BIOWARFARE AND BIOTERRORISM - THE DARK SIDE OF BIOTECHNOLOGY

Edgar J. DaSilva
Section of Life Sciences, Division of Basic and Engineering Sciences, UNESCO, Paris, France

Keywords: Biowarfare, bioterrorism, biodefense, robobiology, biosensors, and Biological and Toxin Weapons Convention (*BTWC*)

Contents

Summary

Biowarfare is the intentional use of microorganisms, and toxins, generally of microbial, plant or animal origin to produce disease and death in humans, livestock and crops. The attraction of bioweapons in biowarfare and bioterrorism 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. Furthermore, novel and accessible technologies give rise to proliferation of such weapons that have implications for regional and global security. In counteraction of such treats, and in securing the culture and defense of peace, the need for leadership and example in devising preventive and protective strategies has been emphasized through international consultation and co-operation. Adherence to the Biological and Toxin Weapons Convention reinforced by confidence building measures and sustained by use of monitoring and verification protocols, is an important and necessary step in reducing and eliminating the threats of biological warfare and bioterrorism.

1. Introduction

Biological warfare is the intentional use of microorganisms, and toxins, generally, of microbial, plant or animal origin to produce disease and/or death in humans, livestock and crops. The attraction for bioweapons in war, and for use in terroristic attacks is attributed to their low production costs, The easy access to a wide range of disease-producing biological agents, their non-detection by routine security systems, and their

easy transportation from one location to another are other attractive features. Their properties of invisibility and virtual weightlessness render detection and verification procedures ineffectual, and make non-proliferation of such weapons impossible. Consequently, national security decision-makers, defense professionals, and security personnel will increasingly be confronted by biological warfare as it unfolds in the battlefields of the future.

Current concerns regarding the use of bioweapons result from their production for use in the 1991 Gulf War; and from the increasing number of countries that are engaged in the proliferation of such weapons i.e. from about four in the mid-1970s to about 17 today. A similar development has been observed with the proliferation of chemical weapons i.e. from about 4 countries in the recent past to some 20 countries in the mid-1990s.

Other alarming issues are the contamination of the environment resulting from dump burial, the use of disease-producing microorganisms in terroristic attacks on civilian populations; and non-compliance with the *1972 Biological and Toxins Weapons Convention (*Table 1*)*. Microorganisms are known to function as "*pathogens and pals*" as with *Leishmania* infections, and with *Bacteroides thetaiotaomicron* in the intestines of humans and mice; as *"battle strains"* of anthrax, bubonic plague, smallpox, Ebola virus, and as a microbe-based *"double agent"*.

Year	**Convention**	**Remarks**
1899 Hague, Netherlands*	The Laws and Customs of War on Land (II)	• Entering into force in 1900, the Convention in defining the rules, laws and customs of war, based on deliberation of the Brussels Peace Conference of 1874, prohibited the use of poison and poisoned weapons as well as the use of arms, projectiles and/or material calculated to cause unnecessary suffering
1907 Hague, Netherlands**	The Laws and Customs of War on Land (IV)	• Entering into force in 1910, the Convention covers issues, and customs in more detail, relating to belligerents, prisoners of war, the sick and wounded, means of injuring the enemy, and bombardments, etc.
1925 Geneva, Switzerland	Prohibition of the Use in War of Asphyxiating, Poisonous or other Gases, and of Bacteriological Methods of Warfare	• In force since 1928, the protocol prohibits the use in war of asphyxiating, poisonous or other gases, and of all analogous liquids, materials or devices, and, the use of bacteriological methods of warfare

* Year of the First International Peace Conference based on invitations from Czar Nicholas II of Russia and Queen Wilhelmina of the Netherlands

** Year of the Second International Peace Conference. The Third Conference scheduled for 1915 never took place due to outbreak of the First World War.

