is politically sensitive because its stockpile very closely resembled the newest US binary stockpile, showing that the arsenal (and/or the technology for producing it) was probably transferred from the US before the CWC entered into force for either country. South Korea, by the way, does not even allow its name to be included as a declared possessor state at the OPCW, so it is always referred to as “A State Party” (OPCW Conference of the States Parties 1999).<sup>22</sup>

*India:* Another somewhat secretive declared possessor state is India, which declared a stockpile of about 1,056 metric tons of mustard agent when it joined the CWC in 1997. This stockpile was incinerated by March 16, 2009 under OPCW verification inspectors, but there is little known about its location or arsenal specifications. While India is transparent that it is a declared possessor state, it refuses to provide any details about its chemical weapons program or destruction process (OPCW Conference of the States Parties 1999; OPCW 2005).<sup>23</sup>

*Libya:* The Libyan Arab Republic joined the CWC in 2004 after its former leader, Colonel Muammar Gaddafi, agreed publicly to destroy his weapons of mass destruction. Libya declared about 23 metric tons of bulk mustard agent, which was subsequently neutralized and verified by the OPCW in 2010–2013, although the destruction process was interrupted by the civil war in 2011. After the 2011 death of Colonel Gaddafi, the new Libyan government declared another secret stockpile of weaponized mustard agent, about three metric tons, and this was verifiably destroyed by 2015. This was the first known time that a CWC State Party intentionally misled the OPCW by hiding a CW stockpile (OPCW Conference of the States Parties 2005; OPCW 2015).

In 2016 a major effort was made by the OPCW and several States Parties to remove several hundred tons of precursor chemicals from Libya and neutralize the

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<sup>21</sup>Note that the report states that “A State Party” had “destroyed 302.716 metric tonnes, or approximately 50%, of its Category 1 chemical weapons” (OPCW 2005). This is one of the very few times that South Korea’s declared stockpile is noted in tonnage.

<sup>22</sup>Discussion was of “four States Parties—India, the Russian Federation, the United States of America and one other,” [https://www.opcw.org/fileadmin/OPCW/CSP/C-IV/en/C-IV\\_5-EN.pdf](https://www.opcw.org/fileadmin/OPCW/CSP/C-IV/en/C-IV_5-EN.pdf), p. 8.

<sup>23</sup>Note that India’s stockpile is described as “45.14%” destroyed at “476.545 metric tonnes,” indicating that its total stockpile is 1,056 metric tons (OPCW 2005).

toxic materials in Germany. This was catalyzed by an early 2016 request from Libya to the OPCW Executive Council to help destroy these remaining chemicals before non-state actors were able to capture them (OPCW 2016b).

*Iraq:* Iraq was another latecomer to the Chemical Weapons Convention, acceding to the CWC in 2009.<sup>24</sup> It also declared itself a CW possessor state with two large bunkers at Al Muthanna near Falluja containing unknown quantities of chemical agents and related equipment. These bunkers had been bombed in the 1991 Gulf War by the US and reportedly still contained a large unexploded aerial bomb, but were sealed with concrete by United Nations inspectors in the mid-1990s. While Iraq is obligated to destroy these old chemical agents from the 1980s CW program of Saddam Hussein, there has been considerable discussion at the OPCW about how best to evaluate the risks involved and to begin a destruction process. These bunkers were reportedly taken over in 2014 by ISIS but have now been retaken by Iraqi forces.<sup>25</sup> This has led to concern that ISIS could have gained access to the bunkers and/or taken related laboratory equipment which was located nearby to analyze the bunker contents (Cirincione and Walker 2014). Iraq is considering filling the bunkers with concrete to eliminate any further threats of proliferation, although the CWC expressly forbids any burial or dumping of chemical weapons as a means of irreversible destruction.<sup>26</sup>

*Syria:* Syria joined the Chemical Weapons Convention in September 2013, just a month after the sarin nerve agent attack on Ghouta, a suburb of Damascus, in which about 1,400 people died (Human Rights Watch 2013). Under threat of attack from the United States, and with considerable pressure from Russia as well, Syrian President Bashar al-Assad declared 1,308 metric tons of chemical weapons and was presented with a very ambitious timeline to eliminate them in the midst of his ongoing civil war.<sup>27</sup>

The Chemical Weapons Convention prohibits the removal of declared chemical weapons stockpiles out of a country, but an exception was made in this case, given the high risks involved with establishing a safe and secure destruction facility in

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<sup>24</sup>See the opening statement of OPCW Director-General Rogelio Pflirter welcoming Iraq as the 186th State Party, February 20, 2009, before the OPCW Executive Council. <https://www.opcw.org/news/article/opening-statement-by-the-director-general-to-the-executive-council-at-its-fifty-fifth-session/>.

