

## BIOLOGICAL WARFARE : BIOTERRORISM

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### Abstract

Biological warfare is the intentional use of micro organisms and toxins, generally of microbial, plant or animal origin to produce disease and death in humans, livestock and crops. The attraction of bioweapons in war, and for use in terrorist attacks is attributed to easy access to a wide range of disease producing biological agents, to their low production costs, to their non detection by routine security systems, and to their easy transportation from one place to another. The preferred biological agents are *Bacillus anthracis*, *Yersinia pestis*, viruses causing haemorrhagic fever, (Ebola, Lassa), small pox virus or any genetically engineered organism that can survive, express and perpetuate in the natural environment. Dissemination of biological weapons can be undertaken by aerosol sprays, explosives or food and water contamination. Biological weapons can strike suddenly without any warning and inflict considerable mortality and morbidity that can continue for a long period. Attacks by such weapons may create high level of panic, environment contamination and extreme pressures on emergency health services. Current concerns regarding the use of bioweapons result from the increasing number of countries that are engaged in the proliferation of such weapons, and the acquisition of these cheaper weapons by terrorist organizations. The need of the hour is to develop full international cooperation, and to educate the likely target populations as to what precautions and protective actions to take in case of a BW attack. Atypical clinical manifestations and short time distribution of cases should give rise to suspicion of outbreak due to biological weapon.

*Key words* Bioterrorism, Biological agents, Historical events

Biological warfare is the intentional use of microorganisms, and toxins (microbial, plant or animal origin), to produce disease and/or death in humans, livestock and crops.<sup>1</sup> Biological Weapons (BW's) of mass destruction are usually clubbed with the Nuclear and Chemical weapons in the acronym NBC. However, BW's are very different, while nuclear and chemical attacks cause their damage maximally immediately, biological attacks become manifest after sometime.<sup>2</sup> The evolution of chemical and biological weapons is broadly categorised into four phases.<sup>3</sup> In first phase, gaseous chemicals like chlorine and phosgene were used in Ypres in World War I. The second phase ushered in the era of the use of nerve agents e.g. *tabun*, a cholinesterase inhibitor, and the beginning of the anthrax and the plague bombs in World War II. The third phase was constituted by the use of lethal chemical agents e.g. *Agent Orange*, a mix of herbicides stimulating hormonal function resulting in defoliation and crop destruction. This phase included also the use of the new group of *Novichok* and *mid spectrum* agents that possess the characteristics of chemical and physiologically active compounds. The fourth phase

coincides with the era of the biotechnological revolution and the use of genetic engineering.

The attraction for BW's is attributed to their following features:

Low production costs - BW's are aptly called the 'Poor Man's Atomic Bomb'<sup>4</sup> / "Poor Man's Weapons of Mass Destruction"<sup>5</sup>. For atomic bombs, conventional weapons and nerve-gas weapons, the cost per casualty would be approximately \$2000, \$800 and \$600 respectively. However, for BW's the cost would be about \$1 per casualty.<sup>4</sup> Large quantities can, in most cases, be produced in a short period (a few days to a few weeks) at small facilities scattered over a large area.<sup>5</sup> Non detection by routine security systems<sup>5</sup> and easy access to a wide range of disease-producing biological agents<sup>6</sup> are other attractions. Biological toxins are among the most toxic agents known e.g. the quantity of botox in the dot of an 'i' is, when delivered properly, enough to kill ~ 10 people.<sup>5</sup> A single microbial bioweapon can, because it reproduces in the host, theoretically produce the desired detrimental outcome in a target host.<sup>5</sup> BW's have the added advantage of destroying an enemy while leaving his infrastructure intact as booty for the winner.<sup>5</sup>

### Disadvantages of BW's

1. Difficulty of protecting the workers at all stages of

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production, transportation, loading of delivery systems and final delivery.

2. Difficulty in maintaining quality control and sufficient containment during growth and harvesting of agents. Recently, in 1992, after 15 years of denial, president Boris Yeltsin admitted to the accidental release of anthrax spores from a test facility in Sverdlovsk during 1979 that claimed over 200 lives.'
3. Effective delivery problems: Most biological materials, including spores, are destroyed by exposure to UV light and drying. Agents released in the air may disperse in unexpected ways due to the vulgarities of wind patterns.
4. Poor storage survival: Many BWs must be stored under special conditions to maintain efficacy. Further, they are often difficult to maintain in a weapons - delivery state (e.g. loaded and ready to be fired in a rocket).
5. Difficult to control once released.

