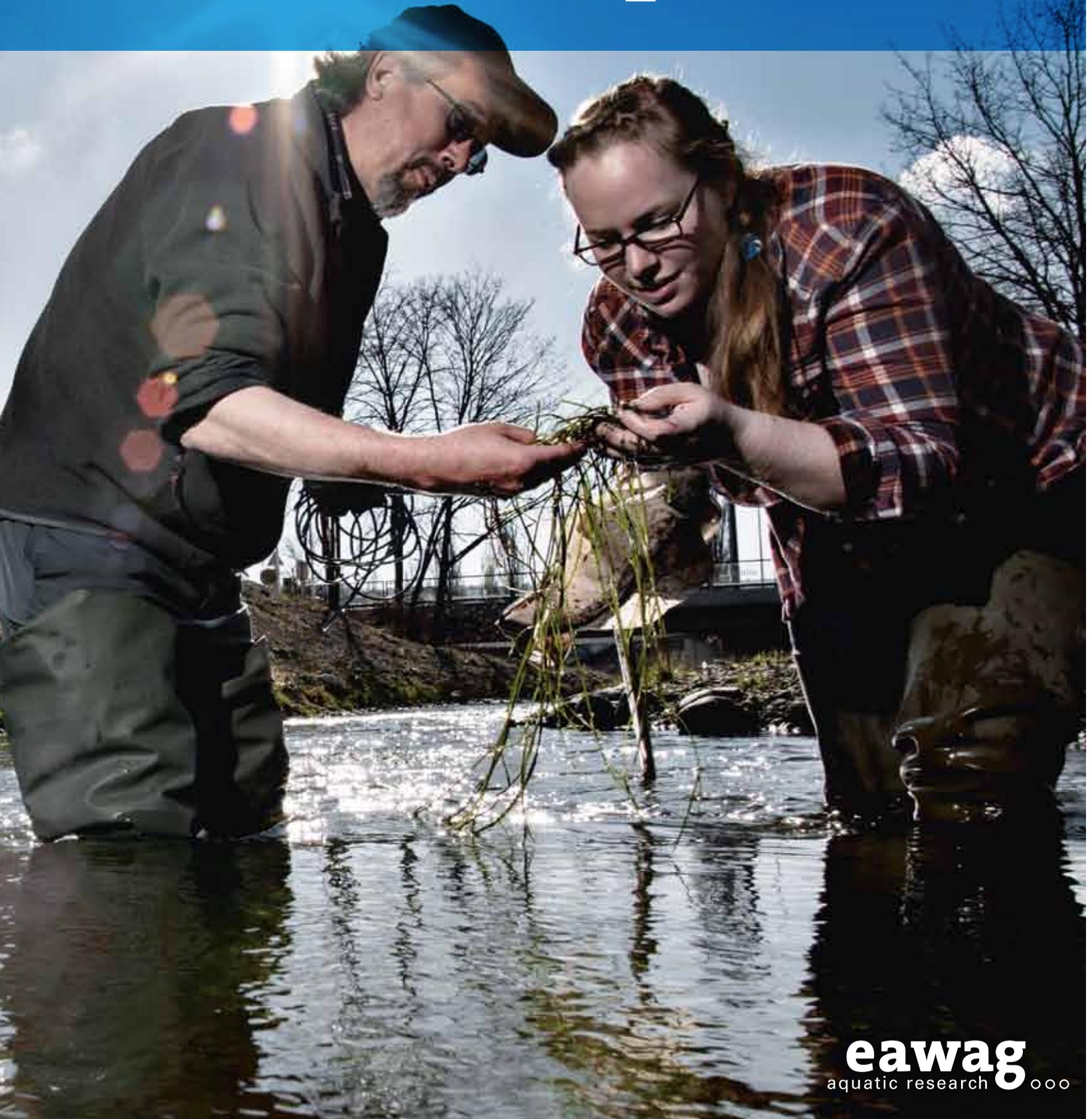


# Annual Report 2013





Eawag, the Swiss Federal Institute of Aquatic Science and Technology, is part of the ETH Domain. This comprises the Swiss Federal Institutes of Technology in Zurich (ETHZ) and Lausanne (EPFL), Eawag and three other independent, application-oriented research institutes – the Paul Scherrer Institute (PSI), the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) and the Materials Science and Technology Research Institution (Empa). Nationally rooted and internationally networked, Eawag is concerned with concepts and technologies for the sustainable management of water resources and aquatic ecosystems. In cooperation with universities, other research centres, public authorities, the private sector and NGOs, Eawag strives to harmonise ecological, economic and social interests in water, providing a link between science and practical applications. In total 486 staff are employed in research, teaching and consulting at the Dübendorf (Zurich) and Kastanienbaum (Lucerne) sites.

#### Cover photo

Chris Robinson and Simone Baumgartner of the Aquatic Ecology department are investigating changes in the diversity of aquatic organisms following the restoration of the Chriesbach river. (Photo: Aldo Todaro)

# Editorial



Every year at Eawag brings a huge variety of activities in research, education and expert consulting. It is always difficult to decide what to include in this report, which, of course, comes out only once a year. So, in 2013, Eawag launched an electronic newsletter to bring our work directly into the e-mail in-boxes of about 3,500 recipients. (If you are not yet one of them, you can subscribe at: [www.eawag.ch/subscription](http://www.eawag.ch/subscription).) This replaces print issues of Eawag News with four electronic newsletters and allows us to communicate with our readers more often. We have also taken this opportunity to condense and focus our Annual Report; we invite interested readers to find additional information, including policy-relevant factsheets, on our website.

## Need for transdisciplinary research

Under our Target Agreement with the ETH Board for 2013–2016, Eawag is focusing on the themes of water for human welfare, water for ecosystem function and strategies for trade-offs among competing demands. These issues are increasingly relevant as Switzerland begins to implement a number of recent changes in its environmental laws and regulations, including the energy transition, river restoration and the upgrading of wastewater treatment plants to remove micropollutants. Eawag is working with many partners in practice who are responsible for this implementation. We seek to provide necessary technologies and concepts, as well as the scientific basis for new policies and decision-making. To this end, Eawag is committed to conducting transdisciplinary research that integrates the natural, social and engineering sciences.

Eawag researchers also have much to contribute to solving pressing problems worldwide. In 2013, the results of Eawag's many years of research on the occurrence of arsenic in groundwater in Asia were featured in top scientific journals, and our innovative "blue diversion toilet" was successfully field-tested in an African slum.

## International exchange and cooperation

Science itself is international, and Eawag researchers collaborate on projects with researchers and students in over 60 different countries. Such international exchange and cooperation is critical for the expansion of the common heritage of human knowledge. Excellence in research and teaching are the cornerstones of intellectual progress, and Eawag is committed to the pursuit of excellence.

In the coming years, Eawag will be opening new facilities for research and education. We look forward to welcoming members of the public to our open-air laboratory and aquarium on the newly revitalised section of the Chriesbach this year. A building to house large-scale experiments is under construction, and an outdoor facility for conducting ecological experiments is being designed. These investments will allow Eawag to maintain its position at the forefront of aquatic science and technology.

Janet Hering

Director

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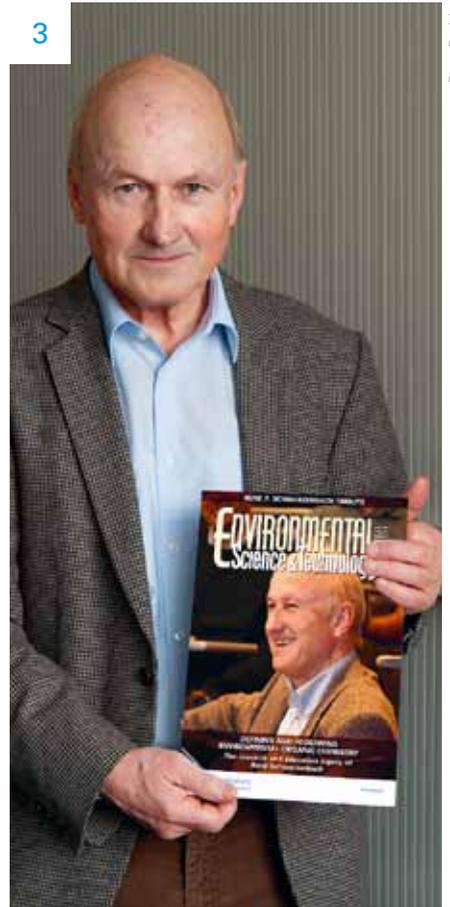
Peter Penicka