1972 Geneva, Switzerland	Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction	• Entering into force in 1975, the Convention - prohibits the development, production, stockpiling, acquisition and retention of microbial or other biological agents or toxins that have no justification for prophylactic, protective or other peaceful purposes - their use as weapons, or in military equipment, missiles and other means of delivery for hostile use or in armed conflict - furthers development and application of scientific discoveries in the field of bacteriology (biology) for the prevention of disease, or for other peaceful purposes
1974 Paris, France	Prevention of Marine Pollution from Land-Based Sources	• Amended by a protocol in march, 1986, the Convention covers - prevention of pollution of the sea inclusive of marine estuaries, by humankind either by direct or indirect means, through introduction of substances of energy resulting in deleterious effects as hazards to human health, living marine resources, marine ecosystems, and damage to amenities, or interference with other legitimate uses of the sea
1976 Geneva, U.N.	Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques	• Adopted by the Resolution 31/72 of the U.N. General Assembly on 10 December, 1976, and open for signature in Geneva, 18 May, 1877, the Convention focuses on any technique that changes "through deliberate manipulation of natural processes-- the dynamics, the composition or structure of the Earth, including its biota, lithosphere, hydrosphere and atmosphere, or of outer space"
1981 Abidjan, Cote d'Ivoire	Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region	• The Convention which entered into force in 1984 covers - the marine environment, coastal zones, and related inland waters within the jurisdiction of the States of the West and Central African Region - the introduction, directly or indirectly, of substances or energy into the marine environment, coastal zones, and related inland waters resulting in deleterious effects that harm living resources, endanger human health, obstruct marine activities (inclusive

		of fishing) and alters the quality and use of seawater and reduction of amenities. - promotes scientific and technological co-operation to monitor and assess direct and/or indirect pollution, and to engage in networking exchange of scientific data and technical information.
1983 Bonn, Germany	Co-operation in Dealing with Pollution of the North Sea by Oil and Other Harmful Substances	• Agreement, by the governments of Belgium, Denmark, France, Germany, the Netherlands, Norway, Sweden, the U.K., and the European Economic Community, based on an agreement reached in Bonn, 1969, covers - prevention of pollution of the sea by oil and other hazardous substances - development of mutual assistance and co-operation in combating marine pollution and destruction of marine bioresources
1989 Basle, Switzerland	Control of Transboundary Movements of Hazardous Wastes and Their Disposal	• Known as the Basel Convention, it entered into force in 1992, and covers a variety of hazardous wastes resulting from wastes such as clinical wastes, household wastes, radioactive wastes, and toxic wastes resulting from the production of biologicals, medicines, the chemical industry, etc.[***]
1991 Bamako, Mali	Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes with Africa	• Known as the Bamako Convention, and yet to enter into force, the Convention focuses on the - need to promote the development of clean production methods, including clean technologies, for the sound management of hazardous wastes produced in Africa, in particular, to avoid, minimise, and eliminate the generation of such wastes - protection, through strict control, the human health of the African population against the adverse effects which may result from the generation and movement of hazardous wastes within the African Continent.
1992 Bucharest, Romania	Protection of the Black Sea against Pollution	• The Convention takes into account the - special hydrological and ecological characteristics of the Black Sea, and the susceptibility of its flora and fauna to pollutants and noxious wastes of biological and chemical origin resulting from disposal

[***] The reader is referred to Annexes I – V appended to the Treaty and which covers the range, categories and characteristics of hazardous wastes and conditions concerning their transboundary movement and disposal.

		systems, and dumping by aircraft and seaborne craft - need to develop co-operative scientific monitoring systems to minimize and eliminate pollution of the Black Sea
1993 Geneva, Switzerland	Prohibition of the Production, Stockpiling, and Use of Chemical Weapons and on Their Destruction	• Entering into force in 1997, the Convention prohibits the development, production, stockpiling, acquisition or retention of chemical weapons, their transfer, directly or indirectly to anyone, as well as their use in any military preparations or in missile delivery systems or weapons

Table 1: Chronological summary of conventions, protocols and resolutions curbing biological warfare

-
-
-

Bibliography

a. Articles from Books and Journals

[The historical, economic, social and political aspects of biowarfare, and bioterrorism; the range and types of bioweapons, and biological warfare against crops as a means of aggravating food insecurity are provided in the list of books and journals cited below].

Also provided are sources focusing on:

(1) electronic indicators e.g. biosensors and preventive measures using e.g. vaccines to complement public health preparedness and responses in counteracting threats to environmental degradation, loss of human resources and national security

(2) bioelectronics in developing biorobots to monitor capabilities, intentions, and type of resource materials for use in biowarfare and bioterrorism

(3) strengthening the applications of the Biological and Toxin Weapons Convention.

N.B.: Synoptic themes of the issues referred to above are explicit in the titles of the following bibliographic citations]

Alper J. (1999). From the bioweapons trenches, new tools for battling microbes, *Science* 284:1754-1755.

