The UNEP Magazine for Youth

TUNZA

UNEP

for young people · by young people · about young people

FRESHWATER

Small solutions, big results

Message in a bottle

More food, less water

TUNZA
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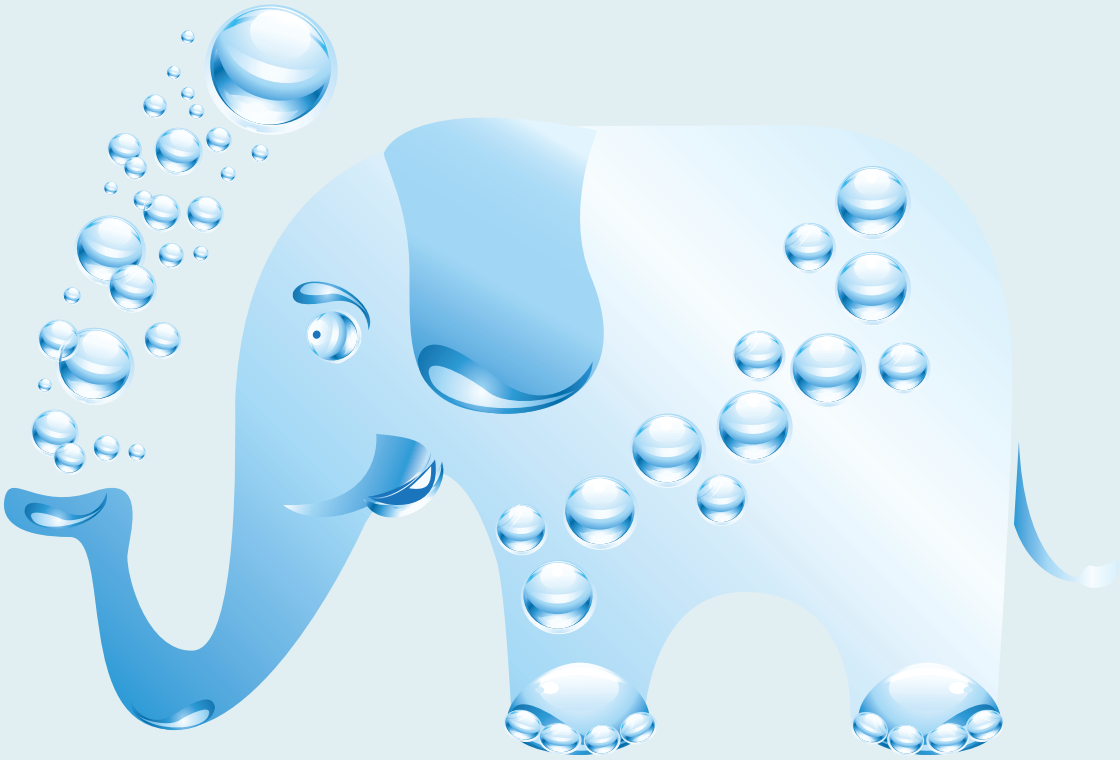
Partners for Youth and the Environment

UNEP and Bayer, the German-based multinational involved in health care, crop protection and high-tech materials, are working together to strengthen young people's environmental awareness and engage children and youth in environmental issues worldwide.

A partnership agreement, originally signed in 2004 and renewed in 2007 and 2010, runs through 2013. It lays down the basis for UNEP and Bayer to implement the projects under the partnership. These include: TUNZA Magazine, the International Children's Painting Competition on the Environment, the UNEP Tunza International Youth and Children's Conferences, youth environmental networks in Africa, Asia Pacific, Europe, Latin America and the Caribbean, North America and West Asia, the Bayer Young Environmental Envoy Program and a photo competition, 'Ecology in Focus', in Eastern Europe.

The long-standing partnership between UNEP and Bayer has become a public-private partnership that serves as a model for both organizations.

EDITORIAL



Every living thing on Earth depends on water. We humans, who are 60 per cent water, can't survive without it for more than five days. But it's not just that we need to drink and wash. Food production accounts for more than two-thirds of the world's fresh-water withdrawals.

Inevitably, as the human population continues to grow and as we work to ensure that all people have enough to eat and drink – and have access to sanitation – water use is increasing. According to UNEP's *Global Environment Outlook 5* (*GEO5*), withdrawals have increased three-fold over the past 50 years.

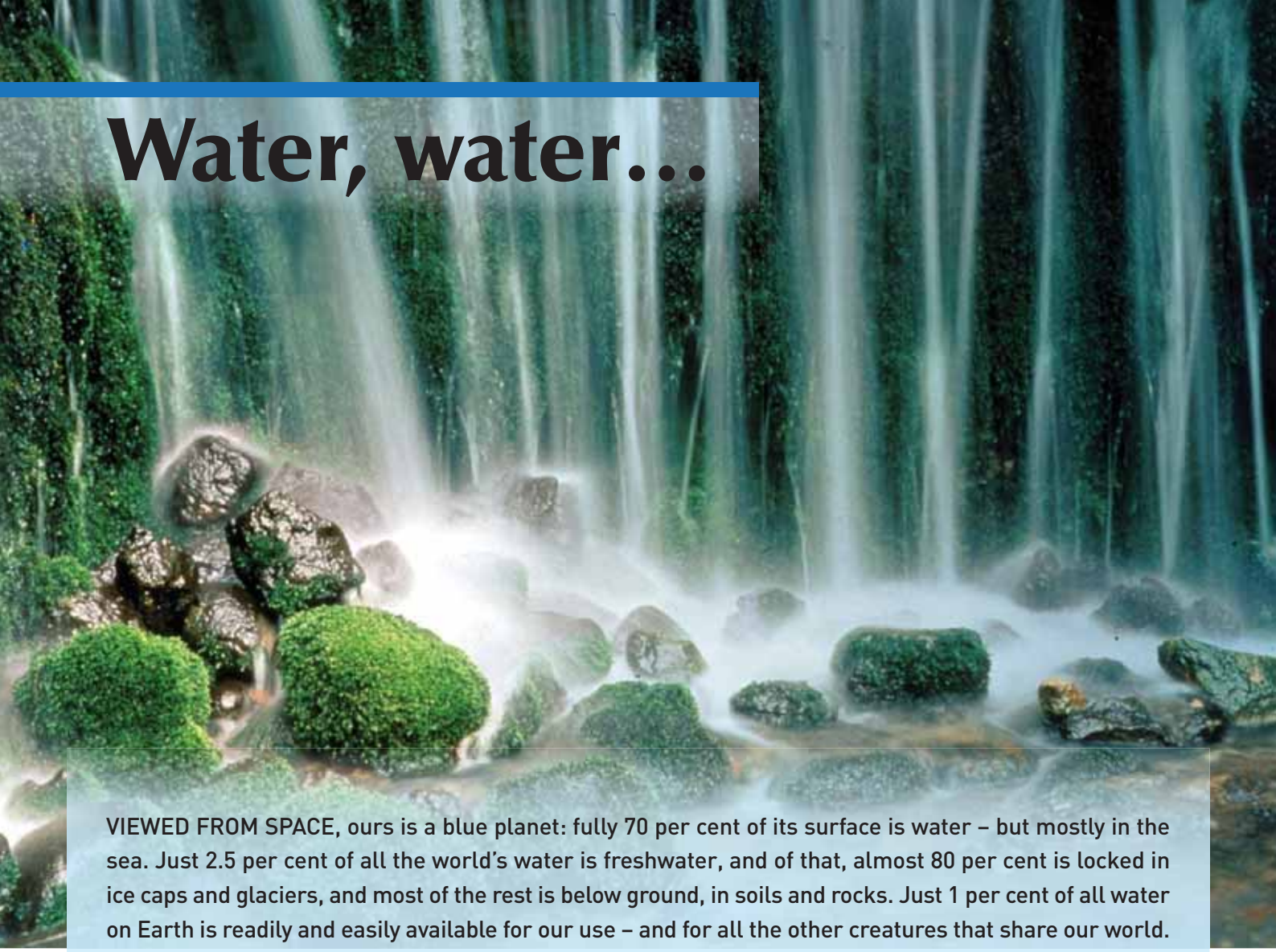
But the amount of freshwater in the world is more or less fixed, so we need to cherish what we have and preserve the ecosystems that help manage its supply. That includes the world's forests, which increase water absorption by soils, slow run-off, and help to regulate both rainfall and evaporation. It includes conserving our river systems and their associated floodplains and wetlands, which are vital to maintaining natural water flows. And it also means reducing the amount of pollution we think we can just wash away.

Another problem is that water isn't always in the same place as the people who need it most. Canada, for example, has around 20 per cent of the world's freshwater resources, but less than 1 per cent of its people. According to *GEO5*: *'about 80 per cent of the world's population lives in areas with high levels of threat to water security. The most severe threat category encompasses 3.4 billion people, almost all in developing countries. More people are likely to experience more severe water stresses in the coming decades, with projected climate change impacts and continuing population growth.'*

We must get smarter in our use of water. That means improving vital irrigation systems so that they deliver the right amount of water to where plants actually need it. It means selecting crop varieties that thrive with less water – some will be older varieties; others will be specially bred for the new reality. And it will mean developing systems to allow wastewater to be recycled and then used for irrigation, or for sanitation.

As you can read in these pages, lots of you are already actively seeking solutions to the world's water problems, but we all have a part to play. It can be as simple as not leaving the tap running while you wash your teeth, taking a shorter shower than usual or sharing a small bath, and applying the 3Rs – reduce, reuse, recycle – in everything you do. It takes around 3,000 litres of water to make a pair of jeans, while it takes 1,500 litres to grow enough cotton for a t-shirt. So make your clothes last longer – and when they wear out, consider garments made from less thirsty crops like linen, hemp or even nettles.

