

WORLDWIDE EMERGING ENVIRONMENTAL ISSUES AFFECTING THE U.S. MILITARY
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Note to Readers: Pages 1-12 comprise the summary and analysis of this report. Expanded details for some items that might not be available via the Internet at a later date are in the Appendix beginning on page 13.

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Item 1. Protocol on Explosive Remnants of War Comes into Effect

Protocol V on Explosive Remnants of War, part of the UN Convention on Certain Conventional Weapons (CCW), will enter into force on 12 November 2006. The Protocol stipulates that parties to armed conflicts must mark, clear, and destroy all explosive remnants of war on the territory, including internal waters, under their control; offer assistance in areas not under their control; and share information with organizations involved in clearance activities. It applies to ordnance that existed even prior to the entry into force of this Protocol (Art. 2, Par. 5).

Military Implications:

Although not Party to the Protocol, the US might consider collaborating with States Party to facilitate their compliance. Also, since each Party is required to ensure that “its armed forces and relevant agencies or departments issue appropriate instructions and operating procedures and that its personnel receive training consistent with the relevant provisions of this Protocol” (Art 11, Par. 1), the military should consider taking appropriate preparative actions in the eventuality of future accession to the Protocol.

Sources:

Treaty on explosive remnants of war to enter into force

<http://www.icrc.org/Web/eng/siteeng0.nsf/html/treaty-weapons-news-160506!OpenDocument>

Protocol on Explosive Remnants of War (Protocol V to the 1980 Convention)

<http://www.icrc.org/ihl.nsf/FULL/610?OpenDocument>

Item 2. New “European Citizens’ Initiative” Could Affect Environmental Politics

A coalition has formed to establish the "European Citizens’ Initiative" as a tool of direct democracy to bypass the need for EU parliamentarians to introduce legislation. If the ECI becomes law, then any EU citizen(s) that secures one million signatures supporting a proposed law would have it autocratically introduced for a vote in the EU. The campaign also plans to get at least one million signatures within 18 months to prove viability of the concept. Since the ECI would enable European citizens to directly influence the political agenda of the EU, and there are many grass roots environmental organizations, then it is reasonable to expect an increase in environmental politics if the ECI becomes law.

Military Implications:

Monitoring the campaign and eventual ECI should provide a heads-up on potential future changes in European environmental regulations that could affect the military.

Sources:

An alliance of European civil societies have launched a campaign entitled the "European Citizens’ Initiative"

<http://www.eph.org/a/2225>

European Citizens’ Initiative <http://www.citizens-initiative.eu/>

Item 3. Call for International Intervention to Save the Jordan River

During a session at the Woodrow Wilson Center, mayors and executives of the EcoPeace/Friends of the Earth Middle East asked the international community to increase efforts to save the Jordan River and the ecosystem it supports, including the Dead Sea. They want the governments of Jordan, Israel, Syria and the Palestinian Authority to develop a regional integrated rehabilitation plan. The international community does not understand how serious the issue is becoming, since much of the river flows through a closed military zone. Without intervention, the river's deterioration is expected to increase conflict in the region. Note: The Third International Symposium on Transboundary Waters Management is being held from 30 May–2 June 2006 in Ciudad Real, Spain.

Military Implications:

This is a clear example of a situation where international military cooperation could prevent or reduce conflict exacerbated by environmental deterioration. The military should explore how it can collaborate in the region to turn around the deterioration of the Jordan River.

Sources:

Rehabilitating the Jordan River Valley Through Cross-Border Community Cooperation

http://www.wilsoncenter.org/index.cfm?topic_id=1426&fuseaction=topics.event_summary&event_id=177929

Vanishing Jordan River Needs Global Rescue Effort

<http://www.ens-newswire.com/ens/may2006/2006-05-16-10.asp>

Third International Symposium on Transboundary Waters Management

<http://www.uclm.es/congresos/twm/Index.htm>

Item 4 African Security and Environmental Matters Should Be Addressed Together

Scholars agree that Africa's deteriorating environment means that the continent's security and poverty problems cannot be solved without improved environmental management. Ways have to be found to integrate security, poverty, and environmental programs on the continent. Note: The European Union Environmental Diplomacy Network created in 2003 could serve as an example for a similar African Diplomacy Network [See June 2003 environmental security report.]

Military Implication:

Those responsible for military-to-military activities in Africa should explore ways to integrate their activities with poverty and environmental programs. This is another opportunity to show how international military cooperation could prevent or reduce conflict exacerbated by environmental deterioration.

Sources:

Report of the AU Ministerial Conference on Disaster Risk Reduction

[http://www.africa-union.org/root/au/Conferences/Past/2006/May/infrastructure/22-May/EX.CL.%20228%20\(VIII\)%20-%20Disaster%20Risk%20Reduction.1.doc](http://www.africa-union.org/root/au/Conferences/Past/2006/May/infrastructure/22-May/EX.CL.%20228%20(VIII)%20-%20Disaster%20Risk%20Reduction.1.doc)

11th Regular Session of the African Ministerial Conference on the Environment in Brazzaville, Congo on 24 May 2006

<http://www.africa-union.org/root/au/Conferences/Past/2006/May/infrastructure/22-May/welcome-en.htm>

Conflict and Cooperation in Eastern Africa: Making the Case for Environmental Pathways to Peacebuilding (VIDEO)

http://wilsoncenter.org/index.cfm?topic_id=1413&fuseaction=topics.event_summary&event_id=181986

Cattle Disease, Ethnic Tension Strain Uganda Border Region

<http://www.ens-newswire.com/ens/may2006/2006-05-11-03.asp>

Their animals are dead. These people are next

<http://observer.guardian.co.uk/world/story/0,,1784611,00.html>

Item 5. UN Commission on Sustainable Development Fosters Energy Security

The 14th session of the UN Commission on Sustainable Development (CSD) reviewed progress of the efforts on energy for sustainable development, climate change, air pollution/atmosphere, and industrial development. Energy security issues dominated the discussions along with the urgency of achieving Agenda 21, and the cost of inaction, as well as the need for addressing climate change and its consequences, including a long-term, predictable policy framework to move to a low carbon emission society. Meantime, the UN Environment Program (UNEP) report *Class of 2006: Industry Report Cards on Environment and Social Responsibility*, analyzing progress across some 30 industry sectors since the 2002 World Summit on Sustainable Development, notes that industries are trying to improve environmental and social performance, mainly related to climate change and greenhouse gas emission issues.

Military Implications:

The UN CSD and UNEP reports should be reviewed for military implications and opportunities for cooperation on environmental security.