<sup>25</sup>See CIA fact sheet, "Al Muthanna Chemical Weapons Complex," [https://www.cia.gov/library/reports/general-reports-1/iraq\\_wmd\\_2004/chap5\\_annxB.html](https://www.cia.gov/library/reports/general-reports-1/iraq_wmd_2004/chap5_annxB.html); see also <http://www.globalsecurity.org/wmd/world/iraq/muthanna.htm>.

<sup>26</sup>Article IV, paragraph 10, of the CWC states: "Each State Party, during transportation, sampling, storage and destruction of chemical weapons, shall assign the highest priority to ensuring the safety of people and to protecting the environment." Part IV(A), paragraph 13, of the CWC Verification Annex states: "the following processes may not be used: dumping in any body of water, land burial or open pit burning." See <https://www.opcw.org/chemical-weapons-convention/>. See also [http://www.nytimes.com/interactive/2014/10/14/world/middleeast/iraqs-plan-to-entomb-remnant-chemical-weapons-in-bunker-complex.html?\\_r=0](http://www.nytimes.com/interactive/2014/10/14/world/middleeast/iraqs-plan-to-entomb-remnant-chemical-weapons-in-bunker-complex.html?_r=0).

<sup>27</sup>See the special section on "Syria and the OPCW," <https://www.opcw.org/special-sections/syria/>. See also the Green Cross blog postings on Syria, 2014–2016, <http://www.gcint.org/?s=Syria>.

Syria. The removal of this tonnage, most of it precursor chemicals in storage barrels, but also including about 20 metric tons of mustard agent, took place from January until June 23, 2014, out of the Syrian port of Latakia. The chemicals were loaded on board two freighters, the *Ark Futura* from Denmark and the *Taiko* from Norway. The *Ark Futura* departed for the southwest Italian port of Gioia Tauro where it transferred about 600 metric tons of chemicals to an American Merchant Marine ship, the *Cape Ray*, which had been outfitted with two semi-mobile neutralization units, “field deployable hydrolysis systems.”<sup>28</sup> The reason for this ship-to-ship transfer in Italy was that Syrian President Assad refused entry of any US ships into Syrian waters.

Of the 1,308 metric tons of chemical agents and precursor chemicals removed from Syria, 600 metric tons were neutralized on board the *Cape Ray* in the Mediterranean, without any serious incidents, and the resultant hydrolyzed liquid was delivered by the *Cape Ray* to Germany and Finland for second-stage incineration. The *Ark Futura* delivered the remainder of its tonnage, about 150 metric tons, to the United Kingdom, where it was incinerated at two sites. The *Taiko* delivered its chemical cargo to Finland and to Port Arthur, Texas, in the United States, where its tonnage was incinerated (Walker 2014).

By mid-October 2014, about 98% of the Syrian chemicals were fully destroyed; the final 2% took another fourteen months in the US due to technical challenges with corroding tanks and was completed in January 2016 (OPCW 2016a).<sup>29</sup> In the end, the Syrian chemical destruction operation was judged a great success, thanks to the ten or more countries which participated in the naval convoy and destruction operations, to the OPCW and United Nations which jointly managed the enormous logistics, and to the two dozen or more countries which contributed financial resources to the OPCW totaling over 50 million euros to fund inspections and operations.

The Syrian operation was not, however, without a few major challenges. One of the largest was the lack of transparency in the effort which helped to catalyze large citizen protests throughout the Mediterranean, including politicians, environmental activists, the fishing industry, and the tourist industry, all of whom worried that any at-sea neutralization operation could impact the environment and public health. Efforts by non-profit environmental groups such as Green Cross International to facilitate dialogues and proactive outreach in and around the Mediterranean were rebuffed by the OPCW, the United Nations, and the US which argued that the tight schedule just did not allow for more democratic consensus-building.<sup>30</sup> Public concern created large demonstrations in Greece, Crete, Italy, Turkey, and

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<sup>28</sup>See the US Army Edgewood Chemical Biological Center description of the Field Deployable Hydrolysis System, <http://www.ecbc.army.mil/about/posters/2015/D13.pdf>.

<sup>29</sup>See also [http://archive.defense.gov/home/features/2014/0114\\_caperay/](http://archive.defense.gov/home/features/2014/0114_caperay/).