Water, water…



VIEWED FROM SPACE, ours is a blue planet: fully 70 per cent of its surface is water – but mostly in the sea. Just 2.5 per cent of all the world's water is freshwater, and of that, almost 80 per cent is locked in ice caps and glaciers, and most of the rest is below ground, in soils and rocks. Just 1 per cent of all water on Earth is readily and easily available for our use – and for all the other creatures that share our world.

Several international conventions and agreements address a fundamental human right to water, most explicitly the International Covenant on Economic, Social and Cultural Rights, which asserts: '*The human right to water entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses. An adequate amount of safe water is necessary to prevent death from dehydration, to reduce the risk of water-related disease and to provide for consumption, cooking, personal and domestic hygienic requirements.*' To this end the Millennium Development Goals (MDGs) aim to: '*halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation.*'

The absolute minimum amount of water needed for human survival is around 3 litres per person per day. But if you take account not just of drinking, but of sanitation and hygiene, that rises to around 50 litres per person per day.

But it is not just the direct provision of water that matters. Water is needed for food production too, and the MDGs also have the intention of '*halving, between 1990 and 2015, the proportion of people who suffer from hunger*'. Over the past 50 years, farmers have done a remarkable job in feeding the world. The number of people going hungry today is almost the same as it was in the 1960s, despite the world population more than doubling. But much of this is the result of the extensive use of irrigation to increase yields. Today, agriculture extracts more water than any other sector.

But water is like so many other natural resources: limited. The amount of water within this planet's hydrological cycle is more or less fixed. It circulates, but doesn't increase. In all, there's estimated to be 1.4 billion cubic kilometres of water within that system, of which only about 14 million km^3 are easily available to us as freshwater. No matter how many of us there are, that's all we have to share. Nonetheless, because of rising human numbers, and our efforts to provide a decent standard of living to all, water withdrawals from rivers and underground reserves have increased by an average of 2.5–3 per cent a year since the 1940s.

Today, the waters of some of the world's major rivers, including the Colorado in the USA and the Nile in Egypt, barely reach the sea. In Central Asia, by the end of the 20th century, the Aral Sea had shrunk by up to 80 per cent due to vast irrigation withdrawals from its feeder rivers to supply the cotton industry. In Africa, Lake Chad has diminished to around 10 per cent of its original size, largely due, according to UNEP, to human water use, including inefficient damming and irrigation methods. And several major urban areas – including Bangkok, Houston, Jakarta, Mexico City, Osaka, San Jose, Shanghai, Tokyo and Venice – are experiencing significant land subsidence caused by the draining of ground water.

Eliminating mercury

It's a fascinating substance – a metal that's liquid – and mercury's effects on the human nervous system have been known for more than 100 years: hat-makers, like the Mad Hatter in Lewis Carroll's *Alice in Wonderland*, were affected as they breathed in poisonous fumes from mercury used to strengthen brims. Today, mercury is commonly used in small-scale goldmining, and an estimated 10 million miners and their families – from Brazil and Venezuela to India, Indonesia, Papua New Guinea and Zimbabwe – may be suffering from related problems, including impaired thyroid and liver function, irritability, tremors, disturbances to vision, memory loss and perhaps cardiovascular problems.

Around 6,000 tonnes of mercury enter the environment each year, some 2,000 tonnes from power stations and coal fires in homes. Once in the atmosphere or absorbed in water, mercury can travel thousands of kilometres and continues to circulate in the environment for many years. In Sweden, for example, around 50,000 lakes have pike with mercury levels exceeding international health limits, while one study in the USA has found that almost 5 million women – that's about 1 in 12 – have more mercury in their systems than is considered safe.

Governments have recognized the threats mercury poses and have taken action on a voluntary basis. Following an assessment of the concerns, it was agreed in 2009 that a global legally binding agreement was needed. Spearheaded by UNEP, the Minamata Convention on Mercury will be open for signature in October 2013.

Garry Walter/UNEP/Topham

Increasing cooperation

The United Nations has designated 2013 as the International Year for Water Cooperation, recognizing that water issues, like so many environmental problems, show little regard for borders. You just have to think of the international waterways of Africa such as the Congo and Nile, Europe's Rhine and Danube, Asia's Euphrates, Ganges and Mekong or Latin America's mighty Amazon. All cross national borders, so whatever happens upstream has an impact on the lives and livelihoods of those living downstream.

The objective of this International Year (www.unwater.org/watercooperation2013.html) is to raise awareness, not just of the challenges facing water management in light of the increasing demand for water access, allocation and services, but also of the potential for increased cooperation. The Year will highlight the history of successful water cooperation initiatives, as well as identify burning issues on water education, water diplomacy, transboundary water management, financing cooperation, national and international legal frameworks, and links with the MDGs. It will also provide an opportunity to capitalize on the momentum created at the United Nations Conference on Sustainable Development (Rio+20), and to support the formulation of new objectives that will contribute towards developing water resources that are truly sustainable. And all this is in the shadow of climate change, which is already affecting the world's water systems.

M. Haba/UNEP/Topham

At a glance

- **2 billion people have gained access to safe drinking water since 1990.**
- **2.6 billion people lack access to basic sanitation services – lavatories or latrines.**
- **5,000 children die each day, on average, due to preventable water- and sanitation-related diseases.**
- **Hydropower is the most important and widely used renewable source of energy, representing 19 per cent of total electricity production worldwide.**
- **Around 70 per cent of all available water is used for irrigation.**
- **Floods account for 15 per cent of all deaths related to natural disasters.**

Progress

The Millennium Development Goal (MDG) target of halving the proportion of people without sustainable access to safe drinking water was met by 2010, and by the end of 2012, 89 per cent of all people were using an improved water source. But the work is not yet done: 783 million people are still living without access to an improved source of drinking water and it is likely that, in 2015, 605 million people will continue to lack coverage.

Sanitation availability is somewhat behind. Coverage increased from 36 per cent to 56 per cent between 1990 and 2010 in developing regions, with progress slow in Western Asia and sub-Saharan Africa, and no improvement in Oceania. Overall, by 2015, the world will have reached coverage of only 67 per cent, rather than the 75 per cent needed to achieve its MDG target of halving the proportion of people without sustainable access to basic sanitation.

Connie Sullivan/UNEP/Topham

Inspiration in Leverkusen

PROFESSOR WOLFGANG PLISCHKE is a member of the Bayer Board of Management and is responsible for technology, innovation and sustainability. At the Bayer Young Environmental Envoy (BYEE) study week, TUNZA asked him about the pressing environmental issues of our time.

WP: 'In my opinion, there are three main environmental challenges that affect everyone: climate change, water supplies and the protection of biodiversity. In all three, the focus is on sustainability, so that generations to come have a world worth living in. We must use natural resources with utmost efficiency. We're moving in the right direction. But there's still a lot to do. We simply cannot go on living, producing and consuming at the cost of the future.'

TUNZA: What part do you think that science and technology will play?

WP: 'Science and technology will play a key role, as they drive innovation. But only if we succeed in creating economic, social and ecological benefits will development really be sustainable. I'm always fascinated by the smart ideas our researchers come up with – and their commitment to making these accessible all over the world. These include energy-efficient technologies for the better insulation of houses and effective cooling systems for the transport of food. Everyone should think about new ways of tackling the challenges we're facing.'

TUNZA: And what are the most important things that young people can do to help?

WP: 'Be active! Young people will be affected by the decisions being made today, but you are also the decision makers of the future. You will make the difference. So, find out what's going on, get involved and set an example to others. Many smart young people are already positively influencing the future of their generation – that's exactly what the Bayer Young Environmental Envoys are doing.'

Vincentius Dito Krista Holanda

Elisa Altuna

In November 2012, Bayer convened 49 young people from 19 countries in Asia, Africa and South America at its headquarters in Leverkusen, Germany, to learn about efficient innovation and production processes and give them the opportunity to hear what sustainability experts have to say about what the green economy can offer.

One strong theme at the conference was the use of waste as a resource for sustainable social entrepreneurship – upcycling rubbish into saleable products while generating employment to help lift people out of poverty. TUNZA spoke to Elisa Altuna (Argentina), Vincentius Dito Krista Holanda (Indonesia) and Mwanyuma Hope Mugambi (Kenya) about the common threads in their work.

What values did you hope to address with your project?

Elisa: My project, Responsible Fashion, aims to reduce the pollution produced by the waste of vinyl advertising posters, which are usually sent to landfill. We make these into bags and other accessories, building skills and generating employment for low-income women, and promoting responsible consumption.

Dito: My project, Ganesha Holding, manufactures women's dresses from textile waste found in dumpsters, abundant and free. Our initiative keeps this material from incineration. We provide jobs for rural women, who otherwise depend on farming. We also teach them financial literacy.

Hope: We recruit women and girls to gather and crochet polythene bags into products for sale. In doing so, we reduce litter and boost financial independence.

You all seem to want to empower women. How, and why?

Dito: Typically, it's frowned upon for women in the poorer sectors of Indonesia's society to work away from their families. Our initiative allows women to be employed at our production house while watching their children. We also build

confidence in their creative skills, which we channel into clothes production. And sewing is a lifetime skill. Some day, they may even be able to open up their own businesses!