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Andri Bryner

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Peter Penicka

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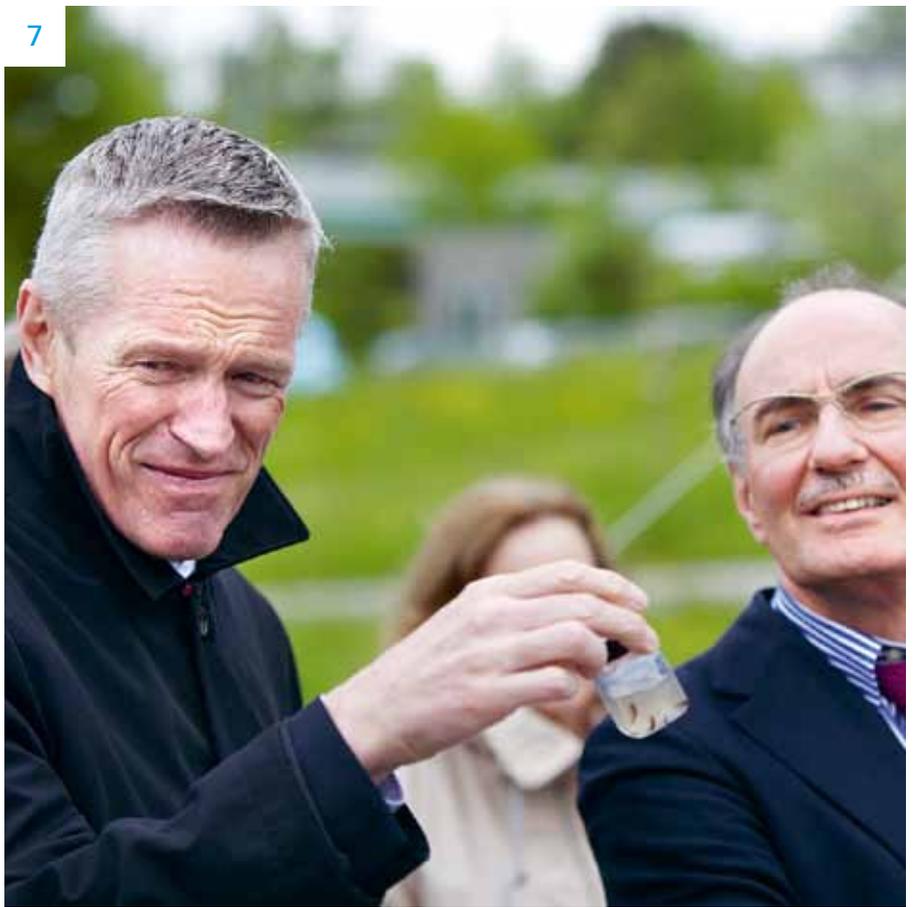
Andri Bryner

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WBF

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Raoul Schaffner

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Peter Penicka

# Highlights of 2013

**1 EU grant for Eawag researcher.** Environmental chemist Kathrin Fenner has been awarded a European Research Council (ERC) Consolidator Grant. The grant, worth around CHF 2.5 million, will be used to finance a 5-year research project designed to facilitate prediction of the biotransformation of pollutants under specific environmental conditions. The aim of ERC Consolidator Grants is to support the development of the next generation of leading researchers, and to prevent the loss of research talent in Europe.

**2 New research vessel launched.** Eawag's new research vessel, launched on Lake Greifen in April, has been named "Otto Jaag" in honour of the former Director of Eawag, who led the institute from 1952 to 1970. Jaag's personal commitment was instrumental in improving the protection of natural waters in Switzerland. The boat was ceremonially launched in Maur by Jaag's widow, Elisabeth. Eawag has been studying Lake Greifen for several decades – observing, for example, its recovery from the pollution of the 1970s and 1980s. As well as supporting research projects, Eawag has been training students on the Lake for many years.

**3 Special issue in honour of René Schwarzenbach.** The July 2013 issue of Environmental Science & Technology was dedicated to the life's work of René Schwarzenbach, emeritus Professor of Environmental Chemistry at the ETH Zurich, who was head of the Department of Interdisciplinary Limnological Research at Eawag's Kastanienbaum site. As a member of the Directorate, he promoted the integration of social scientific research into the natural and engineering sciences. Since his retirement, he has chaired the Steering Board of the Competence Center Environment and Sustainability (CCES) at the ETH Zurich.

**4 Science press conference in Dübendorf.** At a press conference held at Eawag in Dübendorf, the US journal Science presented a study on the likelihood of groundwater arsenic contamination across China, using risk maps produced by Eawag researchers in collaboration with Chinese colleagues. Their estimates are based on a new risk model incorporating geological and hydrological data, as well as measurements of arsenic in wells. According to these estimates, almost 20 million Chinese face a health risk from consuming groundwater with elevated arsenic concentrations (see page 7).

**5 Janet Hering in South Africa with Federal Council delegation.** In September, Eawag Director Janet Hering visited South Africa, together with other representatives of the business and science communities, in a delegation led by Federal Councillor Johann Schneider-Ammann. The aim of the mission was to strengthen bilateral trade and scientific ties. Eawag collaborates closely with various South African universities. A joint project in Durban, for example, is seeking to develop an affordable sanitation system based on dry toilets, which will allow nutrients recovered from urine to be processed into fertilisers. As well as reducing water pollution, this should also promote local entrepreneurship.

**6 Awards for research in Environmental Social Sciences.** Environmental social scientist Bernhard Truffer has been named by the International Association for Management of Technology as one of the world's top researchers in the field of technology innovation management. In addition, Truffer received the 2013 Best Paper award from the Regional Studies Association for an article on environmental innovation and sustainability transitions published in Re-

gional Studies. Truffer is head of Eawag's Environmental Social Sciences department, which was established in 2012 to ensure that the social-science perspective is given appropriate weight in aquatic research.

**7 Parliamentary committee visits Eawag.** At the invitation of Janet Hering, the Council of States Committee for Science, Education and Culture (WBK-S) visited Eawag in May 2013. Along the revitalised stretch of the Chriesbach river, the parliamentarians were given an insight into current research projects, such as the removal of nutrients from wastewater. During discussions, the visitors emphasised the importance they attach to direct contact with scientists.

# Research excellence: the key to innovation in practice



Simulating natural ecosystems: Blake Matthews and Rebecca Best of the Aquatic Ecology department use mesocosms to investigate microbial diversity. (Photo: Aldo Todaro)



The three strategic priorities for Eawag's research are water for human welfare, water for ecosystem function and strategies for trade-offs among competing demands in the water sector. The results of this research are a source of innovation, driving new developments in the practical sphere. In its quest for solutions to pressing problems, Eawag can rely on scientists accustomed to inter- and transdisciplinary research – one of the unique features of Eawag. Underlying these activities is an ongoing commitment to high scientific quality and the pursuit of excellence, calling in turn for long-term investment.

**Billions of people worldwide lack access to safe drinking water and appropriate sanitation – problems for which Eawag is seeking solutions.**

In 2013, studies of groundwater arsenic contamination in China (page 7) delivered important findings for national and regional authorities and this high-quality research was published in *Science*. Another project earning global recognition was the interdisciplinary effort to develop an innovative toilet for slum dwellers (page 7), which received further support from the Bill & Melinda Gates Foundation.

**The Swiss water sector benefits from national research projects.**

Eawag is playing a key role in the National Research Programme on Sustainable Water Management (NRP 61) and is currently preparing two thematic syntheses in close collaboration with stakeholders. The findings of this research programme are published in journals for Swiss water professionals such as *Aqua & Gas*. Another topic of relevance to society is sustainable energy: from 2014, scientific experts from Eawag will be participating in two Swiss Competence Centers for Energy Research

**System-level understanding is essential in assessing environmental effects.**

In order to understand effects on aquatic systems, Eawag scientists are investigating both cellular mechanisms (page 7) and population-level processes (page 9). Equally, it is necessary to understand mechanisms operating within society – for example, different urban water management models (page 9) – before effective strategies can be developed to manage competing demands for resource use. Accordingly, 2013 saw further expansion of the environmental social sciences at Eawag and continued efforts to integrate this perspective into the natural and engineering sciences.

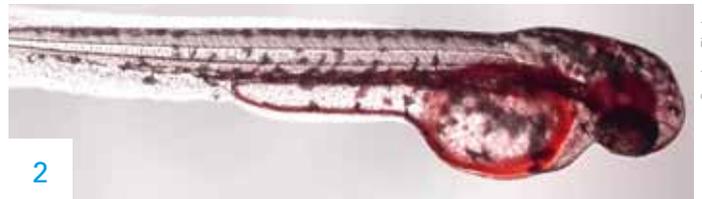
Harald Gründl, ECOOS



1

The blue diversion toilet – a modern squatting toilet with a urine-separating system – is transported for household testing. In the Kampala field trials, public acceptance was very high. In Uganda, a turquoise-coloured model was used rather than the original blue toilet so as to ensure that the project could not be appropriated for political ends – blue being the colour of the opposition to the government.

Various chemicals can inhibit the function of the ABCB4 transporter, making the zebrafish embryo more sensitive to toxic substances. This was demonstrated experimentally: the embryos shown here were both exposed to a red fluorescent dye. Under natural conditions, the substance taken up by the embryo is pumped out of the cells as a result of ABCB4 transporter activity (top micrograph). The addition of a transporter-inhibiting chemical leads to increased accumulation of the dye in the embryo (bottom micrograph).



2



Stephan Fischer

Eawag



3

In order to measure arsenic in groundwater around Hanoi, samples were obtained from various depths. Geogenic arsenic contamination has not yet affected all areas: according to Professor Rolf Kipfer of Eawag, who measured groundwater ages using helium and hydrogen isotope dating techniques, the movement of dangerous arsenic levels is much slower than the migration of groundwater itself.

