THE STORY OF THE STOCKHOLM WATER PRIZE LAUREATES

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The Story of the Stockholm Water Prize Laureates

Photo: Peter Hanneberg

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The Stockholm Water Prize

First awarded in 1991 and now celebrating its 20th anniversary, the Stockholm Water Prize is the world's most prestigious prize for outstanding achievements in water-related activities. The annual prize, which includes a USD 150,000 award and a crystal sculpture specially designed and made by Orrefors, honours individuals, institutions and organisations whose work contributes broadly to the conservation and protection of water resources and to improved health for the planet's inhabitants and ecosystems.

His Majesty King Carl XVI Gustaf of Sweden, who is well-known for his interest in and concern for environmental issues, is the Patron of the Stockholm Water Prize. It is announced each March in connection with the UN World Water Day and presented during the World Water Week in Stockholm at a Royal Prize Ceremony followed by a banquet in the Stockholm City Hall.

An international nominating committee appointed by the Royal Swedish Academy of Sciences is responsible for reviewing the nominations and proposing a candidate to the Stockholm Water Foundation Board, which makes the final decision. The Founders of the Stockholm Water Prize are Swedish and international companies and organisations in co-operation with the City of Stockholm. The Stockholm International Water Institute administers the activities of the Stockholm Water Prize.

Over the years the Stockholm Water Prize Laureates have represented many water-related activities, professions and scientific disciplines and have come from around the world. The combined achievements of the Prize Laureates are immense, as is their importance for future generations.

This is their story.

Photo: Sara Moses

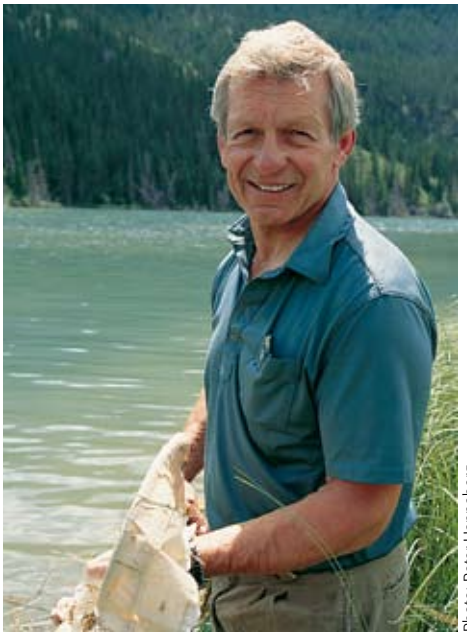

Photo: Peter Hanneberg

David Schindler of Edmonton, Canada, has been fortunate in having the spectacular wilderness of the Canadian Rockies as the setting for his field research.

1991 – David W. Schindler, Canada

"For research into excess nitrification and acidification of freshwater lakes."

A spectacular North American wilderness forms the backdrop to a canoeist on a Canadian Rocky Mountains lake. This extremely beautiful part of Canada enjoys protection by a vast national park system that draws millions of visitors every summer. The nature-loving man in the canoe is no doubt enjoying the beautiful scenery around him, and yet he has not come to Jasper National Park as a tourist.

David W. Schindler, a professor of ecology based at the University of Alberta, Edmonton, loads samples of aquatic organisms into his canoe with the help of a bag-net. Another instrument chews into the clay sediment, bringing it up to the surface, while in a plastic bottle he collects water from different depths in the lake.

Professor Schindler's field samples provide him with data about the abundance of certain species, biological diversity, levels of acidity, and concentrations of nutrients, toxic trace metals and chlorinated organic compounds, just a few of the variables he wishes to study.

David Schindler has been doing field research of this kind in the mountain lakes and watersheds of Canada for more than three decades. It all began back in 1968, when he set up the Experimental Lakes Project for Canada's Department of Fisheries and Oceans in Ontario. He headed the research carried out under the auspices of this project until 1989. As a limnologist and ecologist, his aim was not to study individual parameters in isolation, but all of them simultaneously, in order to construct an image of the entire lake as an integrated ecosystem.

Learning the lessons of the mountain lakes

Professor Schindler's results, particularly from the late 1970s and early 1980s, were to be instrumental in persuading regulators in the United States and Canada to introduce stricter controls on phosphates and acidifying pollutants such as sulphur dioxide. Measurements of eutrophication levels showed quite clearly that atmospheric nitrogen and carbon have important effects in maintaining phosphorus limitation in lakes, as well as promoting blooms of blue-green algae.

A famous photograph of a Canadian lake drew attention to the effects of phosphorus and played an important part in generating public support for tackling the growing problem of eutrophication, an over-abundance of nutrients in aquatic systems and one of the most serious environmental threats facing freshwater bodies and semi-enclosed seas like the Baltic. That photograph has since been reproduced hundreds of times, for students, scientists and the general public.

Graphic evidence of pollution's effects

Equally important was the research that showed that the effects of acidification can work their way through the food chain, and once again photographic documentation was a crucial factor in shaping public opinion. Many of the results of the project have proved to be highly relevant in the context of sustainable development worldwide.

Since Professor Schindler received his Prize in 1991, he has initiated new programmes to study the fates and effects of organic pollutants and climate warming in mountain and boreal lakes. Schindler has received a number of additional awards for his work.

In 1998, he and Professor Malin Falkenmark shared the Volvo Environment Prize; in particular, he was cited for his "insights in the processes of eutrophication and acidification of freshwater and of ways to counteract these processes".

Professor Schindler has also received the Gerhard Herzberg Gold Medal for Science and Engineering, Canada's highest scientific honour, and he has been elected to the U.S. National Academy of Sciences, the Royal Society of London, and the Royal Swedish Academy of Engineering Sciences.

His current research interests include the study of fisheries management in mountain lakes, the biomagnification of organochlorines in food chains, effects of climate change and UV radiation on lakes, and global carbon and nitrogen budgets.

Photo: Ingrid Landahl

Photo: Institute of Env. & Research

Photo: John Nyberg

Taking over after the late Poul Harremoës (left), Professor Mogens Henze (right) is the leader of the Department of Environmental Engineering, today one of the leading and largest environmental engineering university institutes in Europe.

1992 – Department of Environmental Engineering at the Technical University of Denmark

"For research within water purification, contaminated groundwater and tools and techniques to protect it."

In August 1992, the Prize ceremony in Stockholm was attended by a substantial proportion of the staff of the Department of Environmental Engineering at the Technical University of Denmark. Its head since 1969, Professor Poul Harremoës (1934–2003), received the Prize on the department's behalf.

The successes of this department in its various areas of work stemmed from a collective effort, underpinned by a climate of creativity. In 1969 the department had a staff of one. By 1992 the number had risen to 50, and the Prize acknowledged that the department's achievements were the fruits of constructive and far-reaching collaboration among a group of individuals working towards the same goal – under the influence of an inspiring leader, Poul Harremoës.

Those achievements encompassed several different fields of water treatment. What distinguished the Department of Environmental Engineering was the depth of its research in all these different fields. Mathematical models were developed and applied all over the world. In addition, considerable effort was put into teaching and training a new generation of experts.

Worldwide benefits won by determined pioneers

The department contributed significantly to our understanding of pollutants in groundwater and to the development of tools to safeguard this vital resource. Abatement of pollution from urban storm drainage and combined sewer overflows was also high on its list of priorities. Fundamental theories were developed concerning nitrogen removal processes in activated sludge and wastewater.

"When we launched this research project on nitrogen in the early 1970s, not many people believed in it, either technically or in terms of feasibility. But it proved to work, throughout Scandinavia and then across Europe. As pioneers who refused to give up, we managed to make a number of important contributions," said Professor Harremoës at the time.

The results generated technologies that are now being used in wastewater plants all over the world. By the time the department was awarded the Stockholm Water Prize, some five hundred new treatment plants had been planned for Scandinavia up to the year 2000, combining processes to remove both phosphorus and nitrogen from wastewater.

The research carried out on metals in wastewater sludge showed sludge to be a minor contributor of metals to agricultural land, compared with the much larger inputs from fertilisers and the atmosphere.

The department was at the forefront in enhancing our understanding of the need for an integrated approach to the total system: sewerage, wastewater treatment and receiving waters.

Winners on every count

To summarise the citation for the award, the department received the Prize for its research and development programme, its scientific approach, its international collaboration with the water industry in search of practical applications, and its contributions to water pollution abatement, in Scandinavia and worldwide.

The Department of Environmental Engineering, now headed by Professor Mogens Henze, is one of the leading and largest environmental engineering university institutes in Europe, with a staff of 25 professors and senior lecturers, 15 part-time lecturers, five visiting researchers and 55 PhD students. Significant new activities begun at the Institute since 1992 are in solid waste management, groundwater geochemistry, ecotoxicology and remediation of contaminated sites. The Institute has a unique flat research and teaching structure where the faculty can move freely between research areas. This allows it to develop new cross-disciplinary activities on the boundaries between single specialisations. Since 1995, teaching at the master level has been in English, and 80 master students graduate each year.

1993 – Madhav Atmaram Chitale, India

"For his achievements in the fields of water conservation and public education programs in Southeast Asia."

Dr. Madhav Atmaram Chitale has played a major role in getting India's decision-makers and strategic planners to think of water as a resource whose quality and availability need to be safeguarded. Moreover, he has increased public awareness, above all in the 1980s when he introduced an annual, nationwide Water Resources Day. A different theme is chosen for the day each year. These information campaigns have influenced neighbouring countries in South Asia.

But Dr. Chitale was already hard at work back in the 1960s. He frequently travelled to different parts of the country, and his family always went along and lived out in the field with him. In 1961 the dams at Panshet and Khadakwasala collapsed, leaving the people of the nearby city of Pune without water. Dr. Chitale energetically participated in the efforts to restore the water supply in a short space of time, an achievement that earned him considerable renown.

Reaping all of development's benefits

In the mid-1960s a World Bank project was planned to supply the giant city of Bombay (now Mumbai) with drinking water, carrying it 60 kilometres from a reservoir by pipeline. Dr. Chitale managed to get the plan changed to involve irrigation canals, a hydropower station and under-stream tunnels. When the scheme was completed two billion litres of water could be pumped to Bombay every day, and people and farms over an area of 250 square kilometres between the reservoir and the city gained access to drinking water and irrigation. Beyond that, there were turbines to provide electricity.

"My view has always been that development projects as big as this should be as fully integrated as possible with other development opportunities," says Chitale.

The Yamuna, for instance, a major tributary of the Ganges, has been redirected into a branching system of artificial channels, which, down to their finest capillaries, irrigate verdant cropland to the east of the capital, New Delhi.

Dr. Chitale has been rewarded in various ways for his efforts. In 1989 he was appointed to the highest post an engineer can hold in Indian central government, that of Secretary at the Ministry of Water Resources. 1990 saw the creation of a new government body, the National Water Board, and Dr. Chitale was one of the prime movers behind both this agency and the national water strategy it was set up to implement.

Working for India, and for the world

He was also one of the originators of a mammoth project to improve the water of the Ganges, the Ganga Action Plan (GAP). This was developed into a nationwide programme covering several rivers. In January 1993 he was appointed Secretary-General of the International Commission on Irrigation and Drainage (ICID), an India-based organisation for improving the effectiveness of irrigation and drainage systems, and for mitigating floods.

He was involved in the development of the World Water Council and the Global Water Partnership. In South Asia he promoted local and national water partnerships. A thirty-year perspective of water development was prepared and published by Maharashtra state's water and irrigation commission under his chairmanship.

