

Chemical and biological weapons

Dr Carlo Kopp

CHEMICAL AND BIOLOGICAL WEAPONS HAVE BECOME A POPULAR BUZZ-TERM IN THE current media lexicon, but a broader appreciation of the dangers of such weapons remains to be seen. With the end of the Cold War the extensive civil defence training observed especially in European nations has vanished and public knowledge has largely declined. Conversely, publicly available source material is much more available now, enabling a better understanding of the capabilities and limitations of these weapons.

A feature of the contemporary media debate is often confusion between these categories and unrealistic expectations of destructive effect, not unlike that seen in the popular debate on nuclear weapons. Chemical and biological weapons vary widely in effects and ease or difficulty in manufacture and deployment.

From a philosophical perspective these weapons have been with us for millennia – the time honoured practice of catapulting animal carcasses into fortifications or throwing them down wells effected both chemical and biological weapons delivery. However, the industrial age brought massed production and use of these weapons, along with the development of far more potent agents compared to those occurring in nature.

With the exception of small arms and man-portable weapons, most conventional weapons are built to destroy an opponent's military technology, with anti-personnel effects amounting to collateral damage. The opposite is true of chemical and biological weapons, which exist primarily for the purpose of incapacitating, injuring or killing human beings, leaving technology largely intact. It is for this reason that various conventions, written and unwritten, have not seen such weapons used in combat by developed nations since the Great War.

CHEMICAL AGENTS

A wide range of chemical agents have been devised or used since the beginning of the 20th Century, varying widely in effects and measure of effectiveness. Typically the effectiveness of any chemical weapon is measured by its persistence, lethality or effect and the manner by which the agent enters victims' bodies.

Persistence is the duration of the agent's effect before the agent has dispersed or decomposed to a non-lethal or ineffective concentration. Broadly, agents are divided into 'non-persistent', with effect duration of minutes or tens of minutes, and 'persistent' where effects may last for longer periods.'

Lethality/effect is a measure of how many deaths, injuries or what level of incapacitation can be inflicted on however many personnel given some

quantity of the agent. This measure can be problematic since effect often depends on the manner in which the agent entered the body of the victim, as well as delivery system performance and local ventilation. Entry method refers to the means of absorption. Chemical agents can be inhaled but can also enter the body via skin or mucous membranes or digestive tract. Typically, inhalation produces the most rapid effect as the agent gains direct access to the bloodstream of the victim. By the same token, agents that enter via the skin may result in persistent effects.

Chemical agents are most frequently categorised by their effect or damage mechanism employed.

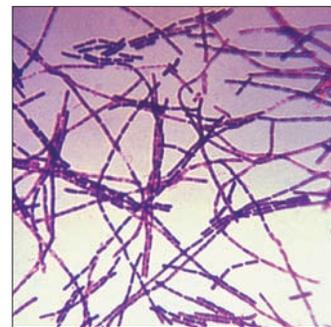
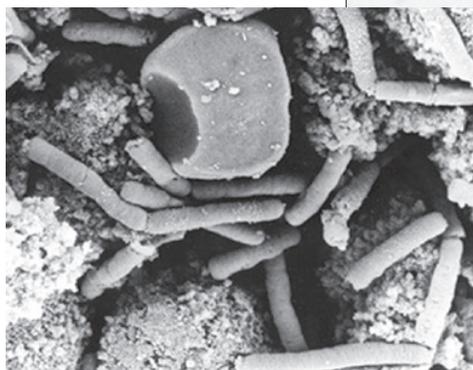
The earliest agents used in modern combat were choking or pulmonary agents and blistering agents, both of which were used during the Great War and repeatedly in conflicts since then.

Choking / pulmonary agents incapacitate or kill their victims by producing intensive irritation or inflammation of the respiratory tract and lungs. In extreme cases victims suffer bronchial spasms or drown in mucus. Survivors often suffer permanent breathing problems. Gaseous chlorine and phosgene are the best-known and most widely used agents in this category, although nitrogen oxides and hydrogen chloride are also listed in this category. In general, any gaseous or vapour species that attacks the respiratory paths and lungs could be

used as a pulmonary agent. Typically such agents are non-persistent.

Blistering agents incapacitate or kill their victims by producing acidic compounds in exposed skin and mucous membranes, which result in the formation of painful weeping blisters. Heavily exposed victims can lose large areas of skin and succumb to infection or choke as a result of damage to the respiratory tract and lungs. A range of mustard gas species, including Sulphur mustard agents (HD and H aka Yperite), nitrogen mustard agents (HN-1, HN-2 and HN-3), Lewisite (L) and phosgene oxime (CX – CHCl_2NO) are classed as blistering agents. Such agents are usually persistent, and survivors suffer disfiguring skin damage and often blindness and permanent breathing problems. Some sources also claim carcinogenic effects. While some blistering agents have instant effects, many may not produce effect until hours later.