Sources:

UN Department of Economic and Social Affairs. Division for Sustainable Development.

<http://www.un.org/esa/sustdev/csd/review.htm>

Summary of The Fourteenth Session Of The Commission On Sustainable Development

<http://www.iisd.ca/vol05/enb05238e.html>

UNEP DTIE contribution to CSD 14 (*Class of 2006: Industry Report Cards on Environment and Social Responsibility*) <http://www.unep.fr/outreach/csd14/>

Item 6. UN Launched the Principles for Responsible Investment

The Principles for Responsible Investment, launched by the UN and backed by many of the world's largest investors from 16 countries representing more than \$2 trillion in assets owned, is an effort to include the environmental and social dimensions in global financial markets.

Developed by the UNEP Finance Initiative and the UN Global Compact, the six overarching Principles, which are voluntary, are backed by a set of 35 possible actions that institutional investors can take to integrate environmental, social and corporate governance (ESG) considerations into their investment activities.

Military Implications:

The military, in its effort to improve environmental and social performance, should consider encouraging its contractors to explore the implications of joining and implementing the Principles for Responsible Investment.

Source:

Principles for Responsible Investment website <http://www.unpri.org/>

Item 7. Technological Breakthroughs with Environmental Security Implications**7.1 New Opportunities for Old Engine Idea**

One of the areas currently attracting the attention of the alternative energy sector is the Stirling engine, an alternative to the internal combustion engine, which turns any source of heat into mechanical power, sufficient, for example, to run an electrical generator. The fact that the heat can be created by any external source, from biomass to solar, means that the energy generation can be much more environmentally friendly than other schemes. STM Power, of Ann Arbor MI, says that its use of the Double Acting Swash Plate Drive External Heat (DA/SH) design avoids the problems that have kept Stirling engines from wide acceptance.

Military Implications:

If not already explored, the military should investigate this development for its possible application to reducing the environmental footprint of military facilities and also allowing those facilities to be independent of possibly unreliable local power grids.

Sources:

5 A Sterling Solution

<http://www.msnbc.msn.com/id/10020271/site/newsweek/page/5/>

Manufacturer's site: www.stmpower.com

7.2 Possibilities to Considerably Increase Solar Cells Efficiency

Solar power technology might become more efficient and economic due to a new discovery by Victor Klimov, a physicist at Los Alamos National Laboratory in New Mexico, who has shown that each photon captured by a solar cell reduced to nano-dimensions can be made to generate not one, but two or even more charge carriers. This discovery could change the whole energy debate by giving a considerable boost to solar power research. In all solar cells now in use, each incoming photon contributes a maximum of one energized electron to the electric current it generates.

Military Implications:

The military should follow the DOE research for more energy-efficient and environmentally friendly systems.

Source:

Solar power - seriously souped up

<http://www.newscientist.com/article/mg19025531.600;jsessionid=LDLFFIFHFLJB> (by subscription only; full text in the [Appendix](#))

Item 8. New American Association for the Advancement of Science (AAAS) Global Website on Sustainability

AAAS has announced the opening of its new website "Forum: Science and Innovation for Sustainable Development" (< <http://sustainabilityscience.org> >). This new service builds on a site previously operated by Harvard University, but is greatly expanded from being primarily a repository of scholarly works. It will now serve that library function and also add discussion forums, commentary, and international event listings. It is formatted to ensure that limited bandwidth users can have access. Institutions from across the spectrum of society are acceptable as members, in order to ensure that the range of scientific and related societal issues aired will be as complete as possible. The intent is to provide a growing, interdisciplinary forum that will be flexible and long-lived to meet many needs. Currently, the Forum has 300 members in 41 nations.

Military Implications:

This new resource should be valuable for military environmental managers to help meet sustainability goals, such as in the Army Strategy on the Environment, and to share technical and policy innovations developed by the armed forces. The Army Environmental Policy Institute would seem to be particularly appropriate for membership, as might many other organizations whose operations, research, and planning activities affect and are affected by sustainability issues and opportunities.

Source:

AAAS, Partners Launch Global Web Site on Sustainability Science

From Vol. 312 SCIENCE, 28 April 2006, page 542

<http://sustainabilityscience.org>

Item 9. Over 4,000 Chemicals in Use in Canada to be Assessed for Safety

A comprehensive review of chemicals in use in Canada has determined that about 4,000 of 23,000 reviewed should have additional safety assessments as to their potentials for persistence in the environment, ability to bio-accumulate, direct health threats to humans or wildlife, and whether their extensive use poses a health or environmental threat. The list will be released September 14, 2006 by Environment Canada and Health Canada. They escaped previous detailed scrutiny because they were developed before modern pollution laws existed. Once the testing is complete, Canada will be ahead of Europe and the US in chemical safety assessments.

Military Implications:

As a result of the assessment, it is likely that many of these chemicals will be banned or come under new regulations in Canada that will influence other countries' regulations. The military should keep updated on the latest findings to anticipate the need for eventual chemical substitutions.

Source:

Canada's Chemical Reaction

<http://www.theglobeandmail.com/servlet/story/LAC.20060527.CHEMICALS27/TPStory/Environment>
(article available for a limited time on the website; full text in the [Appendix](#))

Item 10. Updates on Previously Identified Issues

10.1 RoHS Closer to Deadline (July 1)

Under the Restriction of the use of certain Hazardous Substances (RoHS) directive, beginning July 1, the European Union will bar the import of electronic components that include lead, mercury, cadmium and several other substances. [See *Recycling Regulations in the EU* in August 2005 and *Two E-waste laws entered into force in the EU* in February 2003 environmental security reports.]

Military Implications:

[Same as previous on the same issue] Military commands deployed in EU Member States should be prepared to comply with the new directives and consider substitutes for hazardous substances, if not already in place.

Source:

EU's lead-free law will also affect U.S. IT products

http://www.computerworld.com/hardwaretopics/hardware/story/0,10801,110944,00.html?source=NLT_AM&nid=110944

10.2 National Initiatives for Implementing the Stockholm Convention

At the second meeting of the Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants (POPs) (COP-2), governments focused on concrete measures to be taken at the national level for implementing the Convention and eliminating 12 extremely hazardous chemicals. Parties have to submit their National Implementation Plan (NIP) that establishes particular priorities and detailed action plans within two years of joining the Convention and then report on progress every two years. Several countries have already submitted their NIP. The Stockholm Convention targets 12 hazardous POPs; it entered into force on May 2004. [See also *Stockholm Convention Updates* in November 2005 and other related items in previous environmental security scanning reports.]

