WATER QUALITY OUTLOOK

GEMS Water

World Water Assessment Programme
www.unesco.org/water/wwap

UNEP

Water Quality Outlook

ISBN 95039-11-4

Prepared and published by the United Nations Environment Programme Global Environment Monitoring System (GEMS)/Water Programme.

© United Nations Environment Programme Global Environment Monitoring System/Water Programme.

This publication may be reproduced in whole or in part and in any form for educational or non-profit purposes without special permission from the copyright holder provided acknowledgement of the source is made. UNEP GEMS/Water Programme would appreciate receiving a copy of any publication that uses this publication as a source. The designation of geographical entities in this report, and the presentation of the material herein, do not imply the expression of any opinion whatsoever on the part of the publisher or the participating organisations concerning the legal status of any country, territory or area, or of its authorities, or concerning the delineation of its frontiers or boundaries.

The views expressed in this publication are not necessarily those of UNEP or of the agencies cooperating with GEMS/Water Programme. Mention of a commercial enterprise or product does not imply endorsement by UNEP or by GEMS/Water Programme. Trademark names and symbols are used in an editorial fashion with no intention of infringement on trademark or copyright laws.

UNEP GEMS/Water Programme regrets any errors or omissions that may have been unwittingly made.

This document may be accessed and downloaded from the GEMS/Water website at http://www.gemswater.org/

UN GEMS/Water Programme Office
c/o National Water Research Institute
867 Lakeshore Road
Burlington, Ontario, L7R 4A6 CANADA
http://www.gemswater.org
http://www.gemstat.org
tel: +1-306-975-6047
fax: +1-306-975-5663
email: info@gemswater.org

Mission

To be the leading provider of data and information on the state and trends of global inland water quality required for their sustainable management, to support global environmental assessments and decision-making processes.

Preface

This report presents a snapshot of global water quality issues as they relate to achieving the internationally agreed goals on water, sanitation and biodiversity. Evidence suggests that there have been improvements in the quality of water in some parts of the world. However, there are serious problems that must be addressed for health and prosperity to be reached universally.

There are five key points and questions that we illustrate in the pages ahead:

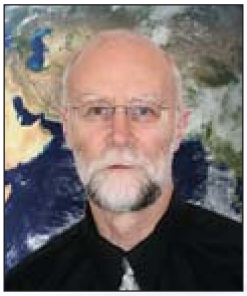
1. One of the key considerations in meeting the Millennium Development Goals is that water quality must be improved at all levels;
2. A critical issue is the quality of inland waters: is it improving or deteriorating?;
3. Appropriate responses to water environment problems are opportunities for development;
4. Governments share the responsibility for assessing the global water environment in a regular manner; and
5. Future needs for water quality monitoring.

Although many challenges remain to properly protect aquatic ecosystems, success can be reached with planning, political and institutional will, and financial and technical resources.

The GEMS/Water Programme provides a vital contribution to monitoring progress towards meeting the MDGs on water, sanitation and aquatic biodiversity. Information on water quality can also contribute to the United Nations World Water Assessment Programme (UN-WWAP), which was established in 2000 in responding to the relevant decision of the UN Commission on Sustainable Development. UN-WWAP is a collective response of the 24 entities comprising UN-Water with a view to assist countries in reaching their commitments in key water-related challenge areas. It creates a sustainable mechanism for reporting on progress made in these areas through the production of a series of World Water Development Reports (WWDRs).

The target audience for this publication includes decision makers and practitioners working to improve integrated water resource management at all levels. We trust that readers will find this report interesting and useful, and we welcome your comments and feedback.

András Szöllösi-Nagy D.Sc.
Deputy Assistant Director General
Secretary of the International Hydrological Programme
Director of the Division of Water Sciences
UNESCO



Richard D. Robarts, Ph.D.
Director
UNEP GEMS/Water Programme

By Improving Water Quality, We Will Meet the Millennium Goals

No single measure would do more to reduce disease and save lives in the developing world than bringing safe water and adequate sanitation to all.[1]

Access to fresh water and sanitation services is a precondition to all the other internationally agreed goals and targets (see Box 1). By focusing on water *quality*, the water, sanitation and aquatic biodiversity targets can be met. The way we perceive nature and the value of the goods and services that aquatic resources provide to people is fundamental to peace, security and prosperity. Water is vital to the survival of ecosystems, and in turn ecosystems help to regulate the quantity and quality of water.

Box 1

Millennium Development Goals and Water Quality

In 2000, the United Nations established eight Millennium Development Goals (MDGs) with the aim of speeding up poverty alleviation and socio-economic development by 2015. The MDGs were expanded at the World Summit on Sustainable Development, in Johannesburg in 2002.

Millennium Development Goals:

1. Eradicate extreme hunger and poverty
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development.

Water quality management contributes both directly and indirectly to achieving all eight MDGs, but it is most closely tied to the targets of Goal 7:

- Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources;
- Halve by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation;
- Significantly reduce biodiversity loss by 2010; and
- Achieve significant improvements in the lives of at least 100 million slum dwellers, by 2020.

[1] UN Secretary General, 2000. "We the Peoples: the role of the United Nations in the 21st century." *Millennium Report*. http://www.un.org/millennium/sg/report/ch4.pdf page 7.