In parallel with Dr. Madhav Chitale's technical and administrative skills, there is a spiritual communion between him and water. Dr. Chitale is a devout Hindu, and the importance of water permeates the whole of Hinduism. Paintings in Hindu temples often portray the god Shiva trapping water in the long hair on his head, and the goddess of wealth – Laxmi – sitting on a huge lotus flower in a lake.

"These pictures symbolise the richness of water and the way water needs to be managed," comments Dr. Chitale. "For Hindus, the river is a mother. Without water, there is no life."

Photo: Peter Hanneberg

Photo: Peter Hanneberg

Dr. Madhav Atmaram Chitale by the Yamuna River outside New Delhi, looking back on a great career supervising large-scale river and irrigation projects. To a devout Hindu like Dr. Chitale, the Ganges is a holy river, and he was one of the initiators of the Ganga Action Plan, set up to improve its water quality.

Photo: Peter Hanneberg

Dr. Takeshi Kubo in his own neighbourhood, strolling on a sidewalk of bricks made from dried sewage sludge. Kubo was one of the pioneer engineers who tackled the environmental effects of Japanese urbanisation.

1994 – Takeshi Kubo, Japan

"For his bridge-building work between nations in Asia and Europe."

Dr. Takeshi Kubo takes a walk along a suburban street in Tokyo, close to where he lives. The sidewalk is paved with reddish bricks made from dried wastewater sludge, fired in huge kilns. This very hard and resistant material is being used more and more in Japan as a foundation for buildings, sidewalks, paths and roads.

A small example perhaps, and yet a spectacular one, of the technical solutions that have grown out of Japan's efforts in the area of wastewater treatment and sludge disposal.

How can a sewerage system for 12 million people best be organised? Dr. Kubo devoted almost half a century to answering that question, beginning in the early 1960s as the guiding hand in the planning of wastewater treatment facilities in Japan. In 1994 – the year he was awarded the Stockholm Water Prize – he rounded off a long career, at the age of 74, with the top position of General Director of the Research Institute for Wastewater Management.

As recently as the early 1970s, the rivers of Tokyo were white with foam and fetid with untreated wastewater, from both households and factories. This was the downside of Japan's rapid process of industrialisation and urbanisation.

Tokyo's rivers transformed

"Things look very different today," Kubo points out. "We have tough water quality standards which industry has to comply with, and almost the whole of Tokyo is linked up to the city's wastewater treatment plants."

In 1994, 93 per cent of the inner city was served by Tokyo's 18 wastewater works, and there were almost 22,000 kilometres of pipes below the streets of the capital. By then, the outlying suburbs had a double-piped network to separate surface run-off and wastewater. And the citizens of Tokyo have Kubo to thank for most of these improvements.

Several waterways, long given up for dead, have been resuscitated by a supply of treated wastewater. One of them is the 350-year-old Tamagawa Canal from the Edo dynasty, now revived and full of thriving carp. Another example is the city's pocket parks, whose beauty is greatly enhanced by tiny waterways fed by recycled wastewater.

But Takeshi Kubo's interests have stretched far beyond the horizons of Tokyo and Japan. One of his contributions has been to get many Asian water professionals involved in cooperation with Western organisations, ensuring an exchange of knowledge across international borders. In the West he collaborated with Britain, the United States and Germany, in the East with Asian and Pacific nations as chair of the Asia/Pacific Rim Steering Committee of the Water Environment Federation. Kubo even managed to bring China and Taiwan together to tackle the important issues of wastewater treatment and clean water, and to do so with a holistic approach.

Understanding how soil and water interact

"It is essential to be able to control the whole catchment area of a river system, including the use of soils," comments Dr. Kubo. "Whatever chemicals or fertilisers you use to increase yields in agriculture, sooner or later they will end up in a river. There is no way you can deal with land and water in isolation from each other."

Since 1993 Dr. Kubo has been officially retired, but he nonetheless has found time on occasion to meet friends and colleagues at various international conferences, including the annual Water Environment Federation conference, the 3rd World Water Forum, and the Stockholm Water Symposium. For the 3rd World Water Forum, in fact, he prepared a special Japanese-language edition of the summary conclusions from the 10th Stockholm Water Symposium.

One highlight in recent years for Dr. Kubo was when he and fellow Hokkaido University alumnus, Prof. Takashi Asano – the 2001 Stockholm Water Prize Laureate – were honoured in May 2004 at the university's opening of a permanent Prize exhibit honouring the accomplishments of two of its distinguished graduates.

Photo: Mikael Ullén

Photo: Peter Hanneberg

Photo: WaterAid

British charity WaterAid has introduced a system in poor villages where people pay for their share of drinking water, the aim being to give them a greater sense of responsibility. Receiving the award under the leadership of Jon Lane (above right), and continuing under current Chief Executive Barbara Frost (above left), WaterAid has long been respected for its water, sanitation and hygiene delivery programmes.

1995 – WaterAid, Great Britain

"For bringing water and sanitation facilities to over three million people in the world's poorest countries."

Every day, around the world, 25,000 children die as a result of infections spread by contaminated water. Two billion people are daily at risk of contracting water-borne diseases. Eighty per cent of all ill health in the world is due to poor-quality water and inadequate hygiene.

The British charity WaterAid provides education in water hygiene for poor people. But before starting to educate the population of a village, it first makes sure they have a permanent supply of clean water. This tangible change tends to convince the village women – who are the main focus of the organisation's efforts – better than words. A fundamental element in its approach is to reduce the distance they have to go to get clean water.

In Britain householders receive, along with their water bills, an invitation to support WaterAid's projects. The water companies, which were among the organisations that set up the charity, have every confidence in its work and are happy to let it send out such an appeal to the 23 million households they supply.

In fact WaterAid has gained respect at every level, among governments, the aid establishment and local communities. And in 1995 it also gained the respect of the Nominating Committee for the Stockholm Water Prize, which chose WaterAid as that year's winner. The award was collected by the charity's then-director, Jon Lane.

Helping people to feel the water is theirs

The organisation owes its success to its down-to-earth approach. It collaborates with villagers and with water and health ministries. It tries to draw on local knowledge, and to use straightforward, practical methods and technologies, which need to be cheap but effective. Another important aim in every project is to ensure that local people develop a sense of responsibility for their limited water resources, for example by having to pay a charge for every bucket of water they collect. This money, paid into a communal bank account, is used to maintain pumps and supply points.

In the projects supported in Tanzania, a driving force has been what are known as 'wamma' teams – made up of people from WaterAid and the Ministries of Water, Health and Community Development. These teams convene village meetings about the projects, help villagers to set up water committees, and employ supervisors and pump technicians. They also organise education for villagers in water conservation and hygiene.

WaterAid is seeking to provide 'sustainable development assistance' – assistance which does not simply dry up when the pump breaks down, but goes on working in the long term. Its strategy includes handing over full responsibility for projects to villagers and wamma teams, once they have learnt how to manage their own water.

By 1995 three million people in the Third World had gained access to an ample supply of clean drinking water, thanks to projects supported by WaterAid. In Tanzania more than half a million people who had previously lacked a sufficient water supply were helped over the period 1983–95.

Prize money put to good use

WaterAid's methods in Tanzania and twelve other African and Asian countries have proved to be an effective way of tackling the worldwide problem of poor-quality water.

Since receiving the award, WaterAid has increased its water, sanitation and hygiene delivery programmes and estimates that a cumulative total of over eight million people in Africa and Asia have benefited from its safe water services. The Prize money was used to set up a dedicated research policy and advocacy department which has provided evidence-based work at country and international levels to make the case for increased investment in equitably distributed technologically appropriate and sustainable water and sanitation services in pursuit of the Millennium Development Goals. WaterAid now works in 26 countries in Africa, Asia and the Pacific region. WaterAid Sweden was established in 2009.

Photo: Peter Hanneberg

Photo: Aik Ming Toh

Professor Jörg Imberger of the University of Western Australia demonstrates internal waves and the resulting transport of contaminants, using a wave machine of his own design. In parallel with his research, he has invented several instruments for use in studying different water parameters and patterns of motion.

1996 – Jörg Imberger, Australia

"For his contributions to the understanding of mixing and transport in lakes, estuaries and coastal seas and their influence on water quality."

Professor Jörg Imberger is an environmental engineer with an interest in how water moves and how substances disperse in stratified bodies of water. Often lakes are the focus of his attention, but he also studies streams and rivers, estuaries, lagoons, reservoirs and coastal waters.

Jörg Imberger is seen as a landmark in this area of research. The most respectful commentators talk about "before and after Imberger".

Most bodies of water become stratified, for example as a result of differences in salinity or temperature. Winds and natural movements of the water are not always able to generate sufficient mixing to affect the water at greater depths. So a given volume of water may exhibit widely varying characteristics. Several of the patterns of motion which Professor Imberger is studying were unknown before he started work.

Keeping an eye on the depths beneath

In the course of his research, Professor Imberger has also developed, in collaboration with industry, a wide range of sophisticated instruments. They have been vital to his research aims, which have proved to be the mother of invention. Imberger lowers one of the instruments he has devised into the Swan River, within sight of the skyscrapers of his home city of Perth. In appearance, it is reminiscent of a milking machine; in practical and technical terms, it has numerous functions. Precise data on a dozen important parameters, measured at each of the depths investigated, appear on the screens of two laptops on deck, which are hooked up to the instrument. The professor's doctoral students keep a watchful eye on the results, and a printout is produced with a dozen curves showing physical, chemical and biological data from the different levels of the water column studied.

On larger computers back at the University of Western Australia, Imberger and his students can monitor spectacular graphic models, whose behaviour changes according to the parameters fed into them. A wave movement pulsates in different colours across the screen. The effects on the motion of deeper layers of water can also be seen.

"By comparing flux paths with data from the different levels, we've been able to build computer models that can be used to predict how contaminants will behave and how quickly they will be diluted," Imberger explains.

This approach offers a better understanding of water-related environmental problems, and a better basis for tackling them. And it allows the future responses of aquatic environments to be predicted with greater certainty, in advance, say, of development projects or planned discharges. These are just some of the potential environmental benefits of Jörg Imberger's research.

Researcher with a worldwide reach

The global span of Professor Imberger's work was another factor behind the decision to award him the Water Prize. To give just a few examples of the projects simultaneously claiming his attention, he has been studying internal waves in tidal flows in the Netherlands, ways of maintaining water quality following the building of the Bakun dam in Borneo, the impact of bottom topography on water motion in the Valdivia estuary in Chile, the effects of waves on the biogeochemical balance of Lake Kinneret in Israel, the amounts of wastewater a reservoir in Brazil can absorb, and transport mechanisms in Lake Biwa in Japan and their consequences.

The beneficiaries of his global experience are, perhaps, the next generation of water researchers. Professor Imberger was responsible for initiating the first environmental engineering course in Australia and also founded the Department of Environmental Engineering at the University of Western Australia.

Professor Imberger's achievements are all the more noteworthy since, as a researcher, he has gained worldwide eminence, but remains equally committed to improving outcomes for students.

1997 – Peter S. Eagleson, USA

"For his achievements in developing models for dynamic hydrology and eco-hydrology."

What makes Professor Peter S. Eagleson special is that he is no traditional hydrologist; he is also at ease with Darwinian ecology and mathematics. With his open mind, Eagleson is exposing the role played by natural selection in the development of the various shapes, features and functions of forests, as well as the role of climate in this process.