Military Implications

[Similar to previous on the same issue] Although the U.S. is not Party to the Convention, it should be prepared to comply, within Status of Forces agreements, with its requirements when acting in countries Party.

Sources:

Second meeting of the Conference of the Parties (CoP-2) of the Stockholm Convention

http://www.pops.int/documents/meetings/oewg_nc/notice.htm

National Plans for Eliminating 12 Extremely Hazardous Chemicals

<http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=475&ArticleID=5263&l=en>

10.3 Five Countries Organize CWC National Authorities

The Organization for the Prohibition of Chemical Weapons (OPCW) announced that five member states (Haiti, Niue, Suriname, Tanzania, and Yemen) have established national authorities to assure proper implementation and compliance with the Chemical Weapons Convention (CWC). Additionally, these national authorities have the role of liaison with the organization and other states parties.

Military Implications:

Since the U.S. is Party to the CWC, the military, if not already doing so, should consider collaboration and offer assistance to the newly established authorities to fulfill their countries' obligations under the treaty.

Source:

OPCW Press Releases 2006 (see press releases #26: United Republic of Tanzania Establishes OPCW National Authority; #25: Haiti Establishes OPCW National Authority; # 24: Suriname Establishes OPCW National Authority; #23: Yemen Establishes OPCW National Authority; #22: Niue Establishes OPCW National Authority)

<http://www.opcw.org/pressreleases/2006/index.html>

10.4 Indonesia Joins the Partnership to Improve Environmental Governance

Indonesia became the seventh national government and the first in Asia to join the International Partnership for Principle 10 (PP10) of Rio Declaration on Environment and Development that advocated citizen participation in environmental matters. In joining the PP10, the Indonesian government commits to implementing a series of activities designed to increase access rights in the country, including: increasing public involvement in the Environmental Impact Assessment (EIA) process, responding to public grievances in environmental cases, and publishing more environmental information on the Internet, as well as issuing environmental regulation booklets. [See also *Meeting of the Parties (MOP-2) to the Aarhus Convention* in May 2005, and other related items in previous environmental security scanning reports.]

Military Implication

Military environmental expertise should be offered to assist Indonesian military authorities in meeting their obligations. There is a trend toward improving transparency and citizens' participation in the decision-making process concerning environmental matters. Increased scrutiny of environmental impacts associated with military activities is expected as public involvement continues to rise.

Sources:

Partnership for Principle 10

<http://www.pp10.org/index.htm>

Indonesia joins partnership to improve environmental governance, public access to information

http://governance.wri.org/newsrelease_text.cfm?NewsReleaseID=360

10.5 EU Imposes New Battery Restrictions

The European Union has imposed new requirements on the manufacture and disposal of batteries. Limits are placed on the amount of mercury and cadmium portable batteries may contain (Certain classes, such as those for emergency systems and handheld tools, are excepted.) The new law also prescribes minimum used battery collection rates of 25% of annual sales by 2012 and 45% by 2016. [See also *Two E-waste laws entered into force in the European Union (EU)* in February 2003, *EU to Ban the use of Cadmium in Batteries* in December 2004, and *WEEE comes into effect* in August 2005 environmental security reports.]

Military Implications:

[Similar to previous on related issues] In countries covered by the new legislation, military equipment using batteries should be adapted to comply with the EU regulations. The military should consider substitutes, participate in the collection action, and pay attention to disposal, as well as to use of any materiel that could release cadmium. It should set up battery recycling programs in all areas, as an environmental stewardship activity, even where not legally required.

Source:

EU to mandate battery recycling

<http://www.computerworld.com/newsletter/0,4902,111106,00.html?nlid=PM>

10.6 Iraqi Chemical Attack Victims Seek Compensation from Supplying Companies

On behalf of the survivors, the Halabja Chemical Victims' Society is seeking compensation from the companies and governments that helped former Iraqi President Saddam Hussein's regime acquire the weapons for the 1988 chemical attack on the Kurdish town of Halabja. Over 5,000 people died in the attack, the survivors continue to have serious health problems, and the environment was never cleaned up. The commercial firms and governments involved in chemical weapons-related trade have never been publicly identified, according to AFP. [See also War in Iraq triggers UNEP environmental study and plans for post-conflict clean-up in March 2003, and *UNEP's Post-conflict Environmental Assessment's May One Day Get Extended to On-going Environmental Assessments* in February 2003 environmental security reports.]

Military Implications:

Although there is no international legislation addressing liability and redress issues related to human health and environmental damage in intra-state post-conflict situations, one would expect that all countries and companies responsible would have moral obligations, and common international customary law should demand action for cleanup and protection of humans and environment against the imminent hazards that this kind of attack represent. Since incidents such as Halabja are not isolated and access to information is increasing, it is likely that, under civil society pressure, adequate international regulations will be adopted.

Source:

Halabja wants Saddam's chemical suppliers to pay

<http://www.kurdmedia.com/articles.asp?id=12383>

10.7 Germany Sets BioFuel Quota in Fuel

Germany is introducing compulsory quotas of biofuels to be mixed with fossil fuels by refiners effective at the beginning of 2007. Until 2009, German oil refineries will have to blend 2% biofuel content in petrol and 4.4% biodiesel content in conventional diesel. [See also *Biodiesel Increasingly Considered a Viable Alternative to Crude Oil* in February 2006 and *New European Energy Policy Developments* in March 2006 environmental security reports.]

Military Implications:

[Same as previous on similar issues] The military should consider following the EU new energy and car standards policies and the consequently emerging strategies, for eventual impacts on energy-related planning and to ensure that its activities in the region comply with the new energy

policy framework. Also, since the car standards will apply as well to imported cars, the military should review its vehicles standards in/for the European theater to comply with the new standards.

Source:

Germany Sets BioFuel Quota in Fuel

<http://www.petrolworld.com/news/europe/?guid=7e7bda97-cf92-4f58-9a26-91b14acb626e>

10.8 Climate Change

10.8.1 Greenhouses Rising, Show NOAA 2005 Index

The Annual Greenhouse Gas Index (AGGI) compiled by the National Oceanic and Atmospheric Administration (NOAA) is 1.215 for 2005 (vs. 1.00 at the 1990 benchmark), reflecting a continuous rise in the accumulation of greenhouse gases as well as a positive change in the amount of radiative forcing. The AGGI increase is mostly due to considerable growth of carbon dioxide (CO₂) and rise of nitrous oxide (N₂O), while methane (CH₄) seems to level off, and the two chlorofluorocarbons (CFCs) are decreasing. During 2005, global CO₂ increased from an average of 376.8 parts per million (ppm) to 378.9 ppm; the pre-industrial CO₂ level was approximately 278 ppm. The AGGI will be included in the World Meteorological Organization's annual Greenhouse Gas Bulletin to be published in November.

