EAWAG

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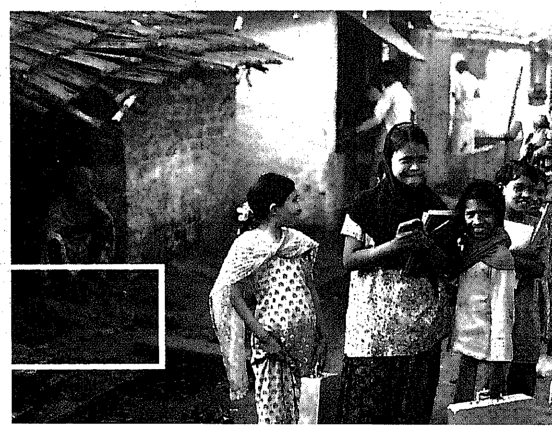
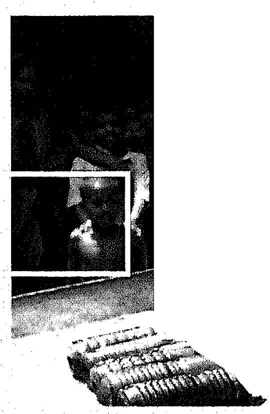
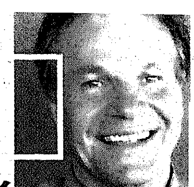
Strategies in Urban Water Management







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Strategies in Urban Water Management

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From the Director's Desk

Alexander J.B. Zehnder
Director of the EAWAG

Most of us take our efficient and well-functioning urban water management for granted. Only when the water stops flowing from the faucets do we realize how dependent we are on the well-managed delivery and removal of water. Broken water mains and construction sites in streets give us only a small glimpse of the immense infrastructure that we use every day but which lies hidden under ground. This infrastructure will have to be replaced in Switzerland over the next 25 to 30 years. The cost is currently estimated to be near 150 billion Swiss Francs, to be paid for by the public. It seems only right to ask whether these immense sums of money should simply be used to replace the existing structures with a more modern version, or whether there are alternatives that would bring us closer to sustainability. This issue will confront you, Dear Reader, with a few thoughts on this topic. We do not concentrate our attention solely on industrialized countries, but also present a few aspects of the problem in developing countries. The articles in this issue are intended to stimulate discussion and thoughtful consideration.

In 1999, EAWAG was restructured, and its mission refocused. Our work will increasingly concentrate on issues related to water and its sustainable use. Another area we want to emphasize is the practical relevance of our research. For more details, please read the article on page 21. The reorganization of EAWAG is intended to also bring a revitalization of our institution. Adjustments among different disciplines and entirely new combinations will no longer be the exception but the rule. This will allow us to more efficiently find new solutions to water management problems. Obviously, this puts a higher demand on the flexibility and adaptability of our staff; we need to be willing to put ourselves into the mindset of other disciplines. I think we are motivated to embark on this experiment; our success will be reflected in a higher quality of research, teaching and service.

With this issue of EAWAG news, our long-time editor Diana Hornung is leaving us. She would like to express her deepest appreciation to the ever-growing readership and circle of subscribers. Diana Hornung took over the editorial duties of EAWAG news in 1983, after graduating from the post-diploma course in urban water management. Under her leadership, EAWAG news has changed dramatically and grown into a very attractive publication. I thank Diana Hornung for all her efforts and wish her all the best for the future.

A. Zehnder

On the Path to New Strategies in Urban Water Management

The most important functions of urban water management (UWM) are the prevention of water- and feces-borne diseases, avoidance of floods in developed areas and securing of the ecological integrity of surface waters. With the systematic construction and upgrading of conventional wastewater systems which collect the wastewater and treat it in centralized sewage treatment plants, it has largely been possible to perform these functions in the industrialized countries of the North; however, these practices contradict important sustainability criteria.

The Development of Urban Water Management in Industrialized Countries

Improved Sanitation in Developed Regions through Urban Drainage

Viewed historically, the first goal of urban water management was the improvement of sanitation. As a result of the Industrial Revolution, many people moved to urban areas in search of work over the last century, both in Europe and in North America. This dramatic increase in population density was coupled with a deterioration in public hygiene; feces and refuse were disposed of in streets and backyards. Apart from esthetic concerns, hygienic problems increased and with them the contamination of wells and drinking water, ultimately resulting in widespread epidemics.

As urban areas developed in climatic zones with ample precipitation distributed evenly throughout the year, canals had to be constructed in order to divert the rainwater and prevent floods. As the problems increased, it was obvious that the existing drainage canals would be used for disposing of fecal waste, infested with human pathogens, from the developed areas as well. In this way, the water-borne sewage system was born; i.e., the concept of urban drainage, which is still used in the industrialized countries of the North and in several regions of the South.

From Urban Sanitation to Water Protection

The introduction of water-flushed toilets and the disinfection of drinking water in large water supply systems have markedly improved the hygienic situation in urban areas and brought water – and feces-borne diseases largely under control. Epidemics resulting from insufficient urban hygiene have only rarely occurred in Europe and North America over the past century.

As a consequence of the input of pollutants into natural waters, new problems arose. The rapid growth of urban areas led to a pollution load which significantly exceeded the assimilation and self-purifying capacity of natural waters. Sewage disposal systems had to be successively upgraded by additional sewage treatment plants. If at first simple sedimentation systems had sufficed, soon only biological treatment could reduce the pollutants to a degree that would be tolerated by the rivers and streams that received the treated water. Economic development and increased production of chemicals after the Second World War caused both a quantitative increase and qualitative change in urban pollutants. Together with increasing demands on the environment, existing sewage treatment plants must be continually upgraded and expanded with additional treatment stages.

Deficiency of Conventional Urban Water Management with Regard to Sustainability

Central water supplies, water-borne sewage systems and centralised sewage treatment plants could, to a large degree, solve the problems of sanitation and aquatic ecology in the highly industrialized countries of the North. Incumbent in this progress though, are large investments and high maintenance and operating costs. In this system, nutrients such as phosphorus and nitrogen are regarded as hazardous water pollutants – not resources. This view is understandable (i.e., given today's market prices for energy, nitrogen and phosphorus fertilizers), but does not correspond to the basic criteria of sustainability. The situation

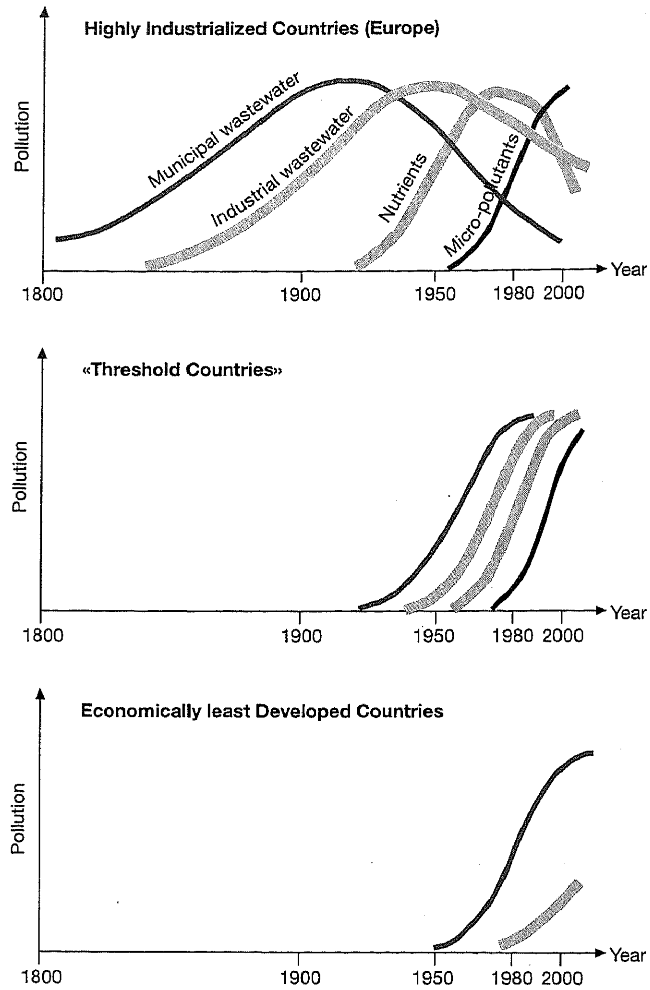


Fig. 1
The succession of water pollution in different countries.

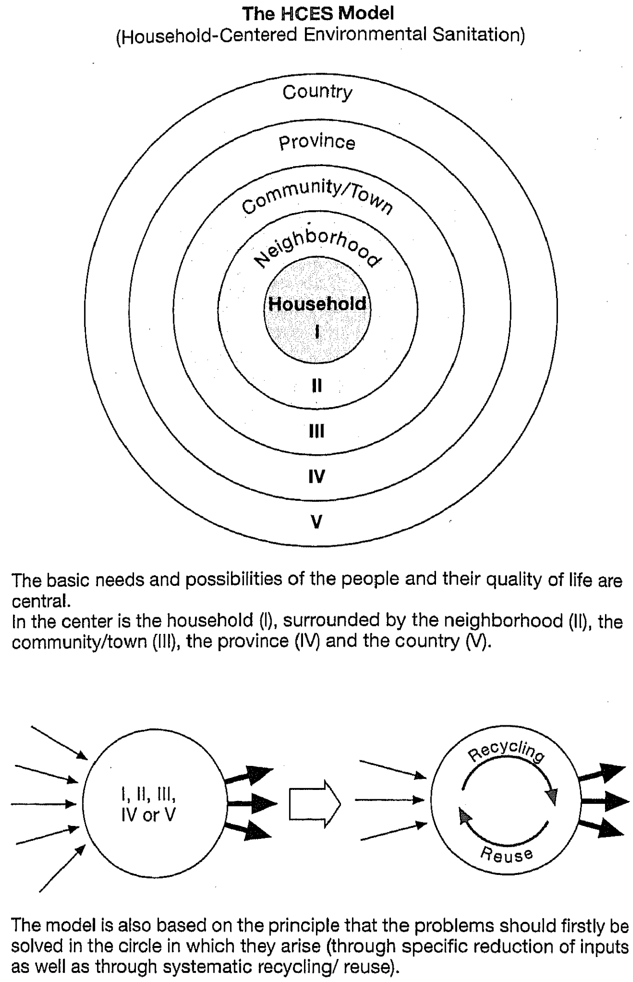


Fig. 2
Household-centered approach in Environmental Sanitation.

becomes dramatic if the present concept of urban water management does not remain a privilege of a small minority of the world's population in Europe and North America, as it is today, but also becomes the norm for the rapidly-growing urbanized regions of Asia, Latin America and Africa. Viewed from a global perspective, the development and implementation of new urban water management concepts are also necessary in the industrialized countries.

Current State of Urban Water and Waste Management in Developing Countries

Urban Sanitation Still Predominates

Despite enormous efforts made during the past 10–20 years, 1.2 billion people still have no access to clean drinking water. Three billion people lack hygienic excreta disposal systems, while less than half of the municipal refuse in developing countries is being collected, and even much less disposed of in an environmentally compatible way. Consequently, four million people die each year from diarrheal diseases (e.g., cholera and typhoid fever), which are transmitted by feces and insufficient water supply systems. The World Health Organization estimates that 1.5 billion individuals are infested with parasites due to undisposed feces and refuse and are thereby weakened in their economic productivity. Therefore the primary goal of urban water and waste management for the majority of the world's population is still to find solutions to fundamental hygienic problems.

