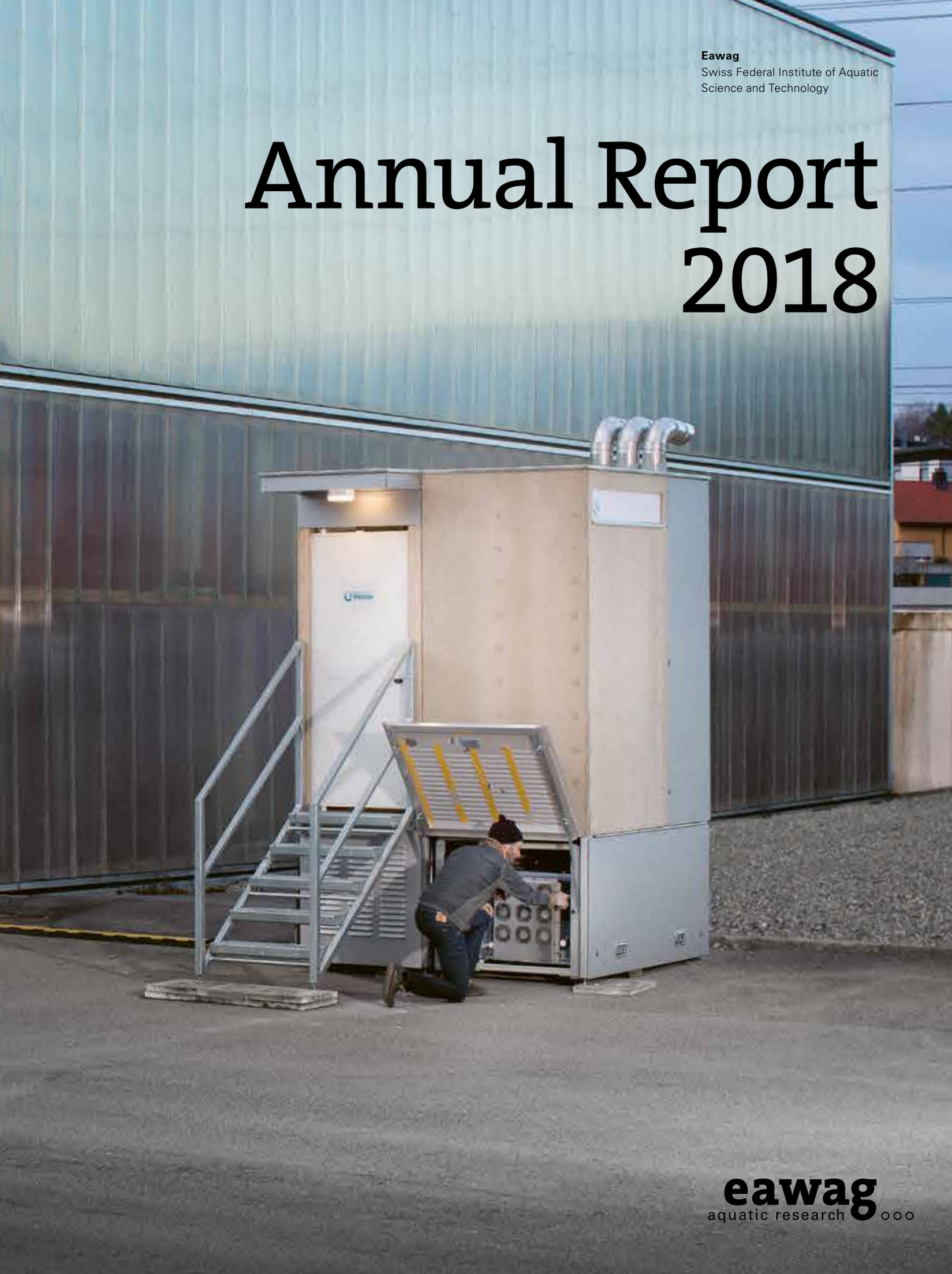
Eawag
Swiss Federal Institute of Aquatic
Science and Technology

Annual Report 2018



eawag
aquatic research

Aldo Todaro, Eawag

Contents

Cover Eawag project manager Kai Udert checks the treatment modules during a test phase for the off-grid toilet. In the Blue Diversion Autarky project, Eawag scientists – in collaboration with three other institutions – are developing new technologies for on-site source separation and treatment of urine, faeces and wastewater (cf. p. 16).

Aldo Todaro, Eawag

Eawag

Eawag's research activities focus on how to secure a balance between humanity's use of water resources and the preservation of resilient aquatic ecosystems. Eawag offers 30 professors, over 300 scientists and around 140 doctoral students a unique environment for pursuing research to generate new scientific findings and develop solutions for fundamental societal challenges.

Here, an important role is played by an interdisciplinary approach and knowledge transfer to authorities and stakeholders from business and society. The 4,500-plus teaching hours at Swiss higher education institutions and the supervision of around 175 Bachelor's and Master's theses per year make an important contribution to the education of young professionals for the Swiss water sector.

Forefront research and societal relevance go hand in hand

Science is often pictured as an activity in the "ivory tower". Short of the Nobel Prize, accomplishments that are highly valued by scientists bring little recognition in broader society. Outside of the scientific profession, people may well wonder at the emphasis that scientists place on the reputation of scientific journals or on obscure metrics applied within the profession. Within the profession, scientists often assume that there is an unavoidable trade-off between conducting forefront research and addressing problems of societal relevance. At Eawag, however, researchers demonstrate every day that problems relevant to society offer fertile ground for forefront research and for the application of cutting-edge technologies.

Identifying exciting research topics through engagement with stakeholders

Eawag's stakeholders include utility managers, consulting engineers, regulators and civil society organisations that are concerned with water supply, water and wastewater management, as well as with the use and protection of aquatic ecosystems. In their daily business, these stakeholders experience situations where current practices are inadequate or may become so under anticipated future conditions. Our researchers are informed about such actual or anticipated deficits through their informal stakeholder networks, as well as through contacts in expert consulting projects, on commissions of professional associations or cantonal and federal offices, or through Eawag's practice-oriented PEAK courses, which have been offered for 25 years. These professional exchanges can help us identify topics for exciting new research projects.

Accessing new technologies and other opportunities through collaboration

Our researchers are highly motivated to apply innovative technologies to problems in the water sector. One example is the application of artificial intelligence so that sewer systems can be used to mitigate urban flood risks. This requires cooperation with external data science experts from ETH Zurich. Eawag is fortunate to have collaborations through joint and adjunct professorships with ETH Zurich, EPFL, several cantonal universities and, starting in 2018, the University of Applied Sciences and Arts Northwestern Switzerland (FHNW). For Eawag and the Swiss Centre of Applied Ecotoxicology (which celebrated its tenth anniversary in 2018), this last joint appointment in ecotoxicology will provide greater access to industrial partners centred in Basel. With their networks and partners, Eawag researchers are well positioned to meet future challenges in water research.

Janet Hering

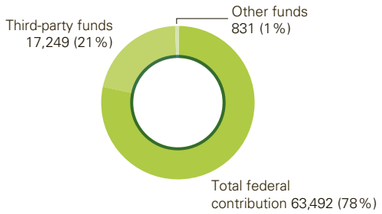
Eawag Director

Eawag in figures

Finances

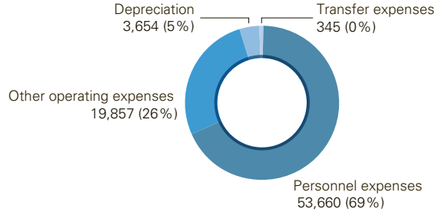
Operating revenue (CHF thousand)

81,572



Operating expenses (CHF thousand)

77,517

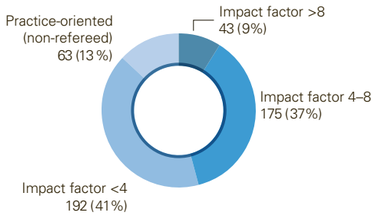


Due to rounding, individual figures may not sum to the totals shown (see Annual financial statements 2018, published separately).

Research

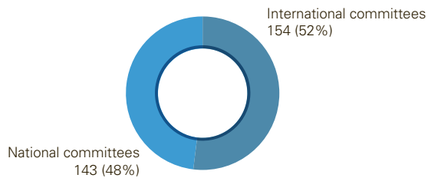
Publications

473



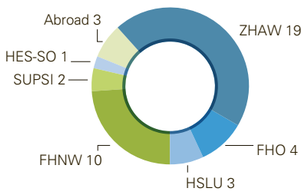
Committee memberships

297



Joint projects with universities of applied sciences

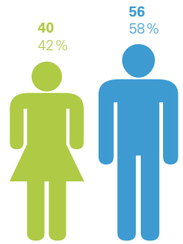
42



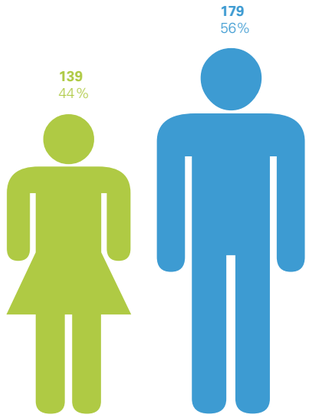
Personnel

Employees by function

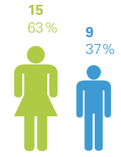
510 49% 51%



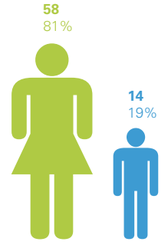
Technical 96



Science 318



Apprentices 24



Administration 72

Annual financial statements: eawag.ch/2018

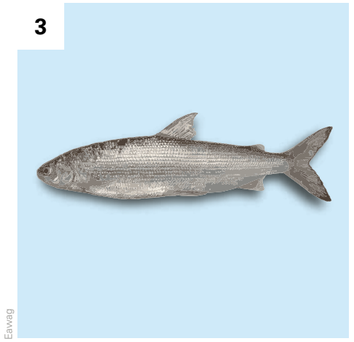
1

NWRI

2

Michael Huwiler

3

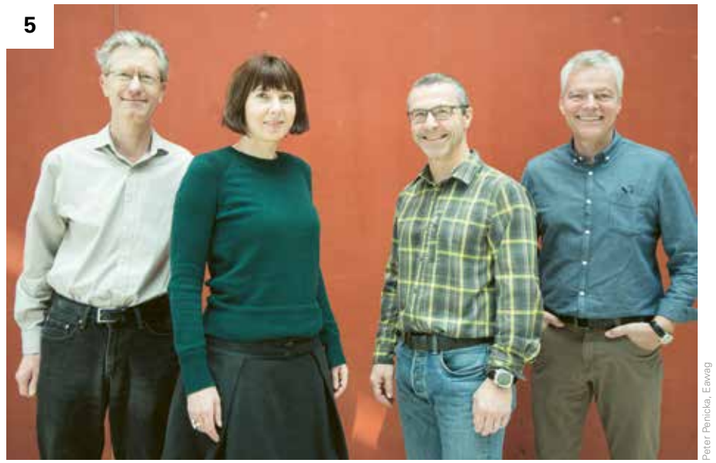


Eawag

4

Peter Penicka, Eawag

5



Peter Penicka, Eawag

6

Shutterstock

7

Ilja Tschanen

Highlights 2018

1 Janet Hering receives Clarke Prize Eawag Director Janet Hering received the 2018 Clarke Prize for Excellence in Water Research, in recognition of her contributions to water resource sustainability and resiliency. The Clarke Prize, consisting of a medallion and USD 50,000, is awarded each year by the US National Water Research Institute (NWRI) to honour outstanding achievements in solving real-world water problems. Established in 1994, it is among the world's most prestigious awards for water research.

2 Eawag exhibits black soldier flies at OLMA As part of an ETH Zurich exhibit highlighting innovative world food system research, Eawag was also represented at the 2018 Swiss Fair for Agriculture and Nutrition (OLMA). The Sanitation, Water and Solid Waste for Development department (Sandec) presented its research on black soldier fly larvae, which can not only break down biowaste but also be used as a source of protein for animal feed, e.g. for fish (cf. p. 19). People visiting the exhibit learned about the opportunities and difficulties associated with this type of waste treatment and saw at first hand how black soldier flies are reared.

3 New whitefish species discovered in the Bernese Oberland Whitefish are important both ecologically and commercially for the prealpine lakes. For this reason, whitefish diversity in Switzerland and neighbouring regions is being investigated by the Fish Ecology and Evolution department. Researchers have now discovered a new species in Lakes Thun and Brienz: provisionally named "Balchen2", it is clearly differentiated (morphologically, ecologically and genetically) from the five Lake Thun whitefish species previously described. The only lake known to harbour a higher number of whitefish species is the Russian lake Onega, which is 200 times bigger.