International pressure and more serious incentives to persuade developing countries to adopt environmentally friendly practices seem inevitable, considering the size and scope of countries like India and China. According to the *Little Green Data Book 2006*, annual publication of the World Bank, although the worldwide average CO₂ emissions increase was 15% in the period 1992-2002, in developing countries it was much higher, with China and India showing the highest increase, with 33% and 57%, respectively, in the interval. With their sustained economic growths, unless drastic measures are taken, this trend will probably continue.

10.8.2 Possible Tougher European Carbon Limits

Due to a huge decrease of CO₂ emissions prices after several countries lowered demand for carbon credits thus weakening the incentive to clean up, it is likely that the EU will introduce tougher pollution targets. Polls indicate that 75% of Britons would favor a new law forcing successive governments to commit to reducing CO₂ emissions by 3% each year, as a contribution to tackle climate change.

10.8.3 New Evidences on Climate Change and Its Consequences

Two recent research projects concluded that if the amount of CO₂ in the atmosphere were to double, global average temperature could rise by between 1.5°C and 4.5°C, which is more than previous studies have estimated. The two scientific teams, from Berkeley, U.S., and Europe respectively, used different methodologies and data from different historical periods. The consistency of the results indicates validity. The Australian Greenhouse Office endorses the results.

Scientists from the Chinese Academy of Sciences have announced that the glaciers of the Tibetan plateau might be reduced by 50% every decade, with devastating environmental consequences, such as drying out many of the world's greatest rivers, increasing droughts and sandstorms over the rest of the country as the ice-capped "roof of the world" would turn into desert.

Glaciers in East Africa (including Kilimanjaro [in Tanzania] and Mount Kenya), and Equatorial icecaps in the Ruwenzori Mountains are also shrinking, researchers warning that they might disappear within the next 20 years, with catastrophic impact on water resources in Africa.

According to current predictions, Africa will be the most affected by climate change. In sub-Saharan Africa, in addition to increasing poverty, global warming could increase the spread of disease and kill an estimated 185 million people by the end of the century, reveals *The climate of poverty: facts fears and hope*, a report by Christian Aid.

10.8.4 Post-Kyoto Agenda Agreed

Delegates to the UN conference on climate change agreed on a long-term agenda of discussions for the post-Kyoto Protocol period, aiming to build consensus on how to address greenhouse gas emissions reduction, and climate change. “There is strong consensus about the urgency of the problem; that there really needs to be action taken and that the international community needs to work together to address the problem,” said Richard Kinley, acting head of the Climate Change Secretariat. The “Dialogue on long-term cooperative action” is open to all 189 parties to the UN Framework Convention on Climate Change, the Kyoto Protocol’s parent treaty. It was agreed that negotiations should be based on the latest scientific data and reduction policies be focused on technology development and research. Developing countries and Europe called for much more significant reduction targets for industrialized countries than those stipulated by the Kyoto Protocol (the EU had suggested 15–30%, compared to the average 5% called for by the Kyoto Protocol.) The meeting was held in Bonn, Germany, May 15-16. The next round of negotiation will take place in Nairobi, Kenya, in November. Meantime, the UN Climate Change Secretariat said that there had been an exponential rise in investment in emission reductions through the Kyoto Protocol, referring to the carbon market growth and the clean development mechanism (CDM) that now has more than 176 registered projects and approximately another 600 in the evaluation process.

Military Implications:

[Similar to previous on the same issue] There is compelling evidence of the consequences of anthropogenic climate change, and the growing world option for action. The military should continue to accelerate their efforts to reduce its greenhouse gas emissions. New international environmental security-related policies and cooperation to avoid potentially large-scale disasters and conflicts seem inevitable.

Sources:

NOAA Issues Greenhouse Gas Index

<http://www.noaanews.noaa.gov/stories2006/s2621.htm>

Global warming risk 'much higher'

<http://news.bbc.co.uk/2/hi/science/nature/5006970.stm>

Ice-capped roof of world turns to desert

<http://news.independent.co.uk/environment/article362549.ece> (by subscription only; full text in the [Appendix](#))

Equatorial African Icecaps Melting Away

<http://www.ens-newswire.com/ens/may2006/2006-05-17-04.asp>

UN conference agrees agenda for negotiations on new emission reduction targets under the Kyoto Protocol http://unfccc.int/files/press/news_room/press_releases_and_advisories/application/pdf/20060526_final_26_may_press_release-english.pdf

Other sources also available in the [Appendix](#)

Item 11. Reports Suggested for Review

11.1 OECD Workshop on the Safety of Manufactured Nanomaterials

The Organization for Economic Co-operation and Development (OECD) released a report on its Workshop on the Safety of Manufactured Nanomaterials. The workshop was held to identify the human health and environmental safety issues related to manufactured nanomaterials, as well as to identify opportunities for other forms of cooperative activities in the area of nanomaterials. The workshop dealt with current information on the field, and also recommended the establishment of an OECD Working Group to advise on planning for future safety-related work, and the implementation of a collaborative program with the OECD Business and Industry Advisory Committee (BIAC) to create a public database on the health and environmental effects of nanomaterials.

11.2 New Essays in Nanotech Journal

The Center for Responsible Nanotechnology published eleven new essays about molecular manufacturing in the journal *Nanotechnology Perceptions*, including, "Considering Military and Ethical Implications of Nanofactory-level Nanotechnology", by Brian Wang. This is a relatively new journal, now producing its 2006 four-issue Volume 2.

11.3 Nanotechnologies for Wearable and Non-Wearable Textiles

This comprehensive report includes in depth profiles of R&D centers and technologies under commercialization or in research related to wearable and non-wearable textiles using nanotechnology. It covers textiles based on nanofibres, nanotubes, nanocapsules, and nanoparticles with new functional properties, such as soil repellence, UV protection, anti bacterialism, abrasion resistance, and healing textiles.

11.4 Nanotechnologies for Anti-Bacterial and Self-Cleaning Coatings

Anti-bacterial and self-cleaning protective coatings have many applications and therefore represent an area of strong interest for industry. This report covers: prevention of biofilm formation in medical devices; anti-microbial surfaces for food and drink applications; anti-microbial encapsulation; photocatalytic coatings for anti-soiling and anti-bacterial; self-cleaning coatings for tiles, glass and steel; and hydrophilic and super hydrophobic coatings.

Military Implications:

These papers can be a good source of information as nanotechnology evolves and its applications expand. Military components concerned with long-range environmental security planning should follow this kind of material in order to be prepared for future developments and applications of nanotechnology.