Data from the Joint Monitoring Programme of WHO/Unicef show that since 1990, investments in public provision of safe water for consumption and sanitation facilities have improved coverage around the world. If current trends continue, then by 2015, global drinking water coverage could be 85% and global sanitation coverage could rise to 63%. (See Tables 1 and 2.) However, more effort is required, particularly in Africa and parts of Asia, for the target to be achieved in full.

Table 1 *Improved Drinking Water Coverage (Percent)*

REGION	1990	1995	2000	2004	2010*	2015*
Africa	56	59	61	62	64	66
Asia + Pacific	74	77	80	82	84	86
Latin America + Caribbean	82	86	89	91	92	93
North America	100	100	100	100	100	100
West Asia	84	85	85		85	85
Europe		95	96	97	98	99
Global	**77**	**79**	**82**	**83**	**84**	**85**

Source: *WHO/Unicef JMP 2004, UNEP GEO Data Portal*
* UNEP GEMS/Water linear extrapolated estimates

Table 2 *Improved Sanitation Coverage (Percent)*

REGION	1990	1995	2000	2004	2010*	2015*
Africa	38	40	42	44	46	48
Asia + Pacific	30	37	44	47	50	53
Latin America + Caribbean	68	72	75	77	79	81
North America	100	100	100	100	100	100
West Asia		66	69		72	75
Europe						
Global	**48**	**52**	**57**	**59**	**61**	**63**

Source: *WHO/Unicef JMP 2004, UNEP GEO Data Portal*
* UNEP GEMS/Water linear extrapolated estimates

2

Is the Quality of Inland Waters Improving or Deteriorating?

Indicators of water quality can be used to demonstrate progress toward the MDGs, by plotting trends in water quality over time and over space. Aquatic ecosystem and human health depend on the physical, chemical and biological composition of water. Human activities have the greatest impact on the quality of water resources, even in remote areas.

Good quality water depends on dissolved salts and minerals, since they are necessary components to help maintain the health and vitality of the organisms that rely on aquatic ecosystem services.[2]

Human Health

Unsafe water and poor sanitation cause an estimated 80 per cent of all diseases in the developing world. The annual death toll exceeds five million people, and more than half are children. Metallic contaminants and microbial pollution are serious concerns in many water bodies around the world.

Metallic Contaminants

Metals occur naturally and become integrated into aquatic organisms through food and water. Trace metals such as mercury, copper, selenium, and zinc are essential in low concentrations. However, metals tend to bioaccumulate in tissues and prolonged exposure or exposure at higher concentrations can lead to illness. Elevated concentrations of trace metals can have negative consequences for both wildlife and humans. Human activities such as mining and heavy industry can result in higher concentrations than those that would be found naturally.

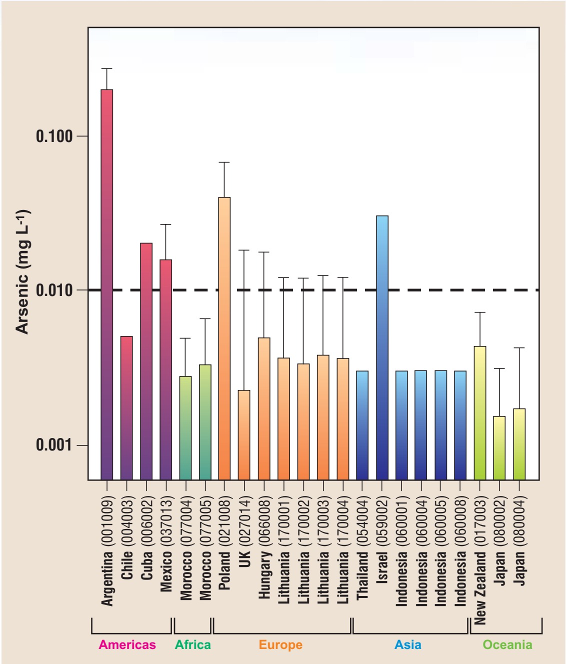


Figure 1. Arsenic levels in groundwater samples. Data are mean ± 1 standard deviation; where error bars are lacking, all observations had the same value which is equal to the analytical limit of detection for that station. The dashed line shows the WHO drinking water guideline, which most countries are safely below.

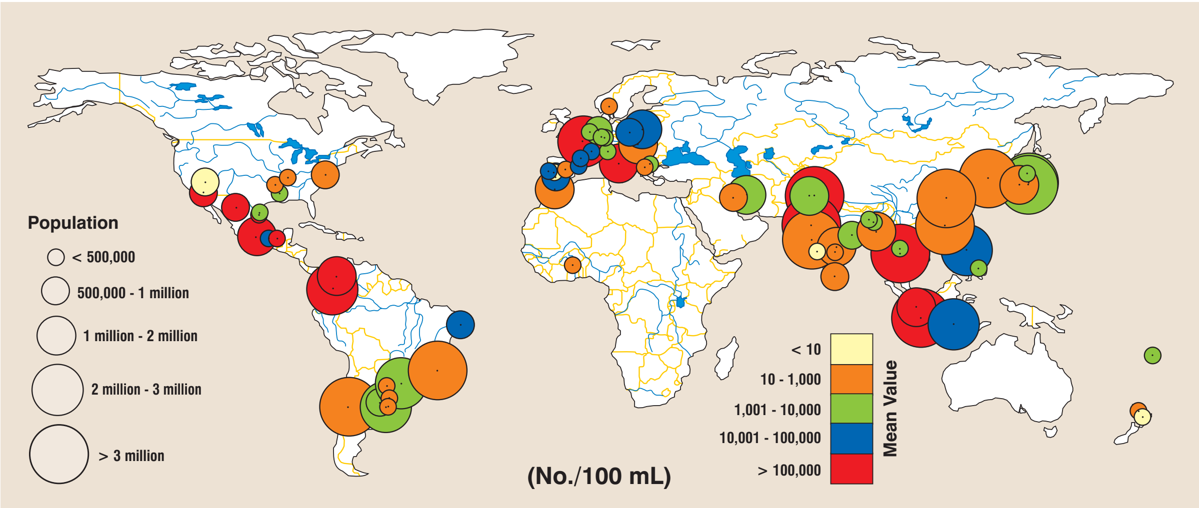
Monitoring metals in surface and ground water supplies provides background information needed to determine the suitability of water resources for human consumption. Evidence suggests that levels of arsenic in groundwater aquifers in many parts of the world, for example, are acceptably below the WHO drinking water guideline (see Figure 1). It should be noted however, that arsenic remains a serious threat to health in some parts of the world such as Bangladesh and Cambodia, where shallow aquifer tube-wells are abundant.