Environmental Problems are also Increasing

Even before the urban sanitation problems in developed countries are solved, the water ecological problems are also increasing markedly. While most water protection problems in today's industrialized countries have occurred and been dealt with progressively, these problems are arising simultaneously in many countries of the developing world (Fig. 1). This is primarily the result of rapid industrialisation and urbanization. Ironically, this problem is exacerbated by the blind adoption of the urban water management practices developed in the industrialized countries of the North. Often financial resources are being allocated for the construction of sewer systems, but are sorely lacking for the construction and maintenance of centralized wastewater treatment plants. For example, in the cities of Latin America, a large part of the sewage is being collected in sewers, but only about 5% flows into sewage treatment plants, resulting in heavily polluted surface waters exceeding even the largest rivers' self-purification capacity.

New Concepts and Approaches Needed

There are a number of reasons why a large part of the world's population still has no access to safe drinking water and hygienic disposal of excreta and waste. This deplorable state of affairs is rooted in a lack of political will at the governmental level, coupled with many other issues such as low prestige, the official lack of acknowledgement of the wastewater and solid waste sector, insufficient strategies on all levels, weak institutional infrastructure and inadequate and inefficient utilization of financial and natural resources. Due to the highly differing climatic, socio-economic and cultural factors, the concepts governing urban water management system in the industrialized North are unable to significantly improve the sanitary situation in developing countries and, under some circumstances, are even leading to the degradation of surface waters. Examples from China and other Asian countries suggest that the adoption of Western concepts even negatively influences the management of natural resources; nutrients not only cause environmental problems in receiving waters, but at the same time are lacking in local agriculture and must be replaced by artificial fertilizers requiring large amounts of energy.

A New Strategy for both Urban Water and Solid Waste Management

A working group appointed by the Water Supply and Sanitation Collaborative Council recently developed a vision for a new strategy in "Environmental sanitation in the 21st Century" under the direction of SANDEC, the research department for "Water and Sanitation in Developing Countries" at EAWAG [1]. The new strategy puts people and their quality of life at the center and can be symbolized by a concentric model: in the middle is the household, surrounded by the neighborhood, community/town, district and national government area (Fig. 2, HCES model). This concept is based on the following principles:

- Environmental sanitation problems are solved with priority in the circle in which they arise; only when this is not possible and when it is sensible to do otherwise are the problems transferred to the next circle.
- The output of solid and liquid waste is minimized for every circle by (a) the specific reduction of waste-producing inputs such as water, materials and goods and by (b) systematic recycling and reuse within each circle.

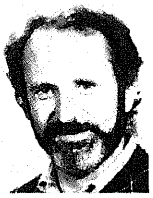
This "household-centered" approach is different from the conventional approach of exporting the problems to the outer circles and having them solved by the government far from their source; instead, the responsibility for problem solving is shifted inwards, to where the problems originate. This new strategy seems especially promising for developing countries where governmental authorities are often not in a position to solve the problems of environmental sanitation without the active help and support of the population. However this approach is basically also applicable in industrialized countries. Although the situation in the industrialized countries greatly differs from that in developing nations, the general strategy of solving the environmental sanitation problems as close to their source is basically applicable everywhere. However, its implementation and the specific solutions probably look very different depending on physical, socio-economic and institutional conditions.

EAWAG's Activities on the Path to Sustainable Urban Water Management

Various efforts and projects are currently undertaken at EAWAG which focus on the development and implementation of new concepts and approaches in urban water management.

The projects in the Engineering Department focus on developing urban water management in industrialized countries; i.e., measures taken at the source should not jeopardize resources (Larsen and Gujer), historically evolved rules in decision-making should be rethought (Tillman), and valuable substances should not be lost (Steiner). Even if the results of these projects cannot be directly transferred to developing countries, their importance for developing countries should not be underestimated. It is extremely important for professionals and decision-makers in developing countries to realize that even the industrialized countries question their conventional approaches in urban water management and are developing new strategies and concepts. In addition, large financial institutions in industrialized countries play an important role in the water industry's course of action in developing countries.

But if developing nations do not acquire their own experience and develop their own concepts, they will mostly continue to try to use those of the industrialized world. The activities and projects conducted by the Department of Water and Sanitation in DC (SANDEC) directly concern the types of problems prevailing in developing countries. Projects are mostly being carried out in close collaboration with local partners on aspects of water treatment in rural and semi-urban areas (Wegelin, p. 11/12), management of fecal sludge from latrines and septic tanks (Strauss and Montangero, p. 15/16), as well as solid waste management in slums (Zurbruegg, p. 13/14). Some of the current projects and their importance for sustainable urban water management and solid waste management in developing countries are presented and discussed in this issue of EAWAG news.



Roland Schertenleib, Engineer, Director of SANDEC, Research Department of Water and Sanitation in Developing Countries and lecturer at the ETHZ.

Willi Gujer, Prof. for urban sanitation with focus on biological sewage treatment and a comprehensive approach

[1] WSSCC/SANDEC (1999). Household-Centred Environmental Sanitation. *Report of the Hilterfingen workshop on Environmental Sanitation in the 21st century.*

Tackling Problems at the Source – Even in the Household

By pursuing measures at the source, the water treatment process is not only simplified, but allows us to overcome problems which have to date been impossible to solve. Such measures have their cost, however, and are only rarely profitable in a financial sense. In order to design a system which in its conception will be viable at our latitude as well as in developing countries, we have to consider a host of actions at the source.

Urban drainage systems represent a compromise between the task of transporting wastewater out of communities (hygiene) and the treatment of the wastewater (water protection).The "combined system" is a convenient means for transporting wastewater, but has the disadvantage of mixing all wastewater components and leading to an unnecessarily large volume of wastewater to be treated.

There are a number of arguments against this kind of drainage system:

- The mixing of "dirty" wastewater and rain water during rain events can cause untreated wastewater to run directly into surface waters.
- Sewer systems have to be maintained; maintenance typically is more expensive than the original construction.
- Micropollutants in the wastewater (pharmaceuticals, products derived from musk root, etc.) have emerged as the newest potential water pollution problem [1].
- Sewage sludge contains anthropogenic organic compounds and heavy metals (micropollutants). Its disposal in agriculture is no longer a preferred practice.
- Because known phosphate reserves are projected to be used up within about 150 years under current consumption rates and phosphate fertilizers show an increase in heavy metal content, the recycling of phosphate from the urban waste streams is highly desirable; however, this is very difficult to accomplish in today's drainage systems.

In order to make progress in urban water management, we need a thorough examination of the technical possibilities as well as the courage to experiment. New and unconventional technologies have to be tested in pilot studies in order to assess their feasibility, acceptance and environmental impacts (see the schematic representation on the opposite page).

A few possible measures at the source are listed on the vertical axis of the schematic. The measures are arranged by decreasing wastewater output, starting with the status quo at the top and ending with the household producing zero wastewater at the bottom. This last scenario is not discussed in this article. Even in today's system (without infiltration), some of the source measures have become common practice. For example, regulations on what may or may not be disposed of in household sinks or toilets represent an efficient measure at the source of pollution, reducing clogging and severe contamination of sewage sludge.

Tove A. Larsen, Chemical Engineer, with a graduate degree from the Institute for Environmental Engineering at the Technical University of Denmark. She has been Chief Assistant in Urban Water Management at ETHZ since 1992 and has received a teaching mandate in Process Engineering and Wastewater Treatment. Her primary research interests are sustainable urban water management and the closing of nutrient cycles.

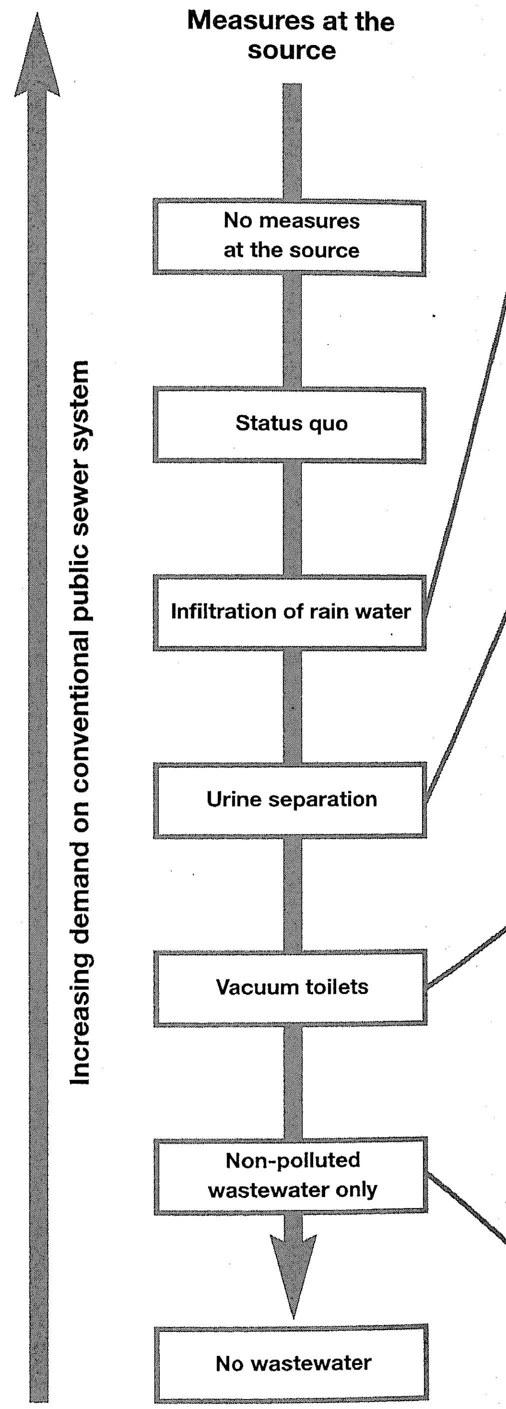
Coauthor: Willi Gujer

[1] BUWAL (1999): Einfluss von Abwassereinleitungen aus Kläranlagen auf Fischbestände und Bachforelleneier. Mitteilungen zur Fischerei. Nr. 61.

[2] U.S. Geological Survey, Mineral Commodity Summaries, Januar 1999 (http://minerals.usgs.gov/minerals/pubs/commodity).

[3] Larsen, T.A. (1999) Nutrient Cycles in Urban Water Management, EAWAG news 46 E, 1999.

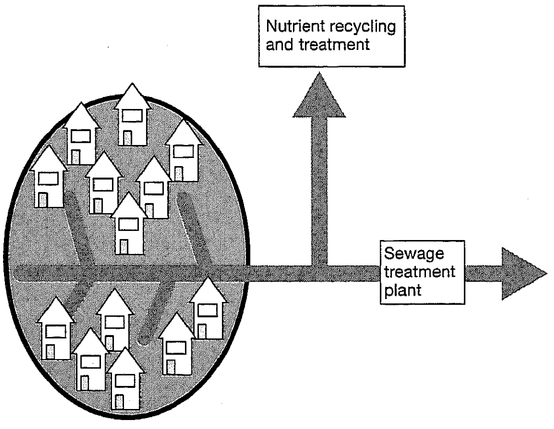
[4] Lange, J. und Otterpohl, R. (1997) Abwasser: Handbuch zu einer zukunftfähigen Wasserwirtschaft. Mall-Beton-Verlag.