<sup>30</sup>This point was underlined in several meetings and calls by this author with UN, OPCW, and US State and Defense Department officials in 2013 and 2014. See also the letter from OPCW Director-General Ahmet Uzumcu to the Pancretan Commission, July 29, 2014, [https://www.opcw.org/fileadmin/OPCW/ODG/uzumcu/DG\\_Letter\\_Pancretan\\_Commission.pdf](https://www.opcw.org/fileadmin/OPCW/ODG/uzumcu/DG_Letter_Pancretan_Commission.pdf).

elsewhere. In the end, the demilitarization operations went well, but a lesson was learned that any such future operation must include proactive outreach, dialogue, and information-sharing as a central feature and best practice in order to build more broad support and to preclude such public opposition.<sup>31</sup>

The Syrian process, however, still continues as both chlorine and mustard are being used in Syria as well as in Iraq, and the latest report from the United Nations-OPCW Joint Investigative Mechanism (JIM) confirms that the Syrian government used chlorine at least twice, while ISIS used mustard at least once.<sup>32</sup> Also, the OPCW Director-General stated at the OPCW Executive Council meeting on July 12, 2016 that Syria's declaration to the OPCW of its chemical weapons program and activities still remains replete with "gaps, inconsistencies, and discrepancies."<sup>33</sup>

## 5 Other Chemical Weapons Challenges

*Buried Chemical Weapons:* The Chemical Weapons Convention also takes note of "old" and "abandoned" chemical weapons, recognizing the fact that many chemical weapons stockpiles were dumped at sea or buried on land long before the Convention entered into force. We know, for example, that there were many other countries with chemical weapons stockpiles than the eight which have officially declared them under the CWC.<sup>34</sup>

The United States has been the most transparent on this issue, publicly identifying 224 suspected burial sites at 96 locations in 38 states, the Virgin Islands, and

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<sup>31</sup>See, for example, an NGO letter to US Secretary of State John Kerry and US Secretary of Defense Chuck Hagel proposing public dialogues in Rome, Athens, Istanbul, and elsewhere, as well as video uplinks from the *Cape Ray* to build confidence in the at-sea neutralization operations; there was no response to these written suggestions. The NGO letter of February 2, 2014, can be found on the Green Cross International website, <http://www.gcint.org/public-awareness-over-syria-chemical-weapons-destruction-needed-amid-mediterranean-region-concerns/>. The Greek NGO Archipelagos Institute of Marine Conservation also organized a joint protest letter signed by many NGOs in Europe in 2014; see the Green Cross blog posting at <http://www.gcint.org/page/6/?s=Syria>.

<sup>32</sup>Joint Investigative Mechanism, "Third Report of the Organization for the Prohibition of Chemical Weapons-United Nations Joint Investigative Mechanism," August 24, 2016, [http://www.un.org/ga/search/view\\_doc.asp?symbol=s/2016/738](http://www.un.org/ga/search/view_doc.asp?symbol=s/2016/738). The JIM concluded that two incidents of chlorine use in Talmenes, April 21, 2014, and in Sarmen, March 16, 2015, were caused by the Syrian government, and one incident with mustard use in Marea, August 21, 2015, was caused by ISIS.

<sup>33</sup>See the statement by the US Ambassador to the OPCW, Kenneth D. Ward, <https://www.opcw.org/fileadmin/OPCW/EC/82/en/merged.pdf>.

<sup>34</sup>See Article IV, paragraph 17, of the CWC which states that destruction requirements shall not "apply to chemical weapons buried on its territory before 1 January 1977 and which remain buried, or which had been dumped at sea before 1 January 1985." See also Part IV(B) of the CWC Verification Annex which defines old and abandoned CW.

in Washington, D.C. Most of these sites have not yet been surveyed and investigated, but one very large dump site, which the US Army Corps of Engineers has focused on since 1993, is a region of downtown Washington, D.C. called Spring Valley. With over 1,000 expensive private homes and the campus of the American University, this area was a testing and dumping ground during and after World War I, given that the university housed the US research and development laboratory for chemical weapons during the war. In 1993 buried chemical weapons were discovered during a private construction effort, and the ongoing survey, excavation, and remediation project has now taken over two decades and hundreds of millions of dollars.<sup>35</sup>