Sources:

Report of the OECD Workshop on the Safety of Manufactured Nanomaterials Building Co-operation, Co-ordination and Communication

[http://appli1.oecd.org/olis/2006doc.nsf/43bb6130e5e86e5fc12569fa005d004c/b69b32217944d8a1c125715e0038d403/\\$FILE/JT03208175.PDF](http://appli1.oecd.org/olis/2006doc.nsf/43bb6130e5e86e5fc12569fa005d004c/b69b32217944d8a1c125715e0038d403/$FILE/JT03208175.PDF)

Nanotechnology Perceptions. A Review of Ultraprecision Engineering and Nanotechnology
<http://pages.unibas.ch/colbas/ntp> (synopsis; full text by subscription only)

The Institute of Nanotechnology. State of the Art and Future Outlook Reports
<http://www.nano.org.uk/reports.htm> (synopsis; reports available for purchase)

Item 12. Upcoming Events with Environmental Security Implications

Water Disinfection Conference to be Held in February 2007

The Disinfection Committees of the Water Environment Federation, American Water Works Association, and the International Water Association are sponsoring DISINFECTION 2007, a specialty conference to be held February 4-7, 2007, in Pittsburgh, Pennsylvania. The conference will focus on all aspects of the disinfection of water, wastewater, reuse water, and biosolids. Current key disinfection issues include the following: bioterrorism; pathogen detection and treatment; microbial risk assessment; research and application of UV, ozone, and halogens; membranes; microbial indicators in the environment; biosolids; future trends; infrastructure security and sustainability; and integrated and sustainable disinfection approaches.

Military Implications:

Military personnel with responsibility for environmental planning, particularly in during-conflict and post-conflict contexts, should consider attending this comprehensive conference.

Source:

Disinfection 2007. Current Practice and Future Trends in Disinfection: Water, Wastewater, Stormwater, Water Reuse, and Biosolids

<http://www.wef.org/ConferencesTraining/Conferences/SpecialtyConference/Disinfection2007.htm>

APPENDIX

Reference Details

This Appendix contains expanded background information on some items, and the full text for the articles that are not available on the Internet or are usually stored for a limited time on the respective Web sites.

Item 7. Technological Breakthroughs with Environmental Security Implications

7.2 Possibilities to Considerably Increase Solar Cells Efficiency

Solar power - seriously souped up

From New Scientist Print Edition. 27 May 2006

Herb Brody

<http://www.newscientist.com/article/mg19025531.600;jsessionid=LDLFFIFHFLJB> (by subscription only)

IF YOU want efficient solar power, Victor Klimov has a deal for you. Give him one photon of sunlight, and he'll give you two electrons' worth of electricity.

Not impressed? You should be. In all solar cells now in use - in everything from satellites to pocket calculators - each incoming photon contributes at most one energised electron to the electric current it generates. Now Klimov, a physicist at Los Alamos National Laboratory in New Mexico, has broken through this barrier. He has shown that by shrinking the elements of a solar cell down to a few nanometres, or millionths of a millimetre, each captured photon can be made to generate not one, but two or even more charge carriers.

Producing this multiplicity of electrons - an achievement that has been replicated by a group at the National Renewable Energy Laboratory (NREL) in Golden, Colorado - is a remarkable piece of physics. If the effect can be harnessed, it could change the whole energy debate by making solar power much more efficient and economical. While there are many ongoing efforts to improve solar efficiency - by concentrating sunlight, for example, or by making it easier for electrons to move around within a cell - the new approach is unique in that it gets to the very root of the process and also complements other methods.

For decades, photovoltaics have been stranded on the effete fringe of energy technologies - ideal for niche applications such as satellites, but not economically competitive here on Earth. Made from semiconducting materials, most often silicon, solar cells convert a dismayingly small fraction of the sun's energy into electricity. Radically improving efficiency could give solar energy a boost at a time when it is sorely needed and funding decisions hang in the balance. "If this could be translated into a robust system that could generate multiple carriers, it could be revolutionary," says Eric Rohlffing, acting director of the chemical sciences, geosciences and biosciences division in the Office of Basic Energy Sciences at the US Department of Energy.

The latest results trace back to 1982, when materials scientist Alexander Efros at the Naval Research Laboratory in Washington DC showed it was theoretically possible for a photon to generate multiple charge carriers in certain semiconductors. Over the next two decades, researchers learned to control the properties of tiny semiconducting structures called nanocrystals, or quantum dots. Then in 2002, physical chemist Arthur Nozik of NREL predicted that the production of multiple carriers should be enhanced in nanocrystals relative to bulk semiconductors. It wasn't until 2004 that Klimov's group - interested in developing lasers as well as photovoltaics - showed that such behaviour could be reliably detected (Physical Review Letters, vol 92, p 186601).

The benefits of multiple carriers arise from the way photovoltaic devices interact with the solar spectrum. When an electron in a semiconducting material becomes free to move about and conduct current, it leaves behind a vacant site in the crystal, called a hole; the electron-hole pair is called an exciton. The amount of photon energy needed to create an exciton in a particular material is called the band gap (the term refers to the difference in energy levels between a fixed electron in the so-called "valence band" and one that is part of the sea of freely moving electrons in the "conduction band"). Sunlight consists of a variety of wavelengths, which we see as colours, and the photons of each colour carry a characteristic amount of energy: lower at the infrared and red end of the spectrum, and higher towards the blue, violet and ultraviolet end.

To make an efficient solar cell, you need to match the photon energy to the cell material's band gap. Silicon has a band gap that corresponds to wavelengths in the near-infrared region of the spectrum. Incoming photons with less energy than that will not have the quantum oomph to create even a single exciton. A photon with exactly the band-gap energy will create one exciton and have no energy left over, so the solar cell will make perfect use of the energy from photons in that part of the spectrum.

Most of the light streaming down from the sun, however, has a shorter wavelength than infrared, so its photons have higher energy than the silicon band gap. Each of these packets of electromagnetic energy, no matter how potent, can still liberate only one electron. Anything left over will dribble away as heat and contribute exactly zero to the device's electrical output. Klimov's technique taps this otherwise wasted energy and turns it into electricity.

The key, he says, is the small size of the quantum dots used to absorb photons. When structures shrink to the size of a few thousand atoms, their physics takes a turn for the weird. The multi-exciton phenomenon, which can barely be made to occur at all in conventional silicon, becomes possible in specially fabricated nanocrystals. In his latest series of experiments, Klimov claims to have produced as many as 7 excitons per photon in crystals of lead selenide 4 to 8 nanometres in diameter (Nano Letters, vol 6, p 424). "They're very cheap and only take a few minutes to grow," says Klimov. "It's like making new atoms, to go beyond what nature provides."