Hope: Many women in my community didn't go to school, and so become reliant on others, but often the men neglect their families, leaving the women asking the government for funds to support the children.

Elisa: In Argentina, women in low-income households have to help support their families, but typically have received little education. Teaching them skills like sewing gives them access to financial independence.

Is it important for you to make money?

Hope: Yes. Africans have often depended on donor funding from foreign countries. With small projects like this, we can get our own money. I'm trying to get women away from the mentality of dependence.

Elisa: Money is very important for the sustainability of our project, to help build more capacity amongst women.

Mwanyuma Hope Mugambi

Dito: With financial incentives, women are motivated to take a greener attitude. We also need money to replicate and expand our activities.

What have you gained from taking part in the BYEE conference?

Elisa: It's been encouraging to see that despite our differences, we all face the same problems, and are developing similar solutions.

Hope: I've been both challenged and empowered to know that high-tech is not always the appropriate solution. And I'm encouraged to find that other people are in the same boat. I thought that these problems existed only in Africa.

Dito: I'm inspired by the energy here. I've talked to other Envoys about collaborating to expand our markets. I know I can make an even bigger impact now that I have access to this network.

What YOU are doing

Oscar Muñoz Cofré (Chile) creates job opportunities by collecting good-quality bottles from rubbish tips and turning them into tableware and jewellery in his Green Glass workshop. He's now targeting markets in North America, and hopes to open glass workshops elsewhere in both South and North America.

Oscar Muñoz Cofré

Swapnil Kokate (India) has designed an electricity-free egg incubator, currently in the patent process. It uses a special 'heat-humidity buffer box', a metal box heated by hot water to keep eggs at the right temperature for hatching. This makes producing chickens more affordable for small-scale rural farmers who don't have reliable access to electricity.

Swapnil Kokate

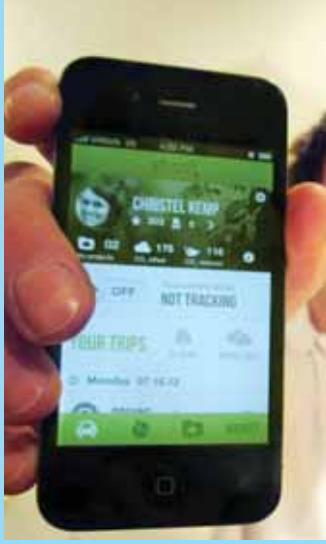
Primary school teacher **Ruiz Joy Escollar (Philippines)** has created a 'SIM Eco-Kit' made of rubbish – snack packets, plastic bottles and cartons – that looks and works as a colourful toolkit for teaching children about the environment. She also produces a handbook to help others use recycled materials for teaching and other creative activities.

Ruiz Joy Escollar

Wan Nurhidayat (Malaysia) founded the Green Soldier Club at the National Defence University of Malaysia to harness the high energy, organization skills and social profile of the military to lead such environmental campaigns as mangrove tree planting, awareness raising and beach clean-ups.

Wan Nurhidayat

Joaquín Dufeu Aguirre (Chile) has created a mobile app, *Give02*, which measures your carbon footprint. 'A lot of people, while they feel green, don't actually walk the talk,' he says. '*Give02* is a free app that measures your transport-related carbon footprint – automatically. There's not even an on/off button! Just carry your iPhone and *Give02* senses whether you're biking, walking or travelling by car. It delivers an estimate of your emissions, which you can then neutralize by buying carbon offsets via the app. We also reward users with points whenever they choose greener options, which can be exchanged for discounts in popular retailers.'



Joaquín Dufeu Aguirre

Environmental entrepreneurs

Michael Rennertz/Bayer

A highlight of every BYEE conference is the Bayer Young Environmental Leader Award. This year, 19 nominees – one from each participating country – presented projects covering a wide range of interests and expertise, with the three winning projects meeting environmental and social needs in a sustainable way, benefiting people economically while taking local values into account. Each winner received a cash prize and development support from Bayer.

Chitosan nanogels

Adriana Maria Villalobos Delgado, Costa Rica

In Costa Rica, shrimp fishing is big business. The men catch them, then their wives extract the meat and throw the heads and shells back into the sea, polluting the water. I'm researching how this waste can be used to make 'chitosan' – a substance produced from the shells of crustaceans that is already used commercially as a seed treatment and pesticide, as well as in pharmaceuticals. My plan is to develop chitosan nanogels, a drug-delivery system that introduces medicines deep into the body. Chitosan nanogels don't just have a potential market in Costa Rica, and if we do manage to create an international industry using shrimp waste, the environmental impact could be huge. When shrimp shells become more valuable than the meat, people will have an incentive to stop polluting the ocean.

Recycling polythene bags

Mwanyuma Hope Mugambi, Kenya

Polythene shopping bags are often used once and then thrown away. They clog drains, and wild and domestic animals eat them and die. The biggest rubbish tip in Mombasa, Kenya, where I live, is near the sea, so many bags also end up in the ocean, where they kill sea life. I created this project to tackle these problems as well as to empower the young women, who come from very poor backgrounds. Our group, *Taru Girls*, collects bags from rubbish tips and from around our neighbourhood. We clean them, cut them into strands, and crochet them into table mats, laptop cases, phone cases, handbags and more, which we sell to tourists. The money generated gives the girls financial independence and benefits the wider community, and the only costs are protective gloves and boots, scissors and crochet hooks. At the same time, the project raises awareness about environmental issues and teaches young women valuable entrepreneurial skills. I plan to expand this project throughout Kenya.

Green handbook for housewives

Dang Huynh Mai Ahn, Viet Nam

One day, when I was watching TV with my mother, we saw a programme about young people's environmental projects, and my mother wondered why environmental activities aren't aimed at mothers and housewives. This intrigued me, and as a business student, I knew I needed to do some market research. Several surveys told me that my target group – middle-class housewives aged 25-40 living in the Phu Nhuan District in Ho Chi Minh City – enjoyed handicrafts and worried about saving money, but considered the 3Rs (reduce, reuse, recycle) a waste of time. To address their concerns, I designed an eye-catching, user-friendly booklet of creative and practical green tips – encouraging housewives to apply the 3Rs because it's enjoyable and saves them time and money. The first trial run of 100 copies proved very popular, so I launched a commercial edition of 600 copies on Vietnamese Women's Day in October 2012. That sold out, mostly to young people buying them as gifts for their mothers. Buoyed by this success, I'm now planning different versions targeting other markets, such as students living on their own for the first time.

All around the world...

Mason Perez, from Reno, Nevada, was just seven years old when he noticed that the water gushing out of the tap at a local baseball park hurt his hands as he tried to wash. So he turned the flow down and found he could wash just as well, and far more comfortably. This made Mason wonder whether turning down water pressure could help conserve water.

Two years later, for a science fair project, he conducted experiments at a number of houses, measuring the volume of water coming out of each tap when the house's mains water inlet valves were wide open and when they were half shut. He discovered that a reduced flow saved up to 23 per cent of water without making any difference to lifestyle. Mason's system has been taken up by the park, which has since saved 20 per cent on its monthly water bill and now his idea is spreading throughout the community. Mason won the science fair's top prize.

londonmumsmagazine.com/2012/helpful-tips-to-save-your-water

Here are some other inspirational projects you have told us about:

Xi Chen

Along with members of the environmental protection volunteer club at my university, I regularly gather data to keep track of pollution in Dian Lake near Kumming, the capital of Yunan Province. The 340-square-kilometre lake, one of China's largest, is highly polluted with industrial waste, agricultural run-off and domestic sewage, causing eutrophication and destroying biodiversity. The algal blooms also make the water smell terrible. Our aim is to raise public awareness and help people understand how and why the lake is so polluted. We hope this knowledge will encourage well-informed dialogue with the government and improve the state of the lake.

Xi Chen, China

Marija Dlevska, the principal of a secondary school in Prilep, Former Yugoslav Republic of Macedonia, knew she had a water problem when the school's accountant confronted her with high utility bills. She turned to the school's Eko club. With the aid of biology, chemistry and art teachers, the club researched and built a model of a system to pipe untreated well water from beneath the school to flush lavatories and water the school grounds. The local authorities were impressed and have funded the digging of a well and fitting of pipes. The school now has two water lines – one for lavatories and sinks using well water, the other for drinking water – and student volunteers ensure the right taps are being used. Best of all, the student-designed system has cut the school's water bills by 90 per cent.

Blaze Koneski Secondary School, FYR Macedonia, Volvo Adventure 2012 finalists

Blaze Koneski/Volvo Adventure

Ethan Welty/Aurora/Specialist Stock

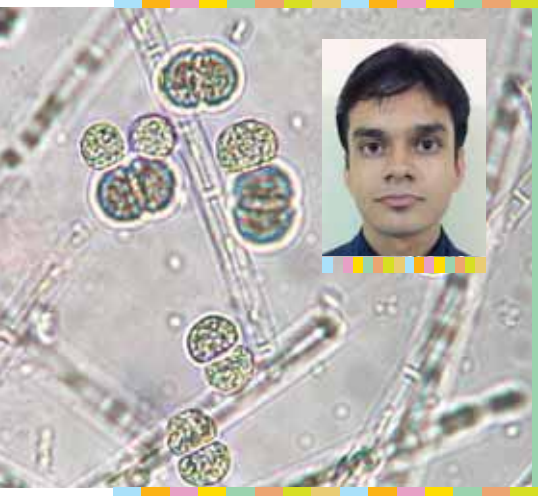
In Cuenca, Ecuador, the textile industry generates large amounts of wastewater contaminated by indigo dye, which contains harmful heavy metals and other pollutants. This water is discharged into the Yanuncay River, causing disease among the domesticated animals and people for whom the river is the principal source of water, as well as harming biodiversity. I am working on a bioremediation process using ligninolytic fungi. We have entered an initial implementation phase at a small factory, using the fungi to treat the wastewater in concrete containers. We expect it to take two to three months to achieve 80 per cent remediation. Widely applied, this could make a big difference to the health of the river and the community.