#### Characteristics of a perfect BW :

Highly infectious and highly effective

Efficiently dispersible

Readily grown and produced in large quantities

Stable on storage

Resistant enough to environmental conditions

Resistant to treatment

#### Definition of a Biological Weapon:

Biological weapons are defined as microorganisms that infect and grow in the target host producing a clinical disease that kills or incapacitates the targeted host. Such microbes may be natural, wild-type strains or may be the result of genetically engineered organisms.

These may be the products of metabolism (usually, but not always, of microbial origin) that kill or incapacitate the targeted host. These include biological toxins, as well as substances that interfere with normal behaviour, such as hormones, neuropeptides and cytokines. With our knowledge of the mechanisms of biological processes it is now possible to design and manufacture substances that mimic the action of biologics. For example, we already make nerve gases and their close relatives, pesticides, that act by binding specifically to receptors of targeted organisms. We will be able to create "designer" substances that can be specifically targeted to a particular cell-type in an enemy (e.g. people with blonde hair and blue eyes). Table-1 lists the bacterial agents, viral agents and toxins that can be potentially used as BWs.

**Table 1 : Potential bacterial, viral and toxic BWs**

BACTERIA	VIRUSES	TOXINS
<i>Bacillus anthracis</i>	Variola virus	Cholera toxin
<i>Clostridium perfringens</i>	Louping ill virus	<i>C. perfringens</i> toxins
<i>C. tetani</i>	Murray Valley encephalitis virus	Tetanus toxin
<i>C. botulinum</i> toxins	Omsk haemorrhagic fever virus	Trichothecenes
EHEC 0 157 and other verotoxin serotypes	Oropouche virus	Modescin
	Powassan virus	Volkensin
<i>Legionella pneumophila</i>	Rocio virus	Viscum Album
<i>Yersinia pseudotuberculosis</i>	St. Louis encephalitis virus	Lectin 1 (Viscumin)
<i>Brucella abortus</i>	Rift Valley fever virus	Conotoxin
<i>B. melitensis</i>	Crimean-Congo haemorrhagic fever virus	Ricin Abrin
<i>B. suis</i>		
<i>Chlamydia psittaci</i>	Hantaan virus	Botulinum toxins
<i>Francisella tularensis</i>	Eastern equine encephalitis virus	Saxitoxin
<i>Burkholderia mallei</i>	Western equine encephalitis virus	Shiga toxin
<i>B. pseudomallei</i>	Venezuelan equine encephalitis virus	<i>Staphylococcus aureus</i> toxin
<i>Salmonella Typhi</i>	Japanese encephalitis virus	Tetrodotoxin
<i>Shigella dysenteriae</i>	Chikungunya virus	Verotoxin
<i>Vibrio cholerae</i>	Dengue fever virus	Microcystin (Cyanginosin)
<i>Yersinia pestis</i>	Ebola virus	Aflatoxins
<i>Coxiella burnetii</i>	Marburg virus	
<i>Bartonella quintana</i>	Junin virus	
<i>Rickettsia prowuzekii</i>	Lymphocytic choriomeningitis virus	
<i>R. rickettsii</i>	Monkey pox virus Tick-borne encephalitis virus	

### Genetically-modified B Ws

Russia has developed a new form of anthrax that may be able to elude the vaccine that American troops receive. This may become the first genetically modified microorganism (or BDBS) to be officially listed as a BW. As it is possible to place multiple virulence/toxic capacities within a single organism or to fuse two toxic proteins together so that both would be functional as a BDBS BW (e.g. botox and ricin), these types of BWs can be expected to appear on the scene sooner rather than later.<sup>5</sup>

### Ethnic Bomb

In the fall of 1998 there was a report that white South Africa government had ordered a program to develop a genetically engineered BW that would specifically kill blacks. Recently a rumour surfaced (in the English Press) that Israel was working on a BW that would specifically harm Arabs carrying certain genes.

It is possible to conceive of genetically engineering a virus or toxin-synthesizing gene in a bacterium which is "activated or induced or regulated" by the product of a gene or by binding to a specific receptor that determines an "ethnic" characteristic; e.g. pigment formation for skin or eye color or some other characteristic that is a single-gene characteristic (e.g. ear lobe attachment, hitchhiker's thumb etc.). Another general approach that would theoretically work is being actively pursued as a means of treating cancer; i.e., find a unique antigen on a cancer cell; make an antibody against it; attach a cell toxin to the antibody and inject.<sup>5</sup>