Source measures being discussed today usually try to reduce the load on the conventional drainage and treatment system. By comparing the gain made due to load reduction to the cost incurred as a consequence of the new measures at the source, we can obtain a preliminary assessment of the various options. Four different scenarios are roughly sketched out in this schematic.

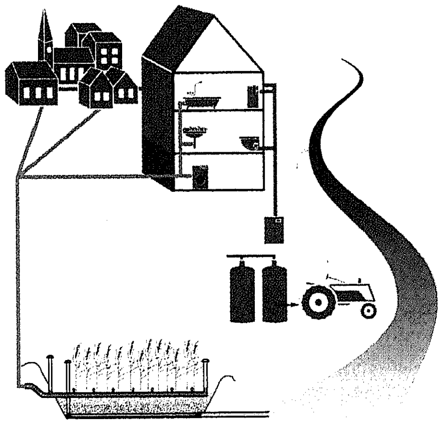
A

The new water protection law requires "unpolluted wastewater" – for the most part relatively clean rain water – to be disposed of by infiltration into the ground wherever possible. This significantly reduces the pollutant load reaching surface waters during rain events, slows down the hydrological cycle, and reduces the size of the sewage pipes required to handle the waste stream, which is important when aging systems have to be rebuilt. Disadvantages are that infiltration is not practical in all situations and that it can be a relatively expensive alternative.



B

Separating and storing urine in toilets, collecting it at night via the regular sewage system, and subsequently processing it into fertilizer [3] significantly reduces the waste stream reaching sewage treatment plants. Elimination of nutrients is no longer necessary and 70–80% of pharmaceuticals and hormones secreted by humans no longer reach the sewage treatment plant. In addition, direct discharge of nitrogen, phosphorus and pharmaceuticals into surface waters during rainy periods is prevented – assuming the storage capacity is large enough to hold secretions for several rainy nights in a row. Nutrients can be recycled from concentrated urine much more efficiently than from a dilute waste stream, although application of these nutrients in agriculture requires treatment in order to reduce the levels of pharmaceuticals. The cost to individual households for such a system is currently relatively high, mostly because it requires a duplicate plumbing system in the house. Until new technologies in plumbing design (e.g., "twin pipes") bring down the cost of such installations, the retrofitting of current plumbing is neither necessary nor reasonable.



C

If wastewater from toilets is collected in a completely separate vacuum system and subsequently treated in a putrefaction basin, the traditional sewage treatment plant can be replaced by a simpler "gray water" treatment plant. Nutrients from human waste can be recycled very efficiently and will never reach surface waters, not even during rain events. As in the case for urine collection only, pretreatment may be necessary before the nutrients are acceptable for use in agriculture. In addition to different plumbing installations in households, this option also requires a new transport system; namely the vacuum system, which is clearly a disadvantage, especially in areas which are already heavily urbanized. The transition phase can be a logistical nightmare since a neighborhood of approximately 1000 people has to be switched over one at a time; premature replacement of toilets and plumbing would, therefore, be necessary. In newly developed areas, this system is already economically competitive, while in existing neighborhoods it is not.

D

"Unpolluted wastewater" produced in households (unpolluted by the definition in the Water Protection Law) can be disposed of together with rain water. This relatively radical option is still highly speculative, but would leave the public sector with only a very minor task: to dispose of unpolluted wastewater. This solution is feasible using currently available technologies; for example, the production of drinking water from any wastewater by reverse osmosis. The primary problems with this approach remaining to be solved are the relatively high energy cost, space requirements in households, and the disposal of residual matter. It will take a major research effort to overcome these obstacles.

Assessing Effects of Behavior Patterns

Early Recognition of Structural Problems

What effects do the different behavior patterns of involved parties have on the technical and financial aspects of water systems supply? Analysis and modeling of these behavior patterns and interactions allow us to assess the efficiency and potential risks of engineering and management measures currently being implemented and to recognize problems early on.

Politicians, operators of drinking water supply facilities, engineering firms and others are faced with the task of upgrading existing drinking water supply systems as well as adapting these systems to current and future demands. In comparison to the growth phase of today's drinking water system (before 1990), the political and socio-economic boundary conditions have changed dramatically. What was once a stable and calculable field has changed into a constantly changing and uncertain domain. Correspondingly, it will not suffice in the future to only meet the needs of consumers. Increasingly, the flexibility of water supply operators will have to be accommodated by adequate planning and management. Currently, operators are relatively restricted in their options: first, because of the infrastructure itself, which is buried and therefore difficult to modify; secondly, because of increasing influence from skeptical politicians, price-conscious consumers, as well as price pressure from competition (push towards privatization); thirdly, because of more recent financial uncertainties (e.g., falling acceptance levels for actually needed price increases), or technical risks (e.g., operational problems due to gradually falling water consumption).

Recognition of Characteristic Behavior Patterns

Because of the long life expectancy of the drinking water infrastructure, once it is

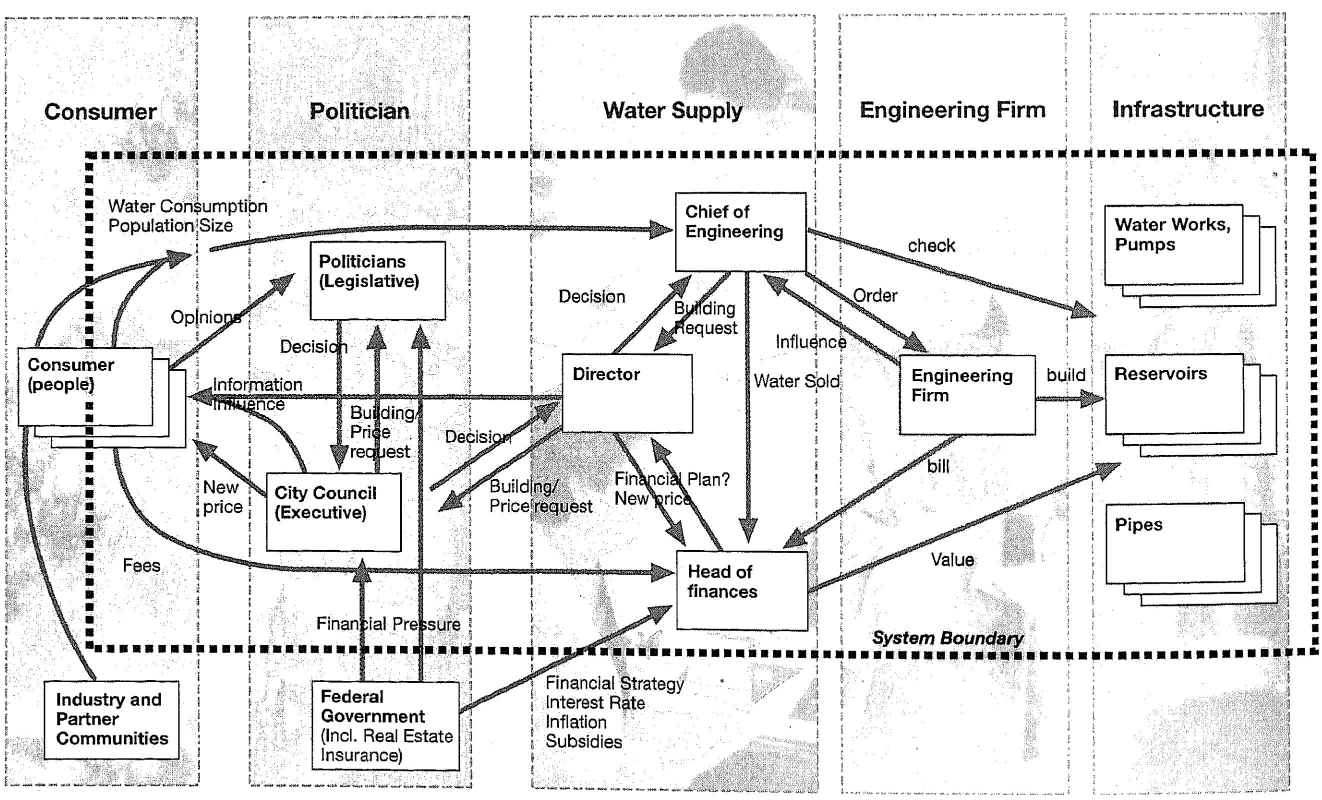


Fig. 1
The stakeholder model of the drinking water supply system represents reality in a simple and abstract form. The stakeholders shown in the model are typical representatives of their professions. The model represents them as "agents" which gives the model a novel structure. Elements of the infrastructure are incorporated in the model because they age and have to be replaced periodically; they are also represented as agents.

installed, it is crucial to recognize problems as early as possible. The previously mentioned stakeholders on the drinking water stage all operate with different goals, interests and perspectives, yet they all shape the future development of the drinking water supply system. This project [1] is attempting to focus on the actions of the individual parties and the interactions between them. In a newly developed model (Fig. 1), the characteristic behavior patterns and the effects of their actions on administrative and technical aspects of the drinking water supply system are being described and evaluated.

The individual stakeholders are characterized by their typical behaviors, corresponding to their strategic goals. Their actions are represented in the model by annually repeated behavior patterns (if – then rules). The model distinguishes between strategies or patterns used in the past (which were adhered to during the build-up phase in the last few decades) and strategies pursued today. One such pattern or "rule" would be: "If the demand for drinking water exceeds the capacity of the supply facility, then trigger the planning process for an expansion of the facility." The postulated behavior patterns were critically evaluated by experts in the field before they were incorporated into the model. All of the behavior patterns were compiled in a catalog which served as a transparent communication tool, allowing us to put the subjective knowledge of experts on paper and later to incorporate it into the model.

Behavior patterns can then be validated by comparing model predictions to characteristic parameters of water supply facilities (e.g., supply capacity, total length of water mains, water prices, investments, etc.). This validation is represented in Figures 2 and 3. Despite the apparent inadequacy of representing a complex reality with a simple set of rules, the model succeeds in describing the general trends in the historic development of the drinking water supply, both in terms of technical and financial parameters (validation between 1908 and 1996; see Figs. 2 and 3). While the incorporation of additional behavior patterns most certainly will improve the agreement between model prediction and reality, the current set of simple rules is adequate in describing the large-scale context.

This tool now allows us to discuss behavior patterns and interactions between different stakeholders in a focused and structured way. It is a particular benefit of the model that we now can isolate and clearly document the effects of individual behavior patterns. This aspect alone will help us significantly in complementing the well-established technical know-how with socio-economic and behavior-oriented knowledge, which has been largely missing until now.

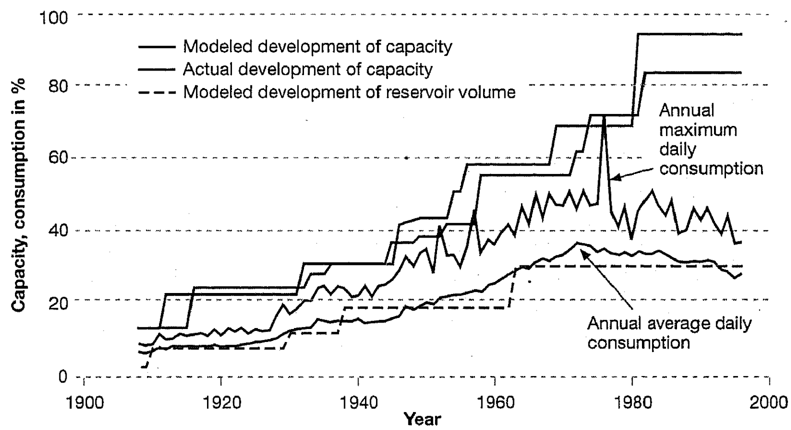


Fig. 2
Observed and modeled development of capacity (supply capacity of drinking water supply system). Actual data and model prediction between 1908 and 1996 do not coincide exactly, but show the same trend. Model inputs are data on the annual maximum and average daily water consumption.