Maribel Tenesaca, Ecuador

In Singapore, people grow a lot of bamboo, which needs regular trimming. I teach secondary school pupils and community members how to use the bamboo waste to create 'constructed floating wetlands', biodegradable rafts that serve as growing platforms for plants that help clean polluted water in ponds and reservoirs. To determine which plants to use for bioremediation, we first test the water to determine what pollutants it contains, typically nitrates, phosphates and heavy metals, mostly from surface run-off. Once we know, the rafts simulate natural floating wetlands, providing breeding grounds for wildlife while improving water quality and preventing algal blooms. The project has, to my surprise, helped two species of bird and one species of dragonfly. Dragonflies are a very important bioindicator of water quality because they are very sensitive to pollutants. Their return proves that the system is really working. Keeping water clean also reduces the burden on water treatment systems, saving on electricity, chlorine and other chemicals used to treat drinking water.

Law Yu Hui, Singapore

Law Yu Hui



Kristian Peters/CC-BY-SA-NC 3.0

In rural India, centralized wastewater treatment facilities aren't economically viable, so wastewater is discharged from homes directly into the environment. I am researching ways of using algae that consume nitrogen and phosphorus to decontaminate wastewater locally. The algal biomass itself has many potential uses: for example, as an organic fertilizer or as a feedstock for the production of biofuels. So far, I've applied three strains of algae – *Chroococcus* sp.1, *Chroococcus* sp.2 and *Chlorella minutissima* – to wastewater and have observed that water quality improved to the standard of India's Central Pollution Control Board for surface discharge, suitable for irrigation. I've also recorded a steady growth in algal biomass within just 10 days. Now, I'm searching for a strain of algae that is resistant to changes in temperature.

Guarav Maheshwari, India

To make people aware of the importance of conserving water I installed a rainwater harvesting system – a simple tank system that collects rainwater from the roof and makes it accessible for anyone to use – on my university campus at Universiti Putra Malaysia. The water isn't treated, so it's not drinkable and can't be used in contact with skin, but it's good for watering plants and cleaning. The system saves fresh drinking water, and the university saves money on its water bills. The biggest challenge I had was convincing the university authorities to let me install the tank. Now that I've demonstrated how easy and practical it is, both they and my fellow students are enthusiastic, and I've had requests to install similar systems at other sites.

Nur Hazirah 'Aqilah Ramli, Malaysia

Nur Hazirah 'Aqilah Ramli

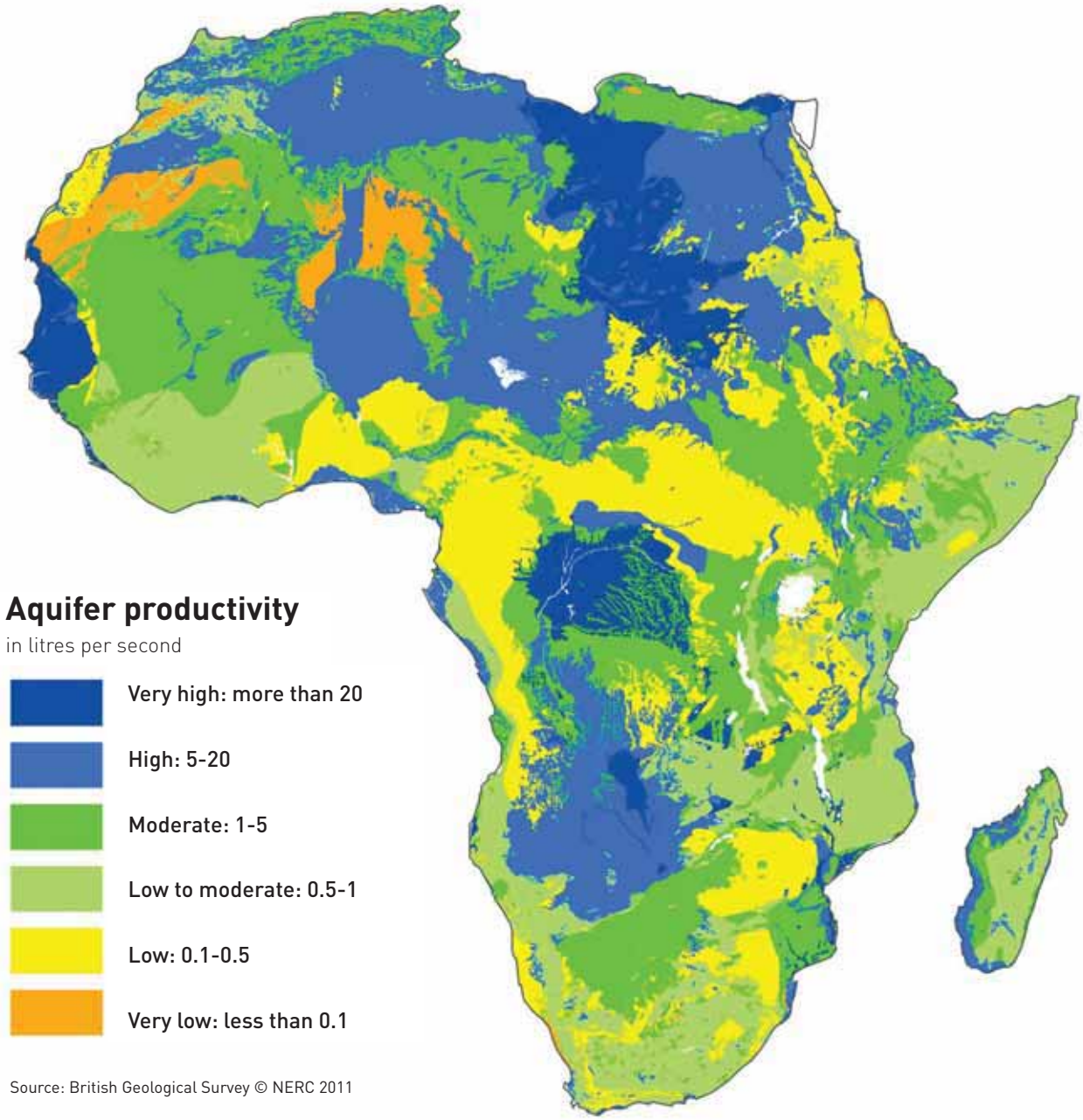
Muhammad Asri Bin Yacob

My mother sometimes forgetting to turn off the tap gave me an idea for a community water conservation project. Singapore's water resources are scarce, so we are always looking for ways to use them wisely. I came across a mechanical device that can be attached to taps to both control water flow and automatically turn taps off. I installed these in the houses of elderly people from lower-income families because they are more prone to leaving their taps running. Feedback has been positive, and I am now researching ways of designing and manufacturing my own water-saving device to suit more users.

Muhammad Asri Bin Yacob, Singapore

Africa's ancient aquifers

Africa has long been a focus of worry around water scarcity in a time of global warming and rising population. Now, all this might be about to change, as scientists have recently mapped vast reservoirs of ancient groundwater stored in sedimentary basins all over the continent, raising the possibility that they could be tapped as a resource. The majority of the groundwater is underneath northern Africa – Libya, Algeria and Chad – and is at least 5,000 years old. Because these so-called fossil aquifers have been sealed off from the hydrologic cycle and therefore not replenished for thousands of years, this paleowater cannot be considered a renewable resource. However, if the water is accessed and used mindfully, it could provide water for drinking and small-scale irrigation, helping the continent's people adapt to climate change. Used wisely to plant trees and vegetation, it might even encourage rainfall, which will help to replenish renewable aquifers and encourage moisture retention in the soil, improving environmental conditions on a long-term basis. The map shows what borehole yields can be expected.



Source: British Geological Survey © NERC 2011

Still waters

Philippe Prigent/UNEP/Topham

Seventy per cent of our blue planet is water but only 2.5 per cent of it is freshwater. Of this, almost 80 per cent is locked up in ice, including Arctic sea ice, the vast polar ice sheets of Greenland and Antarctica, and glaciers – the slowly moving 'rivers' of ancient ice and snow in polar and mountainous regions. Collectively, Earth's glaciers cover an area the size of South America, and billions of people rely on these vast frozen reservoirs for year-round water.

But for some time now, glaciers have been shrinking at an unprecedented rate as temperatures rise and not enough rain or snow falls to replace the ice that melts – some into the sea, some feeding rivers and lakes. Global warming? It certainly looks that way. Glaciers have been retreating since around 1850, but rates of melt seemed to accelerate in the last two decades of the 20th century, and have, on average, doubled since then. For example, the Greenland ice sheet – the world's second largest after Antarctica's – is melting ever faster, from a melt rate of 55 billion tonnes a year in the 1990s to 290 billion tonnes a year more recently.

Clearly, melting ice has a huge potential impact on our freshwater supply: the Himalayan glaciers alone feed seven rivers in Asia, providing water for 2 billion people. Along the Ganga river, retreating Himalayan glaciers are causing water shortages for 500 million people, who use more than a third of their water for irrigation. Kazakhstan's mountain glaciers also provide water for agriculture, while big cities in Bolivia, Ecuador and Peru all rely on the supply from glaciers for electricity generation as well as for drinking and irrigation.