### Miscellaneous

There are no parasitic microbes (protozoans) listed above as BWs. But that does not mean they could not be employed for such a purpose. For example, a variety of protozoa species are candidates for BWs - *Cryptosporidium* spp., *Entamoeba histolytica*, and *Giardia lamblia*. All that is required is to find a way of mass cultivating them in the laboratory.<sup>5</sup> Cash crops that have been targeted in anticrop warfare are sweet potatoes, soybeans, sugar beats, cotton, wheat, and rice. The agents used to cause economic losses with the latter two foreign-exchange earnings were *Puccinia graminis tritici* and *Piricularia oryzae* respectively. The use of such warfare focuses on the destruction of national economies benefiting from export earnings of wheat - an important cereal crop in the Gulf region. In addition, the personal health and safety of the harvesters is also endangered.\*

### The Top Biological Weapons

With an abundance of potential BWs to choose from, what are the top choices and why? This is a difficult question to

answer because of the extreme secrecy surrounding biological warfare. Based on what is known, combined with some reasonable assumptions, the following are prime suspects in this rogue's gallery of biological horrors:<sup>5</sup>

#### *Bacillus anthracis* (Anthrax) :

It is a preferred BW because:

"Toughest known biological agent" : In 1988, Russian scientists in the city of Sverdlovsk transferred hundreds of tons of anthrax bacteria - enough to destroy the world many times over - into giant stainless-steel canisters, poured bleach into them to decontaminate the deadly pink powder, soldiers dug huge pots and poured the sludge into the ground, burying the germs in the Renaissance island. Their tests, show that, although the anthrax was soaked in bleach at least twice, some of the spores are still alive - and potentially deadly. The stockpile had to be destroyed in case the US and Britain demanded an inspection and this was done in great haste and total secrecy.

Highly lethal : A millionth of a gram of anthrax constitutes a lethal inhalation dose. WHO estimated that 50 kg of *B. anthracis* releases upwind of a population centre of 5 lacs would result in up to 1 lac fatalities with an additional 1.25 lacs persons incapacitated." Doctors who have treated anthrax patients have found that they will be asking a patient how he feels, and the patient dies in mid-sentence."

Easy to weaponize: It is extremely stable and can be stored almost indefinitely as a dry powder. It can be loaded, in a freeze-dried condition, in ammunition or disseminated as an aerosol with crude sprayers.<sup>12</sup>

Low barriers to production: Its production is easy, cheap and no high-technology is needed.

Currently, there is limited detection capability to detect this agent.

#### Small pox:

Small pox virus has long been used as a lethal weapon in a biological warfare - the decimation of the American Indian population in 1763 is attributed to the wide distribution by the invading powers of blankets of smallpox patients as gifts.<sup>13</sup> The idea that smallpox virus is stored only in Russia and USA is not true. At least 10 countries have quietly kept it.<sup>14</sup> It is a prime candidate for a BW because of the characteristics<sup>5</sup> such as genetic code sequenced, easily cultivable, highly infectious, extremely hardy, most of the world's population is susceptible, mortality rate ~ 50%, no known treatment. Table 2 describes the various types of BW agents.

Table 2 : Biological weapon agents

Agent	Infectious dose	Incubation period	Transmission	Disease	% Lethal	Treatment	Chemoprophylaxis & vaccine
<i>Bacillus anthracis</i>	8000-50,000 spores	1-5 d	Air-RT Direct contact-skin	Anthrax, Woolsorter's disease	85%	Cipro, Doxy, Pen	Cipro, Doxy Licensed vaccine; 0.5 ml s.c. at 0,2,4 wk And 6,12,,18 mo, then annual boosters
<i>Yersinia pestis</i>	100-500 org	23 d	Air-RT Direct contact-skin	Plague (Black death)	80%	Spm, Doxy, Chlmp	Tetra,Doxy Licensed inactivated vaccine; 1.0 ml prime and then 0.2 ml boost at 1 & 3 mo
<i>Clostridium botulinum</i>	.001µg/kg (type A)	1-5 d	Oral-digestive tract	Botulism	100%	Heptavalent antitoxin, Igs	NA
<i>Brucella suis</i>	10-100 org	5- 60 d*	Air-RT	Brucellosis (Undulant fever)	Low	Doxy, Rfmp	Doxy, Rfmp
<i>Coxiella burnetii</i>	1-10 org	1 0-40 d	Air-RT	Q fever	Low	Tetra,doxy	Tetra, doxy
<i>Francisella tularensis</i>	10-50 org	2-10 d	Air-RT	Tularemia	High	Spm, Genta	Tetra, doxy Live attenuated vaccine
VEE, EEE, WEE	10-100 org	VEE=2-6 d EEE/ WEE =7-14 d	VEE: Air-RT Direct contact-skin	Viral Encephalitis	VEE= 70%	Supportive, Analgesics, Anticonvulsants as needed	VEE= Live attenuated vaccine
AHF, BHF, Rift valley fever, Congo HF, Hantaan, DHF etc.	1-10 org	4-21 d	Arthropod borne (except Hantaan)	Viral haemorrhagic fevers	Hantaan = 5-10%	Supportive, Ribavirin, Passive transfer of Igs	Vaccine available for few
Variola virus	Assumed low (10-100 org)	7-17d	Air-RT Direct contact-skin	Small pox	35%	Cidofovir (effective in vitro)	Live attenuated vaccine
Ebola virus		4-10 d	Air-RT Direct contact-skin / mucous membrane	Haemorrhagic manifestations	85%	Supportive	NA
<i>Staphylococcus</i> Enterotoxin B	30ng/person (incapacitating); 1.7µg/person (lethal)	1-6 hours	Oral-digestive tract Air-RT	Food poisoning		Ventilatory support and supportive care	