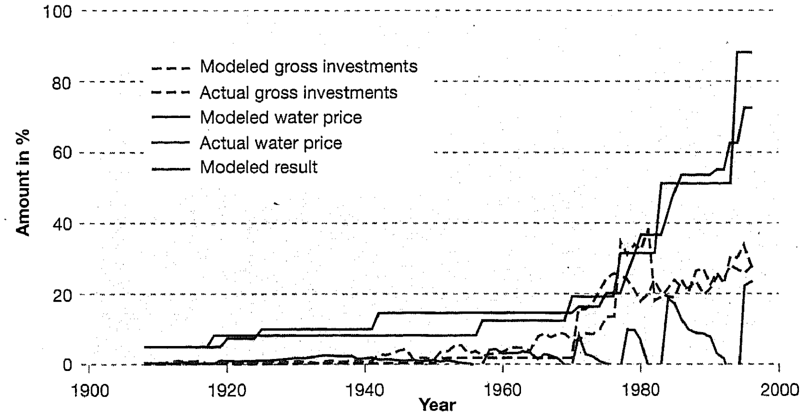


Fig. 3
Observed and modeled development of gross investments as well as water price for a validation period from 1908 until 1996. The curve representing the model prediction of investments shows somewhat of a time lag, but follows a pattern very similar to actual investments.

Construction of Scenarios for Future Development

The model also allows us to start building scenarios for future oriented "what if ..." questions and to assess the effects of different strategies; in particular, to determine the sensitivity of the system with respect to the behavior of the stakeholders. We use the basic scenario (keep "rules" used in the past and assume gradual stabilization of the recently falling water consumption rate) to establish a reference scenario describing development for the near future. We can now compare the basic scenario to scenarios where the rules and strategies are changed, and the different outcomes can be evaluated. This allows us to judge the "viability" of new rules and to put suggestions for rule changes up for discussion.

The transformation and adaptation of the drinking water supply system requires much more flexibility than it did in the past, mostly due to the circumstances mentioned at the beginning of this article. We believe that the approach described here, which is new in engineering science, will greatly help us in providing the basic knowledge needed in this endeavor.

Donald Tillman, Engineer ETH, Environmental Engineer MIT. Previously active in private industry, currently doctoral student in the Engineering Department at EAWAG.

Project in cooperation with Tove A. Larsen, Claudia Pahl-Wostl and Willi Gujer

[1] Tillman, D., Larsen, T.A., Pahl-Wostl, C. and Gujer, W. (1999). Modeling the actors in water supply systems. Wat. Sci. Tech. 39: *4*, 203–211.

Heavy Metals in Roof Runoff are Unwanted

As precipitation drains from roofs, heavy metals (mostly copper, zinc, lead and cadmium) run into the infiltration layer of soil and may enter the ground water. Until measures applied at the source are able to reduce this pollution, such material fluxes should be kept under control in drainage installations.

The new Water Protection Act requires the drainage of roof runoff. There are many advantages to this practice, but it likewise results in several disadvantages.
Because roof runoff may contain copper, zinc, lead and cadmium, these heavy metals enter the environment in various ways, depending on the type of drainage chosen. If drainage occurs via a living soil layer (vegetated swale), the metals accumulate, causing their levels to exceed the reference standards for excavated topsoils within a few years. In underground drainage (shafts, drainage trenches), the heavy metals become rather diffusely distributed in the infiltration body and can enter the groundwater aquifer if the subsoil is permeable: therefore, the question arises as to how to deal most sensibly with heavy metals in roof runoff.

Strategy

It is obvious that a solution to the problem is only possible if we can prevent the heavy metals from being a constituent of roof runoff, implying that measures aimed at replacing the problematic substances should be pursued. The improvement of air quality by reducing emissions and finding alternatives for copper and zinc sheet metal for outside installations are the long-term goals. But until such measures take effect, solutions must be sought which permit a temporally and spatially controlled enrichment in the infiltration layer. Furthermore, the professional disposal (i.e., treatment) of this hazardous waste has to be guaranteed after the saturation point is reached; for this reason, it is necessary to keep a land register of drainage installations.

Control of the Heavy Metal Load

Materials are being researched which can be installed as adsorptive layers in drainage installations (Fig. 1, Tab. 1). Because the dissolved fraction of the heavy metals can amount to over 50%, such materials must possess distinctive adsorptive properties, a high affinity for the metals in question, and a large adsorptive capacity. From a hydraulic point of view, sufficiently high conductivity and structural long-term stability must be guaranteed. According to a recent literature study, substances do exist which at least partially satisfy these requirements. Iron hydroxide, zeolites and activated carbon have proven to be very effective; however, no corresponding experiments have yet been conducted using them in systems with natural roof runoff. Thus, the use of adsorption materials still has to be experimentally tested.

Experiments

Experiments using a column pilot plant (Fig. 2) and a batch experiment will create the basis for understanding such systems. Of special interest are the adsorption capacity at low concentrations of heavy metals, the influence of complexing agents, competitive adsorption on surfaces and variable pH and redox conditions.
In order to identify and verify the central processes and parameters, both natural roof runoff and synthetic solutions will be used. From these experiments, it should be possible to determine the retention capacity, as well as the lifetime of adsorptive layers, under various operating conditions.

Michele Steiner
Environmental engineer and doctoral student in the engineering department of EAWAG.

Co-author: Markus Boller

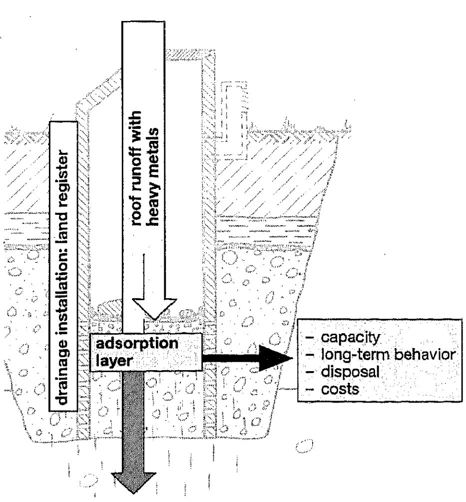


Fig. 1
Application site and effects of adsorption materials in a drainage shaft.

adsorbent	material	retention
1	containing Ca	78,0%
2	containing Ca & Fe	99,4%
3	containing SiO_2	70,0%
4	containing Fe	90,0%

Tab. 1
Degree of elimination achieved by different adsorption materials.
Preliminary results of experiments with four different adsorption materials demonstrate a high degree of elimination for materials containing iron oxides. At a copper concentration of 300 µg Cu/l in enriched roof runoff, the following Cu retention could be measured.

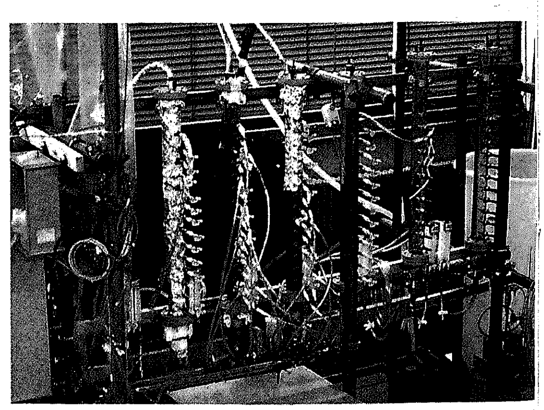


Fig. 2
Pilot installation for investigating adsorption materials for the treatment of roof runoff. The apparatus is located in EAWAG's experimental station Tüffenwies and and consists of seven independently controlled columns.

Back to the Household – Also in Water Treatment

Drinking water in developing countries, taken from the tap or drawn from an unsafe water source, is a possible carrier of pathogens. The urban water supplies often do not function properly; in rural areas they may be even nonexistent. In either case, households are required to find and treat their own drinking water.

The World Health Organization (WHO) statistics for 1994 reveal that about 800 million rural inhabitants and 300 million urban dwellers have no access to a sufficient drinking water supply [1]. Unfortunately, this data only considers the amount of water (over 15–50 liters per person per day) and its availability (transport distance within 50–1000 meters). The report contains no details on the number of people suffering from qualitatively inferior drinking water. Reality often shows that the "well-to-do" urban segment stocks up with mineral water or tries to operate its own household treatment system. The poorer inhabitants are told to boil their water, a recommendation which can sometimes be difficult to follow given firewood and energy shortages. The development and dissemination of alternative technologies for the individual treatment of drinking water is, therefore, urgently needed. For households living along the poverty line, these treatment methods must be cheap, user-friendly and self-sufficient in order to be economically viable, acceptable and sustainable.

Solar Water Disinfection

The bactericidal effect of sunlight is generally known, but has so far rarely been applied directly to water treatment. Through extensive laboratory and field experiments, co-financed by the Swiss Agency for Development and Cooperation (SDC), EAWAG has, over the past few years, developed and disseminated information on solar water disinfection (known as SODIS: SOlar Water DISinfection). SODIS utilizes the germicidal effect of the sun in the form of heat and UV-A radiation. The simplest SODIS application makes use of half-blackened plastic bottles filled with contaminated raw water and exposed to the sun for about five hours. The water usually heats up to over 50 °C, thereby killing bacteria and viruses and reducing fecal coliform *(E. coli)* concentrations by four to five log units. Field experiments have shown that *Vibrio cholerae* is also efficiently inactivated by SODIS.

SODIS fulfills the aforementioned criteria of a simple water treatment method; i.e., plastic bottles are ubiquitous and a consumer waste product. They can be used not only for water treatment, but also for its transport and storage. The necessary energy is provided by the sun. Conditions for a widespread dissemination of SODIS, therefore, seem good – the method has, nevertheless not yet experienced a total breakthrough. The process is so simple that it seems suspect; boiling of water has been recommended to many generations, thereby making a change of approach more difficult. In addition, a sufficient number of plastic bottles is often lacking. For this reason EAWAG will continue to promote the dissemination of information on this process and support national SODIS networks.