Many other countries, including most of Europe, Japan, Russia, China, and Australia have buried chemical weapons on their territories, primarily from the two World Wars in the last century, and these dangerous weapons are typically discovered in land excavation and development projects. Germany has been carefully evaluating and destroying both chemical and conventional weapons for years at its site in northern Germany, GEKA-Munster, just south of Hamburg.<sup>36</sup> Belgium has a weapons destruction site at Poelkapelle, not far from Ypres, which was also a famous WWI battlefield in West Flanders (De Bisschop et al. 2006). The largest current buried CW excavation project is in China, where Japan left hundreds of thousands of chemical weapons after World War II at dozens of sites.<sup>37</sup>

*Sea-Dumped Chemical Weapons:* After World War II most of the warring parties had large stockpiles of chemical weapons which were dumped at sea. This was seen at the time as the safest and most efficient means to rid the world of these dangerous stockpiles, but the practice has now left over 300,000 metric tons dumped in all oceans and seas of the world between 1946 and 1965.<sup>38</sup> There are an estimated 29,000 metric tons dumped in US coastal waters, another 40,000 metric tons in the relatively shallow Baltic Sea, 21,000 metric tons off the coasts of Australia, and 6,600 metric tons around Japan.<sup>39</sup>

While sea-dumped chemical weapons do not necessarily pose a serious terrorist or proliferation threat, they are now corroding and releasing their toxic agents into nearby waters, posing potential health and food-chain threats. They have also been appearing in fishermen's nets, injuring or killing dozens of fishermen around the world, and have washed up on beaches in the Baltic, Mediterranean, and Black Seas as well as in the Caribbean and elsewhere. While the CWC does not deal directly with sea-dumped CW, it does recognize that any such weapons which are raised

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<sup>35</sup>For the US survey of buried chemical weapons, see US Army Program Manager for Chemical Demilitarization, *Survey and Analysis Report, Second Edition*, Aberdeen, Maryland, December 1996. For the Spring Valley ongoing cleanup and remediation effort, see <http://www.nab.usace.army.mil/Home/SpringValley.aspx>.

<sup>36</sup><http://www.geka-munster.de/index.php?id=2>.

<sup>37</sup><http://www.china.org.cn/english/2003/Dec/81536.htm>.

<sup>38</sup><http://www.nonproliferation.org/chemical-weapon-munitions-dumped-at-sea/>.

<sup>39</sup><http://www.helcom.fi/baltic-sea-trends/hazardous-substances/sea-dumped-chemical-munitions/>.



from the ocean floor must be declared to the OPCW and destroyed under international verification.

## 6 Other Lessons Learned in Chemical Weapons Destruction

*Cost Escalation:* When the United States began unilaterally destroying its large chemical weapons stockpile in 1990, the cost estimate for its destruction program was about \$2 billion. After over 25 years of CW destruction operations at nine declared stockpile sites, this estimate is now well over \$40 billion and still growing (US GAO 1991; Freeman and Alikhan 2013).<sup>40</sup> Each of the nine demilitarization sites, both incineration and neutralization facilities, will average well over \$4–5 billion each, many times original project estimates.

The Russian chemical weapons destruction program was initially estimated at \$3–4 billion in the mid-late 1990s, but its current cost is well over \$10 billion (Green Cross Russia et al. 2008). These US and Russian cost escalations have been caused by the complexity of destruction operations, by the need to address environmental and public health risks and protections, and by the need for transparency and public involvement. But the unpredictable growth in costs has also extended schedules, stretched federal budgets, required \$2–3 billion in support for Russia from the G-8 Global Partnership, and much foreign support for the Albanian, Libyan, and Syrian CW destruction operations. None of the eight declared CW possessor countries has been able to meet all of its legally binding destruction deadlines under the CWC, necessitating official requests for extensions and finally acknowledging that at least three countries—Libya, Russia, and the US—have missed the final 2012 deadline, and one other, Albania, missed its final 2007 deadline.

*Technology Development:* High temperature furnaces were deemed the technology of choice early on in CW destruction programs, seen by thermal engineers as the most mature, most cost-effective, and most manageable and safe. However, many questions were raised in both the US and Russian programs about the safety of the incinerators, even with new, high-tech, and effective scrubbers, and about the manageability and scientific understanding of toxic emissions. Both the Clean Air Act and the Clean Water Act in the US pose certain limits to toxic gaseous and liquid emissions, complicating the monitoring of emissions.

As noted earlier, the US finally determined that it would introduce alternative technologies, primarily neutralization, at four US CW stockpile sites, while Russia refused to use incineration as its first-stage destruction technology. Other secondary technologies were developed under the Assembled Chemical Weapons Assessment (ACWA) Program including bioremediation, super-critical water oxidation

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<sup>40</sup>Also [https://en.wikipedia.org/wiki/United\\_States\\_chemical\\_weapons\\_program](https://en.wikipedia.org/wiki/United_States_chemical_weapons_program).