Precision timing

To detect these multiple excitons, the nanocrystals' behaviour needs to be measured at excruciatingly precise time intervals. Klimov and his colleague Richard Schaller illuminated samples of lead selenide with laser pulses lasting only 5×10^{-14} seconds - that's 50 millionths of a

nanosecond. They then shone another laser beam to probe the crystal, monitoring how much light it absorbed over the next few thousandths of a nanosecond. Single excitons are stable, so if just one is present, absorption remains constant during that period. If multiple excitons are created, however, that is no longer the case: the excitons rapidly disappear, causing the crystal's absorption properties to change in a characteristic way that can be picked up by sensitive optical detectors. Of course, the ability of a photon to generate multiple charge carriers has its limits. The fundamental laws of physics dictate that the total energy of the excitons cannot exceed the energy of the photons striking the cell. "We are still constrained by the conservation of energy," Klimov says.

Or are they? How the multiple excitons are produced remains a bit of a mystery. According to Klimov, when an energetic photon strikes the material, the electron jumps to what he calls a "virtual" state in which it has actually gained more energy than was carried by the photon; this seeming contradiction is permitted because the virtual state lasts for such a brief time. The hyper-excited electron will transfer some of its energy to another, unexcited electron essentially by bumping into it. The result: two energised electrons from a single photon.

Nozik suggests a different model. There is a "coherent superposition" of energy states, he says - a quantum mechanical effect that defies concrete analogy. Following the absorption of a high-energy photon, an electron will inhabit two different energy states: one of them consistent with the formation of a single exciton, and one consistent with multiple excitons. In effect, says Garry Rumbles, a member of Nozik's team, "you prepare a mixture of states - one state looks like three excitons, and another state looks like a single exciton with very high energy". This superposition holds for a very brief period, until the electron makes a decision, says Rumbles.

However it works, a solar cell does no good unless the electric charges created can be drawn into a circuit. And therein lies the major obstacle to building a real-world device. "To produce current, you need to separate electrons from holes, and that's a big problem," Klimov says. The difficulty is that multiple excitons are extremely short-lived, lasting only tens of picoseconds, or trillionths of a second, before the holes and electrons recombine; in ordinary photovoltaic devices, electrons and holes remain apart for much longer, closer to a microsecond.

This means that practical applications of Klimov's work are still some way off. "We can take this as a proof of principle," says chemist Paul Alivisatos of the University of California, Berkeley, but figuring out how to separate and harvest the multiple charge carriers produced in a nanocrystal remains a puzzle. "It's worth spending time on this," he says, because if it works it is bound to yield an increase in photovoltaic efficiency.

Nathan Lewis, a chemist at the California Institute of Technology in Pasadena who led a recent US Department of Energy workshop on research needs for solar energy, takes a similar view. The work is an "important confirmation of theoretical predictions", he says. "It's like knowing that there's nuclear fusion happening on the sun," he explains. "Doing it on Earth is another story."

The first step is to reliably separate the multiple electrons and holes. That requires finding materials with electronic energy characteristics that match those of the quantum dots. One approach uses a conductive polymer to extract the holes. Klimov's group is collaborating with Anvar Zakhidov, a physicist at the University of Texas at Dallas, on a prototype that blends the

lead selenide crystals with such a polymer. After a photon creates an electron-hole pair, the holes migrate into the polymer and travel through it to an electrode; the energised electrons, meanwhile, hop from nanocrystal to nanocrystal until they reach the other electrode.

The work has encountered its share of technical difficulties, however. "We are at the very beginning of experimental demonstration," Zakhidov says. One issue is that the nanocrystals must be in "intimate contact" with the polymer. Moreover, the conduction of electrons through the array of nanocrystals is very inefficient. "There are lots of dead ends," he says.

An alternative method for collecting the solar-induced charges has been proposed by Peidong Yang, a chemist at Berkeley who is also an expert in nanomaterials. Instead of requiring electrons to hop from one nanocrystal to another, Yang is testing nanowires - highly conductive filaments with a diameter of only a few nanometres. In principle, Yang says, the electrons and holes could zip through an array of nanowires straight to a pair of collecting electrodes "like cars on a freeway with no stop lights". Whether nanowires could harvest multiple excitons in the short time they are available, however, is anyone's guess.

Another area for progress is in the material used for making the quantum dots. The lead selenide used so far is less than ideal. First, it is toxic, making its fabrication a tricky business. Second, its band gap is large. For a photon to produce multiple excitons, its energy must equal at least twice the band gap of the material, and with lead selenide only photons at the high-energy end of the spectrum are powerful enough to achieve this.

Big is beautiful

There may be a way around this. The smallest crystals have the largest band gaps, as the confinement of electrons to a very tight space ratchets up the energy levels. The way to generate the largest number of excitons would be to engineer the crystal so that its band gap is small. One way to do this, says NREL physicist Randy Ellingson, would simply be to grow the nanocrystals larger. That would make it possible to use the abundant photons in the middle of the solar spectrum to generate multiple excitons. The trade-off, Ellingson points out, is that a lower band gap means a lower voltage across the electrodes, which may limit the total power output of the cell.

The researchers are also exploring alternative materials. Both Klimov and Nozik have observed multiple-exciton generation in other semiconductors, including lead sulphide, lead telluride and cadmium selenide. What's more, Klimov says his group has identified two new materials that are less toxic and have band gaps better matched to the solar spectrum than lead selenide, though he will not identify the materials as he has yet to publish the work.

If each photon can generate multiple charge carriers, the overall power efficiency of solar cells could be dramatically increased. The world record for a ground-based cell is 24.7 per cent, achieved by a device made in Australia at the University of New South Wales. Klimov predicts that the multiple-carrier generation could one day yield a cell with double that efficiency, approaching 50 per cent. Ellingson is slightly more conservative, but he still projects efficiencies around 45 per cent. With more work, the chips cranking out extra electrons in New Mexico and Colorado could one day bring a bright solar future for us all.

Solar fuel

Electricity is not the only useful form of energy that ultra-efficient solar cells might generate. They could also be used to induce a chemical reaction that creates fuel. While this approach is not strictly dependent on a cell in which each photon yields more than one current-carrying electron, the additional charge carriers would help by accelerating the reaction.

In one compelling scenario, nanocrystals could be immersed in water, and the current flowing out of the solar cell would break down the water molecules into hydrogen and oxygen. As with direct production of electricity, the benefit of a multiple-exciton solar cell would come through more efficient exploitation of the solar energy that hits it, says chemist Nathan Lewis of the California Institute of Technology in Pasadena.

