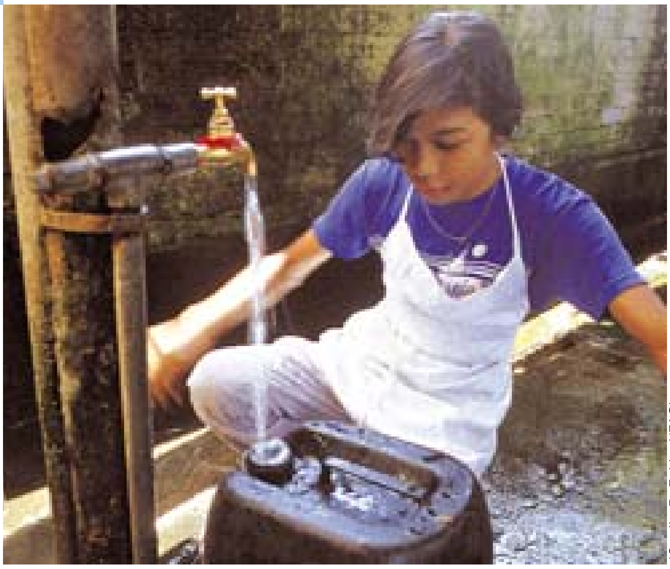
Subterranean Blue

Sustaining Water Lifelines for Cities

Already half of the world's people live in urban areas, and more are moving in. Many of them depend on groundwater for living. But as cities grow, can subterranean water sources be sustained?

by John Chilton



(Credit: R. Faidutti/FAO)

Cities used to be centres of plague and illness. During the past 150 years urban sanitary engineering and medical epidemiology have promoted rapid improvements to human health in the cities of the industrial world. A celebrated example was the pioneering work of Dr. John Snow who, in the mid-19th century, traced the source of a London cholera epidemic to a public water pump on Broad Street.

Most cities evolved from small settlements and the availability of a suitable water supply was often the primary factor in their location. Often, though, these original water sources quickly became inadequate in quality or quantity, and sometimes are now completely forgotten. New sources and larger quantities of water were required. Groundwater may have been drawn from deep aquifers, even from beyond city boundaries. Today, groundwater plays a critical but complex (and often largely unrecognized) role in the urban environment.

Urban aquifers

Underground aquifers are major sources of municipal and industrial water supply. Some of our largest cities (Beijing, Buenos Aires, Dhaka, Lima, Mexico City) draw heavily from them, and some of the fastest growing cities are completely dependent on groundwater. Groundwater from aquifers beneath or close to Mexico City, for example, provides it with more than 3.2 billion litres per day.

But, as groundwater pumping increases to meet growing water demand, it can exceed the aquifers' rates of replenishment, and in many urban aquifers water levels show long-term decline. With excessive extraction comes a variety of other undesirable effects:

- Increased pumping costs;
- Changes in hydraulic heads and underground flow directions (in coastal areas this can result in intrusion of seawater);
- Saline water may be drawn up from deeper geological formations;
- Poor-quality water from polluted shallow aquifers may leak downwards to deeper aquifers.

Severe depletion of groundwater resources is often compounded by serious deteriorations in its quality from these effects.

Problems of land subsidence can also follow rapid depletion of aquifers. This can affect both upland and lowland cities. Mexico City (about 2,000 metres above sea level) and Bangkok (at sea level), for example, are both suffering severe groundwater-induced subsidence, resulting in millions of dollars worth of damage. Land subsidence not only damages individual buildings and roads, but also underground piped services, further increasing water depletion and contamination. Leaks from water mains and sewers, and ruptured oil pipelines and underground tanks can add to water shortages and produce soil and groundwater pollution.

Where a town or city's water demand has increased rapidly and aquifers have become depleted or polluted, groundwater must be brought from further away, often from peri-urban areas. The development of water sources in the areas around cities and towns can cause different

(continued on page 40)

2003: THE YEAR OF FRESHWATER

Water has been called the planet's lifeblood – it pulsates through every crevice of our existence. Yet today, we are facing a crisis as the demand for freshwater outstrips supply and pollution continues to contaminate rivers, lakes and streams. "Lack of access to water – for drinking, hygiene and food security – inflicts enormous hardship on more than a billion members of the human family," said United Nations Secretary-General Kofi Annan. "Water is likely to become a growing source of tension and fierce competition between nations, if present trends continue, but it can be a catalyst for cooperation."