(SCWO), high steam treatments, plasma arc, and other systems. Closed detonation and treatment systems have also been developed, primarily for old and abandoned chemical weapons, to preclude the need to use harmful open-burn and open-detonation (OB/OD) practices.<sup>41</sup>

The abolition of chemical weapons has thereby spawned a whole range of new treatment systems for high toxic waste, which is being found useful and relevant for many dangerous waste management programs.

*Emergency Preparedness:* Most communities around chemical weapons stockpile sites in the US, Russia, and elsewhere felt totally ill-prepared for such major destruction programs and demanded much more effective warning and evacuation planning. In the US, communities became very involved in planning efforts, with local schools outfitted with sealed, air-conditioned facilities to house all faculty and students in an emergency. Gas masks and emergency “shelter-in-place” kits were widely distributed to communities, and early warning sirens and radios were given to each household. All of this planning went hand in hand with local outreach and information efforts and Citizens’ Advisory Commissions (CACs) at each site.<sup>42</sup>

Russia agreed to very similar emergency preparedness planning in its first decade or more of chemical weapons destruction efforts, including establishing CACs and local outreach offices managed by Green Cross Russia. Russia also actively participated in community study visits between the US and Russia to share best practices in the 1990s and early 2000s (Green Cross Russia et al. 2007). Unfortunately, much of this outreach effort came to an end in Russia as facilities began active operations in the early 2000s and Moscow wanted to maintain more control over public information. Green Cross Russia, which had operated public information and outreach offices at all Russian chemical weapons stockpile sites since the mid-late 1990s, was forced to close all offices at the request of federal authorities and the pullout of all Global Partnership countries by 2010.<sup>43</sup>

Albania, India, Libya, and South Korea no doubt had some minimum emergency and evacuation planning in place for their operations and workers, but not much is known about these efforts due to the secrecy of the projects, especially in India and South Korea.<sup>44</sup>

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<sup>41</sup><http://www.peoacwa.army.mil/>. This author was very involved in the creation and management of the ACWA Program in the 1990s and 2000s, and was a member of the ACWA National Dialogue process to build consensus on acceptable and effective technologies.

<sup>42</sup>[https://www.peoacwa.army.mil/about-peo-acwa/acwa-public\\_involvement/](https://www.peoacwa.army.mil/about-peo-acwa/acwa-public_involvement/).

<sup>43</sup>See the websites of Green Cross Russia, <http://www.green-cross.ru/programms/legacy/>, and Green Cross International, [www.gcint.org](http://www.gcint.org).

<sup>44</sup>No public information is available for these programs except what is on the OPCW website, [www.opcw.org](http://www.opcw.org). At the 13th Conference of States Parties in The Hague, the OPCW Director-General, referring to South Korea, stated: “On 10 July 2008, A State Party became the second possessor State, after Albania, to eliminate its entire chemical weapons stockpile. This notable achievement deserves to be commended and represents yet another important milestone in the process towards complete chemical disarmament.” [https://www.opcw.org/fileadmin/OPCW/CSP/C-13/en/c13dg09\\_en.pdf](https://www.opcw.org/fileadmin/OPCW/CSP/C-13/en/c13dg09_en.pdf). And at the 14th Conference of States Parties in 2009, the Director-General stated: “India became, on 16 March 2009, the third State Party, after Albania and

*Community Involvement:* The chemical weapons abolition program has clearly shown the value of involving local communities and stakeholders. Some countries are reluctant to engage in public processes which can be contentious, costly, and time-consuming, but the Russian and US programs have documented the value of engaging interested and relevant segments of local and regional populations.

Public engagement is particularly important when local populations are at risk of environmental and public health impacts, and need to be involved in order to determine best practices, including choice of technology, emergency planning, risk assessments, and risk mitigation actions.<sup>45</sup> If a community is not involved, a program manager runs the risk of public demonstrations and lawsuits which can also complicate and stall, perhaps even kill, a project.<sup>46</sup>

*Transparency:* A critical part of any public involvement effort is to provide as much information and be as transparent as possible within limits of national security. Unfortunately, transparency is sometimes a victim of exaggerated national security concerns or overly ambitious schedules, leaving no time for any public discourse. This was shown in the Syrian chemical weapons destruction program, and has also been noted in both the Indian and South Korean programs.<sup>47</sup>

But even in the US CW destruction program there have been moments when transparency was intentionally blocked; in 2006 and 2007, when the US was trying to meet its interim 45% destruction deadline under the CWC, the US Army secretly devised a program to ship all the neutralized nerve agent by truck from Newport, Indiana to Port Arthur, Texas, against all prior agreements with the local community to treat the secondary waste on site with super-critical water oxidation. This catalyzed Indiana lawsuits and protests in Port Arthur, a poor African-American community sensitive to environmental justice issues (see Middleton 2007).