## 1 Diversion toilet successfully field-tested

With support from the Bill & Melinda Gates Foundation, an interdisciplinary team of Eawag researchers together with an Austrian design firm developed a modern squatting toilet in which urine, faeces and used wash water are collected separately. Last year, the so-called blue diversion toilet was tested successfully for the first time under real-life conditions in the slums of Kampala. According to project coordinator Ulrike Messmer: “Our toilet attracted a lot of attention. Altogether, over the three-month testing period, it was used around 1,200 times by over 400 people. Most found it attractive and modern, and use of the toilet seems to be clear and intuitive.”

The field test, however, also revealed a number of weak points. In collaboration with the Swiss engineering firm Tribecraft, the height of the toilet has now been reduced, and the faeces tank closing mechanism and hydraulic system have been optimised. Another aim of the revision process was to reduce the number of components. Field-testing of the new model began in February in Nairobi. This model is also being presented to potential investors and industrial partners at an exhibition in Delhi organised by the Gates Foundation. The Eawag team hopes that the diversion toilet will attract sufficient interest to allow further development to be financed with a view to commercialisation. As Messmer explains, “It’s important to develop our toilet so that it’s suitable for mass production.” For example, a lot of work still needs to be done to simplify the electronics.

Because the design calls for regular emptying of the faeces and urine tanks and waste processing, the researchers have also developed a suitable business model: local entrepreneurs are to rent out toilets, coordinate waste collection, operate treatment plants – producing biogas and urine-based fertilisers – and sell the recycled products. This should provide attractive sources of income for local businesses.

## 2 Chemical defence mechanisms in fish embryos

Researchers at Eawag and the Helmholtz Centre for Environmental Research (UFZ) in Leipzig have discovered a protein that transports chemicals out of the embryo in zebrafish, thus providing protection against toxic substances. While so-called ABC transporter proteins have been studied extensively in mammals, little was known to date about their function in fish.

The newly discovered ABCB4 transporter could play a significant role in toxicological and ecotoxicological research. As Stephan Fischer of the Environmental Toxicology department explains, the transport mechanism is blocked by certain chemicals, allowing other harmful substances to penetrate the organism: “Compounds which inhibit the transporter open the door to toxic substances.” As these compounds make the organism more sensitive to toxicants, they are known as chemosensitisers. This indirect toxic effect is particularly important when embryos are exposed to mixtures of substances, such as those typically found in the environment.

By measuring the activity of the transporter system, the researchers were able to determine which chemicals are transported by ABCB4. They then investigated the effects of various environmentally relevant substances on the ABCB4 transporter – individually and in mixtures. It was found that many effects of mixtures can be explained in terms of ABCB4 protein activity. As zebrafish embryos are used for the assessment of chemicals and for studies of environmental effects, the researchers hope that these findings will lead to recognition of the need to incorporate ABCB4 transport processes in toxicity test methods.

## 3 Arsenic in groundwater

In various regions of China, levels of arsenic in groundwater pose a risk to public health. Vietnam’s capital, Hanoi, also faces a growing threat of arsenic contamination. As more and more water is

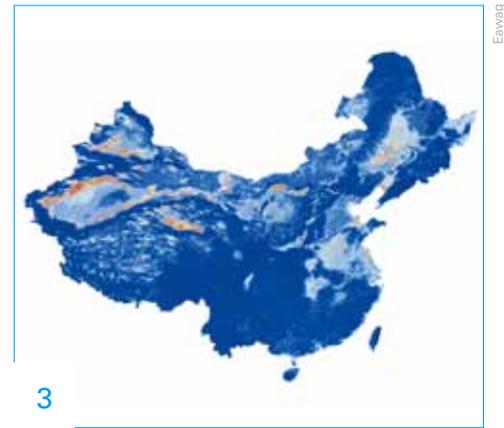
pumped from a deep (previously uncontaminated) aquifer, arsenic-laden water from shallow sediments is advancing towards the wells of Hanoi. These findings, confirming what had been suspected for some time, were reported in a study – with Eawag participation – published in *Nature*.

Although the movement of arsenic contamination is slow, the process appears to be unstoppable. In the city itself, water is treated, and filtering ensures that any arsenic is largely removed. But in many suburban areas, where households are not connected to the municipal supply, water is pumped directly from private wells. At some sites investigated near Hanoi, arsenic concentrations in groundwater are already 10–50 times higher than the guideline level of 10 micrograms per litre recommended by the WHO.

According to a study of arsenic contamination in China – published in *Science* by researchers from Eawag and the China Medical University in Shenyang – concentrations above the WHO limit are predicted for a total area of 580,000 square kilometres. This estimate is based on a newly developed statistical risk model, using existing data on geology, soil characteristics and hydrology. The model was calibrated using available arsenic measurements. The predictions showed a high level of agreement, both for known high-risk areas and for areas where elevated arsenic levels had been ruled out by sampling campaigns.

In addition, new areas were identified as potentially at risk for elevated arsenic concentrations. When these results were combined with the latest available population data, it was found that almost 20 million people across China live in high-risk areas. Geochemist Annette Johnson concedes: “This figure may be an overestimate, as we lack reliable information on the number of people with treated water supplies.” But, she adds, the model can complement conventional groundwater quality monitoring

The risk map for China, based on the statistical model developed by Eawag, shows areas at high risk for excessive levels of arsenic in groundwater. The model could also be applied to other countries where groundwater is known or suspected to be contaminated with arsenic – e.g. in Africa or Central Asia.



Eawag



Gesa Luchinger

The Lengg lake water facility – one of Zurich’s four water treatment plants. The city’s wholly public water utility performs better than the private (Leeds) and public-private (Berlin) utilities studied – especially in terms of resource protection, supply security and public participation.

Mesocosms – large outdoor containers filled with lake water – allow natural aquatic ecosystems to be simulated accurately. By setting up a number of identical mesocosms, it is possible to determine whether experiments performed under replicated conditions produce the same results. This is not possible in field experiments, as natural lakes are influenced by a wide variety of environmental conditions and it is virtually impossible to find comparable lakes.



Blake Matthews

efforts, permitting more targeted sampling campaigns. The Chinese authorities are already using the risk maps in the national monitoring programme.

#### 4 Good marks for public water utilities

Public or Private? Which water supply and sanitation service providers perform better? This question is widely discussed in both academic and professional circles. In a case study comparing different forms of water governance in Zurich (public), Berlin (public-private) and Leeds (private), Eva Lieberherr found that public organisations perform better overall than wholly or partly privatised enterprises. As well as effectiveness – covering public service, supply security, resource protection and public acceptance – the study assessed participation, cost-effectiveness and accountability.

Zurich offers greater security of supplies, better protection of resources and a higher degree of citizen participation than Berlin or Leeds. Accordingly, public acceptance is also higher. Private and mixed service providers only fare better with regard to cost-effectiveness, as they both have a strong focus on costs and profit orientation. However, as shown by the example of Zurich, a public enterprise can also achieve a moderate degree of cost-effectiveness. If this is to be increased, it is important for public utilities to have sufficient entrepreneurial freedom. Surprisingly enough, the mixed form – often regarded as the golden mean – fares worse overall than the purely public or private forms.

#### 5 Investigating microbial diversity

Although bacteria and viruses play an important role in aquatic ecosystems, they have scarcely been studied to date in their natural habitats. This gap in research is being addressed by Blake Matthews of the Aquatic Ecology department.

The community composition of bacteria and viruses differs from one ecosystem to another, depending on factors such

as physical conditions, nutrient availability and carbon sources. Such communities can adapt rapidly to changes in environmental conditions. As there will almost always be certain species that reproduce particularly well in the new environment, the composition and hence the function of the microbial community may be altered – which in turn may affect the ecosystem. These interactions are the focus of Blake Matthews's research.

In a recent project, he investigated how community composition is affected when exchanges of bacteria and viruses occur among ecosystems. In this outdoor experiment, large containers filled with water – known as mesocosms (cf. photo left) – were used to simulate pond ecosystems. Water and sediments – including bacterial and viral communities – were taken from various lakes. Small volumes of water were then regularly exchanged between pairs of containers. Matthews says: "We observed that, even with very low exchange rates, community composition became more similar for the two containers concerned. This could also lead to greater similarity in ecosystem function."

This project makes an initial contribution to our understanding of the complex processes involved in the development of microbial communities. As Matthews explains, "Research on microorganisms in their natural habitats is still in its infancy." As a next step, he plans to investigate how the diversity of bacteria and viruses is affected by other organisms – especially fish and plankton, which feed on microorganisms and their metabolic products.

# A new generation of skilled professionals for the Swiss water

Teaching and learning in the field: for Jukka Jokela, Professor of Aquatic Ecology (left), and his students, a mountain torrent in Canton Ticino provides an ideal setting for applied research. (Photo: Aldo Todaro)



As well as being an investment in the future, teaching provides new perspectives and raises new questions for research, and also represents a platform for the integration and synthesis of new knowledge. Accordingly, Eawag considers the education of students and young professionals – at all levels – to be a profitable activity, not just for the ETH Domain but also for Switzerland. With a total commitment of over 3000 hours per year, Eawag scientists account for a significant proportion of teaching activities in the Swiss higher education sector. They adopt a systemic approach, dealing with the water system in its entirety. Apart from theoretical knowledge, they attach great weight to practical training in the lab and field. Their expertise often fills a niche, and they can also offer an applied research perspective.