To raise awareness and galvanize action to better manage and protect this crucial resource, the United Nations General Assembly proclaimed 2003 as the "International Year of Freshwater." This proclamation comes at an important time just as world leaders have agreed on key targets to tackle water and sanitation problems for the 1.2 billion people without access to safe drinking water, the 2.4 billion people who lack proper sanitation and in memory of the more than 3 million people who die every year from diseases caused by unsafe drinking water.

The "International Year of Freshwater" is a year of action, a year of events and a year to make a difference to make sure people have the water they need.

To learn more, visit www.wateryear2003.org

MILESTONE AT THE IAEA

The year 2003 marks the 40th anniversary of the first IAEA international symposium on water resources – a sign of how widely nuclear science can reach. The IAEA is mandated to assist its Member States in using nuclear science and technology for peaceful purposes, including water development. The programme aims to increase the global hydrological knowledge base, including a better understanding of the water cycle, and scientific capacity of developing countries to assess water resources. A project with UNESCO and others is preparing a global assessment of fossil groundwater resources based upon isotope data on the origin and age of groundwater.

The IAEA has invested about US$30 million in 150 projects in 60 countries to improve water management using isotope hydrology. These projects have helped provide valuable hydrological information and strengthened capabilities for managing water resources.

In May 2003, the IAEA brought together hundreds of experts to review and plan their joint work at the "International Symposium on Isotope Hydrology and Water Resource Management," marking a milestone of progress.

To learn more, visit:
www.iaea.org/worldatom/Press/Focus/Water/index.shtml

THE THIRD WATER FORUM: 100 WATER WAYS

Participants of the eight-day 3rd World Water Forum, the most heavily attended international water meeting ever, made more than 100 new commitments on water. The Forum was held in the three neighbouring Japanese cities of Kyoto, Shiga and Osaka from March 16-23, holding 351 separate sessions on 38 interlocking themes dealing with water, especially on how to bring safe water and sanitation to the entire world. The key issues addressed revolved around balancing increasing human requirements for adequate water supplies and improved health and sanitation with food production, transportation, energy and environmental needs, while recognizing that most countries will require more effective governance, improved capacity and adequate financing.

To learn more, visit www.world.water-forum3.com/

THE U.N. WORLD WATER DEVELOPMENT REPORT

Water for People, Water for Life

More than ten years later, how far has the world progressed in meeting the sustainable development targets set at the Rio Earth Summit in 1992 and subsequently at the UN Millennium Declaration of 2000? Perhaps more importantly, how far have we yet to go, and what can we do to hasten our way? The IAEA and 22 other UN organizations collaborated in producing the landmark UN World Water Development Report (WWDR) that takes stock of the world's water situation and provides a comprehensive and up-to-date picture of the current state of the world's freshwater resources. Coordinated by the World Water Assessment Programme (WWAP), the report lays the foundations for regular, system-wide monitoring and reporting by the UN, together with development of standardized methodologies and data.

Although it offers a broad global picture, the WWDR focuses particularly on the situation in developing countries, where the need for better infrastructure and governance is highest. With this report, the WWAP is aiming to show where systems are failing, and to provide the information needed for efficient and effective capacity building throughout the world.

To learn more, visit:
www.unesco.org/water/wwap/wwdr/index.shtml

Facts and Figures
from the WWDR

BASIC HUMAN NEEDS

Asia shows the highest number of people unserved by either water supply or sanitation. Proportionally, however, Africa has the highest share of people without access to water and sanitation systems.