Eagleson's equation for a climatic water budget led him to exciting conclusions about how limitation of water in the soil can control vegetation patterns.

Long before he involved Darwin, Eagleson had frequently 'disturbed' hydrology as an established science. He did so in 1970, for example, when he published his book Dynamic Hydrology, which provided a new, modern base for the entire discipline.

Redefining hydrology and its role

Since 1952, Professor Eagleson has worked at the renowned MIT, Massachusetts Institute of Technology, in Cambridge, Boston. Since 1965 he has held a chair as Professor of Civil and Environmental Engineering, a combination which hints at multidisciplinary aspirations.

For decades he has been seeking to develop new models of dynamic hydrology, looking at the hydrological cycle as the key process linking the physics, biology and chemistry of the Earth system. It was for this work, among other things, that he was awarded the Stockholm Water Prize in 1997.

"By working on a larger scale in hydrology, and taking into account a greater range of the complex geophysical-ecological interactions, we can do a lot better at long-term forecasting of both the availability and the hazardousness of water," he explains.

"We need to get away from a view of hydrology as a purely physical science. Life on Earth also has to be a self-evident part of the discipline. In particular, I'm thinking of vegetation and its powerful interactive relationship with the atmosphere, at both a local and a global level. In attempting to get the full picture, we must not be afraid to express the role of plants in our mathematical equations. Until we can successfully describe the behaviour of a tree – for example, establishing the relationship between productivity and environment – it will not be possible to make credible statements about changes in the climatic water balance," says Eagleson.

Peter Eagleson is the scientist who integrated ecology and hydrology into what Europeans often consider a new science, 'ecohydrology', and who redefined hydrology from an ad hoc engineering speciality to a multidisciplinary, global environmental geoscience, in which the green living features of ecosystems have an important part to play.

Looking to a climatically-different future

At the MIT Professor Eagleson created a new platform for longer-term and more credible forecasts, be it of weather, water availability, or threats from water and potential floods. And he dared to bring different disciplines together, for example by integrating hydrological processes into mathematical computer models for large-scale climate forecasts.

Since 1997 Professor Eagleson has continued his exploration of the Darwinian connections between vegetation and climate; the practical goal being to anticipate, temporally and spatially, the biological changes that climate change will bring. His book, Ecohydrology: Darwinian Expression of Vegetation Form and Function, containing his early results, was published in 2002. The book bridges the fields of hydrology and ecology and proposes new unifying principles derived from the concept of natural selection. It also has potential application in determining the response of vegetation to slow variations in climate. His latest book has the title Range and Richness of Vascular Land Plants: The Role of Variable Light. It was published in 2009.

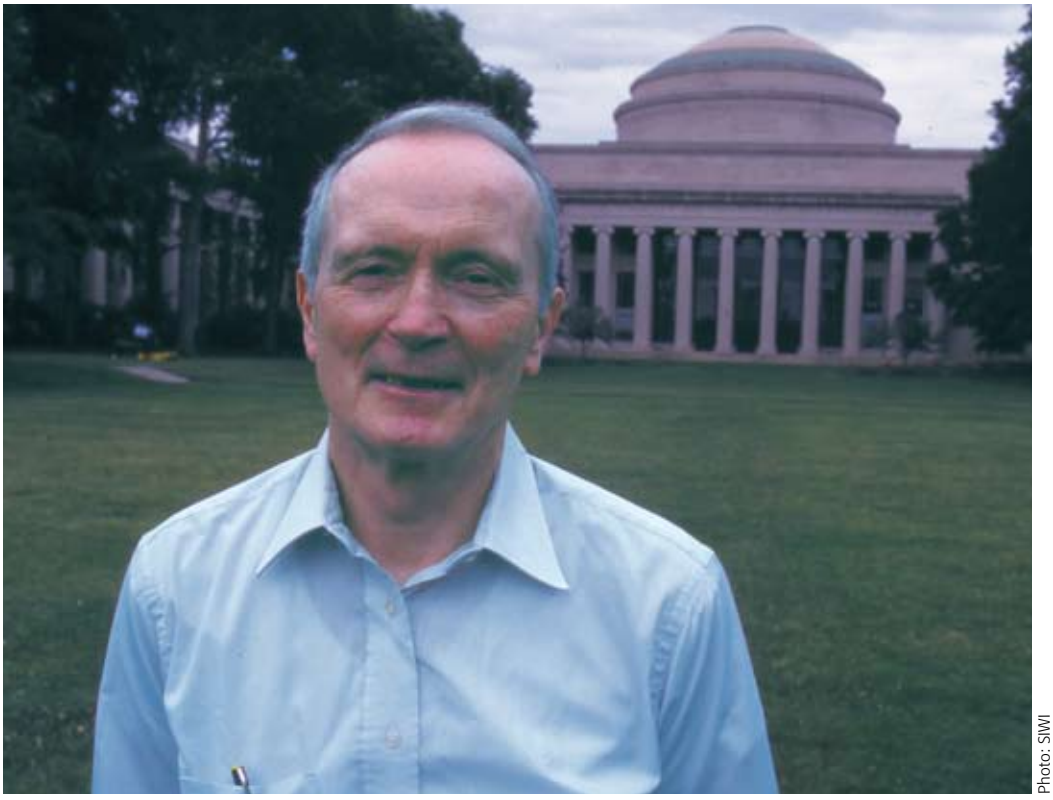

Photo: SIWI

Photo: Oshin Beveridge

Professor Peter S. Eagleson has integrated hydrology and ecology and created a partly new science, ecohydrology. For decades he has been seeking to clarify the role of the hydrological cycle in linking the physics, biology and chemistry of the natural systems on our planet.

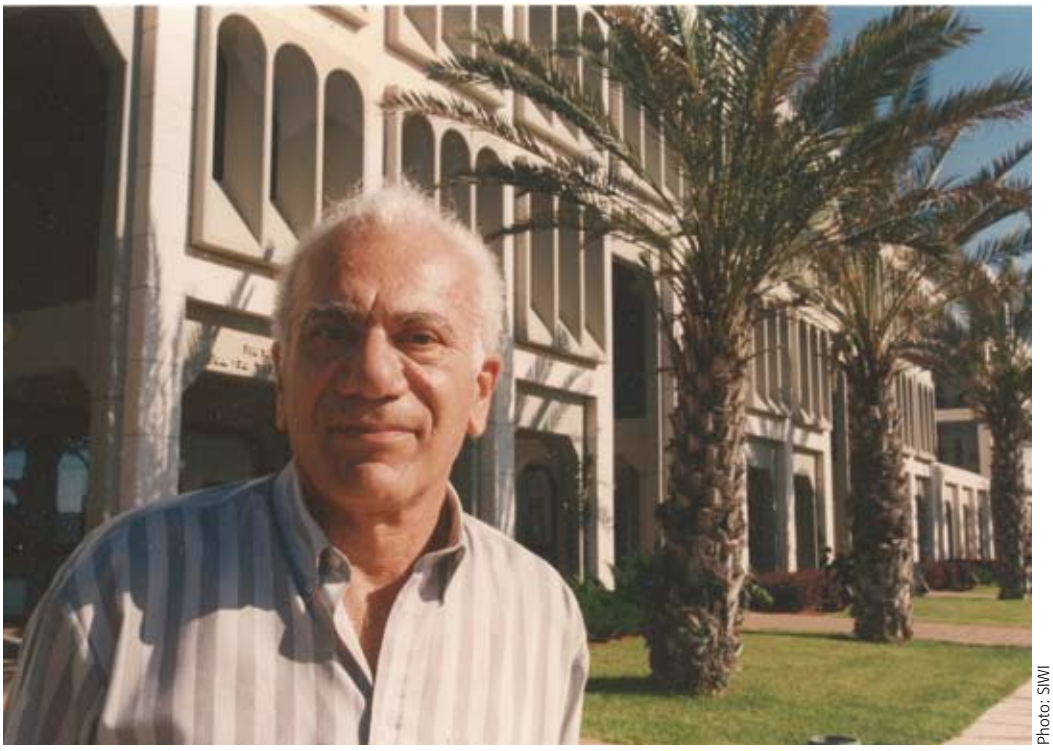

Photo: SIWI

Photo: Katarina Andrzejewska

Professor Gedeon Dagan's mathematical models lay a foundation for a better understanding of how chemicals, metals, radioactive substances and other pollutants disperse with water as it moves through the ground.

1998 – Gedeon Dagan, Israel

"For having established the basis of a new field within geohydrology where contaminant spreading in the subsurface environment is determined in such a way that it accounts for heterogeneity and for biochemical processes."

"Groundwater is incredibly valuable all over the world, but especially in dry regions like the Middle East and northern Africa," says Professor Gedeon Dagan, standing on a hill east of Tel Aviv. "Close international cooperation is essential if these limited and vital natural resources are to be wisely managed."

Beneath him, inside the hill, lies a huge aquifer, stretching further to the east and right under the West Bank. Groundwater stores are no respecters of political boundaries, but they are essential resources to all the people who have their homes on top of them, whichever country or political system they happen to live in. Research to investigate the characteristics of this water is therefore of the utmost importance.

It was for his outstanding research on groundwater that Professor Dagan of Tel Aviv University was awarded the 1998 Stockholm Water Prize. He seems to have a sixth sense for the dark, invisible aquifers below.

Modelling how water and pollution move

"The problem is that you can only make measurements and observations at individual points, which have to be fairly widely scattered," he explains. "Another problem is that the rocks and sediments which contain groundwater are so heterogeneous."

Over the last twenty years Dagan has developed mathematical models – referred to as 'stochastic models' – to describe how groundwater moves through porous materials and transports pollutants and other substances. 'Stochastic' means that the aim of these models is to account for uncertainty and to improve decision-making under risk. They are based on probability in a way that brings them as close as possible to reality.

"Changes below the ground surface take a long time, and that means there's also a long delay effect when it comes to halting pollution," Dagan explains. "A functioning model enables us to see approaching problems at an earlier stage. With good predictions, we will perhaps be in a position to stop or reduce the spread of pollution. This kind of advance warning is useful, since any proposals for action are subject to another kind of delay, resulting from the fact that the decisions have to be taken by politicians."

"Forecasts can relate to likely movements of chemicals, metals or radionuclides, for example. Sweden may have a potential problem stored up for the future in its nuclear power programme. The waste is held in rocks in the ground, and from there radioactive substances could disperse with groundwater."

Fears over potential nuclear legacy

Carcinogenic radioactive substances from nuclear explosions can also pose a threat to groundwater. Near Las Vegas in Nevada, it has recently been established that plutonium from atom bomb tests in the 1970s has been carried several kilometres from the test site by groundwater. In the case of Russia, it is feared that the scale of such problems could be immense.

Dagan immigrated to Israel from Romania as a young engineer, back in 1962. After twelve years at the Israel Institute of Technology in Haifa, he became a professor, before moving to the engineering faculty of Tel Aviv University two years later, in 1976. Professor Dagan collaborates with researchers and universities all over the world. In a distinguished career that has spanned more than 40 years, he has served ten visiting professorships. His travels have taken him to such distinguished institutions of higher learning as the University of California at Berkeley; Imperial College, London; Ecole des Mines, Paris; and Princeton University.