**Substantial investment in education in Switzerland delivers excellent results.** In 2013, Eawag scientists supervised around 130 bachelor's and master's theses (page 27) and around 140 Doctoral dissertations, many of which earned awards from external institutions and organisations (page 21). Vocational training activities are equally diverse and include participation in research projects and collaboration with external companies. This allows trainees to gain broad experience in their occupational field, preparing them for the employment market.

**Eawag-educated professionals apply their knowledge in Switzerland and abroad.** In the course of their (often ex-

ceptional) careers, Eawag alumni maintain not just professional but personal contacts with the institute. But Eawag also makes its presence felt in the area of continuing education: its practice-oriented (PEAK) programme has now been running for 20 years. These courses represent a form of knowledge transfer in which scientific topics are treated in depth and new questions can be fed into research. The 20th anniversary proved to be a record year, with around 360 people attending PEAK courses.

In contrast to the Western world, many people in developing countries do not automatically have access to knowledge and further education. Eawag is therefore committed to building education capacity in these countries. Eawag's Department of Water and Sanitation in Developing Countries, Sandec, is active in this area. Each year, it awards fellowships to talented master or doctor degree students from developing countries, who receive training in Switzerland. In collaboration with the EPFL, Sandec has now also developed a massive open online course (MOOC) on household water treatment and safe storage, which is addressed in particular to graduates in developing countries. Finally, Bernhard Wehrli – a member of Eawag's Directorate – gave a series of lectures on geochemical processes, precious minerals and drinking water chemistry at universities in five African countries (page 13).



unknown

1 Bernhard Wehrli with professors and students at the University of Antananarivo in Madagascar.

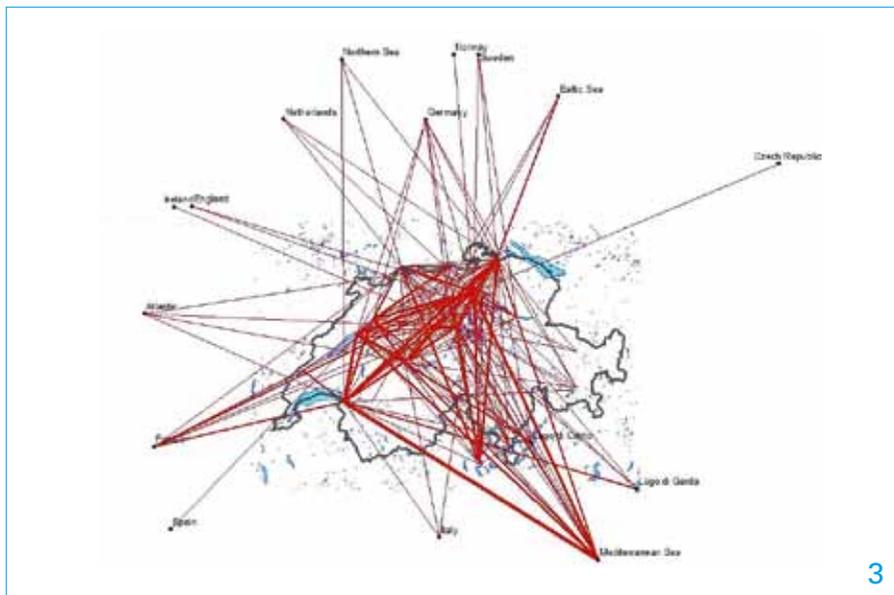
At the Federal Office for Agriculture, alumna Katja Knauer is responsible for weighing up environmental interests against economic needs and developing appropriate guidelines for sustainable plant protection. As a former Eawag doctoral student, she also appreciates opportunities to participate in international workshops and working groups.



Peter Pernicka

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Nora Weissert



3

Overland movements of Swiss boats investigated in a Master's thesis: the most frequently travelled routes (thickest lines) are between Lakes Zurich and Constance, and Lakes Geneva and Neuchâtel. Boats are frequently also transported to the Mediterranean. The lower the temperature, the longer mussels can survive out of water. At 12°C, a quarter were found to be still alive after 42 hours.

## Equipped for practice

In their teaching, Eawag scientists emphasise practical aspects, with students spending about the same number of hours in the laboratory or field as they do in the lecture theatre.

Bachelor students of environmental sciences, for example, spend a week in a valley in the mountains of Canton Ticino to improve their knowledge of aquatic ecology in the field and to get a taste of everyday applied research. Led by Jukka Jokela, Professor of Aquatic Ecology, they formulate their own research question, carry out field studies, interpret the results and present their findings to fellow students. They are thus familiarised with the various steps involved in a research project.

Jokela is enthusiastic: “Our students are motivated and dedicated.” On field trips, the groups are smaller than in the lecture theatre, and there are more opportunities for detailed individual discussions – not only on the week-long Ticino course, but on the other practical courses that punctuate the semester. On nearby streams and lakes, as well as in the Eawag labs, students learn the fundamentals of ecology and the methods of field research. “We also prepare them for the realities of working life,” says Jokela. For example, the young scientists learn how to assess environmental quality and to carry out the necessary observations and measurements. “This means we make an important contribution to the Swiss job market.”

## 1 Knowledge transfer to Africa

Every year in sub-Saharan Africa, 800,000 children die because they lack access to safe drinking water. Universities in the region could make a substantial difference by exploring groundwater resources or analysing drinking water, but they lack the means to do so. This discrepancy between research needs and available resources repeatedly struck Bernhard Wehrli, Professor of Aquatic Chemistry, when he visited a number of African universities last year as an outreach lecturer, sponsored by the Geochemical Society and the Euro-

pean Association of Geochemistry. What emerged from his discussions with professors and students in Ethiopia, Madagascar, Cameroon, Ghana and Kenya was that, quite apart from the lack of wells and sanitation technology in Africa, there are major deficiencies in teaching and research infrastructure – a lack of funding, inadequate equipment and severely limited access to scientific literature.

Wehrli calls for an intensification of the dialogue between researchers from the North and South. He suggests, firstly, that more papers should be published in open-access journals. His second recommendation: “Invite not only your colleagues from Stanford and Cambridge to your institute, but also those from universities like Antananarivo and Addis Ababa.” Finally, he proposes that learned societies should waive membership fees for scientists in low-income countries: “The continent needs a globally networked research community to develop solutions in Africa for Africa.”

## 2 The interface between science and policymaking

Are our bees adequately protected? Do pesticide concentrations in natural waters give grounds for concern? What measures to reduce pesticide inputs are practicable and appropriate? These are the kinds of questions addressed by policymakers to the biologist Katja Knauer, who works in the Sustainable Plant Protection Section of the Federal Office for Agriculture. Knauer explains: “We evaluate research findings and then develop recommendations for implementation. This work at the interface between science and policymaking is not just important, it’s also fascinating.”

Knauer owes her expertise, in part, to Eawag, where she wrote her doctoral dissertation on interactions between aquatic organisms and trace metals – including copper, which is used as a crop protection agent in organic farming. But, as Knauer points out, the benefits she derived from her time at Eawag go beyond the purely scientific: “I built up an extensive network.” She frequently has dealings with

other Eawag alumni now working at other agencies and environmental consultancies or in research. There has been a lot of interaction among the roughly 80 doctoral researchers who studied with her at Eawag. “The whole place sticks together,” she says. “Eawag is not just a world class institute, the scientists also know how to enjoy themselves.”

## 3 Stowaways on transported boats

When recreational boats are transported overland, they are often accompanied by zebra mussels attached to their hulls. This alien species, which first appeared in Switzerland in 1960, is thus able to invade other natural waters unless preventive measures are taken. In a master’s thesis written at Eawag, aquatic ecologist Nora Weissert shows that, on average, 60 per cent of boats that are kept in the water all year round are infested with zebra mussels. In contrast, boats with dry berths are scarcely affected. Weissert found substantial differences between individual lakes: while levels of infestation are high in Lakes Zurich and Constance, they are low in Lakes Thun and Lucerne. Another interesting finding was that two thirds of wet-berthed boats treated with antifouling paint were nonetheless encrusted with zebra mussels.

Weissert concludes that, before being transported, boats should be thoroughly cleaned or allowed to dry for several days. This is particularly important in view of the risk of another invasive species spreading across Switzerland – the quagga mussel, which is advancing up the Rhine. Both mussel species can crowd out native species and give rise to high maintenance costs if they clog cooling systems or water intake pipes.

# Providing a sound scientific basis for decision-making

Collaboration with water professionals: Marc Böhrer of the Process Engineering department discusses the results of tests at the new ozonation facility with Max Schachtler, Director of the Neugut WWTP. (Photo: Aldo Todaro)

Consulting is one of Eawag's core functions, with the aim being to make research findings available to users. Scientific knowledge is to provide a basis for decision-making in both the private and public sector. One organisation that serves as an important link between research and practice is the Swiss Centre for Applied Ecotoxicology, jointly run by Eawag and the EPF Lausanne. Exchanges between academics and water professionals also often generate new ideas and reveal new challenges for research. In Switzerland, collaboration with federal and cantonal authorities is of crucial importance for Eawag (page 17), driving research activities and facilitating the development of practicable solutions.