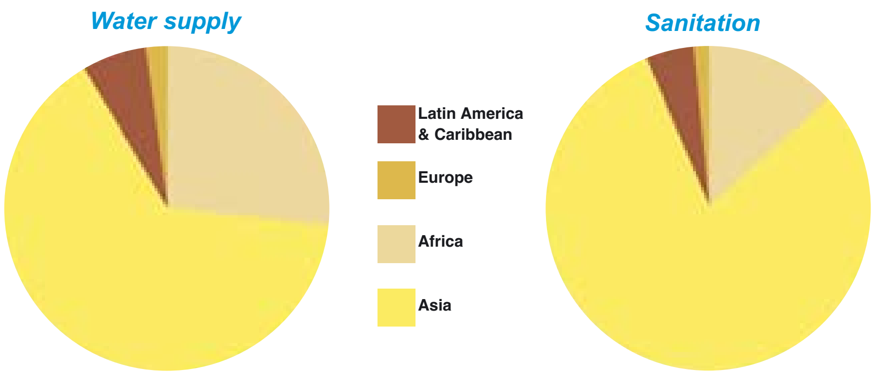


Figure source: Extracted from the Executive Summary of the WWDR.
WHO/UNICEF Joint Monitoring Programme, 2002. Updated in September 2002.

WATER & CITIES

Worldwide, about 94% of households in major cities are connected to piped water, and about 86% are connected to sewers. But the situation differs dramatically by region, as the graphs shows.

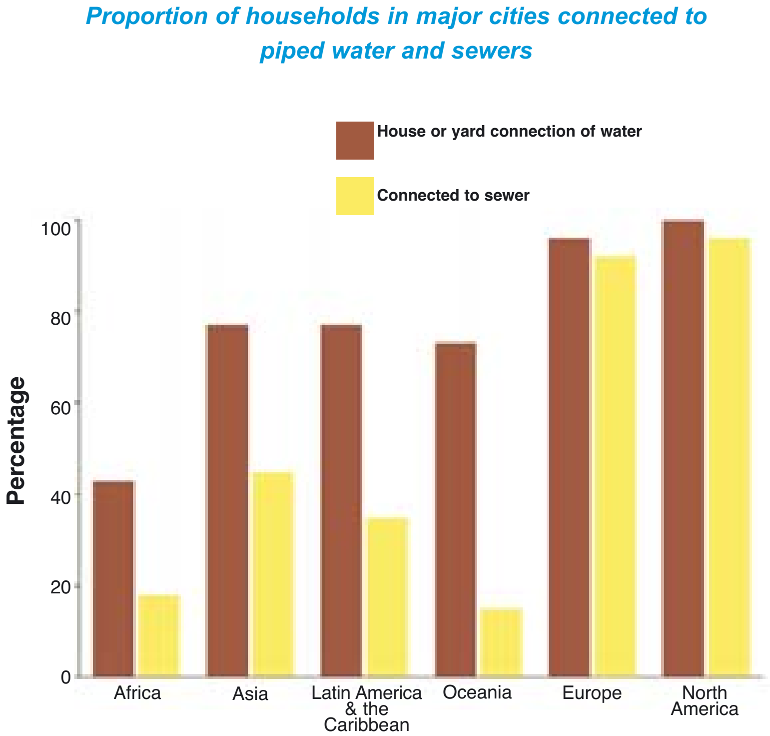
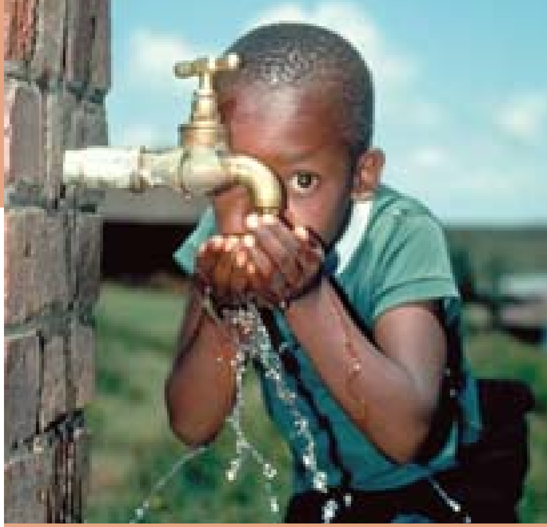


Figure source: Extracted from the Executive Summary of the WWDR. WHO/UNICEF, 2000.
Global Water Supply and Sanitation Assessment, 2000 Report, Geneva.