Av-Gay Y. (1999). Uncontrolled release of harmful micro-organisms, *Science* 284:1621.

Butler, D. (1997). Talks start on pooling bio-weapons ban, *Nature* 388:317.

Buzby J. C., Roberts T., Jordan Lin C-T. and MacDonald J.M. (1996*). Bacterial food borne disease: medical costs and productivity losses*, Agricultural Economic Report Nº 741, publ. Economic Research Service, U.S. Department of Agriculture, Washington, D.C., pgs.80.

Cherry M. (1999). South Africa reveals plans to make AIDS a notifiable disease, *Nature* 399:288.

Cole C.A. (1997). *The eleventh plague - The politics of biological and chemical warfare* (ed. Cole, L.A.), W.H. Freeman and Company, New York, pgs 289.

DaSilva E.J. and Iaccarino M. (1999). Emerging diseases: a global threat, *Biotechnology Advances* 17: 363-384.

Department of Defense (1996). *Proliferation: threat and response*, April, US Government Printing Office, Washington, D.C., 20402-9328.

Department of Foreign Affairs and Trade (1999). Strengthening the biological weapons convention, *Australian Biotechnology* 9:112-114.

Harris R. and Paxman J. (1982). *A higher form of killing*, Noonday Press, New York, pg. 74.

Henderson D.A. (1999). The looming threat of bioterrorism, *Science* 283:1279-1281.

Holmes A., Govan J. and Goldstein R. (1998). Aquacultural use of Burkholderia (Pseudomonas) cepacia: A threat to human health, *Emerging Infectious Diseases* 4:221-227.

Hoogendorn E. J. (1997). A chemical weapons atlas, *Bulletin of the atomic scientists* 53:35-39.

Institute of Medicine (1999). *Chemical and biological terrorism: research and development to improve civilian medical response*, U.S. National Academy Press, pgs 304.

Kadlec R. P. (1995). Biological weapons for waging economic warfare. In*: Battlefield of the future: 21st century warfare issues*, (eds. Schneider, B.R. and Grintner, L.E.), Department of Defense, Air University, U.S. Department of Defense, pgs.287.

Kaufmann A.F., Meltzer M.I. and Schmid G.P. (1997). The economic impact of a bioterrorist attack: are prevention and post attack intervention programs justifiable*? Emerging Infectious Diseases* 3:83-94.

Käppeli O. and Auberson L. (1997). The science and intricacy of environmental safety evaluations, *Tibtech* 15:342-349.

King K.D. Anderson G.P., Bullock K.E., Regina M.J., Saaski E.W. and Ligler F.S. (1999). Detecting staphylococcal enterotoxin B using an automated fibber optic biosensor, *Biosensors and Bioelectronics* 14:163-170.

Kolavic S. and Kimura A. (1997). An outbreak of Shigella dysenteriae type 2 among laboratory workers due to intestinal food contamination, *Journal of the American Medical Association* 278:396-398.

Krueger G.P. and Banderet L.E. (1997). Effects of chemical protective clothing on military performance: a review of the issues, *Military Psychology* 9:255-286.

Lehrach H., Bancroft D. and Maier E. (1997). Robotics, computing and biology, *Interdisciplinary Reviews* 22:37-43.

Marshall E. (1999). Bioterror defense initiative injects shots of cash, *Science* 283:1234-1235.

Monath T.P. and Gordon L.K. (1998). Strengthening the biological weapons convention, *Science* 282:1423.

Morse S. (1998). Defending against biological warfare: programs of defense advanced research projects agency (DARPA). In: *Technology and Arms Control for Weapons of Mass Destruction*, publ. New York Academy of Sciences, N.Y., USA, ed. Raymond, S.U., pgs 23-28.

Mulchandani P., Mulchandani A., Kaneva I. and Chen W. (1999). Biosensor for direct determination of

organophosphate nerve agents 1. Potentiometric enzyme electrode, *Biosensors and Bioelectronics* 14:77-85.

Muramatsu H. Kajiwara K., Tamiya E. and Karabe I. (1986). Piezoelectric immunosensor for detection of *Candida albicans* microbes, *Analytica Chimica Acta* 168:257-261.

New York Academy of Sciences (1998*). Technology and arms control for weapons of mass*

destruction, ed. Raymond, S.U., publ. New York Academy of Sciences, New York, USA, pg. 45.