Asphyxiants or 'blood' agents incapacitate or kill their victims by impairing the ability of red blood cells (cyanides) to carry oxygen, causing red blood cells to break down (Arsine). Carbon monoxide, although not listed, is similar in effect. All of these compounds are classed as chemical weapons, although only hydrogen cyanide is suspected of operational use. The best-known historical use of hydrogen cyanide (Zyklon B) and carbon monoxide was by the SS in a number of death camps during



Anthrax bacillus (left and bottom) and Marburg virus (upper). Both of these biological agents have been weaponised.

World War II. Cyanide has also been widely used in 'suicide pills'. Asphyxiant agents are typically non-persistent and work best in enclosed spaces. There are claims the Aum Shinrikyo cult attempted a subway attack using hydrogen cyanide. Victims often suffer nausea, spasms and dizziness, followed by loss of consciousness.

Nerve agents are by far the most lethal chemical agents known, and chemically are closely related to many insecticides, typically being organophosphate species. These agents block the acetylcholinesterase enzyme and this causes the victim's nervous system to cease functioning. Symptoms of exposure include eye pupil contraction, drooling, running nose, convulsions or spasms, dizziness, blurred vision, vomiting, spontaneous urination and defecation and ultimately death by asphyxiation as the autonomic and voluntary nervous systems shut down. Survivors of nerve agent attacks often suffer permanent neurological damage and disability. Nerve agents are usually volatile liquids, but not regarded as highly persistent. In some military applications, the agent may be dissolved in a gel so that it slowly evaporates over many hours.

Nerve agents were first developed in Nazi Germany, which produced no less than 12,500 tonnes of Tabun or GA agent by 1945 for use in aerial bombs and artillery shells. Saddam's regime used Tabun during the Iran-Iraq war. GB or Sarin is another World War II era agent, of which Germany was claimed to have produced up to ten tonnes, and which was also used by Saddam against Iran. Other related agents are Cyclosarin (GF) and Soman (GD). Cyclosarin was produced by Saddam's regime and as a component of US binary chemical munitions during the Cold War.

Rather than engineering mice or pigs that glow in the dark, a weapons designer might enhance relatively innocuous but highly infective and transmissible microorganisms with genes from highly lethal microorganisms to produce specifically tailored effects on victims.

Post war UK scientists discovered the VX agent, the first of the 'V-series' agents (VE, VG, VM) and regarded as ten times as toxic as the 'G-series' agents, with 200 micrograms enough to kill a person. VX proved to be popular in weapons applications as it is a viscous fluid, which slowly evaporates, making it highly persistent. The US and Soviets manufactured large stockpiles of VX, the disposal of which now presents genuine difficulties. There are claims that Saddam's regime experimented with VX but it is unclear whether it was successfully weaponised. VX may be absorbed by inhalation or skin contact.

The third generation of nerve agents was developed by the Soviets during the Cold War in a program designated 'Foliant' and are known as Novichok (newcomer) or Foliant family agents. Publicly available sources describe the A-234 agent, which is produced as a fine powder and is not detectable by existing warning equipment. There are unconfirmed claims that this agent has

been produced by Syria.

Cytotoxic agents are poisons that cause cellular damage. The best-known example is Ricin, extracted from castor beans; as little as 0.2 milligrams can be lethal. Another biologically produced poison is Botulinum toxin, like Ricin it has been used as an assassination weapon but is often listed amongst biological weapons despite it not being an organism.

By far the most dangerous chemical agents are nerve agents, since even modest quantities can produce significant casualties and permanent injuries. Legacy chemical weapons such as choking agents, blistering agents and blood agents need to be delivered in quantities of tonnes or more to produce large scale effect. Vastly greater damage effect is produced by a single 500 lb bomb or large calibre artillery rocket filled with a modern nerve agent.

The case study of a nerve agent terrorist attack is the Aum Shinrikyo cult Sarin strike against the Tokyo subway in 1995. A single litre of Sarin was divided into multiple plastic bags, which were punctured and left on subway trains. Around 5,500 people were affected, 12 died, and an unknown number suffered permanent injuries. This attack followed the 1994 Matsumoto city attack, in which seven died and around 200 were injured, when the cult released Sarin in a Matsumoto suburb.