**Effective transfer of expertise depends on sound scientific knowledge.** Following decades of research – conducted by Eawag among others – Switzerland is now upgrading its wastewater treatment plants to ensure that micropollutants are more effectively removed. A number of Eawag research groups are providing scientific support for the development of an ozonation step at the Neugut treatment plant in Dübendorf (page 17). The leading role played by Switzerland in this field was also demonstrated by the success of "Micropol & Ecohazard 2013" – a conference organised in Zurich by Eawag, which attracted more than 350 delegates from around the world.

**Research projects often lay the foundations for practical solutions and legislation.** For example, Eawag researchers were commissioned by the Federal Office

for the Environment to assess the effectiveness of various types of block ramps in Swiss rivers. These structures are designed to allow fish to overcome barriers to migration (page 17). Another research group, collaborating with international partners, has developed a method that allows toxicity tests involving adult fish to be replaced with tests using zebrafish embryos. The new method has already aroused widespread interest and was included in the new OECD Test Guidelines for 2013.

**Innovation apart, scientific expertise is also needed for the preservation of an intact and healthy environment in the long term.** For some years, Eawag has been responsible for monitoring levels of radioactivity in Swiss surface waters, and we work together with international partners to monitor the water quality of the Rhine. Environmental toxicologists at Eawag discovered that neonicotinoids can have adverse effects not only on bees but also on aquatic organisms such as freshwater shrimps (page 17). To ensure that society continues to benefit from the findings of its research over the long term, Eawag supports the transfer of certain activities to external companies and organisations. In 2013, four Eawag spin-offs were established, and responsibility for implementation of the long-running SodiS project was transferred to Helvetas, the development organisation (page 17).

Helvetas



1

The partnership between Helvetas and Sodis is bearing fruit: the organisation is increasingly integrating the solar water disinfection method into its own development Projects, as here in Vietnam. In addition, planning is underway for a joint project that is to be implemented by Helvetas with Eawag providing scientific support.



Eawag

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Freshwater shrimps, as well as bees, are adversely affected by neonicotinoids: after 2–3 weeks' exposure to low concentrations of a neonicotinoid insecticide, they die of starvation.



Aldo Tordaro

3

The country's first commercial ozonation facility, at the Neugut WWTP. Here, micropollutants are removed, which – even at very low concentrations (just a few micro- or nanograms per litre) – can pose risks to the health and reproduction of aquatic organisms or adversely affect drinking water resources. For the removal of micropollutants, an alternative to ozonation is powdered activated carbon treatment – the two processes are roughly equivalent.

## Facilitating fish migration

The innumerable sills and weirs found along Switzerland's rivers impede the migration of fish and are therefore increasingly being replaced by block ramps. With these ramps, the difference in bed level is overcome by a shallow slope, rather than by a single step. At the request of the Federal Office for the Environment, the effectiveness of these structures was investigated by a group of researchers led by fish ecologist Armin Peter. Summarising the findings, Peter says: "The passage efficiency of block ramps varies according to the type of ramp and depends on the fish species and body size." Dispersed block ramps seem to be more suitable than classical uniform ramps. Dispersed ramps of the structured type offer the advantage of providing pools after each of the transversal sills, where fish can rest. However, under low discharge conditions, vertical drops arise which can only be cleared by leaping.

Upstream passage is generally easier for larger than for smaller fish and strong-swimming species also have an advantage. The researchers recommend that monitoring should be carried out prior to the construction of a block ramp, so that the target species can be determined and their particular requirements taken into account.

### 1 Sodis and Helvetas: an ideal partnership

Since 2011, under a partnership agreement with the Sodis (solar water disinfection) Reference Centre, the development organisation Helvetas has been gradually taking over responsibility for existing Sodis projects and integrating the method into its own water projects. Eawag carries out applied research and provides technical support for projects. Helvetas has a long-standing commitment to the provision of safe water supplies in developing countries. To date, its work has focused on spring development and the construction of wells. But, as Valérie Cavin of Helvetas points out, "A lot can still happen before the water is used." For this reason, household water treatment is now also included in the organisation's activities.

"Sodis is an ideal partner," says Cavin. "It's a tried-and-tested method, and through our close collaboration we benefit from the Eawag experts' knowledge and broad experience – not only with solar disinfection but also with other treatment methods or questions of behaviour change." As a result of the partnership, she adds, greater weight is now attached to household water treatment at Helvetas. A number of Sodis projects – in Senegal and Togo, for example – are now being managed by Helvetas. Household water treatment also forms an integral part of two new projects launched by the organisation in Bangladesh and Mali.

### Overview of collaboration

Eawag promotes the application of research findings and collaborates closely with water professionals in project-related or consulting activities. A new online information platform provides an overview of Eawag's partnerships and projects involving cantonal agencies, local authorities and private enterprises. By clicking on an interactive map of Switzerland, users can view a list of projects for each canton, which includes brief descriptions, as well as the partners involved and the contact at Eawag.

### 2 Insecticides: death by starvation

Neonicotinoid insecticides are believed to be contributing to the decline of bee colonies. The use of these neurotoxic agents has therefore been banned in the EU and in Switzerland. A study carried out by the Environmental Toxicology department has now shown that neonicotinoids also have toxic effects on freshwater invertebrates. In this study, native freshwater shrimps were exposed to pulsed high and constant low concentrations. After exposure to pulses lasting no more than a day, the organisms recovered rapidly. However, exposure to lower concentrations persisting for several days or weeks led to starvation after 2–3 weeks, as the organisms' mobility and feeding behaviour were impaired. This slow starvation effect is not detected by conventional toxicity tests.

The study also indicated that seasonal and environmental factors can be crucial: the results of experiments are significantly affected by organisms' fitness and lipid reserves. To eliminate these effects and to identify processes other than starvation that influence survival rates, the research team has also developed a mathematical model which makes it possible to predict harmful concentrations and exposure times.

### 3 First ozonation facility comes on stream

Over the next 20 years, inputs of micropollutants to Switzerland's waters are to be reduced by half. This is to be achieved by upgrading 100 of the country's 700 wastewater treatment plants (WWTPs) with an advanced treatment step. In 2013, the first full-scale ozonation facility was installed at the Neugut WWTP in Dübendorf. After extensive testing, it has now come on stream. This advanced treatment step removes micropollutants deriving from medicines, cleaning agents, cosmetics and industrial products.

Eawag has been investigating the effects of micropollutants – and exploring ways of eliminating them – for almost 20 years. This expertise fed into the planning of the ozonation facility in Dübendorf and is also being utilised and further developed at the plant. Marc Böhler of the Process Engineering department explains: "We're testing a system that will allow precise dosing of ozone." In addition, the engineers are testing alternatives to the sand filtration system currently used for downstream biological treatment. Environmental chemists and ecotoxicologists are assessing the effectiveness of the ozonation process and analysing transformation products and their effects on aquatic organisms.

# An attractive workplace with an international reputation

Eawag's efforts to support the professional development and increase the proportion of women in research are proving successful: 40 per cent of scientific staff and over 50 per cent of doctoral students are female. (Photo: Peter Penicka)

Eawag owes its success to its staff and to an excellent working environment. In 2013, numerous Eawag scientists received awards for outstanding research (page 21).

**To maintain its attractiveness, Eawag continues to invest in research infrastructure, such as a new facility for experiments in evolutionary ecology.**

It recognises the exemplary nature of publicly funded facilities of this kind and is therefore committed to sustainable construction and conservation of resources. 2013 also saw the completion of the Chriesbach river restoration project, which has enhanced the amenity of the area around Eawag in Dübendorf. This will also serve as a site for research projects and a recreational area for visitors (page 23).

**Eawag sites are increasingly receiving official visits from Asia and elsewhere.**

Eawag maintains contacts and shares knowledge at the national and international level. Last year, for example, we hosted discussions with members of Singapore's Water Quality Office. Likewise, Eawag representatives are frequently invited to es-

tablish contacts and share their expertise abroad. Eawag also pursues dialogue with policymakers. In 2013, we welcomed members of the Council of States Committee for Science, Education and Culture (WBK-S) and representatives of Canton Zurich's Green Liberals.

**The institute's reputation and staff attract national and international attention.**

This is based on the good working environment and favourable employment conditions which make it possible to combine a research career with family life. In 2013, the childcare centre jointly established by Eawag and sister organisation Empa celebrated its 20th anniversary in its spacious Dübendorf facilities (page 23).

**Employee satisfaction is crucial.** In 2013, a staff satisfaction survey conducted by the Directorate produced excellent results with a high level of participation. Measures to promote good working conditions were supplemented by work-life balance training for all employees. The outstanding performance of Eawag's highly motivated staff was reflected in a wide variety of awards.

Peter Penicka



1

At the Swiss-Dutch Water Technology Event hosted by Eawag, over 60 representatives from industry and academia explored possible collaboration on cleantech projects.

Christoph Ort (right) led a project that was shortlisted for the Swiss Academies Award for Transdisciplinary Research. In his project, illicit drug use was investigated by analysing drug residues in wastewater.



2

td-net

Klaus Marquardt



3

Christoph Moschet (right) receives the Paul Crutzen Prize, awarded by the German Chemical Society (GDCh) for outstanding research in the field of environmental chemistry and ecotoxicology.