The Arsenic Problem in Bangladesh

The population of Bangladesh used to draw its water from ponds, the consequence of which were frequent attacks of diarrhea. Following the recommendations of water experts, large well construction programs have been carried out over the past 20 years, and polluted pond water has been largely replaced by groundwater. To date, 95% of the population of Bangladesh is being supplied with groundwater, and the infection rate for diarrhea has decreased by 50%. However, six years ago, the first cases of arsenic poisoning were diagnosed

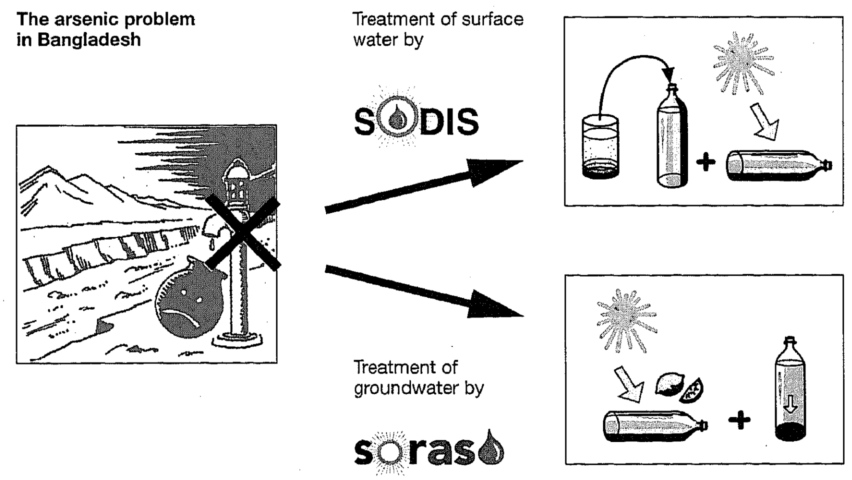


Fig. 1
Individual drinking water treatment options in Bangladesh.

among the population. Analyses shockingly revealed that some of the groundwater sources contained high arsenic concentrations. The arsenic originates from river sediments that contain pyrite which is dissolved in the groundwater under anaerobic conditions. International and national relief organizations are now in the process of assessing the extent of the disaster, informing the affected, mostly rural population, and finding solutions to the problem. Preliminary estimates suggest that 50–80 million people are exposed to increased arsenic concentrations. The World Health Organization expects that in a few years the cause of death for 1 in 10 Bangladeshi will be arsenic poisoning [2].

A possible alternative to solving the arsenic problem is to return to using the fecally polluted pond water and applying SODIS as treatment method. The SDC is currently studying the acceptance and efficiency of SODIS in a large demonstration project in which 16 local organizations (NGOs) are participating. Early indications suggest, however, that people prefer the clear but arsenic-containing groundwater to the often turbid pond water. Furthermore, the toxic substances have different effects on health; i.e., consumption of fecally contaminated surface waters often leads to acute diarrhea, while the effects of arsenic traces in the groundwater insidiously manifest themselves only after 5–15 years.

EAWAG, therefore, aims at developing a simple method for separating arsenic from drinking water. The process, which is substantially funded by the SDC and currently tested in laboratory and field experiments, using sunlight for photo-oxidation and sedimentation for elimination of arsenic, has been named SORAS (Solar Oxidation and Removal of ArSenic). Since SORAS also uses the plastic bottle technique, it is complementary to SODIS. To enhance photo-oxidation, a few drops of lemon juice are added to the arsenic-containing groundwater. Preliminary field experiments reveal that SORAS can reduce arsenic concentrations by 50–70%. Therefore, life expectancy of the affected population can be extended substantially.

Help to Self-Help

The upgrading of public water supplies will never be able to keep pace with the increasing population growth in developing countries, especially in the future – the number of people who are poorly supplied with water will only continue to increase. The affected population has to rely on self-help. This fact can, however, also be the beginning of a new economical and sustainable water supply strategy in developing countries. Problems should be solved, as far as possible, by the smallest organizational unit. It is economically absurd to treat large amounts of water if only a small amount is consumed, if at all (see replacement by mineral water). Depending on the available financial resources, provision and distribution of possibly pretreated water could, thus, be a task for the public sector, and final treatment of drinking water would have to be solved at the household level. To realize such new water supply strategies, appropriate technologies are also required. SODIS and SORAS may provide possible answers.

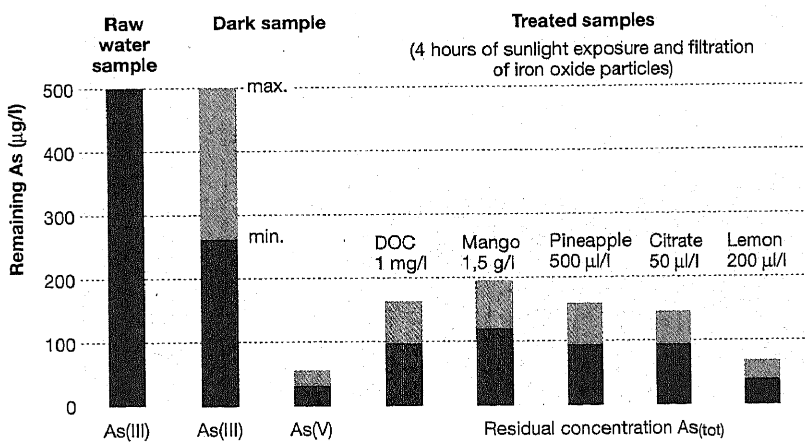


Fig. 2
Arsenic reduction through SORAS, using different catalytic substances.

Martin Wegelin, Program Officer Water Treatment, Department of Water and Sanitation in Developing Countries at EAWAG (SANDEC).

In collaboration with Stefan Hug, Markus Boller, Daniel Gechter and Swen Vermeul

[1] WHO et al (1996), Water Supply and Sanitation Sector Monitoring Report, WHO/EOS/96.15

[2] Lepkowski W., Arsenic Crisis in Bangladesh, Chemical and Engineering News, November 1998

Domestic Waste Management in Slums

Rapidly growing cities in developing countries are not in a position to guarantee the satisfactory collection and disposal of refuse. Largely inaccessible, marginal urban areas, often inhabited by the poor, remain without refuse collection.

In developing countries, household refuse is deposited in the streets, drainage canals and rivers or is burned on the spot. Apart from esthetic detriment and stress through foul smells and smoke, these practices lead to enhanced transmission of infectious diseases and the pollution of water, air and soil. SANDEC's solid waste management research is testing new approaches in refuse collection and recycling at the community level. Investigations on existing systems have shown that certain efforts must be made in order to insure the long-term viability of alternative approaches [1]:

- Informing and motivating the population
- Selecting inexpensive, simple technologies
- Coordinating with municipal refuse collection
- Developing organizational and funding structures

Each of these points is clarified below.

Participation

Inhabitants of a city usually know little about the problems of domestic refuse management; therefore, this issue often stands far lower on the list of management priorities than water supply or sewage treatment. Promoting participation primarily means developing public awareness through information, education and technical support in effecting strategies for improvement. Taking socio-cultural aspects into consideration (i.e., differing cultural, religious and language backgrounds) plays a preeminent role in information campaigns. Gender-specific information is also very important; for example, in Islamic communities, men are the heads of the families, especially in the determination of outside affairs; women, however, play the decisive roles in the household and in issues regarding hygiene.

Appropriate Technologies

The choice of technologies, especially the collection vehicles, has to be adapted to local conditions and match the community's financial situation. Access roads in slums are often narrow and in poor condition. In view of operational and maintenance costs, as well as limited financial resources, locally produced carts drawn by hand often provide a good solution. As salaries in developing countries are low compared to other maintenance costs, recycling approaches (e.g., composting) have to be sought which emphasize manual labor rather than complex infrastructure and complicated machinery.

Coordination with Municipal Refuse Collection

Transfer pionts, where waste is deposited by community refuse collection schemes and is collected by the next higher level, usually the municipal collection system, are critical intersection points. Apart from achieving appropriate technical implementation of such transfer points, it is especially important to guarantee good coordination between the various actors involved.

Organizational and Financing Structure

A clear organizational structure should help harmonize the roles of the various players. Financing via taxes must be simple and, above all, transparent. Experience has shown that small- and medium-sized enterprises as well as cooperatives are suitable for domestic waste disposal services at the community level. Their main advantage over volunteer-based community organizations is their business approach.

Implementing Refuse Collection and Recycling

The main objective of a pilot project in a slum in Karachi (Pakistan) was enhancing self-help initiatives to implement such a waste collection scheme. The project was carried out in close collaboration with the local organization "Association for Protec-

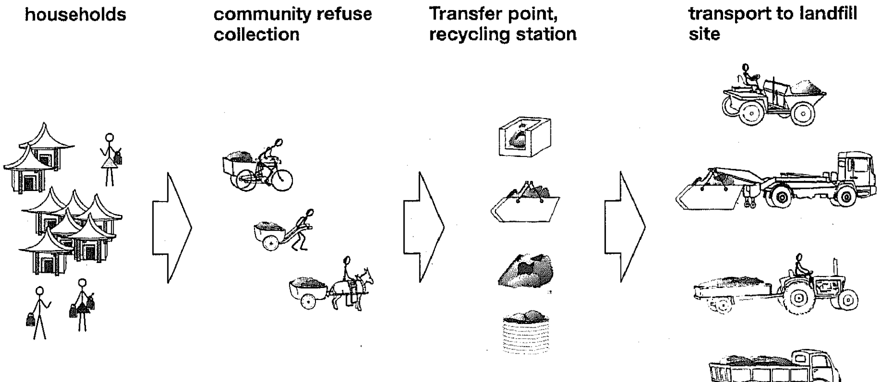


Fig. 1
Model of a more sustainable way to collect refuse, including recycling. Collection by the community consists of simple collection vehicles, a transfer point or recycling station, then the critical intersection with the next level of collection and further transport.

Fig. 2
Refuse collection with the help of wheelbarrows in a slum in Karachi, Pakistan. The technology is adapted to the local conditions as well as the financial situation of the community's inhabitants.

tion of the Environment" and funded by the Swiss Agency for Development and Cooperation (SDC). General information campaigns on urban sanitation and domestic waste were first initiated. The inhabitants' motivation to improve the situation gave the crucial impetus to the collective realization of a refuse collection system (Fig. 2).

Domestic waste management at the level of the community, however, encompasses much more than refuse collection. Minimizing the transfer of refuse to the next higher organizational level (e.g., through recycling) promotes community independence and sustainability of systems. As opposed to the industrialized countries, recycling in developing countries is usually covered by a well-developed informal sector. Here also improvements can be made, especially with regard to biological treatment and re-use of the organic waste fraction, which often amounts to over half of the accumulated refuse. The decentralized treatment of most of the refuse at the community level can significantly reduce costs for transport and deposition. An added benefit is the ecological one; through the re-use of organic material, nutrient cycles can be closed to a large extent and contribute to sustainable resource management.

Chris Zurbrügg, geologist, at EAWAG/SANDEC since1998, works on problems of solid waste management in developing countries.

[1] Pfammatter R. und Schertenleib R. (1996). Non-Governmental Refuse Collection in Low-Income Urban Areas. Lessons Learned from Selected Schemes in Asia, Africa and Latin America. SANDEC Report No. 1/96, 70 pp. Water and Sanitation in Developing Countries EAWAG/SANDEC, Duebendorf, Switzerland.

The Public Discusses EAWAG's Activities

The Foundation "Science et Cité" promotes constructive confrontation between science and society.

Its purpose is to stimulate new forms of dialogue in which the public and scientific community participate as equal partners. Both sides have the opportunity to share and discuss their experiences, which can be very different in nature and may lead to an entirely new communication culture. Among other things, the Foundation would like to establish "roundtable discussions" as a platform for interactions between the public and representatives of scientific institutions.

EAWAG has agreed to participate in a pilot project for such roundtable discussions. About 10 members of the public and 10 EAWAG representatives will meet two to three times a year to participate in discussions led by a moderator. Scientists will present their activities and plans for future research; they will update the members of the roundtable group on their current projects and discuss how much progress has been made. The members of the public can then share their perceptions, fears and expectations. The overall goal is to enhance mutual understanding and to learn of new criteria by which research may be judged. Conclusions from these discussions should provide feedback for the development and performance of future research.