[2] Stark, J.R., Hanson, P.E., Goldstein, R.M., Fallon, J.D., Fong, A.L., Lee, K.E., Kroening, S.E., and Andrews, W.J., 2000. "Water Quality in the Upper Mississippi River Basin, Minnesota, Wisconsin, South Dakota, Iowa, and North Dakota, 1995-98." *United States Geological Survey, Circular 1211*. http://pubs.usgs.gov/circ/circ1211/pdf/circular1211.pdf.

Microbial Pollution

The largest concern about microbial pollution is the risk of illness or premature death to humans and livestock after exposure to contaminated water. Communities downstream of intensively farmed areas or municipal sewage outfalls, and people working or recreating in infected waters, are at the highest risk of illness due to microbial pathogens. Indicator organisms, such as coliforms, can be used to detect the presence of faecal contaminants in water resources.

In general, the levels of faecal coliform bacteria in rivers correlate with population size of cities located upstream of sampling points, as depicted in Figure 2. With continued population growth and urbanization, more investment needs to be made in improving water supply infrastructure and sanitation facilities in both developing and developed countries.



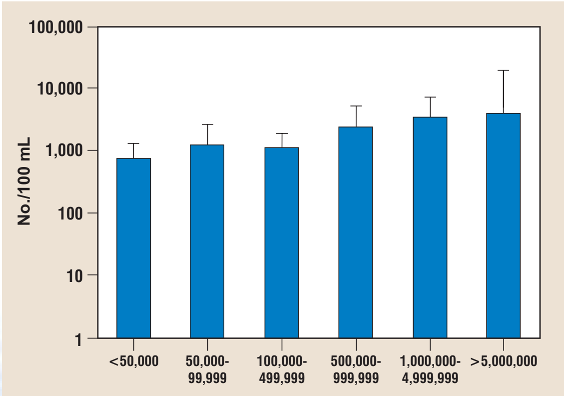


Figure 2. Faecal coliform concentrations at river monitoring stations located near major cities, plotted according to population size (top figure). Bottom figure shows mean (± 1 standard error) faecal coliform concentrations separated by population size class of nearby cities.

Ecosystem Services

The health of the aquatic environment impacts both human health and socioeconomic development. Restoration of some impaired aquatic ecosystems has been demonstrated to varying degrees, including correcting damage caused by eutrophication and acidification.

Eutrophication

Productivity of aquatic ecosystems can be managed by regulating direct or indirect inputs of nitrogen and phosphorus with the aim of either reducing or increasing primary production. Examination of changes in median nitrate concentrations in rivers between the early 1980s and the early 2000s, as presented in Figure 3, shows that improvements (measured as decreases) in nitrate concentrations can be detected at most Swiss river monitoring stations and about half of the Indian river stations, whereas nitrate has increased or remained the same in most Japanese and Russian river stations. The improvements in nitrate concentrations are likely due to local and regional efforts at curbing or eliminating point-source pollution, agricultural runoff, and discharge of municipal waste into rivers and lakes.