## Broad dialogue

### Stormwater management in urban areas.

“Water protection during wet weather” – the third in a series of annual Aqua Urbanica conferences – brought together over 100 water professionals from Germany, Austria and Switzerland. The event (organised by Eawag researcher Jörg Rieckermann and held in Dübendorf) clearly showed, that while solutions are available for sustainable stormwater management, they need to be considered at an early stage in urban development planning. This requires a multidisciplinary dialogue, as water protection increasingly calls for close collaboration between town planners, engineers and ecologists.

1

### Successful matchmaking event.

The Swiss-Dutch Water Technology Event was organised by Eawag in collaboration with the State Secretariat for Education, Research and Innovation, Dutch partners and the Enterprise Europe Network. The event, held at Eawag, brought together representatives of enterprises and research institutes from the Netherlands and Switzerland to discuss cooperation on R&D projects in the field of water technology and, in particular, cleantech. According to Kai Udert of Eawag, the event attracted over 60 Swiss and Dutch participants from industry and academia.

### International conference on micropollutants.

In collaboration with the authorities, Eawag has carried out pioneering research and developed practical solutions for the problem of micropollutants in wastewater. Largely as a result of these efforts, Switzerland is now a world leader in this field. Accordingly, over 350 delegates from around 40 different countries attended the “Micropol & Ecohazard 2013” conference in Zurich – an event organised by Eawag – to find out more about the latest developments in the analysis and elimination of micropollutants.

## Awards

2

### Christoph Ort: innovative project shortlisted.

A project led by Eawag scientist Christoph Ort was shortlisted for an award by the Network for Transdisciplinary Research (td-net) of the Swiss Academies of Arts and Sciences. Ort’s project involved monitoring illicit drug use via wastewater analysis. The Swiss Academies Award for Transdisciplinary Research is designed to honour work which is outstanding in its conception and content, as well as motivating young scientists to pursue transdisciplinary research.

3

### Christoph Moschet wins Paul Crutzen Prize.

Christoph Moschet received the Paul Crutzen Prize – a German Chemical Society (GDCh) award worth EUR 1500 – for a publication in the field of environmental chemistry and ecotoxicology. In his master’s thesis, Moschet developed a novel integrated approach for the assessment of polar organic micropollutants in the catchment area of Lake Constance. This work not only spans various disciplines (chemistry, modelling, ecotoxicology) but also bridges research and practice. His study was recently published in *Environmental Science & Technology*.

### Best Practice Award for Sandec project.

The Urban Affordable Clean Toilets (U-ACT) project received the 2013 Best Practice Award from the Poverty Reduction, Equity and Growth Network. The project is being run by the Department of Water and Sanitation in Developing Countries (Sandec), in partnership with the ETH Zurich, Makerere University and the Ugandan NGO Sustainable Sanitation and Water Renewal Systems (SSWARS). The aim of U-ACT is to improve access to sanitation and maintenance of facilities for communities in the slums of Kampala by implementing innovative economic interventions. The results of the research are to be shared not only through scientific publications, but also through policy briefs, videos, websites, exhibitions and workshops relevant to policymakers.

**Awards for dissertations.** In 2013, four young academics received awards for their doctoral dissertations. Flavio Piccapietra and Remo Freimann were both awarded an ETH Medal. Manuel Fischer won the Swiss Political Science Association’s Young Scholar Award for Best Dissertation. Philip Leifeld received not only the Südwestmetall Employers Federation Award but also the Dissertation Award of the University of Konstanz Science and Society Foundation.

**Award for Laura Sigg.** Laura Sigg of the Environmental Toxicology department received an Environmental Science & Technology “Excellence in Review” award.

According to the ES&T Editor, the journal relies on high-quality, constructive and timely reviews from more than 5000 reviewers to ensure the excellence of the papers published.

## Personnel news

### “Swiss Rivers” programme led by

**Christine Weber.** The “Swiss Rivers” programme, initiated by Eawag and the Federal Office for the Environment, was launched in March 2013. It is designed to provide applied research support for federal and cantonal efforts to rehabilitate rivers and streams, and also contributes to the environmentally sound use of hydropower. The programme will involve close cooperation with practitioners. In addition, work carried out under the earlier “Rhône-Thur” and “Integrated Watershed Management” programmes is to be pursued and expanded. The leader of “Swiss Rivers” is biologist Christine Weber.

4

### Retirement of Hansruedi

**Siegrist.** Hansruedi Siegrist retired at the end of 2013. He worked as a senior scientist at Eawag from 1986 to 1997 and then became head of the Process Engineering department. From 1990, he also taught at the ETH Zurich, first environmental chemistry and later sanitary engineering. His research focused on physical, chemical and biological processes in wastewater and sludge treatment, math-

Peter Penicka



4

Hansruedi Siegrist, who retired at the end of 2013, had worked at Eawag since 1986, serving for many years as head of the Process Engineering department.



Peter Penicka

5

For 20 years, staff have been able to have their preschoolers looked after at the Eawag/Empa childcare centre – housed since 2006 in a purpose-built facility.

Peter Penicka



6

A showcase project on our doorstep: thanks to Eawag's commitment, a section of the Chriesbach river has been restored and will now serve as a research site and recreational area. Pictured here: Eawag project manager Thomas Lichtensteiger and foreman Hanspeter Ziegler.

ematical modelling of these processes, and the fate of micropollutants in wastewater treatment. As a member of various national and international bodies and working groups, he was instrumental in establishing close links between Eawag and professionals in the urban water management sector.

## Equal opportunities

**National Future Day.** National Future Day is a fixture in the Eawag/Empa calendar. In November, the two institutes invited around 70 girls and boys to explore the world of scientific research. At the Eawag Dübendorf site, the youngsters enthusiastically examined pygmy backswimmers and damselfly larvae under the microscope and listened to researchers explaining their projects. At Kastanienbaum – despite the cold weather – a group of six children accompanied researchers retrieving a sediment core and collecting water samples on Lake Lucerne. Laboratory technicians also showed them how to measure dissolved oxygen in water samples using the Winkler method and how to measure water hardness using colour reactions.

**5 20 years of childcare in Dübendorf.** In July, around 150 people attended a summer party to celebrate the 20th anniversary of the “IG Kinderpavillon” Parents’ Association. The interest group was established in 1993 with the aim of opening a childcare centre for Empa and Eawag. Just one and a half years later, the centre was duly launched in what was then Empa’s guest house, with facilities comprising two rooms, a kitchen and bathroom, and a large garden. Today, the facility that was purpose-built in 2006 can accommodate 34 children in three groups. Now a well-established part of the two research institutes, the centre provides optimal childcare for employees’ preschoolers.

## Infrastructure

### Construction of “Aquatikum” underway.

A laboratory building dating back to the 1970s is being converted and extended in Dübendorf. Construction of the new “Aquatikum” began in 2013. The new research facility will offer more room for large-scale experiments, better fieldwork infrastructure and additional space for drinking water research.

### 6 Chriesbach revitalised: enhanced habitat and recreational area.

“Without Eawag’s sustained commitment, the project would probably never have got off the ground,” says Christian Marti of the Canton of Zurich Office for Waste, Water, Energy and Air (AWEL), who led the Chriesbach restoration project. In the 1970s, large-scale engineering works were carried out on a kilometre-long section of the river where it flows into the Glatt as a flood control measure for the Eawag/Empa site. The waterway degenerated into a drainage ditch, but thanks to Eawag’s initiative, and with financial support from the Dübendorf local authority and the Zurich electricity works, the Chriesbach has now been revitalised as a diverse natural habitat. It will also be the site of an open-air laboratory for researchers and serve as a recreational area for visitors.

## Eco-management

### Exemplary energy conservation efforts.

Eawag is committed to the use of electricity from renewable sources and has made significant progress since 2006. The combination of solar power generation – its own photovoltaic system supplies around 5 per cent of its needs – and certified green power (“naturemade star”) ensures that Eawag’s electricity requirements are met almost entirely by renewables. With regard to hydropower, the criteria specified for the Swiss eco-label are based on Eawag research. Requirements for heating and cooling have been substantially reduced at the Dübendorf and Kastanienbaum sites as a result of renovation work. Primary energy consumption has decreased not only per capita and per unit area but also in absolute terms – from almost 25 terajoules in 2006 to 14 terajoules in 2013.

**Support for cycling.** As well as energy conservation and landscaping, mobility is a key issue. Here, the priorities are improving public transport links and promoting bike use. In 2013, following the renovation of the shelters at Kastanienbaum the previous year, the Dübendorf shelters were extended and weatherproofed; once again, this work was financed by levies on air travel. Also improved were the workshop facilities for maintenance of bicycles used by academic guests. The lockable shelter jointly operated by Eawag and Empa at the Stettbach railway station was one of three facilities inspected by visitors as part of an event organised by the Canton of Zurich Cycling Coordination Centre.