Lately, Professor Dagan's achievements have been recognised by the Institute for Scientific Information, which has included his name among the highly cited researchers in the fields of Environment and Engineering. Professor Dagan was awarded the 2005 Horton Medal of the American Geophysical Union, and the Rothschild Prize in 2006

Photo: Michael Cavanaugh

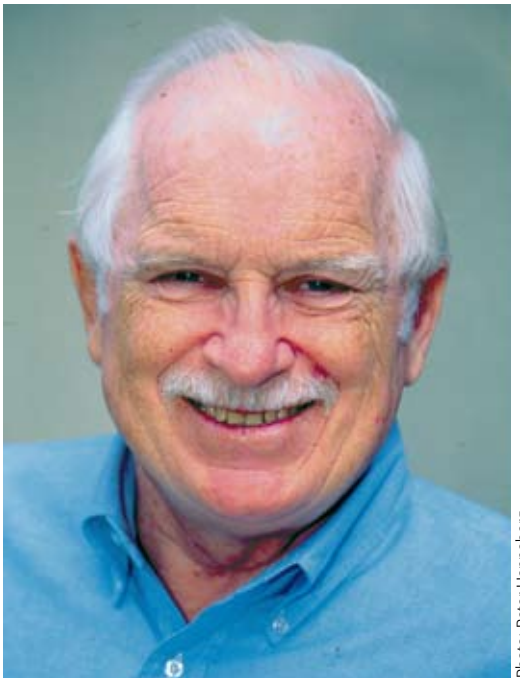

Photo: Peter Hanneberg

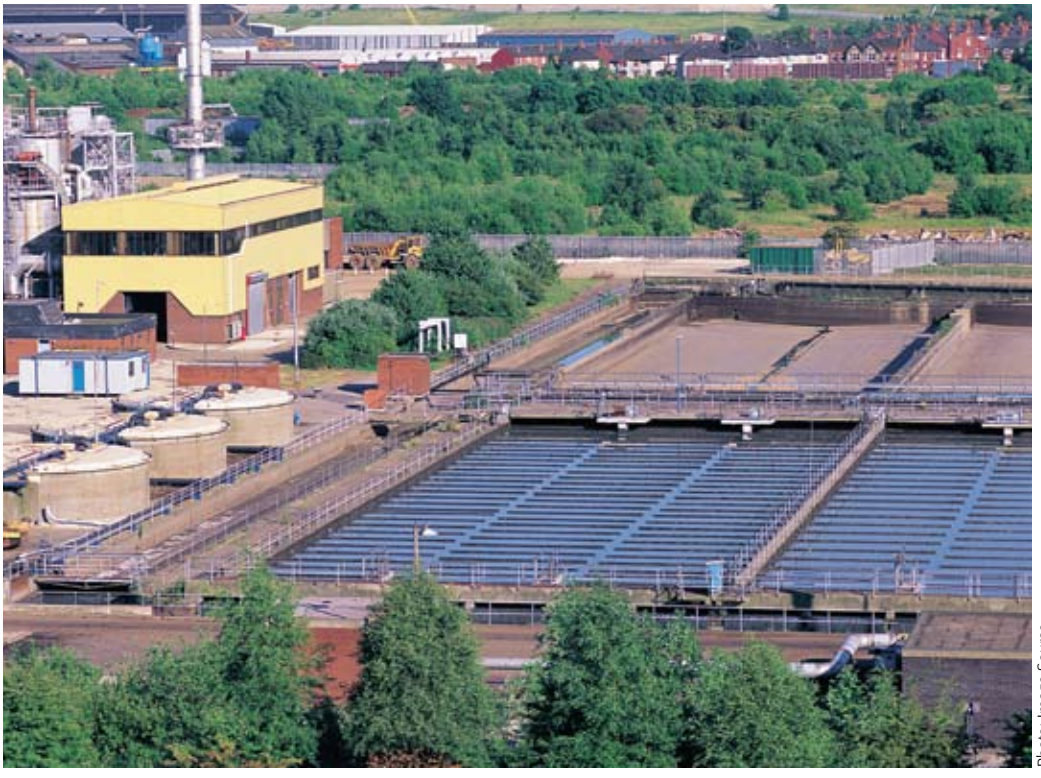

Photo: Image Source

The two professors the late Werner Stumm (left) and James Morgan (right) have had a radical and global influence on the development of more reliable water treatment. A treatment basin at the Metropolitan Water District of Southern California is just one of the many monuments to their work.

1999 Werner Stumm, Switzerland and James J. Morgan, USA

"For outstanding contributions to aquatic chemistry of great importance for understanding chemical reactions in the water environment and which contributed to the development of techniques for treatment of wastewater and drinking water."

An ocean between them did not stop the two water researchers working closely together over a period of forty years. James J. Morgan was based at the renowned California Institute of Technology (Caltech) in Pasadena, USA, while Werner Stumm (1934–1999) was active at the Swiss Federal Institute of Technology (ETH) in Zurich. Sadly, however, Professor Stumm passed away during the spring of that year. Professor Morgan, once a PhD student of Stumm's, spoke for both at the ceremony where they were awarded the 1999 Stockholm Water Prize.

As a 20-year-old, James Morgan became interested in how pollution was disturbing the oxygen balance of rivers. The United States passed its first water legislation in 1948, and by the mid-1950s this legislation was forcing the paper and pulp industry to look for ways of preventing the pollution it was causing.

"At that time, the foam from phosphate-containing detergents could reach waist-high above the water surface," recalls Morgan. "My confrontation with that sight made me study chemistry for four years in parallel with my job."

Finding new ways to cleaner water

His interests developed in the direction of iron and manganese. Morgan heard of a professor at Harvard with similar interests, looked him up, and in 1960 became his PhD student. The professor was a Swiss scientist by the name of Werner Stumm. At Harvard, Professor Stumm guided the education and research of the young Morgan and nine other doctoral students in water chemistry. These 'academic children and grandchildren' have become the leaders in the field of aquatic chemistry and populate the world's major water research centres.

From that point on, Stumm and Morgan studied coagulation as a means of removing particles from water, and their pioneering papers are still widely cited. Particles carry toxic contaminants and make water unsatisfactory from an aesthetic point of view. A joint scientific paper in 1962 on chemically induced coagulation, and its practical use, brought them a scientific award in 1963 from the American Water Works Association.

They continued to ask themselves how manganese (Mn) could be removed from water. The answer was to convert it into a solid form by oxidizing it.

Mn_2+ ions in solution were found to adsorb to the surface of solid particles of the oxide MnO_2. This reaction was greatly accelerated by a higher pH, i.e. increased alkalinity. An increase of one pH unit, e.g. pH 9 instead of pH 8, resulted in the reaction taking place a hundred times faster. The adsorbed manganese was oxidised by oxygen. Furthermore, it was discovered that MnO_2, i.e. the product itself, was also a catalyst which promoted this reaction. These conclusions proved relevant to other contaminants, too, such as phosphorus and arsenite.

Scientists who shared their knowledge

In California asbestos fibres were once discovered in drinking-water. By raising the pH and adding aluminium, it was possible to remove 99.99 per cent of the hazardous asbestos. While they developed their research into coagulation and flocculation, Stumm and Morgan did not neglect the education of future scientists. The many editions of their book Aquatic Chemistry, deemed by many the best aquatic chemical book ever written, have become a bible and a worldwide citation classic for most scientists and students in this field. Between them, Stumm and Morgan have produced some 75 PhDs over the years – seventy-five apostles who will carry their important knowledge out into the world.

In the year following the award, James Morgan was promoted to professor emeritus at Caltech. Since then he has lectured and written about his research into the chemistry and technology of water treatment, the scientific basis for establishing criteria and standards for water quality protection, and rates of manganese transformations in fresh and marine waters.

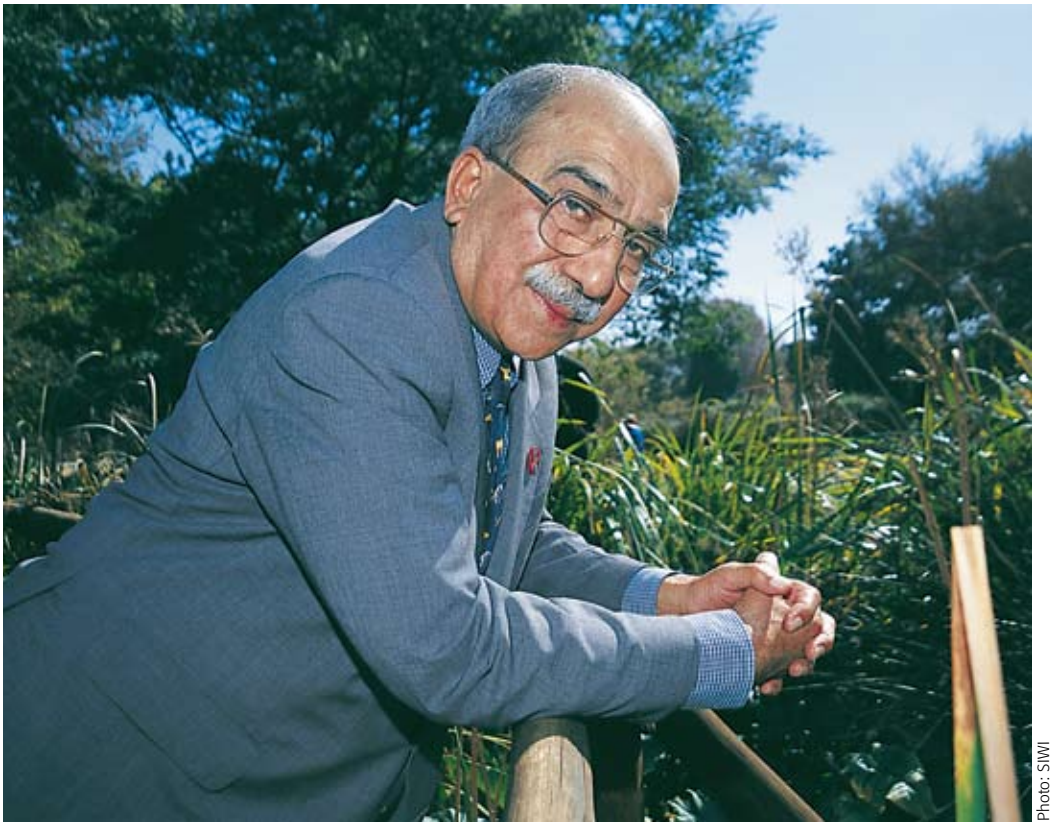

Photo: SIWI

Photo: Anton Earle

Professor Kader Asmal, then the Minister of Education in South Africa, was awarded the Stockholm Water Prize for 2000 in recognition of his unprecedented efforts in the development of vision, legislation and practice in the field of water management in South Africa.

2000 – Kader Asmal, South Africa

"For unprecedented efforts in the development of vision, legislation and practice in the field of water management in South Africa."

Professor Kader Asmal, the 2000 Stockholm Water Prize Laureate, is the law professor who in 1998 rewrote his country's water laws, having already paved the way for a range of water reforms that would benefit the poor black population of South Africa, not simply the rich, mostly white community. In 1994, when he was offered the post of Minister of Water Affairs and Forestry in the government of Nelson Mandela, an estimated 16 million South Africans were without clean drinking water. Since then, ten million of his compatriots have gained access to water in the vicinity of their homes, at schools and in their workplaces. These advances are due in large part to the efforts of Kader Asmal.