4 Extended approval for urine-based fertiliser Since 2018, the liquid fertiliser Aurin has been approved by the Federal Office for Agriculture for all types of plants – including fruit and vegetables. This recycled nutrient product was developed in Eawag's "VUNA" project. It is produced from human urine and contains all the nutrients required for plant growth. A combination of biological stabilisation, activated carbon adsorption and evaporation ensures that the fertiliser is free of odours, pharmaceutical residues and other micropollutants. The valuable nutrients recovered from urine – a waste product – would otherwise have to be produced using energy-intensive processes.

5 Sandmeyer Award for drinking water research Michael Berg, Stephan Hug, Annette Johnson (in memoriam), Andreas Voegelin and Lenny Winkel received the Sandmeyer Award from the Swiss Chemical Society (SCS) for their studies on geogenic contamination of water resources (cf. p. 14). This award recognises outstanding research in the field of industrial or applied chemistry. The five scientists started this work 20 years ago, when the problem of arsenic contamination of groundwater in India and Bangladesh became known worldwide. They were among the first to investigate household arsenic removal methods using locally available materials. The Sandmeyer Award will be presented to the researchers in September 2019.

6 Accolade for CENTAUR flood management technology At the 2018 UK Water Industry Awards, the novel sewer flow control system CENTAUR was recognised as the "Most Innovative New Technology of the Year". This award is made annually by two leading British water industry publications Water & Wastewater Treatment and WET News. Researchers from the Urban Water Management department played a key role in the CENTAUR project. The smart, artificial intelligence-based technology allows urban flooding to be managed much more effectively. This is particularly important as the frequency and severity of urban flooding is expected to increase due to climate change. The technology is currently being tested by the research team in the Portuguese city of Coimbra.

7 Tenth anniversary of Ecotox Centre In October 2018, an event was held at Bern's Town Hall to mark the tenth anniversary of the Ecotox Centre. Around 80 guests – including policymakers, officials, scientists and practitioners – celebrated the successful establishment of the Centre and the milestones achieved over the past 10 years. After several speeches and presentations, a reception provided an opportunity for informal exchanges, while spectacular contributions from soap bubble artist Nicky Viva demonstrated the beauty of physicochemical phenomena. Pictured: Inge Werner, manager of the Ecotox Centre.

Research

Practical issues and societal challenges are central to Eawag's research, which focuses on water for human welfare and ecosystem function, as well as strategies for resolving resource-use conflicts. Eawag researchers pursue a systems approach, seeking a holistic understanding of processes and relationships. These efforts are supported by transdisciplinary collaboration in national and international research networks, as well as contacts with water professionals and authorities.

Pictured opposite Research staff member Franziska Böni analyses the microbial content of water that has flowed through various shower hoses: when drinking water comes into contact with plastic materials, ideal conditions arise for the growth of bacteria and fungi. These processes and their potential effects on water quality are investigated by the Drinking Water Microbiology research group at Eawag.

Bath toys and shower hoses – breeding grounds for microbes

The diversity of bacteria and fungi growing in our bathrooms is surprisingly high. Fortunately, most of these microorganisms pose no risk to human health. However, as Eawag microbiologists discovered, a number of pathogens may also be present.

Andri Bryner, Eawag

Dense growths of bacteria and fungi are found on the inner surface of a bath toy

From sealing rings and bath toys, to shower hoses – plastic materials are increasingly used in households. When these materials come into contact with drinking water, organic carbon compounds such as plasticisers are released, which serve as nutrients for bacteria. In combination with a warm, humid bathroom environment, this provides ideal conditions for the growth of bacterial and fungal biofilms. For several years now, the Drinking Water Microbiology group led by Frederik Hammes has been investigating what factors promote such growth, which species of microorganisms occur in biofilms and how they affect water quality.

A striking example of biofilm growth is offered by rubber ducks. In a doctoral research project, Lisa Neu characterised biofilm communities inside used plastic bath toys: between 5 million and 75 million cells per square centimetre were observed on the inner surfaces. This luxuriant microbial growth is probably attributable to the low-quality polymers of which these plastic toys are made. Frederik Hammes says: "Although most of the bacteria and fungi were harmless, some potential pathogens were identified, such as legionella and pseudomonas, a resistant organism responsible for hospital-acquired infections." Pathogenic bacteria were detected in 80% of all the toys studied.

Research still at an early stage

To gain a better understanding of biofilm formation, Hammes' group analysed shower hoses from 11 countries. Complex communities consisting of various microorganisms were found in all the hoses, with legionella being detected in around 30%. Surprisingly, hoses with high levels of legionella were found to contain low levels of pseudomonas and vice versa. So, as Hammes points out, "If we find a way of controlling legionella, we may possibly create a problem with pseudomonas." This makes it all the more important to fully understand biofilm formation, so that it can be controlled. To date, Hammes' team has focused on finding out which bacteria occur on plastics. Biofilm growth has been shown to be a selective process, promoted by organic carbon in plastics. In other words, of the roughly 5,000 different bacterial species found in drinking water, no more than 500 will colonise a shower hose. Based on these findings, the next step for the scientists is to investigate how bacteria actually become established in shower hoses and whether the bacterial composition of the biofilm in plumbing systems can be positively influenced – for example, by seeding of beneficial bacteria.

The ugly ducklings hit the headlines all over the world: the "dark side" of bath toys was reported not only in all the main Swiss newspapers but also in the New York Times, on the BBC and in a dozen other major media outlets.

Plastic degraded by soil microorganisms

Every year, millions of tonnes of plastic end up, not only in the oceans, but also in agricultural soils. This is because farmers around the world use plastic mulch films (made of polyethylene) to control weeds, increase soil temperature and retain moisture, thus increasing crop yields. After harvest, however, debris from the ultra-thin films is frequently left in the fields. These residues accumulate in the soil, impairing soil fertility. Scientists from Eawag and ETH Zurich have now identified an alternative to conventional mulching – films made of the polymer PBAT, which can be degraded by soil microorganisms.

Trick with isotopes

To assess biodegradation of PBAT in agricultural soil, the scientists used specially synthesised films labelled with a stable carbon isotope (^{13}C). This label could then be tracked in carbon dioxide from microbial respiration and in microbial biomass. The scientists thus demonstrated that the material is indeed biodegraded by microorganisms, rather than merely disintegrating into tiny particles. But this does not mean that the global problem of plastic pollution has been resolved – longer-term studies under real environmental conditions are now required. In addition, biodegradable films currently make up a very low proportion of the total used worldwide. In Switzerland, for example, farmers mainly use thicker sheeting, which can be retrieved intact.

Thomas Alföldi/FiBL

Mulch films are mainly used in the cultivation of vegetables.

Contaminated groundwater can damage your health

If rivers are polluted, people often drill groundwater wells in search of safe water. But in many regions, this “solution” has been shown to create new problems, as the groundwater may contain elevated concentrations of arsenic, fluoride, aluminium or manganese.

Dipak Shelare/Shutterstock.com

In many parts of India, there is a high risk of fluoride contamination in groundwater.

Surface waters are polluted even in the remotest areas of the world. Many people living along the Amazon have to tap groundwater resources, as the river water is not safe to drink. But even the groundwater is not necessarily safe: in many cases, water pumped from wells is contaminated with arsenic, manganese or aluminium. This was demonstrated by geologist Caroline de Meyer of the Water Resources and Drinking Water department (W+T), using groundwater samples systematically collected at sites along the Amazon. The potentially harmful trace elements do not derive from industrial pollution, but are released from sedimentary deposits in the subsurface and are thus “geogenic”. Consumption of contaminated water over long periods can give rise to conditions such as cardiovascular disease or cancer.

Data from groundwater samples has also been used by the W+T department to assess the risks of geogenic contamination across whole countries. To generate hazard maps, the scientists developed a geostatistical prediction model incorporating not only measurement data but also topographical, geochemical and hydrological parameters. This allowed geophysicist Joel Podgorski to estimate fluoride concentrations in groundwater throughout India, for example.

Millions of people affected

By combining the results with current population figures, Podgorski found that around 120 million people in India are potentially exposed to excessive fluoride concentrations. Similar calculations were performed for Pakistan, where arsenic contamination in groundwater may pose a health risk for 50 to 60 million people.

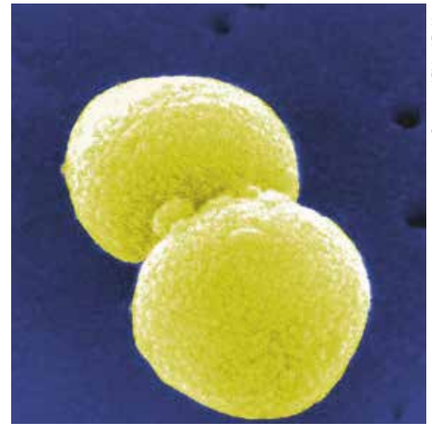
Hazard maps can help to target investments in groundwater safety checks. But for authorities in developing countries, the production of hazard maps can pose major financial and technical challenges. With support from the Swiss Agency for Development and Cooperation (SDC), Eawag has therefore developed a free online Groundwater Assessment Platform (GAP), which enables experts around the world to upload their own data and generate hazard maps.

Resistance genes archived in sediments

When environmental conditions for bacteria are unfavourable, certain species form spores, which can survive for long periods even under harsh conditions and are dispersed by wind or water. Whether antibiotic resistance genes can also be preserved and spread via this pathway has been investigated by scientists from Eawag and Neuchâtel University, who analysed sediments from Lake Geneva. For their analyses, they used two drill cores containing sediments deposited over the past 100 years. They extracted bacterial spores and determined the abundance of genes conferring resistance to two widely used antibiotics – tetracycline and sulphonamide. Helmut Bürgmann of Eawag says, “We found a veritable archive of resistance genes in the sediments.” For example, the introduction of tetracycline in the 1960s was reflected by a rapid increase in resistant spores in the corresponding sediment layers.

The scientists also showed that the frequency of tetracycline resistance genes correlated strongly with the presence of Firmicutes – spore-forming bacteria found in the human gut. This indicates that human intestinal flora serve as a reservoir for antibiotic resistance genes which can be spread by spores.

Commons / Richard Packham



Pneumococci – bacteria belonging to the phylum Firmicutes – are frequently found in human intestinal flora.

Reinventing the toilet

Worldwide, one in three people lack access to appropriate sanitation. In the Blue Diversion Autarky project, researchers are developing an off-grid toilet, with on-site treatment allowing valuable resources to be recovered.

With the Blue Diversion Autarky toilet, faeces, urine and wastewater are separated at source. This means that the three streams can be independently treated according to their particular characteristics: pathogens can be removed more effectively, water can be recycled both for flushing and for handwashing, and nutrients can be recovered.

Project partners

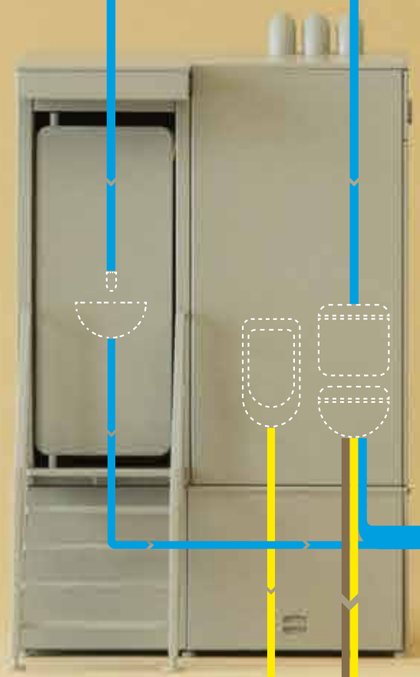
Autarky comprises four subprojects, involving close collaboration between engineers, scientists and designers. The project managers come from various institutions:

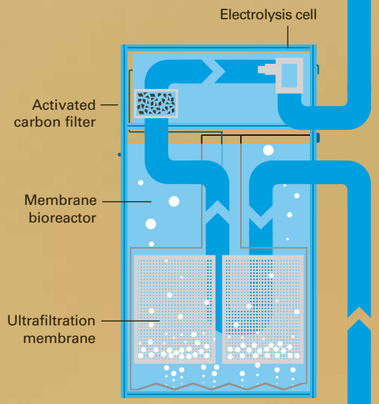
Kai Udert
Eawag and ETHZ
Urine treatment

Fréderic Vogel
PSI
Faeces treatment

Eberhard Morgenroth
Eawag and ETHZ
Water treatment

Harald Gruendl
EOOS Design
Urine trap-toilet
overall design



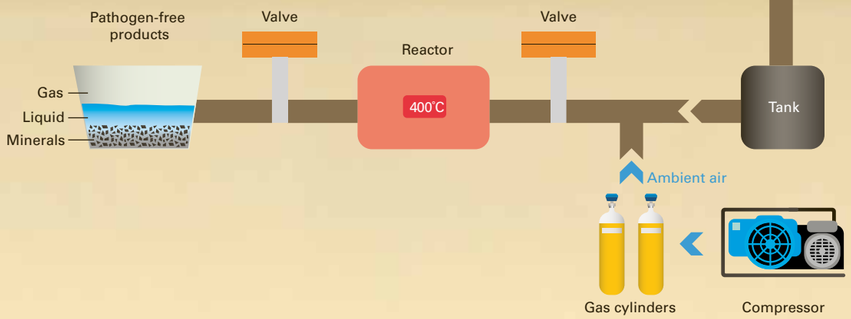


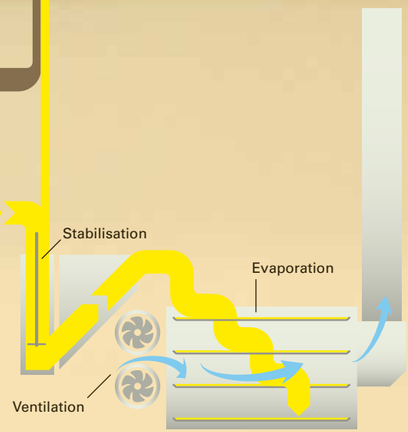
Water treatment

The core of the water treatment system is the membrane bioreactor, in which contaminants are degraded by microorganisms. Bacteria and most viruses are retained by the fine-pored ultrafiltration membrane. The activated carbon filter removes colour and odour from the water. The electrolysis cell produces chlorine – a long-term disinfectant – from dissolved salts still present in the water.