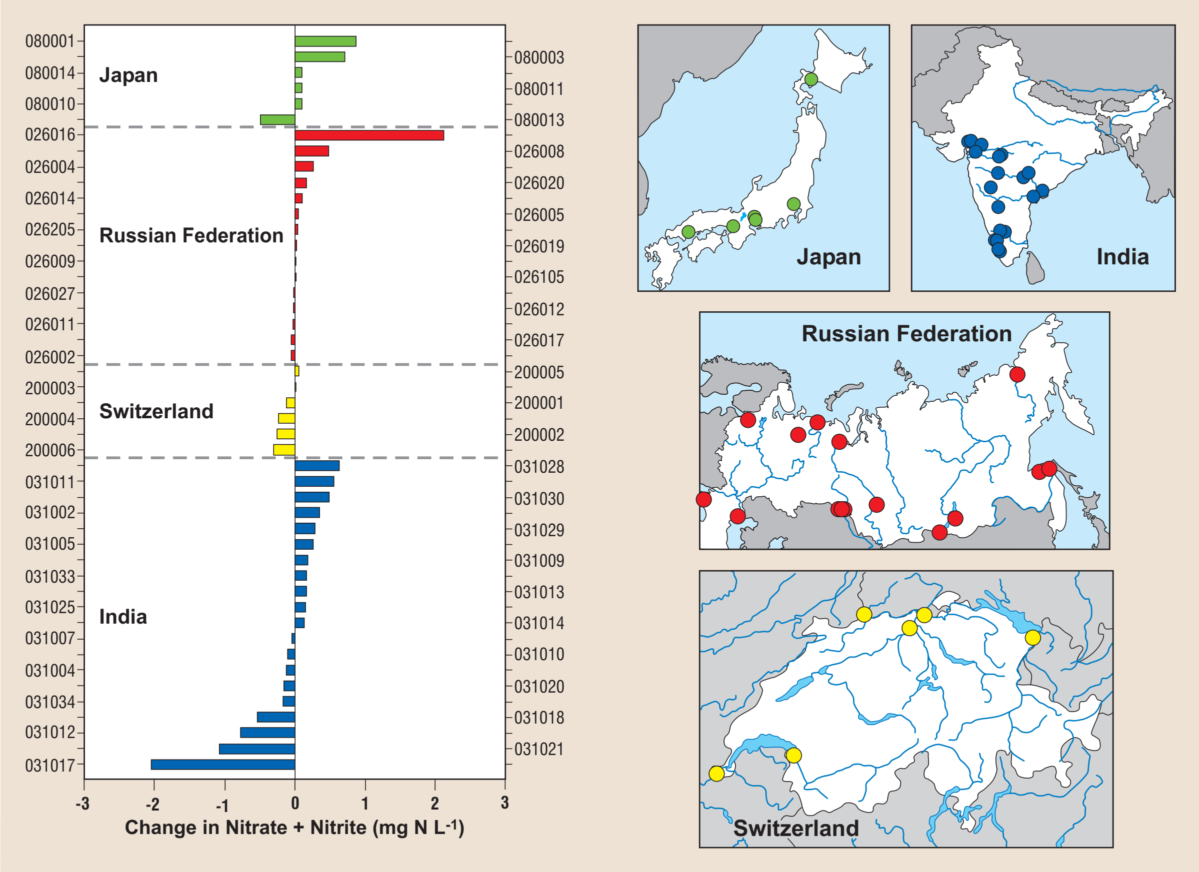


Figure 3. Change in median combined nitrate and nitrite concentrations at river monitoring stations between 1980-1984 and 2000-2004. Positive values indicate an increase and negative values indicate a decrease in combined nitrate and nitrite concentrations over time. Station identifiers are shown on the vertical axis.

Acidification

The pH of an aquatic ecosystem, which measures acidity/alkalinity of the water, is important because it is closely linked to biological productivity. Although the tolerance of individual species varies, pH values between 6.5 and 8.5 usually indicate good water quality and this range is typical of most major drainage basins of the world. Data on pH levels as shown in Figure 4 reveal that pH falls within the 'good water quality' range of values in many drainage basins around the world. Significant improvements in pH have been made in parts of the world, likely as a result of global and regional efforts to reduce sulfur emissions.

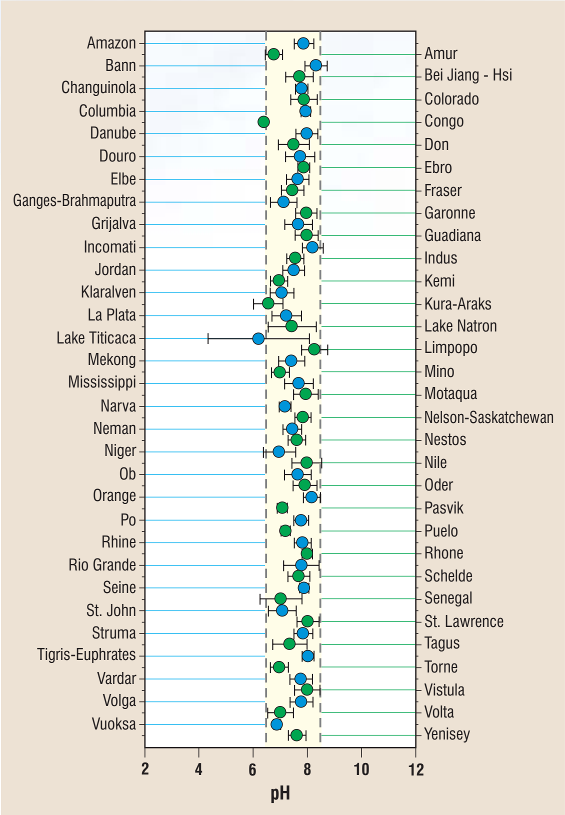


Figure 4. Mean pH (± 1 standard deviation) of major drainage basins in the world. Dashed lines indicate approximate pH range suitable for the protection of aquatic life.

Fish

Fish are important not only for ecosystem function, but also may provide socioeconomic value in the form of fishery resources for people. Loss of fish species due to changes in water quality or over-fishing may result in dramatic shifts in ecosystem dynamics, as grazing pressure on invertebrates and algae can be released, enabling rapid growth and potential blooms of algal populations.