Professor Asmal was entrusted with the task of developing an action plan to solve the serious water problems facing South Africa, including unequal access to water. Energetically, he set about a comprehensive overhaul of existing water management policy and practice. Asmal already had considerable experience of major organisational reforms, such as working for Mandela on the country's new constitution as a member of the African National Congress's negotiating team. In his action plan, Professor Asmal linked water issues in a natural way to the three key concerns of his efforts in earlier years: human rights, social justice and environmental sustainability.

Water no longer a tool of segregation

Professor Kader Asmal's initiatives include the Working for Water Programme, the Community Water Supply and Sanitation Programme, and the National Water Conservation Campaign. By the end of 1998, the Working for Water Programme involved 24,000 people in over 300 projects across the country, the aim being to clear alien plant species that are major consumers of water and threaten biodiversity. The Community Water Supply and Sanitation Programme, initiated to ensure health for all South Africans, has since employed 300,000 people, with a large majority of these being women.

Now, with the National Water Act of 1998, South Africa's water can no longer be politically misused to fuel racial segregation. The new law is sometimes described as the world's most comprehensive and visionary piece of water legislation, incorporating as it does a 'water reserve' concept that puts human needs and basic ecological functioning before commercial or industrial interests. The Act also includes water-use rights, an economic instrument which allows the poor to pay whatever they can afford, while forcing water-intensive industry and agriculture to pay more. In addition, the legislation drafted by Kader Asmal states that neighbouring countries are to have an equitable share of water from shared rivers.

Taking forward the debate on dams

Professor Asmal, a South African teacher and lawyer who trained and worked in Britain and Ireland during his 27 years in exile, is internationally renowned as a human rights scholar and activist. He served as chair of the World Commission on Dams, which had the goal of developing international ethical standards and guidelines for all parties interested in large dams. The Commission's work has had a far-reaching influence on the dams debate and on water utilization and sustainable development in general, yet another important task for Professor Asmal in a world that has seen the construction of some 40,000 dams more than fifteen metres high.

In 1999, when the African National Congress was re-elected to government, Professor Asmal became South Africa's Minister of Education under President Thabo Mbeki. Since then he has retired as Minister of Education but has remained as a Member of Parliament. He has chaired the UNESCO negotiation forum discussing a draft convention on cultural diversity, and in 2005 he was elected as president of the Financial Action Task Force. He continues to write on water and educational matters and lectures on these topics internationally.

2001 – Takashi Asano, USA

"For his outstanding contributions to efficient use of water in the domain of wastewater reclamation, recycling and reuse through theoretical developments, practical research and worldwide adaptation and promotion.

When Professor Takashi Asano received the Stockholm Water Prize from H.M. King Carl XVI Gustaf of Sweden on, it was a grand moment that honoured his life's journey. It took him from his birthplace, the beautiful city of Sapporo on the island of Hokkaido, through the era-defining social and scientific moments of the 1960s in Berkeley, California, and onward to many noteworthy professional accomplishments in both government and academic service.

By the time of the award, Professor Asano had been engaged in both theoretical research and practical applications in wastewater reclamation, recycling and reuse for over 20 years. The basic studies were made in the 1980s and 1990s, resulting in the safe use of reclaimed water and culminating in the California water recycling regulations and practices. These investigations formed a reference point for efficient use of water and most international projects and decrees within the water reuse discipline. Professor Asano used these original investigations for a world-wide promotion of the field: water reuse in agricultural and landscape irrigation, groundwater recharge, industry and environmental enhancement.

A recognised and trusted mediator

Professor Asano expanded the original investigations and adapted the concept in both developed and developing countries. His main achievement was as a promoter of the concept, taking into account the scientific base and a risk management approach in the complex world of technology, reliability, health protection and public acceptance. Substantial achievements by Asano included the microbial risk assessment concept, and expansion of this area within the field of wastewater reuse. Here he and his co-workers combined virus-monitoring data with new approaches in reliability and expectation using statistical evaluations and simulations, and as such this area is rapidly expanding as a policy and management tool.

His contributions to science and technology in that field went far beyond his role as an academic and government employee. He acted as a catalyst for technological advancement and as a mediator among scientists, practitioners and politicians in arid and semi-arid countries where water is needed most and priced the highest, and among Asian countries and the western world.

Professor Asano recognised early on that developing countries in semi-arid or arid regions, with a fast-growing population and limited economic resources, need special attention and his work contributed significantly to solving developing countries' water scarcity problems. Countless local, regional, national, and international agencies have benefited from Professor Asano's expertise and advice.

Quick to share credit with colleagues

There is arguably no other name so widely recognised and highly appreciated world-wide in the field of wastewater reclamation, recycling and reuse than Professor Asano's. But he is quick to recognise others. In fact, he gives the credit for his Stockholm Water Prize honour to the collaborative efforts with colleagues and mentors in the USA, the Mediterranean countries, Northern Africa, the Middle East, South America, Japan and elsewhere.

"One common thing that I learned from visiting these countries was that there were many well-educated and well-trained people in water sciences and engineering, and public health," Asano says. "We certainly need to get valuable advice from them."

The textbook Wastewater Reclamation and Reuse: Water Quality Management Library, Volume 10, from 1998, was in 2007 followed by Water Reuse: Issues, Technologies, and Applications by Takashi Asano et al. This textbook treats water recycling and reuse as a sustainable option in integrated water resources management. Professor Asano is developing a framework for how wastewater reuse must be integrated into water resources with advanced treatment technologies and resultant public health protection.

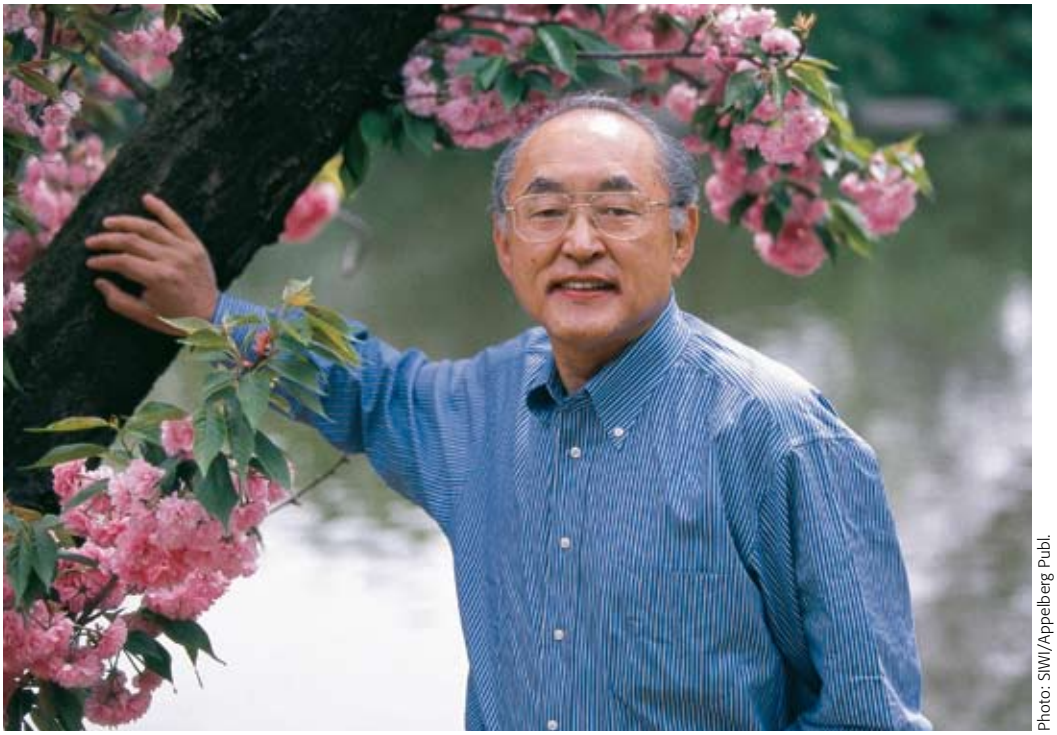

Photo: SIWI/Appelberg Publ.

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Photo: StockBite

Providing a dependable system of water supply and wastewater disposal is becoming increasingly difficult all over the world. Takashi Asano showed that reclaimed water is a resource available right on the doorstep of the urban world, where water resources are needed most and priced the highest.

2002 – Ignacio Rodríguez-Iturbe, USA

"For lasting contributions to surface hydrology, where he has been in the forefront of the scientific evolution that placed hydrology in the fellowship of Earth Sciences."

For Professor Ignacio Rodríguez-Iturbe, professional inspiration stems from "a profound desire to understand how nature works." Such a desire helped Professor Rodríguez-Iturbe reach the top in his chosen profession, hydrology. The Venezuela-born Rodríguez-Iturbe is the first South American to receive the Stockholm Water Prize.

His scientific contributions have had important theoretical and practical meaning for hydrology's development as an earth science, and have also helped increase understanding of the planet's climatic system, where water's circulation plays a decisive role. His research has led to greater understanding of meteorological and hydrological events such as extreme floods and droughts, which can cause human suffering, environmental damage and economic loss.

During the 1970s Rodríguez-Iturbe developed a mathematical model for long-term extremes such as these. His formulations have been used extensively throughout the world, for example in forecasting river flows and variations in water levels.

Determined to ensure the accuracy of data

In addition, Professor Rodríguez-Iturbe contributed to the development of methods to quantify the accuracy and value of hydrologic data. This concept is now adopted in hydrological and meteorological services. It has been used in the USA, Canada and Great Britain to evaluate the utility of their data collection systems.

It was in the mid-1970s thatProfessor Rodríguez-Iturbe introduced 'Bayesian approaches' (a mathematical tool to combine information from many different sources which have varying degrees of accuracy) to improve different models for river flows and to predict the likelihood of extreme hydrological events. This type of approach is now adopted in many earth sciences, as a way of combining outputs from different weather or climate models or as a way of integrating models and opinions for environmental risk assessment.

In the 1980s and through the 1990s, RodríguezIturbe and his collaborators proceeded to reformulate the theories on the formation of river basins in a geomorphological respect, geomorphology being the science of Earth's surface terrain. Through work that showed that nature transports water and sediment out of the watershed in the most energy-efficient way possible, he was able to establish equations that, once solved, yielded the drainage pattern that nature will produce under different climatic and geological conditions.

He also spearheaded and formulated the mathematical representation of rainfall as random, active point processes. Because of this it is now possible to simulate rainfall patterns in time and space over many years, creating sequences that mimic how nature may behave in the future. The results have an important use in engineering design or analysis.

A new tool for understanding the climate

Recently, Rodríguez-Iturbe defined the concept of ecohydrology to explain the interaction of the atmosphere and hydrology with plants and soil in a natural system. In-depth studies within this new field now constitute a new scientific front within hydrology and ecology, and the results of research in this area will be important for the understanding of global carbon cycles and climate variation.

Professor Rodríguez-Iturbe's passion for teaching is well-known, as is his dynamic way of solving problems. He is a distinguished lecturer and author of many scientific articles and several books, and is now the James S. McDonnell Distinguished University Professor and Professor of Civil and Environmental Engineering, Princeton University, USA. In all his work, the strongest motivation has been a profound desire to understand how nature works. "When I walk through the forests or savannas in different ecosystems, or when I distinguish the drainage network of a river from an airplane seat, or when a dry spell seems to go on in time longer than anyone expects, I ask myself, Why? What is behind all this?"