The first meeting was held 4–5 February 2000. The Institute for Philosophy and Social Studies of Science at the ETH Zürich will evaluate the project. By participating in these roundtable discussions, EAWAG exposes itself to a critical evaluation of its activities and research directions by members of the public. We are anxious to see how this project develops and what it will bring in the form of concrete results. We will keep you informed! **Ueli Bundi**

Cities without Sewers

In cities of developing countries (DCs), feces are normally not disposed of through water-borne sewerage systems as in industrialized countries, but are pumped out and hauled away as fecal sludge from latrine pits and septic tanks (FS). Technologies for low-cost and sustainable treatment of such sludges are still mostly lacking. The research division for Water and Sanitation in Developing Countries (SANDEC) is testing suitable options in collaboration with local institutions in developing countries.

In contrast to sewage treatment, the disposal of fecal sludge (FS) in cities of developing countries has received very little attention to date. Untreated sludges are discharged in an uncontrolled manner into waters, onto vacant plots or used for cultivation. This is surprising, since 65–100% of the city dwellers in Africa and Asia and 20–50 % in South America are connected to on-site sanitation systems rather than to sewer systems. Large cities such as Bangkok, Manila and Jakarta for example each produce up to 3000 m^3 (or 50 railroad tanker trucks!) of FS per day. The health and environmentally compatible disposal or recycling of the sludges or their treatment and recycling in agriculture poses almost insurmountable problems to urban authorities, private enterprises and end users [1]. The development and use of appropriate treatment methods would contribute to alleviating these problems.

The Challenge Posed by Fecal Sludges

In compliance with the concentric model of urban sanitation responsibilities (see lead article, Fig. 2), the treatment of FS becomes the responsibility of community organizations and/or urban authorities – depending on the degree of decentralization. Here, smaller and larger private enterprises can play a significant role. The search for appropriate institutional/organizational solutions presents as big a challenge as the development of sustainable treatment processes and technologies.

The properties of fecal sludges vary greatly both in space and in time, depending on the type of disposal installation, of emptying method and groundwater infiltration. They differ markedly from those of sewage (Tab.1, [2]).

For economic and institutional reasons, mainly non-mechanized or only slightly mechanized, so-called low-cost technologies, are appropriate for the treatment of FS (and also of sewage) in DCs. The demand for external energy must be minimal, and chemicals should not be used at all. Therefore, relatively large areas are required for the treatment of fecal sludge (FS). Figure 1

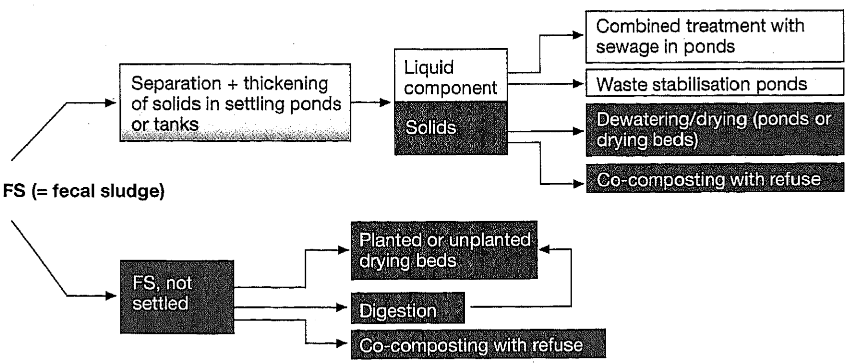
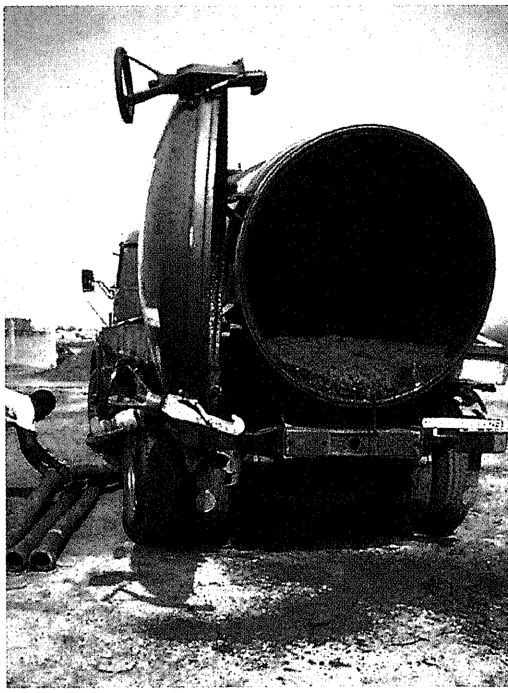


Fig. 1
Selected options for the treatment of fecal sludge (FS) in developing countries.

		Fecal sludge	Municipal sewage (Tropics)
solids	mg/l	12 000–50 000	<10 000
Org. solids	%	60–75	–
COD	mg/l	7000–50 000	500–2500
NH_4-N	mg/l	500–3000	30–70
Worm eggs	per l	4000–50 000	500

Tab. 1
Comparison of fecal sludges and wastewater characteristics.



Transport of fecal sludge, Accra, Ghana. (photo M. Strauss)

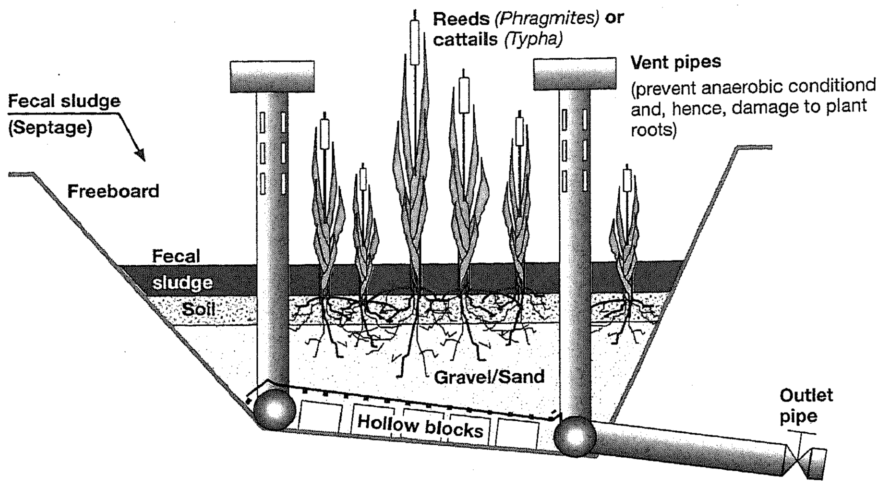


Fig. 2
Constructed wetlands for fecal sludge stabilization and dewatering (diagram)
+ low maintenance since dewatered sludge has to be removed at intervals of several years only instead of weeks
+ combined sludge stabilization and dewatering in one treatment step
– requires careful control of moisture to maintain reed growth
– does not allow regular delivery of treated sludge to agriculture
– post-treatment of leachate may be required
± suitable for tropical/humid climates, less so for arid climates

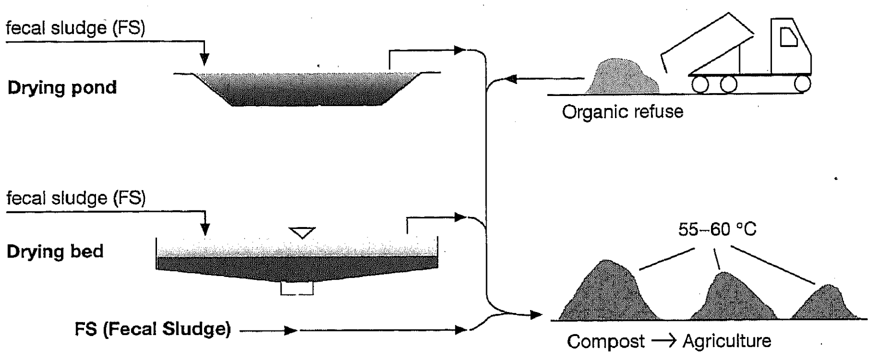


Fig. 3
Co-composting (schematic)
+ stabilization and hygienization in one treatment step
+ allows regular delivery of treated sludge/compost to agriculture
+ suitable for all climatic zones
– requires careful management (e.g. FS/refuse ratio, window structure for adequate natural or forced aeration)

presents FS treatment options which are thought to be appropriate under the economic, institutional and technological conditions prevailing in most of the developing countries [2].

For economic reasons, it is usually not possible to meet Swiss or European sewage treatment standards in DCs. Much progress could, however, be achieved by applying processes and technologies that can consistently and reliably attain 75–80% removal efficencies (as against 90–95% stipulated in industrialized countries). Compared to the status quo, improvements would be significant for the environment and for public health, although relatively high effluent levels may still have to be tolerated. A further reason why the standards valid in industrialized countries cannot just be adopted per se are the partly different objectives regarding the treatment of feces. In industrialized countries, sewage treatment mainly has to serve the protection or improvement of natural water courses (reduction of oxygen-consuming substances and nutrients). In DCs, however, sewage and fecal sludge treatment has, in many cases, to be oriented towards its possible use in agriculture. Hygienic criteria, such as the worm egg concentration, then gain priority.

Process Engineering and Planning/Economic Issues

Since 1994, research partners in Argentina, Ghana and Thailand (in collaboration with SANDEC) have developed selected options for the treatment of fecal sludges, viz. separation of solid/liquid components, anaerobic and aerobic pond treatment, constructed wetlands for sludge stabilization and dewatering, combined composting of FS and organic household refuse. In Figures 2 and 3, two of the selected processes – constructed wetlands and co-composting – are illustraded schematically along with a listing of DC-centered advantages and disadvantages.

Apart from process engineering research and development, it is increasingly important to address such strategic and FS-management issues as:

- Agronomic Potential and need of organic matter and nutrient use from human waste in urban and peri-urban agriculture
- Economic, marketing and institutional aspects of fecal sludge disposal and use

The aim of SANDEC's R+D activities in the field of fecal sludges is to provide guidance to engineers and planners on strategic and technical aspects of fecal sludge disposal and use.

Martin Strauss, Sanitary Engineer, worked for several years in development coorperation before joining EAWAG/SANDEC in 1982. His current special working field pertains to the management, treatment and use of fecal sludges in developing countries.

Agnès Montangero, Environmental Engineer, works in the field of fecal sludge management and treatment in developing countries, SANDEC.

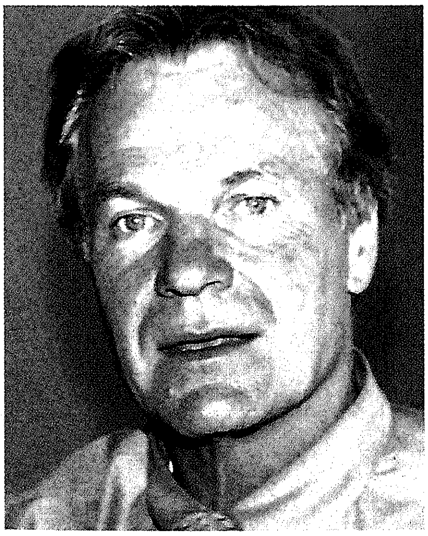
[1] Strauss, M., Heinss, U., Montangero, A. (1999). «On-Site Sanitation: When the Pits are Full – Planning for Resource Protection and Faecal Sludge Management». Water Research & Technology, im Druck.
[2] Heinss, U., Larmie, S.A., Strauss, M. (1998). Solids Separation and Pond Systems for the Treatment of Faecal Sludges in the Tropics – Lessons Learnt and Recommendations for Preliminary Design, EAWAG/ SANDEC, Report No. 05/98.
[3] Koottatep, Th., Polprasert, C, Oanh, N.T.K. (1999). «Preliminary Guidelines for Design and Operation of Constructed Wetlands Treating Septage». Proceedings, AIT/SANDEC Seminar on Septage Treatment, Bangkok, March. Im Druck.