Faeces treatment

Portions of faeces are conveyed by compressed air to the reactor, where they are heated to around 400°C under high pressure. Under these conditions, the organic matter, including all pathogens, is broken down into gas, water and minerals, which can potentially be used as a fertiliser. This process is known as hydrothermal oxidation (HTO).





Urine treatment

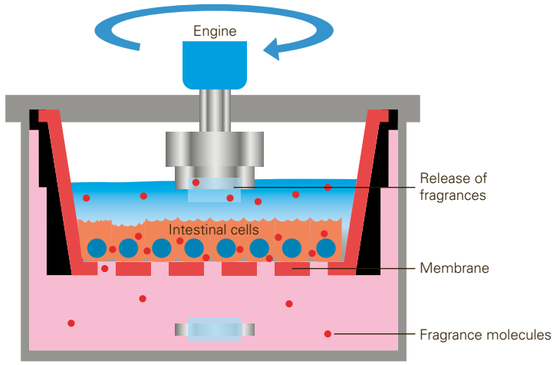
Stabilisation of fresh urine with calcium hydroxide not only prevents unpleasant odours and the loss of nutrients but also inactivates pathogens. Water is then removed from the urine by evaporation. The resultant product is a concentrated nutrient solution, which can be used as a fertiliser.

To find out more, visit: autarky.ch

Keeping track of fragrances

A new device developed at Eawag now allows scientists to determine whether, and to what extent, fragrances in the environment are absorbed by fish. This is possible thanks to the use of a mirror-polished stainless steel chamber and a permeable membrane with a layer of intestinal fish cells.

Fragrances are used in a wide variety of consumer products – cosmetics, detergents, cleaning agents and air fresheners. If they are not completely eliminated at wastewater treatment plants, they can end up in rivers and lakes. Companies are therefore required to perform an environmental risk assessment before fragrance compounds are used in products. One important test parameter is the accumulation of substances in fish. However, the properties of fragrances make them difficult to test: some may readily stick to surfaces and they have to be volatile so that we can smell them. "What this means," says biologist Hannah Schug, doctoral student in the Environmental Toxicology department led by Kristin Schirmer, "is that, during the experiments, fragrances virtually dissipate."



The new analytical device consists of two compartments separated by an intestinal cell barrier.

An intestinal epithelial cell line serving as a barrier

For this reason, Hannah Schug designed a novel test system in collaboration with a leading fragrance company. The device – the size of a small Rubik's cube – has an inner surface made of mirror-polished stainless steel to reduce losses due to adhesion, with an air-tight lid to minimise evaporation. The "TransFEr chamber" system consists of an upper and a lower compartment separated by a cellular barrier. The barrier is comprised of intestinal epithelial cells – the intestinal epithelium serves as a "gatekeeper" in fish. The exposure solution is added to the upper compartment, and measurements are made in the lower compartment to determine the rate of transfer across the intestinal cells. The results indicate to what extent compounds – in this case fragrances – can be absorbed by the intestine and potentially accumulate in fish.

Potential benefits for pharmaceutical research

As well as being useful for environmental toxicologists, the device developed by Hannah Schug is likely to prove valuable in the future in other fields of research – for example, in human toxicology and pharmacology. Pharmaceutical companies already use human cell lines to determine the intestinal absorption of active substances. However, when such substances have properties similar to those of fragrances, they are difficult to test. Schug explains: "With our device, this would now be possible. In cases where a substance was unable to cross the human intestinal barrier in the TransFEr system, animal tests might not even be needed." Cell-based assays thus have the potential to reduce and perhaps even replace animal experiments in environmental and medical research.

Science relies on animal experiments to determine the toxicity and accumulation potential of chemical substances. The team led by Kristin Schirmer is working on alternatives to animal testing by developing experimental and theoretical tools designed to reduce or even replace animal experiments for environmental risk assessment in the future.

Insects as waste recyclers

Growing consumption of meat and fish makes it all the more important that animal feed is sustainably sourced – for example, from insects feeding on organic waste or even faecal sludge.

Eawag

A female black soldier fly lays up to 400 eggs in the cavities of a plastic ball. These develop into larvae, which pupate and can be used for rearing.

According to UN estimates, the world's population will reach 9 billion by 2050. And as demand for meat and fish continues to rise, so will the mountains of waste produced by humans. Even now, particularly in developing countries, municipal organic waste often ends up in the environment or in poorly managed landfills, where it contaminates water resources.

Scientists at Eawag and ETH Zurich are developing technologies for recycling biowaste. Moritz Gold – a doctoral student in the Sanitation, Water and Solid Waste for Development department led by Christian Zurbrügg – is focusing on the cultivation of black soldier fly larvae, which feed on organic waste. "These larvae could provide a sustainable alternative to soybean or fishmeal in animal feed," says Gold. Not only would this help to reduce waste volumes, but the larvae would themselves become a marketable product.

At a test facility in Dübendorf, Gold is currently studying how various types of waste should be mixed and treated to increase the performance of insect cultivation. As well as organic waste, he is experimenting with the use of faecal sludge, which is proving surprisingly effective: "The larvae develop just as well on that," says Gold.

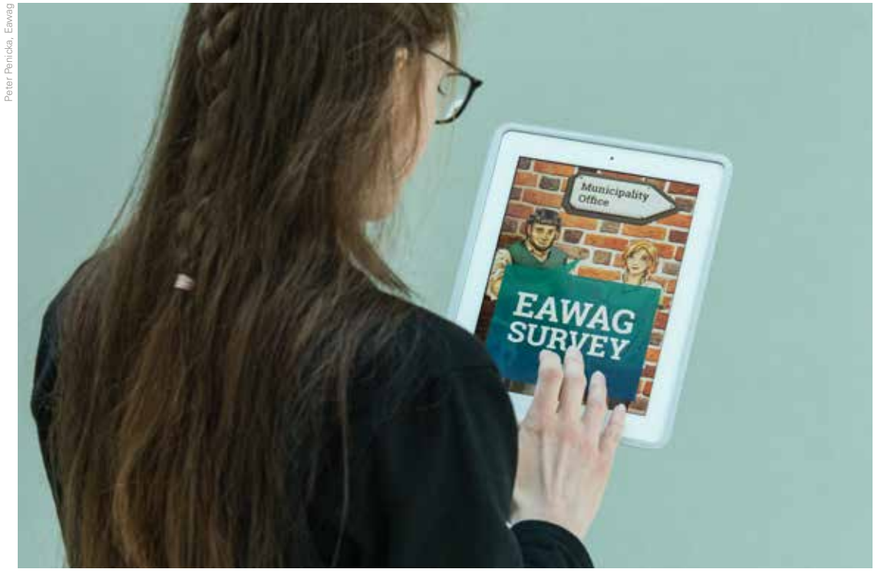
Feed for Swiss aquaculture

About five years ago, Eawag researchers installed a pilot facility in Surabaya (Indonesia), where organic waste is converted into animal feed for fish and poultry. In Switzerland, it is already possible to apply for a licence to use black soldier fly larvae as an aquaculture feed. But as Zurbrügg points out, "We must be able to guarantee that the feed is safe." Among the research projects currently being carried out for this purpose, an Eawag study is investigating whether and to what extent the larvae absorb heavy metals and mycotoxins.

Game-like app promotes sound decision-making

Environmental decision-making is often a complex matter, and it is important to take the views of the public into account. Eawag has now developed an app to facilitate this process.

Peter Penicka, Eawag



In the new app, Leon and Alice guide participants through the questionnaire, asking questions and offering encouragement and praise.

Should a wind farm be built, or is greater weight to be attached to protection of the landscape? What form should wastewater infrastructure take in the future? Multi-criteria decision analysis is a recognised method for dealing with environmental questions of this kind. A key step in the process is to elicit stakeholders' preferences. While individual interviews or moderated workshops can be useful for this purpose, they are time-consuming, and online surveys may be more appropriate. However, questionnaires are frequently not completed because participants are unfamiliar with the complex material or find the questions monotonous. This was what inspired Alice Aubert of the Environmental Social Sciences department to develop an innovative survey app, focusing on wastewater infrastructure.

Motivating users

Aubert explains: "We packaged the questionnaire in a story, where virtual characters communicate with the user." These game-like elements are designed to provide an enjoyable experience and keep the user motivated. The required knowledge is imparted through a series of interactive learning loops. But the main point of the questionnaire is to get participants to reflect on and weight their goals. Here, conflicts may emerge: in Aubert's app, for example, a high level of phosphorus recovery from wastewater is only possible with unconventional toilets, which may have lower social acceptance. Participants then have to decide what is ultimately more important for them.

Concept successfully tested

According to Aubert, the prototype was well received by the 100-plus test subjects. She is convinced of the potential of survey apps: "Online tools allow us to gauge public attitudes more widely." This means, she adds, that long-term environmental decisions are more broadly based and implementation should enjoy greater public support.

Glyphosate eliminated by cyanobacteria

Eawag and Agroscope scientists studying the fate of glyphosate in Lake Greifen have found that, under certain conditions, the controversial herbicide is rapidly degraded. The mass balance (inputs vs exports) established by the researchers indicated that a large proportion of the herbicide is "lost" within the lake. Concentration profiles showed a similar picture: in the upper layer of the lake, concentrations of glyphosate and its main metabolite AMPA rose markedly in July and then declined sharply in August – even though glyphosate continued to enter the lake.

Having excluded chemical and physical elimination processes, the scientists concluded that the decline in concentrations must be due to biological processes. As Michael Stravs of the Environmental Chemistry department explains, "Cyanobacteria – also known as blue-green algae – are able to utilise phosphorus compounds such as glyphosate as an alternative source of phosphorus." And in the months in which glyphosate was rapidly eliminated, high densities of cyanobacteria were indeed observed in Lake Greifen. Laboratory experiments confirmed that the substance can be rapidly degraded by cyanobacteria. However, as Stravs emphasises, "Biodegradation only occurs when phosphate concentrations in the water are extremely low."

Alpine lake ecosystem disrupted by summer storms

As a result of climate change, the clear waters of mountain lakes may increasingly often turn cloudy.

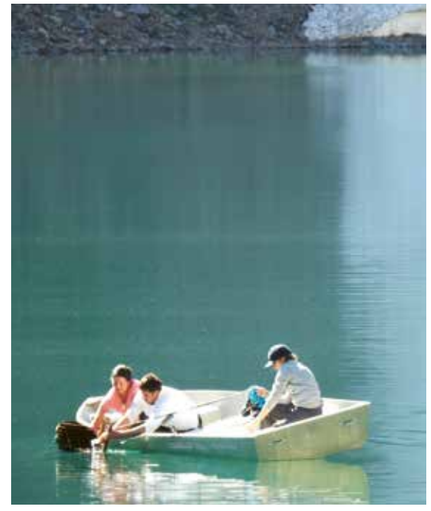
Climate models predict that extreme weather events such as intense summer storms will become increasingly frequent. Researchers from Lausanne University, Eawag and the French National Institute for Agricultural Research have investigated how alpine lake ecosystems will be affected. Their study focused on Lac de la Muzelle, a high-altitude lake in the French Alps. Over three summer seasons, the scientists monitored all rainstorms and windstorms with the aid of weather station data.