In Russia, the very first effort to secretly build a centralized facility at Chapayevsk met with thousands of protesters who caused the Russian military to cancel plans.<sup>48</sup> The OPCW in The Hague has also sought to increase transparency

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(Footnote 44 continued)

A State Party, to complete the destruction of all its chemical weapons stockpiles. I have commended India, and I do so again today, for the exemplary commitment it has shown to fulfilling its obligations under the Convention, and I think it deserves the recognition of us all.” [https://www.opcw.org/fileadmin/OPCW/CSP/C-14/en/c14dg13\\_en.pdf](https://www.opcw.org/fileadmin/OPCW/CSP/C-14/en/c14dg13_en.pdf).

<sup>45</sup>For a recent discussion of chemical safety and security, see <http://www.gcint.org/green-cross-co-hosts-washington-dc-discussion-chemical-safety-security/>.

<sup>46</sup>For more on the US outreach program, see [https://www.peoacwa.army.mil/about-peo-acwa/acwa-public\\_involvement/](https://www.peoacwa.army.mil/about-peo-acwa/acwa-public_involvement/). For the Russian outreach efforts, see annual national dialogue reports from Green Cross Russia.

<sup>47</sup>The OPCW, United Nations, and the US Defense Department finally organized an “Open House” on board the *Cape Ray* which had been docked at the US naval base in Rota, Spain for a month or more, waiting for the removal of chemicals from Syria, but this was organized with less than a week’s notice to non-governmental organizations and with no travel support, so was limited to only a few media representatives.

<sup>48</sup>See, for example, a summary of Russian chemical weapons and their destruction at Federation of American Scientists, <https://fas.org/nuke/guide/russia/cbw/cw.htm>.

and involve non-governmental stakeholders and experts in the last decade; representatives of the CWC Coalition, a global network of non-governmental experts, was given permission, for example, to address the plenary sessions at annual OPCW meetings for the first time in 2013.<sup>49</sup>

## 7 Conclusions

The elimination of a whole class of weapons of mass destruction—in this case, chemical weapons—has been a long time in coming to the current success which we have seen in recent years. The use of chemicals in warfare has been widely condemned for well over a century, but it took the horrors of World War I, and the more recent indiscriminate use of chemicals in Iraq in the 1980s, to strengthen the taboo of chemical weapons use embodied in the 1925 Geneva Protocol. The 1993 Chemical Weapons Convention, bolstered by the bilateral disarmament commitments of the two largest possessor states—Russia and the United States—further solidified the specific plans for abolition of these dangerous and inhumane weapons.

But to see this process through so that we not only rid the world of all chemical weapons, but also never allow them to re-emerge in any capacity as we now see in Iraq again and in Syria, the following concluding remarks remain very important:

- The world must acknowledge that chemical agents are no longer viable military weapons, and have become “taboo,” morally reprehensible, and a dangerous and costly burden for all countries.
- All possessor states must complete safe elimination of chemical weapons stockpiles in the near term—Iraq, Libya, Russia, and the United States.
- All non-member states must join the CWC—Egypt, Israel, North Korea, and South Sudan. The membership of Palestine and Taiwan must be resolved.
- The ongoing use of chlorine, a dual-use industrial chemical, in barrel bombs in Syria must stop, along with the most recent use of mustard by ISIS in Iraq. The OPCW and the United Nations must continue their investigations of chemical use by States Parties and by non-state actors in Iraq and Syria and hold those guilty parties accountable.
- All CWC States Parties must fulfill their national obligations under the Convention, including accurate annual trade reporting, implementation of a National Authority, and criminalization of nefarious chemical use.
- Protection of the environment, public health, and worker safety in weapons demilitarization activities is an absolute necessity, trumping deadlines and budget limits.

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<sup>49</sup>For the NGO presentations at the OPCW, see the 2014 19th annual Conference of States Parties, <https://www.opcw.org/documents-reports/conference-states-parties/nineteenth-session/national-statements/>.