Urban Water Management Needs New Initiatives

Prof. Herrmann H. Hahn is in charge of a number of international students at the University of Karlsruhe (Germany). We asked him about new developments in his field.

EAWAG news*: In the lead article of this issue, R. Scherteinleib and W. Gujer are of the opinion that conventional systems in urban water management are not sustainable in the long term and that both industrialized and developing countries (IC, DC) must endeavor to find new concepts and solutions. Do you share this view?

H. Hahn: Yes, I absolutely share this view. Traditional technologies used in ICs were developed at a time when the population to be served was much smaller. Over the years, more conventional solutions were adapted but not changed fundamentally. Our current practices are, therefore, very much in the old tradition and, strictly speaking, not sustainable. For financial, climatic or structural reasons, they are also not applicable in DCs. In the future, it will be necessary to develop a coordinated set of measures. This means that we need to weigh the costs and benefits of individual measures in the area of water supply and waste disposal, integrated into the framework of the natural water cycle. Additionally, we will need to consider spatial aspects and the temporal behavior of the integrated system.



Prof. Hahn was sensitized towards the problems of developing countries by his interactions with students from those countries. He began to collaborate and initiate projects with colleagues in Egypt, Burundi, Morocco, and Thailand, where he gained insight into the problems and boundary conditions of developing countries. Currently, Prof. Hahn has ties mostly to India and Brazil.

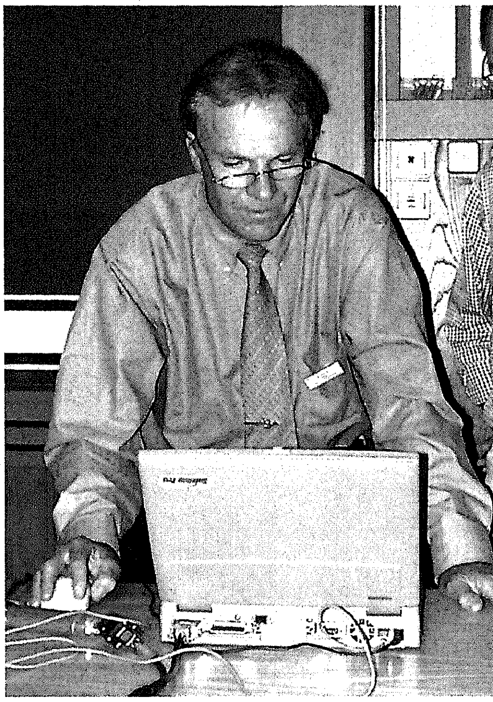
Where do you see the primary shortcomings of conventional concepts with respect to sustainability?

In the behavior of the major actors, who will have to change their practices without any incentives in sight – a difficult undertaking. This is why we also need new concepts in the planning, implementation, realization and operation of new infrastructure. Cooperation is the key since water protection is not only the right thing to do, but also a very expensive thing to do. Projects that are partially or entirely motivated by private interests are often realized in a shorter time frame and frequently built at a lower cost. By private interest, I do not necessarily mean the operation of the water supply and waste disposal systems by large private corporations, but I am rather thinking of truly private interests and small-scale initiatives by individuals, especially in the case of DCs. With this in mind, it becomes obvious that entirely new aspects have to be considered in the planning, construction and operation of such new systems.

What are the advantages of privatization?

In my opinion, privatization in the field of water resources can have two effects: first, the influx of private capital (not only from large corporations), and second, initiatives by private individuals (mostly from the middle-class and small enterprises). Since issues of hygiene must outweigh commercial considerations and public welfare and foresight must remain the guiding principles, the government is called upon to set the boundary conditions for such private solutions and to maintain their monitoring functions.

* This interview was conducted by Roland Schertenleib, Willi Gujer and Diana Hornung.



Prof. Hahn, one of Prof. Stumm's PhD students at Harvard and a leading expert in the area of urban water management, spoke at the international IAWQ Meeting held at EAWAG August 22–24, 1999. He addressed continuing education for environmental engineers ("EEE, Environmental Engineering Education, as part of Social Sciences Curricula").
Contact: Hermann.Hahn@bau-verm.uni-karlsruhe.de

It sounds as if privatization would guarantee sustainability?

No, unfortunately not. Privatization normally entails a number of problems: the danger of encouraging monopolies, putting economics ahead of technical considerations, lacking foresight in social and ecological issues, and in reduced exchange of know-how. Despite the potential pitfalls, however, I favor privatization because I consider it to be the only viable alternative.

How can we convince engineering firms in industrialized countries that they should be looking for new solutions?

Any "positive approach" has to be encouraged and reinforced. Financial incentives, for example, have always been a good motivator. We should have design competitions, which is common practice in architecture. Engineers would receive a prize for new and intelligent solutions, allowing the old approaches to concept modification to collect dust on their shelves.

Particularly important is the life-long process of continuing education, which, in my opinion, could also be encouraged by appropriate incentives. For example, the "Association for Quality Control in Sewer System Construction" trains its members and offers quality control and assurance (training) to government agencies.

Another important factor to consider is the regulatory authority, which influences technical progress in many different ways. One could establish a fund providing risk insurance for innovative projects. One could, for example, try an entirely new approach in one out of ten new projects. If the project fails, the financial risk is carried by the fund.

There are a number of new, still technically oriented approaches, described in this issue (pages 7–14). Do they point in the right direction?

Yes, but in addition to the separate collection of urine, one should also pursue the use of gray water and rainwater. We should also keep in mind the importance of "endocrine disruptors", a large and heterogeneous group of chemicals.

Where do you see the most important research needs in the area of urban water management, for industrialized countries on the one hand and for developing and threshold countries on the other?

In developing countries, we are facing enormous research needs with regard to water management, if these needs haven't already overwhelmed us. The problems will require interdisciplinary solutions. The more "languages" spoken, the more successful the teamwork will be. For example, it will be important to have research projects involving more than one discipline; as scientists and engineers, we need to acquaint ourselves with the vocabulary and especially the knowledge of sociology, for example, and not only the other way around. The importance of non-technical aspects has increased even for engineers. Cultural differences have to be recognized and incorporated, since they can be as important or more important than economic considerations, especially when we are talking about smaller private initiatives in the area of water supply and management. In addition to enhance communication, we also need to improve our understanding of ecology. Furthermore, it seems to me that we need to develop solutions which give us maximum flexibility; we should not create irreversible structures and changes, but find ways to leave room for corrections and adaptations as our understanding of the whole system improves. Beyond that, I can only re-emphasize the importance of continuing education for all the experts working in the field, whether they come from natural science, engineering or the social sciences. This is equally important for both developing and industrialized countries.

"I have served as an expert to the World Health Organization and other UN agencies. Their requests have lead to a mouth-to-mouth propaganda about my research. Since then I can barely keep up with all the requests for new studies and research. Sadly I have to admit that even in collaboration with all my colleagues, I can hardly answer one tenth of all the requests."

For years you have been successfully engaged in promoting the IAWQ (International Association on Water Quality). Since 1998, you have been one of the two vice presidents. What do you see as the future role of this association of experts after the fusion with the IWSA (International Water Services Association), particularly with respect to the development and implementation of sustainable urban water management in the "North" on the one hand and the "South" on the other?

The joining of the two associations allows us to come one step closer to the end consumer. My goal is to discuss and promote the approaches proposed by Gujer and Schertenleib in our association. In the "North", this means experimentation and continuing education; in the "South", it means, to just give one example, assistance in the overall structural design to allow small enterprises to become independent within a useful framework and to provide start-up financing in a culturally sensitive and adequate way.

Many thanks for this conversation!

The Tianjin-Switzerland "Ping Pong Course"

A Pilot Project for Continuing Education on a Partnership Basis

At the end of 1997, EAWAG received a request from the Tianjin Environmental Protection Bureau (TEPB) to organize a 20-day course "Water Environmental Management and Monitoring Training Program" for a delegation of 20 Chinese environmental professionals. The inquiry came from Ms. Yang Jienan, the Vice-Director of the Department for International Cooperation of the TEPB who, while visiting EAWAG, learnt about EAWAG's PEAK Program for continuing education.

EAWAG would not normally have the capacity to prepare a conventional course at short notice exclusively for professionals from Tianjin, China; and was neither convinced of the usefulness of such a project. The request was, therefore, answered in a hesitating manner, though help was offered in searching for other qualified institutions. Nevertheless, the water problems faced by the urbanized province of Tianjin with its approximately 9 million inhabitants are enormous; supporting the local authorities in solving them therefore seemed more than sensible. The efforts to manage the environmental problems are not able to keep abreast of the surging economic development of the area. Support for the TEPB should, however, not be limited to a single course for a few select people but has to be oriented towards a well-directed collaboration over a longer period of time. Both sides should profit as much as possible from it.

The idea of an exchange of experiences on a partnership basis, instead of a classical teacher-student course, was born; the idea of the "Ping Pong Course". The partners teach each other and learn reciprocally. The chosen focus and central theme is to be a current problem. The TEPB and EAWAG agreed to carry out a joint "Ping Pong" pilot course. The Swissino, a joint venture of small- and medium-sized companies with representation in Beijing, and the Alliance for Global Sustainability (AGS) of the ETH Zürich, were won as additional partners. The "current problem" is the eutrophication of drinking water reservoirs and monitoring water quality in the catchment area of the Haihe River.

A Swiss delegation travelled to Tianjin in April of 1999 for the "Ping" part, letting itself be educated on structures, responsibilities, capabilities, problems and approaches to solutions by the Chinese partners. The results were discussed, the problems were laid out openly, the gaps in knowledge determined and the focus for the "Pong" part established. This part will take place in May 2000. We shall report on it later.

Herbert Güttinger

The reception of the Swiss delegation in Tianjin and the opening ceremony of the course took place in a very formal setting in the presence of important public officials of the city.

EurAqua

EurAqua is a European network of freshwater research organizations whose members represent 16 institutions from 16 countries. EAWAG represents Switzerland in EurAqua. The goals of EurAqua are:

- To foster the transfer of knowledge from science to practice and politics on a European as well as a national level in order to support sustainable development in the use of water from natural sources.
- To promote and facilitate Europe-wide collaboration between scientists with the aim of identifying urgent problems with regard to the protection of water resources by realizing solutions through research and development.
- To make expertise available within the European Union in order to contribute to the competitive viability and environmental compatibility of the European economy.

EurAqua organizes an annual conference (Scientific and Technical Review) on a current issue in water management. The aim of the conference, to which non-EurAqua experts are also invited, is to review the current state of knowledge on a European Scale and to discuss research priorities. 1999's conference focused on the topic of "Urban Water Management" and was held in Lisbon on 20–21 October.