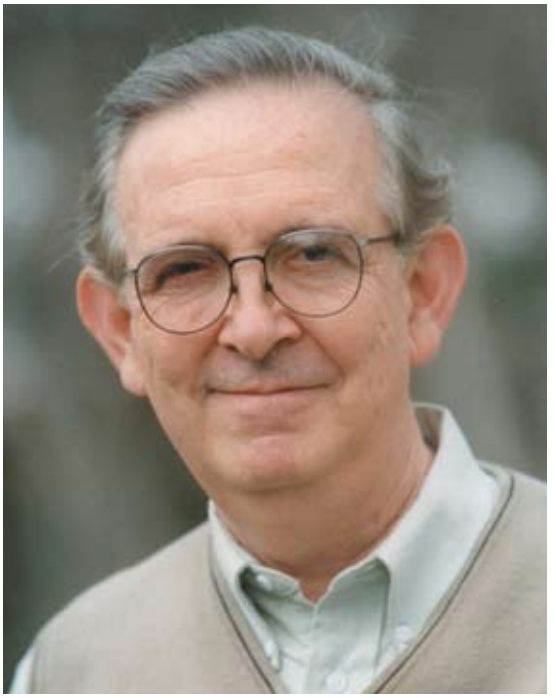

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Photo: Gety Images

Photo: Gety Images

Ignacio Rodriguez-Iturbe's contributions, as a researcher and scientist, have helped us understand the planet's climatic system better, including why and where flooding occurs. As an educator, he has shared his knowledge with the coming generation of scientists and water experts.

Photo: Stephanie Blenckner

Professor Peter A. Wilderer has promoted and developed holistic, interdisciplinary research for more than 30 years in the pursuit of sustainable water use and sanitation. His research is marked by a rare combination of detailed technology development and a deep concern for the environment and quality of human life.

2003 – Peter A. Wilderer, Germany

"For the development and demonstration of integrative approaches to water and wastewater management across the spectrum of fundamental research, applied research, technology implementation and sustainable water management."

For a man determined in his youth to become an architect, things turned out quite differently for Professor Peter A. Wilderer. Instead of designing buildings, he has helped design a more sustainable water and sanitation future. For this, he won the 2003 Stockholm Water Prize.

In the long term, Professor Wilderer believes water management can only be successful if the interrelationships between environmental factors, ecological and microbiological systems and human activities are understood in detail. Based on this - and his frequently demonstrated ability to define scientific problems across disciplinary borders - Professor Wilderer has developed and shown a profoundly holistic vision of sustainable and integrated water and wastewater management.

Drawing on different disciplines

Peter Wilderer is a professor at the Technical University of Munich and serves also as Director of the Institute of Advanced Studies on Sustainability (IoS). Educated as a civil engineer, he recognised as early as the 1970s the need to understand the different ways humans affect the water cycle. By bringing scientists of different disciplines together to solve problems, and by communicating with the public, industry, business and public institutions, he has demonstrated that decision-making should be based on sound science and appropriate technology and should result in sustainable water management.

His initiation of the international programme 'Safe Blue Danube' on water-related risk management is one example. The aim is to develop appropriate measures to detect, avoid and counteract disastrous events concerning flooding and accidental pollution in the Danube river, its tributaries and delta on the Black Sea.

The hallmarks of Professor Wilderer's research are a rare combination of detailed technology development and a deep concern for the environment and quality of human life. His contributions to basic discoveries, now applied in modern biofilm reactors, enable treatment facilities world-wide to clean wastewater from homes, business and industries, and return it safely every day for reuse in the water cycle.

He was one of the first researchers, however, to question the sustainability of transferring Western sanitary concepts, with their traditional emphasis on centralised, large-scale solutions used in big cities, to the rest of the world. He thus recognised and promoted early on the importance of decentralised, cost-effective small-scale wastewater treatment and reuse of water, essential since 95 per cent of the urban population growth by 2025 will be in rapidly-growing cities in developing countries.

Adapt or die

"I have to stress that I am not a philosopher, but I think that human societies have to remain adaptive in order to be able to survive," he says. "When the surroundings are changing, the society must be able to respond positively to those changes, or it will die out. This also applies to technological concepts, which have to be adjustable to individual cultural preconditions. For me sustainability does not mean that we have enough oil for the next generation, but that the coming generations will be able to adjust to any energy resource available in future."

For Professor Wilderer, his early ambition to become an architect is still reflected in his career. Creative construction and curiosity are the essential building blocks for any path in life. "Even if you do not have the technical equipment or an expensive analysis kit, it is all in your mind," he says. "The Internet offers wonderful possibilities to learn and to know, but it is the individual's creativity and ability to find adapted solutions which is the key."

Such creativity, he concludes, already exists in developing countries and will help in their search for solutions to their specific water problems. "Wastewater is far too valuable to send it away, out of sight. Transforming wastewater and its ingredients into a useable form is the essence of sustainable water management."

Photo: Private

Photo: Private

Photo: Josh Paglia

Professors Sven-Erik Jørgensen (left) and William Mitsch (right) have shown the value of lakes and wetlands. The latter, in constructed form, offer great opportunities for low-cost wastewater treatment in the developing world.

2004 – Sven Erik Jørgensen, Denmark and William J. Mitsch, USA

"For their pioneering development and global dissemination of ecological models of lakes and wetlands, widely applied as effective tools in sustainable water resources management."

Sven Erik Jørgensen is professor of environmental chemistry at the Danish University of Pharmaceutical Sciences in Copenhagen, and William Mitsch is a professor of natural resources and environmental science as well as director of the Olentangy River Wetland Research Park at the Ohio State University in Columbus. Their theoretical and applied work on lake and wetland ecosystems, management of lake and wetland water quality, and lake, river and wetland conservation, restoration and usage has been acknowledged and implemented in both developing and developed countries, and earned them the 2004 Stockholm Water Prize.

Lakes and wetlands have inestimable value and are important and often easily available water resources. Lakes supply drinking water, hydropower, food, irrigation and recreation, yet are threatened by pollution and excessive water withdrawal. Wetlands are cradles of vital biological diversity and provide the water and primary productivity upon which numerous species of plants and animals depend for survival. But they are threatened by drainage for use in agriculture and for other purposes. The cultural, ecological and socio-economic value of lakes and wetlands makes their preservation a necessity for people in many regions of the world.

A better understanding of eutrophication

Professor Jørgensen's unique ecosystem models encompass entire lake and wetlands systems and the physical, biological and chemical interactions taking place within them. These system models provide managers and planners with concrete tools to address problems and implement solutions. As an example, Professor Jørgensen and his co-workers developed modelling software for the United Nations Environment Programme to support planning and decision-making for the management of lakes and wetlands in developing countries and countries in transition. Today, more and more freshwater bodies have become polluted by nutrients originating from agricultural, domestic and industrial sources; a situation which causes them to become eutrophic (where excessive algal growth results in severe changes of water quality and the ecology). The software developed by Professor Jørgensen provides an easy-to-use-tool that allows for a better understanding of eutrophication processes.

Helping nature to clean the water

Professor Mitsch was the inspiration behind the Olentangy River Wetland Research Park at the Ohio State University, a world-class wetland research and education facility. There, among other focus areas, research on the ecological restoration of the Mississippi-Ohio-Missouri Basin is being spearheaded. To help reduce coastal pollution in the northern Gulf of Mexico, the ultimate depository of the Mississippi, Professor Mitsch has also taken the role of leader in the debates, studies and resolutions dealing with coastal wetland losses in the US state of Louisiana. He has also shown that constructed wetlands can be engineered for use as buffering and purification systems, as has Professor Jørgensen, who has been responsible for a project in Tanzania to develop better knowledge of such systems. In practical terms, artificial wetlands can be ideal for use as an inexpensive, final stage in the domestic wastewater treatment process.

As educators, authors and speakers, Jørgensen and Mitsch have directly or indirectly influenced and inspired many of the scientists and environmental engineers responsible for lake and wetland protection in all parts of the world. Professor Jørgensen has led many courses in developing countries and advises both agencies and authorities on the use and protection of wetlands. Professor Mitsch founded the leading publication in the field, 'Ecological Engineering,' and co-authored the university standard textbook 'Wetlands,' which today influences future water professionals around the world.

The Laureates have always emphasised the importance of assisting countries and regions which have states of technical and scientific development that differ from those of Western nations.

Photo: CSE

Photo: CSE

Photo: CSE

Sunita Narain, director of the Centre for Science and Environment, leads a dynamic group of researchers, scientists, journalists and advocates who among other successes have revived the idea of rainwater harvesting as a means to manage water sources locally and eradicate rural poverty.

2005 – Centre for Science and Environment under the directorship of Sunita Narain

"For a successful recovery of old and generation of new knowledge on water management."

The award of the Stockholm Water Prize to the Centre for Science and Environment (CSE) India, acknowledges the growing crisis of water management in many regions of the South and the need for new approaches that provide local food and water security to communities. CSE's work, through its many publications, its research and advocacy has helped create new thinking on how traditional systems of water management, which use rainwater endowment, once rejuvenated, could become the starting point for the removal of rural poverty in many parts of the world.

"It is clear that the management of water, and not scarcity of water, is the problem in many parts of the world. CSE's work on rainwater harvesting has shown the many ingenious ways in which people learnt to live with water scarcity," says Director Sunita Narain. "The solution practised diversely in different regions lies in capturing rain in millions of storage systems – in tanks, ponds, stepwells and even rooftops – and using it to recharge groundwater reserves for irrigation and drinking water needs." As CSE's rainwater harvesting website proclaims, 'The supply is in the sky.'

Enlisting all in a joint effort

The world, she says, faces a critical challenge to improve the productivity of rain-fed and marginalised lands. In this challenge, water can turn a large part of a country's currently parched fields into productive lands, reduce poverty and increase incomes where the need is greatest. CSE has shown through its advocacy that localised water management is a cost-effective approach and, more importantly, that local water management – harvesting and storing water where it falls – can be achieved only with community participation.

The work of CSE has highlighted the fact that water cannot become everybody's concern until there are fundamental changes in the ways we do business with water. Policy will have to recognise that water management, which involves communities and households, has to become the biggest cooperative enterprise in the world. For this, the organisation forcefully argues that the prevalent mindset that water management is the exclusive responsibility of government must give way to a paradigm built on participative and local management of this critical life source. This powerful idea is gaining ground to become the policy and practice in many regions of the world.

More water means less poverty

The 2005 Prize acknowledged CSE's contribution to building a water-literate society that values the raindrop and teaches people to learn from the frugality of our ancestors, and to building a water-prudent world. The movement has the potential to change the water futures of the world. Two eye-opening CSE books – 'Dying Wisdom: Rise, Fall and Potential of India's Water Harvesting System' (1997) and 'Making Water Everybody's Business' (2001) – helped spawn a rediscovery of this practical, traditional and inexpensive technique of capturing rainwater for drinking, sanitation and agricultural purposes, and so help to alleviate pressure on India's inefficient, centralised water system – itself a remnant of colonial times.

But CSE's work has not been limited to water. The institution has tackled issues from global climate change to the scrutinising of different Indian industries. Its goal has always been to distinguish itself in the global crowd of NGOs through its insistence on hard facts before rhetoric. This philosophy has given the Centre considerable social capital within civil society, politics and the media in the push for policy change. CSE uses media outreach and information dissemination effectively to support its advocacy. The Centre produces an impressive and steady output of timely publications and other learning aids, including the fortnightly magazine 'Down to Earth'. The magazine has become an important voice of the practitioners of hope and change.