Office of Technology Assessment (1993*). Proliferation of weapons of mass destruction: assessing the risks*, Washington, D.C., U.S. Government Printing Office, pg. 50.

Perrier J.J. (1999). Les nouveaux visages de la vaccination, *Biofutur*, Mai, pgs 14-18.

Rogers P., Whitby S. and Dando M. (1999). Biological warfare against crops, *Scientific American* 280:70-75.

Russell P. K. (1999). Vaccines in civilian defense against bioterrorism, *Emerging Infectious Diseases* 5:498-504.

Schutz S., Weiszbecker B., Koch U.T. and Humonel H.E. (1999), Detection of volatiles released by diseased potato tubers using a biosensor of intact insect antennae, *Biosensors and Bioelectronics* 14:221-228.

Schneider B. R. and Grintner L. E. (1995). (Eds.*) Battlefield of the Future: 21st Century warfareissues*, Air University, U.S. Department of Defense, pgs.287.

Stephanov A.V., Marinin L.I., Pomerantsev A.P. and Staritsin N.A. (1996). Development of novel vaccines against anthrax in man, *Journal of Bacteriology* 44:155-160.

Strauss E. (1999). Microbes features as pathogens and pals at gathering, *Science* 284:1916-1917.

Swenson, F.J. (1992). Development and evaluation of optical sensor for the detection of bacteria, *Sensors and Actuators* B 11:315-321.

Torok T. and Tauxe T. (1997). A large community outbreak of salmonellosis caused by intentional contamination of restaurant salad bars, *Journal of the American Medical Association* 278:389-395.vv

Treindl R. (1999). Les biorobots: des insects à puces, *Biofutur*, Mai pgs.34-37.

Tucker J.B. (1999). Historical trends related to bioterrorism: an empirical analysis, *Emerging Infectious Diseases* 5:498-504.

United Nations Institute for Disarmament Research - UNIDIR (2000*). Biological weapons from the BWC to biotech, Disarmament Forum*, pgs. 77, Palais des Nations, Geneva.

United Nations (1997). Annex VI. *Confidence-building Measures* F., Document No.

CDA/BWC/1997/CBM, 30 May, pg. 688.

Van der Meer P. J., Schenkelaars P., Visser B. and Zwanugobani E. (1993). (eds.) *Proceedings African Regional Conference for International Cooperation on Safety in Biotechnology*, 11- 14 October, Harare, Zimbabwe, pgs. 190.

Vasil I.K. (1998). Biotechnology and food security for the 21st century: A real-world perspective, *Nature Biotechnology* 16:399-400.

Weller R.E. Lyu C.W., Wolters C. and Atlas R.M. (1999). Universities and the biological and toxin weapons convention, *ASM News* 65:403-409.

Whitby S. and Rogers P. (1997). Anticrop biological warfare - implication of the Iraqi and U.S. programs, *Defense Analysis* 13:303-318.

World Health Organization - WHO (2000). World Health Assembly Document A53/27, 2 May; Agenda item 12.14

Wright S. (1985). The military and the new biology. *Bulletin of the Atomic Scientists* 41:10-16.

Wu T. Z. (1999). A piezoelectronic biosensor as an olfactory receptor odour detection electronic nose, *Biosensors and Bioelectronics* 14:9-18.

Zoon K. C. (1999). Vaccines, Pharmaceuticals Products, and Bioterrorism: Challenges for the U.S. Food and Drug Administration, *Emerging Infectious Diseases* 5:534-536. (Table1) : Chronological summary of conventions, protocols and resolutions curbing biological warfare.

b. Newspapers and magazines

[The citations below contain pertinent information aimed at increasing public awareness to the issues and spectre of biological warfare and countermeasures in eliminating such hazards and risks. The emphasis on public education needs to be continued and sustained on a regular basis]

Atlas R.M. (1998). Biological weapons pose challenge for microbiological community, *ASM News* 64: 383-388.

Barthélémy P. (1999). Les textiles antibactériens et anti-odeurs passent avec succès l'épreuve du marché, *Le Monde*, Samedi, 16 Janvier.

Cole C.A. (1996). The spectre of biological weapons, *Scientific American* 275:60-65.

Dobson R. (1999a). Germ warfare lotion can protect you against flu, *Innovation -The Sunday Times*,18 July.