Not just water

Persistent organic pollutants (POPs) – the harmful compounds found in such pesticides as DDT, industrial solvents and plastics – last a long time and bioaccumulate in the tissues of living animals, including humans, disrupting hormonal balance and causing cancers and other illness. POPs are now largely banned, but they are still around. Molecules that were transported in the air to cooler areas and locked in glacial ice are now being re-emitted into the environment as the ice melts. Ancient ice sheets also store microbial cells (bacteria and viruses), some of which have been living buried in ice for millions of years. Scientists are investigating how these might affect human life and our current ecosystems should they be released.

Rising tide

As land-based ice – glaciers and ice sheets – melts and flows into the oceans, it contributes to sea-level rise. (Melting sea ice, such as that in the Arctic, is simply floating seawater, so it doesn't contribute directly to rising water levels.) The average contribution of melting land-based ice used to be 0.2–0.4 millimetres per year, but this rate doubled between 1991 and 2004, and passed 1 millimetre per year in 2006. Sea-level rise affects coastal regions, causing flooding and erosion, and contaminating freshwater habitats and aquifers with saltwater. A global sea-level rise of 1 metre would displace 24 million people in Bangladesh, India and Indonesia, and inundate 80 per cent of the Maldives. Small islands are already losing land area, and are also particularly vulnerable to coastal inundation during severe storms, as happened during the December 2012 typhoon in Palau.

Habitat loss

Though glaciers may seem uninhabitable, they are actually home to a variety of organisms, including sea birds like the Kittlitz's murrelet, which feeds where glacial water enters the ocean, and the ice worm, which disintegrates at temperatures over 5°C. Even distant biodiversity is affected by glacial melt: as sea level rises, it will affect corals' access to sunlight for photosynthesis, reducing their growth. One study predicts that some Caribbean corals will not be able to cope with projected sea-level rise, which will have a devastating effect on the marine ecosystem and the human beings who rely on it. Even further away, the mangrove forest habitat of the royal Bengal tiger is under threat from rising waters.

Bursting forth

As glaciers melt, the excess water forms natural lakes contained by sediments. Sudden breaching of these glacial lakes due to a build-up of water – sometimes made worse by seismic activity – causes catastrophic outburst flooding, unleashing millions of cubic metres of water that rushes downhill, devastating everything in its path. This is a serious hazard for all regions with melting glaciers, particularly in the Himalayas and Andes.

UNEP/Topham

Where on Earth?

In Antarctica

Antarctica's vast ice sheets hold about 95 per cent of the planet's frozen freshwater. Melting is happening beneath the glaciers at the juncture between land and sea, and floating ice shelves are also thinning and breaking up. The Antarctic ice sheet currently appears to be getting thicker in some places, but scientists aren't sure whether this accumulation is enough to compensate for the loss of ice at the edges.

In Greenland

Second only in size to Antarctica's ice sheet, Greenland's ice is more than 100,000 years old and covers nearly 2 million square kilometres. But it has diminished by more than 16 per cent in the last 30 years. Climate change models suggest that temperature rises this century in Greenland could be as high as 9°C, endangering this huge mass of ice. Were it all to melt, sea levels would rise by around 7.2 metres.

In Asia

Most of Himalaya's glaciers have been thinning and retreating for three decades. The glaciers in the Bhutan Himalayas are retreating at a rate of up to 40 metres annually, and the Tien Shan glaciers in Kazakhstan have lost an average of 0.7 per cent of their total mass every year since 1955, for example.

In Europe

Glacier melt in the Alps has accelerated since 1980, with up to 20 per cent of Alpine glaciers lost within two decades.

In Africa

The ice fields that topped Mount Kilimanjaro for 10,000 years are now likely to disappear by 2020. Of the 18 glaciers that existed on Mount Kenya in 1900, seven have disappeared and four more have lost between 60 and 92 per cent of their area.

In the South Pacific

The Carstensz Glaciers in Papua Province, Indonesia, lost 80 per cent of their collective area before 2000, while the West Meren Glacier had melted away by 1999. New Zealand's Southern Alps have lost a quarter of their area since the mid-1850s, though they have advanced in recent years.

Benoit Chalifour/UNEP/Topham

R. Dirscherl/WaterFrame/Specialist Stock

Milo Burcham/Alaska/Specialist Stock

Hans Otto/UNEP/Topham

Message in a bottle

TODAY, according to the United Nations, almost 90 per cent of all people have access to clean drinking water. This is, however, a fairly recent phenomenon, even in the developed world, where safe water flowing out of taps for cooking, drinking and washing has only been available to all for around 50 years. Yet, more or less simultaneously, it has become the norm almost everywhere to sip specially bottled water from single-serving plastic bottles.

Ancient tradition

Water that bubbled from the ground in natural springs has been prized for its minerals and purity since the days of the Roman Empire, more than 2,000 years ago. In places like Baden-Baden, Germany, and Bath in the United Kingdom, 'taking the waters' became highly fashionable, as people believed these Roman spas conveyed an array of health benefits – from improving fertility to curing kidney stones. These medicinal values, along with a growing understanding that dirty water is a real health hazard, are the origin of today's global bottling industry.

David Iliff/CC-BY-SA 3.0

Initially, the bottling of water was an attempt to share the health benefits of such waters as Evian from France, San Pellegrino from Italy or Germany's Fachinger – the favoured drink of literary giant Johann Wolfgang von Goethe. But the bottling industry also aimed to evoke the sophistication and luxury of spa towns. And then in the 1970s and 1980s, bottled water came to be seen as more healthy than tap water, which was considered less tasty or safe – both assumptions that have been scientifically disproven. By the mid-2000s, bottled water was the fastest growing product in the global drinks industry, with consumption more than doubling between 1997 and 2005. Today, bottled water is considered by many to be a must-have accessory.

Who in the world drinks bottled water?

In some places, bottled water really is the safe option, particularly in the developing world. But bottled water is mostly consumed in industrialized countries where it is least needed. The USA and Europe are leading consumers of bottled water.

Today, bottled water is becoming increasingly popular in less developed nations, too, as rising incomes allow people to buy it. But this is happening in areas where the tap water has been improved, even if it was once known to be poor. For example, the world's highest per-person bottled-water consumption is in Mexico, despite the country's significant efforts to bring clean tap water to its citizens. The public still mistrusts water quality and therefore buys bottles of purified water from local vendors.

But as so often happens, there is a real problem: those with the greatest need for clean drinking water are both the least able to afford it and the least likely to buy it. For them, bottled water remains a hopelessly expensive luxury.

The environmental consequences

There's no question that the growing demand for bottled water – currently about 114 billion cubic metres per year – is an environmental issue. Withdrawal of mineral or spring water from natural sources can threaten streams and groundwater. The bottles themselves are made from millions of tonnes of plastics, typically polyethylene terephthalate (PET). Around 31 billion 1-litre water bottles are being consumed annually in the USA alone, requiring more than 17 million barrels of oil to produce. And most PET bottles also contain bisphenol A, an endocrine disruptor that has been linked to

cancers, diabetes, and neurological and reproductive problems.

Most of these water bottles are not recycled, but go to landfill or are dumped into the oceans, where they can take up to 1,000 years to decompose. And of all the PET bottles that are sent to recycling – about a third globally – many are shipped around the world for processing into lesser-quality plastics.

Then there's the energy required to ship water around the world, not to mention refrigerate it. Can it really be sustainable to transport water the 9,000 kilometres from Fiji to California or the 16,500 from Fiji to Paris? And it takes water to produce bottled water – about 3 litres per 1 litre bottled.

Bottled water is also incredibly expensive – at least a thousand times the cost of municipal water. Ironically, up to 40 per cent of water bottled in the USA comes from municipal taps anyway!

Slowing down

Things may be changing. According to recent data, the increase in the US bottled water market is expected to be smaller this decade. On university campuses across the continent, student movements are encouraging administrations to stop stocking bottled water in vending machines and canteens, and are promoting reusable water bottles stamped with college logos.

Joe Ravi/CC-BY-SA-3.0

Cities, too, are joining the battle to reduce plastic waste and cut carbon footprints. In 2009, the Australian town of Bundaboon banned bottled water completely, and in the same year the city of Paris installed a public drinking fountain at Jardin de Reuilly, flowing with both still and sparkling water. In London, the Find-a-Fountain campaign offers an online map enabling people to find public sources of free, clean drinking water (www.findafountain.org), while the majority of US mayors have voted to phase out bottled water from local-government offices.

Ultimately, the bottled water habit comes down to us. We convinced ourselves that we need it; now we must train ourselves out of our dependence. Part of the solution is investment in water and sanitation infrastructure, but, even more importantly, consumer trust in the goodness of what flows from the tap has to be built.

Remember, choose tap water whenever possible. It's a simple, cost-effective way of reducing your carbon footprint and playing your part in encouraging sustainability.

Cheers!

In places and times when clean drinking water was a scarce commodity, people came up with ways of making drinks safer, from boiling water and making coffee, tea and herbal infusions to drinking fermented alternatives such as beers from grains, and wines from fruit, honey, cactus plants and other sources of sugar. The fermentation process produces alcohol, which kills harmful microbes and preserves nutrients.

Chicha, a traditional drink from South America, is made from ground maize or cassava, which is chewed and fermented with warm water.

Kumis is an ancient Central Asian drink fermented from mares' milk.