Algae die

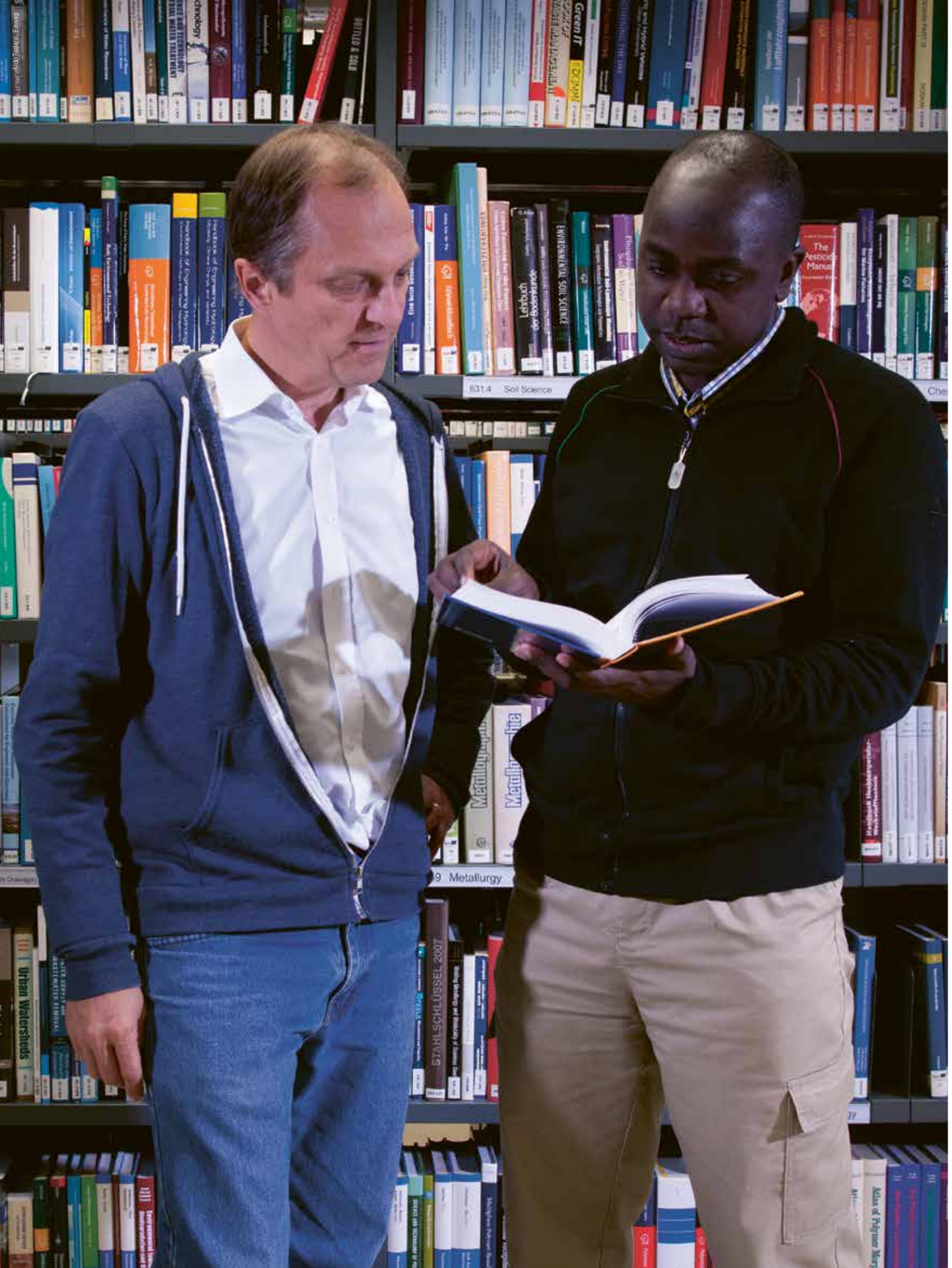
Altogether, ten storms were recorded. In eight cases, the surface waters were stirred up but within a week the lake returned to normal. The other two, however, were "turbid storms": large amounts of suspended particles from the glacial catchment turned the waters cloudy for several weeks. When this occurs, penetration of light to deeper waters is reduced, photosynthesis is inhibited and algae die as a result. This leads to depletion of oxygen and nutrients, with harmful effects on fish.

Surprisingly, turbidity was not associated with the intensity of the storm. Instead, the weather conditions over the previous weeks were crucial: turbid storms were more likely to occur after hot and dry spells. As these conditions will become more frequent with climate change, the future for alpine lakes may be cloudy.

Marie-Elodie Perga



Measurement campaign on Lac de la Muzelle



Teaching

Eawag's teaching activities extend beyond the ETH Domain and are based on the institute's own research. They cover specialised fields, considering the effects of various types of water use on ecosystems. As well as supervising undergraduates and doctoral students, Eawag scientists make a valuable contribution to practice-oriented training at higher education institutions. Eawag is also committed to providing continuing education for water professionals, as well as vocational education and training.

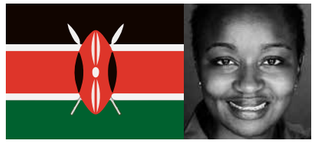
Pictured opposite Christoph Lüthi in conversation with a former EPP Fellow: training and research in developing countries are an important component of Eawag's mission. The Eawag Partnership Programme (EPP) strengthens collaboration with students and academic institutions in the Global South. This programme celebrated its tenth anniversary in 2018.

Eawag Partnership Programme turned ten in 2018

To mark the tenth anniversary of the Eawag Partnership Programme, which has so far supported over 80 Fellows from 28 different countries, four EPP alumni from Africa and Asia describe their experiences.

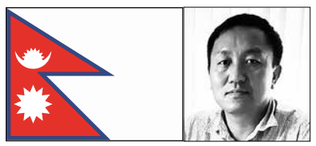
Dr Charles B. Niwagaba (Uganda), EPP Visiting Scientist 2012 Associate Professor of Civil and Environmental Engineering at Makerere University

I found out about the EPP programme as a result of the long-term collaborative research relationship between Eawag/Sandec and Makerere University. During my time in Switzerland, I prepared lecture material for a course on solid waste management that I have been teaching at Makerere University. I also completed a book chapter that was published in the first ever textbook on faecal sludge management.



Pauline Cherunya (Kenya), EPP Fellow 2015
Doctoral student in water and sanitation

Through the experiences I have gathered at Eawag, I see myself contributing to the developments in the water and sanitation sectors of African cities – through research, policy processes and project implementation. I am still at Eawag, now as a doctoral student, investigating demand-side perspectives of transitions towards adequate sanitation access in the informal settlements of Nairobi. I am happy to have the opportunity to continue sharing my experiences with new EPP Fellows.



Mingma Gyalzen Sherpa (Nepal), EPP Fellow 2010
Director, 500B Solutions Pvt. Ltd., Kathmandu

The time during my EPP Fellowship was very fruitful. I was really able to focus, and could develop and submit a manuscript based on my research findings. Currently, I lead a private consulting company, providing services in urban sanitation in Nepal that particularly focuses on citywide sanitation planning and faecal sludge management.

Professor Fabrice Muvundja Amisi (DR Congo), EPP Fellow 2008 Associate Professor, Institut Supérieur Pédagogique de Bukavu, and Dean of the Faculty of Sciences, Catholic University of Bukavu

My time at Eawag was a very valuable opportunity for me to push forward my scientific career dream. The fellowship allowed me to obtain my MSc degree and hence to pursue my PhD study. I liked so much how the EPP organisers made our life enjoyable during our stay at Eawag. We went on excursions, had meetings with other Fellows from various countries and attended conferences.

Seeing how flooding affects river ecology

At the tenth week-long Swiss Summer School held in September 2018, doctoral and postdoctoral students from all over Europe gained insights into experimental flooding on the River Spöl in the Swiss National Park.

Eawag

Excursion to the Punt dal Gall dam

For five days, a variety of experts provided Summer School participants with up-to-date theoretical and practical knowledge relating to experimental floods. The week began with a seminar day, where presentations were given by invited lecturers. Christopher Robinson of Eawag described the 18-year experimental flood programme on the River Spöl and discussed the increased ecosystem resilience generated by repeated floods. Rémy Estoppey of the Federal Office for the Environment (FOEN) explained the current hydropower situation in Switzerland and strategic planning for the phase-out of nuclear power by 2050. Michael Döring, an ecohydrologist at the Zurich University of Applied Sciences (ZHAW), focused on hydropower production and floodplain ecosystems, describing the effects of experimental floods on the Sarine river (canton of Fribourg).

Fascinating fieldwork
A highlight of the Summer School was an experimental flood in the lower Spöl: the students collected samples and studied changes in relevant biotic and abiotic characteristics of the river during flooding. At various sites, they measured water conductivity, temperature, turbidity and flow velocity. They investigated which aquatic plant and invertebrate species benefit and how water chemistry and dissolved organic carbon concentrations are affected.

Drone flights
The young researchers also visited the Punt dal Gall dam, where Ruedi Haller of the Swiss National Park reported on PCB contamination in the upper Spöl. Michael Döring gave a hands-on course on drone surveys, the analysis of aerial images and the generation of orthophotos. Guido Zolezzi and Emilio Politti of Trento University introduced some of the participants to field techniques for data collection for physical habitat modelling.

Controlling disease in crisis regions

In conflict zones or after natural disasters, there is a high risk of infectious diseases spreading due to the breakdown of water supply and sanitation services. How can these health risks be reduced in humanitarian crises? What solutions are available? These questions are addressed by a new MOOC entitled "Introduction to Public Health Engineering in Humanitarian Contexts", jointly developed by EPFL, Sandec and the International Committee of the Red Cross (ICRC). The free online course is designed for technical specialists in water, sanitation, energy, the environment and other related fields. It is offered in English (with subtitles in French and Spanish) and runs for five weeks. The course supplements the MOOC series on "Sanitation, Water and Solid Waste for Development". These MOOCs, launched in 2014, have reached more than 80,000 participants, mainly from Asia, Africa and Latin America.

“Sometimes I think back rather nostal-gically to my time at Eawag”

Morgane Minnig, from Neuchâtel, earned her Bachelor’s degree in Environmental Sciences and Engineering at the Technical University of Munich, and her Master’s in Energy Management and Sustainability at EPFL. She now works as a hydrologist at a consultancy in Dresden and is mainly concerned with groundwater remediation.

Privat

Environmental scientist Morgane Minnig won the prize for the best Master’s thesis in Hydrogeology, awarded annually by the Swiss Hydrogeological Society (SGH). In her case study, she discovered that urbanisation has led to a roughly 50% increase in groundwater recharge rates at Dübendorf. In this interview, Morgane recalls what she particularly appreciated about the time she spent at Eawag.

What prompted you to come to Eawag from EPFL?
Since my internship at the Lausanne water utility, I knew I wanted to do something practice-oriented in hydrology for my Master’s thesis. Because, as a student, I had attended some fascinating lectures by Eawag researchers, this was my first-choice institution. So I contacted Mario Schirmer, and he suggested a great project. Fortunately, Urs von Gunten was also enthusiastic about the project, and he was the professor who supervised my research.