- Transparency, stakeholder involvement, public dialogue, and consensus-building are essential to program success.
- All States Parties must support—financially and politically—the OPCW to continue both stockpile and industrial inspections, to prevent the reemergence of chemical weapons, to promote chemical safety and security, and to remain a strong and accountable implementer of the Chemical Weapons Convention (Walker 2016a).
- The CWC is an excellent model for non-discriminatory and verified abolition of a whole class of weapons of mass destruction, with implications for a future ban on nuclear weapons.

Building a world free of chemical weapons is a historic achievement which has taken over a century to realize, including the loss of tens of thousands of soldiers and civilians in global and regional wars and, most recently, in terrorist acts, but this major step forward will hopefully serve to accomplish similar arms control and disarmament steps in other areas, including nuclear and biological weapons, and will certainly serve to build a more safe, secure, and peaceful world.

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# Statement by HE Ghislain D'hoop, Ambassador of the Kingdom of Belgium

Ghislain D'hoop

In 1929, survivors of the French 418th infantry regiment erected a monument in Zuidschote, just to the North of Ypres. It was dedicated to the memory of their comrades killed or maimed by the chlorine gas attack at 5 pm on the 22nd of April, exactly one hundred years ago. The main victims of the attacks on that day and two days later were French, Moroccan, Algerian and other colonial forces, as well as 2,000 Canadian soldiers and more than 1,000 men of the Belgian Grenadier Guards and Carabiniers. Together with the British and Commonwealth forces, all were engaged in what later became known as the Second Battle of Ypres.

The 1929 French monument no longer exists. It was destroyed in 1942, during the Second World War. In its place, on the same spot, now stands a cross of reconciliation erected by the French and Belgian authorities. A moving Canadian memorial, the Brooding Soldier, stands somewhat further along the former front-line. And in Ottawa, paintings by William Patrick Roberts and Richard Jack also evoke the first chemical attack in the Ypres Salient. The Council Room at OPCW's headquarters in The Hague is called the Ypres Room. And famously, of course, the gas attacks are given strong poetical meaning in Wilfred Owen's poem, *Dulce Et Decorum Est*.

Commemoration, reconciliation, peace, international cooperation: they are key principles of humanity, embedded in our minds and in our hearts, and they must always be rekindled and never forgotten. Monuments in stone or bronze help us to achieve this difficult but necessary undertaking. So do paintings, poems and music since they touch our soul, help us to comprehend the unfathomable and make us better human beings. There is a special role to play for diplomats and scientists, in making sure that the world fully understands the horrors of chemical warfare and unites in condemning its manufacturing, stockpiling and use.

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I therefore congratulate you on this initiative to take stock of historical and scientific research on the use of chemical weapons. Today, it is fitting that we commemorate all the men and women, soldiers and civilians alike, who fell victim to the atrocious, horribly painful and debilitating effects of chlorine gas, of phosgene and of mustard gas, all used in the trenches of Flanders.

If the attack one hundred years ago teaches us anything, it is not only the particularly horrifying and perverse impact of chemical weapons upon the human body but also the extreme fear and psychological damage they cause. Indeed, the mere possibility of their use instils primeval fear and feelings of horror into any decent human being. Because of these effects, chemical weapons are truly a deterrent and can easily be construed as an instrument of mass annihilation.

A hundred years later, much has been achieved in our global reaction to chemical weapons. We abhor those who use them or threaten to do so, we are working together to destroy the remaining stockpiles, and we set up an international organisation, the OPCW, which won the Nobel Peace Prize for its unrelenting efforts toward a universal ban on chemical weapons.

But as the horrific events in Syria show, our vigilance must never abate. Sarin gas was used in a Damascus suburb in August 2013, and chlorine, the same chemical released on the Ypres front one hundred years ago, was used against innocent civilians.

Belgium knows what it means to remain vigilant. Especially the Flemish farmers ploughing their lands on what a hundred years ago was an international battlefield know the importance of careful handling of unexploded ammunition. Every spring, the land yields a harvest of warfare when around 200 tonnes of such explosive ordnance are found. Some 5% of the ammunition found is of a chemical nature. These shells have to be disposed of through specialized techniques. The Explosive Ordnance Disposal Company of the Belgian army works all year round to eliminate these dangerous relics of World War I.

Because Belgium has suffered so severely under the impact of chemical attacks, we—its government, researchers, NGOs, and industry—are forerunners in international efforts to guarantee that the ban on the production, storage, and use of chemical weapons is effectively implemented worldwide.