Banana beer, a popular alcoholic drink throughout Africa known as ***urwaga*** in Kenya and ***lubisi*** in Uganda, is made by extracting juice from ripe bananas, mixing it with sorghum flour and water, and leaving it to ferment for up to 24 hours.

Mead, a drink fermented from honey, has been around for at least 9,000 years. Ancient Greeks, Mayans and Indians all made and drank variations of mead, and it is still popular in Nepal, where it is called ***dandaghare***, across to Ethiopia, where ***tej*** is highly alcoholic and ***berz*** is weaker.

Bottled water consumption

Countries where consumption exceeds 100 litres per person per year

	2000	2005	2010
Mexico	124	179	243
Italy	160	191	187
United Arab Emirates	114	181	153
Belgium/Luxembourg	118	160	148
Germany	102	128	134
France	126	139	132
Spain	105	146	124
Lebanon	77	107	121
Thailand	70	77	114
Hungary	39	70	111
Switzerland	90	104	108
USA	67	99	107
Slovenia	56	81	107
Croatia	47	78	101

Source: www.worldwater.org

Small solutions, **big results**

By Fred Pearce

Rutty Rajmohunsing/UNEP/Topham

Water is what limits the productivity of many of the world's farms. But in many places, rains are scarce and unpredictable. Moreover, modern high-yielding crop varieties often need more water – and more regular water – than old varieties. So, with 7 billion people now needing to be fed around the world, increasing numbers of farmers are using irrigation to grow crops where none grew before, or to increase yields on existing fields.

Until recently, widespread irrigation almost always meant relying on governments to deliver water. Only governments could build the megadams that capture water by barricading the world's biggest rivers. Only governments could build the thousands of kilometres of canals that then delivered the water to farmers. But, with many irrigation schemes badly built and inefficiently run, the amount delivered was often not very much.

So farmers have begun taking water supply into their own hands, with spectacular results. They are buying newly available Chinese pumps, now on sale in farm stores across the world for as little as $200. The farmers take their pumps to the riverbank or attach them to boreholes sunk beneath their fields. Hey presto, they have water whenever they need it.

Today, more than two-thirds of all the water that people take from nature is used by farmers to irrigate their crops. And more and more of that is the result of farmers' own efforts. Suddenly, giant government irrigation schemes look like yesterday's solution.

But is there enough water for all these pumps? Not always. In drier states in India, farmers are pumping so much water that they are destroying the reserves. In some villages, underground water levels are falling fast. With no government control, it has become 'hydrological anarchy', says Tushaar Shah of the International Water Management Institute's (IWMI) groundwater research station in Anand, Gujarat. The only solution, now adopted by Gujarat state government, is to restrict electricity supplies to the farmers to eight hours a day.

But elsewhere, including much of Africa as well as India, there is still plenty of water, and not just underground or in rivers. Many farmers are tapping the rains themselves. Haradevsinh Hadeja, a retired Indian village policeman, encouraged fellow inhabitants of Raj Samadhiyala village to dig channels and earthworks to catch the monsoon rains that fall for three months of the year. They divert the floodwater into ponds, storing it for use during the long dry season. Now they get three crops a year rather than one. They call this technique 'rainwater harvesting', and it is now taking off in Africa, too.

Often, we hear about poor farmers being the victims of poverty, climate change and other problems. But when it comes to water, today's farmers are the technological innovators. They are finding solutions to problems that have defeated the best government scientists and engineers. That's good for them and good for us.

Fred Pearce

Secret revolution

'Cheap pumps are transforming farming and boosting income all over Africa and Asia,' says Meredith Giordano of the International Water Management Institute (IWMI), based in Sri Lanka, who's just finished a three-year study, *Water for Wealth and Food Security*.

Indian farmers alone have installed more than 20 million pumps. They are so popular that farmers with pumps are hiring them out to fellow farmers. The going rate is about a dollar an hour. In India, they take them round the villages on bicycles or donkeys.

In many parts of the world, big government irrigation projects have been expensive failures. A study for the World Bank, which funded many schemes, found that a quarter of them delivered only a third of the water their designers had promised. Just down the road from the riverside pumps on the River Hadejia in northern Nigeria, the expensive state-run Kano irrigation project sits largely empty, with canals clogged by weeds, fields untended and water evaporating in the sun.

Meredith's report says that governments should often forget about building more old-style irrigation projects and get behind this hidden revolution. It could increase crop yields three-fold in some places. But will they? Many governments know nothing about it. In Ghana in West Africa, farmers' pumps irrigate 25 times more land than government projects. As IWMI's recently retired director Colin Chartres explains: 'When I asked the agriculture minister there about these schemes, he hadn't even heard of them.'

Fred Pearce

Transforming lives

Hundreds of pumps were lined up on one short stretch of bank on the Hadejia River in northern Nigeria. Chugging away noisily in the sun, the diesel-powered motors were sucking water from the river, and pouring it onto nearby fields where corn and sorghum grew. Ten litres a second, for hour after hour. Up and down the river, thousands more pumps were doing the same. All this on the edge of the Sahara desert. Without the pumps, the fields would be dry and the crops dead.

A continent away, in the Indian state of Gujarat, Jitbhai Chowdhury powers up his own electric pump to bring water up from the rocks to irrigate his two small alfalfa fields. He feeds the crop to his cows, which he milks every day to supply the local dairy. Millions of farmers across India are doing the same thing.

There is a new sound in the countryside across Africa, India and many other poor parts of the world. It is the sound of tens of millions of small Chinese-made pumps, powered by diesel or electricity. They are irrigating fields that would otherwise be dry, and giving livelihoods to people who would otherwise have left the countryside for the city slums.

Most of this has happened in the past decade. It is a rural revolution that has only recently begun to be noticed. Yet it is transforming the lives of millions of peasant farmers, and changing the way water is managed across huge areas of the planet.

Sean Sprague/Still Pictures

Farmers' ingenuity

Where water is short, many farmers are trying to use water more efficiently. Most irrigation schemes are hugely wasteful: often only a third of the water poured on to fields reaches the roots of plants. The rest is lost, evaporating into the sky or seeping underground.

The solution is to get smart. The best way is drip irrigation: rather than just flooding fields, farmers lay pipes with holes so the water can drip into the soil close to plant roots. Until now the pipes have been too expensive for most farmers, but about 15 years ago somebody had a brilliant idea. He, or more likely she, thought of replacing expensive pipes with the cheap polythene tubing that street sellers all over India use to package ice lollies. These come in long rolls stamped with perforations, which the lolly sellers use to tear off each individual lolly container. It turns out that the perforations are perfect for dripping water onto the soil.

So the farmers lay the plastic tubes across their fields near plants, fill them with water and wait for the drips of water to irrigate their crops. It is cheap and very efficient.

More food, less water

Drought has always been with us – civilization has long had to contend with lengthy periods of lack of rainfall. But as Earth's climate changes, scientists are worrying about droughts becoming more severe, particularly affecting the world's arid and semi-arid areas, where 40 per cent of our crops are grown. Drought is the most common cause of severe food shortages in developing countries, and caused more deaths than any other natural disaster in the 20th century.

Countries already affected by water scarcity are especially vulnerable to drought. This is a real and growing problem: around 700 million people in 43 countries already suffer from water scarcity, and it's predicted that by 2025, 1.8 billion people will be living in water-scarce regions, and two-thirds of the world's population will be living in water-stressed conditions. This will seriously affect farmers' ability to produce enough food to feed growing populations.

In 2011, severe drought led to food shortages and deaths in the Horn of Africa, affecting 13 million people and leading to famine in Somalia. The following year, the USA saw its most severe drought in at least 25 years, damaging soybean and maize crops and raising the global price of food.

Ronnie Israel/Specialist Stock

J. Giustina/Wildlife/Specialist Stock

Thundafunda

Jemima Griffiths

Plants for a thirsty planet

Clearly humanity needs to find a sustainable way to feed itself. To that end, plant breeders are hurrying to develop crops that use water efficiently while maintaining healthy yields.

Some traditional crops already have drought resistance built in – for example sweet potatoes, cassava, pigeon peas, chick peas, cow peas, sorghum and pearl millet. Kenya's ministry of agriculture, amongst others, is promoting such crops as alternatives to traditional staples like maize to help farmers cope with climate change. These and other crops are being further bred to improve their resilience.

For crops that are more sensitive to moisture levels, such as wheat, maize and rice, plant breeders are looking for ways to increase their capacity to use water efficiently. One approach, for example, is to cross wild relatives of wheat with existing domesticated varieties in order to access the drought-resistant traits of the former. Tinkering with plant genes to develop desirable traits used to take generations, but recent progress in plant biotechnology and DNA sequencing allows scientists to much more rapidly identify useful genes and directly introduce them into plants to test their efficacy – whether they are looking to create a higher-yield, drought-resistant variety of wheat or a salt-tolerant strain of rice.

Did you know...?

Dry rice

Rice fields don't need to be submerged in water in order to thrive. Using an alternative wetting and drying technique for rice, farmers insert bamboo tubes into the soil to determine the moisture level below ground, and only pump water into paddy fields if it falls below 10 centimetres from the surface, reducing water use by at least 30 per cent and methane emissions by 75 per cent. The technique is used with drought-resistant 'aerobic' rice and is being rolled out in Asian countries including Thailand and Bangladesh.

Identifying drought resilience

Scientists from the USA and China have found a quick way to measure the drought tolerance of plants by identifying the 'turgor loss point', the point where leaf cells become so dehydrated that their cell walls become limp. Measuring leaves using a method called osmometry allows researchers to make fast estimates of the drought tolerance of various species. The method works for diverse plants across ecosystems around the world, offering potential for quickly identifying species that may be threatened by climate change.