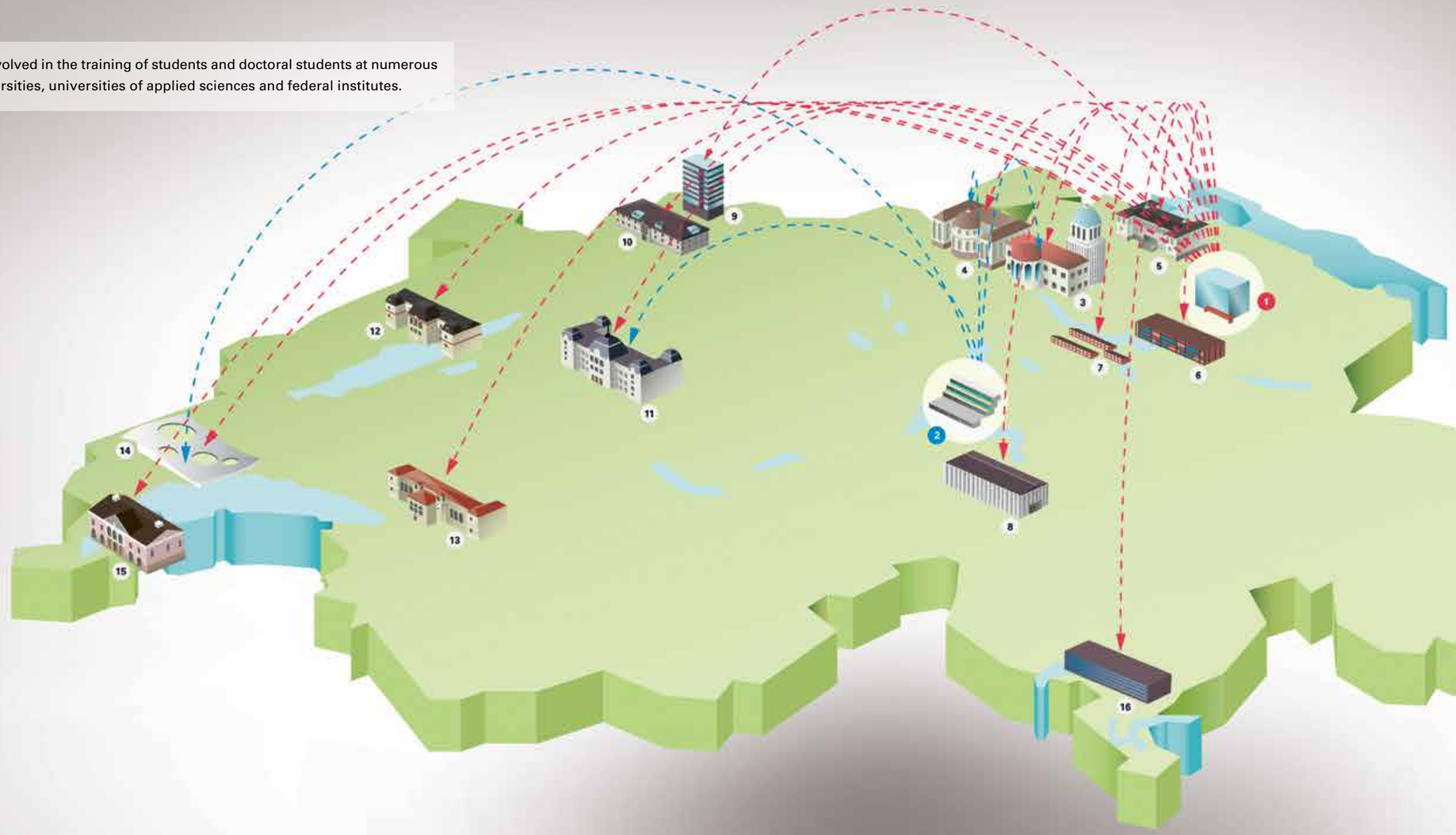
What exactly did your project involve?
We wanted to find out how urbanisation has affected groundwater recharge in the commune of Dübendorf. So I performed water budget calculations for 1880, 1955, 1980 and 2009. This involved developing a geostatistical model, incorporating data on precipitation and evapotranspiration, as well as information on water main leakages and runoff. We discovered that groundwater recharge has increased markedly – by around 50 per cent – since urbanisation began. We were surprised by this value, and the results were published in the *Journal of Hydrology.*

How do you explain your findings?
There seem to be two main reasons why groundwater recharge can increase with urbanisation: firstly, less water can evaporate, as green spaces disappear and, secondly, more water is lost from pipes, since water consumption increases as the population grows.

What did you particularly like about Eawag?
There was a good atmosphere in our research group, and the working climate was very pleasant: we were always exchanging ideas and helping each other. My supervisor was also highly supportive, for which I’m very grateful.

Did the practice-oriented research at Eawag prove beneficial for your current job in an engineering consultancy?
Definitely. In particular, I learned how to cope with a lack of data. In my Master’s study, I was constantly looking for data and had to find creative solutions for dealing with absent or deficient data. I’m now working for a consultancy concerned with contaminated groundwater, for which scant data is available – so I can draw on my Master’s thesis experience.

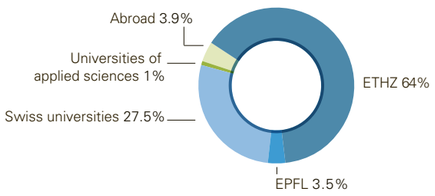
Eawag is involved in the training of students and doctoral students at numerous Swiss universities, universities of applied sciences and federal institutes.



1 Eawag Dübendorf
2 Eawag Kastanienbaum
3 University of Zurich
4 ETH Zurich
5 Zurich University of Applied Sciences (ZHAW), Winterthur
6 University of Applied Sciences of Eastern Switzerland (FHO), Rapperswil
7 Zurich University of Applied Sciences (ZHAW), Wädenswill
8 Lucerne University of Applied Sciences and Arts (HSLU)
9 University of Applied Sciences and Arts of Northwestern Switzerland (FHNW), Muttenz
10 University of Basel
11 University of Bern
12 University of Neuchâtel
13 University of Lausanne
14 EPF Lausanne
15 University of Geneva
16 University of Applied Sciences and Arts of Southern Switzerland (SUPSI)

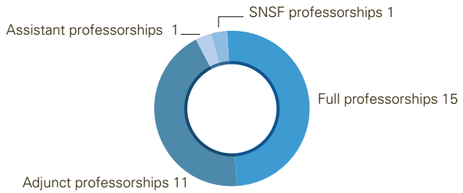
Tertiary-level teaching

4541.5 h



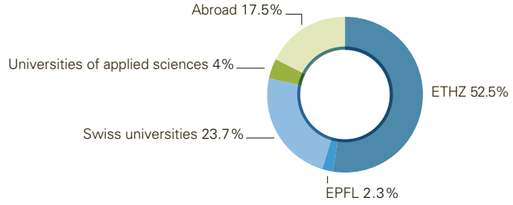
Professorships

30



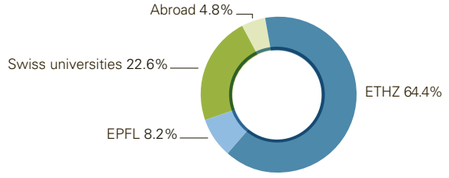
Bachelor's and Master's theses supervised

177



Doctoral theses supervised

146



Thomas Egli

Consulting

Eawag scientists collaborate with water professionals in numerous projects and provide technical input to a wide variety of national and international bodies. In addition, they serve on expert committees and take on consulting contracts. Eawag also operates various Competence Centres, further promoting exchanges between research disciplines and practice. Eawag disseminates the latest research findings in application-oriented publications, thus ensuring knowledge transfer to practitioners.

Pictured opposite Frank Blumensaat analyses data from the Fehraltorf sewer network: Where does the wastewater flowing into treatment plants come from? At what points does the network need to be expanded to cope with stormwater? To date, it has been difficult to answer these questions, since for a long time it was not known precisely what was going on underground. In partnership with Zurich University of Applied Sciences (ZHAW), Eawag scientists have been working on a low-power wireless transmission system which permits efficient data collection in urban drainage networks.

High-tech in the sewer system

To manage an urban drainage network effectively, one needs to know precisely where, when and how much wastewater enters the sewers. Together with Zurich University of Applied Sciences (ZHAW), an Eawag team has been developing a system which permits efficient data collection underground.

Thomas Egli

Frank Blumensaat lowers one of roughly sixty sensors into a sewer in Fehraltorf.

Where does the wastewater flowing into treatment plants come from? Where should a sewer network be expanded to cope with stormwater? According to Frank Blumensaat, engineer at ETH Zurich and the Urban Water Management department, "It's been difficult to answer these questions in the past, as we didn't know what was going on underground." Existing flow-monitoring sensors need a lot of energy, are expensive and – due to being high-maintenance – are not widely distributed. In addition, conventional radio signals can only penetrate the ground to a limited extent. For this reason, Frank Blumensaat and engineer Christian Ebi, in collaboration with ZHAW, have been developing an emerging technology known as LoRaWAN (Low Range Wide Area Network), which permits extremely energy-efficient, spatially distributed monitoring in sewer networks.

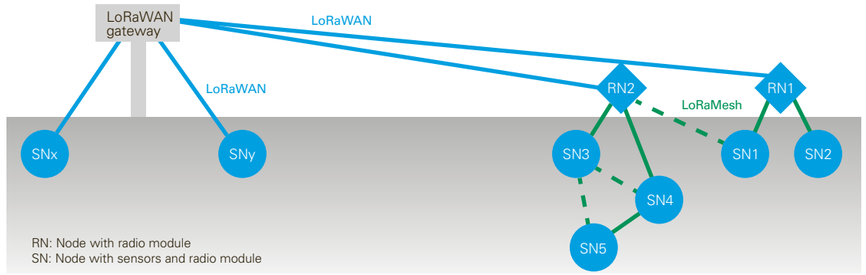
Low-power, low-maintenance sensors

Blumensaat explains: "We've extended the existing LoRaWAN protocol." In the new mesh network (provisionally known as LoRaMesh), relay nodes sited above ground permit the establishment of individual sub-networks below ground (see diagram). Data is transferred from node to node, making transmission more stable and flexible overall. Thanks to LoRaMesh, sensors installed in sewer pipes can thus transmit measurement data to the surface, which would not be possible with conventional radio signals. In addition, the energy consumed by the sensors was reduced through so-called multihop transmission: "This means that, depending on the measurement and transmission interval, the batteries will last for several years," says Blumensaat.

Small amounts of data, high information content

LoRaMesh was developed as part of the Urban Water Observatory (UWO) – a joint Eawag-ETH initiative. In the urban water system of the commune of Fehraltorf, researchers have set up a monitoring network to develop and test the technology. Since 2016, a total of 62 sensors have been installed not just in sewers but also in groundwater and rivers; within this network, data is increasingly being transmitted via LoRaMesh.

The innovative low-power technology does, however, have one drawback: in this network, only small amounts of data can be transmitted, at low frequency. Frank Blumensaat and his team have therefore made various adjustments: the measurement data collected is locally compressed, and measurement and transmission intervals are reduced if necessary. Explaining his current research, Blumensaat says: "Data processing and interpretation remains challenging. But the potential of LoRaMesh is enormous, as we can use it, for example, to study how precipitation runs off or determine where unwanted extraneous water enters the sewers." This would make it possible not only to dramatically reduce operating costs at wastewater treatment plants but also to plan upgrades more effectively.



In LoRaMesh, data passes from node to node, making transmission more stable. Data is thus stably transmitted with low power consumption from below ground to relatively distant surface receivers.

New information leaflets on sediment transport

What flora and fauna are found in and around streams with high sediment transport rates? What happens in rivers where supplies of fresh gravel from upstream are restricted? These are some of the questions addressed by a new set of leaflets in the Umwelt-Wissen/Connaissance de l'environnement series published by the Federal Office for the Environment (FOEN). The seven leaflets, designed for practitioners, summarise the findings of the interdisciplinary research project "Bedload and habitat dynamics". They cover the topics of bedload regime and restoration of bedload dynamics using engineering and operational measures (e.g. bypass tunnels or gravel fills).

The research project is part of the "Hydraulic Engineering and Ecology" programme run by the FOEN, Eawag, WSL and the ETH and EPFL hydraulic engineering laboratories. The next phase of this research collaboration has already begun: the "Riverscape" project (running until 2021) will continue to address sediment dynamics, but will additionally focus on lateral connectivity.

Markus Zeh

The River Sense near Zumholz (canton of Fribourg).

Restoration measures to maximise ecological benefits

In the coming decades, many rivers in Switzerland are to be restored to a natural state. To identify those river reaches where restoration would be ecologically most valuable, Eawag scientists have developed a new assessment procedure.

Markus Bolliger, Shutterstock

A restored reach of the Emme in the Bernese Oberland

Today, very few Swiss rivers or streams still flow in a natural bed. Since the eighteenth century, around 15,000 kilometres of watercourses have been modified, engineered or channelised. The degradation of aquatic habitats has had a severe impact on biodiversity. To tackle this problem, the federal government has requested the cantons to restore around 4,000 kilometres of rivers and streams by 2090.

But what criteria should be used to select the river reaches to be restored? To help answer this question, scientists in Eawag's Systems Analysis, Integrated Assessment and Modelling (SIAM) department have developed a new assessment procedure to evaluate the outcomes of different restoration strategies. "This allows you to determine where restoration would be particularly worthwhile for the ecosystem as a whole," says ecological modelling expert Nele Schuwirth, who developed the procedure together with Peter Reichert and Mathias Kuemmerlen. "Our method also makes it possible to identify deficits in the current ecological state and to evaluate future development scenarios."

Integrated assessment

The new procedure starts by integrating existing physical, chemical and biological assessments at the reach scale. It is then determined how individual river reaches influence the state of the entire catchment – based on the following five spatial criteria:

- good ecological state
- near-natural fish migration potential (connectivity)
- resilience-supporting habitats (availability of refugia)
- low network fragmentation (potential for dispersal)
- near-natural habitat diversity

The new assessment procedure is designed not only to maximise the ecological benefits of restoration projects but also to support policymakers. As well as facilitating the coordination of various measures, it should enable synergies and conflicts with other important ecological services (e.g. flood protection and drinking water abstraction) to be taken into consideration in decision-making processes. According to Nele Schuwirth, "Transparent processes of this kind are essential for public acceptance." The proposed method is now to be further refined in consultation with representatives of cantonal authorities.