Delivery of chemical agents was initially by direct dispersal, where gas bottles were vented upwind of the target area. Soon artillery rounds were adapted to deliver chemical payloads. By World War II aerial bombs and artillery rockets were also developed. During the Cold War tactical ballistic missiles also became an option. In practical terms, any weapon that can deliver an explosive warhead of suitable volume is a potential chemical weapon delivery system. The principal consideration for an attacker is achieving intended concentration of the agent in an area of interest. Weather conditions can frustrate users of chemical weapons, since wind and thermal air currents may rapidly disperse an agent and compromise its effect.

BIOLOGICAL AGENTS

Biological agents are naturally occurring or engineered pathogens that infect humans to effect incapacitation, injury or death. Any organism – bacterium, virus, parasite or fungus - which produces such an effect can be regarded as a biological weapon if delivered with this aim.

The best-known use of biological warfare predating the industrial age was the practice of using catapults to throw corpses infected with the plague into besieged cities or castles.

Like chemical weapons, biological weapons can be assessed in terms of persistence, lethality or effect and the manner by which the agent infects the victim. Additional considerations include how infectious the agent is and what its incubation period is until victims become symptomatic and

can be diagnosed, isolated and treated.

Unlike chemical agents where the lethal effect is bounded by the delivered quantity of agent, a biological agent may be highly infectious and thus self-replicating and self-propagating. From a lethality perspective, an attacker would regard the ideal agent as one that is highly infectious, has a long incubation period during which it can be transmitted, and is rapidly progressing and highly lethal once symptoms appear. In effect, such a weapon presents as a man-made pandemic aimed at an opponent – the reasoning being that 'friendly' populations can be vaccinated prior to an attack. Historically, biological agents have seen little use



Chemical warfare requires that combat troops carry protective masks or suits, which present genuine difficulties in hot climates.

in modern times compared to chemical agents, for a variety of reasons. From a targeting perspective, the effect of the weapon can be unpredictable and the footprint difficult or impossible to control. Another major problem is delivery, as few agents are robust enough to cope with the rigours of projectile delivery and dispersal, and many cannot cope with exposure to sunlight or oxygen. Shelf life of the agent in storage is another issue. Ideally an agent would be dispersed in powdered form or an aerosol.

Anthrax is the most widely used biological agent to date, and it was weaponised by several nations. While details of the weaponisation process are not public, a probable approach would be to cultivate anthrax bacteria in a nutrient, dry the resulting spore rich residue, and then pulverise it down to a powder with a sufficiently small grain size to lodge in the lungs, and if possible penetrate typical gas mask filters. It is likely that a surface treatment is applied to ensure that the micron sized powder granules do not stick together and disperse cleanly. This agent would then be delivered in a warhead with a dispersal charge that would not subject the spore to unwanted temperature or pressure conditions.

The aim of an Anthrax attack is to have the victims inhale the spores, resulting in a pulmonary infection (Woolsorter's disease) which is difficult to treat, progresses rapidly, and is nearly always fatal, unless treatment is administered very early.

The best-documented instance of Anthrax effect was the accidental release of weapons grade Anthrax spore from a Soviet Biopreparat plant in Sverdlovsk during early April 1979. It is claimed that 94 people were infected and 68 died as a result. The best-known example due to media coverage in the West was the 'Anthrax letter' attack in the wake of 911.

While the UK and US initially developed Anthrax capabilities, the Soviets mastered large-scale production in the latter Cold War period, and designed a range of Anthrax and other biological weapon systems.

The best analysis of Soviet capabilities was authored by Dr Ken Alibek, a former senior research scientist in the Soviet Biopreparat organisation who was intimately involved in a range of Soviet programs through the 1970s to early 1990s. He defected in 1992 and published 'Biohazard' a 320-page book discussing Soviet programs. Alibek describes Soviet achievements in this area as 'spectacular breakthroughs'.

The Soviets invested heavily in the development of a range of biological agents, lethal to humans and livestock. They also developed submunitions bomblets for delivery, presumably by cluster munitions. Alibek describes a program to integrate biological agent delivery submunitions on a cruise missile, presumably the standard Kh-55 Granat, the aim being to program the missile to visit multiple targets and drop a twenty-litre submunition or more on each.

Smallpox was the cause of numerous epidemics until vaccination was discovered. The basic form of the infection sees pustules break out on the victim's skin, which in severe cases causes the skin to detach and is usually fatal. The effects of severe smallpox infection have been compared to burn injuries. Haemorrhagic smallpox is a strain that causes bleeding under the skin and in internal organs usually resulting in death.