## Directorate



Aldo Todaro

**Jukka Jokela**  
Group Leader, Aquatic Ecology department  
Professor of Aquatic Ecology ETHZ

**Rik Eggen**  
Deputy Director  
Professor of Environmental Toxicology ETHZ

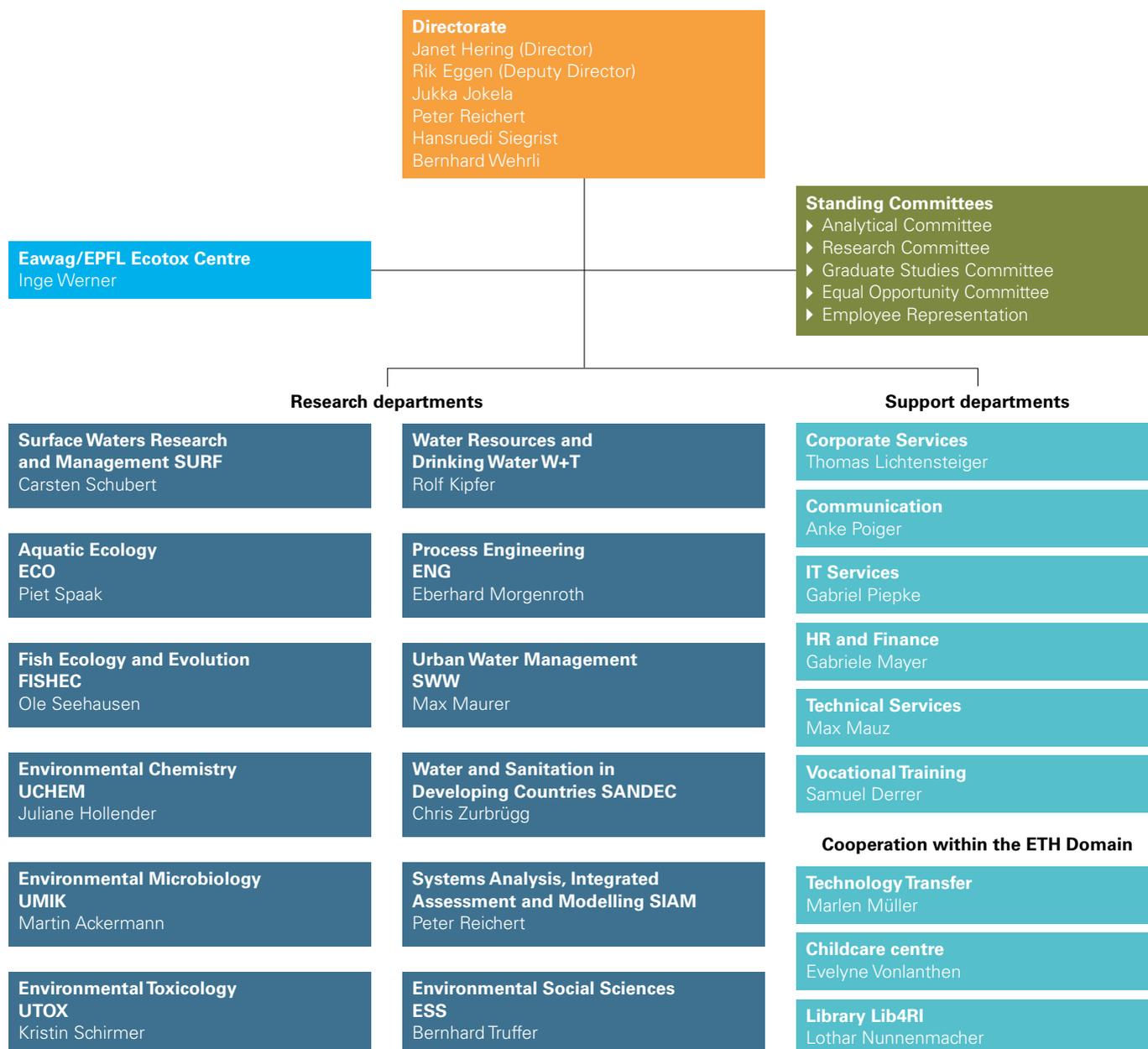
**Peter Reichert**  
Head of Systems Analysis, Integrated Assessment and Modelling department  
Professor of Systems Analysis ETHZ

**Hansruedi Siegrist**  
Group Leader, Process Engineering department  
Professor of Urban Water Management ETHZ

**Bernhard Wehrli**  
Group Leader, Surface Waters department  
Professor of Aquatic Chemistry ETHZ

**Janet Hering**  
Director  
Professor of Environmental Biogeochemistry ETHZ  
Professor of Environmental Chemistry EPFL

## Organisation



## Advisory Board

**Ursula Brunner** (Chair), Ettler Suter law firm, Zurich

**Claus Conzelmann**, Vice President for Safety, Health and Environmental Sustainability, Nestlé Group

**Heinz Habegger**, Head of Water and Waste Management Office (AWA), Canton Bern

**Gabi Hildesheimer**, Director, Öbu – Swiss Sustainable Business Network, Zurich

**Peter Hunziker**, Director, Hunziker Betatech AG, Winterthur

**Anton Kilchmann**, Director, Swiss Gas and Water Industry Association, Zurich

**Michael Matthes**, Head of Environment, Safety & Technology, Science Industries Business Association, Zurich

**Stephan R. Müller**, Head of Water Division, Federal Office for the Environment, Bern

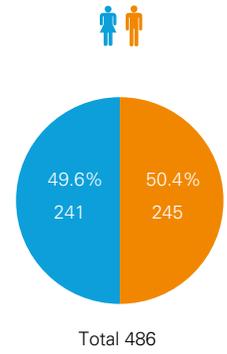
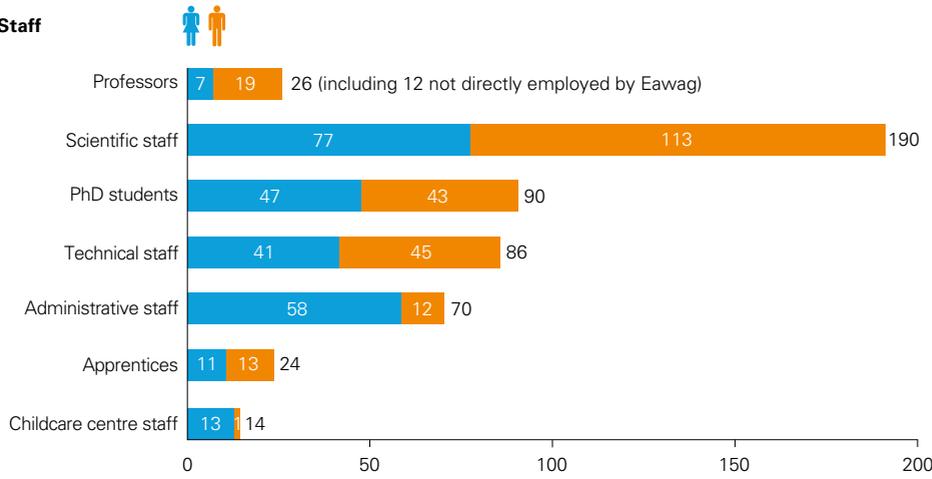
**Reto Schneider**, Head of Emerging Risk Management, Swiss Re, Zurich

**Felix von Sury**, Consultant, Von Sury Consulting, Solothurn

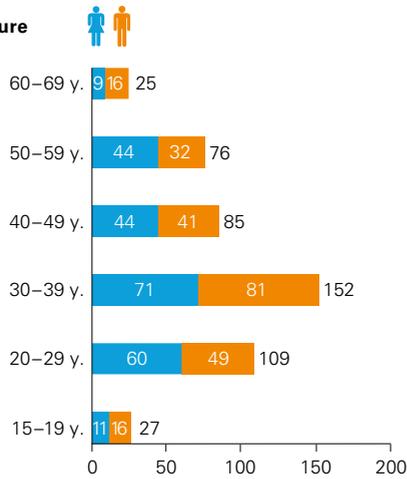
**Thomas Weibel**, National Councillor, Green Liberal Party, Canton Zurich

## Personnel

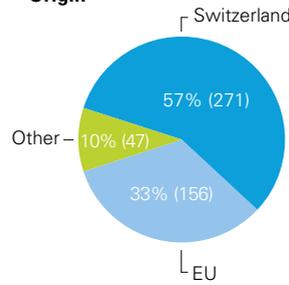
### Staff



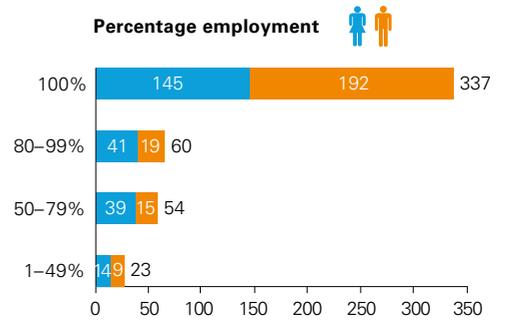
### Age structure



### Origin



### Percentage employment



## Research

### Publications

■ Impact factor > 8    ■ Impact factor < 4  
■ Impact factor 4-8    ■ Non-refereed



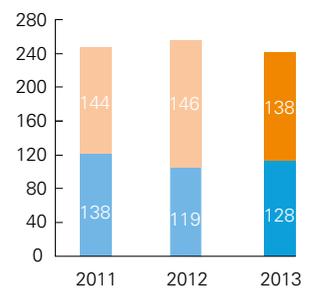
### Swiss National Science Foundation research proposals