This study was carried out as part of the EU-funded AQUACROSS project, which aims to support European efforts to protect biodiversity in Europe's lakes, rivers, coasts and oceans.

How Swiss rivers respond to environmental changes

Chemical conditions in Switzerland's major watercourses have been monitored continuously since 1974. A recent analysis of the data shows that geochemical processes are influenced by climate change and human activities.

The National River Monitoring and Survey Programme (NADUF) was initiated 45 years ago by Eawag and the Hydrology Division of the Federal Office for the Environment. "In 1974, the continuous monitoring system was a novelty," recalls Eawag researcher Jürg Zobrist, who was involved in developing the programme. Since then, around 20 substances have been monitored, including calcium and magnesium, or nutrients such as nitrates and total nitrogen. In addition, discharge, water temperature, oxygen concentrations and pH are continuously measured. Over the years, a vast trove of data has thus been accumulated. In his latest research project, Zobrist – now retired – carried out a statistical analysis of long-term trends from seven monitoring stations.

Reflection of agricultural practices

The results show that, whereas water discharges remained largely unchanged, water temperatures increased by 0.8–1.3°C over the 39-year period. The intensification of agriculture is also reflected in the data: from the early 1980s, inputs of nitrogen to surface waters from agricultural land increased markedly. From the 1990s, changes in fertiliser use and improved wastewater treatment led to a decrease of up to 50% in the total nitrogen load.

Changes in the geochemical carbon cycle

Zobrist also observed changes in geochemical parameters. For example, concentrations of bicarbonate (HCO_3^-) have increased, partly as a result of climate change: "Rising atmospheric temperatures lead to increased activity and respiration of microorganisms in the subsurface, and more CO_2 is released." In wet ground, CO_2 is dissolved as carbonic acid. With higher concentrations of carbonic acid, the rate of rock weathering increases and bicarbonate concentrations rise. Overall, the long-term trends indicate that the geochemical carbon cycle is subject to changes and sensitive to human influences.

Wikimedia Commons

The Aare at Brugg (canton of Aargau) is the site of a monitoring station.

Detecting hormones with bioassays

Even at low concentrations, endocrine disruptors can have adverse effects on aquatic organisms. Fortunately, these compounds are being increasingly removed at wastewater treatment plants in an efficient way – as shown by highly sensitive biological test methods.

Aldo Todaro, Eawag

Bioassays in an Ecotox Centre laboratory: this method is suitable for initial screening of samples for endocrine activity.

Residues of female hormones in streams, rivers and lakes can, at worst, lead to feminisation or impaired reproduction in male fish. However, concentrations of these substances in surface waters are generally so low that they cannot be detected by conventional chemical analytical methods and are thus difficult to monitor. The situation is different with biological methods: "Using bioassays, we can detect tenfold lower concentrations of substances in surface water samples," says environmental toxicologist Eszter Simon of the Ecotox Centre. A further advantage is that, rather than determining the concentrations of individual endocrine substances, bioassays indicate the potential effects of the entire cocktail of hormones on an organism. According to Simon, "This makes biological methods suitable for initial screening of water samples for endocrine substances, complementing chemical analysis."

However, bioassays are not yet established as official monitoring and screening tools.

Europe-wide collaboration

The Ecotox Centre therefore sought to demonstrate the value of bioassays in an international project led by former staff member Robert Kase. In this project, the results of biological and chemical analyses were compared for 16 surface water and 17 wastewater samples collected across Europe. The bioassays were shown to detect substances which cannot be measured by chemical analysis.

In another project, the scientists investigated whether three steroidal estrogens pose a risk to the quality of European waterbodies. Although these three substances are currently included in the EU "watch list", routine monitoring cannot be initiated, as inadequate data is available. Simon says: "Our results show that many surface waters in Europe – particularly in Switzerland – no longer show critical concentrations of estrogenic substances." However, this is only the case where treatment plants are appropriately equipped and operate effectively.

Assessing the effectiveness of treatment plants

Eszter Simon is currently leading a joint project with the Zurich Cantonal Office for Waste, Water, Energy and Air (AWEL), in which various bioassays are used to determine estrogenic activity in treated wastewater. The initial results are encouraging: estrogenic compounds are being effectively removed at those wastewater treatment plants which have been upgraded with an additional treatment step to eliminate micropollutants. "Bioassays thus also have the potential to assess the effectiveness of WWTPs," says Simon. She is therefore pleased that some cantonal authorities have already recognised the value of this recently standardised method.

Climate-friendly nitrogen removal method

Nitrogen is a valuable nutrient, but excessive nitrogen emissions pollute surface waters and the atmosphere. Thanks to an innovative method, reactive nitrogen can now be removed from wastewater and turned into a fertiliser.

Nitrogen compounds are generally removed from wastewater using biological processes. However, as this method is prone to failure, nitrogen is not always completely removed – and the greenhouse gas nitrous oxide may possibly be emitted. "At the same time, for fertiliser production, nitrogen has to be extracted from the air using the energy-intensive Haber-Bosch process," says Marc Böhler of the Process Engineering department. With the membrane stripping process, Eawag aims to close the nitrogen cycle as far as possible. Together with various partners, Böhler is investigating this new physicochemical method for removing nitrogen from wastewater and recycling it as a fertiliser.

Diffusion of nitrogen through a membrane

Nitrogen is removed from the sludge liquid which – of the various wastewater streams in the treatment plant – has the highest concentration of nitrogen in the form of ammonium. To prevent clogging of the membranes, solids are removed by pretreatment. In addition, the water temperature is increased using waste heat from the plant, and the pH is raised. "That makes the process more efficient," Böhler explains. In the stripping process, the pretreated sludge liquid passes over a hollow fibre membrane. While the water flows over the hollow-fibre bundle, ammonia nitrogen diffuses through the gas filled pores of the membrane into the hollow fibres. Circulating inside the hollow fibres is concentrated sulphuric acid, which combines with ammonia to form ammonium sulphate. This can be used directly as a liquid fertiliser.

Eawag

The membrane stripping module used for nitrogen removal at the treatment plant in Yverdon-les-Bains.

Remarkable biodiversity in Swiss rivers

By systematically collecting samples from Switzerland's rivers, "Progetto Fiumi" has documented more than forty species of fish. In addition, within the various species, the Eawag research group has found a rich diversity that had not been fully assessed before. The project thus provides a basis for the protection of this genetic and ecological diversity.

Eawag

Jakob Brodersen removes a muscle tissue sample from a young fish for laboratory analysis.

Switzerland's rivers harbour a unique biodiversity. From 2013 to 2018 – in order to assess this diversity in more detail for the first time – scientists from the Fish Ecology and Evolution department systematically collected fish samples (in September and October in each case) from hundreds of rivers and streams. The project, known as "Progetto Fiumi", is funded by the Federal Office for the Environment and coordinated by Jakob Brodersen. "More than half of the fish caught were trout," he says. "And we found them in almost all habitats – from small mountain streams at an altitude of over 2000 metres above sea level right down to the lowlands." Altogether, fish were sampled at 308 sites across all types of river and stream throughout Switzerland.

Trout have long been known to exhibit considerable diversity: to date, five species have been distinguished, which developed in complete isolation from each other in the major river systems – Atlantic trout *(Salmo trutta)* in tributaries of the Rhine, Rhône trout *(Salmo rhodanensis)*, marble trout *(Salmo marmoratus)* and Northern Italian brook trout *(Salmo cenerinus)* in rivers draining to the Adriatic, and Black Sea trout *(Salmo labrax)* in the Inn. In the early twentieth century, Swiss fish biologists also drew attention to different forms of trout around the lakes of the Engadine.

New findings on trout diversity

In systematically recording the multiple variations between and within species, Brodersen's group found forms that differ in appearance, behaviour and in some cases also genetic composition. For example, studies in the catchment of Lake Lucerne showed that trout in streams with constant flows show greater individual specialisation in prey selection than trout in mountain torrents with highly variable flows. In Graubünden, the researchers compared lowland river trout – living in relatively favourable environmental conditions – with their relatives in the inhospitable upper reaches of mountain torrents. Contrary to expectations, however, the "Alpine trout" were not smaller at first spawning but in fact significantly larger than the lowland trout – an important consideration when minimum catch sizes are specified. In the canton of Vaud, authorities and fishery inspectors drew the researchers' attention to a stream where spotted trout live alongside unspotted specimens. Genetic studies revealed that the spotted fish are closely related to other river trout living nearby, but not to their unspotted neighbours, with which they do not generally mate.

Fish biodiversity database

The Eawag group also found various ecological adaptations and local forms in all other fish species – from the widely distributed bullhead to barbel, minnow and other cyprinids which are the dominant species in large, slow-flowing rivers. In some cases, initial genetic analyses did not confirm existing assumptions, suggesting that further surprises may be in store with these species.

To facilitate further research on previously largely unknown within-species diversity, a collection has been established. This currently comprises around 10,000 fish, 20,000 tissue samples and environmental samples providing information on the food web at sampling sites. Jakob Brodersen says: "The collection at Eawag in Kastanienbaum is available as an extensive database for local studies. At the same time, it is being continuously updated and refined by reports from the public and local investigations."

The collection is already being used for a variety of applied research projects, since fish diversity is threatened by river engineering, barriers to migration, hydropeaking downstream of hydropower plants and other anthropogenic factors. Under the new Waters Protection Act, severely degraded habitats are to be restored in Switzerland. Among other things, Progetto Fiumi provides a basis for monitoring programmes and applied research. It will help to ensure that investments in restoration measures are targeted in such a way that fish actually benefit and genetic diversity is not lost before it has even been properly recorded.

Eawag

Trout caught in the River Ticino: altogether, the Progetto Fiumi collection comprises 10,000 individuals.

Alessandro Della Bella, Eawag

Institution

Eawag is committed not only to excellence in research, teaching and consulting, but also to creating a motivating and supportive working environment. Contributing to this attractive environment are the various support departments, which ensure smooth operations, as well as the outstanding infrastructure available at the Dübendorf and Kastanienbaum sites. Great importance is attached to work-life balance, equal opportunities and respect for employees at Eawag.

Pictured opposite Under the directorship of environmental chemist Janet Hering, Eawag has consolidated its position as one of the world's leading water research institutes. In summer 2018, Professor Hering was reappointed by the Federal Council as Director of Eawag for another four-year term.

Awards

Janet Hering receives Geochemistry Fellow title
The Geochemical Society and the European Association of Geochemistry (EAG) bestowed the honorary title of Geochemistry Fellow on Eawag Director Janet Hering. She received this accolade for her track record as an internationally respected expert in biogeochemistry. The EAG, an international non-profit organisation promoting geochemical research, cited her pioneering contributions to fundamental aspects of aquatic chemistry, to the public health problem of arsenic contamination of drinking water, and to the interfacing of science and policy for sustainable management of water resources.

Two awards for Wenfeng Liu
Environmental engineer Wengfeng Liu (Systems Analysis, Integrated Assessment and Modelling department) received two awards for his doctoral thesis – the Otto Jaag Water Protection Prize and the Chinese Scholarship Council's Government Award for outstanding academic achievements by Chinese doctoral students abroad. Wenfeng developed a grid-based crop model which provides an integrated approach for assessing crop management options to ensure global food security while keeping environmental costs and fertiliser and water use to a minimum. His primary focus was on the development of strategies for efficient agricultural intensification and global food trade.

Early Career Award for Jennifer Inauen
Health psychologist Jennifer Inauen received an Early Career Award from the European Health Psychology Society. These annual awards recognise outstanding contributions to research in health psychology made by EHPS members within the first five years after completing their doctorate. Jennifer Inauen investigates how people deal with environmental hazards and how their health behaviour in their daily lives changes as a result. The award was made in recognition of Inauen's efforts to develop and apply health psychology theories and methods to safe drinking water consumption and sanitation in developing countries.

Peter Penicka, Eawag

Jennifer Inauen: "I am absolutely thrilled and feel very honoured that the EHPS has awarded this prestigious prize to me."