Photo: Keith Dannemiller

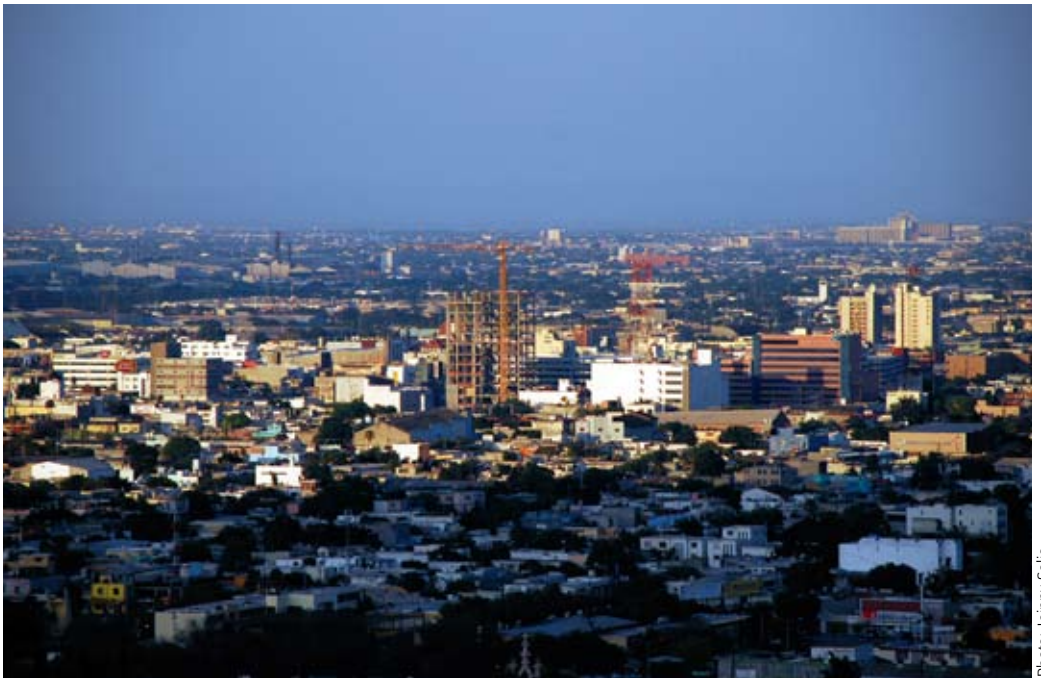

Photo: Jeinny Solis

Challenging the global status quo on water, Professor Biswas received a prize for his outstanding and multifaceted contributions to global water resource issues, including research, education and awareness, water management, and human and international relations, in both developed and developing countries.

2006 – Asit K. Biswas, Mexico

"For his outstanding and multi-faceted contributions to global water resource issues, including research, education and awareness, water management, human and international relations in both developed and developing countries."

While many water experts through the years have contributed highly effective methodologies to the rational use and management of water resources, Professor Asit K. Biswas – the Indian-born Canadian recipient of the 2006 Stockholm Water Prize – fostered a new "socio-economic and political climate" which enabled the effective translation of scientific (both natural and social) and technical advances into meaningful measures. His role as a global facilitator of international platforms where organisations and individuals can take concrete action on water has taken many forms.

As the main scientific advisor to the Secretary-General of the United Nations Water Conference in Mar del Plata, Argentina, in 1977, he helped to formulate and promote the International Water Supply and Sanitation Decade. After approval of this initiative by the UN General Assembly, Professor Biswas advised international and national institutions on how the Decade could be implemented. During the Decade, strides were made in finding affordable technologies and participatory approaches to help serve those without access to improved water and sanitation services. Together with the former UN Undersecretary- General, Dr. Peter Hansen, he reviewed the work of all the UN agencies for the Mar del Plata Conference and advised on how the impact of their water-related activities could be maximised.

Laying the foundations of water treaties

Believing water to be a source of collaboration rather than conflict, Professor Biswas chaired the Middle East Water Commission from 1993 to 1997, with the support of the Sasakawa Peace Foundation. He managed to involve high-level personalities from most countries in the region to review and assess the water problems face to face. The actual treaties on water issues between several countries were based on many of the recommendations of this Commission.

Finally, his concern with the fact that potential water leaders of the next generation are not being heard at major international forums inspired Biswas to initiate a three-year programme, with the support of the Nippon Foundation, to select and mentor potential water leaders from all over the world under the age of 40 years.

Many of his additional activities have also resulted in outstanding contributions to solving international and regional water problems. Professor Biswas has acted as an advisor and confidant to policymakers in water and environmental management in many countries, to six heads of United Nations agencies, and to other intergovernmental and international organisations. The Third World Centre for Water Management, a 'think tank' initially set up by Professor Biswas to give independent and authoritative policy and knowledge support to developing countries, also regularly advises many industrialised countries.

Professor Biswas founded the International Journal of Water Resources Development and has been involved in the writing of 64 books on many water-related topics. He has also published over 600 scientific and technical articles. His work has been translated into 31 languages.

A dream of water security

Professor Biswas speaks convincingly of how forces like globalisation, free trade, the information and communications revolution, the accelerated quest for energy security, technological developments, population growth and urbanisation are not only unprecedented in human history, they are also changing the boundary conditions of water management.

While he was in Stockholm to receive the Prize, Professor Biswas expressed his 'dreams' for the future. "I have a final dream that every one of the world's citizens will live in a water-secure world within my lifetime," he said. "This is not an impossible dream but an achievable dream. If we fail, as Shakespeare has said in Julius Caesar, 'The fault, dear Brutus, is not in our stars, but in ourselves that we are underlings'."

Professor Biswas received an honorary doctorate of science in technology from the University of Strathclyde, Glasgow, Scotland in 2007, and from Helsinki University, Finland, in 2008.

2007 – Perry L. McCarty, USA

"For pioneering work in developing the scientific approach for the design and operation of water and wastewater systems."

Professor Perry L. McCarty likes to think big but look at the small things of life. He openly confesses an unabashed fascination with the inner workings of septic tanks and an unbounded excitement for getting behind the microscope to search for the next big thing in the sustainable and healthy reuse of water resources. Receiving the 2007 Stockholm Water Prize from the hands of H.M. King Carl XVI Gustaf, he humbly joked to the audience that such passions might not be shared by the average person. This is fitting, because the lifetime of pioneering achievement in the design and operation of water and wastewater systems for which he was recognised has been nothing short of extraordinary.

A pioneer of environmental biotechnology

His journey began at Stanford University nearly half a century ago, in 1962, when he arrived at the Ivy League school to develop their environmental engineering and sciences program. But he has managed to do much more than build up a single academic institution's department. Since beginning at Stanford, Professor McCarty's work has defined the entire field of environmental biotechnology, which is the basis for small-scale and large-scale pollution control and safe drinking-water systems.

The author of over 300 publications and textbooks on biological processes that can be utilized to control and remove environmental contaminants, such as nitrogen and hazardous chemicals, McCarty has provided key insights into the movement, fate, and control of groundwater pollutants that have allowed for new opportunities in water reuse and applied advanced wastewater treatment.

As both an icon and an active member of the academic and professional community, Prof. McCarty has served in numerous positions in addition to his role as teacher and researcher. He has in past and present served in varying capacities as: chairman of Stanford's Department of Civil and Environmental Engineering, director of the Western Region Hazardous Substance Research Center, and on the National Academy of Engineering as well as the American Academy of Arts and Sciences. Before receiving the Stockholm Water Prize, he had been honoured with multiple awards including the 1992 John and Alice Tyler Prize for Environmental Achievement and the 1997 Athalie Richardson Irvine Clarke Prize for Outstanding Achievements in Water Science and Technology.

His decorated career devoted to engineering solutions for the better use and protection of water resources, and of people, has been dedicated to showing that we simply cannot afford to waste water in the manner we have done and continue to do. To change this we must change the way we view an essential resource.

So-called 'wastewater' is not waste at all, it is rather its value to society that is far too often wasted. Reduced pollution of groundwater resources and better utilisation of the understanding of scientific and natural processes, to which Professor McCarty's work has greatly contributed, provides countries with the capacity to clean and recycle water resources for invaluable reuse.

What bacteria can teach us about cooperation

While in Stockholm to receive the prize Professor McCarty offered sage advice for nations and scientists seeking sustainable solutions in the upcoming generations. Never straying from his passion for the miniature universes and infinite innovations yet to be discovered in microorganisms, McCarty implored all his hearers to take inspiration from the tiniest of sources.

"Now I am not sure that I have made you as excited as I am about what happens in a septic tank," he quipped. "But it is the community of organisms all working together that we need to study and learn more about. We ourselves obviously have much to learn about living together cooperatively, and perhaps they can help us to learn how to do this much better than we have… With the coming climate changes we will have to adapt as well, and I hope we do it successfully. I expect we can if we all work together as the micro-organisms in a septic tank have learned to do."

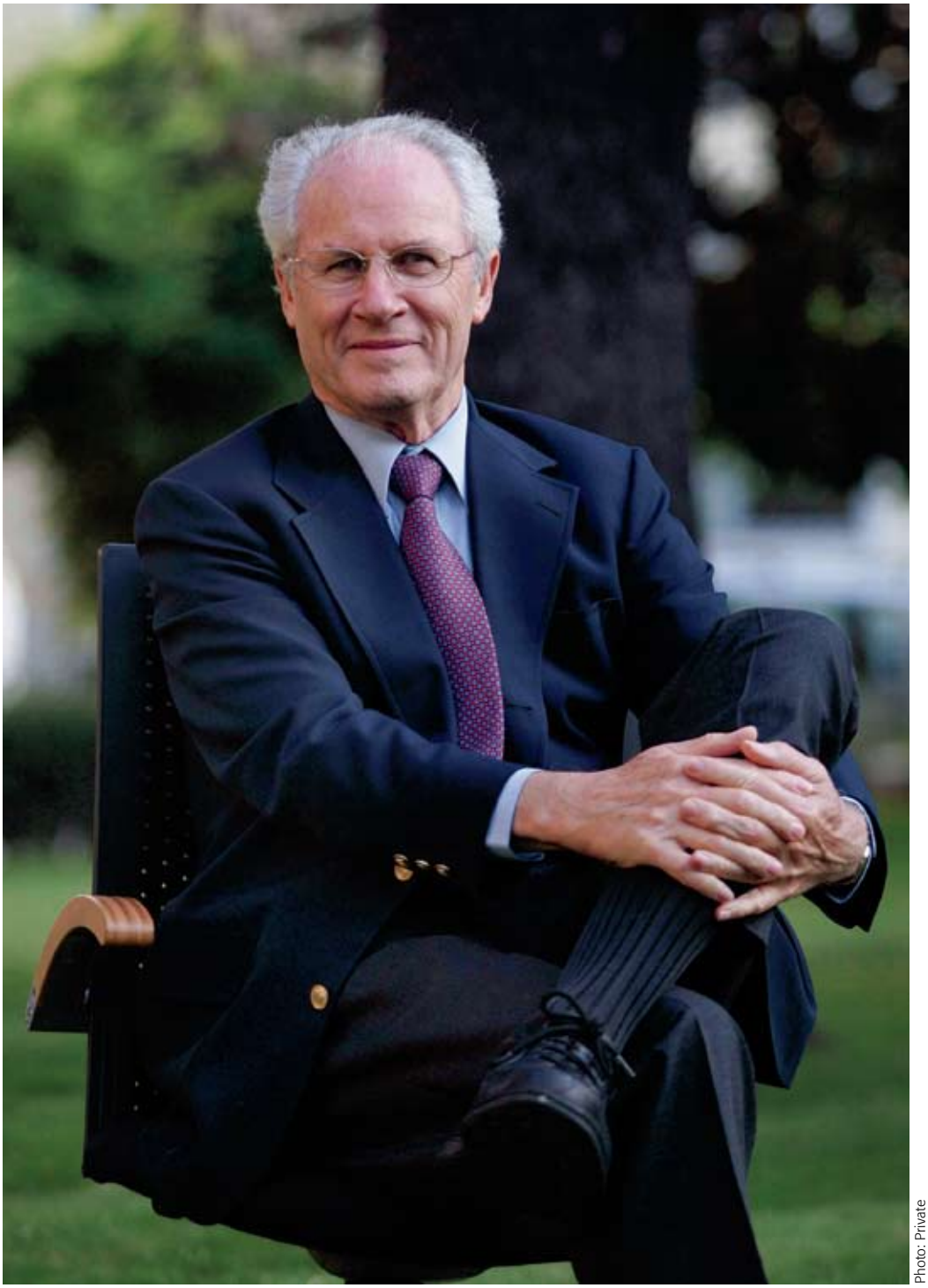

Photo: Private

Professor Perry L. McCarty's professional journey began at Stanford University nearly a half century ago, sparking a lifetime of pioneering achievement in the design and operation of water and wastewater systems that has been nothing short of extraordinary.