👍 approved    👎 not approved



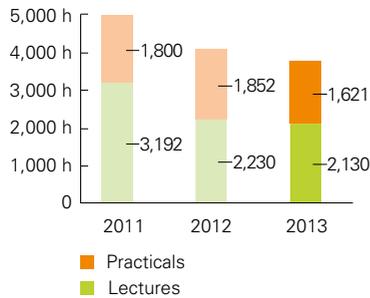
### Committee memberships

■ National committees    ■ International committees

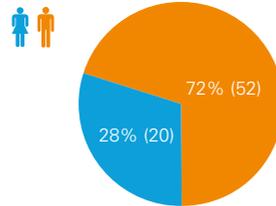


## Teaching

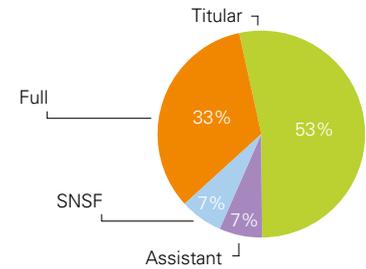
Teaching hours



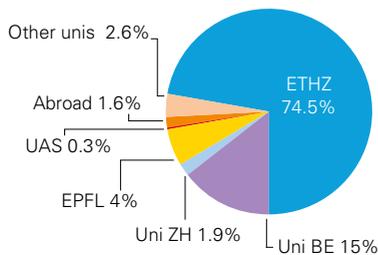
Lecturers



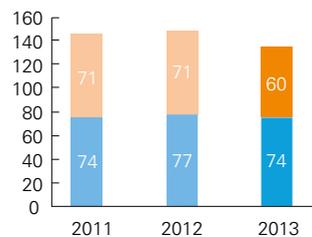
Professorships



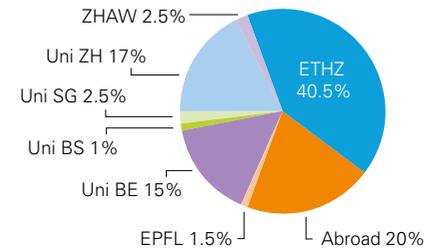
Tertiary-level teaching



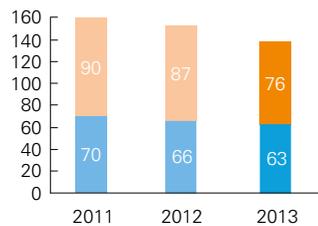
Supervised bachelor's and master's theses



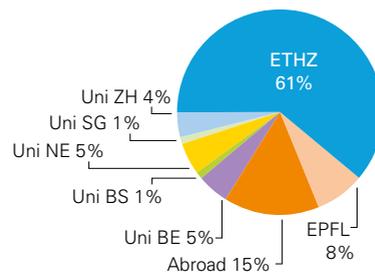
Student home institutions



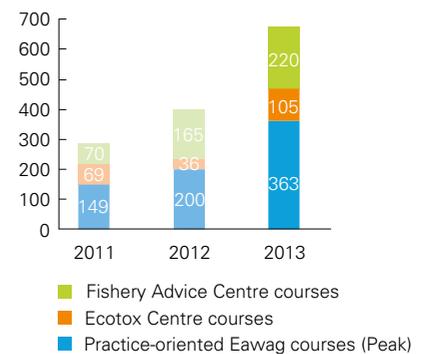
Supervised dissertations



PhD student home institutions



Practical education and training (participants)



## Awards

**Award**

Best Practice Award, Poverty Reduction, Equity and Growth Network  
 Engineering Award, School of Engineering, University of KwaZulu-Natal  
 Paul Crutzen Prize, German Chemical Society  
 Best Paper Award, *Journal of Regional Studies*  
 Best Paper Award, *Integrated Environmental Assessment and Management*  
 ETH Medal for Doctoral Dissertation, ETH Zurich  
 ETH Medal for Doctoral Dissertation, ETH Zurich  
 Young Scholar Award for Best Dissertation, Swiss Political Science Association  
 Dissertation Award, University of Konstanz Science and Society Foundation  
 Südwestmetall Employers Federation Award

**Recipient**

Sandec  
 Urban Water Management  
 Christoph Moschet, Environmental Chemistry  
 Bernhard Truffer, Environmental Social Sciences  
 Peter Reichert, Systems Analysis and Modelling  
 Flavio Piccapietra, Environmental Toxicology  
 Remo Freimann, Aquatic Ecology  
 Manuel Fischer, Environmental Social Sciences  
 Philip Leifeld, Environmental Social Sciences  
 Philip Leifeld, Environmental Social Sciences

## Finances

### Financial statement 2013

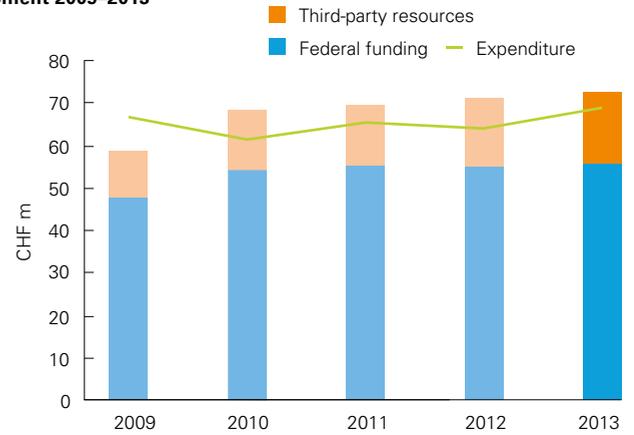
Personnel	47,112,487
Materials	2,855,770
Operations and infrastructure	16,683,718
Depreciation	2,154,088
Provisions	1,563,442
<b>Expenditure</b>	<b>70,369,505</b>
Federal government funding	55,611,973
Third-party resources	16,894,610
Miscellaneous revenue	806,132
<b>Income</b>	<b>73,312,715</b>
<b>Result</b>	<b>2,943,210</b>

### Investments 7,705,966

Real estate	4,523,974
Movables	3,120,734
IT	61,258

all figures in CHF

### Development 2009–2013

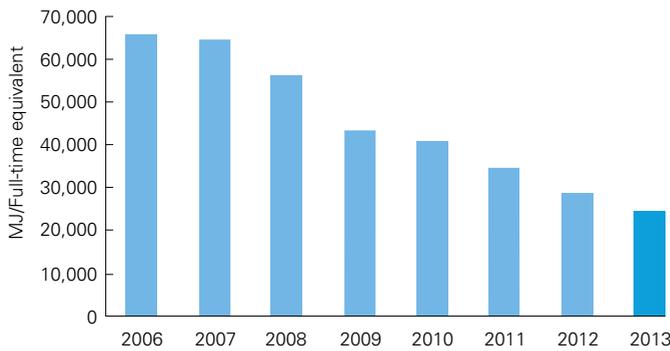


### Third-party resources 2013

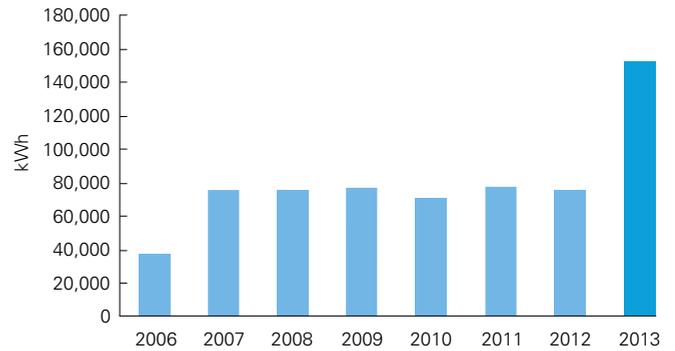


## Environment

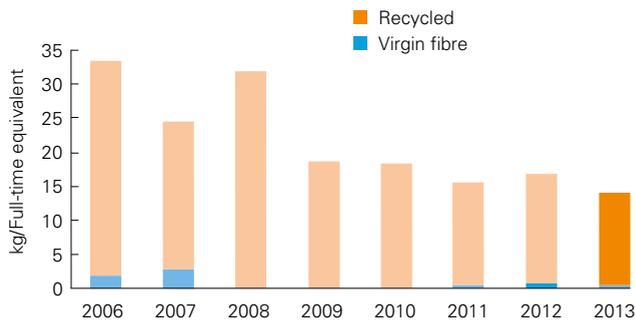
### Energy consumption per capita



### Photovoltaic electricity generation



### Paper consumption per capita



The Annual Report 2013 presents only a small selection of Eawag's research, teaching and consulting activities. A database of all publications by Eawag researchers (including summaries of articles) is available online at: [www.lib4ri.ch/institutional-bibliography/eawag.html](http://www.lib4ri.ch/institutional-bibliography/eawag.html). Open access publications can be downloaded free of charge.

The Annual Report is also available in German and French.

Publication details

Editing: Andres Jordi / Contributors: Irene Bättig (Sprachwerk), Andri Bryner, Anke Poiger, Thomas Lichtensteiger

Layout: Peter Penicka

Translation: Jeff Acheson, Laurence Frauenlob

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"Eawag – aquatic research: Annual Report 2013".

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