Fish communities can be used to indicate longer term or wider ranging effects of changes in the aquatic environment because many fish species are relatively long-lived and mobile. They tend to integrate effects of lower trophic levels, thereby providing a measure of integrated environmental health. Fish are important for assessing contaminants in ecosystems since they generally represent the top of the food chain and are susceptible to bioaccumulation and bio-magnification of heavy metals and synthetic organic contaminants. They are relatively easy to collect and identify to species level and can sometimes be collected and released unharmed (non-destructive sampling) when fish tissues and organs are not required for analysis.[3]

[3] Barbour, M.T., Gerritsen, J., Snyder, B.D., Stribling, J.B., 1999. "Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers:" *Periphyton, Benthic Macroinvertebrates and Fish*, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

3

Responses to Water Environment Problems are Opportunities for Development

Well-managed water resources have helped to promote economic development, which in turn contributes to human well-being. Services provided by inland waters are vital for human well-being and poverty alleviation.[4]

Integrated watershed resource management (IWRM) tools are widely recognized for their ability to incorporate socioeconomic, environmental and technical dimensions of aquatic environments and their drainage basins into any management scheme. If aquatic resources are not properly managed and aquatic ecosystems deteriorate, then human health and well-being may be compromised.

It has been estimated that for each dollar invested in improving water and sanitation, a return of $3-34 can be expected. The economic benefits of simultaneously meeting the drinking water and sanitation targets on households and the health sector amount to $84 billion per year, representing reduced health care costs, value of days gained from reduced illness, averted deaths, and time savings from proximity to drinking water and sanitation facilities for productive endeavour.[5]

Although projected funding requirements for economic development and meeting the MDGs for the entire water sector are estimated to reach $111-180 billion a year, current investments in sanitation and water supply total only about $10-30 billion a year.[6]

Effective wastewater treatment can remove microbial contaminant loads to safe levels, indicating that proper sanitation and wastewater treatment facilities in cities and rural areas are instrumental in achieving success in meeting the MDG targets. This would result not only in improvements in human health on a global scale, but also improved ecosystem health. Healthy people and environments are the most productive economically.

Improved scientific understanding of the interaction between hydrological, chemical and biological processes within aquatic ecosystems can be used to design and implement ecohydrological solutions to water use, treatment, and extraction.

The ability to realize gains from investments is often constrained by lack of data and information on inland water quality. This means that more effort is required to strengthen monitoring and assessment in many parts of the world.

4 Millennium Ecosystem Assessment, 2005. *Ecosystem and Human Well-being Volume 1*. USA: Island Press.

5 WHO, 2004. http://www.who.int/water_sanitation_health/wsh0404/en.

6 UN World Water Assessment Programme, 2003. *World Water Development Report 1*.

4

Governments Share the Responsibility for Keeping the Global Water Environment under Review

The primary objective of inland water quality monitoring is to provide safe water for human consumption. Depending on the scale of the issue, actions to ensure water sustainability can be effective at global, regional, national or local levels. Baseline monitoring data for aquatic ecosystems is a priority. Long-term monitoring is also required to track the effectiveness of policies and interventions.

At the global level, governments monitor and assess water quality by participating with UNEP's GEMS/Water Programme, and contributing data to GEMStat, the global water quality database. GEMStat provides environmental water quality data and information that is scientifically credible, accessible and interoperable. The GEMStat website at http://www.gemstat.org shares surface and ground water quality data sets collected from the GEMS/Water Global Network, including over 2,800 stations, two million records, and over 100 parameters (see Figure 5). These data serve to strengthen the scientific basis for global and regional water assessments, indicators and early warning. GEMStat is also geospatially referenced with Google Earth (see Figure 6).

There are 263 international water bodies around the world. Water basins offer an important opportunity for collaboration at regional levels, that may be important in avoiding or redressing conflict. The EU Water Framework Directive, the, SADC Water Protocol 2000, and the Nile Basin Initiative (NBI) are good examples of managing shared waters. The difficulties involved in monitoring and managing inland water resources are not insurmountable, and certainly there have been many positive examples of successful management.

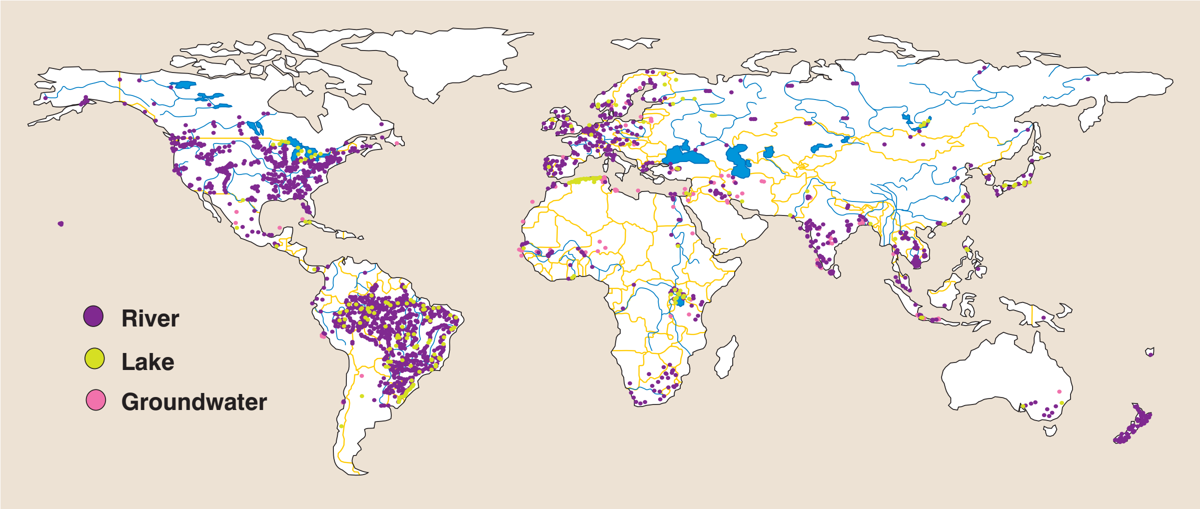


Figure 5. *UNEP GEMS/Water Global Network worldwide distribution of over 2,800 monitoring stations. Coverage has doubled in the last two years, but still needs improvement in Africa, Small Islands, and West Asia.*