Dobson R. (1999b). Race hots up to counter bio-terrorism weapons, Innovation -*The Sunday Times*, 15 August.

Miller J. (1999). In Soviet Dump, Deadly germs live on, *International Herald Tribune*, Paris, 3 June.

Mulbry W. and Rainina E. (1988). Biodegradation of chemical warfare agents, *ASM News*

64:325-331.

Scott S.J. and Shea J. (1999). Anthrax feared in Afghanistan outbreak, *The American Reporter*, 5, February 26.

Thompson, D. (1999). The germ warrior, *Time*, July 26, pg 73.

c. Web-pages

[Relevant and as indicated in the titles of explicit significant information resources concerning varied aspects of biological warfare, bioterrorism and bioweapons are available in the following webpage references]

American Society for Microbiology (1999). Bioterrorism: frontline response, evaluating U.S. preparedness, March 30

(http://www.dev.asmusa.org/parc/bioterrorismdef.htm)

Christopher G.W., Cieslak J.T., Davlin J.A., and Eitzen Jr. E.M. (1997). Biological warfare: a historical perspective
(http://www.usamriid.army.mil/content/BiowarCourse/HX-3.html)

Ecker D. and Griffey R. (1998). Drugs to protect against engineered biological warfare

(http://www.ibisrna.com/public/biowar/2/003.html)

Pearson G.S. (1998). The threat of deliberate diseases in the 21st Century

(http://www.brad.ac.uk/acad/sbtwc/other/disease.htm)

Preston R. (1998). Statement before the Senate Judiciary Subcommittee on technology, terrorism and government information, and the select committee on intelligence on chemical and biological weapons threats to America: are we prepared?

(http://www.senate.gov/~judiciary/preston.htm)

Purver R. (1995). Chemical and biological terrorism: the threat according to the open literature, CSIS/SCRS; (http://www.csis-scrs.gc.ca/eng/miscdocs/tabintre.html)

Serageldin I. (1999). Biotechnology and water security in the 21st Century,

(http://www.mssrf.orgsg/d99-biotech-water.html)

Biographical Sketch

Edgar DaSilva, a graduate of the University of Bombay in microbiology and chemistry, was awarded, in 1962, the Bachelor of Science Degree (First Class with Honours). In 1966, he obtained the Master of Science Degree, and in 1969 his Doctoral Degree for research studies on the cyanobacteria. As a NORAD Fellow, his research study, on the marine algae at the Norwegian Seaweed Research Institute, Trondheim, Norway, in 1970, was followed by a teaching assignment at the University of Helsinki, Helsinki, Finland. Two years later, he joined the Institute of Physiology, University of Uppsala, Uppsala, Sweden as a UNESCO fellow. He is a former Vice-President of the World Federation for Culture Collections (WFCC), author of several scientific publications, and member of well-known microbiological societies. Moreover, he has also been a keynote plenary speaker at several international events in, Argentina, China, Kuwait, Nigeria, South Africa, Sweden, Thailand, USA, etc. on biopolicy issues in regional co-operation, microbiological education, and on globalization and sustainable development.

At UNESCO since 1974 in various capacities within the Division of Scientific Research and Higher Education and the Division of the Basic Science Dr. DaSilva has been instrumental in the planning and implementation of several UNESCO regional and international programmes in applied microbiology as well as in the development of the global networks dealing with management and use of microbial resources and training opportunities in the fields of marine and plant biotechnology. Moreover he mobilized several extrabudgetary programmes in close cooperation with UNEP and UNDP and Donor Member States for activities in national development in biotechnology and regional cooperation in microbiology.

He also was the Director, Division of Life Sciences that was subsequently transformed into a Section of the Life Sciences within a new Division of the Basic and Engineering Sciences prior to his retirement from UNESCO.

Currently Dr. DaSilva has had teaching assignments as Visiting Professor at the International Centre for Biotechnology (ICBiotech) in Osaka University and its outreach station, and teaching assignments at the UFS, and at the Outreach station of ICBiotech at Mahidol University, Thailand and at the University of the Free State, Republic of South Africa.

A fellow of the World Academy of Art and Science and following a keynote lecture to the Biotechnology Division of the Royal Swedish Academy of Engineering Sciences and the Biofocus Foundation, Dr. DaSilva was awarded the Biopolicy Award in 2003.