D. Harms/Wildlife/Specialist Stock

Team work

When there's not much water in the soil, roots partner up with microbes, such as bacteria, that help the plant photosynthesize and grow more efficiently. Scientists understand well the effect of drought on plants – when they become dehydrated, they lose their ability to photosynthesize and grow. But researchers are just discovering that lack of moisture around plants' roots causes microbial communities around the roots to grow, helping the plant to increase photosynthesis by up to 40 per cent and enabling plants to survive in times of drought. The implication: healthy plants are actually metaorganisms of plant and microbiome. This knowledge may help scientists develop higher-yielding plants that require less water.

Plant stress response

When plants are water stressed, they respond by activating molecules which in turn switch on processes that help the plants cope, such as closing guard cells on leaves to help reduce moisture loss, stopping growth to reduce water consumption, and so on. Scientists have discovered how to heighten this natural response in plants, which will help them survive better in dry conditions.

K.J. Smith/UNEP/Topham

The dry garden

Want a garden but have little rainfall? Here are a few tips to help your plants, wherever your garden grows!

- Before you plant, dig organic matter into your soil to help it retain moisture. Good choices include leaves, compost, animal manure, crop wastes and so on.
- To retain moisture in your bed and prevent the growth of weeds, spread with a layer of mulch, whether hay, straw, bark, or even pebbles or gravel. One clever way to rid your bed of weeds and mulch it at the same time is to put a layer of cardboard or newspaper on the soil, and cover that with a layer of mulch. Cardboard covers encourage earthworms to stay in the cool, moist soil and improve its quality, while decomposing roots provide organic matter deep in the soil, and allow water and air to penetrate.
- Prevent evaporation by watering in the early morning or late afternoon. Better yet, set up a drip irrigation system – a line of pipes that sit at the base of your plants so that water can seep out slowly and be absorbed directly into the earth near the roots. You can also create a slow-release watering system using recycled plastic bottles with holes poked into them and half-buried in the soil next to your plants. Just fill the bottles with water and liquid compost as necessary.

Dag Endresen/CC-BY-2.0

R. Giling/Lineair/Still Pictures

Mickey Liaw/CC-BY-NC-2.0

Flushing away gold?

No one likes to talk about the management of human waste, but it's a life-or-death matter that links human and environmental health. And at a time when freshwater and energy resources are diminishing, perhaps the discussion should focus on how not to waste our waste.

Until now, the primary aim of sanitation systems has been to keep excrement out of contact with human beings. Over the millennia there have been many variations on the toilet: in ancient Egypt sand was used in lavatories; on the island of Crete in around 1600 BC the Minoans had water-based sewerage systems; the Romans built sewers for the collection of waste and rainwater and pioneered public lavatories; and toilet paper was first used in China around 1,500 years ago.

When flush toilets and sewage systems became the standard in Europe, water was plentiful. On the principle that dilution made wastewaters safe, raw sewage was flushed into rivers, streams and oceans. It was only 150 years ago that it was fully recognized that waterborne pathogens cause disease, leading to the development of today's wastewater treatment, which separates solids from liquids and cleans the liquids for reuse, while incinerating or burying the remaining sludge.

While this system has greatly reduced disease, sewerage systems need complex infrastructure and a lot of water: current systems require 50-100 litres of water to remove up to 1.5 litres of human excreta per day. Further, wastewater treatment requires energy, and while decontaminated water and sludge can be put to good use, we are producing more than we can manage. And remember, it costs around $1,000 per person to install and maintain sewers.

Today, more than a third of the world's population, some 2.6 billion people, have no access to adequate sanitation and 1.1 billion people have no access to any sort of toilet. Instead, they have to defecate wherever they can, including in rivers and fields, polluting surface and groundwater and transmitting disease. Clearly, it's time for a rethink.

Reinventing the toilet

Providing clean and safe sanitation can really transform people's lives, reducing diarrhoea in children by a third and increasing school attendance, particularly for girls – amongst other benefits. And at a wider scale it helps with development: for every $1 invested in sanitation, nations can see a return of more than $9 in increased productivity, lower healthcare costs, less illness and fewer untimely deaths.

Understanding this, the **Bill and Melinda Gates Foundation** has challenged inventors to engineer a toilet to process human waste into a resource without the need for running water, electricity or a septic system – at a cost of less than 5 cents a day. Innovative schemes are being worked on around the world.

A self-contained, solar-powered toilet and wastewater treatment system that breaks down water and human waste has been designed by the **California Institute of Technology (USA).** Excess power generated will be stored to provide a backup energy source for night-time operation or use under low-sunlight conditions.

In the Netherlands, Delft University of Technology is using microwave technology to transform human waste into electricity. The waste is turned into a gas, which can then be fed to a solid oxide fuel cell to generate electricity.

The National University of Singapore is experimenting with biological charcoal (biochar) to dry and combust faeces. The heat generated will be used to extract water from urine by boiling it under pressure. The system can be further improved using activated carbon and ion-exchange resins to recover highly purified water.

The University of Kwazulu-Natal, South Africa, is developing a system that can safely dispose of pollutants and recover materials such as water and CO_2 from urine in community bathroom blocks.

In India, Eram Scientific Solutions hopes to make public toilets more accessible to the urban poor using the eco-friendly and hygienic eToilet, which can be maintained and operated remotely, improving local services in terms of both quality and consistency.

RTI International (USA) is developing a self-contained toilet system that disinfects liquid waste and turns solid waste into fuel or electricity through a revolutionary new biomass energy conversion unit.

The University of Colorado Boulder (USA) is using sunlight, directed and focused with a solar dish and concentrator, to disinfect liquid-solid waste and produce biological charcoal (biochar) that can be used as a re-

placement for wood charcoal or chemical fertilizers.

Using the natural world

Compost toilets use no water, instead dehydrating waste using sawdust, ash, grass, straw or peat. Organisms such as worms and aerobic bacteria break waste down into liquid and solid organic fertilizers. The heat and bacteria also destroy pathogens and viruses, making the compost safe to use.

The Living Machine is a patented wastewater treatment system modelled on the principles of wetland ecology. The system, which can be installed in individual buildings as well as in larger complexes and communities, uses a series of basins filled with gravel that promotes micro-ecosystems that include aquatic and wetland plants, algae, freshwater clams, snails, plankton and beneficial bacteria. Water is moved through the basins and then drains away, clean and reusable.

Japanese enterprise

The Japanese are highly imaginative when it comes to finding good uses for human waste.

Brick house

The Fujimi Tile Company of Nagoya, Japan, has invented a process for manufacturing bricks from a clay comprising sewage sludge ash, ceramic raw materials and recycled tile debris. It's moulded and baked into a highly porous brick that lets water seep into the ground, eliminating the need for drainage systems.

Poo burger

Scientist Mitsuyuki Ikeda has developed a low-carbon, low-fat meat alternative from proteins extracted from sewage sludge. While this seems unlikely to take off, the scientist thinks some environmentally responsible diners will be keen to close the consumption loop.

Poo power

This three-wheeled prototype motorcycle is powered by poo – biogas generated from livestock waste and household wastewater. The waste and water go through a fermentation process to create methane, which is then purified to make biogas. The prototype motorcycle demonstrates the possibilities of using excrement as a fuel source, but is only for show. Fortunately, so is the toilet seat: the vehicle doesn't require the rider's excrement for fuel!

TOTO

Natural fertilizers

For millennia, people around the world have used human excreta on fields as fertilizer, making good use of the energy and nutrients it contains, such as nitrogen, potassium and phosphorus.

Today, the same principle is used in the application of sewage sludge to agricultural fields. After sewage is processed to extract and clean wastewater, what's left is a semi-solid mass known as biosolids. Good-quality, uncontaminated biosolids are applied to fields around the world, especially in Europe and Japan. But fertilizing fields with biosolids must be done with great care, because biosolids can contain pathogens, heavy metals, industrial chemicals, pharmaceuticals and so on.

Biosolids can also be used for forest remediation, to fill landfill sites and for urban landscaping. They are a useful feedstock for biodigesters or can be incinerated for heat recovery and electricity generation. Biosolids can even be used as a building material, such as for pavement materials or building bricks.

City of Fayetteville, Arkansas

7 water innovations

Faisal Chohan/Pakreport.com

Mapping waste

Due to lack of sanitation, waterborne diseases like cholera are the second biggest killer of children in South Asia. In Pakistan, for example, only 18 per cent of the population has access to proper sewerage infrastructure. Young tech entrepreneur Faisal Chohan decided to help solve this problem. In 2010, during catastrophic flooding in Pakistan, he implemented Pakreport.com – an online platform that allowed ordinary citizens to send in flood information by SMS, which was then mapped in real-time and made available both to disaster-response teams and to the public. Today, Faisal is applying this system to map the sewerage infrastructure in Rawalpindi, the fourth largest city in the country. The project will enlist the help of citizens to report on the city's open sewers and places where untreated waste is dumped into waterways. Faisal hopes the public maps will raise both awareness and investment. Subsequent mapping will track both improvements and instances of waterborne diseases, to show the relationship between sanitation and disease. Rawalpindi is just the first: Faisal plans to implement the scheme in cities around the world.