Silver Medal of ETH Zurich for an outstanding doctoral thesis
Caitlin Proctor (Environmental Microbiology)

Outstanding Reviewer for Environmental Science: Water Research and Technology in 2017
Timothy Julian (Environmental Microbiology), Barbara Ward (Sanitation, Water and Solid Waste for Development)

Outstanding Reviewer for Environmental Science: Processes and Impacts in 2017
Elisabeth Janssen (Environmental Chemistry)

Luce Grivat Prize
Carolin Drieschner (Environmental Toxicology)

American Genetic Association Key Distinguished Lecturer
Ole Seehausen (Fish Ecology and Evolution)

Highly Cited Researchers 2018 in the Environment/Ecology category
Adriano Joss (Process Engineering), Urs von Gunten (Water Resources and Drinking Water)

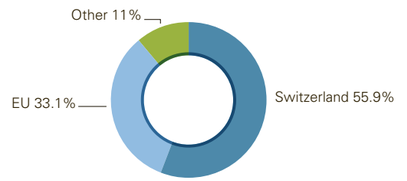
Headcount and personnel structure

As of 31 December 2018, Eawag's headcount (excluding interns, visiting academics and temporary staff) was 510 people (460.2 full-time equivalents/FTEs), distributed among the following functions: scientific, technical and administrative staff, and apprentices. Women account for 49.4% of the total. Eawag continues to provide training for 24 apprentices – chemical and biological laboratory technicians, business administrators and computer scientists.

Eawag's international character as a world-leading aquatic research institute is reflected by the diverse origins of its employees: they come from 44 different countries altogether.

Origin of employees

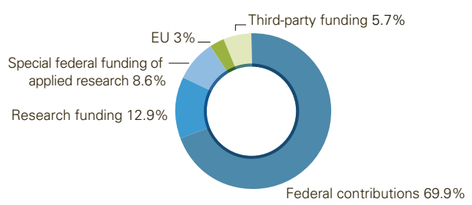
510



Financing for staff derives not only from federal contributions but also from research funding obtained on a competitive basis. As of 31 December 2018, the financing of the FTEs (excluding apprentices) breaks down as follows:

Sources of funding for personnel (CHF thousand)

17,249



Personnel policy

Eawag is a responsible employer, offering flexible working models, excellent training opportunities and integrated health management. It focuses continuously on the recruitment and career development of first-class employees, both in research and in technical and administrative areas. For its 99 doctoral students, Eawag provides an excellent infrastructure, specific training options and tailored information platforms.

Internal training focuses in particular on leadership skills and management development. For many years, Eawag has also invested in language courses at all sites, reflecting the institute's international ethos. In addition, financial support is provided for numerous individual training courses, so that employees' qualifications are maintained at a high level.

Personnel news

Joint professorship for FHNW School of Life Sciences and Eawag
Much research remains to be done on how organisms and ecosystems are affected by pollutants from industry, transport and agriculture. A joint professorship in applied ecotoxicology has therefore been created by the FHNW School of Life Sciences and Eawag. Miriam Langer, the biologist appointed to this position, has conducted applied research at the Ecotox Centre since 2015. Under the NAWA SPEZ programme, she carried out ecotoxicological monitoring of pesticides in Swiss streams.

Peter Penicka, Eawag

Biologist Miriam Langer took up her professorship at the FHNW Muttenz Campus in autumn 2018.

Associate professorship at ETH Zurich
Eawag scientist Lenny Winkel has been appointed by the ETH Board as Associate Professor of Environmental Inorganic Geochemistry. In her research, she focuses on the environmental behaviour of selenium and other trace elements that can affect health. She investigates the sources, pathways and sinks of naturally occurring selenium and explores the production of volatile forms of selenium by marine phytoplankton. Lenny Winkel also teaches in the Department of Environmental Systems Science at ETH Zurich.

Peter Pernicka, Eawag

ETH Associate Professor Lenny Winkel is also head of the Environmental Inorganic Geochemistry group in the Water Resources and Drinking Water department of Eawag.

New management team at Fisheries Advisory Service
At the Swiss Fisheries Advisory Service (FIBER) in Kastanienbaum, biologist Philip Dermond has become the new co-director alongside Corinne Schmid. Dermond joined Eawag's Fish Ecology and Evolution department in 2015 to carry out doctoral research on Lake Lucerne trout migration. FIBER – financed by Eawag and the Federal Office for the Environment – brings together professional associations, authorities and researchers with the aim of promoting sustainable fishing and protection of natural waters.

Remote sensing research expanded
Eawag is developing a joint research cluster with the Department of Geography at Zurich University in the area of remote sensing. The growing team includes Alexander Damm, who has held a joint assistant professorship in Remote Sensing of Water Systems at Eawag and Zurich University since August 2017. In 2018, Daniel Odermatt was appointed as head of the newly established Remote Sensing research group at Eawag.

Associate professorship at Zurich University
Ecologist Florian Altermatt has been appointed as Associate Professor of Aquatic Ecology at Zurich University. His research focuses on biodiversity in aquatic ecosystems. With the aid of mathematical models, laboratory experiments and natural river networks, he and his team investigate, for example, how terrestrial and aquatic ecosystems influence each other. His group is also developing and testing methods of monitoring biodiversity in rivers using environmental DNA. This newly established professorship should also help to promote synergies between Eawag and Zurich University.

Presidency of Swiss Biodiversity Forum
In addition to his associate professorship, Florian Altermatt has been appointed by the Swiss Academy of Sciences as President of the Swiss Biodiversity Forum. The Forum supports biodiversity research and facilitates dialogue and cooperation between scientists and decision-makers in government, business and society.

Peter Pernicka, Eawag

Florian Altermatt previously held an SNSF professorship at Zurich University (2014–2018).

Adjunct professorship at University of Southern Queensland
Hydrogeologist Michael Berg has been appointed as Adjunct Professor at the University of Southern Queensland School of Civil Engineering and Surveying. In this capacity he will also become a member of the UNESCO Chair on Groundwater Arsenic. Berg investigates organic and inorganic contaminants in groundwater and the associated biogeochemical processes. He focuses in particular on trace elements in drinking water, such as arsenic, manganese or fluoride, which can have harmful effects on human health. Since 1998, he has been involved in environmental research projects in South and Southeast Asia and in Africa. A more recent interest is the Amazon Basin, where little is known about groundwater quality to date.

Peter Pernicka, Eawag

Michael Berg joined Eawag in 1992 and has been head of the Water Resources and Drinking Water department since 2014.

Spin-off

enviBee: monitoring micropollutants in water
Analysis of scientific data is a complex task: large datasets need to be mined for relevant information or interesting trends, and the results prioritised, summarised and visualised. With the right computational tools, these processes can now be automated. Environmental chemist Martin Loos of Eawag develops software solutions for analysis of mass spectrometry data in long-term monitoring of organic micropollutants in aquatic systems and in drinking and wastewater treatment. Loos is now offering these services as an Eawag spin-off (enviBee GmbH).

Broad dialogue

Info Day on wastewater: recycling instead of disposal
As wastewater is foul-smelling and contains pathogens, it is usually rapidly disposed of. However, this out-of-sight-out-of-mind approach is costly and wasteful: after all, valuable resources such as energy, nutrients and water can be recovered from wastewater. The 2018 Info Day provided an opportunity for Eawag scientists to discuss wastewater treatment and the current limits of recycling with around 200 scientists, officials, policymakers and water professionals.

***Flows of Science:* milestones in source separation**
Eawag has a long tradition of developing innovative source separation technologies. Environmental historian Luke Keogh was commissioned by the Directorate to chart the milestones of Eawag's journey and describe its research collaborations in a report entitled Flows of Science. The result of this oral history project is a sensitive portrait of the scientists who have been involved in this work over the years.

Environmental historian Luke Keogh was commissioned by Eawag's Directorate to prepare *Flows of Science*.

PEAK: 25 years of engagement with practice
In autumn 1993, Eawag launched a series of courses under the PEAK label (practice-oriented Eawag courses). Following somewhat critical ratings from practitioners – "too elitist", "working in an ivory tower" – and a federal initiative to promote continuing education, Eawag wished to underline the importance of its (existing) contacts with water professionals. The event held to celebrate PEAK's 25th anniversary in autumn 2018 demonstrated the continuing success of this programme.

Peter Pernicka, Eawag

PEAK instructors of the first hour took part in a panel discussion at the 25th anniversary event.

Future Day: biofilms and underwater worlds
Once again, National Future Day gave numerous children an opportunity to explore the fascinating world of water research. At Dübendorf, the fifth- to seventh-graders analysed biofilms in the lab and were also introduced to the topic of aquatic biodiversity: they studied the various organisms present in water samples collected from the Chriesbach stream. At Kastanienbaum, the visitors enjoyed an excursion on Lake Lucerne. The gadget freaks were particularly thrilled by the underwater drone which captured fascinating images of life below the surface.

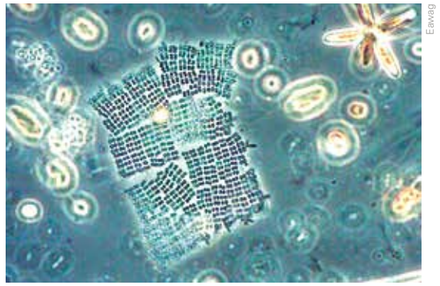
Eawag

At Kastanienbaum, the children enjoyed a trip on Lake Lucerne aboard a research vessel.

Handwashing unit exhibited during fundraising campaign
Eawag took part in last year's SRF/Swiss Solidarity fundraising campaign "Every penny counts", whose motto was "A roof over their heads". As well as physical shelter and security, this refers to dignity and protection against abuse, disease, epidemics and natural hazards. Dignity includes access to sanitation – which in many countries is not (widely) available. In the Blue Diversion Autarky project, Eawag scientists developed a system which enables greywater (relatively clean wastewater from showering, bathing and handwashing) to be treated on-site and recycled. During the campaign, this unit was exhibited at the Inseli park in Lucerne.

The sound of plankton
Can you hear a melody in a lake? What does plankton diversity sound like? Ecologist Francesco Pomati and colleagues transformed datasets from a monitoring platform on Lake Greifen into music. The platform automatically collects samples and measures phytoplankton diversity, generating large amounts of data – which the researchers used to synthesise music. For this, they were awarded a prize for scientific data visualisation at an ETH Zurich science and art event.

Eawag



Plankton diversity in Lake Greifen.

Equal opportunities

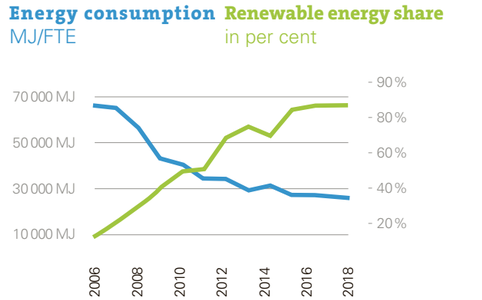
The Equal Opportunities Committee (EOC) aims to prevent workplace discrimination. To this end, it supports initiatives such as, in recent years, "Fix the leaky pipeline" – a career development programme for women in science. This programme offers young female scientists the opportunity to reflect on their professional situations, to develop a strategy for embarking on or continuing their career paths, to receive targeted further training, and to extend their personal and scientific networks. At Eawag, the high proportion of women in management positions (32.65%) has once again been increased (+1.3%).

Under the Tailwind programme, the Directorate continues to provide grants to support mothers returning to work. The term of employment for tenure-track female scientists is automatically extended if they start a family, and new fathers can temporarily reduce their working hours. As well as supporting the Empa-Eawag childcare centre, Eawag contributes to the childcare costs of low-income parents.

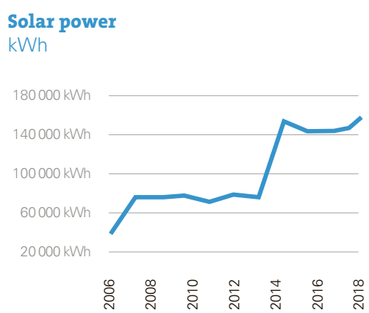
Environment

The aim of the joint Empa-Eawag energy supply project known as "Energie-Areal Empa Eawag" is to reduce CO_2 emissions in the buildings and operations sector by up to 60% compared to 2012. The two institutes are therefore expanding their mid-temperature network, and the construction work required for this purpose was carried out in 2018. Eawag's main building and additional newer or refurbished buildings on the campus are now being connected to this network. Research facilities and cooling machines in particular create a lot of waste heat on the site, not all of which is currently used. From 2019, however, thanks to the mid-temperature network, older, poorly insulated buildings can be heated to the previous high-temperature level with the aid of innovative heat-pump technology. Excess waste heat is also to be held in an underground thermal energy store for use during cold periods. The phase-out of the existing high temperature network will reduce emissions and costs.