Hydrogen is the basis for fuel-cell vehicles that would operate emissions-free and require no gasoline. Oxygen from the air would react with hydrogen in the presence of a catalyst to produce electricity, with water as a by-product. Calls for a move to a hydrogen economy, however, tend to gloss over the fact that producing hydrogen requires energy - and if that energy comes from fossil fuels the environmental benefit of hydrogen power is questionable. Using solar energy to generate the hydrogen would overcome this objection.

What's more, there are other ways of putting a solar fuel generator to work. "I'd rather do like the plants do," says Lewis. "Use sunlight to convert water and carbon dioxide into ethanol or methanol." These liquids are more compatible with existing fuelling stations than hydrogen. Whatever the product, Lewis says, "making a multiple-exciton-per-photon solar cell for any purpose would be a major tour de force".

Item 9. Over 4,000 Chemicals in Use in Canada to be Assessed for Safety

Canada's Chemical Reaction

A review by federal regulators has determined that chemicals once thought to be benign are potentially dangerous for the physical health of Canadians.

Environment reporter MARTIN MITTELSTAEDT investigates

<http://www.theglobeandmail.com/servlet/story/LAC.20060527.CHEMICALS27/TPStory/Environment>

(article available for a limited time on the website)

TORONTO -- Federal regulators have determined that about 4,000 chemicals used for decades in Canada pose enough of a threat to human health or the environment that they need to be subjected to safety assessments.

The sheer number of chemicals needing review means there is probably not a person in Canada who hasn't been exposed to some of them.

While many are industrial compounds, others are widely used to make everyday products found in practically every home and office in the country, ranging from hair dryers to water bottles, fast-food wrappers, TVs, computer casings and the inside of tin cans.

The chemicals needing review were culled from a list of 23,000 substances grandfathered from a detailed safety study because they were in widespread commercial use before Canada adopted its first comprehensive pollution legislation, the Canadian Environmental Protection Act, in 1988.

Although federal officials are publicly playing down the huge number of substances that they've deemed need a review, an environmentalist who participated in the federal effort to place chemicals into safe and risky categories was surprised by the magnitude.

"We didn't expect that many chemicals to come through," said Fe de Leon, a researcher at the Canadian Environmental Law Association, a non-profit organization that uses existing laws to protect the environment and advocates environmental law reforms. "I don't think Environment Canada and Health Canada did, either."

The review has become a pressing health and ecological issue because research is indicating that many substances once thought to be benign could be dangerous.

In the past 20 years, hundreds of peer-reviewed scientific papers have linked chemicals in long-term use to a host of health problems and modern disease trends, including learning disabilities, hyperactivity disorders, low sperm counts, altered thyroid function, and breast cancer, among others. Surveys have also found that many of the chemicals causing adverse effects in laboratory animal tests are found in human tissues and in wildlife.

Ms. de Leon has seen a preliminary copy of the list of chemicals to be reviewed and said it contained around 4,000 substances she characterized as including "the baddies of the bad."

They include bisphenol A, the basic building block for polycarbonate plastic, which is used to make such things as 20-litre water-cooler jugs, coatings on compact disks, and Nalgene water bottles. It's also a component in dental sealants for children's teeth and is found in the resins that line almost all tin cans sold in North America.

The list also includes some types of perfluorocarbons, which are used to make non-stick, stain-resistant or water-repellant products and are commonly found in fast-food packaging, furniture, clothing and cookware.

The approximate size of the list has been confirmed by David Morin, an Environment Canada official who has worked on classifying the chemicals. Health Canada said in a statement that it has identified "a large number of chemicals for further study," including bisphenol A.

Environment Canada and Health Canada are required to make public the names of all the chemicals they believe need safety assessments by Sept. 14.

Although most substances in use today have been tested to see if they are acutely poisonous, many haven't been subjected to the kind of in-depth analyses that would determine whether they cause cancer, disrupt hormone functions, interfere with fetal development or accumulate in wildlife.

Some environmentalists contend that allowing tens of thousands of chemicals to be used without full knowledge of their effects is a major regulatory lapse.

"There is clearly a significant, present, growing health risk from a lot of these chemicals," said Rick Smith, spokesman for Environmental Defence, an activist group that last year found residues from chemicals in consumer products in the blood of every Canadian they monitored.

He called for the government to ban or restrict the most dangerous of the 4,000 chemicals, an approach that he said would deal with "the worst of the worst."

For the past seven years, federal health and environment scientists, along with environmentalists and industry representatives, have been going over the list of grandfathered chemicals. Under federal law, these are defined as substances that were used in Canada between 1984 and 1986, so it includes many chemicals developed in the 1950s and 1960s, and even earlier. They have concluded most of their work, leading to a fairly accurate estimate of the total that will need further study.

"They are essentially done," said Ms. de Leon, who was critical of the length of time it has taken to see which chemicals are safe. "It boggles my mind."

Canada is one of many countries around the world that is investigating the safety of chemicals that are in use but have never been subjected to full reviews.

Most of these chemicals escaped detailed scrutiny because they were developed before modern pollution laws existed. When those laws were established, it was common for governments to exempt existing substances from the more rigorous evaluations they started applying to any new chemicals.

In Europe, about 100,000 chemicals were on the market before 1981 and were exempt from detailed reviews. European regulators say that safety information is sketchy for around the vast majority of these chemicals. Since 1981, about 4,300 new chemicals have been subjected to in-depth testing.

Canadian regulators say their evaluation of the 23,000 grandfathered chemicals is the most comprehensive such action in the world, and puts Canada ahead of both Europe and the United States in terms of chemical safety.

"The government of Canada is now leading the world in addressing chemicals introduced" before modern pollution laws, Health Canada said in its statement.

Based on the new research, Canadian regulators have been going over the list of grandfathered chemicals to check for four factors that might signal they pose risks:

- whether they persist for long periods in the environment without breaking down into harmless compounds;

- whether they bio-accumulate, the scientific term for becoming more concentrated in the tissues of living things higher up on the food chain;
- whether they are "inherently toxic," the government's term for substances that pose health threats to humans or wildlife;
- whether their extensive use means they present the greatest potential for human exposures.

An Environment Canada official said that just because a substance meets the threshold for further review doesn't necessarily mean it will be found to be a health danger. The full extent of the hazards won't be known until the government conducts assessments on the individual chemicals and determines actual human or animal exposure levels. It is not known how long this process will take.

"Because the substances meet the criteria does not mean that they pose a risk," Mr. Morin said.