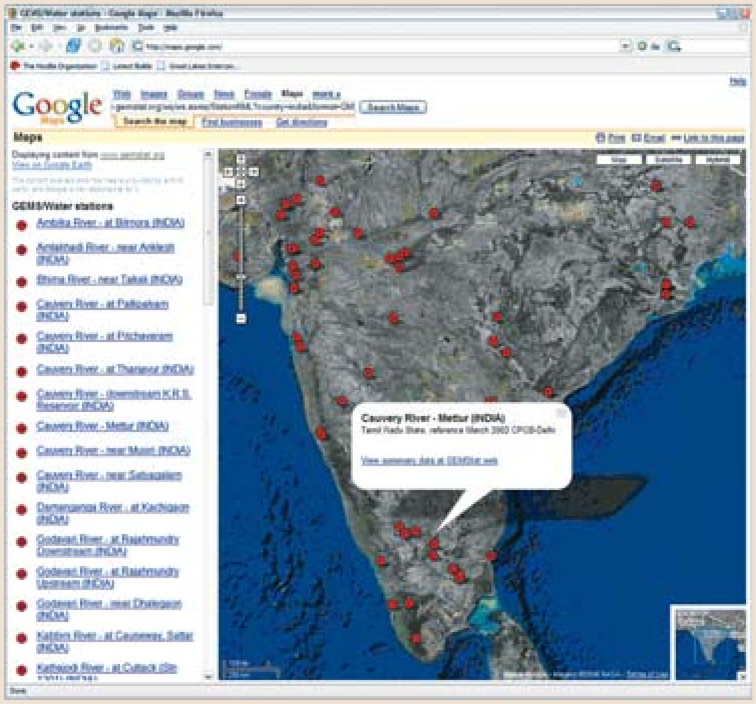


Figure 6. *GEMStat stations mapped in 3-D using Google Earth™, a free online tool that shows the stations in their surroundings.*

For example, concerns over health effects of certain compounds in humans and animals have led to bans of some pesticides and other chemicals in different parts of the world. Such bans can result in noticeable improvements in surface water quality, as shown for several rivers in China in Figure 7. HCH is an organochlorine insecticide that was banned from use in China in its technical form in 1983 (dashed line). HCH is composed of several isomers; the insecticide lindane is composed almost entirely of γ-HCH, and was made available in China in 1991 under restricted use. Lindane is still in use in many parts of the world today, and residues have been detected in surface waters. However, pesticides are capable of undergoing long-range atmospheric transport, and pesticides or their breakdown products have been detected in precipitation, surface waters, and biota in regions far from the original source. The deposition of pesticides in remote environments, often in Arctic and alpine regions, threatens already sensitive terrestrial and aquatic ecosystems.

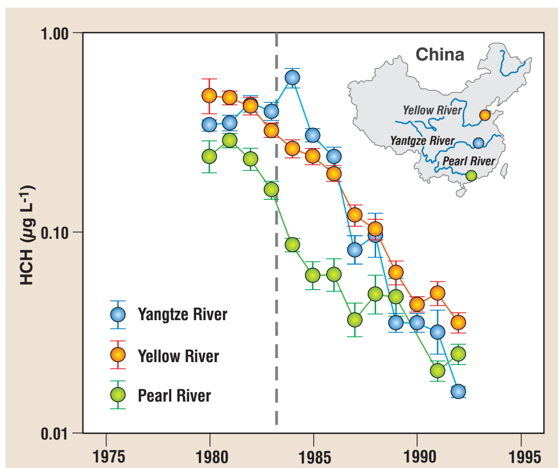


Figure 7. *Mean (± 1 standard error) annual concentrations of technical hexachlorocyclohexane (HCH; also known as 'benzene hexachloride' or BHC) in three Chinese rivers between 1980 and 1993.*

At the national level, the development of integrated water resource management (IWRM) approaches to regulate over-exploitation of water holds promise for helping to prevent and/or reverse the degradation of water resources in many countries. Examples of effective water quality monitoring systems, within IWRM, can be found in countries as diverse as South Africa, Mexico and Japan.

South Africa has recognized the need to tailor long-term water resource monitoring programmes to address issues such as salinization, eutrophication, threats to biodiversity, and microbial contamination, in addition to an extensive national hydrological monitoring programme. Long-term monitoring of three drainage basins in South Africa shows contrasting trends in electrical conductivity as a result of human activities. Conductivity in the Orange River drainage basin increased significantly between 1980 and 2004 as a result of intensive irrigation practices and varying rainfall patterns, whereas conductivity decreased significantly in the Great Fish drainage basin over the same time period as a result of interbasin transfers of water from the Orange River basin. No significant change was detected in a third drainage basin, the Tugela, over the same time period (see Figure 8).

River restoration in Japan is extensive and many successes have been documented in systems that are heavily urbanized and located in areas of extremely high population densities.

Although many challenges remain to properly protect aquatic ecosystem health, there is evidence that success can be achieved given sufficient planning, political and institutional will, and financial and technical resources. Box 2 highlights three top priorities for governments to address in their water quality resource management strategies.