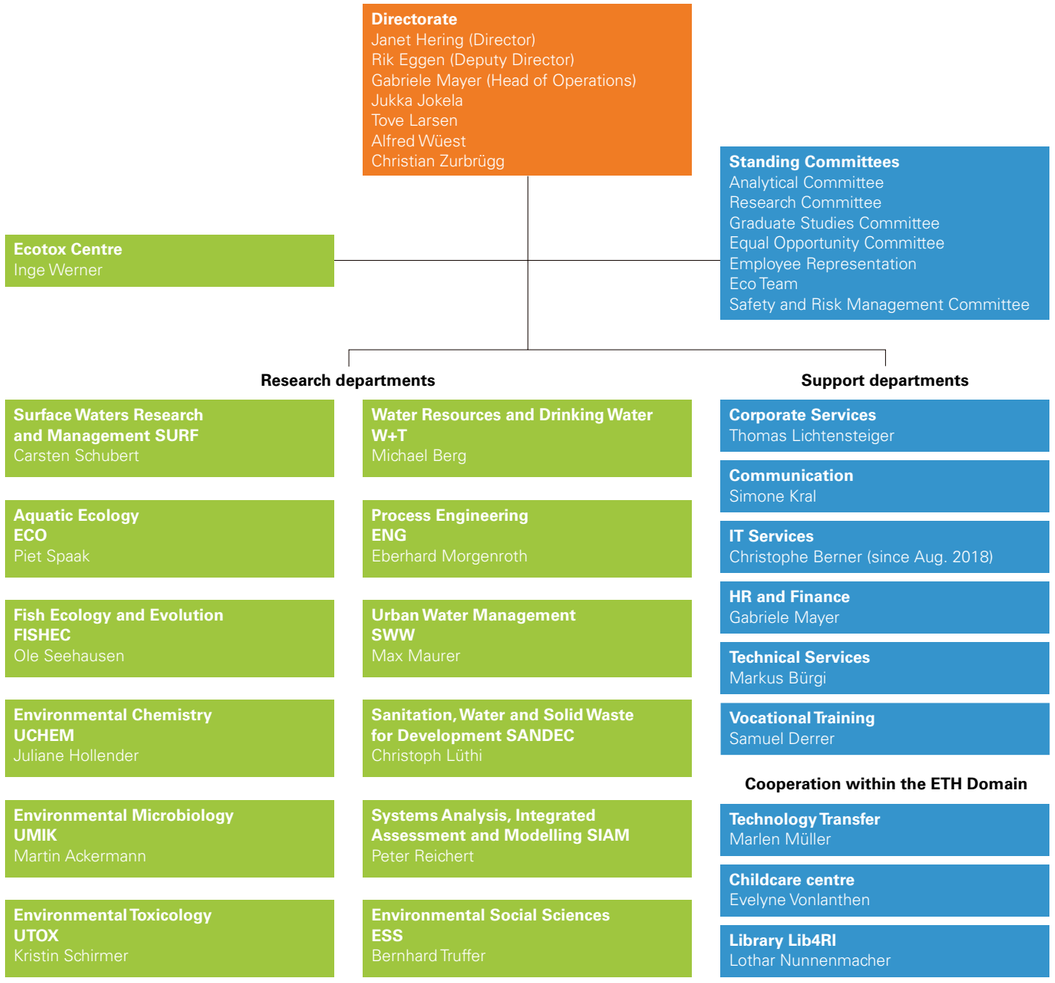
Energy consumption per capita



Photovoltaic electricity generation



Organisation



Advisory Board

Peter Hunziker (Chair), Director, Hunziker Betatech, VSA representative / **Anna Bozzi,** biotechnology and nutrition research expert, scienceindustries / **Heinz Habegger,** Water Excellence AG / **Catherine Martinson,** Head of Regional Work, Executive Board member, WWF Switzerland / **Stephan Müller,** Head of Water Division, Federal Office for the Environment / **Martin Sager,** Director, Swiss Gas and Water Industry Association / **Thomas Weibel,** National Councillor, Green Liberal Party, Canton Zurich

As of 31 December 2018

Directorate

Janet Hering Director

Janet Hering, a chemist, is an expert in processes for the treatment of contaminated water and in the biogeochemical behaviour of trace metals. She is Professor of Environmental Biogeochemistry at ETH Zurich and Professor of Environmental Chemistry at EPFL. She is also a member of various national and international bodies. In 2015, she was inducted into the US National Academy of Engineering.

Rik Eggen Deputy Director

Rik Eggen, a biologist, is particularly interested in the effects of aquatic chemical pollution on environmental and human health, the underlying mechanisms, and the development of mitigation strategies. He is Adjunct Professor of Environmental Toxicology at ETH Zurich and is also a member of the Board of Directors of the Ecotox Centre.

Gabriele Mayer Head of Operations

Gabriele Mayer, a business manager, has considerable experience in the fields of internal control systems and international accounting. She has held executive positions with US and Swiss corporations. At Eawag, she is responsible for the Support departments and cross-institutional infrastructure. This includes the operation and further development of the SAP system used by the four research institutes within the ETH Domain, as well as projects such as the changeover to International Public Sector Accounting Standards (IPSASs).

Jukka Jokela Group Leader ECO

Jukka Jokela is an internationally renowned expert on the evolution of aquatic organisms and on coevolutionary host-parasite interactions. In his applied research, he develops management methods to control the spread of invasive species and pathogens. He is Professor of Aquatic Ecology at ETH Zurich and a member of the Directorate and the Advisory Board of the ETH Zurich Genetic Diversity Centre.

Tove Larsen Group Leader SWW

Tove Larsen, a chemical engineer, works on sustainable urban water management. Her research focuses on technologies for source separation and on-site wastewater treatment. For example, she led the award-winning Blue Diversion project (development of a grid-free urine-diverting toilet). She is Adjunct Professor at the Technical University of Denmark and a member of the Advisory Boards of the FHNW School of Life Sciences and the ZHAW School of Life Sciences and Facility Management.

Alfred Wüest Group Leader SURF

Alfred Wüest, an environmental physicist, investigates and models mixing processes and biogeochemical fluxes in lakes. In addition, he studies how the aquatic environment is affected by pumped-storage hydropower operations and lake heat use. He is Professor of the Physics of Aquatic Systems (Margaretha Kamprad Chair) at EPFL, where he is also Director of the Limnology Centre.

Christian Zurbrügg Group Leader SANDEC

Christian Zurbrügg, an expert in water supplies, sanitation and waste management, studies concepts and technologies for upgrading infrastructure and services in urban areas of low- and middle-income countries. He has led several international programmes and projects in this field. He teaches at ETH Zurich, EPFL and various universities

Risk management at Eawag

Background
Requirements for the management of risks are specified in the ETH Board's directives of 4 July 2006 on risk management at ETH and its research institutes, issued in accordance with Art. 19a para. 2 of the Ordinance on the ETH Domain (SR 414.110.3). These directives regulate the essential aspects of risk management and define the goals of the risk policy pursued by the ETH Board. Based on a decree of the ETH President, the directives came into force on 15 February 2007. They regulate in particular:

– the goals of risk policy and responsibilities
– risk identification
– risk assessment
– risk minimisation and financing
– risk controlling

The goal of Eawag's risk policy is, in a circumspect and timely manner, to identify and draw attention to any material risks threatening Eawag's operations and activities, and to take appropriate measures – adapted to the institute's cultural diversity and organisation – to absorb or mitigate such risks.

Responsibility and risk management process
In accordance with the autonomy granted to ETH's six institutions under the Federal Act on the Federal Institutes of Technology, which is fundamental to their work in the fields of teaching, research and knowledge/technology transfer, each institution is responsible for managing the risks existing in its own sphere of operations. The Presidents of the Federal Institutes of Technology and the Directors of the research institutes thus have overall responsibility for risk management within their respective institutions. Accordingly, the two Federal Institutes of Technology and the four research institutes have each introduced their own risk management process, based on the requirements specified by the ETH Board. This process comprises the identification and assessment of individual risks, risk minimisation strategies and risk controlling. Eawag has a risk manager, who coordinates risk management activities and controls the risk management process. The risk manager is supported by the other individuals responsible within Eawag's risk organisation. The implementation of risk management is monitored by the Directorate and by the ETH Board's internal audit, which reports to the ETH Board's Audit Committee.

Risk situation

Risks
Eawag's individual profile is reflected in its risk catalogue; its core risks and the assessment thereof are influenced by the fact that Eawag is relatively small compared to the other institutions within the ETH Domain.

The risks identified, and the potential loss or damage in each case, are described in detail in the risk catalogue and assessed in terms of the likelihood of occurrence and the financial impact (potential losses). In addition, particular attention is paid to the potential impact of risks on the institute's reputation. Eawag updates its risk catalogue at least once a year, taking account of new developments and changes in the risk situation. The catalogue covers the following risk categories:

– financial and economic risks
– legal risks
– property, infrastructure and natural hazard risks
– personnel and organisational risks
– technological and scientific risks
– social and political risks
– environmental and ecological risks

Core risks are those with a potentially high financial impact and an above-average likelihood of occurrence which pose a direct threat to the fulfilment of the institute's legal duties.

Each spring, the risk organisation meets for its annual discussion of the risk situation at Eawag and, under the leadership of the risk manager, prepares a risk report. In addition to the minutes, this report includes the revised risk catalogue, as well as brief reports by all risk owners, comprising a review of the year and outlook. The risk report is submitted to the Eawag Directorate for consideration and approval. In its annual reporting, Eawag provides information on its core risks, in particular the extent and potential impacts of these risks. In addition, the ETH Board, as the supervisory body of the ETH Domain, is directly informed, in a timely manner, of any exceptional changes to the risk profile or exceptional loss events. Eawag's core risks are considered to lie in the following areas:

– quality of teaching, research and services
– scientific misconduct
– damage to or loss of test systems/samples
– accidents suffered by employees or visitors
– IT risks (data loss, unauthorised access, etc.)

Risk management instruments and measures
As a fundamental element of risk management, subsidiary to other measures, Eawag is required to obtain insurance covering possible losses.

Insurance situation

Despite prudent risk management, the risk cannot be excluded that an institution might be affected by an event resulting in loss or damage that jeopardises its ability to fulfil its duties as set out in federal legislation. In such a case, the ETH Board, under Art. 19a para. 4 of the Ordinance on the ETH Domain (SR 414.110.3), would submit an application to the Department, for the attention of the Federal Council, concerning an adjustment of the performance mandate or an increase in the federal financial contribution. For the evaluation of this subsidiary risk for the Confederation (i.e. the federal guarantee under Art. 19 para. 1 of the Government Liability Act, SR 170.32), the insurance policies taken out by the institutions within the ETH Domain are of particular importance. The institutions are, however, required to take their individual risk situation into account and to strive for an appropriate cost benefit ratio, as well as complying with the relevant provisions concerning federal public procurement. These insurance policies must meet the usual standards of the Swiss insurance market and must be issued by an insurance company licensed in Switzerland.

Each institution is responsible for taking out its own insurance policies and managing its own insurance portfolio. In its directives, the ETH Board merely specifies that, in addition to the insurance required by law, the two Federal Institutes of Technology and the four research institutes must obtain basic coverage by taking out the following types of insurance:

– property and business interruption insurance
– general liability insurance
– insurance policies required to provide the broadest possible coverage of core risks

It should be borne in mind that not all core risks can be insured, and that such insurance cannot always be financed. Eawag has taken out property and liability insurance policies covering losses or damage. Eawag also has smaller policies covering specific risks, as required by the directives.

Disclosure of risks

In the preparation of the annual accounts, it is ensured that risks are fully recognised within the existing reporting. Based on the estimation of the likelihood of occurrence, risks are reported either under "Provisions" (>50% likelihood of occurrence) or in the Notes under "Contingent liabilities".

Internal control system

In accordance with the requirements specified by the ETH Board, Eawag operates an internal control system (ICS) that promptly identifies and assesses the relevant financial processes and risks related to bookkeeping and the rendering of accounts and incorporates appropriate key controls to cover those processes and risks. The ICS encompasses those procedures and measures that ensure proper bookkeeping and rendering of accounts and accordingly form the basis of all financial reporting. It thereby ensures that financial reporting is of a high quality. Eawag sees the ICS as an activity aimed at the continuous improvement of processes.

Annual financial statements: eawag.ch/2018

Editor: Eawag Communication

Contributors: Johann Dossenbach, Sibylle Hunziker, Thomas Lichtensteiger, Gabriele Mayer
Irene Bättig, Christine Arnold (Sprachwerk)

Graphics and layout: Peter Penicka

Translations: Jeff Acheson, Laurence Frauenlob

The Annual Report is published in German (the authentic version) and also
in English and French.

Eawag
Überlandstrasse 133
8600 Dübendorf
Switzerland
+41 (0)58 765 55 11

Eawag
Seestrasse 79
6047 Kastanienbaum
Switzerland
+41 (0)58 765 21 11

info@eawag.ch
eawag.ch

Akio Todaro, Eawag

Eawag
Überlandstrasse 133
8600 Dübendorf
Phone +41 (0)58 765 55 11
info@eawag.ch
eawag.ch