DMS Ltd/www.dmsltd.com

Smart water

Traditional water meters are only checked every few months. And some municipal water systems don't measure actual use at all, instead billing according to an average. With water such a precious resource, it's the right moment for 'smart' water meters – those that measure water use in a household as it's being used, offering feedback on consumption and savings. New technologies involving water meters with sensing capabilities are now being developed and installed in existing water infrastructure in the USA, Australia, Europe and beyond to create the so-called 'smart-water grid'. Systems can measure water use at 15-minute intervals, warn of possible leaks, allow for accurate billing for water consumers, and keep people conscious of how much water they are using, which often leads to behavioural change. It's good for economies, too: as citizens, municipalities and technology companies have woken up to the real need for conserving water, investments in smart water solutions are forecast to grow by $3.3 billion by 2016.

J. Schultz/UNEP/Topham

From thin air

We've heard of making fuel from algae or maize. But out of air and water? Researchers at Air Fuel Synthesis (AFS) in the UK have developed a way to combine atmospheric CO_2 with hydrogen split from water vapour and turn it into petrol that can be used in existing fuel tanks. The science is not new, but the process is, and the team hopes it will be efficient enough for production on a commercial scale. But of course it takes energy to make energy, so to solve this conundrum, the AFS is looking at renewable energy sources to make fuel production sustainable. In fact, the fuel may be most suitable for small island states with abundant renewable energy resources such as solar, wave or wind power, but with less access to fossil fuels. AFS plans to build a commercial-sized plant that can produce a tonne of petrol daily within a couple of years, and a refinery-scale operation within 15 years. Meanwhile, the fuel is first likely to be used blended with conventional petrol.

Shower-free shower gel

In regions where drinking water is scarce, people are not able to wash frequently. Yet it is necessary to maintain health. When high-school student Ludwick Marishane – who grew up in a chronically water-short area of South Africa – discovered that 500 million people are at risk of trachoma, a disease that causes blindness and is preventable by face washing, he decided to develop an inexpensive, effective cleanser that could be used without water. He came up with DryBath, an antibacterial gel that creates an odourless biodegradable film that cleans and moisturizes skin. The product is already saving water and improving lives: it is sold for 50 cents per packet to corporate customers such as airlines, hotels and the military, and for each packet sold, another is made available to communities in need.

DryBath

Pasteurization Technology Group

Closed loop

Pasteurization works to sterilize milk, fruit juices and other foods; why not use it to disinfect wastewater and produce renewable energy at the same time? US-based Pasteurization Technology Group's new approach to wastewater treatment uses solid waste extracted from sewage to feed biogas digesters, which generate electricity to be used onsite or sold to the grid. The excess heat from electricity generation is used to bring wastewater to 82ºC, ridding it of pathogens. Cooling the outgoing pasteurized wastewater in a heat exchanger simultaneously helps to heat incoming wastewater. The self-contained technology, which obviates the need for chemicals such as chlorine, requires less than 3 per cent of the energy typically needed to disinfect wastewater. It's currently in the optimization phase, but is capable of processing a large amount of effluent – enough to serve municipalities, as well as food-processing and energy companies, cities and towns, and agriculture.

Lifesaver

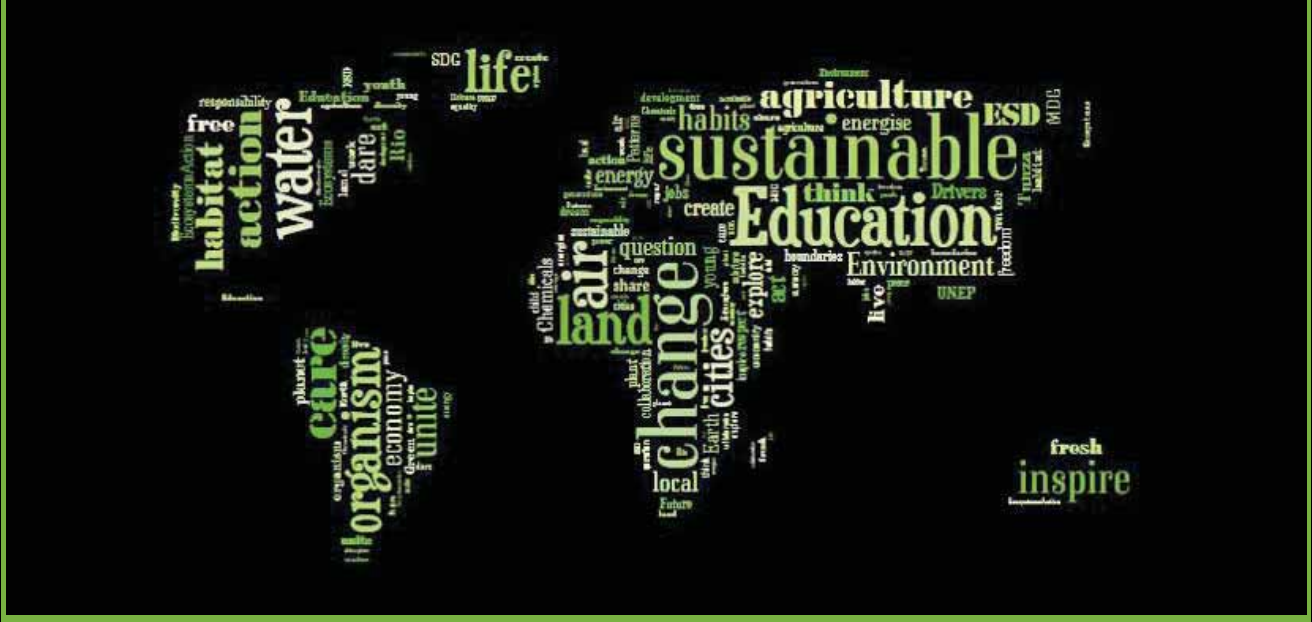
Water at source

When tragedy struck the world in the in the form of the Asian tsunami of December 2004 and Hurricane Katrina in 2005, water treatment expert and engineer Michael Pritchard watched in dismay as disaster victims waited for clean drinking water to be delivered. In response, he invented the Lifesaver Water Bottle and the 18.5-litre Lifesaver Jerry Can, which use a nanofilter – a membrane with 15-nanometre holes – to filter out both debris and pathogens. (The smallest bacteria are about 200 nanometres – or 200 billionths of a metre – and the smallest virus is 15 nanometres.) The bottle's filter can produce 6,000 litres of safe drinking water before it needs to be replaced, while the jerrycan's filter can produce 20 tonnes, and the devices stop working automatically when it's time for a change. Lifesaver products are being deployed around the world for disaster relief, distributed to military personnel, and sold to adventure travellers.

Water Canary/Sonaar Luthra

Canary in the watermine

Water safety is a life-or-death issue for all of us, yet traditionally, the equipment needed to test it is expensive and time consuming, and requires specialist knowledge. Now there is an inexpensive, easy-to-use device under development that gives results immediately, then transmits the GPS-tagged information over mobile networks, alerting authorities and helping to prevent widespread disaster. The Water Canary, developed by Indian-American Sonaar Luthra, is an open-source invention that uses spectral analysis – shining light through water – to determine the presence of contaminants, nutrient pollution and volatile chemicals, indicating safety levels with a red or green light. The system can be used both for continuous monitoring and in post-disaster situations, directing water-safety professionals to hazards.



CHANGE STARTS **HERE AND NOW**

As THE THREE YOUTH EDITORS, ANDREW (CHUCKY) BARTOLO, SABA LOFTUS AND KARUNA RANA, say: 'We all have a responsibility to implement sustainable solutions ... we can no longer wait for someone else to fix things. The time for action is now. Don't wait until it is too late to make a difference! Change has to start with each of us.'

Building on UNEP's flagship ***Global Environment Outlook 5*** (www.unep.org/GEo/geo5.asp), ***GEO for Youth*** (www.unep.org/tunza) has been developed as a resource for young people everywhere. It fills the reader in on the state of the world's environment, and explains current thinking on where overall trends are likely to take us.

But *GEO for Youth* isn't just another publication suggesting we are on the road to ruin. It is a positive document that presents a plethora of examples from around the world showing how we can all get involved and change things – starting in our own communities.

GEO for Youth **is easy to assimilate and act on. It is presented in three main sections that inform, entice and inspire.**

1. **Our World and its Challenges Today** reports on where we are and provides case studies highlighting successful action from around the world – encouraging you to create your own success stories.

2. **The Future We Want** explores the process and impact of Rio+20 from a youth perspective. As 25-year-old Aashish from India explains: 'We are all in this together; it's not just for policy wonks, super scientific or nerdy types. We all must, we all should and we all need to keep working on creating a world that enhances our well-being and respects the finite nature of our planet. And we can all do this right now.'

3. **Change Countdown** introduces key concepts like the green economy and education for sustainable development. It also introduces One-One, UNEP's invitation to you to make one change that takes a specific unit of time. So, what can you do in just one second, minute, hour or week to create change?

GEO for Youth **challenges young people to get active, make the world one in which you want to live and one in which you want to participate by:**

- **reaching out and sharing information.** Sufficient information on the current environmental crisis and possible solutions is easily available. But not everyone has access to it, and billions of people don't see why they should care ... it's up to all of us to say something and raise awareness – no one else is going to do it if you don't.

- **convincing people to move towards sustainable development.** How do we convince individuals, organizations and governments to make sound choices to ensure a sustainable future for us all?

- **bringing about behavioural change.** Once we have convinced people of the ideas, how do we ensure that words are converted into action? Science, technological innovations and policies alone will not save us; changing behaviour is just as vital, even though it takes more effort.

So, dive in, get informed, be inspired, and use *GEO for Youth* with your friends, your family, your school, your organization and even your governments.