The Soviets initiated development of a smallpox weapon in 1947. During the 1960s the capability was improved when the more virulent 'India-67' strain was acquired in the process of a Soviet sponsored campaign to eradicate smallpox in rural India. Alibek claims that a stockpile of 20 tonnes of the agent was kept, with ongoing production to cover shelf-life losses. Delivery was in aerosol form. A further improved variant of the weapon was tested in 1990 and a plant set up at Koltsovo to manufacture 80-100 tonnes of the agent annually. Marburg and Ebola are closely related haemorrhagic fever filoviruses that have been the cause of numerous epidemics in Africa, and achieve very high mortality rates. Victims initially suffer nausea, fever, headaches, and rashes over an incubation period of days. Once the infection develops fully, internal haemorrhages and organ breakdown occur, with numerous sources describing an effect not unlike the victim's organs dissolving into mush.

Alibek describes a successful Soviet program in 1989 to weaponise and produce a weapon based on the Marburg virus. The most aggressive strain the Soviets had, 'Variant U', was apparently isolated from the tissue of a deceased researcher who infected himself accidentally while handling a lab animal.

Lassa fever is a haemorrhagic fever virus common in West Africa that kills thousands annually. The virus incubates for up to three weeks, and a fully developed infection may attack the gastrointestinal tract, the respiratory tract, the cardiovascular system, or the nervous system. Mortality rates are described as high as 50 per cent. The Soviets also developed a weaponised Lassa fever agent.

The Soviets also invested in the development of agents based on Tularemia, a highly infective rabbit and rodent disease, which can cause multiple organ failure in humans, Plague, Brucellosis (a livestock disease), Glanders (a horse disease) and its close relative Melioidosis, which can cause internal abscesses and septicemia and has mortality rates of up to 90 per cent.

Soviet programs also included the development of antibiotic resistant strains of a number of existing bacterial agents, and genetically altered strains intended to increase lethality.

SUMMARY

Chemical and biological weapons largely disappeared from the public debate with the end of the Cold War, only to re-emerge after 911 and in the subsequent debate over the invasion of Saddam's Iraq.

What Saddam's chemical weapons program and the Soviet biological weapons program demonstrate is that any nation state prepared to make the investment can deploy a potent arsenal of such weapons. A major issue long term will be rogue states such as Iran or North Korea developing such capabilities, which can be far more easily concealed than nuclear weapons programs. As terror weapons aimed at an opposing nation's populace, the more potent chemical and biological weapons are credible.

The biggest concern from a long-term strategic perspective are biological weapons, since the detectable footprint of production facilities is small and the increasing availability of commercial equipment for medical and DNA analysis makes it very difficult to control. Indeed, the Soviets made enormous strides using only 1980s technology.

Genetic engineering techniques involving the transplanting of genes between organisms open up a plethora of choices for a biological weapons designer. Rather than engineering mice or pigs that glow in the dark, a weapons designer might enhance relatively innocuous but highly infective and transmissible microorganisms with genes from highly lethal microorganisms to produce specifically tailored effects on victims. Another possibility already raised in speculative fiction is that of designing agents that are specific to particular racial groups or ethnicities. The aim of

such agents would be to infect only people of an opponent's dominant ethnic group, to selectively depopulate and cripple the opponent.

These risks however are multiplied by the propensity of microorganisms in nature to mutate and evolve into new strains. An engineered agent that remains in the population may further evolve into more lethal or less targeted strains. A gene that prevents the organism from infecting every possible victim is in evolutionary terms an impediment to propagation, so any mutation that breaks this constraint is apt to multiply rapidly.

The issue of terrorists using biological weapons is a topic in its own right.

DULCE ET DECORUM EST

*Bent double, like old beggars under sacks,
Knock-kneed, coughing like hags,
we cursed through sludge,
Till on the haunting flares we turned our backs,
And towards our distant rest began to trudge.
Men marched asleep. Many had lost their boots,
But limped on, blood-shod.
All went lame, all blind;
Drunk with fatigue; deaf even to the hoots
Of gas-shells dropping softly behind.*

*Gas! Gas! Quick, boys! An ecstasy of fumbling,
Fitting the clumsy helmets just in time,
But someone still was yelling out and stumbling
And floundering like a man in fire or lime.
Dim through the misty panes and
thick green light,
As under a green sea, I saw him drowning.
In all my dreams, before my helpless sight,
He plunges at me, guttering, choking, drowning.*

*If in some smothering dreams, you too could pace
Behind the wagon that we flung him in,
And watch the white eyes writhing in his face,
His hanging face, like a devil's sick of sin;
If you could hear, at every jolt, the blood
Come gargling from the froth-corrupted lungs,
Obscene as cancer, bitter as the cud
Of vile, incurable sores on innocent tongues,
My friend, you would not tell with such high zest
To children ardent for some desperate glory,
The old Lie: Dulce et decorum est Pro patria mori.
[It is sweet and right to die for your country]*

Wilfred Owen (1917)



'Gassed' by John Singer Sargent - American painter - 1918 - Imperial War Museum.