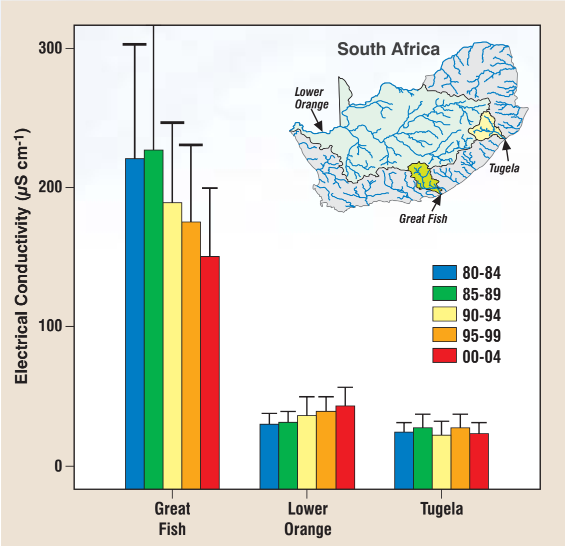


Figure 8. Electrical conductivity at three long-term river water quality monitoring stations in South Africa. Bars represent mean (± 1 standard deviation) conductivity over five-year intervals between 1980 and 2004.

Priorities for Governments in Water Quality Management

Box 2

- Invest in technology for improved risk assessment, monitoring, information and communication
- Improve cooperative water basin management to increase development opportunities and reduce potential for conflict
- Create joint environmental management and scientific assessments, because they are opportunities for building trust and cooperation.

5

Future Needs for Water Quality Monitoring

Even though many of the ongoing problems associated with water quality have not yet been solved, the world is also facing new environmental problems that threaten aquatic and terrestrial ecosystems. Climate variability, biotic invasions and the introduction of new chemicals and microbes to water bodies continuously pose new threats to aquatic ecosystem health that must be addressed by regulatory authorities at local, national and global scales (see Box 3).

Box 3

Emerging Threats to Water Quality

- Climate change and variability;
- Dam removal, causing increased sediment loads;
- Waterborne and water-related pathogens;
- Chemical contaminants including endocrine disruptors, pharmaceuticals, and personal care products; and
- Invasive species.

Changes in average temperature, precipitation levels, and a rising sea level are expected to occur over the next few decades, partially in response to changes in large scale atmospheric circulation indices such as the El Niño Southern Oscillation and the North Atlantic Oscillation, and these are likely to influence inland waters. Long-term monitoring records from lakes and reservoirs in Africa, the Americas, Europe, and Asia show marked increases in temperature over the last three decades (see Figure 9).

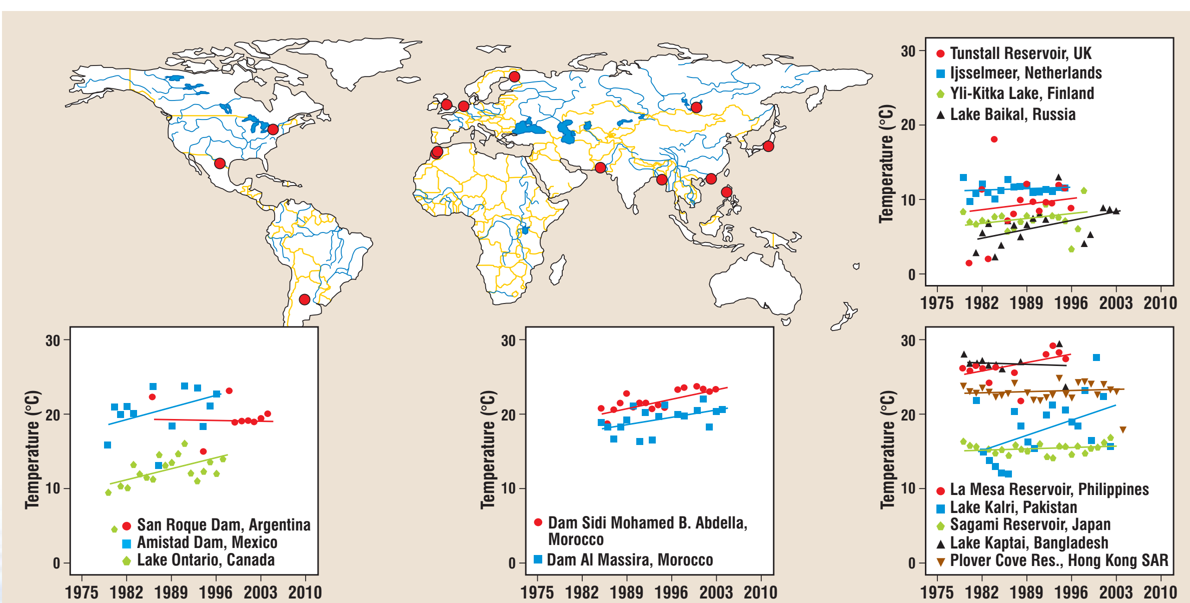


Figure 9. Mean annual surface water lake temperatures over time for long-term monitoring stations in Europe, Asia, Africa, and the Americas. Lines are 'best fit' linear regressions.

The success of local, regional, and global efforts to curb rates of water quality degradation can only be measured if sufficient data are available to track trends over time and space. New approaches and techniques need to be developed and applied to address emerging issues and to provide decision-makers with relevant and accurate assessment data and information. Eight priorities have been identified to meet future needs for water quality monitoring and assessment (see Box 4).