Chemical weapons continue to be produced and even deployed. For this reason, it is crucial that their devastating impact continues to be widely recognized and understood. The current volume contributes magnificently to this noble undertaking. I am optimistic that the strong message conveyed by this joint scientific endeavor, a message of understanding through research and the power of international cooperation, will be heard and that in the coming years will also be acted upon.

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# Fritz Haber and His Institute

Gerhard Ertl

*Dulce et decorum est pro patria mori*  
(It is sweet and honorable to die for one's fatherland).

This verse by Horace not only served during the First World War to stimulate the enthusiasm for the war. It is also the title of a poem by Wilfred Owen, which ends with the cry “the old lie!” Owen himself was killed as a young British volunteer just one week before the end of the war.

It was not only young men who were enthusiastic about the war in those days but also a large fraction of the university teachers and scientists. Among them was Fritz Haber with his maxim: “In peace for mankind, in war for the fatherland,”—a philosophy that he adopted also for his institute, the recently founded Kaiser-Wilhelm-Institut für Physikalische Chemie und Elektrochemie, to which he had been appointed first director in 1911.

Two years earlier Haber had made his most important scientific discovery while still professor at the Technical University of Karlsruhe. While today, climate and energy are the greatest problems for mankind for which solutions are expected to come from science, in those days it was the need for food. As a consequence of progress in technology and medicine, the world population was growing so rapidly during the nineteenth century that, unless crops could be increased considerably by the development of artificial fertilizers, there was a great danger of famine. In a worldwide competition it was Fritz Haber who succeeded in 1909 in his laboratory to produce ammonia from nitrogen (from air) and hydrogen, which then could be readily converted into nitrogen fertilizers (“bread from air”). This reaction was then transferred within a surprisingly short period into a large-scale industrial process, now known as the Haber-Bosch process, by Carl Bosch and Alwin Mittasch at the BASF company, which started production in 1913. At present about 140 million tons of ammonia are produced this way every year, of which 90% are converted

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into fertilizers. According to a realistic estimate, about one third of today's world population would starve if this source were not available.

Alfred Nobel decided in his testament that the prize named after him should be awarded to the person whose research had brought the greatest benefit to mankind. Under this viewpoint no one deserves this prize more than Fritz Haber, who received it immediately after the end of the First World War for the year 1918, despite international protests because of his role during the war. The Janus face of science becomes manifest in this context. Historians agree that without the Haber-Bosch process, the war would very likely have been over within less than a year, since the import of nitrates necessary for the production of explosives was blocked. This problem could be circumvented by the "saltpeter promise" ("*Salpetersversprechen*") of the German chemical industry, which was building large plants for the production of ammonia to be converted into explosives.

The general enthusiasm at the outbreak of the war also seized Fritz Haber, who became a volunteer like many other intellectuals. In a letter to his Swedish colleague S. Arrhenius he explained his reasons as follows:

... now we see it as our ethical duty, to take down our enemies with the use of all our strength and bring them to a peace that will make the return of such a war impossible for generations and give a solid foundation for the peaceful development of western Europe.

What an illusion, one can only say!

Haber followed this maxim not only personally, but also immediately converted the complete research program of his institute to military purposes. At the beginning the work concentrated on the development of alternatives for existing explosives, as for example the replacement of toluene, which could be used for the production of TNT. A severe accident happened in the laboratory on December 17, 1914, when a gifted young scientist, Otto Sackur, was killed and Gerhard Just, Haber's co-worker for many years, lost his right hand.

From the beginning of 1915 the work concentrated on problems of chemical warfare by poison gas, which was partly personally supervised by Haber at the front. On April 22, 1915 favorable wind conditions allowed the valves of containers filled with pressurized chlorine gas to be opened, thus causing the death or injury of many enemy soldiers. This military success prompted the emperor to promote Haber to the rank of *Hauptmann* (captain). In a state dominated by the military, this was an extraordinarily high distinction for him as a Jew.

A particularly tragic event has to be mentioned in this context. Haber's wife Clara Immerwahr, one of the very few female chemists at that time, lived in a broken marriage and also disagreed with the military activities of her husband. After a severe quarrel she shot herself with her husband's weapon during the night of May 2, 1915 in the garden of their home on the grounds of the institute. She was found dying by their 13-year-old son. Nevertheless, this did not prevent Haber from going to the front again the next day.

From then on the institute was the German center for research on poison gas and Haber became head of the chemistry department of the Ministry of War. His institute was transformed into a large-scale institution with 10 departments and up