Canadian regulators and those in other countries have been surprised in recent years to find that some chemicals they permitted to be used for decades without much scrutiny were suddenly found to be harmful. Many involved substances destined for use in consumer products.

In 2000, 3M Co. announced it would phase out perfluorooctanyl sulfonate, a substance used to make one of its signature products, Scotchgard. PFOS, as it is also known, was found to be widely present in human blood samples across the U.S., and in wildlife. Laboratory testing on rodents indicated it also killed rat pups born to mothers that had been exposed to the chemical.

In January, E.I. du Pont de Nemours & Co. and seven other big chemical producers agreed under a deal with the U.S. Environmental Protection Agency to sharp reductions in emissions from their products and factories of perfluorooctanoic acid, a chemical used to help make Teflon brand non-stick products, among other things. The chemical has recently also been deemed a likely carcinogen.

In another case, Great Lakes Chemical Corp. agreed to phase out by the end of 2004 two chemical flame retardants accumulating in wildlife that have been found to induce attention deficit and hyperactivity symptoms in laboratory animals. The flame retardants had been widely used for years in foam mattresses and computers.

Ms. de Leon said current approaches to chemical safety haven't been adequate.

"We just thought that chemicals stayed inert in products and this evidence suggests that no, they escape," she said. "We need to have a better framework to deal with them."

Item 10. Updates on Previously Identified Issues

10.8 Climate Change

Other Sources:

“Little Green Data Book 2006”

<http://siteresources.worldbank.org/INTEEI/936214-1146251511077/20906290/LGDB2006PR.pdf>

ANALYSIS - CO2 Price Crash Signals Tougher EU Pollution Goals

<http://www.planetark.com/dailynewsstory.cfm/newsid/36186/story.htm>

Majority of Britons Want New Environmental Law

<http://www.planetark.com/dailynewsstory.cfm/newsid/36194/story.htm>

European Cities Pledge to Slash Greenhouse Gas Emissions

<http://www.ens-newswire.com/ens/may2006/2006-05-09-06.asp>

Global warming risk 'much higher'

<http://news.bbc.co.uk/2/hi/science/nature/5006970.stm>

Ice-capped roof of world turns to desert

<http://news.independent.co.uk/environment/article362549.ece>

Equatorial African Icecaps Melting Away

<http://www.ens-newswire.com/ens/may2006/2006-05-17-04.asp>

Development, Industrial Development, Air Pollution, Climate Change

<http://www.un.org/News/Press/docs//2006/envdev891.doc.htm>

Poor will feel greatest impact of climate change, scientist tells UN commission

<http://www.un.org/apps/news/story.asp?NewsID=18360&Cr=climate&Cr1=change>

The climate of poverty: facts fears and hope

<http://www.christian-aid.org.uk/indepth/605caweek/index.htm>

UN conference agrees agenda for negotiations on new emission reduction targets under the Kyoto Protocol

http://unfccc.int/files/press/news_room/press_releases_and_advisories/application/pdf/20060526_final_26_may_press_release-english.pdf

Dialogue on long-term cooperative action to address climate change by enhancing implementation of the Convention. First workshop, 15-16 May 2006, Bonn, Germany

<http://unfccc.int/meetings/dialogue/items/3669.php>

Press Conference by Acting Head of United Nations Climate Change Secretariat

http://www.un.org/News/briefings/docs/2006/060512_UNFCCC.doc.htm

Industries trying to improve environmental, social performance – UN report

<http://www.un.org/apps/news/story.asp?NewsID=18416&Cr=UNEP&Cr1=>

Ice-Capped Roof of World Turns to Desert

By Geoffrey Lean, The Independent UK. Sunday 07 May 2006

<http://news.independent.co.uk/environment/article362549.ece> (by subscription only)

Scientists warn of ecological catastrophe across Asia as glaciers melt and continent's great rivers dry up.

Global warming is rapidly melting the ice-bound roof of the world, and turning it into desert, leading scientists have revealed.

The Chinese Academy of Sciences - the country's top scientific body - has announced that the glaciers of the Tibetan plateau are vanishing so fast that they will be reduced by 50 per cent every decade. Each year enough water permanently melts from them to fill the entire Yellow River.

They added that the vast environmental changes brought about by the process will increase droughts and sandstorms over the rest of the country, and devastate many of the world's greatest rivers, in what experts warn will be an "ecological catastrophe."

The plateau, says the academy, has a staggering 46,298 glaciers, covering almost 60,000 square miles. At an average height of 13,000 feet above sea level, they make up the largest area of ice outside the polar regions, nearly a sixth of the world's total.

The glaciers have been receding over the past four decades, as the world has gradually warmed up, but the process has now accelerated alarmingly. Average temperatures in Tibet have risen by 2 degrees Fahrenheit over the past 20 years, causing the glaciers to shrink by 7 per cent a year, which means that they will halve every 10 years.

Prof Dong Guangrong, speaking for the academy - after a study analysing data from 680 weather stations scattered across the country - said that the rising temperatures would thaw out the tundra of the plateau, turning it into desert.

He added: "The melting glaciers will ultimately trigger more droughts, expand desertification and increase sand storms." The water running off the plateau is increasing soil erosion and so allowing the deserts to spread.

Sandstorms, blowing in from the degraded land, are already plaguing the country. So far this year, 13 of them have hit northern China, including Beijing. Three weeks ago one storm swept across an eighth of the vast country and even reached Korea and Japan. On the way, it dumped a mind-boggling 336,000 tons of dust on the capital, causing dangerous air pollution.

The rising temperatures are also endangering the newly built world's highest railway, which is due to go into operation this summer. They threaten to melt the permafrost under the tracks of the £1.7bn Tibetan railway, constructed to link the area with China's northwestern Qinghai province.

Perhaps worst of all, the melting threatens to disrupt water supplies over much of Asia. Many of the continent's greatest rivers - including the Yangtze, the Indus, the Ganges, the Brahmaputra, the Mekong and the Yellow River - rise on the plateau.

In China alone, 300 million people depend on water from the glaciers for their survival. Yet the plateau is drying up, threatening to escalate an already dire situation across the country.

Already 400 cities are short of water; in 100 of them - including Beijing - the shortages are becoming critical.

Even hopes that the melting glaciers might provide a temporary respite, by increasing the amount of water flowing off the plateau - have been dashed. For most of the water is evaporating before it reaches the people that need it - again because of the rising temperatures brought by global warming.

Yao Tandong, head of the academy's Qinghai-Tibet Plateau Research Institute, summed it up. "The full-scale glacier shrinkage in the plateau regions will eventually lead to an ecological catastrophe," he said.