The subjects of previous conferences are listed below:

- Management and Prevention of Crisis Situations: Floods, Droughts and Institutional Aspects (1996).
- Let the Fish Speak: The Quality of the Aquatic Ecosystems as an Indicator for Sustainable Water Management (1997).
- Farming without Harming: The Impact of Agricultural Pollution on Water Systems (1998).

Further information about EurAqua can be found at http://www.euraqua.org

Walter Wagner

Traces of Pesticides in Natural Waters

Each year, 1800 tons of herbicides are used in Switzerland. Pesticides are not only being utilized in farming, but are also being applied along roadsides and railroad tracks, on sports fields and golf courses, in horticulture and private gardens. In spite of increasing IP (integrated production), organic farming and the application of novel, more effective preparations over the past 10 years, herbicides continue to be found in our natural waters.

In addition to the various EAWAG scientists, the following are participating partners:
- **The ETH institutes for Land improvement and Water Management, for Terrestrial Ecology and for Plant Sciences**
- **Federal Department of Agriculture (BLW)**
- **The Department for Wastes, Water, Energy and Air of the Canton of Zürich (AWEL)**
- **Federal Office for Environmental Protection (BUWAL)**
- **The central cantonal authority for crop protection**
- **The agricultural advisory center in Lindau**
- **Novartis CP, Basel**

Pesticides enter streams and lakes through different processes and so can impair the ecology of natural waters and the quality of drinking water. For this reason, the Swiss Federal Department for Agriculture (Bundesamt für Landwirtschaft BLW) formulated the objective within the framework of environmental measures to reduce pesticide inputs to surface waters by 50% by the year 2005.

EAWAG Study in the Greifensee Area

EAWAG is performing a comprehensive study in the catchment area of the Greifensee. Pesticide sources and their behavior in the environment are being investigated. Where do the trace amounts of the chemicals detected in water originate? How are they being transported? What is their fate? What concentrations are found in streams and in the lake itself?
The approximate 160 km^2-sized catchment area of the Greifensee, with its varied uses, offers ideal conditions for this type of investigation. Intensive farming is practiced in the region; in addition to crops like corn, there are dairy farms, orchards and vegetable cultivation. The region is also inhabitated by over 100 000 people. Industry has also settled here; nine sewage treatment plants purify the accumulating wastewater.

EAWAG researchers collecting water samples.

What Does the Monitoring Program Look Like?

Since 1990, EAWAG has regularly measured atrazine concentrations in the Greifensee, which integrates all of the substances which enter the streams in its catchment area. In addition to the routine analysis lake water samples, the tributaries of the Greifensee and its outflow have also been investigated for several years. The following herbicides are being followed: triazines (atrazine, simazine, terbuthylazine), acetanilides (metolachlor, dimethenamid) and several phenoxyalkanic acids (mecoprop, 2,4-D). An integrated approach permits calculation of the annual pesticide load to the drainage area as well as an estimation of the degradation rates of such compounds in the lake.
If the input of pesticides into surface waters are to be reduced, their primary source needs to be determined. For this reason, the two most important pathways for herbicide input in the lake are being traced by EAWAG: direct input through surface runoff or drainage pathways via cultivated land and the input by way of sewage treatment plants. In the spring/summer of 1999, four small sub-catchment areas of the Greifensee, which are mainly used for agriculture, were intensively investigated. Water samples were taken from the outlets of these regions, especially during rainfall events and immediately after the application of pesticides, with a high temporal resolution. In this way, the amount and dynamics of the application of the chemicals from farming areas could be determined. During the same time period, sewage treatment plants in the area were continually sampled.
With these data, the chemical loads from both pathways can now be compared. Exact results of this large field study are not yet available. The data at present, however, suggest that after the first rainfall, about 1–4% of the applied quantity of atrazine, for example, reaches surface waters, while for other compounds (e.g., mecoprop), the input via sewage treatment plants play an insignificant role.

What Will Happen in the Future?

Intensive measurements in the field are now being followed by data evaluation and the planning of additional investigations. The results of the study will serve the BLW as control of the success of the direct payments through environmental subsidies. At the same time, the results are expected to serve as a basis for the optimized application of herbicides and flow directly into practice via the project's partners.

Siegrun Heberle, Heinz Singer, Andreas Gerecke, Christian Leu, Michael Berg, Stephan Müller (project director)

Quo vadis EAWAG?

Over the past year, EAWAG has been significantly reorganized. The guiding principle in the reorganization effort was the EAWAG's mission statement, which strongly affirms EAWAG's commitment to promote the sustainable use of our water resources.

In order to translate its principles into action, EAWAG has to be able to rapidly adapt to new demands and challenges. But EAWAG must go beyond merely reacting to environmental problems and actively influence future problem areas. In practical terms, this means:

- EAWAG will concentrate on its core competence: "water".
- The link between research and practical application will be substantially enhanced by establishing new problem-oriented research areas (e.g., water resources and drinking water) and aquatic environmental analytical techniques. These research areas have the objective to translate primary scientific results into concrete solutions.
- EAWAG's competence will continue to be based on internationally renowned, first-rate research, both in problem-oriented areas as well as basic research.
- EAWAG will increasingly promote itself as a resource for interdisciplinary problem solving on the national and international level.
- Establishing an Office of Knowledge and Technology Transfer will promote the partnership with industry, government agencies and non-government organizations (NGOs).
- Educational offerings will be tailored to the practical needs of professionals in the field.

Overall, EAWAG will increasingly take on the role of interfacing between science and practice and enhance the usefulness of its activities for society.

The new **Directorate** has seven members: **A. Zehnder (Director), U. Bundi, W. Gujer, R. Schertenleib, R. Schwarzenbach, J. Ward, H.-R. Wasmer**

As a consequence of extending the Directorate, ETH faculty within EAWAG will take on more responsibility for the management of research programs. Additionally, this change will ensure a broader base of technical expertise within the Directorate.

In terms of organization, EAWAG is newly divided into **14 research areas** and one business segment (Logistics and Marketing), which are closely linked to one another.

- Water Resources and Drinking Water **(U. von Gunten)**
- Surface Waters **(B. Wehrli)**
- Analytical Chemistry of the Aquatic Environment **(M.Suter)**
- Environmental Microbiology and Molecular Ecotoxicology **(R. Eggen)**
- Limnology **(J. Ward)**
- Environmental Engineering **(H. Siegrist)**
- System Analysis, Integrated Assessment and Modeling **(C. Pahl)**
- Applied Aquatic Ecology **(A. Wüest)**
- Urban Water Management **(M. Boller)**
- Water and Sanitation in Developing Countries **(R. Schertenleib)**
- Water and Agriculture **(S. Müller)**
- Chemical Pollutants **(W. Giger)**
- Human Ecology **(a.i. A.J.B. Zehnder)**
- Resource and Waste Management **(P. Baccini)**
- Logistics and Marketing **(U. Bundi)**

The new organizational structure and the decrees related to this change are in effect as of January 1, 2000. It is now our task to fill this structure with life so that EAWAG can be a stronger institution and tackle new challenges the future will present.

EAWAG – Research About and For Water

Water is a key factor for development and living standard, a crucial element for nature, in food production, public health, and industry. It is not replaceable by anything else and, therefore, has to be managed in a sustainable manner.

EAWAG ensures that concepts and technologies in water use are continuously improved; ecological, economical and social demands on the water resources are brought into agreement.

EAWAG is a first-rate research institution and bridges the gap between science and practical solutions. It promotes a change in thinking towards the sustainable use of water resources and contributes significantly to water policies in Europe, Third-World and "threshold" countries.

EAWAG perceives its role as interfacing between science, practice and society. It fulfills a leadership role in water research which is recognized around the world.

Publications and books

Please use the order form in the center fold of EAWAG news to request individual back issues of EAWAG news.

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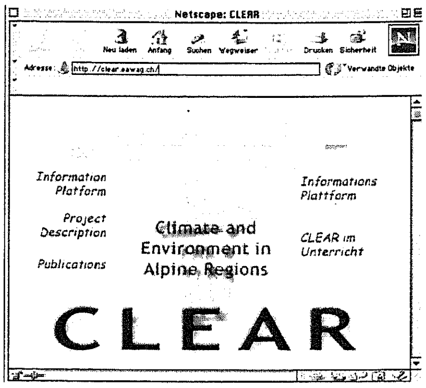
Climate Change in School

Teachers who would like to integrate the current developments in environmental research into their teaching can now get support from researchers. A novel information platform presents the results of the Swiss research project "CLEAR – Climate Change in the Alpine Region" in an integrated and generally understandable way.
Via the internet, students can tackle diverse aspects of the man-made greenhouse effect:

- How much CO_2 did my last holiday cost?
- What will change in my home town due to climate change?
- What political steps can Switzerland take?

In the meantime, there are preliminary reports of experiences from its use in schools and universities. In a game setting, pupils in Davos played the roles of construction firms, environmental activists and tourism managers in asking various questions related to climate change: Should the ski areas be expanded? Do we need new protective constructions? What will happen to the utilization of hydropower? They prepared themselves for their roles using the information system. According to their teachers, the exercise was highly successful, and they even had fun! http://clear.eawag.ch



Martin Büssenschütt, a mathematician and environmental scientist, now works in the field of pedagogy/new media.

EAWAG Field Trip 1999

This year's EAWAG field trip started at the Center for the Protection of Nature at Acquacalda, progressed to the floodplain forest Campra di là and to the floodplain at Loderio. The mountain climbers of the group combined a tour of the dam at Luzzone with an ascent to the mountain hut at Motterascio. Hiking the next day under the professional guidance of Bernhard Wehrli, the group experienced the moisture level of the protected "Greina" plain. "Greina" is a seldom-used Romansch word for humid fog. The NOK (power plants of NE Switzerland) refrained from building the Greina reservoir due to public opposition and because the Greina plain is worthy of protection.

Reader's Letter on the New Concept of EAWAG News

Based on my general impression, I would like to congratulate you on this issue. The concept and the layout are inviting.
The issue offers a good, well-grounded overview of the subject of modelling. I will certainly be able to use the article by Claudia Pahl and Peter Reichert for teaching. The articles on the examples of models supplement the article well. More attention could possibly have been given to the question of model structures as well as to the problems many models present in calibration and validation, especially in the transitional area of man and environment.
It would be useful to have the aspects of "mental models", communication, representation of models and the aspect of creating models and simulations in education appear more in depth in a further issue on this subject along with an overview of the currently available modelling software.

Dr. Johannes Heeb – Beratung, Ausbildung, Auftragsforschung GmbH, CH 6110 Wolhusen, heebjohannes@pingnet.ch

Award for Researchers in Drinking Water

For their work on "Calibration of full-scale ozonation systems with conservative and reactive tracers" ("Kalibration von Ozonungsreaktoren mit konservativen und reaktiven Tracern"), (in AQUA, December 99) the following researchers received the Maarten Schalekamp Prize of the International Water Services Association (IWSA) of CHF 2500.– in September 1999: Urs von Gunten (see photo, on right), Head of the Chemistry Department of EAWAG and specialist in drinking water and groundwater; Mike Elovitz, former postdoctoral fellow with Urs von Gunten and currently scientific coworker at the U.S. Environmental Protection Agency, Water Supply and Water Resources Division, Cincinnati, Ohio, U.S.A.; and Hans-Peter Kaiser, Head of Chemistry of the Department for Quality Control at the Water Supply Agency of Zürich.