The Growing Thirst for Solutions

Events in 2003 highlighted critical water problems facing billions of people worldwide and galvanized collective efforts to solve them.

problems by creating competition for resources between the water-hungry municipality and the surrounding farming areas. The latter may be long-established and highly productive agricultural zones which supply the urban centre with food. Both user communities may have strong claims and may be powerful and influential in pressing them. Such conflicts can be difficult to resolve.

Waste streams

Another direct impact of urban activities on groundwater quality arises from waste disposal. The development of waterborne sewerage systems has enabled domestic and industrial effluents to be more easily collected, and sewerage has become an efficient and unobtrusive feature of urban infrastructure in most developed cities. But elsewhere, in parts of major cities in the developing world for example, urban wastewater is sometimes discharged untreated, or only partially treated, into surface water courses. These water courses become little more than conduits for taking effluents away from the centres. Meanwhile, downstream, particularly in arid and semi-arid settings, these wastewater-dominated surface flows may be used for irrigation. In many cities, substantial areas remain without waterborne sewerage, and domestic and industrial effluents may be directly disposed of into the ground, through septic tank systems or disposal wells. The resulting deterioration in the groundwater quality, in terms of pathogens, nutrients, industrial chemicals and salinity, may pose severe risks to health, or even render the water unusable as a potable supply.

Large-scale urban development can greatly modify the hydrological processes and pathways by which water reaches underlying aquifers. Even though covering the land surface with buildings, roads, car parks and other facilities would intuitively seem to reduce the amount of rain infiltration, the collected runoff from roofs and gutters can still find its way into the aquifer either directly via on-site soakaways or indirectly via storm-drains discharging into unlined canals or river beds. But it does not solve the problem of contamination. Water infiltration from paved surfaces can carry pollutants associated with cars, de-icing chemicals, pesticides and bacteria.

All water distribution systems leak to some extent; water losses ranging from 25 to 40 per cent are not uncommon. Much of it leaks down to the underlying aquifers, and the volumes can be substantial. As an extreme example, in Peru water lost from Lima's distribution system in one district provides up to an equivalent of 360 millimetres per year of aquifer recharge water, compared to the natural level of 20 millimetres per year or less characteristic of an arid region. Although this water would generally be of good quality, where sewer systems are also leaking, the recharge water may be of poor chemical and bacteriological quality.

Rising water tables

The sources and processes of aquifer recharge in urban areas can thus be greatly modified, and the resulting extra infiltration can help to offset the effects of increased abstraction. In an extreme case in the Arabian Gulf region, recharge from imported water is so much greater than the negligible natural replenishment that it exceeds the capacity of the aquifer. As a result, groundwater levels have risen to the surface, causing flooding of basements.

In some developed world cities, the combination of increased recharge and reduced groundwater withdrawal (because of declining or relocated industries) has resulted in local recovery of groundwater levels. Aquifers that had been de-watered over decades are now fully recharged. In fact, such cities as Birmingham, London, and Tokyo are starting to encounter problems of rising water tables affecting road tunnels, foundations, car parks and metro systems constructed before the ground became re-saturated.

Urban development has a significant impact on groundwater, affecting quantity, flow and quality. Changes in groundwater levels, both reductions and increases, can also pose engineering problems for infrastructure and facilities. In fast-growing cities urban groundwater can be managed sustainably, but only if the sometimes conflicting needs and priorities of water supply, waste disposal and underground engineering can be reconciled. This goal should be within human capabilities. Recognition of urban waste water as a vital resource, and its integration into water management strategies is key to reaching this goal. Equitable arrangements to exchange partially-treated irrigation wastewater to compensate for fresh groundwater drawn from outside urban areas may also help to reconcile the conflicting demands for water.

John Chilton has participated in IAEA-supported research on groundwater issues. He is on the staff of the "Groundwater Surveys and Water Quality Programme" of the British Geological Survey, based at Wallingford, United Kingdom. This article is updated from one first published in "Our Planet," the magazine of the United Nations Environment Programme (UNEP), which coordinated UN activities on the occasion of World Water Day 2003. E-mail: pjch@bgs.ac.uk