Photo: Greg Funnell

Photo: Julian Cenkier

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Professor John Anthony Allan introduced the ideas of "virtual water" in the 1990's, later developed into the "water footprint" concept, today used by nations, cities and businesses worldwide.

2008 – John Anthony Allan, UK

"For his unique and pioneering work in education, raising the awareness and the introduction of the concept virtual water."

Water conservation is an issue with which we in the modern world are becoming increasingly occupied, and justly so. It is however through the work of those such as Professor John Anthony Allan that we are starting to look beyond simply switching from baths to showers as a means of regulating our usage of what has long been turning from a valuable commodity to a dwindling one.

Throughout a long and distinguished career dedicated to developing the understanding and communication of water issues, Professor Allan, who has been awarded the 2008 Stockholm Water Prize, has helped to change the way in which we view our relationship with water usage. Perhaps his most striking addition to this cause has been the introduction of the "virtual water" concept.

The water we do not acknowledge

The idea behind virtual water is the acknowledgement that underpinning the production and trade of food and consumer products lies a culture of water usage completely at odds with the final product. For instance, the morning mug of coffee that sits on the breakfast table consumes a far greater amount of water than is used simply to fill the cup. In fact it is reckoned that behind the cup itself 140 litres of water are required to grow, produce, package and ship the beans, a figure that roughly equates to the amount of water used by the average person daily in England for drinking and household needs. Per capita, Americans consume around 6,800 litres of virtual water every day, over triple that of a Chinese person.

It is therefore in highlighting this disparity that the concept of virtual water has become so important to our notion of usage and regulation.

Professor Allan's notion of virtual water has had major impacts on global trade policy and research, especially in water-scarce regions, and has helped to redefine discourse in water policy and management across the world. For instance, by explaining how and why nations like the U.S. and Brazil "export" billions of litres of water each year, while other countries such as Egypt and Italy "import" billions, the concept of virtual water has awakened many to the idea of more productive water use. In areas such as the Middle East, Professor Allan has developed the theory of using virtual water imports, via food, as an alternative water "source", thus reducing pressure on scarce domestic water resources within this and many other water-short regions. This has in turn led to a better understanding of potential and real conflicts in areas such as the Nile Basin, where water resources are shared between countries, while providing perspectives on economic and political processes that can make food and water security possible for all nations in such basins.

How water affects the economy

A scientist, educator and advisor, Professor Allan works at King's College London and the School of Oriental and African Studies. He has developed essential knowledge and communication tools for sustainable and efficient water resource and management policy, and it is through this that scientists, water professionals and business people have gained a greater awareness, not only of the role of water in the production of various types of goods, but also of its impact on global trade and economy.

As well as his work in changing perceptions of water usage across the globe, Professor Allan has authored and edited numerous books and published many papers in political science, natural resource management and interdisciplinary water journals. His work as a consultant for numerous governments, the World Bank and the European Union, notwithstanding his role in educating more than 1,000 current or future water professionals has led to Professor Allan being recognised as one of the most influential thinkers in the global water sector today.

Photo: Sulabh International Social Service Organisation

Photo: Jimmy Mohlin

The Sulabh International Institute of Health and Hygiene has created hygiene curricula for young schoolchildren and their teachers, provided sanitation and health training for volunteer instructors in slums, and opened centres providing basic healthcare for urban poor.

2009 – Bindeshwar Pathak, India

"For his outstanding work to improve the health, dignity and well-being of millions."

Despite its increasing economic growth within the private sector, India remains in many ways a country prone to the ravages of badly-regulated public health, largely because of its fragile infrastructure of healthcare and reform. It is people such as Dr. Bindeshwar Pathak, founder of the Sulabh Sanitation Movement in India and the 2009 Stockholm Water Prize Laureate, who have begun to effect real change in the lives of millions of people. This holds true not simply for India itself, where 50,000 volunteers are supporting Dr Pathak's vision. His Movement is now working in Bhutan and Afghanistan, and there are plans to extend it to 14 African countries and also to other states.

Dr. Pathak works to change attitudes toward traditional unsanitary latrine practices in slums, rural villages, and dense urban districts, and has developed cost-effective toilet systems that improve daily life and health for their users. He also campaigns to abolish the traditional practice of manual "scavenging" of human waste from bucket latrines in India, championing the rights of former scavengers and their families to economic opportunity, decent standards of living, and social dignity.

First-hand experience

He first learnt about the lives of the scavengers in 1968 when he joined the Bhangi-Mukti (scavengers' liberation) Cell of the Bihar Gandhi Centenary Celebrations Committee. During that time he travelled throughout India, living with scavenger families as part of his Ph.D. research. What drives him today is his empathy with those subjected to a life of manual scavenging, a way of life endured mainly by those of the "untouchable" caste. Such practices have long led to an increased risk of disease and contamination. Through Dr Pathak's development of a viable method of sanitation, not only has the need for this activity begun to decline but he has also helped people to recover their dignity, a liberation for the "untouchables".

In 1970 Dr Pathak founded the Sulabh International Social Service Organisation, an NGO that has been a catalyst for improved sanitation and social change across India.

Since then he has worked tirelessly to change attitudes not only towards the unsanitary practices themselves but also towards those obliged to earn their livings from them. He regards the common toilet as one of civilization's most significant advances. The Stockholm Water Prize nominating committee says: "Dr. Pathak's endeavors constitute one of the most amazing examples of how one person can impact the well-being of millions". His dedication to improving sanitation has crossed over into social enterprise and health care education for millions throughout India, and now serves as a model for NGOs and public health initiatives across the globe.

A revolution in development

The development of the cost-effective and culturally appropriate toilet systems that have replaced the traditionally unsanitary bucket latrines is a key part of India's development. The work of Dr. Pathak and the Sulabh Sanitation Movement has been nothing short of revolutionary in its approach, providing technology to transform India's approach to sanitation. The introduction of twin-pit, pour-flush toilet systems and pay-per-use public bathing facilities is helping to provide sustainable, ecological and culturally acceptable solutions to hygiene problems throughout many of the country's crowded urban areas.

Among their other innovations is a toilet which needs only 1.5 litres of water to flush it, while normal toilets need 10 litres. They have also developed an environmentally balanced wastewater treatment based on a duckweed and fish-raising ecosystem that provides economic opportunities for poor rural communities, and several technologies that convert waste from toilets into biogas for heating, cooking, and generating electricity. Working with the Indian Government, Dr. Pathak has also established the Sulabh Environmental Information System Centre to gather and disseminate data on hygiene, sanitation, and sewage treatment.

Photo: John T. Consoli/University of Maryland

Photo: Getty Images

Photo: Zeeshan Chaudhry

Dr. Colwell's pioneering research into the prevention of water-borne infections is protecting not only the health but the lives of millions. She was also the first scientist to research the impacts of climate change on the spread of infectious diseases.

2010 – Rita R. Colwell, USA

"For her outstanding research on waterborne diseases to protect the health and lives of millions."

Dr. Rita R. Colwell of the US has played a pivotal role in developing our appreciation of cleaner water, and her work has improved the quality of life for countless people throughout the world. She is the recipient of the 2010 Stockholm Water Prize, and her citation for the Prize praised her work as of "utmost global importance". Her pioneering research into the prevention of water-borne infections is protecting not only the health but the lives of millions. Dr. Colwell is one of this century's most influential voices in science, technology, and water and health policy. She has made exceptional contributions to controlling the spread of cholera, a water-borne pathogen that infects three to five million people and leads to an estimated 120,000 deaths annually. She has defined our current understanding of the ecology of infectious diseases and developed the use of advanced technologies to predict their spread. Dr. Colwell's explorations into the causes of water-borne diseases have taken her across the globe. Without people like her, the effects of water contamination would be far worse than they are today.

A new understanding of how diseases spread

It was during the 1960s that Dr. Colwell, from the University of Maryland and Johns Hopkins University's Bloomberg School of Public Health, made one of the most prominent breakthroughs of her career. Her observation that the causative agent for cholera, Vibrio cholera, is able to survive by attaching itself to zooplankton led to the groundbreaking discovery that certain bacteria, including that of the Vibrio species, may enter a dominant stage that, under the right conditions, can revert to an infectious state. This corrected the conventional view that cholera passed only from person to person, food or drinking water, and was spread by sewage, and to the realisation that even in areas with no noticeable outbreaks of the disease, aquatic environments can still act as reservoirs for such bacteria. As a result of her work, scientists are now able to link changes in the natural environment to the spread of disease. Discoveries of this kind are fundamental in the fight against diseases that for centuries have ravaged much of the world's population, and it is because of insights such as Dr. Colwell's that the global effects of such infections are being overcome. She has shown how changes in climate, adverse weather events, shifts in ocean circulation and other ecological processes can create conditions that allow infectious diseases to spread. In the 1990s, Dr. Colwell was the first scientist to research the impacts of climate change on the spread of infectious diseases.

A thinker and a doer

Dr. Colwell has also dedicated her career to the battle to improve our understanding of the relationship between clean health and clean water. As author and co-author of 17 books and over 700 scientific publications, she has remained at the forefront of the fight, and has held many advisory positions for the US Government, in non-profit science policy organizations, private foundations and the international science community. She was appointed by President Clinton as the first woman Director of the National Science Foundation, and in 2000 was inducted into the US National Academy of Sciences.

Her dedication to the spread of clean water reaches far beyond the laboratory. She is determined not only to challenge contemporary thinking, but also to inform others, as her work within the education system proves. Here she champions the greater involvement of women and minorities within science and engineering. If Dr. Colwell's example encourages others to follow her lead, the world's growing understanding of the importance of clean water regulation will mean better health for hundreds of millions of people, and a clearer comprehension of the intrinsic relationship between ourselves and our environment.

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The Stockholm Water Prize

Since 1991, the Stockholm Water Prize has been presented annually to an individual, institution or organisation for outstanding water-related activities. The activities can be within the fields of education and awareness raising, human and international relations, research, water management or water related aid and development activities in developing countries.

What began with the valuable but modest aim of rewarding efforts to safeguard water has grown into one of the world's most respected and important water prizes, and now celebrating its 20th anniversary

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