NA = not available,  $\mu$  = micro, d = days, wk = week, RT = respiratory tract, cipro = ciprofloxacin, chlmp = chloramphenicol, doxy = doxycycline, genta = gentamicin, pen = penicillin, rfmp = rifampicin, spm = streptomycin, tetra = tetracycline, AHF = Argentine haemorrhagic fever, BHF = Bolivian haemorrhagic fever, EEE = Eastern equine encephalitis, VEE = Venezuelan equine encephalitis, WEE = Western equine encephalitis

*Botulinum toxin (botox):*

Often tainted as the most toxic substance in the world, addition to municipal water or food supplies are likely ways of introducing botox into a population as it is tasteless and odourless. The advantage of botox is that since its symptoms are delayed (2-14 days), the irreversible damage is done (walking dead) before victims realize what has occurred."

*Ajlatoxin:*

This is a class of toxin, produced by *Aspergillus flavus* that induce liver cancer. Since there is difficulty in differentiating cancer origins between accidental and intentional exposure, even recognizing that a target population had been "attacked" would be laborious; this would be a case of a "stealth BW attack".

*Ricin:*

Ricin is a protein toxin extracted from the castor bean plant. Ricin is already being investigated for its "magic bullet" properties as an agent that might selectively destroy cancer cells. That same principle could be used to specifically target an enemy; in theory one could be specific enough to use this procedure to target a single individual for assassination.<sup>5,15</sup>

*Fusarium oxysporum:*

The potential use of genetic engineering in the production of BW is illustrated by the on-going studies on the possible use of the mould *Fusarium oxysporum* as a candidate for drug plant eradication. This fungus, which has devastated commercial crops (e.g. bananas and muskmelon), is being investigated for its potential to destroy coca and cannabis plants. Preliminary studies indicate that host specificity is narrow and species "jumping" is rare; i.e., targets can be carefully selected without posing danger to other commercial crops. Obviously, the same technology could be applied by terrorists to assail the commercial crops of perceived enemy states.<sup>5</sup>

**Delivery of BWs :**

Scud missiles may be used to deliver BWs having a range of about 500 miles.

A motor vehicle as small as a car could cruise the streets of a city while emitting a fine spray of BW-aerosol through a fake tailpipe or other small vent.

A hand-pumped sprayer like those used to spray insecticide on one's garden.

An individual carrying a large suitcase or backpack could disperse BW material while walking the streets.

A book/letter can be contaminated with anthrax.<sup>15,16</sup>

Umbrella weapon consists of a projectile weapon buried in the disguise of an umbrella. This weapon shoots a tiny pellet having a hole drilled through it, which is filled with a toxin called ricin. The hole is covered with wax that melts when the projectile enters the body due to the body heat.<sup>15</sup>

Remote-control devices can be used. They can even be set to release material periodically over several days depending on the direction of the wind.

Robotic delivery offers another likely possibility. Such robots would be small enough to be camouflaged as pieces of wood or rock and could be programmed to bring themselves under ground until actioned. They could even be solar-powered so they could function independently for long periods.

**Preventive Measures :**

Following are the measures that might be taken to diminish the problem:

Develop full international cooperation on dealing with this problem; probably through the United Nations.

Educate likely target populations

Coordinate the monitoring of the potential producers and users of BW.

Continue to improve on BW monitoring techniques and apparatus.

Stockpile BW fighting supplies.

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The ability to use biological agents in warfare is prohibited by the Biological and Toxin Weapon Convention. Bioterrorism is defined as the deliberate release of viruses, bacteria or other agents used to cause illness or death in people, but also in animals or plants. It is aimed at creating casualties, terror, societal disruption, or economic loss, inspired by ideological, religious or political beliefs. The success of bioterroristic attempts is