Current water quality monitoring information and assessment are based on *in situ* data. An exciting future prospect is that such assessments can benefit from other sources of data, particularly space-based observations, in a reliable and operational matter. Linking the two sources of data would be a valuable scientific resource because of potentially extending the scope, scale and replicability of data gathering for assessment purposes, as well as of developing new models and methodologies.

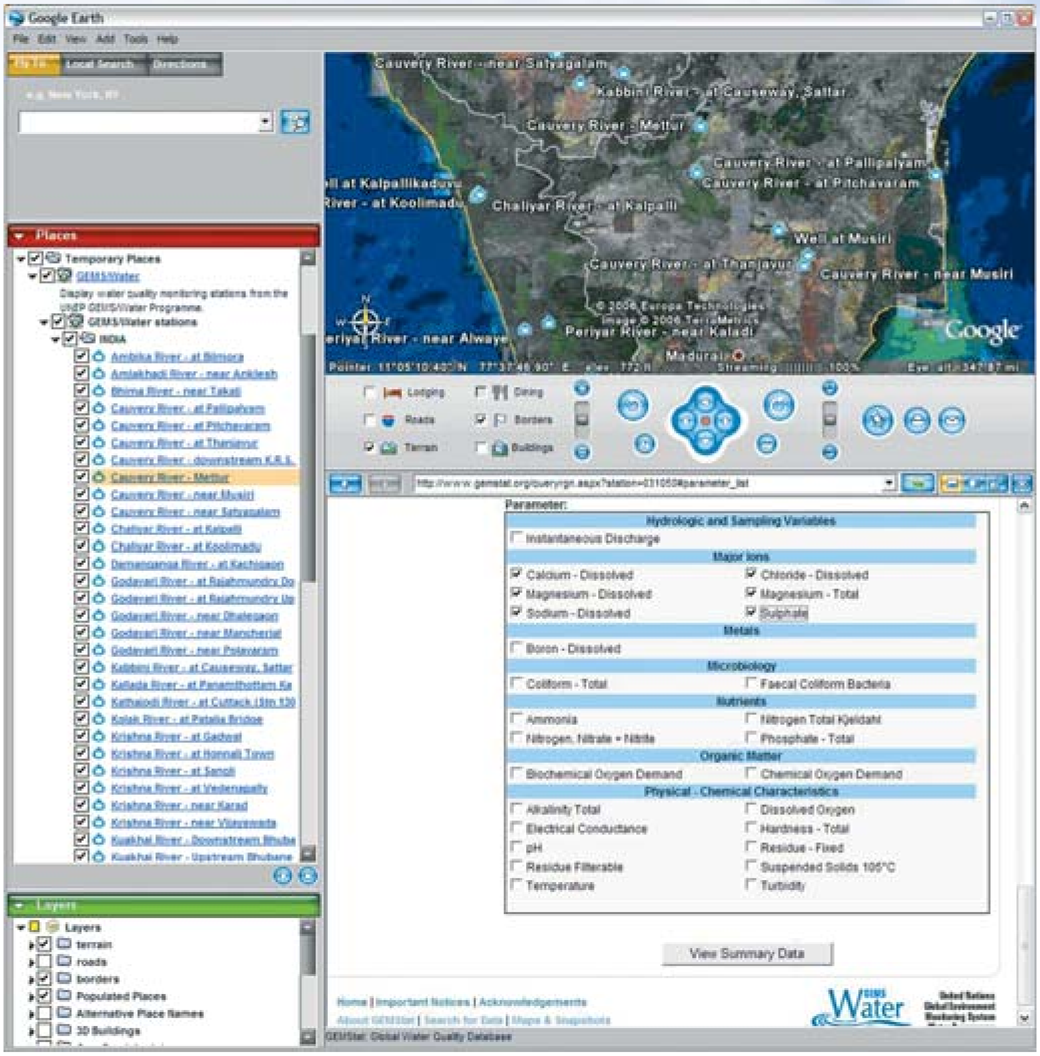
Box 4

8 Priorities for Meeting Future Monitoring Needs

1. Understanding the relationships between water quality conditions and the natural landscape, hydrologic processes, and the human activities that take place within watersheds;
2. Assessing water quality in a "total resource" context;
3. Evaluating water quality in concert with water quantity;
4. Evaluating water quality in concert with biological systems;
5. Monitoring over long time scales;
6. Moving from monitoring to prediction - applying our understanding of the hydrologic system and water quality conditions to unmonitored yet comparable areas;
7. Investing resources to gather ancillary information on landscape and human factors controlling (influencing) water quality; and
8. Advancing monitoring technology, such as measuring water quality in real time.

Source: Hirsch *et al.* (2006), *Journal of Environmental Monitoring.*

The future of water quality at local, regional, and global scales depends on investments of individuals, communities, and governments at all levels to ensure that water resources are protected and managed in a sustainable manner.



Search for global water quality data at www.gemstat.org,
and see the results geospatially mapped using Google Earth™ satellite images.

UN GEMS/Water Programme Office
c/o National Water Research Institute
867 Lakeshore Road
Burlington, Ontario, L7R 4A6 CANADA
http://www.gemswater.org
http://www.gemstat.org
tel: +1-306-975-6047
fax: +1-306-975-5663
email: info@gemswater.org

PRINTED IN CANADA